CIRCLE

LUND UNIVERSITY

Papers in Innovation Studies

Paper no. 2015/30

The role of geographical proximity in the international knowledge flows of European firms: an overview of different knowledge transfer mechanisms

Cristina Chaminade (cristina.chaminade@circle.lu.se)
CIRCLE, Lund University

Monica Plechero (monica.plechero@deams.units.it)
DEAMS – University of Trieste, Italy & CIRCLE, Lund University

This is post-print version of a chapter of the Innovation Union Competitiveness Report 2015.

This version: August 2015

Centre for Innovation, Research and Competence in the Learning Economy (CIRCLE)
Lund University
P.O. Box 117, Sölvegatan 16, S-221 00 Lund, SWEDEN
http://www.circle.lu.se/publications

WP 2015/30

The role of geographical proximity in the international knowledge flows of European firms: an overview of different knowledge transfer mechanisms

Cristina Chaminade and Monica Plechero

Abstract

The paper provides an overview of the international knowledge flows in Europe particularly looking at the drivers and consequences of such flows as well as the general trend. It distinguishes between different types of mechanisms for the acquisition and transfer of knowledge from trade to research and technological collaboration, mobility of human capital and FDI. The paper is empirical in nature and targeted to a wider audience. The analysis reveals that proximity matters significantly for the mobility of human capital as well as for the establishment of collaborative networks. In both cases, intra-Europe knowledge flows are more important that extra-Europe knowledge flows, thus pointing to the role of the European market facilitating these forms of exchange. The patterns of offshoring of R&D as well as trade networks are rather different- more global than intra-European. In other words, trade and investment networks are more dispersed globally than mobility of human capital and research and technological networks.

JEL codes: F2, O3

Keywords: Exports of high tech products, international research collaboration, international mobility of researchers, offshoring of R&D, Europe

The role of geographical proximity in the international knowledge flows of European firms: an overview of different knowledge transfer mechanisms.

Prof. Cristina Chaminade
Circle, Lund University, Sweden
Cristina.chaminade@circle.lu.se

Monica Plechero
Circle, Lund University, Sweden
Monica.plechero@circle.lu.se

Abstract: The paper provides an overview of the international knowledge flows in Europe particularly looking at the drivers and consequences of such flows as well as the general trend. It distinguishes between different types of mechanisms for the acquisition and transfer of knowledge from trade to research and technological collaboration, mobility of human capital and FDI. The paper is empirical in nature and targeted to a wider audience. The analysis reveals that proximity matters significantly for the mobility of human capital as well as for the establishment of collaborative networks. In both cases, intra-Europe knowledge flows are more important that extra-Europe knowledge flows, thus pointing to the role of the European market facilitating these forms of exchange. The patterns of offshoring of R&D as well as trade networks are rather different- more global than intra-European. In other words, trade and investment networks are more dispersed globally than mobility of human capital and research and technological networks.

JEL codes: F2, O3

Key words: Exports of high tech products, international research collaboration, international mobility of researchers, offshoring of R&D, Europe

1. Introduction

It is well known that international knowledge flows are positively related to the innovation performance of firms (Fitjar and Rodríguez-Pose, 2013; Gertler and Levitte, 2005). Empirical evidence shows that local knowledge needs to be complemented with international sources of knowledge for innovation (Giuliani et al., 2005). In fact, most innovative products or services are the result of combining knowledge across different geographical scales (Strambach and Klement, 2012) and most valued patents or publications (in terms of citations) tend to be the result of international knowledge links (OECD, 2014).

Until very recently, the international flows of knowledge were highly confined to neighboring countries (intra-Europe) and other Triad countries (USA and Japan) (Castellacci and Archibugi, 2008) but this is gradually changing (Chaminade et al., 2014). For example, less than one-third of EU R&D offshoring projects are directed towards other European countries. The bulk of such investment is actually directed to non-European countries, being the main recipients of R&D offshoring China and India, followed by developed countries (USA for example) and other South-East Asian countries, Brazil and Russia (Castellani and Pieri, 2013). This requires a change of perspective. Understanding the extent of the changes in the geography of these international knowledge flows as well as the possible impact of that change is paramount and will be discussed in this chapter.

This chapter **aims at** understanding how **international knowledge flows** in Europe have been developing over time and discuss their main **drivers** and **impacts**. Of particular interest is to discuss the importance of intra-European knowledge flows vis-a-vis knowledge flows with non-European countries.

The chapter will distinguish between different types of mechanisms for the acquisition and transfer of knowledge . Knowledge can be exchanged internationally intentionally through market transactions, formal and informal networks and foreign direct investments and unintentionally through networks and the mobility of human capital (also referred to as spillovers) (Chaminade et al, 2015):

- Knowledge exchanged through market mechanisms such as **trade** can be both embodied in artifacts (machinery and equipment) and disembodied (patents). The exports of high-tech goods and services can provide a first indication of the trade of knowledge embedded in goods and services. Global input-output tables can also provide an indication of the trade flows between one country and the rest of the world as well as the value that is captured by individual countries. The international knowledge flows through trade will be discussed in section 2.
- Knowledge can be exchanged through **formal and informal networks.** Networks are characterized by reciprocal, preferential and mutually supportive interactions (Powell 1990). In networks one party depends on the resources controlled by another and they are highly based on trust. Mechanisms such as R&D contracts, R&D alliances or research consortia are examples of formal networks for knowledge creation while epistemic communities or communities of practice are examples of mechanisms through which knowledge is transferred in informal networks. The international knowledge flows through research and technological collaboration will be discussed in section 3.
- Knowledge flows may also happen when the individuals holding that knowledge move creating **unintentional spillovers** of knowledge. Spillovers tend to occur often in close geographical proximity although they can also take place across large geographical distances, for example though international mobility or researchers (Rosenkopf and Almeida 2003). The drivers of international mobility of human capital – including the international mobility of researchers – are varied and include personal

motivations and well as institutional frameworks. The international knowledge flows through the mobility of researchers will be discussed in section 4.

- Finally, knowledge flows internationally through **foreign direct investments** particularly –but not exclusively- cross-border R&D investments. The investment of national companies abroad is a form of hierarchy as it relates to functions that the firm has located offshore over which it exerts control. The international knowledge flows through R&D cross-border investments will be discussed in section 5.

For each section, we will start with a general overview of trends paying particular attention to how Europe is positioned with respect to its competitors. Then we will investigate the importance of intra versus extra European flows of knowledge and generally discuss the expected impact of the observed trends[1].

2. International knowledge flows through trade

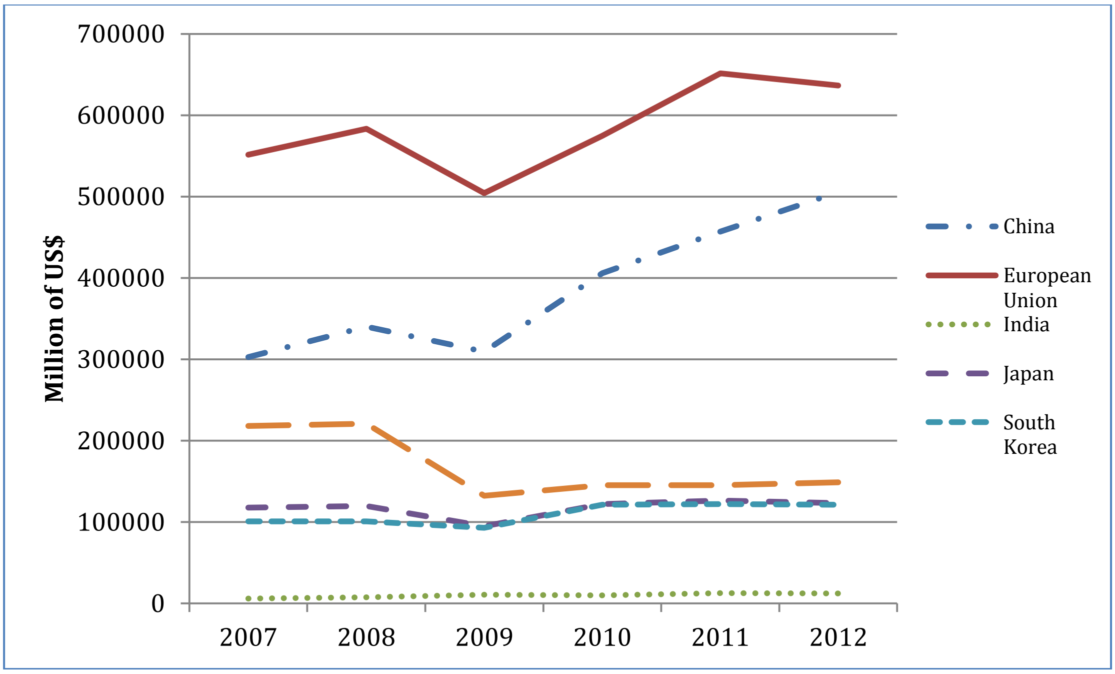
2.1. Overall trends

The aim of this section is to discuss how Europe is positioned in terms of the global trade of knowledge embedded in high-tech products and knowledge intensive services. Of particular interest is to investigate if international fragmentation is increasing or decreasing and what share of value is still kept in Europe.

Figures 1a and 1b show the evolution of high technology exports in absolute and relative terms from the EU to the rest of the world in comparison with a selection of countries. In absolute terms (Figure 1a), the EU portrays the largest volume of high technology exports in terms of value (million US $) as compared to the other blocks. The years after the economic crises (2009 to 2011) the volume of high technology exports increased while the US, Japan and South Korea´s value of high technology exports has stagnated since 2009. Interestingly China´s has gained momentum and has reduced the gap with the European Union in the same period.

Figure 1a. Trend in High technology exports (current US$, milion of $)

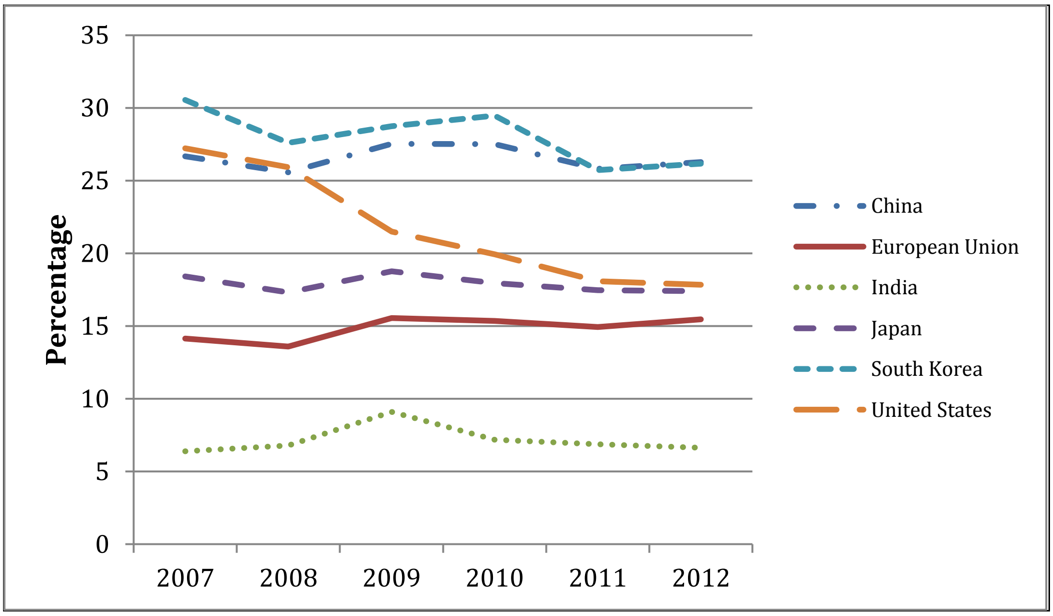
[1] The extent of the analysis is subject to data availability



Source: World development indicators. EU exports do not include intra-Europe
High technology exports are products with high R&D intensity, such as in aerospace, computers, pharmaceuticals, scientific instruments, and electrical machinery.

However, the situation is slightly different when the analysis is made in relative terms – that is looking at the proportion of exports of high-tech products over the total manufacturing exports. As can be observed in Figure 1b, the European Union has one of the lowest percentages of exports of high-tech products over the total manufacturing exports, only above India. In the last years we can observe that the gap with the US and Japan has reduced but this is mostly due to the significant drop of the US rather than an improved performance of the EU. China continues to outperform US, Japan and Europe since 2008 catching up with South Korea in the last period considered. The observed good performance of China can be explained either as a result of higher domestic added value or as reflecting high volumes of high-tech imports that are further assembled and distributed worldwide, as it will be discussed later on.

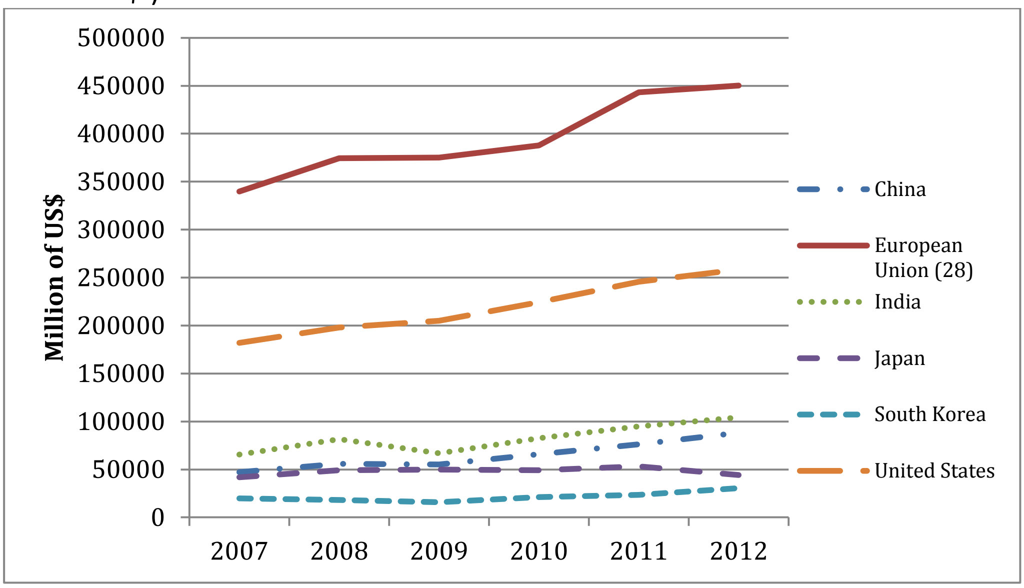
Figure 1.b. Trend in high-technology exports (as a % of manufacturing exports) for a selection of countries.



Source: World development indicators. EU exports do not include intra-Europe
High technology exports are products with high R&D intensity, such as in aerospace, computers, pharmaceuticals, scientific instruments, and electrical machinery.

Europe is performing better in terms of exports of knowledge intensive sectors (KIS)[2] both in absolute and relative terms as shown in Figures 2a and 2b. In absolute terms Europe is followed by the US and much below by India (reflecting the strong capabilities in software and IT services), China, Japan and lastly by South Korea.

Figure 2a. Trend in export of commercial knowledge intensive services (current US$, milion of $)



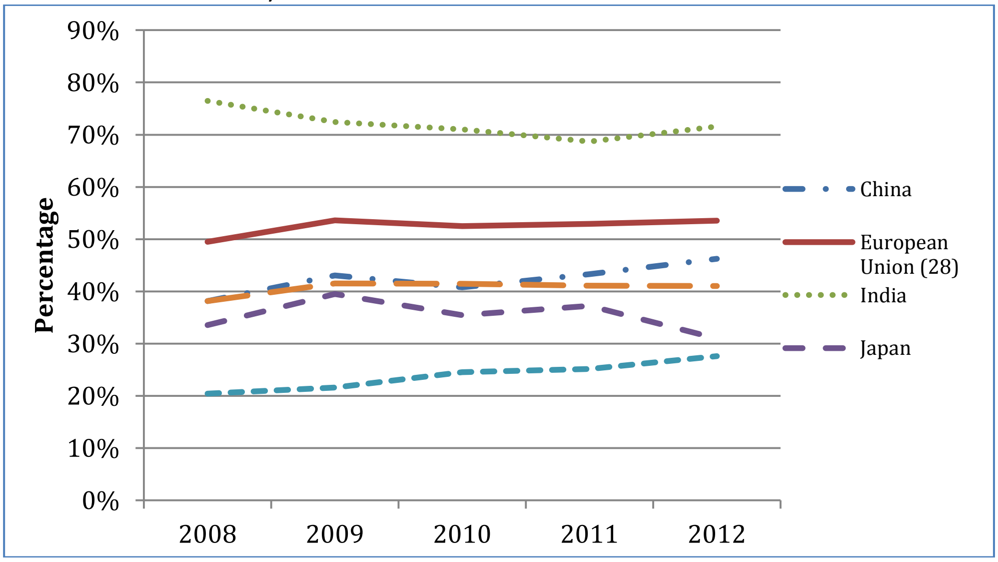
Source: Own elaboration based on WTO data.

In relative terms, India is substantially above all other countries (or blocks) considered. It is followed by the European Union who has been able to maintain the

[2] Commercial knowledge intensive service exports consist of communications, business services, financial services, and computer and information services.

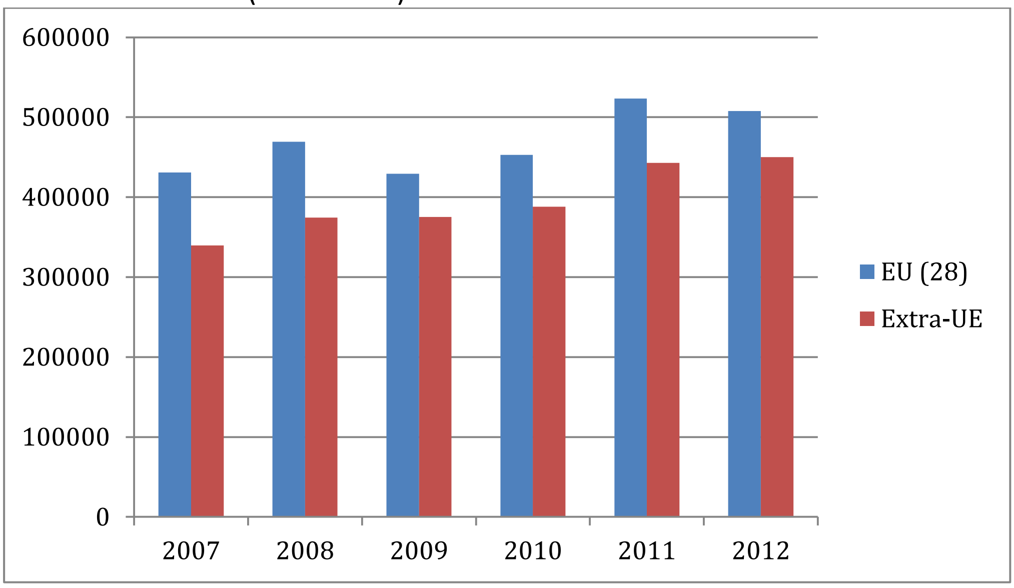
proportion of exports of knowledge intensive services quite stable after the crises. Intra-Europe flows of knowledge intensive services have remained above extra-European flows although the later have been growing steadily since 2007 gradually closing the gap with the intra-European flows, as Figure 3 shows.

Figure 2.b. Trends in export of commercial knowledge intensive services (as a % of commercial services).



Source: own elaboration WTO data based on' Trade in commercial services, 1980-2013 (BPM5)'
Commercial KI services include communications, financial services, computer and information services, and other business services. Financial services includes finance and insurance. India: Computer and other business services have been estimated by UNCTAD-WTO. EU (28) does not include intra-European Union export; Data on total commercial services is not available for EU for the year 2007

Figure 3. Trend in export of commercial knowledge intensive services (current US$) intra and extra EU (2007-2012)



Source: Own elaboration. WTO.

2.2. Impact

Looking exclusively at the exports of high-tech products or knowledge intensive services does not tell us what is the domestic contribution to those international knowledge flows. High volumes of exports of high-tech products or services from the EU do not imply that those high technology products or services have been developed in the EU, only that they are exported from the EU. So the critical question is which added value is generated in Europe and whether that value generation is the result of knowledge intensive activities.

The very recent global input-output tables and related analysis provide a much fine-grained analysis of the positioning of the EU in comparison to other countries in the world and its competitive advantage in terms of knowledge content in trade. The analysis of the global input-output data shows clearly an increasing fragmentation of global value chains, which implies higher share of foreign added value in the added value within Europe (Timmer et al, 2014; Los et al, 2015).

Looking at the intra-EU flows versus extra-EU, Los et al (2015) show that geographical proximity or the belonging to a trade block or single market, like the EU, still explains a great deal of the observable geographical patterns of global value chains. However, they also point out that since 1995 global fragmentation has progressed much faster than intra-Europe fragmentation. In other words, the shares of added value outside the EU are rapidly increasing for all products – including high-tech-, suggesting a move towards a more global knowledge flows embedded in global value chains.

Using global input-output data, Timmer et al (2014) show that generally there is a decrease in the content of low skilled human capital in all manufacturing activities worldwide which points out to a global technological shift in manufacturing and a general technological upgrading. But there are also clear differences between blocks- for example between Europe and China- with regards to the most relevant production factor. While in Europe manufacturing activities are based on high-skilled workers (that is, they are more knowledge intensive), the activities conducted in China are mainly capital intensive thus showing an enhanced specialization in high-skills labor in (high income) European countries. In other words, what these results suggest is that the knowledge component (proxied by the importance of qualified human capital) of European trade is *generally* increasing – that is- it relates to all industries and not only the high-tech manufacturing or high-tech services discussed above.

Furthermore, in terms of what factors in the innovation systems affect how much value is captured by a country, the analysis of the global input-output data (van der Marel, 2015) reveals that high endowment of qualified human capital plus high internet connectivity, high R&D spending in terms of GDP and better innovation climate are associated with higher participation in global value chains and higher value capture.

3. International research and technological collaboration

The trade of knowledge intensive business and services is one of several mechanisms that firms and other organizations use to acquire knowledge. Knowledge flows also through collaborative networks.

This section will look at the patterns of research and technological collaboration across national borders. It will investigate the patterns of intra-EU collaboration versus international collaboration (Van Looy et al., 2014). Using co-patenting data (technological collaboration) and the European community innovation survey data (research collaboration) we will present and discuss the patterns of international collaboration for innovation attending to the location of the partner as well as the type of linkage for all EU countries. The data will also allow us to investigate the importance of intra-EU research collaboration versus networks outside Europe, in particular US, China and India.

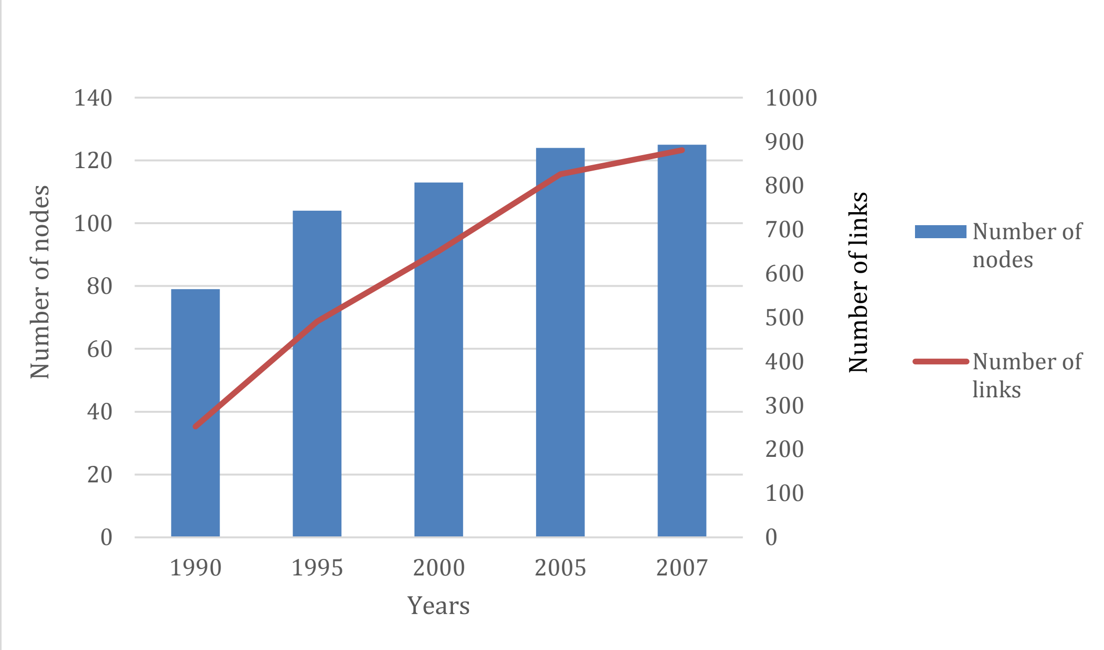
3.1. Trends

Technological collaboration

Technological collaboration at international level captured by the percentage of patents with foreign co-inventors **has intensified** in the last decades (Paci and Batteta, 2003) while the percentage of patents with only domestic investors has suffered a persistent decline since the early eighties (Van Looy et al., 2014).

Prato and Nepelski (2012) map the international technological collaborations by looking at worldwide patent data between 1990 and 2007 using the PATSTAT data base at the European Patent Office. Their comparison of the networks in 1990 and 2007 shows remarkable differences in the network configuration in the two periods. Clearly in 1990 international technological collaborations were dominated by US, Japan and Europe. In 2007 US continues to play a prominent role in the network, in terms of degree centrality, closeness centrality, strength and betweenness centrality but **the 2007 network of international technological collaborations is much denser – with 125 countries, compared with the 79 in 1996**- and with new actors notably South Korea, China and other East Asian countries playing a much more active role.

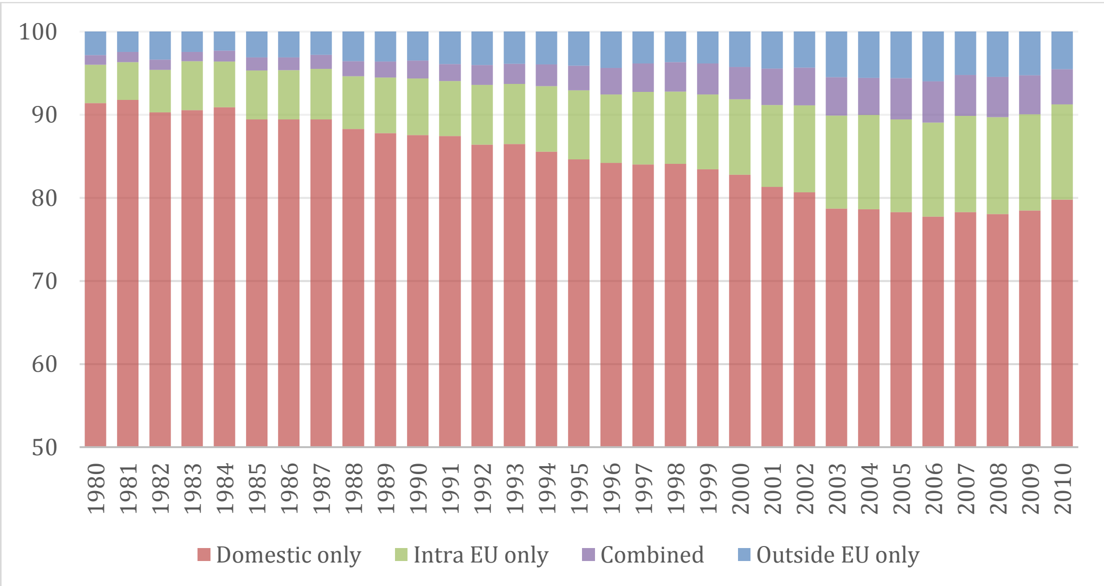
Figure 4. Evolution of international technological collaborations by number of nodes and links. 1990-2007.



Source: Prato and Nepelski (2012) based on PATSAT database, version 2010.

This increased internationalization of technological collaboration can also be observed in Europe. Figure 5 shows the evolution in the number of domestic inventions, foreign inventions and combined in the EU between 1980 and 2010 measured through patent applications in the PATSTAT database. It can clearly be observed **an increasing tendency in the proportion of international technological collaboration over time although the majority of patent applications continue to be domestic.**

Figure 5. Evolution in the share of inventions by location of the inventor (1980-2010)



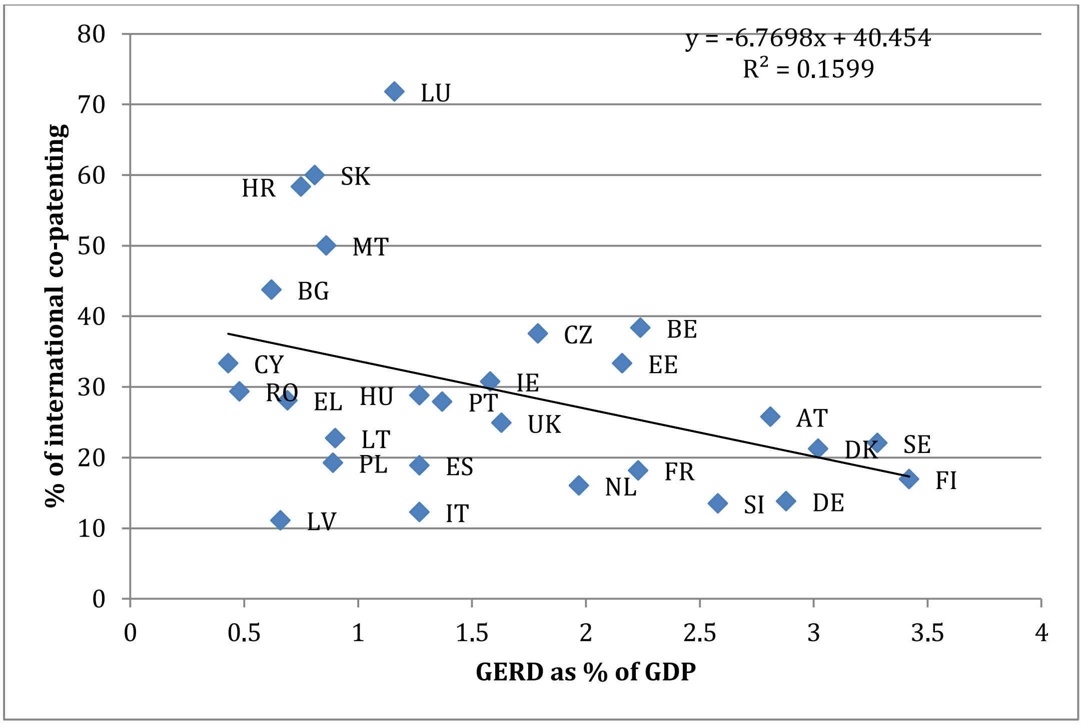
Source: Van Looy et al (2014). All applicants are EU applicants. Domestic only: all inventors are from the same country as the applicant. Intra EU only: at least one inventor is from a different country than the applicant but all inventors are in the EU. Combined: at least one inventor is from the EU and one from outside the EU. Foreign only: All inventors are from outside the EU. Scale starts at 50%.

A further analysis of the location of the foreign partners reveals that most of the international technological collaboration in Europe is within EU27. The proportion of patents combining inventors from Europe and outside EU are truly scarce (Van Looy et al., 2014). This result is highly coherent with the literature. Geographical distance with the technological partner plays a very important role in the establishment of technological linkages (Paci and Batteta, 2003). One of the main characteristics of networks in general is their reciprocal, preferential and mutually supportive character (Powell, 1990). The basic assumption of network is that of mutual dependence (Chaminade, 2015) and requires the firm and the partner to adhere to a certain structure of exchange (Laursen and Salter, 2014). As compared with knowledge exchange through markets of spillovers, networks are reciprocal -that is bidirectional and long term- and are based on trust. And trust, on the other hand, is facilitated by geographical and institutional proximity. This is why **the probability of establishing technological collaboration linkages is higher between countries in close proximity**.

The size of the market as well as degree of innovativeness[3] plays also an important role as a driver for the formalization of technological collaboration networks via co-patenting (Prato and Nepelski, 2012) as well as for patent citations (Paci and Batteta, 2003). The likelihood of establishing international technological networks through co-patenting is inversely related to the innovative capacity of the country measured through GERD as % of GDP, as can be observed in Figure 6 below. Generally, the higher research intensity of the country, the lower the percentage of international co-patenting. Countries with lower research intensity depend more on international technological collaboration while those countries closer to the technological frontier depend less on international co-patenting.

Figure 6. Percentage of International co-patenting on the base of research and innovation intensity (measured as GERD as % of GDP): Year: 2012

[3] Measured by patents



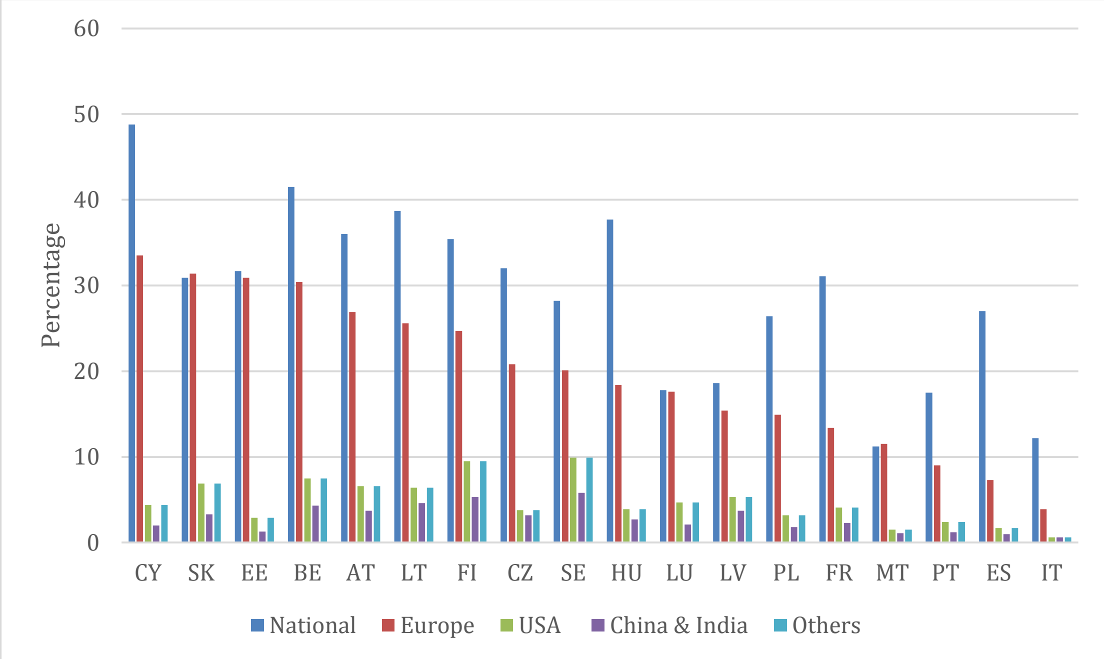
Source: Own elaboration of OECD statistics and patent database. Year: 2012. Significant at 5%. Data for Greece is missing

Research collaboration

Another way of looking at international collaboration in innovation is to use the Community Innovation Survey (CIS) data. The CIS asks the innovative firms to indicate with whom they collaborated in innovation. Figure 7 plots the percentage of innovative firms that collaborate with national partners, European partners, USA partners, Chinese and Indian and others. Despite the high variability among European countries, it can be clearly seen that European firms tend to collaborate with national and European partners, thus confirming the results obtained in the analysis of patent data. For Sweden, Finland and to a lesser extent Belgium, Austria, Lithuania and Slovakia, collaboration with USA partners is important.

The countries with the lowest percentage of firms collaborating for innovation with European -and generally international- partners is to be found in Italy, Spain and Portugal, all moderate innovators. At the other side of the spectrum we find followers and Cyprus, Slovakia, Estonia and Belgium with more than 30% of the innovative firms collaborating with other European partners for innovation. Interestingly, the innovation leaders (Sweden and Finland in this graph) are the ones that collaborate more with US as well as with others (which includes Japan and the Asian tigers).

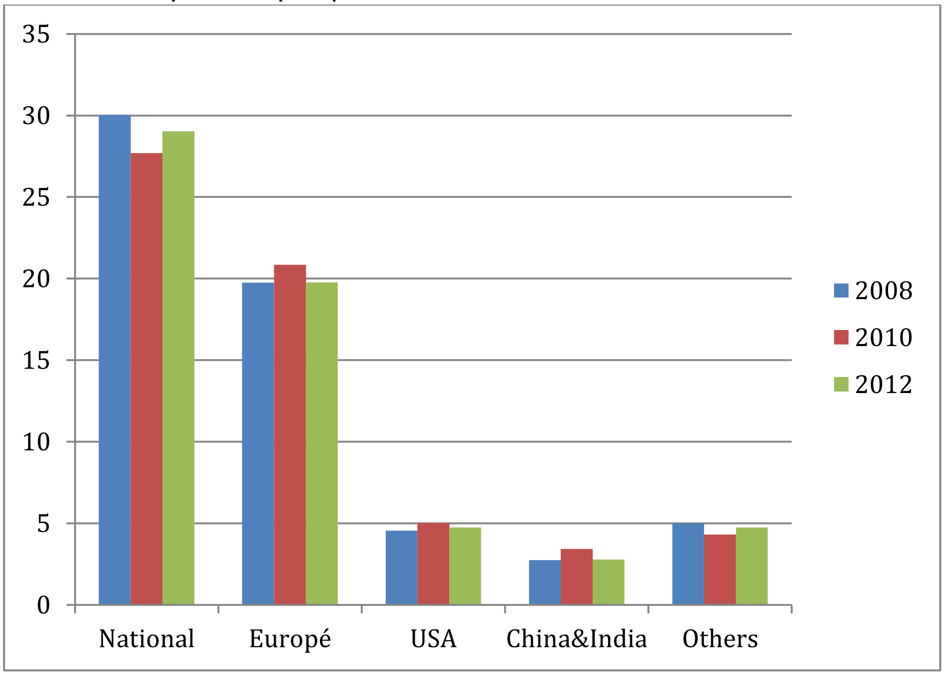
Figure 7. Percentage of innovative firms that collaborate for innovation by country of partner. 2012.



Source: Community Innovation Survey 2010-2012. Europe include the following European Union (EU) and associated countries: Albania, Austria, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Italy, Ireland, Kosovo, Latvia, Liechtenstein, Lithuania, Luxembourg, Macedonia, Malta, Montenegro, the Netherlands, Norway, Poland, Portugal, Romania, Serbia, Slovenia, Slovakia, Switzerland, Turkey, Spain, Sweden and the United Kingdom.

As a general trend, the percentage of firms that collaborate with China and India for innovation has gradually been decreasing, particularly between the 2010 survey (data corresponding to 2008-2010) and the 2012 survey (data from 2010-2012). For example, for Sweden –which was the country with the highest percentage of firms collaborating with China and India for innovation- the percentage has dropped from a 7,29% in 2008 to a 5,8% in 2012. Among the many reasons that can explain this recent trend is the high degree of complexity of coordinating research projects across geographical distances, particularly with partners with high institutional distance, which entail higher costs which tend to offset the potential benefits of the collaboration (Castellani and Pieri, 2013). When the coordination costs are too high, firms may be inclined to substitute or at least decrease the amount of networks in favor of other forms of coordination (offshoring) where they may exert higher control.

Figure 8. Average percentage of European innovative firms that collaborate for innovation by country of partner 2008-2012.



Source: Own elaboration based on CIS 2008, 2010, 2012. Europe includes European Union countries, EFTA and EU candidate countries. However, the number of countries included in Europe varies in the three versions of the CIS.

3.2. Impact of international research collaboration - *Is the increasing internationalization of research collaboration positive or negative for Europe?*

International networks are not substituting local or domestic networks but rather complement each other. European firms actively combine knowledge sources on different spatial scales and from various channels and sources in their innovation process (Grillitsch & Trippl, 2013; Trippl et al., 2009; Fitjar and Rodríguez-Pose 2013). International collaboration for innovation can complement local and regional networks in sustaining firms' innovative performance and the generation of 'non-incremental' innovations (Bathelt et al., 2004; Belussi et al., 2010; Chang, 2009; Gertler & Levitte, 2005; MacKinnon et al., 2002; McKelvey et al., 2003; Moodysson, 2008; Ponds et al., 2007).

For European firms, international innovation networks are found to be significant for new to the world or radical product innovation (Nieto and Santamaria, 2007) but their final impact depends on a variety of factors, including the type and location of the partner or the size of the country. Regarding the types of partners, the impact on the innovation performance is higher when the firm collaborates with international users (Harirchi and Chaminade, 2014; Laursen, 2011) and suppliers (Fitjar and Rodríguez-Pose, 2013). In terms of the size of the country, the degree of international collaboration has a positive impact in small countries but the impact is not significant for innovative firms in large countries. This result reveals that small countries tend to rely much more on international sources of technology and innovation than large countries except if the country is a technological leader, with high R&D intensity, something that is also observable in the previous figures (Ebersberger et al.).

Furthermore, combining domestic and international partners for innovation does not yield similar results in all industries. Although not reported here, both data on technological networks (co-patenting) as well as on research networks (research collaboration) reveal that there is a **high variability in the geographical spread of innovation networks by industry** with traditional sectors showing a more localized pattern of linkages than high-tech industries (Ebersberger et al.; Paci and Batteta, 2003). High-tech manufacturing industries based on scientific knowledge tend to display higher propensity to establish international networks and additionally current evidence suggest that the impact on innovation of combining international and domestic collaboration for innovation is also higher in high-technology manufacturing industries (Ebersberger et al.).

4. International mobility of researchers

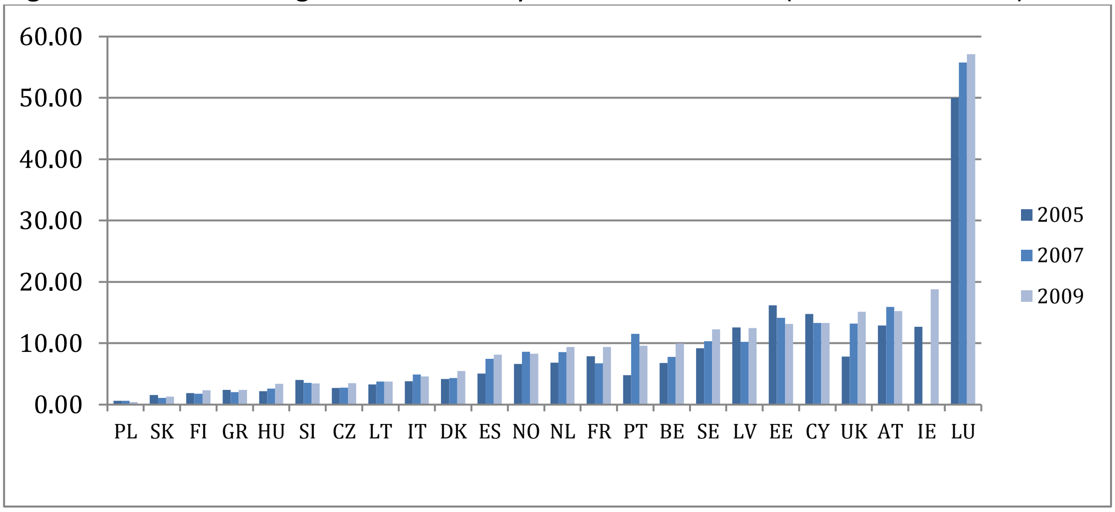
Employee mobility is one of the most important mechanisms for the transfer of knowledge across geographies and organizations since tacit knowledge is sticky in nature and does not flow easily unless the individuals possessing them move. Within the group of knowledge intensive workers, researchers are probably one of the most important collectives. Understanding the trends in the international mobility of researchers and its impact is complex. Their international mobility can be traced by looking at particular groups: scientists, doctorate holders, “star scientists”, as well as using a variety of indicators – from bibliometrics, patent analysis or mobility of R&D personnel- to specific surveys like the one recently conducted by the OECD and Eurostat on career of doctorate holders (OECD, 2014).

4.1. Main trends – *Is the international mobility increasing or decreasing? Is Europe gaining or losing talent?*

Despite the diversity in data sources, the analysis of the trends in the international mobility of the different collectives of researchers and its impact tends to show a similar picture: **internationalization is low but it is increasing and this yields positive impacts in terms of scientific quality** (OECD, 2014), innovation (Maliranta et al., 2009; Marx, 2011; Song et al., 2003; Trippl, 2009, 2011) and growth (Suriñach and Moreno, 2012).

With few exceptions, the general trend in Europe is towards an increase proportion of foreign-born scientists in the EU states. However, as Figure 9 shows, with the exception of Luxembourg, the proportion of foreign scientists is still rather low and, aside from Sweden, Latvia, Estonia, Cyprus, UK, Austria, Ireland and Luxembourg the average of foreign-born human resources in science and technology over the total is lower than 10%.

Figure 9.Trend of foreign-born HRSTC by EU member states (% on total HRSTC)

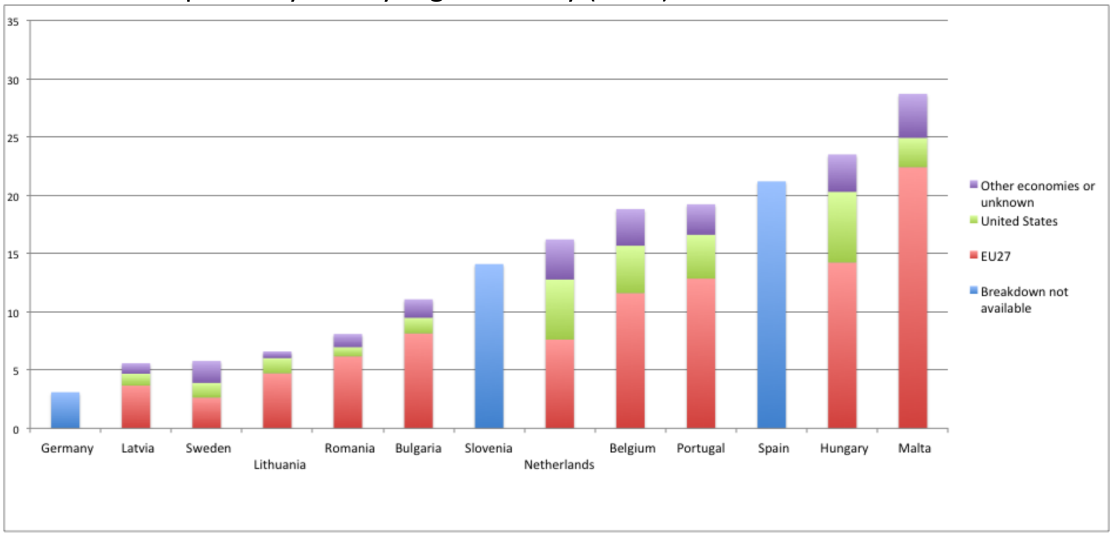


Source: Own elaboration on Eurostat. The Human Resources for Science and Technology Core (HRSTC) population comprises those people who have completed third-level education in an S&T field of study (HRSTE) who also have an S&T occupation (HRSTO). Population from 25 to 64 years. Data not available for all EU countries (no data for Romania, Malta, Bulgaria and Germany, partial data for Ireland

Proximity plays a crucial role in the mobility patterns. Franzoni et al. (2012) looking at **international mobility of scientists** found that most moves tend to happen within neighboring countries. For example Germany is the most likely host of inbound scientists from Netherlands, Belgium, Denmark, Sweden and Switzerland. Similar results were also found by (Miguélez et al., 2009) with regards to the mobility of inventors looking at the affiliation of inventors in patent applications in the patent cooperation treaty (PCT). With regards to the mobility to far distant countries, Franzoni et al. (2012) found that language and cultural proximity may play a role (for example Latin American countries in relation to Spain and Portugal) but also –and to a higher extent- the quality and prestige of foreign research and higher education organizations (for example top ranked American universities like Stanford, Yale or the MIT).

A similar pattern is observed when looking at the percentage of **doctorate holders** that have lived or stayed abroad in the past 10 years by country of destination. Figure 10 clearly shows that **doctorate holders tend to choose another country in Europe 27** as their main destination, thus pointing to the **importance of European academic networks and academic market**. The data also shows significant differences between European countries in the internationalization patterns of doctoral holders, with Sweden and Germany (innovator leaders) portraying very low numbers of international mobility in sharp contrast with Malta, Hungary and Spain (all three moderate innovators) with at least one fourth of the doctorate holders with international experience. An interesting case is Latvia, a modest innovator with very low levels of mobility. These differences are partly explained by the availability of career opportunities in the country of the PhD. But they are also due to strong institutional differences in the academic environment between countries -with countries like Germany where mobility is somehow penalized by the academic community in terms of career opportunities and others in which PhD graduates are highly encouraged to leave the country for a couple of years after the PhD graduation- as well as general mobility patterns in the respective countries.

Figure 10. Percentage of national citizens with a doctorate having lived or stayed abroad in the past 10 years by region of stay (2009)



Source: (Auriol and Freeman, 2013) based on OECD/UNESCO Institute for Statistics/Eurostat data collection on careers of doctorate holders 2010

What the previous data shows is that **there is not evidence yet to believe that there is a loss of talent in Europe as a whole**- at least when it comes to the mobility of doctorate holders. The international mobility of scientists in general and of doctorate holders tends to be mainly intra-Europe mobility which means that the spillovers generated through the mobility of these groups of knowledge-workers tend to remain in Europe. It should be noted, however, that the nature of the data[4] does not provide any clues about trends. Whether the importance of intra-EU mobility of PhD holders has increased or decreased over time and particularly after the crises remains to be studied.

However, one special group of scientist is portraying a different international mobility pattern: the collective of star scientists. Recent data shows that **Europe has been suffering from a net loss of star scientists with a high negative migration balance with the US** with cannot be compensated with the entry of star scientists from Central and Easter Europe (Suriñach and Moreno, 2012). These results are similar to those obtained by Maier et al (2007). Using data on highly cited researchers worldwide they found that **all countries in Europe showed a negative migration balance except France and Switzerland**. Worldwide the major net receiver of star scientists is the USA, which hosts two-thirds of all highly cited researchers in the world.

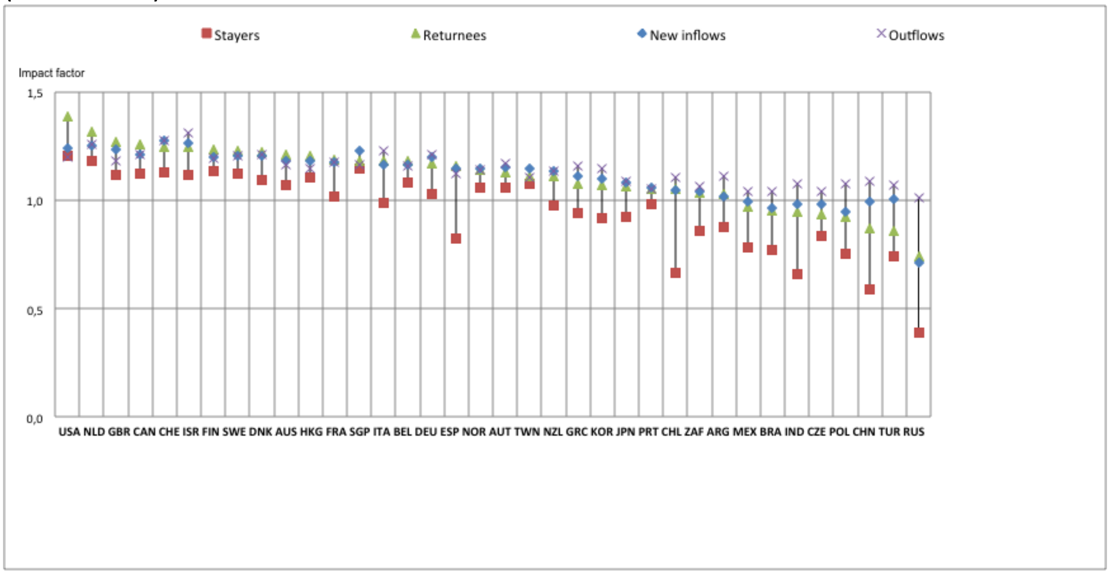
[4] The data comes from a survey conducted in 2010 in collaboration between the EU and the OECD. Hitherto no longitudinal data is available.

3.2. Is the international mobility of researchers positive or negative for Europe?

The international mobility of scientists yields in general a positive impact both in the host and in the home region. International mobility is associated with higher scientific impact, higher innovation performance and higher growth that go beyond the region in which the scientists are located.

By looking at changes in the affiliation of authors in journal articles, the OECD (2014) tracked the international mobility patterns of **scientists** as well as the impact of the move in terms of citations and conclude that the citations of the scientists who move internationally can be up to 20% higher than those that stay in the same place or country. Figure 11 shows the different citation impact of researchers that have stayed in the same country between 1996 and 2011 (*Stayers*), compared to returnees, new inflows and outflows. Clearly outflows, new inflows and returnees have the highest impact in terms of citations while the lowest impact is for publications of scientists that have remained in the same place.

Figure 11. Impact factor of scientific publications by mobility patterns of scientists (1996-2011)



Source: (Oecd, 2014)

Similarly, the existing literature has well established the positive impact of the **international mobility of doctorate holders in terms of knowledge transfer**. The so-called brain circulation may indicate higher career instability – particularly in the research and higher education sectors where mobility rates are highest- but it generates benefits to both home and host countries (Edler et al. 2011). Furthermore, brain drain may be offset by inflows of doctorate holders, thus the net results may be positive for the country (Auriol and Freeman, 2013).

The positive impact of the international mobility is particularly clear for star scientists (Suriñac and Moreno, 2011). Trippl (2011) using data on the mobility of ***star scientists*** provides evidence on a positive relationship between the mobility of star scientists and knowledge networks in the host region as well as between the host and the home regions. Backward linkages to the home region often remain active (Schiller and Diez, 2010) thus pointing out to the bi-directional (or even multidirectional) nature of their knowledge linkages. Star scientists are often engaged in academic collaboration, research projects with firms, co-patenting or licensing to local firms more often than non-mobile researchers, although some of these collaborations are sporadic (Trippl, 2011). In this respect, the observed negative flow of star scientist from Europe to mainly the US does not necessarily mean a net loss for Europe in terms of impact, thus so far the linkages with the European home country is maintained.

5. R&D foreign direct investments

5.1. General trend - Is Europe gaining or losing importance in the global flows of cross border R&D?

The fDi Markets database provides information on the number of cross-border greenfield investment projects announced during the period 2003-2012, including information on countries of origin and destination, nature of the investment and industries around the world in the period between 2003-2012. fDiMarkets classifies the investment events according to the main business activities thus making it possible to distinguish investments related to manufacturing from those related to “R&D” or “Design, development and testing” (DDT). This data allows us to analyse the patterns of technology-driven investments and their potential differences with other forms of offshoring (for example manufacturing)

Researchers have long assumed that R&D tends to co-locate with production facilities (Liu et al, 2013). While this may be true in some cases (Ernst, 2010), it is not in all, particularly in technology intensive industries (Audretsch and Feldman, 1996; Mariani, 2002). Next tables provide some evidence in this direction. They show cross-border investments in DDT and R&D activities by area of origin and destination, including projects in manufacturing activities as a benchmark (Castelli and Castellani, 2013). The first thing that can be appreciated is that the amount of cross-border R&D and DDT projects is substantially lower that the number of manufacturing. But the data also reveals substantial differences in the patterns of internationalization of R&D and DDT with respect to manufacturing.

Tables 1 & 3 show that cross-border investments in R&D-related activities are less bound by geographic distance than projects in manufacturing activities. For example, while intra-Europe investments (Western plus Eastern Europe) in manufacturing account for 47,7% of all cross-border investments of MNCs from Western Europe, this share drops to 36,1% in the case of DDT projects and 37,3% for R&D (Chaminade et al., 2014). The evidence is consistent with some recent econometric studies showing that geographic distance between the home and host country may be less of an obstacle for R&D-related projects than it is for manufacturing. This is because companies may need to locate R&D investments in distant locations to gain access to specific knowledge which they would not be able to access otherwise (Castellani et al, 2013, Chaminade and de Fuentes, 2012).

Europe as origin of the investments

Table 1. Cross-border investment projects in R&D-related and manufacturing activities, by country of origin *(January 2003- August 2012)*

DDT				R&D				Manufacturing			
Rank	Country	N. projects	% share	Rank	Country	N. projects	% share	Rank	Country	N. projects	% share
1	United States	1804	45.3%	1	United States	1351	42.7%	1	United States	5369	17.6%
2	Germany	386	9.7%	2	Germany	287	9.1%	2	Japan	4332	14.2%
3	UK	278	7.0%	3	Japan	253	8.0%	3	Germany	3689	12.1%
4	Japan	274	6.9%	4	France	163	5.2%	4	France	1678	5.5%
5	France	219	5.5%	5	UK	162	5.1%	5	UK	1427	4.7%
6	India	131	3.3%	6	Switzerland	119	3.8%	6	Italy	1055	3.5%
7	Switzerland	114	2.9%	7	China	97	3.1%	7	Switzerland	1031	3.4%
8	Netherlands	84	2.1%	8	South Korea	79	2.5%	8	South Korea	939	3.1%
9	Canada	77	1.9%	9	Netherlands	75	2.4%	9	Netherlands	799	2.6%
10	Sweden	51	1.3%	10	Canada	70	2.2%	10	Taiwan	717	2.3%
11	China	50	1.3%	11	India	65	2.1%	11	Canada	708	2.3%
12	Spain	48	1.2%	12	Sweden	57	1.8%	12	Spain	699	2.3%
13	Finland	46	1.2%	13	Finland	40	1.3%	13	China	635	2.1%
14	South Korea	44	1.1%	14	Italy	38	1.2%	14	Sweden	632	2.1%
15	Denmark	36	0.9%	15	Denmark	38	1.2%	15	India	605	2.0%
	Other countries	338	8.50%		Other countries	268	8.40%		Other countries	605	2.0%
	Total	3980	100%		Total	3162	100%		Total	30554	100%
	Top 5	2742	74.4%		Top 5	2216	70.1%		Top 5	16495	54.0%
	Top 10	2742	85.9%		Top 10	2335	84.0%		Top 10	17550	68.8%
	Top 15	3642	91.5%		Top 15	2894	91.5%		Top 15	24315	79.6%
	Top 20	3787	95.2%		Top 20	3031	95.9%		Top 20	26530	86.8%
Herfindhal Index			0.231	Herfindahl Index			0.208	Herfindahl Index			0.097

Source: Castelli and Castellani (2013)

Looking only at investments **from the EU,** Castellani and Pieri (2013) show that most of the R&D offshoring projects of European firms are directed towards non-European countries and only less that one fourth is intra-European investments. Table 3 shows that the main non-European recipients of R&D offshoring from Europe are China and India, then US, Japan and Canada which together account for 18,70% further followed by other South-East-Asian countries. Other emerging economies, which include important destinations such as Brazil and Russia, attract also a considerable number of projects.

Table 2. Cross-border investments from EU by region of destination and nature of the investments (2003-2012)

	DDT	R&D	MANUFACTURING
Europe 15	21,30%	27,40%	16,10%
Other EU	2,00%	2,50%	4,80%
Developed (US, Canada, Japan)	18,70%	19,90%	13,40%
South-East Asia	7,60%	9,00%	4,50%
Korea	1,20%	1,80%	0,70%
Brazil	3,10%	2,60%	3,70%
China	11,20%	13,50%	11,50%
India	13,70%	8,30%	6,30%
Russia	1,50%	2,20%	6,00%

South Africa	0,60%	1,10%	0,70%
Rest world	9,00%	5,50%	12,80%
Total number	156	725	12665

Source: Chaminade et al. (2014) based on Castellani and Pieri (2013)

The relative importance of China and India as recipients of R&D investments by European firms can be explained by looking at both push and pull factors. On the one hand for European firms, investments in R&D abroad are motivated by the access to knowledge and markets, particularly accessing qualified human resources that are not available in the numbers or quality in the home European regions (Borras and Haakonsson, 2010). Since knowledge is very unevenly distributed across space (Asheim and Gertler, 2005; Malecki, 2010) firms strategically target specific countries and specific regions where that knowledge is located. Offshoring of R&D is used as a mechanism to access ubiquitous knowledge across distance (Liu et al., 2013). On the other hand, the combination of very large growing markets together with a rapid accumulation of technological capabilities (Altenburg et al., 2008) has made China and India very attractive destinations for R&D related investments, particularly in certain regions like Beijing, Shanghai or Bangalore (Chaminade and Vang, 2008; Crescenzi et al., 2012).

Europe as recipient of investments

Europe is also an important recipient of cross-border R&D investments from abroad. Although most of the R&D and DDT related investments worldwide go to China and India and the US, while European countries UK, Germany and France are not far behind. In fact four European countries are among the top 10 destinations of DDT projects and 5 of them are among the top 10 of R&D projects.

Table 3. Cross-border investment projects in R&D-related and manufacturing activities, by country of destination *(January 2003 - August 2012)*

Design, development and Testing				R&D				Manufacturing			
Rank	Country	N. projects	% share	Rank	Country	N. projects	% share	Rank	Country	N. projects	% share
1	India	809	20.3%	1	China	534	16.9%	1	China	4969	16.3%
2	China	511	12.8%	2	India	466	14.7%	2	United States	2776	9.1%
3	United States	316	7.9%	3	United States	249	7.9%	3	India	1879	6.1%
4	UK	261	6.6%	4	UK	187	5.9%	4	Russia	1323	4.3%
5	Germany	140	3.5%	5	Singapore	151	4.8%	5	Brazil	1061	3.5%
6	Singapore	115	2,9%	6	France	126	4.0%	6	Poland	963	3.2%
7	Brazil	99	2.5%	7	Germany	108	3.4%	7	Mexico	959	3.1%
8	Canada	94	2.4%	8	Ireland	106	3.4%	8	Thailand	941	3.1%
9.	Spain	91	2.3%	9.	Spain	90	2.8%	9	France	872	2.9%
10	France	90	2.3%	10.	Canada	83	2.6%	10	UK	834	2.7%
	Total	3980	100%		Total	3162	100%		Total	30554	100%
	Top 5	2037	51.2%		Top 5	1587	50.2%		Top 5	12008	39.3%
	Top 10	2526	63.5%		Top 10	1713	66.4%		Top 10	12971	54.3%
	Top 15	2868	72.1%		Top 15	2408	76.2%		Top 15	20145	65.9%
	Top 20	3132	78.7%		Top 20	2638	83.4%		Top 20	22443	73.5%
	Herfindahl Index		0.076		Herfindahl Index		0.071		Herfindahl Index		0.051

Source: Castelli and Castellani (2013)

Europe is an important destination of Chinese and Indian investments abroad. The analysis of all investments by emerging multinationals in Europe indicates that the

EU represents 31% of all the outward FDI from China to the world and 33% of Indian outward FDI (Chaminade, 2015). A recent study on the technology driven investments by emerging multinationals in Europe reveals that the investments are attracted to particular technological poles – for example automotive to Germany, renewable energies to Denmark and ICT more widely spread (Chaminade, 2015).

5.2. Impact - Are the new trends positive or negative for Europe?

The existing literature suggests that there is a positive impact between R&D offshoring and firm performance. Piscitello and Santangelo (2009) for example find that there is a positive impact of offshoring of R&D towards BRICS countries[5] on the knowledge production of OECD based firms, including European firms. However, the final impact is mediated by a series of factors – particularly the time past after the investment, the managerial capabilities to learn from the environment and manage transnational projects or the ability to chose successful R&D projects, all of which influences the cost-effectiveness of the cross-border R&D investment (Castellani and Pieri, 2013; Chaminade, 2015).

The analysis of offshoring R&D projects by European multinationals conducted by Castellani and Pieri (2013) reveals that offshoring of R&D activities has a positive impact in terms of productivity growth of European regions. Offshoring regions have a higher productivity growth relative to non-offshoring regions, but the effect of R&D offshoring is slightly decreasing with the number of investments. Further analysis by country of destination indicates that the effect is larger and significant in the case of R&D offshoring toward South-East-Asian countries and also positive in the case of R&D investments towards China. On the other hand, regions which are offshoring R&D intensively towards India experience significantly lower productivity growth rates. One possible explanation to these results may lie in the types of projects. While R&D projects to South East Asia are disproportionally concentrated in high-tech manufacturing (43% of all R&D projects in the area are in these manufacturing industries), R&D offshoring towards India is much more concentrated in knowledge-intensive services (52%). As recent evidence seems to suggest coordinating global value chains in services is much more complex than in manufacturing and the benefits of offshoring may be offset by the high costs resulting from managing these complex value chains (Castellani and Pieri, 2013).

What the existing evidence seems to suggest is that offshoring of R&D tends to complement –rather than substitute- R&D conducted in Europe. However, the benefits from these potential complementarities are not similar for all industries. Piscitello and Santangelo (2009) found that firms in high-tech industries benefit more clearly from complementarities between domestic and offshored R&D to BRICS[6], while firms in low tech industries seem to benefit largely from the R&D offshored to BRICS (and not so much from the domestic).

[5] Plus Korea, Singapore and Taiwan
[6] Plus Korea, Singapore and Taiwan

In the case of inward investments in R&D into Europe a recent study based on a survey undertaken in Germany and Italy on MNEs from advanced countries (AMNEs) and emerging countries (EMNEs) investing in the machinery industry (Giuliani et al., 2014) found that in fact investments by EMNEs are more likely to involve local innovation networks in the host countries and create win-win situations in terms of mutual learning than in the case of technology-driven investments by advanced country multinationals (Giuliani et al., 2014). Although one should be cautious with generalizations, these results point out to a positive impact or, at least, to a not generalized predatory behavior by emerging multinationals investing in technology in Europe.

6. Conclusions

In this chapter we have analyzed different mechanisms that facilitate the international exchange of knowledge in Europe, from the trade of high-tech products and services to the mobility of human capital, research and technological collaboration and offshoring of R&D. The previous sections point out to some clear trends.

The EU is still performing well in terms of **exports of knowledge intensive goods** and services in a global perspective although we observe in recent years that China and US are closing the gap with the EU in terms of knowledge intensive products and services respectively. Second, the analysis of the global value chains suggests that the European component of those exports is also very high. Third, the rate of globalization of value chains is accelerating and it is much faster than the fragmentation at EU level. This means that although being part of the EU is still important for trading knowledge intensive products, the shares of added value outside the EU and the number of countries participating in the global chain is rapidly increasing. While maintaining the volume of high-tech exports is important, in the long term it is even more crucial to retain a largest share of value added.

Along the global value chain, advanced countries are specializing in skill intensive activities like design, R&D or marketing, while emerging economies like China are capital and labor intensive (Timmer et al, 2914; Van der Marel, 2015). This suggests that Europe´s competitive advantage in this increasing global fragmentation of production and trade is based on its innovation performance widely defined (not only R&D).

While traditional trade policies such as removing tariffs, facilitating administrative procedures and regulating the single market are effective in promoting the access to global value chains, a different set of policies is needed for upgrading in the value chain towards higher added value activities. The analysis of the new global input-output data shows that investments in innovation (R&D, training of human capital, innovation climate) as well as ICT infrastructure are crucial. This suggests a very tight link between innovation and trade which demands high levels of coordination between this two traditionally separated policies.

The analysis reveals that proximity matters significantly for the **mobility of human capital** as well as for the establishment of **collaborative networks**. Both mechanisms are adequate for the transmission of tacit knowledge, requiring face-to-face interaction and trust and are facilitated not only by geographical but also by institutional proximity. In both cases, intra-Europe knowledge flows are more important that extra-Europe knowledge flows, thus pointing to the role of the European market facilitating these forms of exchange. This is particularly clear in the case of some followers and moderate innovators like Hungary, Portugal, Spain Lithuania for which technological collaboration and in some cases international mobility of doctorate holders is important.

Looking at the main motivations for moving to a different country may provide some useful information for the design of policies to attract scientists in Europe. Mobility of scientists could be related to scientific, economic, cultural and personal factors (Schiller and Diez, 2010). Both in the case of outbound mobility of scientists in general (Franzoni et al., 2012), doctorate holders in particular (Auriol and Freeman, 2013) or star scientists (Schiller and Diez, 2010), academic factors are the most important reasons for moving abroad, followed by economic and job related factors and as a less important reason cultural, family or personal reasons[7]. However, the later gains importance to for returnees (Franzoni et al., 2012; Schiller and Diez, 2010). Being close to family and friends or being in an environment with a similar culture gains importance in the decision to return to the home region.

This has important policy implications. Attracting talent from abroad as well as retaining local talent in Europe, particularly in the case of star scientists, depends largely on the quality of the research and education facilities (outstanding faculty, colleagues or research teams) and attractive working conditions (including good research environments and working conditions). This can explain the lower mobility observed in countries like Germany and Sweden (both innovation leaders) and the highest mobility of scientists from moderate innovation countries. Currently the majority of the programs to facilitate mobility are targeting the economic dimension of mobility (European Commission, 2014) – for example by providing funding to study abroad which may not be a sufficient incentive for the mobility unless the other two conditions (quality of the research and education facilities and attractive working conditions) are met.

The patterns of **offshoring of R&D** as well as trade networks are rather different-more global than intra-European. In other words, trade and investment networks are more dispersed globally than mobility of human capital and **research and technological networks**. These findings are coherent with those obtained by (Cassi et al., 2012; Castelli and Castellani, 2013; Prato and Nepelski, 2012) who also found that trade and investments are less bounded geographically than other forms of knowledge networks.

[7] The study of Franzoni et al focuses only on five scientific disciplines: biology, chemistry, earth and environmental sciences and materials science.

Policy action towards internationalization of innovation activities has to be very aware that while offshoring of R&D tends to yield positive impacts, **differences across industrial sectors and countries of origin and destination are important**. While the internationalization of R&D and other innovation activities related to manufacturing may have a positive impact in terms of productivity growth of the home country, offshoring of R&D related to knowledge intensive services can be more problematic.

On the other hand, the relatively lower organizational problems in high-tech manufacturing and the concentration of cutting edge technologies developed in South-East Asian countries, contribute to a potentially positive association of offshoring R&D to this regions and the productivity growth of EU regions.

Investments decisions are affected by a wider array of policies and barriers which are typically unrelated with trade issues (Los et al., 2015; World Economic Forum (Wef), 2012). Other investment-related policies – ranging from competition, trade and intellectual property rights to environmental and labor market policies – have a greater impact on technology-driven FDI (Chaminade and Rabelotti, 2015). Difficulties in obtaining short-term business visas for the mobility of personnel, capital restrictions or limitations to move capitals between Europe and the home country are some of the non-traditional investment barriers mentioned by several investors in Europe, headquartered in an emerging country (Chaminade, 2015). Additionally, some countries, like Germany have restrictions to the access to IP in cases of acquisition[8], which is one of the main reason causing delays, increases in costs and often requiring changes in the investor strategy. If policy makers want to influence R&D related investments into Europe a much wider set of policies is needed – one that goes beyond traditional trade regimes and includes, for example, provisions for the mobility of human capital, the management of intellectual property and that facilitates the establishment of local linkages with European firms.

8. References

Altenburg, T., Schmitz, H., Stamm, A., 2008. Breakthrough? China's and India's Transition from Production to Innovation. World Development 36.

Asheim, B.T., Gertler, M.S., 2005. The Geography of Innovation: Regional Innovation Systems, in: Fagerberg, J., Mowery, D. And Nelson, R. (Eds.) (Ed.), The Oxford handbook of innovation. Oxford University Press, Oxford, pp. 291-317.

Audretsch, D.B., Feldman, M.P., 1996. R&D spillovers and the geography of innovation and production. The American Economic Review 86, 630-640.

[8] The investor must acquire the 100% of the company

Auriol, L.M.M., Freeman, R.A., 2013. Careers of Doctorate Holders: analysis of labour market and mobility indicators", in: Oecd (Ed.), OECD Science, Technology and Industry working papers. OECD Publishing.

Borras, S., Haakonsson, S., 2010. European Firm´s reasons for taking part of Global Innovation Networks INGENIUS Policy Brief.

Cassi, L., Morrison, A., Ter Wal, A.L.J., 2012. The Evolution of Trade and Scientific Collaboration Networks in the Global Wine Sector: A Longitudinal Study Using Network Analysis. Economic Geography 88, 311-334.

Castellacci, F., Archibugi, D., 2008. The technology clubs: The distribution of knowledge across nations. Research Policy 37, 1659-1673.

Castellani, D., Pieri, F., 2013. R&D offshoring and the productivity growth of European regions. Research Policy 42, 1581-1594.

Castelli, C., Castellani, D., 2013. The internationalisation of R&D: sectoral and geographic patterns of cross-border investments. Economia e Politica Industriale.

Chaminade, C., 2015. Technology-driven FDI by emerging multinationals in Europe. Lund University Lund. www.globinn.lu.se/category/reports

Chaminade, C., Castellani, D., Plechero, M., 2014. The emergence of China and India as new innovation power houses- Threat or Opportunity, in: Entreprenörskapförum (Ed.), Globalization. Entreprenörskapförum, Stockholm.

Chaminade, C., Vang, J., 2008. Globalisation of knowledge production and regional innovation policy: Supporting specialized hubs in the Bangalore software industry. Research Policy 37, 1684-1696.

Crescenzi, R., Rodríguez-Pose, A., Storper, M., 2012. The territorial dynamics of innovation in China and India. Journal of Economic Geography 12, 1055-1085.

Ebersberger, B., Herstad, S.J., Iversen, E., Kirner, E., Som, O., 2011. Open innovation in Europe: effects, determinants and policy.

Ernst, D., 2010. Upgrading through innovation in a small network economy: insights from Taiwan's IT industry. Economics of innovation and new technology 19, 295-324.

European Commission (2014) The Researchers report. http://ec.europa.eu/euraxess/index.cfm/general/researchPolicies. Accessed in June 2015.

Fitjar, R.D., Rodríguez-Pose, A., 2013. Firm collaboration and modes of innovation in Norway. Research Policy 42, 128-138.

Franzoni, C., Scellato, G., Stephan, P., 2012. Foreign-born scientists: mobility patterns for 16 countries. Nature biotechnology 30, 1250-1253.

Gertler, M.S., Levitte, Y.M., 2005. Local Nodes in Global Networks: The Geography of Knowledge Flows in Biotechnology Innovation. Industry and Innovation 12, 487-507.

Giuliani, E., Gorgoni, S., Günther, C., Rabellotti, R., 2014. Emerging versus advanced country MNEs investing in Europe: A typology of subsidiary global–local connections. International Business Review 23, 680-691.

Giuliani, E., Rabelotti, R., Van Dijk, M.P., 2005. Clusters facing competition: the importance of external linkages. Ashgate Publishing, Aldershot and Burlington.

Grose, T., Randolph, S., 2014. Europe and the Bay Area.

Harirchi, G., Chaminade, C., 2014. User-producer interaction and the degree of novelty of inovations: a global perspective. World Development 57, 19-31.

Laursen, K., 2011. User-producer interaction as a driver of innovation: costs and advantages in an open innovation model. Science and Public Policy 38, 713-723.

Laursen, K., Salter, A.J., 2014. The paradox of openness: Appropriability, external search and collaboration. Research Policy 43, 867-878.

Liu, J., Chaminade, C., Asheim, B., 2013. The Geography and Structure of Global Innovation Networks: A Knowledge Base Perspective. European Planning Studies 21, 1456-1473.

Los, B., Timmer, M.P., Vries, G.J., 2015. How global are global value chains? a new approach to measure international fragmentation. Journal of Regional Science 55, 66-92.

Malecki, E.J., 2010. Everywhere? The Geography of Knowledge*. Journal of Regional Science 50, 493-513.

Maliranta, M., Mohnen, P., Rouvinen, P., 2009. Is inter-firm labor mobility a channel of knowledge spillovers? Evidence from a linked employer–employee panel. Industrial and corporate change 18, 1161-1191.

Mariani, M., 2002. Next to Production or to Technological Clusters? The Economics and Management of R&D Location. Journal of Management and Governance 6, 131-152.

Martin, R., Moodysson, J., 2013. Comparing knowledge bases: on the geography and organization of knowledge sourcing in the regional innovation system of Scania, Sweden. European Urban and Regional Studies 20, 170-187.

Marx, M., 2011. The Firm Strikes Back Non-compete Agreements and the Mobility of Technical Professionals. American Sociological Review 76, 695-712.

Miguélez, E., Serrano, R.M., I Caralt, J.S., 2009. Scientists on the move: tracing scientists mobility and its spatial distribution. Documents de Treball (IREA), 1.

Oecd, 2014. Researchers on the move: the impact of brain circulation, in: Reports, S. (Ed.). OECD, Paris.

Paci, R., Batteta, E., 2003. Innovation networks and knowledge flows across the European regions.

Piscitello, L., Santangelo, G., 2009. Does R&D offshoring displace or strengthen knowledge production at home? Evidence from OECD countries.

Powell, W., 1990. Neither market nor hierarchy. Research in Organizational Behaviour 12, 295-336.

Prato, G., Nepelski, D., 2012. Global technological collaboration network: network analysis of international co-inventions. The Journal of Technology Transfer, 1-18.

Saxenian, A.-L., 1994. Regional advantage: culture and competition in Silicon Valley and Route 128. Harvard University Press, Cambridge.

Schiller, D., Diez, J.R., 2010. Local embeddedness of knowledge spillover agents: empirical evidence from German star scientists. Papers in Regional Science 89, 275-294.

Song, J., Almeida, P., Wu, G., 2003. Learning–by–Hiring: When Is Mobility More Likely to Facilitate Interfirm Knowledge Transfer? Management Science 49, 351-365.

Strambach, S., Klement, B., 2012. Cumulative and Combinatorial Micro-dynamics of Knowledge: The Role of Space and Place in Knowledge Integration. European Planning Studies 20, 1843-1866.

Suriñach, J., Moreno, R., 2012. Introduction: Intangible assets and regional economic growth. Regional Studies 46, 1277-1281.

Trippl, M., 2009. Islands of Innovation and Internationally Networked Labor Markets. Magnetic Centers for Star Scientists?

Trippl, M., 2011. Scientific mobility and knowledge transfer at the interregional and intraregional level. Regional Studies, 1-15.

Unctad, 2014. World Investment Report 2013. Global Value Chains. Investment and Trade for Development, in: Unctad (Ed.). UNCTAD, Geneva.

Van Looy, B., Song, X., Callaert, J., Peeters, H., 2014. Intra-European cooperation compared to international collaboration. Measurement and analysis of knowledge and R&D exploitation flows, assessed by patent and licensing data 2014.

World Economic Forum (Wef), 2012. The shifting geography of Global Value Chains: Implications for Developing Countries and Trade Policy. World Economic Forum, Davos.