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## Immigration and Innovation: Review on the Effects on Innovation Outputs and Education<sup>1</sup>

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### Abstract

Notwithstanding its importance in light of current migration patterns, the link between immigration and innovation is of recent interest and mainly confined to research, focusing on the United States and the European Union, with emerging studies also from Oceania. Thus, the present work will focus on this relation by considering the factors which influence immigrants' contribution to destination countries' overall level of innovation, cultural diversity, demographic agglomeration forces and newcomers' educational background emerge as drivers of innovation which influence patenting activity. Our thematic review not only summarizes the overall positive influence of migration on innovation spillovers, but also its effectiveness in isolating the channels related to education history and labour supply through which this positive influence is exerted.

**Keywords:** Immigration; innovation; patenting; education; high-skilled workers

*JEL classification:* O15, O31, J24, J61, F22

### Introduction

In face of the recent rise of immigrants' inflows, migration has become a prominent issue both in the current public debates and for policy-making purposes. The European Commission (2017) reports that in 2015, 4.7 million people immigrated to the EU-28, while upon the recent refugee crisis, the asylum seekers' requests increased by more than 50 % between 2014 and

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2015 (World Migration Report, 2015).<sup>6</sup> Accordingly, a surging amount of both empirical and theoretical studies has been analyzing whether and how migration is a burden or a boon for the economic development of destination countries.

As economic development relies, amongst others, on innovation,<sup>7</sup> it is urgent to identify the channels through which immigration impacts innovation. On the one hand, immigration increases cultural diversity, which implies broader creativity and a faster development of new ideas (Ozgen *et al.*, 2011). In addition, the coexistence of diversified cultural backgrounds for skills and education contributes to knowledge spillovers across countries and to the diffusion of technology otherwise unavailable to host countries.

On the other hand, newcomers tend to establish themselves in large cities, thereby spurring agglomeration forces which, in turn, are deemed to positively impact innovation in the long run (Gagliardi, 2015). More dense and culturally diverse concentration at the local level is the premise for prosperity and, most noticeably for our study, for innovation, as it is strictly related to a greater variety of commercial activities and cultural services (Ozgen *et al.*, 2011).

Moreover, migrants are self-selected into STEM jobs<sup>8</sup> and represented in the high-education sector in STEM activities with higher frequency than natives. Therefore, high-skilled incoming agents bring along higher chances of patent awarding, boosting the overall level of innovation of the destination country.<sup>9</sup> Finally, innovativeness benefits from the inner entrepreneurial spirit of immigrants, which helps make the newly available knowledge more fruitful (Ozgen *et al.*, 2011).

Despite the link between immigration and innovation being of utmost importance for the current unprecedented migration rates and the significant number of channels of influence, the topic appears to be of recent interest and mainly confined to research focusing on the United States and the European Union. The subject of the present study is similarly gaining consideration in Australian and New Zealand literature, due to the relevance of the topic of immigration for the Oceanic continent.

In this regard, the literature frequently converges with the specific US admission system, which tends to favour the entrance of high-skilled migrants, and for the specific US migration history, which attracts migrants from a defined set of countries, such as China and India (Lissoni, 2017).

The present study is a systematic review regarding the investigation of the research status in the field of immigration, ethnic diversity and their impact on innovations, namely the capability to pioneer inventions in the form of intellectual property rights and patents. Specifically, particular attention is placed upon the analysis of innovation at the firm's

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<sup>6</sup> On the one hand, the report accounts for the main migration trends and, on the other hand, their effects on urban settings, including vulnerabilities, growth and development, governance and so forth. Lastly, it provides recommendations for the improvement of urban governance in relation to migration.

<sup>7</sup> For an insight on this topic, the authors suggest the work of Paul M. Romer (1990) and the bibliographic review of Kristian Uppenberg (2009).

<sup>8</sup> The category of STEM jobs designates the areas of science, technology, engineering and mathematics, both in educational and labour-related terms.

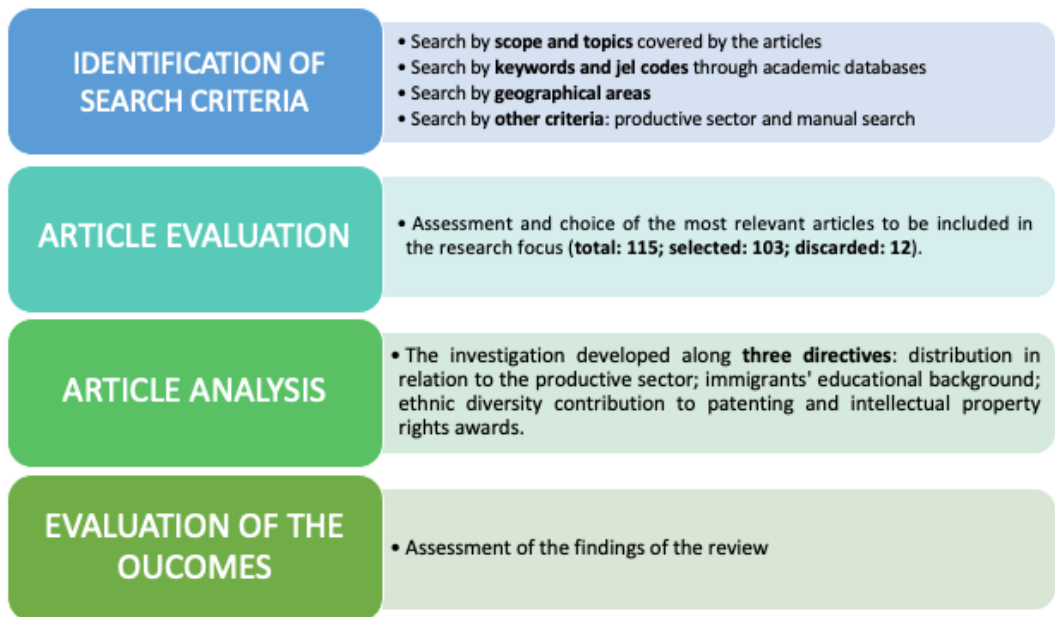
<sup>9</sup> Jennifer Hunt and Marjolaine Gauthier-Loiselle (2010) assessed that approximately 24% of patents are awarded to immigrants, who in turn tend to hold science and engineering degrees in a higher proportion with respect to natives. Consequently, by referring to data from the 2003 National Survey of College Graduates, the authors conclude that immigrants' patent rate amounts to twice the rate of natives.



organizational level. As Denyer et al (2003) thoroughly suggested, the systematic collection of actual and available literature allows the attainment of the double aim of mapping, evaluating and summarising the state of the art, while simultaneously identifying potential gaps or disparities in the research, to be inquired in future studies. In parallel, assembling data in a methodical and systematized manner enabled a straightforward, reliable and reproducible processing in the phase of assessment of the research results.

In operational terms and in light of the research question of the present study, a concrete execution of the above-mentioned methodology has been conducted through the identification of a number of previous studies and the consequent selection of those who deserved to be further contemplated (or denied). At the same time, a clear delimitation of the research fields and areas to be scrutinized has been undertaken. As a consequence, this preliminary selection resulted in a multiple-steps analysis of the elected literature, as it can be more accurately observed in Figure 1.

**Figure 1.** methodology overview



While the majority of literature surveying on the state-of topic prefers a spatial, chronological or methodological approach,<sup>10</sup> we contend that the primacy of a thematic frame lies in its ability to isolate the main drivers that favour innovation spillovers. In addition to its degree of novelty, this methodology is of paramount significance for its policy implications, by segmenting the areas which ought (not) to be targeted in order to boost innovation thanks to migrants' direct or indirect contributions: policymakers, who aim at spurring national technological development, are made aware of the channels through which migration impacts

<sup>10</sup> The interested reader will find comprehensive spatial reviews in Paul H. Jensen (2014), Stefano Breschi *et al.* (2016), Valentina Bosetti *et al.* (2015). For a methodological survey, the interested reader is addressed to Sheida Rashidi and Andreas Pyka (2013).

on it. Alongside, our approach helps scholars identify newly refined research questions, by systematically narrowing down the channels of influence and putting under the spotlight the unexplored areas in each of them. Thanks to this twofold advantage, we claim that our thematic assessment of the relationship between immigration and innovation can give a substantial contribution to the literature: we explore the state of the art on the issue by breaking it down to a series of factors that hold an impact on economic growth, innovation and development of host countries. More specifically, if we assume migrants and natives either as complementary or substitutive factors, immigration impacts innovation through broad labour market effects, such as differences in wages, which result in relocation of human capital thus creating new R&D environments. Furthermore, the universal knowledge imported by migrants in the destination economies constitutes a comparative advantage with respect to natives, who indeed benefit from their “local knowledge” being already acquainted with the local labour market, language and legal system. Due to this trade-off between local knowledge provided by natives and universal knowledge offered by high-skilled migrants, education is a second key factor for an accurate frame of the effects of immigration on innovation. We can witness the impact of these two factors, education and labour market effects, on the patenting activity in the host country as the main indicator for innovation. Overall, we recognize a positive tendency: all the studies under review suggest that the number of patents awarded is positively influenced by immigration.

Our thematic survey of the current state-of-the-art literature proceeds as follows. Section I proposes a comprehensive contextualization of the topic by overviewing the principal drivers of innovation. Secondly, in Section II, a focus on the patenting activity is promoted to quantify the impact exerted by immigration. Consequently, in Section III, the educational background of migrants as an engine of innovation will be considered. Finally, Section IV analyzes the impact of immigration on destination countries’labour market, with a specific concern for employment rates, workforce composition and wages.

### **Criteria and methods used to select the articles**

As mentioned, the present work aims at determining the relation between immigration and innovation considering the factors which influence the overall level of innovation at the firm level. Among these, it is possible to include cultural diversity, demographic agglomeration forces and immigrants’educational background. As a matter of fact, this paper assesses the manner in which these components have an impact on the patenting activity at firm level, which emerges as the main focus of the research. For this purpose, the data collection (and afterwards selection) process developed along a specific direction. In particular, following the narrowing of the scope of the analysis and the formulation of the research question, the criteria displayed in the undernoted figure oriented our choice of articles.

As concerns keywords, a specific set of terms has been investigated by making use of the following academic databases: Scopus, JStor, Google Scholar, EconPapers, ResearchGate and Iza Migration.

A more specific illustration of the databases employed during the research phase can be observed in Figure 3. Indeed, almost 48% of the articles have been selected from Google Scholar, while 18% and 15% of the analyzed papers have been sorted from – respectively – Econpapers and Scopus. Additionally, even though lower in terms of the number of selected



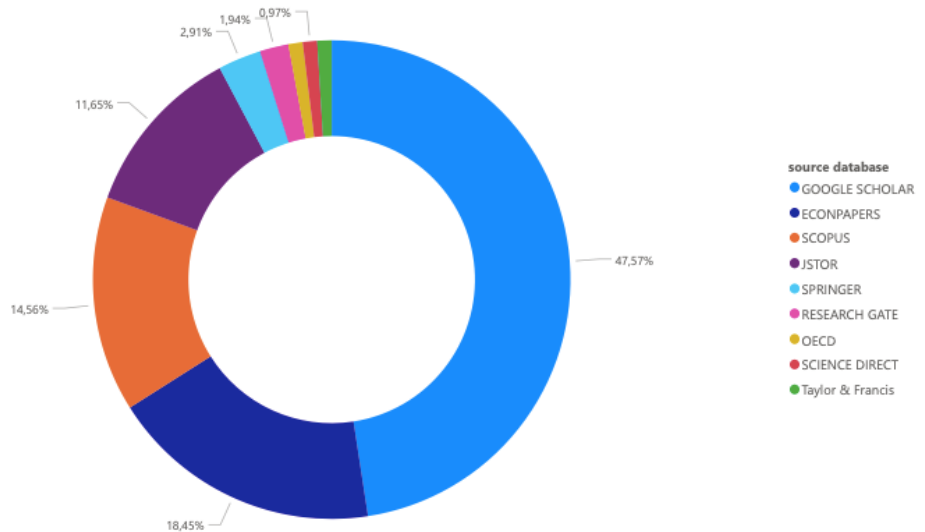
articles, the databases Jstor, Science Direct, Springer and Taylor & Francis have been similarly important for the first phases of our research.

**Figure 2.** overview of the articles’selection criteria



**Figure 3.** analysis of selected articles by source database.

Analysis of selected articles by source database



Concerning keywords, the terms considered included “immigration”, “innovation”, “patenting”, “high-skilled migrants”, “economic growth”, “productivity”, “intellectual property rights” (IPRs), “innovativeness”, “innovation propensity” and “innovation networks”. To this respect, five specific keywords were recurrent in the considered studies: “immigration”, “innovation diffusion”, “high skilled migration”, “cultural diversity” and “patents”.

Out of all the articles selected, 95 have been analyzed, while 12 have been discarded based on the inconsistency of the abstract with the scope and purpose of our research question. In addition, 8 articles have been further added to our selection by virtue of manual search, with a view to supplement and expand the aggregate of data we collected through the evaluation of keywords. Precisely, these concerned studies on the link between immigration and innovation conducted at regional level and, specifically, in the European Union.<sup>11</sup> A total of

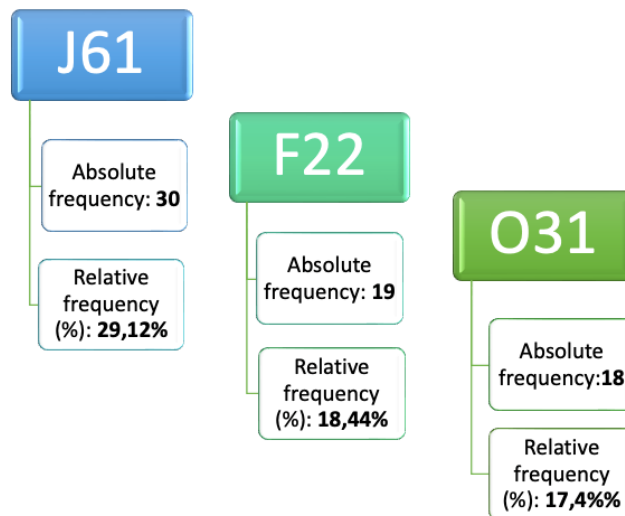
<sup>11</sup> See, *inter alia*, Ivlieva O.D. (2015); Fassio, Montobbio & Venturini (2019) and Solheim & Fitjar (2018).

115 articles was thus included in our database of considered studies and 103 of those were finally examined during the drafting phase of the article.

Notably, 86% of the selected articles followed an empirical approach, while merely 12,6 % tackled the issue from a theoretical perspective.

In the choice of existing literature, attention has also been paid to the recurrence of JEL codes. Specifically, among the selected articles by specific terms and keywords, we focused on the frequency with which the following JEL codes appeared: F22 (international migration), J6 (mobility, unemployment, vacancies and immigrant workers. Peculiar consideration has been dedicated to the JEL Code J61, concerning geographic labour mobility and immigrant workers), O31 (innovation and invention: processes and incentives).

**Figure 4.** Recurrence of JEL Codes in selected articles



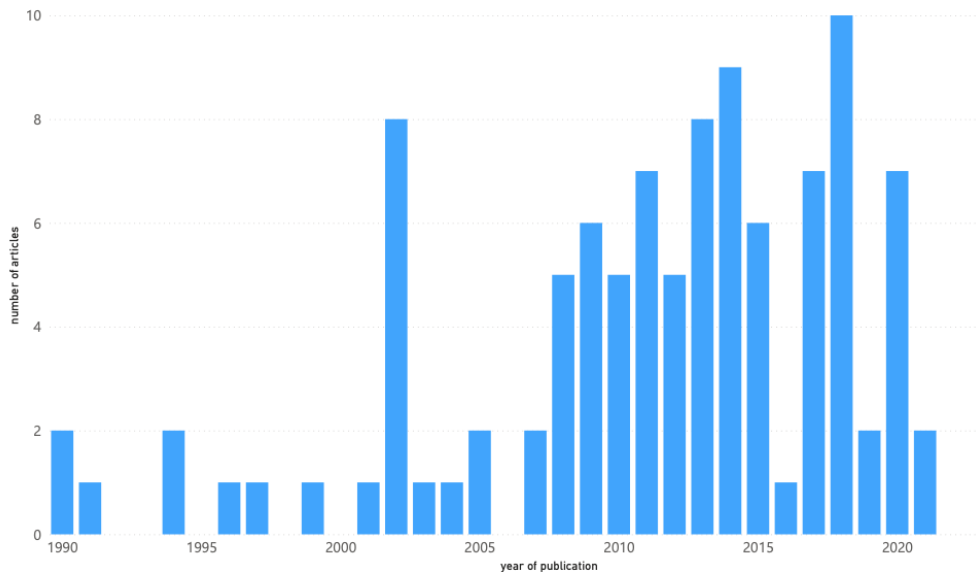
What emerges from Figure 4 is a sizeable recurrence of the Jel code J61, which appears in 29 over 89 selected articles amounting to a relative frequency of 32,6%. Significantly, Jel codes F22 and O31 return in 21,3% and 19,1% respectively of the studies included in our database. The articles' year of publication represent a further selection criterion according to which a personal database for answering the determined research question was created. As it can be observed in Figure 5 the studies opted for predominantly refer to the first two decades of the 21<sup>st</sup> century. Nonetheless, a very limited number of research pertain to the previous century and, precisely, to the period 1991-1999. The reason for the election of less recent articles with respect to the temporal focus we designated is to be found in the relevance of the papers and the overall contribution they brought to the state of the art concerning the topic at issue.

Comprehensively, the frequency of articles by year of publication seems to suggest that the scrutiny of the existing connections between immigration and innovation and, more in general, the assessment of ethnic diversity contribution to the increase in patent applications or awards, is a relatively recent phenomenon. As a matter of fact, by observing the graph it emerges a substantive prevalence of articles (more than 75% of the total amount of considered



papers) published between 2010 and 2021. Therefore, data suggest that the specific thematic focus at issue grasped the interest of scholars in a relatively recent time period.

**Figure 5.** Analysis of selected articles by year of publication (1990-2021)



For the purpose of the research at issue, considerations with respect to the geographical areas on which the focus of the selected articles is placed appear to be necessary.

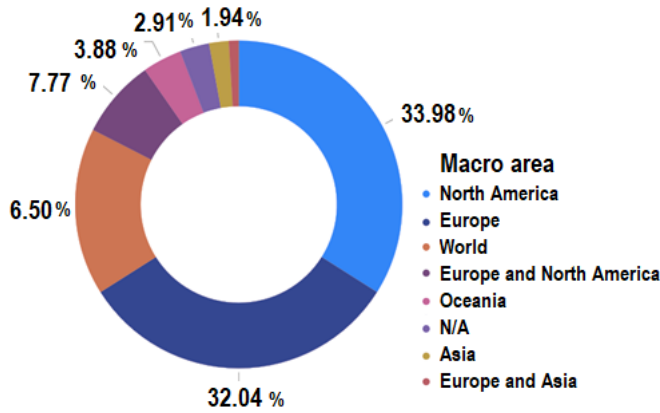
By observing the Figure 6, it appears to be reasonable to draw the conclusion that, from a geographical perspective, the majority of the studies considered refer to the North American and European continents, followed by Oceania. With respect to the latter, the research included in our database focus their attention on Australia and New Zealand. The scarcity of articles focusing on Asia and the rest of the world is probably connected to the importance of the topic for those countries which historically represent a gateway for immigration, namely the United States and Europe.

While proceeding with the process of analysis of the selected articles, a series of elements of continuity among the considered macro-areas, the scope of the studies and the final outcomes have been identified. On the one side, when considering literature contributions from North America (especially the United States), the positive contribution of highly skilled immigrants (both students and workers) is assessed almost universally. More precisely, the great majority of empirical findings favourably evaluated the impact of educated newcomers on the overall level of innovation, measured primarily as local firms patenting and economic and income growth. This approach appears to be confirmed by European researchers, who similarly assessed the positive contribution of skilled professionals of different ethnicities on the level of knowledge creation of regions in Europe. As a matter of fact, in convergence with the approach of US academics, innovation is considered as the creation of private knowledge and new patent applications, and a peculiar attention is dedicated to educated migrants as well. The reason of such consideration mainly resides in the awareness of the role of high-skilled workers in fostering European competitiveness and innovation. As a consequence,



implications for policymakers concerning the attraction of this specific category of migrants emerge.

**Figure 6.** Analysis of selected articles by geographical macro-area per continent



A similar focus is to be ascertained in a relevant number of considered studies centered upon the topic of migration in Oceania. More precisely, the research included in our analysis evaluated the existing systems of high skilled foreign-born selection occurring in Australia and New Zealand and the following mechanism for the granting of a visa to educated workers and students coming from overseas countries, who desire to receive their highest level of education in Australian universities. This evaluation has been placed within the wider local governments' objective to attract skilled professionals, who positively impact the comprehensive outcome of regional innovation by configuring as potential inventors. Along these lines, cost-benefits evaluations of the foreign-student visa program in force in the United States are to be traced in US Journals-published articles as well, thereby representing a further element of convergence between the different geographical areas considered in our review.

Reaching the concluding step of our primary phase of investigation, attention has been placed on the productive sector on which the selected articles focused (Figure 8).

Notably, the greatest share of considered papers empirically researched on educated and high-skilled immigrants' contribution to innovation at firm level, which almost universally translates in the probability of providing new inventions and being awarded a patent. In this regard, the firm-level analysis distinguished in our final scrutiny segment mainly concerned the STEM and ICT sector, to which the majority of highly instructed newcomers tendentially flows. Similarly, the industrial and the manufacturing sector were further examined in a significant number of articles. Eventually, a certain consideration for research and investment (R&D) is to be remarked.

The selection path described in Figure 9 brought us to a total of 103 over 115 articles, which were subsequently sorted and classified according to the source database, author, year of publication, journal, JEL code, keywords, geographic scope and further dimensions which we considered relevant for our analysis. A more precise picture of the selection process we followed during the first phases of our research is described in Figure 9.

**Figure 8.** Analysis of selected articles by production sector





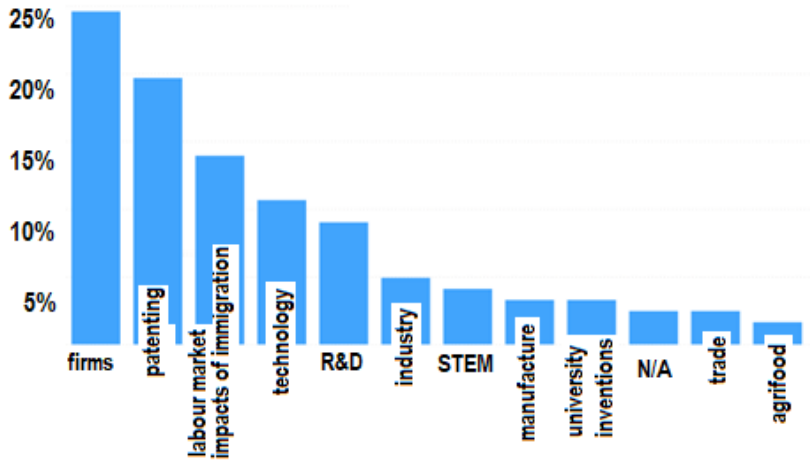
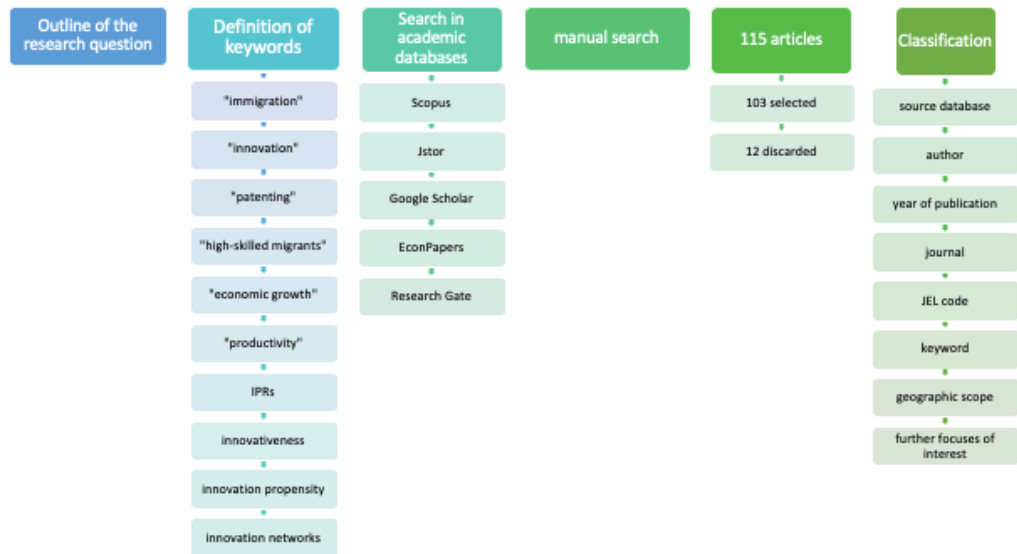


Figure 9. process of articles’selection and creation of a personal database



### Immigration and Innovation: a contextualization

Despite being a complex and multi-faceted phenomenon, innovation undoubtedly plays a prominent role as a driver of growth in modern economies. Nonetheless, universal measurements and widely-accepted indicators to quantify the level of innovation within a specific economic system are still absent, and empirical investigation is still being conducted to identify the main factors which contribute to the spur of innovation and, in turn, economic growth (Bratti, Conti, 2018). In light of the unprecedented size and scale of recent-decades

migration patterns,<sup>12</sup> a novel trend within economic literature began to investigate the role of immigration on innovation, and namely whether the international movement of high-skilled labor force could - either positively or negatively - impact the economic performance of host countries and, more generally, contribute to knowledge spillovers and welfare gains in the long run due to increased competitiveness (Maré *et al.*, 2011).

To this respect, the relationship between immigration and innovation depends on several variables and their interactions. On the one hand, the demographic composition of host countries is altered by immigration inflows. Not only their contribution to the population growth of certain regions in the host countries may foster agglomeration, but it may also heighten the availability of human capital and labor force.<sup>13</sup> On the other hand, how immigrants decide to allocate is not a stand-alone choice, but it is determined by pre-existing conditions and has a grip over them. Among the main pull factors that encourage migration, economic dynamism and the innovativeness of the destination area are considered by high-skilled migrants, along with the ethnic distribution of the foreign communities to which they belong (Mahroum, 2000). Thus, at the local level the exposure to immigrants' different backgrounds in terms of skills, culture and knowledge may enhance the pre-ordered innovativeness and promote innovation activities (Ozgen *et al.*, 2011; Kerr, Lincoln, 2010).<sup>14</sup> Thus, in one case immigrants contribute to the population growth of specific regions of the host countries fostering agglomeration, which potentially results in a heightened availability of both human capital and labor force (Gagliardi, 2015); on the other, immigrants' different backgrounds in terms of skills, culture and knowledge may boost interactions, and thereby promote innovation activities at the local level (Maré *et al.*, 2011). Hence, as noted in the works of Ozgen *et al.* (2011), culturally diverse cities represent a very likely premise for innovation and prosperity, which usually materializes in a wide variety of commercial activities and different cultural services, thereby benefiting development over the long run. At the same time, however, the degree of innovation is directly connected to the resources of the urban agglomerations and to cities' openness to cultural creativity, which promote the spread of information across different economic sectors.<sup>15</sup> Nevertheless, Ozgen *et al.* (2011) acknowledged the double-edged nature of cultural diversity, which on several occasions could even become detrimental for innovation. Accordingly, the coexistence of different ethnicities, religious beliefs and even hostile attitudes towards immigrants could hinder economic growth and, in the extreme, provoke tensions within societies.<sup>16</sup> Furthermore, differences in language inevitably imply communication costs (Bratti, Conti, 2018). Therefore, the multi-layered nature of the concept of cultural diversity has to be scrupulously taken into account in the

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<sup>12</sup> According to the International Organisation for Migration (IOM), and specifically to its World Migration Report 2020, the number of migrants has increased in all UN regions, although significant variations can be noticed among them. In numeric terms, migration has increased from 2.87 % of the population in 1990, to 3.60% in 2020, which represents 281 of migrants today.

<sup>13</sup> As stated in the works of Juan Dolado *et al.* (1994) and Jonathan Coppel *et al.* (2001).

<sup>14</sup> In particular, following the case in point proposed by Konrad B. Buchardi *et al.*, (2020), if a specific community resides in a precise area of country *A*, migrants from country *B* pertaining to the same ethnic community will in all likelihood tend to settle in *A* rather than Kerr and Lincoln (2010) consider ethnic agglomeration patterns by measuring patenting and invention dynamics, concentrated in cities corresponding to specific ethnic agglomerations.

<sup>15</sup> For an insight on the positive externalities of openness, the authors suggest the work of Stephen Roper *et al.* (2003).

<sup>16</sup> The Social Disorganization theory argues that the surge of conflicts in communities that experience high migration is caused by the clash of different cultures (Shaw, McKay, 1942).



analysis of the cross-fertilization of ideas among different cultural backgrounds within the context of urban areas.

As far as knowledge is concerned, immigration may be an enabler of innovation through positive spillovers on the managerial and entrepreneurial capabilities of natives (Sequeira *et al.*, 2020). For this purpose, Koen Jonkers (2011) stressed the intrinsic entrepreneurial nature of the specific category of economic migrants, which are usually perceived as more resourceful and business-oriented due to their opportunity-seeking and risk-taking behavior in countries other than the origin one. Hence, skilled immigrants led by their inherent entrepreneurial drive tend to engage into business activities in the destination country, thereby contributing to the latter's level of development and economic growth. Therefore, through the labor market local enterprises readily dispose of this knowledge, while the combination of high-skilled human capital with firms' attitude to invest in R&D feasibly provide fertile ground for innovativeness (Gagliardi, 2015). National policies are designed to enhance this entrepreneurial attitude from migrants: for instance, the Italian MoneyGram Award financially supports immigrants that engage in high innovation-intensive enterprises (Fondazione Leone Moressa, 2020).

Eventually, according to Ozgen *et al.* (2011) the international movement of skilled labor force may further engender a relevant source of wealth also for immigrant's countries of origin, both in terms of remittances<sup>17</sup> and welfare gains deriving from the homecoming of highly-educated migrants after a period of time spent abroad.

Nevertheless, a significant incoherence between the growing importance of the topic and the existing empirical research on the matter exists. Indeed, academic interest in the link between immigration and innovation is still very recent, and it is especially limited to a few dozens of studies - most of which are geographically confined to the United States (Kerr, 2013; Gagliardi, 2015; Ozgen *et al.*, 2011). Moreover, as far as the impact of immigration on natives is concerned, current studies have an inclination to focus on short-run consequences rather than investigating implications over the long run, thereby limiting their scope (Kerr, 2013).

Consequently, we can conclude that the topic is notably understudied and the limited empirical research on North American data increasingly impels the widening of the gap between the subject's economic importance and the existing literature.

Overall, on the basis of the available studies, immigrants undoubtedly proved to be essential for the leading role of the United States in the field of innovation and entrepreneurship (Kerr 2013: 23). In particular, since 1965, when the approval of the Immigration and Naturalization Act dramatically altered US national immigration policy by allowing skilled individuals from all over the world to enter the United States.<sup>18</sup> A subsequent visa system based on a different classification of incomers replaced the previous national arrangement, which banned Asian immigrants from the US: as a result, immigrants coming from, inter alia, India, Taiwan, China and South Korea, spurred the internationalization of the US technological sector, thus actively supporting the US dominant position as pioneer of innovation (Puffer *et al.* 2018: 374). To this respect, a cluster of academic studies remarked the presence of immigrants among the US highest achievers (Kerr, 2013; Hunt, Gauthier-Loiselle, 2010). Specifically, immigrants

<sup>17</sup> See Reena Agarwal and Andrew W. Horowitz (2002). Are international remittances altruism or insurance? Evidence from Guyana using multiple-migrant households, *World Development*, 30 (11): 2033-44.

<sup>18</sup> This policy evidenced a shift in the perspective taken on immigration, from considerations surrounding provenance and ethnicity to the consideration of skill and family unification as drivers of immigration policies.

constituted 26% of Nobel Prize winners in the decade 1990-2000 (Peri, Sparber, 2009), 25% of the founders of US companies supported by public venture between 1990 and 2005 and finally a quarter of the new enterprises with more than \$1 million sales in 2006 in the field of high-technology (Hunt, Gauthier-Loiselle, 2010). Moreover, Kerr (2013) acknowledged that approximately 25% of inventors in the United States are of foreign origin.

Conversely, when it comes to the assessment of the impact of immigration on innovation in the European region, empirical evidence is markedly restricted (Venturini, 2012). Nonetheless, while taking into consideration some of the structural features which characterize the Eurozone and the so-called *refugee crisis* which affected that specific area during the last few years, it would be erroneous to affirm that migration and innovation follow two different and separated pathways. Specifically, Europe is currently experiencing unprecedented challenges which relate, among others, to ageing population, decreasing birth rates and existing levels of unemployment (particularly exacerbated by the present Covid-19 pandemic), which would eventually impact the pace at which European economies will grow, and ultimately European labor market in future decades. Therefore, both competition and innovation figure among the top priorities of the agenda of the Member States (Venturini, 2012). In addition, the prominent impact of immigration on the population growth rate of European countries is widely accepted among scholars.<sup>19</sup> All this considered, the underlying belief that high-skilled immigrants may be potential drivers of innovation and economic growth in the Member States led the European Union to launch a series of initiatives aimed at attracting trained and qualified migrants. Specifically, the European Council Lisbon Strategy and the Commission Blue Card Directive within the framework of the Global Migration Approach represent a case in point (Venturini, 2012).<sup>20</sup>

Ultimately, in the wake of the above-mentioned considerations, the unquestionable relevance of the topic and its reverse second-class position within the academic world requires duly exploration with respect to the state of the art of the topic at issue.

## Literature Review

While the literature concerning the relationship between immigration and innovation emerged recently, in the early 2000s, the economic effects of immigration have been long and extensively studied. The most prominent works concern the link between immigration and host countries' labor market outcomes, namely wages and employment rates.<sup>21</sup>

Most investigations regard the way in which immigration affects the economies of either host or home countries, with a specific focus on the link between immigrant inflows and wages. In particular, according to George J. Borjas and Lawrence F. Katz (2007), who concentrated their research on immigration from Mexico to the US, the wages of low-skilled workers are negatively linked to increases in unskilled immigration: indeed, immigration was responsible

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<sup>19</sup> For example, Koen Jonkers (2011) estimates that during the last ten years migration flows were the sole determinants for demographic growth in Europe; similarly, the author predicts that from the moment in which deaths will outnumber births, immigration toward European countries would be the exclusive compensation factor.

<sup>20</sup> In more specific terms, the European strategy regarding immigration aimed at promoting economic growth and competition through innovation, and, as a consequence, through more dynamic immigration patterns. Instead, the Blue Card Directive of 2009 aimed at promoting the entry of high-skilled migrants with work offers or contracts in EU countries.

<sup>21</sup> See the works of Jean B. Grossman (1982), Joseph G. Altonji and David Card (1991) and Christian Dustmann *et al.* (2008).



for a considerable wage reduction of relatively poorly-educated native-born workers (around 4-5 %) between 1980 and 2000.

Substantial negative effects were presented also by George J. Borjas (2003) for workers with comparable educational levels and experience. Conversely, further analysis, such as the one of Card (2009), discovered negligible (although real) effects of new immigrant inflows on wage inequality of US citizens, and almost null in the long term. More specifically, the reaction of natives with respect to the inflow of immigrants, which varies for skill levels and degree of substitutability, determines the different resulting impact of immigration on wages.

Immigrants are predominantly distributed in the upper and lower extremities in terms of skills allocation, and therefore residual inequality among them is higher than with respect to natives: for this reason, Card (2009) concluded that the overall wage inequality within the US economic system appears to be positively related to immigration levels.

But, following Gianmarco I.P. Ottaviano and Giovanni Peri (2008), wage implications of immigration differ, according to whether natives and foreign workers are imperfect substitutes or not: indeed, there is all likelihood for natives' wage losses to be mitigated by the fact that, albeit possessing similar education levels, immigrants tend to specialize in distinct occupations. According to Peri and Chad Sparber (2009), immigration pushes natives to specialize in tasks for which higher skills are required, thus avoiding adverse labor market impacts caused by immigrants. Indeed, natives tend to engage in language and communication-intensive occupations and a general task reallocation allows resident countries' workforce to "protect" their wages.<sup>22</sup>

Lastly, the study conducted by Gouranga G. Das *et al.* (2020) considers the effects that innovation as a result of immigration can have on unskilled sectors, consequently reducing existing wage gaps. Moreover, even though changes in the labor market represent one of the most relevant channels through which immigration affects the economy of host countries, international flows affect other important variables as well, such as prices, trade, public expenditure and fiscal balance.<sup>23</sup>

Some studies focused on immigration and innovation, while others considered the impact of cultural diversity on innovative outputs (Niebuhr, 2010). Others analyzed the link between emigration and innovation.<sup>24</sup> As for the most recent works on migration and innovation, a notable contribution to the research is the one of Gnanaraj Chellaraj *et al.* (2008), who recognized that inflows of international students and skilled immigrants positively affect innovation. In particular, such results came from the study of patent applications in the U.S. during the period 1965-2001, and they oppose the works of Borjas (2002, 2004) and Samuel P. Huntington (2004), which present evidence of negative effects on innovation from foreign

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<sup>22</sup> Other relevant contributions concerning the link between immigration and wages can be outlined in the studies of Simonetta Longhi *et al.* (2009), Ottaviano and Peri (2012) and Francesco D'Amuri and Peri (2014).

<sup>23</sup> See Libertad Gonzalez and Francesc Ortega (2009) for immigration and house prices, Sourafel Girma and Zhihao Yu (2002), David M. Gould (1994) and Keith Head and John Ries (1998) for trade; Jorgen Hansen and Magnus Lofstrom (2003) for public expenditures, and Dustmann and Tommaso Frattini (2014) for public finances.

<sup>24</sup> To this perspective, Alireza Naghavi and Chiara Strozzi (2015) explored the interaction between intellectual property rights (IPRs) and emigration in a pool of developing countries, finding that emigration positively impacts innovation in the developing countries. Their results are robust and quite significant when using both first differences and fixed-effects IV estimations. Hence, they used an IV approach, with emigration being instrumented by indicators of corruption and quality of the public sector in the home countries.

students. Furthermore, the latter argue that static analysis such as those advanced by Vernon M. JR. Briggs (1996), Ximena Clark *et al.* (2002) and Donald R. Davis and David E. Weinstein (2002) are not broad enough to include positive effects of immigration on natives' levels of productivity and, most importantly, do not take into account positive effects on innovation deriving from inflows of skilled immigrants (Chellaraj *et al.*, 2008).

Similarly, Hunt and Gauthier-Loiselle (2010) analyzed patent data referring however to a different time span: in particular, they discovered that high-skilled immigration in the U.S. increases the number of patents application and U.S. patent granted as well as the probability of commercializing a patent. Moreover, this research takes into account whether the likelihood of crowding-out effects of immigration on natives exists, therefore distinguishing itself from others, such as Chellaraj *et al.* (2008). By separating short and long-run effects within a panel of fifty years, namely 1940-2000, the authors find that an increase by 1% of foreign college graduates causes a rise in patents per capita by 6.1%, while the same increase for natives yields a positive effect on patents equal to 3.5%.<sup>25</sup> The higher impact of immigrants than natives on patenting is explained by the fact that immigrants tend to graduate in more science-oriented educational programs.

The same analysis on patents has been conducted by Ozgen *et al.* (2011) on European data regarding patent applications, labor force, immigration and production for 12 countries from the *General and Regional Database* of Eurostat (2011). They refer to 170 regions at NUTS 2 level in the period 1991-2008, and they use an IV procedure to solve endogeneity issues. Indeed, higher innovation could attract a higher number of immigrants, thus boosting the intensity of innovation activities. In order to address this issue, Ozgen *et al.* (2011) instrument immigration with the presence of McDonald's restaurants as a symbol of openness and internationalization of the area. In addition, they use as a dummy variable the presence in the NUTS region of a capital city, which normally represents the entrance spot for many immigrants. It is proven that diversity has a positive and significant impact on patent applications. Specifically, an increase in the diversity index by .1 leads to an increase in patent application by 16 % (Ozgen *et al.*, 2011). Furthermore, both GDP growth and the human capital related to science and technology are positively linked to innovation.

Max Nathan and Neil Lee (2013) propose a different analysis that pivots on cultural diversity in general, rather than strictly focusing on immigration, to evaluate its impact on innovation, entrepreneurship and sales strategies. Considering a sample including 7,600 firms in London for the period 2005-2007, they evidenced that diversity positively affects innovation in terms of introduction and commercialization of new products. Furthermore, it increases the access to international markets, and finally it spurs entrepreneurship.

Opposed results with respect to Ozgen *et al.* (2011) and Nathan and Lee (2013) were presented by Bratti and Conti (2018). Their analysis employs province-level total patents applications data for Italy from 2002 to 2009, and through an IV estimation approach using the share of foreign-born citizens in 1995 as the excluded instrument, the authors find that the effects of migration on patents depend on the skill levels of the migrants. Namely, low-skilled

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<sup>25</sup> Daniel Crown *et al.* (2020) study in detail the influence of foreign-born graduates on innovation in Australia, while John V. Winters (2014) analyzes the impact of native and foreign-born STEM and non-STEM graduates on patent intensity.





immigrants have a negative impact on patent applications per million inhabitants, while at the same time high-skilled migrants have a positive effect, though with a low level of significance.

The literature presented so far reached various and at times opposed results of migration and diversity on innovation. In general, most of the works using micro-level data for wider areas, such as regions NUTS-2 in Europe or states in the US, highlight a positive effect of immigration on innovation, in particular on patents, while analysis employing observations but for a smaller area do not find, conversely, a significant effect of immigration. The impact of migration and diversity relies primarily on migrants' educational attainments and sectors of occupation: namely, innovation is privileged or advantaged favoured by high-skilled immigrants in STEM disciplines.

### **Impact of Immigration on the patenting activity**

As far as innovation is concerned, knowledge creation is widely considered the main process through which immigration potentially influences the economic development of destination countries (Sequeira *et al.*, 2020). In this regard, high-skilled immigrants figure at the heart of the discussion, playing a pivotal role as innovators. Nonetheless, as we have previously discussed, the multi-layered nature of the concept of innovation and the shortage of knowledge creation frequently accounted for posing a challenge to the identification of precise indicators of innovation on the part of economists: as a result, two specific benchmarks are conventionally employed within the economic literature in order to measure the level of innovation of a particular economic system, namely the growth rate of Total Factor Productivity (TFP) and the overall number of patent applications (Venturini, 2012; Venturini *et al.*, 2012). Despite not representing the entirety of the existing measurements, such indexes emphasize different dimensions of the innovation phenomenon. When it comes to the TFP, several definitions exist: on the one hand, Robert M. Solow (1957) underlined that it indicates “technical progress in its broadest sense”; on the other hand, Moses Abramovitz (1956) proposed the well-known label of “the measure of our ignorance”. In general, TFP accounts for production advancements deriving from changes in labour quality, which in turn depend on age, education, skills and provenance (Venturini, 2012). Secondly, the patenting activity - both at industry and university level - is broadly accepted as the typical indicator for innovation.<sup>26</sup> Chellaraj *et al.* (2008) provide three specific reasons to evince the use of patents as the fundamental proxy in innovation studies: firstly, as far as patents are closely tied to trade secrets and copyrights, these reveal a significant share of the innovation degree of firms. Secondly, newly-awarded patents reflect the novelty of the invention, which usually stems from an original and non-obvious way to analyze a given phenomenon. Thirdly, the high costs of patent applications are evidence both of the economic value of the technological invention at issue and the economic availability of the firm to have its creation patented.

All this considered, in the present work we will focus on the sole side of patent applications as a measurement of innovation and specifically available data from different time periods which predominantly refer to the United States. Since the last century, technological advancements have played a primary role in US productivity and overall economic growth. Indeed, the US innovation rate rapidly soared thanks to the growing number of patents

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<sup>26</sup> Conversely and according to Ozgen *et al.* (2011), the consideration of patent applications as an indicator of innovation can lead to issues such as the monitoring of patent application procedures, which are subjected to each country, to the analysis of the cultural propensity to register patents or to the measuring of the direct results issuing from this indicator.



awarded to industries and universities as a result of which several scholars started investigating immigrants' contribution to innovation through the analysis of patent data, in order to assess the role of skilled immigration in US technological improvements (Hunt, Gauthier-Loiselle, 2010). First, Ozgen *et al.* (2011) identified a cluster of determining factors through which migrants impact patenting activity, namely: 1) the population scale effect; 2) the population density effect; 3) the share of foreigners in the population; 4) the skill composition of the migrant flow; and 5) the diversity of immigrants. Conversely, based on the analysis of World Intellectual Property Organization (WIPO)<sup>27</sup> data (WIPO, 2005), which records the provenance of inventors and especially their non-US origin, Kerr (2013) estimates that in 2004 patents awarded to Anglo-Saxon and European origin creators dropped to 76%, compared to 90% in 1975. Accordingly, such a trend exacerbated during the last 30 years as a result of the extraordinary growth of Indian and Chinese immigrants, which respectively rose from 2% to 6% and 9%. Overall, several studies reference specific time periods to investigate whether immigrants either positively or negatively contribute to the patenting activity. Based on 1940-2000 data concerning skilled immigration to the United States, Hunt and Gauthier-Loiselle (2010) emphasize that knowledge spillovers of high-skilled immigration result on average in a higher number of patent applications per capita.<sup>28</sup> Specifically, 24% of patents are awarded to immigrants, who patent at a rate which is twice the one of natives: indeed, according to the previously mentioned authors, only 0.9% of natives were granted a patent, compared to 1.9% of immigrants. Likewise, 1.2% of immigrants commercialised a patent with respect to 0.6% of natives. A further boost to innovation occurred in the last decade of the 20th century, during which the share of college graduates and post-college immigrants respectively increased by 1.3 and 0.7 percentage points, thereby enhancing patenting per capita by 21% based on instrumental variables (Hunt, Gauthier-Loiselle, 2010). As far as patenting is concerned, immigrant's disproportionate possession of scientific and engineering degrees marked a notable advantage over natives:<sup>29</sup> Indeed, a STEM background or generally post-college education among immigrants possibly increases the likelihood of patent awards. (Hunt, Gauthier-Loiselle, 2010) In light of this, we may affirm that immigrants' capacity to enhance innovation in the US incomparably benefits the country's innovation level, otherwise unable to reach a similar level of innovation and commercialisation of newly-invented ideas. However, at the same time no crowding-out effect on natives exists, as the local population is neither automatically damaged nor excluded from the patenting activity for the sole presence of high-skilled immigrants. Similarly, a crowding-in effect emerged from the analysis of Venturini *et al.* (2012): by detecting the role of science and technology-trained human capital, these authors emphasised that the disproportionate number of immigrants possessing a STEM educational background, with respect to natives, may be attributed the higher pace at which foreign-origin inventors contribute to innovation.

A beneficial effect of migration on patenting has been presented by Konrad B. Burchardi *et al.* (2020), whose investigation assessed that over a 5-year period, a unitary increase in the annual number of patents per 100,000 inhabitants is determined by the arrival of 10,000 immigrants. Moreover, a further investigation based on data from an earlier time period

<sup>27</sup> The World Intellectual Property Organization was created as a United Nations agency in 1967. With its 193 members, it promotes the Intellectual Property system.

<sup>28</sup> Ufuk Akcigit *et al.* (2017) find similar results considering the period 1880-2000.

<sup>29</sup> The importance of skilled immigrants' contribution to innovation in the US is stressed in the work of Chellaraj *et al.* (2008).



confirmed the positive implications of skilled immigration flows on innovation (Sequeira *et al.*, 2020): evidence from the United States Patent and Trademark Office referring to 1860–1920 showed an increase in the number of patents granted to foreign-origin inventors. Curiously, in the post-1920 era, the patenting rate was significantly influenced by German-Jewish immigrants. Furthermore, the role of universities, though remarkably smaller, deserves to be considered. Indeed, despite being traditionally engaged in publishing rather than patenting, the contribution to innovation through the licensing of university-developed inventions markedly soared following the Bayh-Dole Act in 1980, which authorized the commercialization of US universities' research results (Chellaraj *et al.*, 2008; Stephan, 2010). In this regard, Stephan (2010) investigated the role of foreign-born students within university patenting, premising that several factors upon which such activity depends exist, specifically: 1) R&D expenditure; 2) number of faculty; 3) number of postdoctoral students; 4) PhD enrolment when the patent research was undertaken. Eventually, evidence of a positive correlation between graduate and post-docs immigrants and the patenting activity is found. Likewise, a similar focus on universities and immigrant's educational background emerges in Chellaraj *et al.* (2008), who assessed that graduate students yield positive effects on both universities and all-levels private sector's total patent applications. In particular, the pro-innovation role of non-US graduate students and the consequent benefits in terms of applications and awards reflect in patent estimates: an increase in the number of foreign students equal to 10% potentially raises non-university-granted patents by 5% and at the same time university's patenting activity by 5.8%. However, as maintained by the authors, several variables other than the mere contribution of foreign graduate students determine these results, above all the private sector-academic world partnership<sup>30</sup>, which exerts a significantly positive influence over the total share of patents awarded. Indeed, the practice of subcontracting research to universities or directly to specific academic departments by granting an established quota of royalties is increasingly common among industries. A further indirect gain of the presence of international students derives from the tendency of industries to purchase newly-discovered inventions' intellectual property rights directly from the university where the innovation was implemented.<sup>31</sup>

Therefore, in the wake of the positive spillovers of highly-educated students on the total number of patents awarded to universities as well as to the private sector, a sharp debate on US migration policies with regard to students emerged, and especially concerning employer-sponsored H-1B visas, which represent the gateway to enter the US for workers specialised in science and engineering.<sup>32</sup> Nonetheless, a proper focus on education will be duly conducted in the following section.

Although the greatest share of investigations concentrates on immigrant's impact on American innovation through patents, equivalent research at European level has been conducted.

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<sup>30</sup> See Rigoberto Chinchilla (2013) for a more in-depth analysis on the private sector-academic world partnership and its limitations, with a special focus on the engineering programs.

<sup>31</sup> See Scott Shane's (2002) analysis of the evolution of patent selling from MIT.

<sup>32</sup> Especially, on the one hand it is likely that a more extensive concentration of foreign skilled workers positively impacts the patenting activity; on the other hand, the probability of immigrants' over-representation in STEM disciplines with respect to natives is tangibly present (Hunt, Gauthier-Loiselle, 2010). To this respect, questions concerning the quantity and the class of immigrants to be admitted in the U.S. arise.

In this regard, Ozgen *et al.* (2011) constructed a panel of data relative to 170 regions in Europe (referred to as NUTS 2 level) within two specific time periods, that are 1991-1995 and 2001-2005; additionally, as in the previously examined studies, the number of patent applications per million inhabitants is employed as a proxy of innovation. However, as opposed to precedent investigations, the population increase caused by more sustained immigrants' inflows, per se, is not associated with higher innovation outcomes. Indeed, statistically it is immigrant composition in terms of educational background, professional skills and ultimately cultural diversity which on average positively contribute to patent applications and, in turn, innovation. Therefore, as subsequently explained by Annekatrin Niebuhr (2010), the diversity index considerably outweighs the size of the immigrant population. Such trend seems to be confirmed by Bratti and Conti (2018), whose focus on the Italian peninsula<sup>33</sup> indicated a 3.9% increase in patent applications as a result of 1 percentage point increase of foreign graduate students, despite the patenting activity being relatively stable between 2002-2010.<sup>34</sup>

In conclusion, as far as the impact of skilled immigration on the destination country's innovation output is concerned, a final remark is required because migration flows are usually not in themselves homogeneous, and hence high-skilled immigrants tend to settle in the most innovative regions of a given host country where R&D investments and per capita GDP are on the rise. Consequently, a higher level of patent applications is expected to come from those specific areas, which will thereby become more innovative, albeit the overall number of immigrants might be virtually modest (Ozgen *et al.*, 2011).

### **The role of education as a driving force of innovation**

When it comes to the assessment of the impact of immigration on innovation, the essential role of high-skilled immigrants and consequently their educational background is widely acknowledged both among scholars and within theoretical models. As a matter of fact, highly-educated immigrants undeniably alter the composition and the quality of the local human capital, which in turn has positive spillovers on the development of new ideas (Sinoi, 2021).

Nonetheless, the educational level of migrants is deeply heterogeneous, and this has profound repercussions on the potential to innovate: for example, in a detailed examination of the topic at issue, Burchardi *et al.* (2020) ascertained that flows of relatively uneducated immigrants would be more prone to having no positive repercussion on innovation; conversely, over a 5-year period a group of 2,500 migrants with high schooling levels (estimated around the 8th decile) would possibly contribute to the awarding of one additional patent per 1,000 inhabitants.<sup>35</sup>

<sup>33</sup> For a study on this matter at a European level, see Valentina Bosetti *et al.* (2015).

<sup>34</sup> The latter, however, is mainly to be attributed to specific structural features of Italy, which is characterized by a prolonged inclination to attract young and low-skilled immigrants primarily from Romania, Albania, Ukraine and – due to the adjacent position – Africa. As a matter of facts, for the latter sort of migrants, a perfect breeding ground was enabled by the specialization of Italy in traditional industries and in the export of low-skilled, labour-intensive products (Bratti, Conti, 2018). Consistently with Stefano Solari *et al.* (2018), Italian migrants are employed in low skill-intensive positions thus with a lower likelihood of innovation, such as agriculture, industry and construction (36.4% in total).

<sup>35</sup> Piriya Pholphirul and Pungpond Rukumnuaykit (2017) study the effect of unskilled migration in the case of Thailand, they find this type of migration to be detrimental for the R&D sector, since the availability of cheap labour force makes expenditure on R&D a less attractive option for firms.



To this respect, the Italian experience represents a further case in point: indeed, Italy is prevalently characterized by inflows of unskilled migrants, which provide the country with relevant sources of cheap and low-skilled labour to be employed in the low value-added traditional sectors. However, according to Bratti and Conti (2018), innovation in the country does not appear to be spurred by immigrants per se, but rather by the mere population growth induced by immigrants' arrival which, by virtue of their cultural diversity, likely enhance the concentration of economic activities and thereby the innovation prospects. In addition, the average level of education of natives should be taken into consideration because since the latter is tightly similar to that of immigrants, we can eventually conclude that it is highly improbable that a sustained inflow of low-skilled immigrants would be able to considerably modify the structure of the workforce in terms of skill composition.

Alternatively, immigration in the United States followed a completely different path: firstly, on the basis of the 2008 Current Population Survey,<sup>36</sup> immigrants compose 16% of the US labour force possessing a bachelor degree. Secondly, the majority of high-skilled immigrants are employed in the STEM sector which, in accordance with Kerr (2013), mainly developed, thanks to immigrants' contribution. Likewise, the behaviors of national individuals with respect to immigration patterns should be considered. In this sense, Joan Lull (2018) considers the changes in national education patterns in relation to the changes in their wages as a consequence of immigration patterns, concluding that natives tend to increase or decrease their levels of education depending on the return wages that they obtain. In this regard, foreign students in the US are more likely to be enrolled in STEM-related areas than in the humanities sector (Chellaraj *et al.*, 2008); more noticeably, the percentage of foreign-borns enrolled in doctoral studies in Science & Engineering (S&E) rose in the last decades to the point it equals natives' presence. (Stuen *et al.*, 2012) Still, drawing the conclusion that inflows of science- and engineering-educated immigrants should be reduced to the subsidization of natives in the study of STEM disciplines appears to be inappropriate, since natives could potentially have fostered US economic growth in sectors other than science and engineering. (Hunt, Gauthier-Loiselle, 2010).

Similarly, immigrants' involvement in STEM areas does not depend on the alleged superiority of foreigners in those fields with respect to natives, but rather it may be explained by immigrants' tendency to make educational investments in such disciplines (Kerr, 2013). Indeed, as noted by Peri and Sparber (2009), immigrants are more inclined to engage into analytical and quantitative skill-demanding activities, whereas natives are more prone to partake in occupations in which communication and interactive expertise is required. In this respect, factors such as language barriers and its influence in certain areas of expertise play a considerable role in terms of the specialization of high-skilled immigrants in STEM disciplines. Moreover, Hunt and Gauthier-Loiselle (2010) noted that scientific areas of expertise are not subjected to particular regulations, country-based restrictions or cultural considerations, enabling experts in those areas to easily immigrate, thus increasing the inflow of STEM sectors' members.

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<sup>36</sup> The CPS is a US survey developed by the Bureau of Labour Statistics and the Census Bureau, and constitutes a reference for data collection and evaluation.

At the same time, average schooling levels profoundly vary by source country.<sup>37</sup> Therefore, in light of the above-mentioned reasons, we can conclude in the words of Burchardi *et al.* (2020) that “the impact of immigration on innovation increases with average schooling levels”. Hence, we can consider education among the main variables positively associated with innovation in a given economic system. To this respect, two relevant education-related factors linked to US immigration patterns will be considered in this section, namely US universities’ student composition rates and high-skilled immigrants’ recruitment trends.

In the first place, strong evidence suggests that during the last decades, US campuses have markedly become more international:<sup>38</sup> foreign students account for roughly 25% of tenure-track faculties and around 60% of the post-doctoral community (National Science Board, 2008). However, substantial differences depending on the field exist. In particular, engineering, maths and computer sciences are classified at the top of the faculties with the highest immigrant component, whereas the percentage of foreign-born in earth and environmental sciences and generally life sciences ranks among the lowest (Stephan, 2010). Furthermore, during the last 25 years of the whole doctoral degrees in the field of science and engineering, 43% were awarded to immigrants coming from China, India and ultimately South Korea. In this regard, Stephan (2010) documented the trend of PhD awarding over a 26-year period (1980s-2006) finding that an almost tripled number of US degrees awarded to foreign students did not come along with a corresponding growth among natives, which experienced an increase equal to 30%. As from Figure 1, Stephan (2010) estimated that in 1980 approximately 3,000 of the overall 11,600 science and engineering degrees were awarded to foreign-born students who possessed a temporary or permanent resident visa. In 2006, the opposite trend was observed, as non-native students were awarded further than 11,000 PhDs, which approximately amount to 47.7% of the entire degrees awarded.

To a great extent, the hiring of foreign students by US universities has been fostered by recent modification of the H-1B visa policy<sup>39</sup>, which has been mentioned in the previous section. Precisely, thanks to the 2000 American Competitiveness in the Twenty-First Century Act (AC21), the cap on the number of H-1B visas that for many years generated competition between firms and universities has been revised in favour of the latter<sup>40</sup>. In addition, student placement within the industrial sector outlines a further process through which implicit knowledge is conveyed from universities to the business community.

**Figure 5.** PhDs in science and engineering awarded by citizenship status (1980–2006)

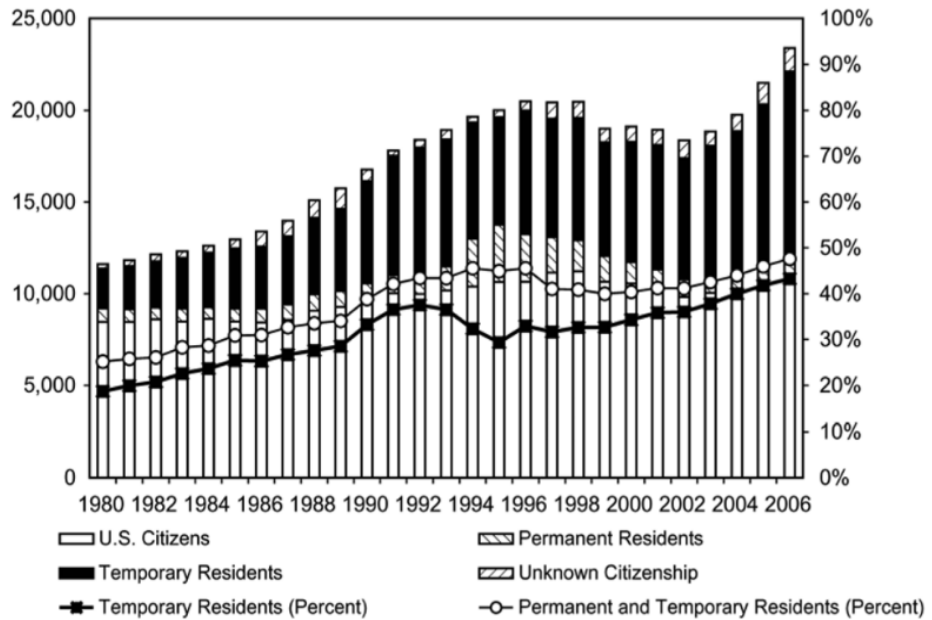
<sup>37</sup> For example, as far as Mexico, El Salvador and Guatemala are concerned, these rank among the least educated immigrants’ source countries. Conversely, Filipinos and Indians, which represent respectively the second and third ethnicity by number of immigrants to the United States, are estimated to be significantly better-educated relative to natives (Card, 2009).

<sup>38</sup> For an in-depth analysis on this subject, the authors refer to the work of Lucia Brajkovic and Robin Matross Helms (2018).

<sup>39</sup> H-1B visas allow skilled workers to enter the United States for a period of three years, which can be renewed by the hiring company. Moreover, visa applications have to be made both by firms seeking to hire high-skilled workers and by potential immigrants themselves. These visas are subjected to a maximum cap of applications per year, at the exceeding of which a lottery is generated in order to complete the cap. The specific number of H-1B visas granted per year is variable, although it has remained at 65,000 visas per year, in addition to which 20,000 extra visas are granted for immigrants having obtained Master’s degrees or higher education levels in the United States.

<sup>40</sup> Indeed, the limitation no longer applies to both research labs, non-profits and generally universities, which allows postdocs to enter the academic world by means of an H-1B visa and at the same time to contribute to the publishing and patenting activity of US universities, thereby enhancing productivity and innovation.





Source: National Science Foundation, WebCASPAR database, <http://webcaspar.nsf.gov>

All this considered, the pivotal role of universities in boosting innovation is understandably uncontested.

Nonetheless, Borjas and Lawrence F. Katz (2007) identified a number of virtual downsides of foreign students’ enrolment in US universities for natives, and specifically a potential displacement of white males from highest-level graduate programs. However, such phenomenon may simultaneously be explained by a kind of “pulling effect” of native students into different careers, which in turn legitimizes an increase in foreign-born students’ enrolment in US universities. Similarly, as far as international students and immigrants as a whole are concerned, a further aspect has to be taken into account, notably the homecoming phenomenon after either a study or working-period in the United States. For this purpose, Stephan (2010) estimates that the share of foreign PhD-awarded students who left the United States roughly 10 years after the assignment of the degree amounts to 40%. More importantly, though contributing to their home or new-destination countries’ levels of innovation and economic growth, positive nexuses between American and international firms persist, as well as strong connections with non-native students who received their university education in US campuses.

Consequent to the importance of education as a leverage for innovation is the global competition for talent, which reflects on countries’ efforts to attract both highly-educated and skilled workers. Thus, the existence of measures which favor the entrance of such category of immigrants led Jonkers (2011) to affirm that a certain level of competition among developed economies for the recruitment of qualified migrants possibly exists. Thus, not only do high-skilled immigrants sustain employment levels in northern industrialized countries, but they also prevent shortages of specific scientific and technological knowledge, which are essential to spur innovation and thus development.



To this respect, specific admission policies have been designed at the European level in order to encourage the arrival of high-skilled immigrants.<sup>41</sup> Nonetheless, as opposed to the existing incentives in terms of taxation and barriers reduction for the movement of human capital, it is worth noting that immigrants' origin countries strongly promote either the retention or the homecoming of talented nationals.<sup>42</sup> Additionally, European governments' efforts proved to be quite inefficient when compared to other OECD countries, inter alia the United States, Canada and ultimately Australia. Indeed, in a comparative investigation on Australian, Canadian and New Zealanders' immigration policies, Richard Bedford and Paul Spoonley (2014) shed light on these countries' selection systems, which condition the entrance of foreigners to the possession of both specific competences and appropriate schooling levels. Moreover, being characterized by a similar international migration narrative, the above-mentioned countries are inclined to influence each other's candidate selection procedures, which are mainly geared toward a prompt settlement of immigrants in the domestic labor market. Overall, there exists all likelihood to assert the efficacious nature of such countries' strict immigration monitoring practices because, for example, selection policies benefited the two Pacific nations and Canada from considerably higher labour market outcomes than would have been possible in the case of a random selection.

### **Immigration, innovation and destination countries' labour market**

Starting from the so-called Age of Mass Migration during the 1850s, over 90% of immigrants were of British, Irish and German nationality (Sequeira et al., 2020). To this respect, immigration proved to be a pivotal driver of industrialization as previously experienced European incomers provided a fundamental source of unskilled labor to be employed in factories and precisely in the manufacturing sector.<sup>43</sup> More recently, the role of immigration inflows as determinant of innovation and the subsequent effect on the labor market of destination countries has been extensively tackled with a focus on employment rates, workforce composition and wages.

For example, Borjas (1999) assessed the presence of positive spillovers in host economies triggered by the incoming of new ideas and working practices. In particular, immigration composition (and specifically the admission of high-skilled workers) may represent a fundamental boost for innovation not only for the knowledge and capabilities they bring along, but also thanks to their entrepreneurial attitude, as outlined in Section 2. Conversely, an analysis of the distribution of immigrants and low-skilled natives across US industrial sectors revealed that an increase of 1 percentage point of immigrants is followed by an analogous growth in the labour supply of low-skilled-employing industries (Altonji, Card, 1991). Nonetheless, empirical data suggest a relatively moderate degree of competition between natives and immigrants: despite a modest displacement of less-skilled natives from

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<sup>41</sup> Particularly, southern Member States as Italy, Spain, Portugal, Greece plus Austria made use of a particular quota system, whereas Belgium, Sweden, Ireland and The Netherlands employed a different approach based on labour demand. Instead, Denmark, Czech Republic and pre-Brexit United Kingdom eventually engaged in a point-based recruitment system (Jonkers, 2011). For a further analysis, we suggest the work of Martin Kahanec and Klaus F. Zimmermann (2011).

<sup>42</sup> As an example for the reader, Nir Cohen (2009) analyses Israel's policy of incentives to return for the most talented nationals living abroad.

<sup>43</sup> At the same time, a significant share of immigrants engaged into skilled occupations as blacksmithing, carpentry and cabinetmaking. In particular, Germans, Italians and Jewish immigrants employed their expertise in trade, retail and generally professional occupations (Sequeira et al., 2020), thus pioneering notable technological innovations in the US economy.





immigrant-intensive industries during the decade 1970-1980, no evidence of a regular and systematic effect on less-skilled natives employment rate subsists.

A further focus on workforce's skill composition is included in the work of Dustmann et al. (2008), in which the authors delineated a possible theoretical model to explain the effects of immigration on host countries' labor market and its subsequent result with respect to native workers. Accordingly, skills configuration represents the paramount variable to understand the way in which the arrival of foreign workers affects domestic outcomes: assuming a perfect elasticity of capital supply and simultaneously an identical skill level between immigrants and natives, the supplementary workforce will be easily absorbed in the economic system through the mechanism of expansion. On the contrary, if different skill distribution among migrants comes along with the exclusion of any adjustment mechanism, the inflow of foreign-born might cause wage adjustments (Ottaviano, Peri, 2008). Moving from the idea that immigration implies redistribution, capital elasticity helps us discern the direction of this redistribution, that is whether immigrant inflows are a loss or a gain for natives. Nonetheless, the authors suggest that a given inflow of migrants would produce dissimilar outcomes depending on the skill composition of incomers on the one hand and of native workers on the other hand.

Alternatively, in their analysis on the manner in which immigration enhances innovation, Ozgen et al. (2011) clarified that immigrants' inflows spur the local aggregate demand due to an increased quantity of imports and through a more varied selection of local production (Mazzolari, Neumark, 2012). However, if over the short run additional labor supply to sustain such output rise is provided by newcomers, additional investment will be required over the long run, notably with respect to technologies, to stimulate innovation in terms of processes and products. This, in turn, may bolster firm growth and the creation of start-ups, which typically represent the cornerstone of innovative activities (Freeman, Soete, 1997). Eventually, the attractiveness of urban centres may further encourage the settlement of job-seeking immigrants, thereby spurring population growth, agglomeration and consequently higher innovation. A different trend emerges from Maré et al.'s investigation (2011). Specifically, an accurate evaluation of average innovation levels and labour force composition of New Zealand led the authors to assert that limited evidence of a positive systematic relationship between workforce specificities and innovation exists. In particular, a detailed analysis of the 2006 New Zealand Census of Population and Dwellings reveals a well-established connection between innovativeness and firm-level variables: hence, firm size, the presence of high-skilled workers and especially R&D expenditures seem to be the main drivers of the implementation of new production processes rather than the share of immigrants residing in a specific area. Instead, skilled newcomers essentially contribute only to the introduction of novel goods and services within the country.

## Conclusion

To conclude, we can affirm that evidence of immigrants' contribution to the overall level of economic growth and innovation in the destination countries exists: albeit with different degrees of consensus, the presence of immigrants is likely to increase the cultural diversity and demographic concentration of host countries, thus increasing agglomeration in large cities which, in turn, are deemed to be more innovative. Moreover, spillovers in terms of entrepreneurial capabilities and scientific and technological knowledge prove to be fundamental for host countries' innovation. In addition, a more controversial debate

surrounds the impact of immigration on the total number of patents awarded: if on the one hand several authors found a positive correlation between immigration and the patenting activity of a specific time period also with respect to university patenting, on the other hand, part of the doctrine maintained that sustained immigrants' inflows, per se, are not associated with higher innovation outcomes. Finally, the role of education as a driver of innovation remains largely undisputed, since positive spillovers of highly educated human capital are pivotal to spur the development of new ideas.

Eventually, as far as the labor market of destination countries is concerned, different trends concerning immigrants' effects exist: as a matter of fact, several investigations found almost no evidence of a regular and systematic displacement of less-skilled natives from the industrial sector, which is able to absorb newcomers simply by expansion, whereas a complementary branch of the literature supports the idea that in order to sustain output rise over the long run, R&D investment in terms of processes and products will be required to stimulate innovation.

Against this backdrop, our thematic review carries along pivotal, yet not surprising implications for policymakers: immigration is not the ultimate panacea to ensure high-level innovativeness for a country. Policymaking which pivots on high-skilled migration to boost the level of innovation in a country is expected to fail as immigrants alone contribute with positive spillovers on innovation only in the short-to-medium run. However, more strict migration policies are not grounded in our findings, as the higher degree of diversity which is associated with migration, does not result in a sparser and more irregular R&D activity: in other words, through all the channels we have considered in our review, there is no support to claim that migration is detrimental to a strong R&D sector. Future research aimed at better framing the role of diversity according to both firm sizes and levels of education in the firm are of major significance to carefully balance all the different inputs.

**Table 1.** Analysis of selected empirical articles by variables and methodology

Author	Year	Variable considered	Dependent variable	Methodology	Dataset	Main findings
Akcigit, Grigsby, Nicholas	2017	Immigration	Innovation, patents	Examination of macro and micro-level aspects of the relationship between immigration and innovation	Use of US patent and Census data	Immigrant inventors were more productive during their life cycle than native born inventors, although they received significantly lower levels of labour income than their native-born counterparts. We also find evidence of an immigrant inventor wage-gap that cannot be explained by differentials in productivity.



Akhmadi, Tsakalerou	2021	Manufacturing	Innovation, IPRs, economic growth	Qualitative methodology: survey and consequent analysis of data.	Use of data from a large swath of German manufacturing firms. Statistics of the 63,409 German manufacturing firms surveyed	A novel model is developed to predict the probability of any given firm registering a specific form of IPR depending upon its size and innovativeness.
Altonji, Card	1991	Immigration	Labour market outcomes, industry distributions of natives and immigrants	Analysis of the industry distributions of natives and immigrants and of the changes in these distributions in cities with higher and lower immigrant shares	Use of information from the 1970 and 1980 Censuses on labour market outcomes of natives in 120 major cities.	The analysis of changes shows no effect of increased immigration on participation or employment rates of less-skilled natives. It does reveal a systematically negative effect on native wages, although the specific estimates depend on the group and on whether we use an instrumental variables procedure to account for the fact that immigration inflows may depend on local labour market conditions.
Amara, Landry	2005	Sources of information	Innovation in manufacturing firms	Qualitative methodology: survey.	The data used in this paper are the responses of 5455 manufacturing firms to the 1999 Statistics Canada Innovation Survey.	Firms that have developed innovations considered as world premieres or national premieres are more likely to: (1) use a larger variety of sources of information, and (2) more especially, to use a much larger variety of research sources to develop or improve their products or processes.
Basset-Jones	2005	Cultural diversity	Innovation, creativity	The paper considers what is meant by diversity, how it is best managed, what its relationship with creativity and innovation might be and how the problems created by the management of diversity, creativity and innovation might be resolved	N/A	Firms seeking competitive advantage therefore face a paradoxical situation. If they embrace diversity, they risk workplace conflict, and if they avoid diversity, they risk loss of competitiveness. The advantages and disadvantages associated with workforce diversity put organizations in a position of managing a paradoxical situation.

Table 1 (Continues)

Author	Year	Variable considered	Dependent variable	Methodology	Dataset	Main findings
Bedford, Spoonley	2014	Immigration	Policy innovations	Examination of the reasons for significant policy shift and reviews some outcomes of the EOI system during the first decade of operation.	Canadian and Australian immigration policy initiatives	As the international competition for talent intensifies, policy innovation to attract high-skilled migrants is essential if countries are going to attract skilled migrants.
Blit, Skuterud, Zhang	2017	High skilled immigration	Patenting	Use of a baseline empirical model which estimates a specification as close as possible to the first-difference (FD) weighted least squares (WLS) specification of HGL.	1981-2006 balanced panel of Canadian Census Metropolitan and Agglomeration Areas (CMA/CAs) with observations on skilled immigrant population shares in 98 cities every 5 years	The modest contribution of Canadian immigrants to innovation is, in large part, explained by the low employment rates of Canadian STEM-educated immigrants in STEM jobs. Our results point to the value of providing employers with a role in the immigrant screening process.
Borjas	1999	Immigration Labour flows	Labour market outcomes	Qualitative methodology: survey	For the most part this literature estimates “spatial correlations” - correlations between economic outcomes in an area (such as a metropolitan area or a state in the United States) and the immigrant supply shock in that area	Labor flows help markets reach a more efficient allocation of resources. It investigates the determinants of the immigration decision by workers in source countries and the impact of that decision on the host country's labor market.
Borjas	2002	Foreign-student visa program	US gains from the program	Cost-benefit evaluation of the foreign-student visa program	US foreign-student visa program	The evaluation concludes that although there are benefits from the program, there is also a substantial taxpayer subsidy to foreign students.
Borjas	2003	Immigration	Labour market outcomes	Use of a key insight of human capital theory to define the skill groups: a worker acquires skills both in school and on the job	The empirical analysis uses data drawn from the 1960-1990 U.S. Decennial Censuses, as well as the 1998-2001 Current Population Surveys.	The comparison of labor market outcomes across these skill groups suggests that immigration has indeed harmed the earnings and employment opportunities of competing native workers. An immigrant influx that increases the supply of workers in a particular schooling experience group by 10 percent lowers the wage of natives in that group by 3 to 4 percent, and reduces weeks worked by 2 to 3 percent.



Table 1 (Continues)

Author	Year	Variable considered	Dependent variable	Methodology	Dataset	Main findings
Borjas	2004	Immigration and education	Number of foreign students enrolled in graduate programs over native enrollment	Empirical analysis on how the growth in the number of foreign students enrolled in graduate programs affects native enrollment in those programs.	Data on admission of foreign and native students at university	There is a strong negative correlation between increases in the number of foreign students enrolled at a particular university and the number of white native men in that university's graduate program. This crowd out effect is strongest at the most elite institutions.
Borjas, Katz	2007	Immigration	Mexican immigrants' presence in the US workforce+F8	Use of a simple framework that attempts to characterize the underlying trends on the evolution of the Mexican-born workforce in the United States.	Use of data drawn from the Integrated Public Use Microdata Samples (IPUMS) of the U.S. Decennial Census throughout the entire twentieth century to describe the demographic and economic evolution of this population.	"Mexican immigrants tend to have demographic and socioeconomic characteristics that differ significantly not only from that of the native-born population, but from that of other immigrants as well. In general, the economic performance of Mexican immigrants lags significantly behind that of other
Bosetti, Cattaneo, Verdolini	2015	Skilled immigration	Innovation, patents, bibliometric data	Empirical analysis through Instrumental Variables (IV): innovation, patenting and bibliometric data	Analysis of data in a panel of 20 European countries between 1995 and 2008	The empirical findings show that a larger pool of migrants in the skilled professions is associated with higher levels of knowledge creation. Skilled migrants contribute both to the creation of "private" knowledge, measured by the number of patent applications, and to more "public" basic research, measured by the number of citations to published articles. Results suggest that policy efforts aiming at attracting skilled migrants to Europe and employing them in skilled professions will indeed foster EU competitiveness in innovation.
Brajkovic, Matross Helms	2018	Immigration and education	Internationalization at American colleges and universities	Qualitative methodology: survey	Analysis of data of the 2016 American Council Education's (ACE) survey	Summary of the results of the American Council on Education's (ACE) 2016 Mapping internationalization on US Campuses survey

Table 1 (Continues)

Author	Year	Variable considered	Dependent variable	Methodology	Dataset	Main findings
Bratti, Conti	2018	Immigration	Innovation	Use of linear and non-linear models	Province-level data on patent applications and firm-level self-reported measures capturing innovation adoption	No evidence is found of either positive or negative effects of migrants on innovation. This result is robust to allowing for different effects of low- and medium-high-skilled migrants, to using linear and non-linear models, and to considering both province-level data on patent applications and firm-level self-reported measures also capturing innovation adoption.
Briggs, Vernon M. Jr.	1996	Immigration	Composition of US labour force	Institutional approach; testing of the ahistorical approach as well as of econometric studies	Analysis of immigration waves	To the degree mass immigration takes place, it is a policy-driven phenomenon. There is no international obligation for any nation to allow others to enter or to work or to permanently settle within its geographical borders. In fact, most nations do not admit immigrants for permanent settlement
Burchardi Tarek Hassan Tarquinio Terry	2020	Immigration	Innovation, growth, local firms patenting, income growth for native workers	Interpretation of results through the lens of a quantitative model of endogenous growth and migrations.	Use of 130 years of detailed data on migrations from foreign countries to US.	Immigration has a positive causal impact on innovation, measured as patenting of local firms, and on economic growth, measured as real income growth for native workers. the large inflow of foreign migrants into the US since 1965 may have contributed to an additional 8% growth in innovation and 5% growth in wages.



Table 1 (Continues)

Author	Year	Variable considered	Dependent variable	Methodology	Dataset	Main findings
Carayannis, Provance	2008	Ability to innovate	Innovation, firms	Use of a model of organisational innovation.	Sample from a collection of German firms listed in a "Top 1 00" German innovation benchmarking competition conducted in both 2002 and 2003 (n = 198). This competition included 26 firms that participated in both years. In order to remove this sample bias we reduced the sample to the 172 remaining firms from 23 industries.	Single or more limited indicators do not offer the degree of fine-tuning to a firm's innovation system that managers require. Thus, we propose the development, and future research into contingent variations, of a Composite Innovation Index (CII). We further demonstrate its use in comparing innovators and allowing managers to design a firm's innovation system.
Card	2009	Immigration	Wages	Adoption of a one-sector model of the demand for labor at either the national or local levels.	Focus on evidence from US cities	Working-age immigrant population concentration in US cities. Connection between immigration and wage inequality, focusing on the evidence derived from comparisons across major US cities
Chaminade, Asheim	2013	Global innovation networks	Knowledge diffusion	Adoption of a structural approach of social network analysis to explore the relational pattern of the GINs. Qualitative methodology: questionnaire and analysis of collected data	Social network analysis based on primary data. Data sources used in this study include interviews, questionnaires, websites, corporate internal reports and documents and press news.	The paper finds that, in addition to influencing the geographic spread of a GIN, the knowledge base also influences the way that a GIN is organized.



Table 1 (Continues)

Author	Year	Variable considered	Dependent variable	Methodology	Dataset	Main findings
Chaminade, Plechero	2015	Global innovation networks in the ICT industry	N/A	Qualitative methodology: survey and consequent analysis of data.	This paper is based on a firm-based survey conducted in 2009-2010 across 9 countries: Brazil, India, China, South Africa, Norway, Sweden, Germany, Estonia and Denmark, as well as case studies conducted in Beijing and Cape Town. In all industries and across all countries 1215 responses were collected.	The results show that GINs are more common in regions which are not organizationally and institutionally thick, suggesting that GINs may be a compensatory mechanism for weaknesses in the RIS.
Chellaraj, Maskus, Mattoo	2008	Immigration	Impact of foreign students on innovation	Estimation of an innovation production function in which graduate students and skilled immigrants are an input into the development of new ideas, both at universities and in the private sector.	US data on foreign graduate students and skilled immigration	Results indicate that the presence of foreign graduate students has a significant and positive impact on both future patent applications and future patents awarded to university and non-university institutions. Our central estimates suggest that a 10% increase in the number of foreign graduate students would raise patent applications by 4.5%, university patent grants by 6.8% and non-university patent grants by 5.0%. Thus, reductions in foreign graduate students from visa restrictions could significantly reduce US innovative activity. Increases in skilled immigration also have a positive, but smaller, impact on patenting.



Table 1 (Continues)

Author	Year	Variable considered	Dependent variable	Methodology	Dataset	Main findings
Chinchilla	2013	Private sector and academia collaboration	Industrial innovation	Qualitative methodology: survey	N/A	It is possible to do both in a four year period that is already stressed with too many demands? What does it mean "to be prepared for a job"? Is the mission of the university to be a substitute place for training or to save money to the private sector by taking out training from their costs?
Clark, Hatton, Williamsons	2002	Immigration	Income, education, demographic composition, inequality	Empirical analysis through IV: income, education, demographic composition and inequality	Use of data relative to the period 1971-1998	Parameter estimates from the panel data are used to implement counterfactual simulations that serve to isolate the effects of immigration policy as well as source-country economic and demographic conditions.
Cohen	2009	High skilled immigration	Policy innovations	Critical analysis of incentive-based programmes geared towards Israeli emigrants	Israel's migration strategy from 1948	Israel's state-sponsored initiatives have been economically motivated, targeting as such a segmented group of highly skilled emigrants.
Corsaro, Cantù, Tunisini	2012	Cultural diversity	Innovation	Empirical analysis through IV: goals, knowledge bases, capabilities and competences, perceptions, power and position, cultures.	Review of literature on actor's heterogeneity	This paper is aimed at pursuing issues in need of further investigation: 1. how the interplay of diverse actors' attributes shapes the interaction process in the development of collaborative innovation; 2. if and how combinations of their attributes are more likely to generate certain consequences in interaction; and 3. the degree to which heterogeneity is preferable to homogeneity for the effectiveness of the innovation network.

Table 1 (Continues)

Coppel, Dumont, Visco	2001	Immigration	Economic, fiscal and social implications	Empirical analysis through IV: immigration trends and their economic impacts in OECD countries, economic, fiscal and social variables	Data from OECD Countries	The study suggests that immigration can confer small net gains to the host country. However, the benefits are not necessarily evenly distributed and some groups, in particular those whose labour is substitutable with immigrants may lose, calling for a smooth working of labour and product markets in OECD countries.
Crown, Faggian, Corcoran	2020	High skilled immigration, Visa program	Design rights Trademarks	Empirical analysis through IV	Combination of data on innovation measures at the regional level with administrative data from the full population of approved Temporary Graduate visa applications	Results show a positive impact of the visa program on the number of patent applications, indicating a positive impact of the skilled immigration visa program on regional innovation.
Das, Marjit, Kar	2020	Skilled immigration	R&D	Empirical verification using a VAR model in the context of the USA confirms the conjecture.	Panel of US data concerning wages	Targeted skilled immigration into the R&D sector that helps low-skilled labor is conducive for controlling inequality and raising wage. Skilled talent-led innovation could have spillover benefits for the unskilled sector while immigration into the production sector will always reduce wage, aggravating wage inequality.
Davis, Weinstein	2002	Immigration	Skilled labour and capital	Use of simple calculations to evaluate the magnitude of losses for US natives	Use of data to make calculations about losses for US natives	A country that experiences immigration of factors motivated by technological differences always loses from this migration relative to a free trade baseline, while the other country gains. Simple calculations suggest that the magnitude of the losses for US natives may be quite large \$72 billion dollars per year or 0.8 percent of GDP.
Dolado, Gorio, Ichino	1994	Immigration	Variations in human capital	Use of a Solow growth model; evidence for a sample of OECD economies to evaluate the magnitude of such effect	Data concerning growth in OECD countries	The negative output and growth effects of immigration tend to become less important the higher the imported immigrants' human capital relative to natives.



Table 1 (Continues)

Author	Year	Variable considered	Dependent variable	Methodology	Dataset	Main findings
Dustmann, Gritz, Frattini	2008	Immigration	Labour market outcomes: changes in factor prices, output mix, production technology	Summary of some recent empirical studies for the UK and other countries	Panel of data from UK	Discussion of mechanisms through which an economy can adjust to immigration:
Dustman, Frattini	2014	Immigration	Fiscal impacts	Computation of the net fiscal contribution of different population groups by assigning individuals their share of cost for each item of government expenditure and identifying their contribution to each source of government revenues.	Panel of data from UK; period: since 1995	When considering the resident immigrant population in each year from 1995 to 2011, immigrants from the European Economic Area (EEA) have made a positive fiscal contribution, even during periods when the UK was running budget deficits, while Non-EEA immigrants, not dissimilar to natives, have made a negative contribution.
Fabling, Maré, Stillman	2011	Immigration	Local workforce characteristics, innovation in firms	Empirical analysis through IV: examination of the relationship between local workforce characteristics	Combination of firm-level innovation data with area-level Census data	Positive relationship between local workforce characteristics and average innovation outcomes in labour market areas, but this is accounted for by variation in firm characteristics such as firm size, industry, and research and development expenditure.
Fasso, Montobbio, Venturini	2019	Skilled immigration	Innovation, patents	Use of an empirical model that adapts standard endogenous growth models	Data from European industries between 1994 and 2005, use of the French and UK Labour Force Surveys and German Microcensus. Use of patents to measure innovation, The characteristics of the labour force are derived from the Labour Force Surveys in France and the UK and the Microcensus in Germany.	Highly-educated migrants have a positive effect on innovation, but the effect differs across industries. It is stronger in industries with low levels of overeducation, high levels of FDIs and openness to trade and, finally, in industries with higher ethnic diversity. The aggregate effect of the skilled immigrant is about one third the one of the skilled natives.

Table 1 (Continues)

Author	Year	Variable considered	Dependent variable	Methodology	Dataset	Main findings
Ferrucci	2020	Immigration	Patenting	Empirical analysis of IV: graduate students, postdocs, contribution to patenting, publications.	Panel dataset of patent production by technology, identifying the technology classes affected by the shock with those in which Soviet inventors were primarily active before 1991.	An increase in patent production in the technology fields in which the Soviet Union was most active, and a tendency for local inventors who had directly collaborated with their Soviet counterparts to explore new technology domains.
Finco, Bucci, Bentivoglio	2018	Agrifood competitiveness	Innovation, economic growth, productivity	Qualitative methodology: questionnaire and a liner regression model.	Data obtained from the Cluster Agrifood Marche members that filled the questionnaires.	This study highlights that Small Size Agrifood Firms can not individually achieve innovation. Therefore, Cluster are seen as successful way to develop new innovation strategies and to increase the competitiveness. Moreover, the results suggest that innovation is not a random process. The propensity for innovation depends both on each firm characteristics and on several variables.
Foged, Peri	2015	Immigration	Labour market outcomes	Use of two different types of empirical approach: a classic two stage least squares (2SLS) panel estimation, and a difference-in-differences approach.	Use of longitudinal data on the universe of workers in Denmark during the period 1991-2008	We find that an increase in the supply of refugee-country immigrants pushed less educated native workers (especially the young and low-tenured ones) to pursue less manual-intensive occupations. As a result immigration had positive effects on native unskilled wages, employment and occupational mobility
Freel	2002	Firms cooperation	Innovation	Investigation on the extent to which cooperation for innovation is associated with firm-level product and process 'innovativeness' and the factors which influence their spatial distribution.	Use of a sample of 597 small and medium sized manufacturing firms	Increasing firms size and export propensity are positively associated with external linkages at a higher spatial level



Table 1 (Continues)

Author	Year	Variable considered	Dependent variable	Methodology	Dataset	Main findings
Freeman, Soete	1997	Immigration	Industrial innovation	Investigation on the relationship of industrial innovation and economic development in terms of economic investment in new processes and materials, effects of technology on firm size, and the role of public policy in fostering technology and stimulating employment.	N/A	Relationship between industrial innovation and economic development in terms of economic investment in new processes and materials, the effects of technology on firm size, and the role of public policy in fostering technology and stimulating employment.
Fritz Foley, Kerr	2013	Immigration	Innovation, patents	Analysis of detailed data on patent applications and on the operations of the foreign affiliates of U.S. multinational firms.	The analysis uses detailed Flings from the U.S. Patent and Trademark Office for all patents granted from 1975-2008.	Increases in the share of a firm's innovation performed by inventors of a particular ethnicity are associated with increases in the share of that firm's affiliate activity in their native countries. Ethnic innovators also appear to facilitate the disintegration of innovative activity across borders and to allow U.S. multinationals to form new affiliates abroad without the support of local joint venture partners.
Furman, Porter, Stern	2002	High skilled immigration	Innovation, patents	Empirical examination of the determinants of country-level production of international patents.	Use of patent data to evaluate the rate of technological innovation	While a great deal of variation across countries is due to differences in the level of inputs devoted to innovation (R&D manpower and spending), an extremely important role is played by factors associated with differences in R&D productivity (policy choices such as the extent of IP protection and openness to international trade,
Gagliardi	2015	Immigration	Industrial innovation	Empirical analysis through IV: human capital, innovation, productivity	Combination of firm-level micro-data with area-level labour force information	The nature of the innovative process and the typology of innovative activities performed by local firms play a key role in the relation between immigration and innovation.

Table 1 (Continues)

Author	Year	Variable considered	Dependent variable	Methodology	Dataset	Main findings
Gima, Yu	2002	Immigration	Trade	Use of a gravity equation of trade augmented by immigration variables.	UK data of immigration from non-Commonwealth countries. Trade relationships between the UK and 48 partners	The study reveals a pro-impacts effect of immigration from the non-Commonwealth countries, whereas immigration from the Commonwealth appears to be reducing imports, perhaps reflecting trade-substituting activities by immigrants.
Gould	1994	Immigration	Trade	Employment of a model which is a modification of Bergstrand's (1985) microeconomic foundation of the gravity equation.	Panel of data from US	Empirical results for the United States suggest that immigrant links have historically been important in increasing bilateral trade flows with immigrants' home countries
Grillitsch, Chaminade	2018	Cultural diversity	Engagement of SMEs into global innovation networks	Empirical analysis through IV and dependent variables: citizenship diversity, firms.	Dataset with 6,771 observations of innovative small and medium size firms in Sweden	The engagement in GINs is positively related to citizenship diversity, depending, however, on the absorptive capacity of firms.
Hart	2007	High skilled immigration	Innovation	Employment of a system of Innovation approach (SI)	Data on high-skilled migration in policy-makers agendas	The paper prepares the conceptual ground for a broader assault on this important issue
Hunt, Gauthier-Loiselle	2010	Skilled immigration	Patenting, innovation	Empirical study of the regional determinants of innovation; individual-level analysis; Use of IV.	Panel of data from US; period: 1940-2000	Immigrants do have positive spillovers, resulting in an increase in patents per capita of 9-18% in response to a one percentage point increase in immigrant college graduates.
Hunt, Jennifer	2011	Immigration	Productivity, entry visa	Estimation of a weighted least squares equivalent with robust standard errors	2003 wave of the National Survey of College Graduates (NSCG), data collected under the auspices of the National Science Foundation. The survey is a stratified random sample of respondents to the 2000 census long form who reported having a bachelor's degree or higher.	Immigrants who first entered on a student/trainee visa or a temporary work visa have a large advantage over natives in wages, patenting, commercialising or licensing patents, and publishing. In general, this advantage is explained by immigrants' higher education and field of study, but this is not the case for publishing, and immigrants are more likely to start companies than natives with similar education. Immigrants without U.S. education and who arrived at older ages suffer a wage handicap





Table 1 (Continues)

Ivlieva O.D.	2015	High skilled immigration	Innovation, patents	Use of two novel datasets that offer internationally comparable information on migration and migrants' labor market integration across cities, towns and rural areas in OECD countries.	Theoretical approaches, citation indices and patenting activity data	Citation indices and patenting activity data were used to conclude about the input of each group of researchers (immigrants, emigrants and re-migrants) to the innovative development of the country and the position of Germany in the international system of highly-qualified migration.
Jensen	2014	Immigration	Innovation, productivity	Empirical analysis through IV: innovation, migration, policy making	International literature on the migration-innovation relationship and their implications for the Australian debate.	Recent developments in the international literature on the migration-innovation relationship are critically reviewed and their implications for the debate in Australia are considered.
Jonkers	2011	Immigration	Innovation, economic growth	Empirical analysis through IV: economic growth and innovation	Use of data from EU member States	Short- and long-term contribution to the economic progress and shared economic prosperity of EU Member States as a result of migration at a range of skill levels
Kahanec, Zimmerman	2010	Skilled immigration	Innovation	Review of the main postwar immigration trends; analysis of data and evaluation of current immigration policies	Review of immigration policies; data from the Institute for the Study of Labour (IZA) Expert survey on high-skilled Labour immigration in the EU (ESHSL).	Since significant political tensions can be expected between native actors that favor and disfavor further immigration, improving European immigration policies and procedures is a formidable challenge. This task involves the need to improve Europe's image among potential migrants, especially the high-skilled ones.
Kangasniemi, Robinson, Martinez	2009	Immigration	Productivity performance	Adoption of both a growth accounting and an econometric approach using a specially constructed industry panel data.	Use of the EUKLEMS database provides the information on output, employment, capital, energy, materials and service inputs. These data are derived from the Labour Force Survey (LFS), in the case of the UK and the Encuesta de Población Activa (EPA) for Spain.	Migration has had very different implications for Spain and the UK, migrants being more productive than natives in the UK but less productive than natives in Spain. This may in part be a function of different immigration policies, particularly related to the skill requirements on entry, but also in part a feature of the host nations' ability to 'absorb' foreign labour.

Table 1 (Continues)

Kemeny	2017	Immigration, cultural diversity	Urban economic performance	Review of an established body of theoretical and empirical research	Data on heterogeneity in workforce composition	This article reviews a growing literature investigating how “immigrant” diversity relates to urban economic performance.
KERR	2013	High skilled immigration	Innovation, entrepreneurship	Measurement of the contribution given by high skilled immigrants on innovation, entrepreneurship and patents in the US.	Studies regarding the impact of immigrants on natives	Immigrants in the United States aid business and technology exchanges with their home countries, but the overall effect that the migration has on the home country remains unclear. We know very little about return migration of workers engaged in innovation and entrepreneurship, except that it is rapidly growing in importance.
Kerr, Lincoln	2010	Immigration, visa program	Technology formation	Empirical specifications comparing how patenting growth in the distribution responded to shifts in H-1B admissions relative to patenting growth in the bottom two quintiles.	Analysis of H-1B Visa related to a period between 1995-2006	Fluctuations in H-1B admissions levels significantly influence the rate of Indian and Chinese patenting in cities and firms dependent upon the program relative to their peers. Most specifications and weak crowding-in effects or no effect at all for native patenting. Total invention increases with higher admission levels primarily through the direct contributions of ethnic inventors.
Khanna, Lee	2020	High skilled immigration	Product reallocation, innovation, economic growth	Use of panel regressions	Use of data on H-1B Labor Condition Applications to retail scanner data on products and Compustat data on firms characteristics	H-1B certification is associated with higher product reallocation and revenue growth. A ten percent increase in the share of H-1B workers is associated with a two percent increase in product reallocation rates – our measure of innovation. These results shed light on the economic consequences of innovation by high-skill immigrant to the United States.
Kotabe	1990	Imports	Innovation	Empirical analysis through IV: innovation propensity.	Analysis of the literature on US firms imports under items 806.30 and 807.00 of the Tariff Schedules	This study attempts to fill this void by empirically examining this issue at the industry level.



Table 1 (Continues)

Laursen et al	2020	High skilled immigration	Innovation	Use of a general method of moments (GMM) estimation	Use of patents and matched employer-employee data for 16,241 Dutch firms over an 11-year period. Link of these data to European Patent Office (EPO) patent and citations data to measure firms' quality-adjusted innovation output. The analysis includes 16,241 firms and 71,092 observations.	Due to migrants' often different experience from that of native high-skilled workers, their perspectives on problem-solving and access to non-overlapping knowledge networks will also differ. The implied complementarity between these worker types makes migrant hires a particularly valuable resource in the context of firm-level innovation.
Lissoni	2017	High skilled immigration	Innovation	Empirical analysis through IV: mobility, migration, directions of flows, contents.	Use of economic history studies	Using economic history studies as a template, the paper organizes several strands of the literature around three main themes: the distinction between mobility and migration; the directions of flows; and their contents
Llull	2018	Immigration	Wages	Equilibrium dynamic discrete choice structural model of a labour market with immigration	US micro-data for 1967-2007.	Individuals adjust to immigration by changing education, participation, and/or occupation.
Longhi, Nijkamp, Poot	2009	Immigration	Wages, employment	Review of analytical approaches for identifying local labour market impacts; adoption of a meta-analytic approach. Use of a simultaneous equations approach to the meta-analysis of wage and employment effects.	Data from 129 meta-observations	The observed local wage and employment effects are very small indeed. Wage rigidity increases the magnitude of the employment impact on the native born and the definition of the local labour market in terms of geography and skills matters.
Mahroum	2002	High skilled immigration	Drivers of innovation: taxation, immigration legislation, quality of work, study, openness, business expansion	Empirical investigations of previous studies	N/A	In addition to immigration legislation, other factors, such as taxation, studying abroad, quality of work, openness in communication, business expansion overseas, labour market supply and demand signals, etc. play important role in the choice of highly skilled migrants to relocate overseas.

Table 1 (Continues)

Author	Year	Variable considered	Dependent variable	Methodology	Dataset	Main findings
Makkonen, Williams, Habersetzer	2018	Foreign board members, cultural diversity	Innovation, trademark, patent	The analyses are based on a large sample of firms within the European Union, utilizing patent and trademark data together with information on the national diversity of the boards.	The relationship between FBMs and the innovation activities of some 1 545 000 currently active firms in the European Union (EU) are explored, utilizing the Orbis database	The analyses confirm that there is a positive association between FBMs and firm innovativeness. Contrary to expectations, FBMs from less innovative countries than the countries of their host companies are more associated with innovative firms than are FBMs from more innovative countries
Matloff, N.	2013	Foreign workers	Wages, patents, R&D	Investigation on the two main reasons for hiring foreign workers—remediating labor shortages and hiring “the best and the brightest”.	Data from US Tech Industry: wages, patents, R&D work, previous research, industry statements.	The primary goals of employers in hiring foreign workers are to reduce labour costs and to obtain “indentured” employees. Current immigration policy is causing an ‘Internal Brain Drain’ in STEM.
Mazzolari, Neumark	2012	Immigration	Consumption choices	Empirical analysis through IV: immigration, diversity of consumption choices	Data from California in the 1990s and focus on the restaurant sector	Focusing on the restaurant sector for which we can better identify the types of products consumed by customers, we find that immigration is associated with increased ethnic diversity of restaurants.
Mohammadi, Brostrom, Franzoni	2017	Cultural diversity	Workforce composition, innovation, firms	Empirical analysis through IV: ethnicity and higher education background.	The final sample comprises 7,389 firm-year observations from 3,888 firms.	This article demonstrates that having greater workforce diversity in terms of both ethnic background and educational disciplinary background is positively correlated to the share of a firm’s turnover generated by radical innovation. Having more external collaborations does, however, seem to reduce the importance of educational background diversity. The impact of ethnic diversity is not affected by external collaboration. These findings hold after using alternative measures of dependent and independent variables, alternative sample sizes, and alternative estimation techniques.



Table 1 (Continues)

Author	Year	Variable considered	Dependent variable	Methodology	Dataset	Main findings
Mosbah, A., Ali, M.A., Aljubari, I. H, Sherief, S.R.	2018	High skilled immigration	Innovation, patenting, high-tech and engineering industry	Qualitative methodology: analysis of literature	Analysis of the literature on high-skilled migrants in high-tech and engineering-intensive industries	By virtue of their specialized knowledge and contribution, the high-tech migrants are globally valued and may enjoy unique privileges. Their key contribution takes forms of filling labour shortages, innovation and patents, business and jobs creation, creation of innovative products and services, competition and technology upgrading, and global expansion and export.
Naghavi, Strozzi	2015	Immigration	IPRs	Empirical analysis through IV: geography, cultural distance and institutions	Panel dataset of emerging and developing countries	Emigration has a favorable effect on strengthening the link between IPR protection and innovation by making a new source of knowledge available to domestic innovators.
Nathan, Lee	2013	Cultural diversity	Economic performance, innovation, entrepreneurship, sales strategies	Use of an econometric method; Employment of a wider economic geography tradition investigating economic development processes in particular cities	Sample of 7,600 firms in London between 2005 and 2007	First, companies with diverse management are more likely to introduce new product innovations than are those with homogeneous "top teams." Second, diversity is particularly important for reaching international markets and serving London's cosmopolitan population. Third, migrant status has positive links to entrepreneurship.

Table 1 (Continues)

Author	Year	Variable considered	Dependent variable	Methodology	Dataset	Main findings
Nathan, M.	2011	High skilled immigration, ethnicity, cultural diversity	Innovation, high-tech, patenting	Use of data to estimate a modified knowledge production function. Use of aggregated LFS client file microdata to construct a range controls.	This paper looks at the role of ethnic inventors in innovation in the UK, using a new 12-year panel of patents microdata. Using the novel ONOMAP name classification system to build on pioneering US work	Controlling for individuals' human capital, I find small positive effects of South Asian and Southern European co-ethnic group membership on individual patenting. The overall diversity of inventor communities also helps raise individual inventors' productivity. I find no hard evidence that ethnic inventors crowd out patenting by majority groups.
Nathan, M.	2014	High skilled immigration	Production, consumption	Qualitative methodology: survey	The 78 studies reviewed involve a mix of quantitative and qualitative approaches, drawing on large-scale data sets, surveys, case studies and in some cases historical analysis. Geography papers and urban studies, management, entrepreneurship, innovation and trade were taken into consideration.	The studies conducted in the US suggest that skilled migrants, especially those of South/East Asian origin, make significant contributions to the science and technology fields, both through innovative activity and entrepreneurship. A number of firm and area-level studies also identify skilled migrant impacts on productivity, with positive selection and co-ethnic groups operating as key channels.
Niebhur	2010	Immigration, cultural diversity	Economic performance, patents	Use of a general production function to assess whether positive or negative effects dominate in the regression analysis	Patent applications in a cross-section of German regions	Differences in knowledge and capabilities of workers from diverse cultural backgrounds enhance performance of regional R&D sectors
Ostergaard, Timmermans, Kristinsson	2011	Cultural diversity	Firms' performance, innovation	Qualitative methodology: survey	The analyses draw on data from a recent innovation survey. This data is merged with a linked employer-employee dataset that allow us to identify the employee composition of each firm	We test the hypothesis that employee diversity is associated with better innovative performance. The econometric analysis reveals a positive relation between diversity in education and gender on the likelihood of introducing an innovation. Furthermore, we find a negative effect of age diversity and no significant effect of ethnicity on the firm's likelihood to innovate
Ottaviano, Peri	2008	Immigration	Wages	Use of a production function framework. The model adopts a widely used nested CES production function.	Use of estimates and census data from 1990 to 2006	Immigration (1990-2006) had small negative effects in the short run on native workers with no high school degree (-0.7%) and on average wages (-0.4%) while it had small positive effects on native workers with no high school degree (+0.3%) and on average native wages (+0.6%) in the long run.



Table 1 (Continues)

Author	Year	Variable considered	Dependent variable	Methodology	Dataset	Main findings
Ozgen, Nijkamp, Poot	2011	Cultural diversity	Wages	Analysis of spatial dependence and of the endogeneity of immigrant settlement within an econometric modelling.	Use of a panel of data on 170 regions in Europe (NUTS 2 level) for the periods 1991-1995 and 2001-2005.	Innovation is clearly a function of regional accessibility, industrial structure, human capital, and GDP growth. In addition, patent applications are positively affected by the diversity of the immigrant community beyond a critical minimum level. An increase in the fractionalization index by 0.1 from the regional mean of 0.5 increases patent applications per million inhabitants by about 0.2 percent.
Ozgen, Peters, Niebhur, Nijkamp, Poot	2014	Immigration, cultural diversity	Workforce composition, innovation, firms	Combination of econometric modeling with employer–employee datasets from Germany and the Netherlands.	Empirical evidence from a range of contexts across Europe, North America, and New Zealand. Use of two unique and harmonized linked employer–employee datasets to provide comparative micro econometric evidence for Germany and the Netherlands. The panel datasets contain detailed information on the generation of new products and services, determinants of innovation success, and the composition of employment in establishments of firms over the period 1999 to 2006.	Focus on the impact of cultural diversity among migrant employees on the innovativeness of firms. Cultural diversity of employees has a positive partial correlation with product innovation. The size and statistical significance of this effect depends on the econometric model specification and the country considered. We conclude from the literature synthesis and the new comparative evidence that cultural diversity of employees can make a positive, but modest and context dependent, contribution to innovation.



Table 1 (Continues)

Author	Year	Variable considered	Dependent variable	Methodology	Dataset	Main findings
Parotta, Pozzoli, Pytikova	2014	Labour diversity	Innovation, firms	Empirical analysis through IV: measures of historical workforce diversity patterns at the commuting area level	Use of data on patent applications filed by firms at the European Patent Office and a linked employer-employee database from Denmark. Register-based linked employer-employee data set from Denmark for the period 1995-2003.	Ethnic diversity may facilitate firms' patenting activity in several ways by (a) increasing the propensity to (apply for a) patent, (b) increasing the overall number of patent applications, and (c) by enlarging the breadth of patenting technological fields, conditional on patenting.
Peri, Giovanni	2016	Immigration	Workforce substitutability and complementarity, wages	Employment of the nested constant elasticity of substitution (CES) structure.	The paper begins with the so-called "national approach," which focuses on immigration changing the relative skill supply in labor markets, largely leaving aside other considerations. Those studies consider different skill groups within the whole US as separate labor markets whose demand are connected by their relative substitutability or complementarity in production. It then turn to the studies focused on the margins of adjustment of native labor supply, and on technology adoption and on externality effects of immigrants	The economic impact of immigration on receiving economies needs to be understood by analyzing the specific skills brought by immigrants. The complementarity and substitutability between immigrants and natives in employment, and the response of receiving economies in terms of specialization and technological choices, are important when considering the general equilibrium effects of immigration
Peri, Sparber	2009	Immigration	Wages	General equilibrium model of comparative advantages in task performance	Use of occupational task-intensity data from the O*NET dataset and individual US census data	Large inflows of less educated immigrants may reduce wages paid to comparably educated, native-born workers. However, if less educated foreign- and native-born workers specialize in different production tasks, because of different abilities, immigration will cause natives to reallocate their task supply, thereby reducing downward wage pressure.
Pholphirul, Rukummuayakit	2017	Innovation	Innovation	Qualitative methodology: survey	Analysis of firm-level survey data in Thailand	Analysis of firm-level survey data in Thailand finds that employing unskilled and cheap labor from neighboring countries, namely Myanmar, the Lao PDR, and Cambodia, is like adopting a kind of "labor-saving technology" which impedes firms'R&D investment.



Table 1 (Continues)

Author	Year	Variable considered	Dependent variable	Methodology	Dataset	Main findings
Puffer, McCarthy, Satinsky	2018	Immigration	Innovation	Qualitative methodology: stories told by 157 people who left the former Soviet Union and are currently residing in the US.	Data from former Soviet Union	The mosaic of perspectives that emerges from the analysis provides valuable insight into the impact of immigration on US economic development, specifically in high technology and innovation.
Rashid, Pyka	2013	High skilled immigration	Policy innovations	Qualitative methodology: survey	Study of migration policies	In the knowledge-based economies of the 21st centuries the ideas of brain circulation and international (diaspora) innovation networks become prevailing and should guide the design of migration policies.
Reinders	2011	Innovation policies, R&D	Innovation, patents	Qualitative methodology: survey and questionnaire	The propensity to patent was analyzed in the 1980's and 1990's, but results vary and more recent research focuses mostly at specific case studies. With the availability of the CIS (Community Innovation Survey) databases of 2000 and 2004 there is a good opportunity to test again, in a structured way, which factors are important for the propensity to patent. For this research CIS data from three North-Western European countries were analyzed: Belgium, Norway and Germany.	Results provide a comprehensive overview of the importance of, and some correlations between, firm level, industry level and country level factors of the propensity to patent.
Romer	1990	Human capital	Growth, technological change	Use of a h a single-state-variable model.	Study of the four basic inputs in the model: capital, labor, human capital and an index of the level of the technology.	The main conclusions are that the stock of human capital determines the rate of growth, that too little human capital is devoted to research in equilibrium, that integration into world markets will increase growth rates, and that having a large population is not sufficient to generate growth.

Table 1 (Continues)

Author	Year	Variable considered	Dependent variable	Methodology	Dataset	Main findings
Romer	1990	Human capital	Growth, technological change	Use of a h a single-state-variable model.	Study of the four basic inputs in the model: capital, labor, human capital and an index of the level of the technology.	The main conclusions are that the stock of human capital determines the rate of growth, that too little human capital is devoted to research in equilibrium, that integration into world markets will increase growth rates, and that having a large population is not sufficient to generate growth.
Roper, Vahter, Love	2013	Openness	Knowledge diffusion	Use of IV regression models	The analysis is based on Irish plant-level panel data from manufacturing industry over the period 1994–2008	Our evidence on the significance of externalities from openness in innovation provides a rationale for public policy aimed at promoting open innovation practices among firms.
Sequeira, Nunn, Quian	2020	Immigration	Cross-country variations	(OLS) estimates of the long-run benefit of immigrants	Study of the effect of Eu immigration to the US during the Age of Mass Migration (1850-1920)	Counties with more historical immigration have higher income, less poverty, less unemployment, higher rates of urbanization, and greater educational attainment today. The long-run effects seem to capture the persistence of short-run benefits, including greater industrialization, increased agricultural productivity, and more innovation.



Table 1 (Continues)

Author	Year	Variable considered	Dependent variable	Methodology	Dataset	Main findings
Shane	2002	University inventions	Commercialisation	Empirical analysis through IV: licensing, inventor licensees, License termination and first sale, royalties	Framework on data on the 1397 patents assigned to the MIT during the 1980-1996 period	A conceptual framework to explain which university inventions are most likely to be licensed, commercialized, and generate royalties, and who will undertake that commercialization. I test this framework on data on the 1,397 patents assigned to the Massachusetts Institute of Technology during the 1980-1996 period.
Simonen, McCann	2008	Geography, human capital mobility	Labour inputs, knowledge, firms	Examination of the issues of firm's innovation performance along with information regarding the origins of a firm's recent labor acquisitions.	Use of a unique dataset from Finland.	Analyzing these data allows to identify the different roles which the geography of knowledge exchanges and the geography of labor markets play in the innovation process.
Sinoi	2021	High skilled immigration	Innovation, technological change, R&D, patents	Fixed-effects linear regression models at the country level	Dataset relative to the period 2011-2017	The econometric estimations highlight a positive correlation between educated migrants and the number of patent applications in all ten countries. This nexus is even strengthened when we take into consideration other relevant impact factors, such as investments in R&D and human capital. Therefore, the more efforts and investments are devoted to R&D and highly educated individuals, the more predictable the innovation is.

Author	Year	Variable considered	Dependent variable	Methodology	Dataset	Main findings
Sinoi, Elena - Alexandra	2019	High skilled immigration, cultural diversity	R&D, innovation, economic development	Use of econometric models on panel data	Analysis of 104 Nuts 1 macro-regions in the EU over the period 2003 to 2012,	The econometric estimations of the international migration impact on intellectual assets (measured by the number of patents) highlight a positive nexus, strengthened when taking into account different factorial combinations related to the economic dimension, such as: financial support in research and development (especially in the business sector and in the whole sector), investment in tertiary education, personnel employed in knowledge intensive sectors, as well as the share of scientists and engineers in population.
Solari, Di Pasquale, Tronchin	2018	Immigration	Innovation	Examination of the results that have emerged in the most important research conducted in the traditional receiving countries of Western Europe and North America,	Data on research conducted in Western Europe and North America.	Italian migrants are employed in low skill-intensive positions thus with a lower likelihood of innovation, such as agriculture, industry and construction
Solheim & Fitjar	2018	Foreign workers, immigration, cultural diversity	Wages, employment, economic growth, innovation	Qualitative methodology: survey	Survey data from 500 firms in Norway, with more than 10 employees, all sectors and regions	Firms with highly educated foreign workers collaborate more frequently with international partners and that there is a positive relation between having a variety of international partners and the probability of product innovation and new-to-market product innovation.
Stephan	2010	Academy	Innovation, firms	Empirical analysis through IV: graduate students, postdocs, contribution to patenting, publications.	Data concerning foreign-born contribution to papers and academic production	The foreign born are a large and growing component of the U.S. university community.
Stuen, Mobarak, Maskus	2012	Education and foreign students	Knowledge production at scientific laboratories	Use of a theoretical model of scholarships	Data relative to the contribution of doctoral students to innovation at 2,300 American science and engineering departments from 1973 to 1998.	Both US and international students contribute significantly to the production of knowledge at scientific laboratories, and their contributions are statistically comparable, consistent with an optimising department. A theoretical model of scholarships helps us to infer the productivity effects of student quality. Visa restrictions limiting entry of high-quality students are found to be particularly costly for academic innovation.



Table 1 (Continues)

Author	Year	Variable considered	Dependent variable	Methodology	Dataset	Main findings
Venturini	2012	Innovation, policies, R&D	Innovation, patenting	Empirical analysis of IV: human capital, nationality, education, patenting	Data and surveys from France, UK and Germany; for Germany, Microcensus data.	The focus on competitiveness becomes a focus on innovation because the race to innovate is a race for survival through costs reduction
Venturini, Montobbio, Fassio	2012	Immigration	Innovation, patenting	Empirical analysis of IV: patent applications, Total Factor Productivity (TFP)	Focus on TFP derived from the KLEMS data and from patents applied at the European Patent Office. Period: 1994-2007.	For any given legislation the number of illegal migrants depends on the social-political and economic conditions of the sending countries and on the organizations which favour frontier transit, but also on push-pull forces in the host countries.
Winters	2014	STEM national and foreign graduates	Patenting	Ordinary Least Squares (OLS); IV methods to estimate causal effects	Examination of the effects of foreign- and native-born STEM graduates and non STEM graduates on patent intensity in U.S. metropolitan areas. Use of data from 2010	Both native and foreign-born STEM graduates significantly increase metropolitan area patent intensity, but college graduates in non-STEM fields have a smaller and statistically insignificant effect on patenting; policies that increase the stocks of both foreign and native STEM graduates increase innovation and provide considerable economic benefits to regions and nations.

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