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Innovation and International High Skilled Migration

Antonio Mihi-Ramirez[1], Yolanda Garcia-Rodriguez[2], Eduardo Cuenca[2]

[1]*Kaunas University of Technology*
K. Donelaicio st. 20. 44309, Kaunas, Lithuania
E-mail. a.mihi@ktu.edu

[2]*Granada University*
Campus Cartuja, 18071, Granada (Spain)
E-mail. ygarcia@ugr.es, ecuenca@ugr.es

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The international mobility of highly skilled employees in the last few decades has become an essential part of an economy. Simultaneously innovation and its' components have a large effect on the migration of skilled people. The goal of this paper is finding out if a greater degree of innovation in a country has a positive impact on the arrival of highly skilled immigrants. In order to achieve the aforementioned goal and following existing literature on the subject, an analysis on an international level was made regarding the effect of relevant innovation factors (number of patents; research and development funding (as % of GDP) and number of articles in scientific and technical journals) on immigration of highly skilled employees. The results of a regression analysis confirmed a significant relation between the number of patents, articles in scientific and technical journals and number of highly skilled immigrants (HQI). This means that countries with a relatively larger amount of the innovation factors have a great incentive that attracts talented people on an international scale, although in order to achieve this there is the need to promote and maintain a favourable institutional, economic and technological environment.

Keywords: *High Skilled Migration, Innovation, Patents, GERD, Scientific Journals.*

Introduction

Migration flows are a transcendental phenomenon on an international scale that have been increasing significantly since the year 2000 (Kaczmarczyk & Okolski, 2008). The emigration is selective depending on the level of education of the migrants (Arslan *et al.*, 2014). On this sense of ideas, according to the OECD data (2014) of 145 source countries that were analyzed, on 137 of them the percentage of highly skilled people of the total amount of people that emigrated from those countries is proportionally higher relative to the amount of highly skilled people in the population of those same countries (OECD, 2014).

According to UNESCO data (2009) brain drain is a specially important concern to less developed countries, because they fear the loss of highly skilled people while this loss benefits more developed countries that can offer salaries more suitable to the level of qualification of such people, increasing the wealth of such receiving countries by means of additional research and technology created by such highly skilled and skilled personnel. Following the aforementioned train of thought it's clear that there is a global necessity for new ideas in social policy in order that the search of prosperity by highly skilled people and the right of their countries for the preservation of their economic and social development can be reconciled.

Simultaneously the level of innovation and the set of factors that help determine it have a large effect on migration flows of highly skilled employees (Bosetti *et al.*, 2015; Naghavi & Strozzi, 2015; Zheng & Ejermo, 2015). A larger degree of innovation in a country could encourage the arrival of highly skilled immigrants, which is the general hypothesis developed in this research paper.

According to Niebuhr (2006), the relation between migration and innovation is a continuous cause of worry for the researchers working in the field of migrations and for countries that are either a source, or a destination of such migration flows. The aforementioned authors have highlighted the fact that generally the lack of innovation in an economy deliver it to higher levers of poverty (absolute and relative), lack of opportunities, larger migration flows, which has the largest impact on groups of people with higher skills or qualification.

We live in a world where scientific or technical knowledge is becoming more and more important each day for the economy and for social and cultural life. More developed countries use science and technology trying to attract high numbers of specialists able to create ideas and products, and apply their knowledge in complex production and innovation processes (Obadic & Poric, 2008).

After reaching this point it´s sensible to think that the changes caused by the factors that make up innovation also have an impact on new gradual changes in migration flows (Masuduzzaman, 2014; Daugeliene & Marcinkeviciene, 2009; Feridun, 2004, 2005, 2007).

In the literature about international migration there can be found research papers that analyze the impact of qualified immigration on innovation (Abdelbaki, 2009), but there are also studies that analyze how the factors that comprise innovation have an effect on the immigration of highly skilled people (Bosetti *et al.*, 2015; Kristkova, 2013).

Keeping in mind the contributions about highly skilled immigration included in migration theories and the importance of innovation processes (Zheng & Ejermo, 2015), this particular paper focuses on the later subject.

So the aim of this research paper is the analysis on an international level of the most relevant innovation factors (number of patents, spending on research and development (as a percentage of GDP) and number of articles in scientific and technical journals) as influencing factors for the immigration of highly skilled people.

Also the increase of international migration of highly skilled personnel, especially since the beginning of the XXI century, implies a greater need for research that includes international comparisons and a more comprehensive perspective on the subject (Arslan *et al.*, 2014).

For this reason an analysis of a sample of 207 countries: 182 countries which are net exporters of highly skilled people and 25 countries, which are net importers of highly skilled people, members of the OECD and receive the immigration of such people from 6 regions of the world: Africa, Asia, Europe, North America, South and Central America and Oceania. This sample has been analyzed by applying the statistic technique of lineal regression in order to determine the relevance of the variables being studied. That's the reason that this particular research papers is one of the few theoretical and empirical studies of an international level of the subject and it also analyzes one of the largest and most recent samples regarding migration of highly skilled personnel.

In order to develop further this paper after the introduction part a theoretical overview of highly skilled immigration is done including the most relevant contributions regarding this type of migration to current migration theories. Innovation, its´ comprising factors and the relationship between immigration of highly skilled people and innovation is studied so as to being able to formulate the hypothesis of this research.

Further down in this text the reasons of selecting this specific sample is explained and an overview of the variables and methodologies used in the research paper is presented. Additionally the results of the empirical analysis are also presented and discussed.

And finally the main conclusions of this research are presented explaining its´ main limitations.

Background

According to the International organization for migration (IOM), migration is the "movement of one person or a group of people from one geographic area to another through an administrative or political border with the intent of establishing themselves temporarily or indefinitely in a different location from their place of origin" (IOM, 2006, p. 2).

In our research we will use the ISCED (International Standard Classification of Education) classification of 1997 as it´s still the most widely used internationally. Our research focuses on the segment of highly skilled employees, which for the aforementioned reason belong to categories 5-6 (according to the ISCED classification).[1]

According to the OECD data (2014), since the year 2000 migrants are more and more numerous and each year their education level is higher. So as to that in the year 2011 there were approximately 35 millions of migrants with tertiary education inside OECD countries, which is an increase of 70 % compared to the amount in the year 2000. This growth is due mainly to immigrants from Asia (79 %), Africa (80 %) and Latin America (84 %) (OECD, 2014).

Anyway the immigrants with a university level education are the largest group of immigrants in all regions and for most countries this shows that migration is a highly selective process in regards of educational achievement (Arslan *et al.*, 2014). Furthermore international scientific cooperation has almost doubled since 1996 (OECD, 2015).

Simultaneously and paradoxically for various reasons (including the after-effects of the financial crisis, the aging of the population, the policies regarding innovation and investment, globalization, greater international competition and concentration of high level research centres, scientific publications and patents in a few countries (Arslan *et al.*, 2014; OECD, 2014, 2015), there is an increasing shortage of local highly skilled employees.

This situation is causing profound structural changes that raise new challenges and opportunities. On the one side some developed countries concentrate a greater amount of highly qualified immigrants by the implementation of policies for attracting and retaining talented personnel due to the fact that such people allow boosting productivity, innovation and economic growth on the long term (Bosetti *et al.*, 2015; Masuduzzaman, 2014; Abdelbaki, 2009; Cekanavicius, 2009; Kerr & Lincoln, 2008; Jaffe *et al.*, 1993). On the other hand countries with lower income have a greater risk of suffering from brain drain and the negative economic and social repercussions that such a process implies (Masuduzzaman, 2014; Jaffe *et al.*, 1993).

Innovation and Migration. Hypothesis

Innovation is a crucial factor for the development of countries and regions (Love & Roper, 1999).

An important question on the subject of innovation is appropriation. Protecting innovations is essential so as to companies can obtain a profit allowing them to keep investing in innovation related activities (Eurostat & OECD, 2005; Schumpeter, 1934). In this sense the data on patents gives us information about the processes and results of R&D activities allowing the familiarization with the technological content of the inventions, the corresponding technical field and the geographic location of the R&D process (OECD, 2010).

Jaffe *et al.* (1993) and Jaffe & Trajtenberg (2002) proved the usefulness of patents and information on

[1] UNESCO (2006, 2009): Level 5. First cycle programs of tertiary education: tertiary education programs with more advanced educational content than levels 3 and 4.
Level 6. Second cycle programs of tertiary education: this is a level reserved for tertiary education programs geared to obtaining a qualification in advanced research (like a PhD) and as such focused on advanced studies and original research.

bibliographic citations as a method for the evaluation of the process of technological change and as a powerful tool for advancing international research.

Chellaraj *et al*. (2005) prepared a study for the World Bank Policy Research Working Paper regarding the effect of international students and highly skilled immigration in the United States on the innovation (R&D) activities, as measured by number of patent applications and prizes for patents in academic and other types of institutions. The results showed the importance of innovation through patents and its´ effect on highly skilled immigration.

Zucker & Darby (2006) analyzed the USA data during the time frame from 1981 till 2004 and reached the conclusion that patents, high salaries and the stock of scientific-technical publications have a positive effect on the number of "star scientists".

Besides in 2010, Hunt & Gauthier-Loiselle analyzed the relation between highly skilled immigration and R&D in the United States. The study which was made based on data from the timeframe of 1950-2000 given by the Patent and Trademark Office. Again it was proven that the increase of graduated immigrants with degrees in sciences and engineering has a positive correlation with the increase of the number of patents.

Kerr (2010) researched the speed of emigration of people in the R&D field. In this sense the cities and technological fields with the greatest growth of number of patents granted for revolutionary inventions (defined in the same study as the most cited (upper 1%) patents in the USA for a certain technologies between 1975 and 1984) are also where the greatest presence of HSI (highly skilled immigrants) can be found. The reverse is true in similar cities and technological areas where such a situation didn't happen, or where revolutionary inventions were rare. Besides the author correlates this differential growth with the mobility of the technological workforce. In other words the Kerr model (2010) asserts that the collective of immigrants with scientific and engineering skills is much more flexible on their working location (are more mobile) than native inventors. Due to this the relocation to such new R&D centres is much faster if the technology has a more mobile workforce as is the case with highly skilled (qualified) immigrants.

Additionally Bosetti *et al.* (2015) focused their analysis on the application for patents and migration in 20 European countries. Specifically these authors showed how the migration of highly skilled personnel is related to the development of innovation focused on patent production. In this way the creation of "private" knowledge (measured as the number of patent applications received) and more importantly the basic "public" research (measured in number of citations of published articles) attract international researchers.

Naghavi & Strozzi (2015) analyzed the combined impact of the emigration of highly skilled (qualified) personnel in a sample of 34 low income countries between 1995 and 2006 and the protection of intellectual property rights in those countries on the level of innovation in them. The aforementioned authors established that emigration can result in a flow of knowledge acquired in foreign countries back to the countries of origin in a form of people returning to their countries of origin. This way that circumstance can be exploited by patent institutions which could become an incentive for innovation by creating a suitable environment for the assimilation of the possible benefits received due to international emigration. The researchers argue that emigration is related to the patents and the innovation potential of a country via the increase of the capacity for assimilation of such benefits in the country of origin.

All of these authors and research show us the importance of the relation between the immigration of highly skilled individuals and the creation of patents as an indicator of development and innovation. So based on the content of the literature sources reviewed above, we propose the following hypothesis:

Hypothesis No. 1: "The number of patent applications in a specific country explains the number of highly skilled immigrants (HSI) received".

On the other side all countries try as much as their means allow for it, maximizing the activities related to innovation, because a high level of innovation implies better products and processes, which allows for a differentiation from other competitors. The level of innovation activities in a country can be found out by the investment in R&D activities made by that country in proportion to their GDP (Fan, 2011).

On this line of though Cekanavicius (2009) made a study that correlates the GDP with the loss of talent. Besides he indirectly highlights that R&D investment is an engine or "pull factor" for such highly skilled emigration.

Gagliardi (2011) analyzed the contribution of HSI on local innovation in the United Kingdom. His results confirmed that investment in R&D is a factor that encourages qualified emigration.

Bénassy & Brezis (2013) asserted that qualified immigration depends partly on the GDP, and particularly on percentage of GDP spent on R&D.

Kristkova (2013) showed the process of internationalization of the R&D process and its´ related factors. Due to this technological companies invest in R&D by founding branches in foreign countries, buying foreign companies and cooperating with foreign research centres, all of which contribute to the international mobility of researchers.

Due to the aforementioned circumstances we consider that there is an intrinsic correlation between the indicators of R&D spending of each economy and the number of HSI it receives. That's why in our research paper we propose the following hypothesis:

Hypothesis No. 2: "The rate of spending on research and development (R&D) as percentage of the Gross Domestic Product of the country has correlation with the number of highly skilled immigrants (HSI) it receives".

Another essential factor of innovation is the spreading of all new knowledge and technology (Eurostat & OECD, 2005; Schumpeter, 1934).

That's why the number of articles published in specialized Science and Technology journals is another indicator which correlates with the level of innovation and development of a country (Smith *et al.,* 2014). We can see its´ importance in scientific literature in research papers

like Jeannin & Devillard (1994), who approached the environment of scientific publications from a demographic point of view in order to determine the treatment of information in research.

If immigrants produce an increase in scientific production that can be confirmed by the increase of patent applications and publication of scientific articles, this would imply that an increase of results per capita could be achieved and helping native researchers become better and more competent (Hunt & Gauthier-Loiselle, 2010)

Similarly the report of the Organization of the Islamic Conference (2012) approached the study of the aforementioned indicator as a measure of the development of countries in the areas of R&D and Science & Technology.

Borjas & Doran (2012) based their argument on the effect that the fall of the Soviet Union and the elimination of emigration restrictions had towards the rest of the western world (specially the USA). This research paper uses information from publications, citations and affiliations of ex-soviet mathematicians in order to examine the effect on scientific production after 1992 on productivity levels when compared to their USA colleagues. The authors found out that the productivity of the research of mathematicians had a correlation with the differences between the number of immigrants received and the relation of the receiving countries with the global market of mathematical publications.

Stuen *et al.* (2012) analyzed how foreign doctorate students contribute towards innovation by working in 2300 different science and engineering departments of USA universities from 1973 till 1998. The analysis highlights that the import of foreign PhD in science or engineering students may be one of the reasons that the USA has maintained its place as the main producer of knowledge and publications, even with the education deficiencies in the fields of science and mathematics of USA high school graduates.

Additionally a study made by Moed & Halevi (2014) presents a bibliometric approach by following the international migration of scientists based on the analysis of the countries of origin of authors that have publications in Scopus indexed journals. The document presents a model that links concepts of migration research with bibliometric constructs, while discussing the advantages and limitations of such an approach depending on the accuracy of the data and its´ interpretations. The results obtained show that the percentage of authors that publish in those journals that migrate and then return to their country of origin is smaller than those that relocate to a foreign country permanently.

Based on the previous data we conclude that there is a correlation between the number of scientific-technical publications and the number of highly skilled immigrants received in a particular country. Due to this we propose the following hypothesis:

Hypothesis No. 3: "The number of articles published in scientific-technical journals in a specific country is related to the number of highly skilled immigrants (HSI) it receives".

Methodology and Results

The increasing and diverse international migration makes international comparisons crucial (Arslan et al., 2014), especially as international migration has been rapidly changing in the last few decades. Because of this and based on the aims of this research and the hypothesis presented an analysis of 207 countries[2] was made: 182 countries which are net exporters of highly skilled people and 25 countries, which are net importers of highly skilled people and members of the OECD, receiving the immigration of such people from 6 regions of the world: Africa, Asia, Europe, North America, South and Central America and Oceania.

The data about highly skilled immigrants, HSI, was obtained from the OECD database on immigration (2011), which includes data from the year 2000 on international migration flows according to different categories. In particular the data on emigration of highly skilled people (people belonging to levels 5–6 according to ISCED) on the year 2011, prepared by UNESCO. It's the most recent worldwide data on HSI migration flows and it's adjusted keeping in mind the differences in migration registration rules in different countries, allowing for international comparisons of data (de Beer et al., 2010). The receiving countries selected are those OECD countries, that based on the database information receive the largest amount of immigrants from HSI donor countries. Regarding HSI donor countries (net exporters of HSI) all the donor countries included in the database were included in the research sample.

The information on patent applications was obtained from the patents database of the Organization for Economic Co-operation and Development (OECD, 2011), which includes the international patent applications presented through the procedure established by the Patent Cooperation Treaty or through a national patent office for the exclusive rights on an invention, product, or process that allow for a new way of doing something or a new technical solution for a problem, which grant protection for the invention of the patent holder for a certain period, usually - 20 years.

The data on R&D spending as percentage of GDP was also obtained through the OECD (2011) which itself bases its´ data on the information on education, science an culture gathered by the United Nations in regards to the information about ongoing and capital (both public and private) R&D spending on the creative process and maintained systematically in order to increase knowledge, including knowledge about humanity, culture and society and the use of knowledge on new applications. This R&D spending includes basic research, applied research and experimental development.

The data on articles in scientific or technical journals means the number of scientific or engineering articles published in the following fields: physics, biology, chemistry, mathematics, clinic medicine, biomedical research, engineering & technology, Earth sciences and

[2] On the final annex of this document there is the list of the countries that were subject of this study.

Space. The OECD (2011) and the World Bank collect this information based on the national registers data on Science and Engineering Indicators of the National Science Foundation.

This paper tries to explain the behaviour of the variable - total number of highly skilled immigrants according to the information given by the other variables (patents, R&D spending as % of GDP and number of articles in scientific and technical journals) analyzing the variance percentage. Meaning what part of the variable - HSI can be explained by independent variables.

A suitable method to do this is multiple regression analysis, because it allows evaluating the contribution of each independent variable regarding the dependent variable (Wooldridge, 2002; Cohen & Cohen, 1983). It's a technique that quantifies the influence of all independent variables on the dependent variable HSI, and allows reaching conclusions on which variables are more relevant when trying to explain its´ variance and/or predict its´ behaviour (Cohen *et al.*, 2003).

Additionally in order to do the regressive analysis, a previous analysis of the data and assessment of the execution of the assumptions was made (Harris, 2014; Berry & Feldman, 1985). On it an evaluation of the size of the sample and the number of variables used in the research was made, besides the data was reviewed searching for atypical, extreme, or influential data points. On this subject the cases of the USA, Canada and Italia seem to be more "atypical" than "influential" cases (Cook, 1977, 1979) and were eliminated, although this didn't seem to have any significant effect on the regression lines.

Furthermore the assumptions of normalcy, homocedasticity, independence and linearity, including the assumption on the absence of multicolinearity between the variables were checked (Berry & Feldman, 1985).

In our case the calculations of the regressive analysis methodology were made based on the statistical data packets "SPSS 23".

The results obtained show that the model fits the data well after a correction of the coefficient of determination (Square of the Pearson correlation coefficient -R^2 corrected-) giving it a value of 0.88, which means that the model proposed on this paper explains 88.9 % of the total variance of the total HSI number (Harris, 2014).

The hypothesis that the regression coefficients may be equal to zero ($F(2.19) = 118.05$, $p<0.01$) is rejected. Meaning that the F value shows us that at least one of the coefficients of the equation is not equal to zero, or in other words, the variance of the dependent variable can be explained in the amount determined by the corrected coefficient R^2 (that is almost 89 %) by at least one of the variables that comprise the equation (or model).

Table 1 shows the aforementioned coefficients and the corresponding variables. The result shows two non null coefficients, so the conclusion is that two covariables contribute in explaining a significant part of the values of the dependent variable. Regarding the last variable the statistic model isn't conclusive based on available data.

Thus the regression equation would be as follows according to the (B) coefficients of the regression line showed on Table 2:

Equation No. 1:

number of immigrants = - 999.13 + 1.57 (Patents) + 1.26 (Number of articles in scientific and technical journals) + ε

This means that besides the prediction error (ε), for each point of increase of the total number of articles the HSI number increases 25,6 %, while for each point of increase of the number of patents, the total HSI number increases 56,6 %.

So hypothesis H1 and H3 are accepted.

Table 1

Regression Coefficients

Model	Non standard coefficients		Standardized coefficients	t	Sig.
	B	Error tip.	Beta		
(Constant)	-999.13	1471.23		-.67	.50
Number of articles in scientific and technical journals	1.256	.124	,69	10.10	.00
Number of patents	1.56	.25	.43	6.22	.00

Finally with respect to the applicable conditions, these are reasonably met. The scatterplots between the standardized remainders and the predicted remainders show a mixed pattern with no clear trend warning of possible heterogeneity of the error variances (Figure 1).

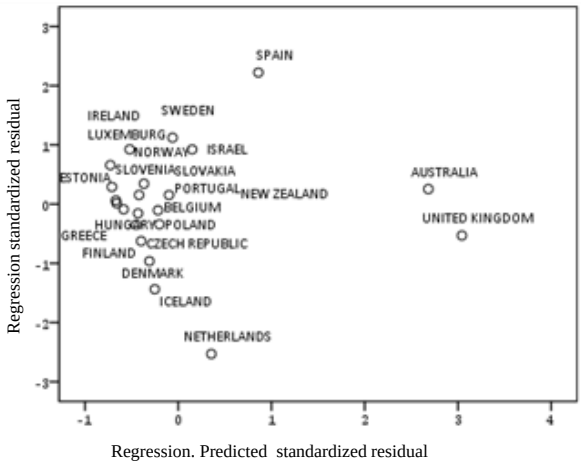

Figure 1. Scatterplot of Residuals Vs Predicted Residuals

Furthermore the characteristics of the sample don't seem to stray too far from normal conditions: in the P-P graph for the distribution of cases (Figure 2) it can be accepted that these do not depart decisively from the diagonal, so that it doesn't seem that there were a serious risk to the assumption of normalcy.

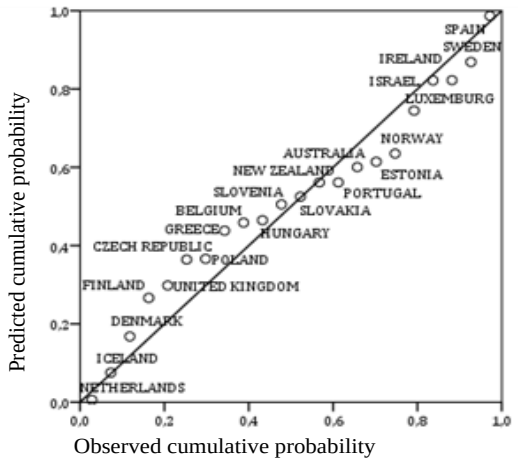

Figure 2. Normalcy Regression Line P-P Graph for the Standardized Residuals

Discussion of the Results

Our results were conclusive regarding the relationship between the production of patents and the HSI received. The countries with the largest amount of patent applications represent a great incentive for immigration of highly skilled personnel, or, in other words, the larger the innovation level as measured by the amount of patent applications, the larger the number of HSI received (hypothesis No. 1). For each point of increase of the number of patent applications of the receiving country, the total HSI number increases by 1.57 (meaning there is an increase of nearly 57 %).

These results allow us to confirm some of the findings addressed in the literature on migration. This means that diversity and attraction of international talent are related to the level of innovation and number of patent applications. Niebuhr (2006) confirmed this at a local and regional level in Germany and Gagliardi (2011) did so in the UK finding the aforementioned positive change. In our case this fact has been confirmed for an international sample of 182 donor countries and 25 receiving countries.

In this sense Abdelbaki (2009) showed an estimate of the increased productivity and innovation that migration of skilled people can bring to the recipient economies. Based on the aforementioned research and the results obtained in this research, the policies of attraction or retention of this type of employees are the most appropriate, as we have seen thanks to our analysis. The number of patents is a good data point for predicting the effect of such policies on the total of HSI received in the receiving country.

The production of patents is greater in countries that receive highly skilled immigration, which shows that any restriction on the access of skilled personnel to the country is a serious problem, due to the negative consequences this has on economic development. Thus the data show that the US produced a total of 271033 patents by non residents in 2011 compared to 30357 in Canada, 23143 in Australia and 6916 in the UK.

In this sense Wadhwa (2009) was already recommending that US policymakers should focus on the task of attracting and retaining better qualified foreign born scientists and engineers, taking steps to eliminate barriers to immigration and provide jobs, security and other services to them. Thus the future strength of the economy would depend on the creation of new enterprises, which require the development of innovative new products and services created by highly skilled and well paid personnel.

Hence to encourage these flows of HSI the following should be provided:

• A stable institutional environment with enough legal guarantees for HSI personnel, work permits and simplified procedures for obtaining visas and citizenship of the country.

• A highly competitive economic and technological environment in which patent generation is high which acts as an attraction and incentive for HSI personnel.

• Simplified procedures for the creation and processing of patents, particularly advantageous for HSI personnel, creating a "call effect" and improving the technological development rates of the receiving country.

In this regard, according to the OECD (2014), among the countries that have promoted most strongly the aforementioned conditions in recent years are Japan, Switzerland, Sweden, Germany and Finland which are in the top five of most inventive countries. Then Austria, Denmark, Israel, Austria, Denmark, Finland, Korea, the Netherlands and the United States. These countries are characterized by having densely populated cities and surrounding municipalities with high levels of commuting to these urban centres, which in some cases can even happen across borders. In such an environment there is a large proportion of specialized and highly skilled workers, companies and capital, where ideas can be easily exchanged in order to create new products and production processes. Good examples of this would be San Francisco, the metropolitan area producing the highest number of patents, meaning a total of 9000 patents and patent applications each year; followed by Tokyo and Osaka, each with over 4000 patent applications a year. Also Eindhoven in the Netherlands with nearly 2200 patents and San Diego with over 700 patents.

Regarding the issue of measures for ease of work for HSI, one of the most important aspects of the migration process for highly skilled workers is the visa processing time, which includes the time spent from the submission of the documents until the person receives the corresponding work permit or visa. For example, in the case of the European Union, the average duration is one month, although in Finland and Portugal is even less (OECD, 2011). Handling times can be reduced by introducing online applications for obtaining work permits or work visas, such as the ones implemented in Canada and Australia. In any case there is a correlation between the existence of an online application service and the reduction of processing time (OECD, 2011).

Similarly, another major challenge that most countries face regarding immigration is the multitude of documents required. So, for example, while countries like US only require one document (meaning, a valid visa stamped on a passport), many European countries require a work permit, an entry visa and local identification card to identify its foreign highly skilled workers.

In any case, regarding the liberalization of the immigration system of a country and its relation to patents and other technology related variables and economic growth, it has been shown that a system that allows the entry of HSI can stimulate productivity, technological innovation and the creation of business fabric in the long-term (Kerr & Lincoln, 2008).

According to Kerr (2010) an industry can become a hotbed for innovation and productivity growth if it first of all starts from revolutionary inventions, and second: if it's able to attract highly skilled employees (willing to move much more easily to innovation and production centres) needed for its economic expansion. Therefore quantifying the time needed to create such centres of innovation and production would help to assess the dynamics of the industry and models of urban evolution speed.

In this sense, based on the number of HSI received in the US from Europe (more than 166000 immigrants) and especially Asia (nearly 340000) / OECD, (2011), we can assert that it is important to evaluate the process of patent creation and application for HSI personnel in order to reduce the time that these processes take for HSI personnel.

Regarding Europe, Ozgen et al. (2011) researched the relationship between immigration an innovation in 170 European regions for the time periods of 1991–1995 and 2001–2005. The results confirmed that the level of innovation clearly depends on the regional accessibility, industrial infrastructure, and human capital of those countries. Furthermore, the number of patent applications is positively affected by the diversity of immigrants beyond a critical minimum level. Thus an increase of 0.1 % of the regional average diversity (of 0.5 %) would increase the number of patent applications per million inhabitants by approximately 0.2 %. Moreover, they confirmed that the average skill level of HSI also has an impact on the number of patent applications.

In this sense, our data indicates that countries that actually receive more HSI from any source are precisely those that produce more patents. Thus, in 2011, the USA, with more than 338000 HSI from Asia, 166000 from Europe, more than 77000 from Central and South America, and more than 31000 Africans, constitutes the country with the highest patent production by non-residents (21.4 % based on the ratio between number of patents and number of researchers in the country).

In line with this research, it is proposed that the authorities provide security to businesses and skilled immigrants, recognizing the value of this type of immigration and its impact on the labour market, by implementing mechanisms for access to talent when it's needed and facilitating the retention of foreign talents graduated from universities of the country.

The creation of patents by highly skilled immigrants generates a "pull factor" that encourages other HSI to migrate to countries where they can develop their professional skills (Jaffe, 2002). Therefore more lax regulatory laws could pose an incentive for the arrival of new researchers immigrants and the corresponding rise in the creation of patents (Jaffe & Trajtienberg, 2002).

Indeed, at a time of an aging society and the rule is the knowledge economy, both countries and their companies prefer highly skilled immigrants even in times of economic crisis. Hence the application of protectionist measures that have an impact on HSI demand, not only doesn't make any sense, but could slow the economic recovery (Jaffe *et al.*, 1993).

In this regard it is noted that the most common objective of migration policies in countries traditionally receiving migrants, are aimed at raising the profile of skills of prospective immigrants and the simultaneous reduction in the number of immigrants allowed (as it involves lower labour costs) (Martinez, 2011). In this regard, according Cerna (2009), following a report from the OECD, the admission criteria of HSI include modifications of various kinds, from changes in allowable quotas, requirements for work experience and qualification, stricter renewal of work permits or even return incentives.

Meanwhile Bosetti *et al*. (2015), in a recent study, collected the most pervasive and widespread implications of the research papers being analyzed. Their results suggest that political efforts to attract qualified immigrants to Europe and their hire for specialized professions (such as those presented in Europe Strategy for 2020), would foster the competitiveness of the European Union in innovation. Also they supplement the discussion about the establishment of a common framework of migration policy in the EU and the fostering of highly skilled migration to the continent.

European competitiveness thus would benefit from attracting HSI, but would require an effective allocation of labour resources. Therefore, a reform of the system for creating an easier and simpler access and hiring of HSI would bring significant benefits in short term knowledge creation. In this regard, measures such as the EU Blue Card would be positive in fostering innovation and competitiveness in Europe. The results also indicate that this would be just one key, because, for example, investment in R&D would also be important in this regard.

As to the number of articles published in scientific and technical journals in a particular country, this variable has been determined as the most important variable to document the behaviour of highly skilled immigrant flow.

Thus for each point of increase of the total number of articles the HSI number increases a little over 25 %. This confirms hypothesis No. 3.

According to the above information the results suggest that in general terms the groups containing countries with a higher production of scientific and technical publications, are also characterized by the fact that they receive a larger number of highly skilled immigrants. Particularly those countries give a greater importance on policies for the attraction of international talents.

Conclusions

Migration flows are an important and growing international phenomenon. Innovation and its economic components are deciding factors regarding the migration of highly skilled workers.

This paper is one of the few theoretical and empirical analyses of an international level on the international mobility of highly skilled workers and its' explanation from the point of view of innovation.

Based on one of the largest and most recent existing sample on skilled migration, we made an analysis at international level of the relevant factors of innovation (number of patents, research and development spending (as a percentage of GDP) and number of articles in scientific and technical journals) as deciding factors in regards to immigration of highly skilled workers.

Patents are indicators of innovation and progress. They allow us to measure the inventive capacity of countries, regions, companies or individual inventors, and as empirical research has shown, they are often a good tool to attract highly qualified personnel.

This benefits the innovation and commercialization in recipient countries. That's why political steps should be taken in order to eliminate barriers for skilled immigrants and take advantage of the enrichment that is always guaranteed by diversity.

As for how spending on research and development (R&D relative to GDP of a specific country) explains the number of highly skilled immigrants (HSI) arriving at the receiving country, a theoretical and empirical analysis of this relationship has been executed. However there hasn't been enough empirical evidence found to prove this relationship.

As in the case of patents, it has been confirmed that the number of scientific and technical publications is an important predictor of the HSI. Thus, the countries with highest productivity in publications, are also the most proactive in terms of policies to attract international talent, so they attract more skilled immigrants.

Also, the increase in HSI provides huge cost and innovation benefits for recipient countries and, vice versa. Restrictions imposed on HSI cause losses for these countries in all aspects of innovation. Therefore recipient countries should put in place appropriate policies to facilitate the flow of HSI. Similarly donor countries should try to somehow exploit the intellectual capital acquired by migrants into local researchers still at the country of origin.

Annex

Donor countries: *Aruba, Afghanistan, Angola, Anguilla, Albania, Andorra, Netherlands Antilles, United Arab Emirates, Argentina, American Samoa, Antigua and Barbuda, Australia, Austria, Burundi, Belgium, Benin, Burkina Faso, Bangladesh, Bulgaria, Bahrain, Bahamas, Belize, Bermuda, Bolivia, Brazil, Barbados, Brunei Darussalam, Bhutan, Botswana, Central African Republic, Canada, Cocos (Keeling) Islands, Switzerland, Chile, China, Côte d'Ivoire (Ivory Coast), Cameroon, Congo, Dem. Rep. Of Congo, Cook Islands, Colombia, Comoros, Cape Verde, Former Czechoslovakia, Czech Republic, Slovak Republic, Cuba, Cayman Islands, Cyprus, Germany, Djibouti, Dominica, Denmark, Dominican Republic, Algeria, Ecuador, Egypt, Eritrea, Western, Sahara, Spain, Ethiopia, Finland, Fiji, Falkland Islands, France, Micronesia, Fed. States of Former Yugoslavia, Bosnia-Herzegovina, Croatia, Former Yug. Rep. of Macedonia, Montenegro, Slovenia, Serbia, Kosovo, Gabon, United Kingdom, Ghana, Gibraltar, Guinea, Gambia, Guinea-Bissau, Equatorial Guinea, Greece, Grenada, Guatemala, Guam, Guyana, Hong Kong, Honduras, Haiti, Hungary, Indonesia, India, British Indian Ocean Terr., Ireland, Iraq, Iceland, Israel, Italy, Jamaica, Jordan, Japan, Kenya, Cambodia, Kiribati, Saint Kitts and Nevis, Korea, Kuwait, Laos, Lebanon, Liberia, Libya, Saint Lucia, Liechtenstein, Sri Lanka, Lesotho, Luxembourg, Morocco, Monaco, Madagascar, Maldives, Mexico, Marshall Islands, Mali, Malta, Myanmar, Mongolia, Northern Mariana Islands, Mozambique, Mauritania, Montserrat, Mauritius, Malawi, Malaysia, Namibia, Niger, Norfolk Islands, Nigeria, Nicaragua, Niue, Netherlands, Norway, Nepal, Nauru, New Zealand, Oman, Pakistan, Lithuania, Peru, Latvia; Philippines; Moldova; Pacific Islands; Russian Federation; Papua New Guinea; Tajikistan; Poland; Turkmenistan; Puerto Rico; Ukraine; Portugal; Uzbekistan; Paraguay; Saint Vincent & Grenadines; Qatar; Venezuela; Romania; British Virgin Islands; Rwanda; United States Virgin Islands; Arabia Saudi; Vietnam; Sudan; Senegal; Samoa; Singapore; Yemen; Saint Helena; South Africa; Solomon Islands; Zambia; Sierra Leone; Zimbabwe; San Marino; Somalia; South Sudan; Sao Tome and Principe; Suriname; Sweden; Swaziland; Seychelles; Syria; Turks and Caicos Islands; Thailand; Timor-Leste; Tonga; Trinidad and Tobago; Tunisia; Turkey; Tuvalu; Chinese Taipei; United Rep. of Tanzania; Uganda; Uruguay; United States; Armenia; Azerbaijan; Belarus; Estonia; Georgia; Kazakhstan; Kyrgyzstan.*

Recipient countries*: Australia, Belgium, Canada, Czech Republic, Denmark, Estonia, Finland, Greece, Hungary, Iceland, Ireland, Italy, Luxemburg, Netherlands, New Zealand, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, United Kingdom, USA..*

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