*Innovation for Growth – i4g*

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# The development of global innovation networks

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## Findings

Internationalisation of R&D has been driven both by the support to global value chains (GVCs) and by the dynamics of innovation processes. Multinational have developed global innovation networks (GINs) including the set of their R&D centres and related networks of cooperation. Within GINs, foreign R&D locations have become more geographically and functionally diversified. They are located in order to take advantage of knowledge resources from different countries and operate a global division of innovation processes.

GINs are effective channels of technology transfer across borders and extend open innovation practices at the international scale. Multinationals' foreign R&D locations have a positive impact on their innovation performance and their productivity. In particular, public-private partnerships in R&D, including long distance, have a positive impact on innovation performance provided they involve excellent research institutions and firms with sufficient absorptive capacity.

Transatlantic technology sourcing mainly involves European firms sourcing technology from the U.S.

## Recommendations

*1. Improve the knowledge of GVCs and GINs*

Given the role of GINs in the dynamics of innovation, policy makers need to better understand their working and their interactions with home economies. This involves both better data and more empirical studies.

*2. Strengthen internal capabilities and promote relevant partnerships*

Policies have fostered innovation partnerships; however they should now be more selective. In the case of partnerships aiming at radical innovation, criteria should be centred on scientific excellence and innovative character. Conversely, conditionality based on institutional characteristics or on the geographic origin of partners may lead to the choice of projects of lesser quality.

*3. Develop local attractiveness for R&D activities*

Countries should try to attract different types of R&D units depending on their position in GVCs. Emerging countries attract new R&D centres of as their markets are expanding. European countries can improve their attractiveness for production units and technical support in some high-tech sectors or niches. In this perspective, policies should stimulate the dynamism of local markets of these industries, which does not only depend on research or innovation policy in a narrow sense.

The U.S. is more attractive than the EU for technology sourcing and frontier research. European countries can increase their attractiveness for global research centres by strengthening their research capabilities and the efficiency of open innovation at the national and European level. This largely depends on the quality of the scientific and technological supply, as well as connexion to international networks. Similarly, firms can upgrade their innovative capabilities by developing GINs and participating to international R&D projects.

*4. Connect clusters through pipelines*

At the global level, agglomeration effects coexist with firms' growing capability to identify and use knowledge from distant origins. International knowledge transfers take place within GINs, which also generate spillovers in firms' home countries. Knowledge exchange through the creation of external connections to GINs is likely to be at least complementary to cluster policy in order to overcome the lack of diversity and the risk of lock in. Clusters should in particular offer efficient interfaces with international partners, in particular for SMEs.

**Summary**

Since the late 1980s, internationalisation of R&D has been driven both by the development of global value chains (GVCs) and by the dynamics of innovation processes themselves. As a result, an increasing number of multinational companies have developed and refined global innovation networks (GINs) including the set of their R&D centres and the related networks of cooperation. As their foreign R&D locations have developed, they have become more geographically and functionally diversified. Besides, within GINs, both foreign and home R&D centres are involved in open innovation practices.

The paper uses empirical results from the literature to argue that GINs are effective channels for technology transfer across borders. It studies how the different types of R&D centers are located and how cooperation with various partners is organised in order to take advantage of knowledge resources from different countries. Studies based on data from various countries have showed that multinationals' foreign R&D locations have a positive impact on their innovation performance and their productivity.

Within GINs different locations and partners play distinctive roles. For example, transatlantic technology sourcing mainly involves European firms sourcing technology from the US. The paper specifically studies the impact of firms' R&D cooperation with academic research. It shows that this type of cooperation can have a positive impact on innovation performance provided certain conditions are met. Most productive cooperations involve excellent research institutions and firms with sufficient absorptive capacity. Provided partners meet such conditions, public-private partnerships to innovation can be international and long distance.

The development of GINs suggests a number of policy implications. In particular, policy makers have to take into account the position of the local innovation systems they aim at upgrading within GINs. The paper develops four policy recommendations.

**1. Improve the knowledge of GVCs and GINs**

Given the role of GVCs and GINs in contemporary economies and in the dynamics of innovation and growth, it matters for policy makers to better understand the firms involved and their interactions with home economies. This involves both an improvement in available firm data and more empirical studies. In particular, more precise typologies should allow countries and regions to clearly identify their positions in GVCs and GINs so as to best take advantage of their engagement in global networks. In the case of EU policies, better knowledge of GVCs and GINs is important for example to implement smart specialisation.

**2. Strengthen internal capabilities and promote relevant partnerships**

Companies that build GINs and open innovation practices nurture their in-house R&D capabilities. In particular, companies that cooperate with academic research also invest in internal R&D capabilities and maintain a broad portfolio of partners to innovate at the regional, national and international levels.

Policies have fostered various types of innovation partnerships, including with financial incentives. The objective however should not be to promote partnerships as such but rather

as a tool to stimulate innovation. As a consequence, policies should promote the right partnerships, which is a challenge. In the case of exploration partnerships aiming at radical innovation funding criteria should be centred on scientific excellence and innovative character. Conversely, conditionality based on institutional characteristics or on the geographic origin of partners may lead to the choice of projects of lesser quality. Such considerations are important both national and EU policies.

**3. Develop local attractiveness for R&D activities**

Strengthening a country's or region's attractiveness for R&D activities implies first to understand the determinants of their location. The paper suggests that countries should try to attract different types of R&D units depending on their more general position within GVCs.

Emerging countries attract a large number of the new R&D centres of multinational companies as their markets are expanding. However, European countries can improve their attractiveness for production units and technical support in some high-tech sectors or niches. In this perspective, policies should stimulate the dynamism of local markets of these industries, which does not only depend on research or innovation policy in a narrow sense.

The United States is more attractive than the EU when it comes to technology sourcing and frontier research. European countries can increase their attractiveness for global research laboratories by strengthening their research capabilities and the efficiency of open innovation practices at the national and European level. This largely depends on the quality of the scientific and technological supply. In turn, this implies that European researchers and centres of excellence are connected to international networks. Similarly, firms can upgrade their innovative capabilities by developing GINs and participating to international R&D projects.

**4. Connect clusters through pipelines**

At the global level, agglomeration effects coexist with firms' growing capability to identify and use knowledge from distant origins. International knowledge transfers take place within multinationals' GINs, but also generate spillovers in their home countries.

In this context, public action must adapt some of its tools and, more fundamentally, modify some of its perspectives. Cluster policies emphasise the promotion of the interactions within local innovation ecosystems. But clusters that focus on local cooperation may be most efficient at supporting incremental innovation rather than radical innovation. They also can to lead to short-living networks incapable of guaranteeing long-run upgrading. In these contexts knowledge exchange over long distance through the creation of external connections and bridges to GINs is likely to be at least complementary to cluster policy in order to overcome the lack of diversity and the risk of lock in. Clusters should in particular offer efficient interfaces with international partners. This role may be particularly important for SMEs, which face more difficulties to cooperate for innovation, including internationally.

## Introduction

Over the last two decades, the fragmentation of production processes across countries has tremendously increased in scale and scope and today, firms can disperse production across the world. As a result, world trade, investment and production are increasingly organised around global value chains (GVCs). A value chain is the full range of activities that firms engage in to bring a product to the market, from conception to final use. Such activities range from design, production, marketing, logistics and distribution to support to the final customer. They may be performed by the same firm or shared among several firms. Progressively, firms have combined outsourcing and offshoring for various functions and steps along their value chains. At the world level, more than half of the manufacturing imports are intermediate goods (primary goods, parts and components, and semi-finished products), and more than 70% of services imports are intermediate services, such as business services (OECD 2013).

GVCs are often cost-driven as sourcing inputs along the value chain from low-cost producers can generate important cost advantages. Outsourcing production also enables firms to benefit from the economies of scale and scope that specialised suppliers can provide. Another category of GVCs is market driven as multinationals reach out for emerging countries growth potential by producing part of their value chain locally.

Internationalisation of R&D activities has grown alongside GVCs. Foreign R&D has traditionally supported foreign production and the development of market driven GVCs largely explains the development of R&D facilities outside multinationals' home countries; Cost-driven GVCs can also generate specific R&D activities abroad. Finally, the fragmentation of value chains and the dynamics of open innovation practices have stimulated international knowledge sourcing. As a result, multinationals organize to gain access to foreign knowledge assets, including local universities and research centres. In order to develop their GVCs, multinationals resort to various types of contracts and transactions, including M&A. as a consequence, there are many interactions between the development of GVCs and the geographical scope of their different activities, including in particular R&D. Overall, internationalisation of R&D is driven both by the development of GVCs and by the dynamics of innovation processes themselves. This paper argues that as a result, multinational companies develop global innovation networks (GINs).

Both GVCs and GINs should be taken into account when designing public policies. Where a country is located in the value chain can affect the degree to which it benefits from participation in a GVC since some activities, such as R&D and design, but also certain services, tend to generate more value added than some production operations. But this differs by industry, so public policy should also depend on the country's specialisation profile. Public policies often aim at changing a country's position in GVCs. Building adequate intangible assets and accessing knowledge are fundamental in this process. As a result, public policies should fully take into account GINs when designing their upgrading policies and their innovation policies more precisely.

## 1. Internationalisation of R&D

### 1. Foreign R&D and R&D abroad

Internationalisation of R&D activities has been increasing since the mid-1980s. The share of foreign R&D has been increasing first in the US, UK and Sweden, then in Germany, France, Italy (UNCTAD 2005). As illustrated in table 1 the phenomenon seems to have reached a plateau in some economies such as Belgium, Canada, Finland and Spain. In others, often larger and less open economies, it is still slowly increasing (France, Germany, US). In Japan, it is very low but slowly increasing.

**Table 1. Share of foreign R&D in national business R&D spending, %**

| | 1985-86 | 1996-97 | 2007-08 | 2009-10 |
|---|---|---|---|---|
| **Austria** | | 45 (2004) | 54 | 52 |
| **Belgium** | | 57 (2003) | 59 | 54 |
| **Canada** | 35 (1988) | 32 | 37 | 35 |
| **Finland** | | 13 | 16 | 15 |
| **France** | 10 | 17 | 21 | 23* |
| **Germany** | 16 (1993) | 17 | 26 | 27 |
| **Ireland** | 62 | 65 | 72 | 70 |
| **Japan** | 1 (1993) | 1 | 5 | 6 |
| **Netherlands** | - | 18 | 33 | 30 |
| **Spain** | 39 (1990) | 36 | 34 | 27 |
| **Sweden** | 8 | 19 | 33 | 30 |
| **UK** | 18 | 33 | 44 | 47 (41 in 2010) |
| **US** | 6 | 12 | 14 | 15 |

**Source**: MSTI OECD, and national sources (1985)

The share of R&D abroad by domestic firms is not monitored by national surveys except in very few countries like the US. Table 2 gathers the available data from several sources. For the US the share foreign R&D and R&D abroad are similar, around 15%. As for foreign R&D (table 1), the share of US firms' R&D abroad has continued to increase in the 2000, from 12.6% in 1999 to 15.7%. In Germany too the share of foreign R&D and R&D abroad are similar, around 25%.

For Sweden the share of R&D abroad by domestic companies is much higher than foreign R&D in Sweden. Japan is in the reverse situation. Taking into account the respective economic size of countries, these country data on R&D spending seem compatible with world patent data: the share of patent applications at EPO with foreign inventors, who tend to be employees at foreign subsidiaries, increased from 10% in 1998 to 18% in 2004.

**Table 2. Share of foreign R&D and R&D abroad in national business R&D spending, %**

| Share, % | Japan | US | France | Germany | Swede n | UK | EU |
|---|---|---|---|---|---|---|---|
| **Foreign R&D in BERD** | 5.1 | 15.2 | 20.8 | 26.2 | 36.0 | 39.3 | n.a. |
| **R&D abroad by domestic firms** | 3.0 | 15.7 | n.a. | 24.4 (27.3, in 2009) | 56.0 | n.a. | 25 (survey 2010) |

*Sources*: OECD, NSF, EFI 2013, Sachwald 2011

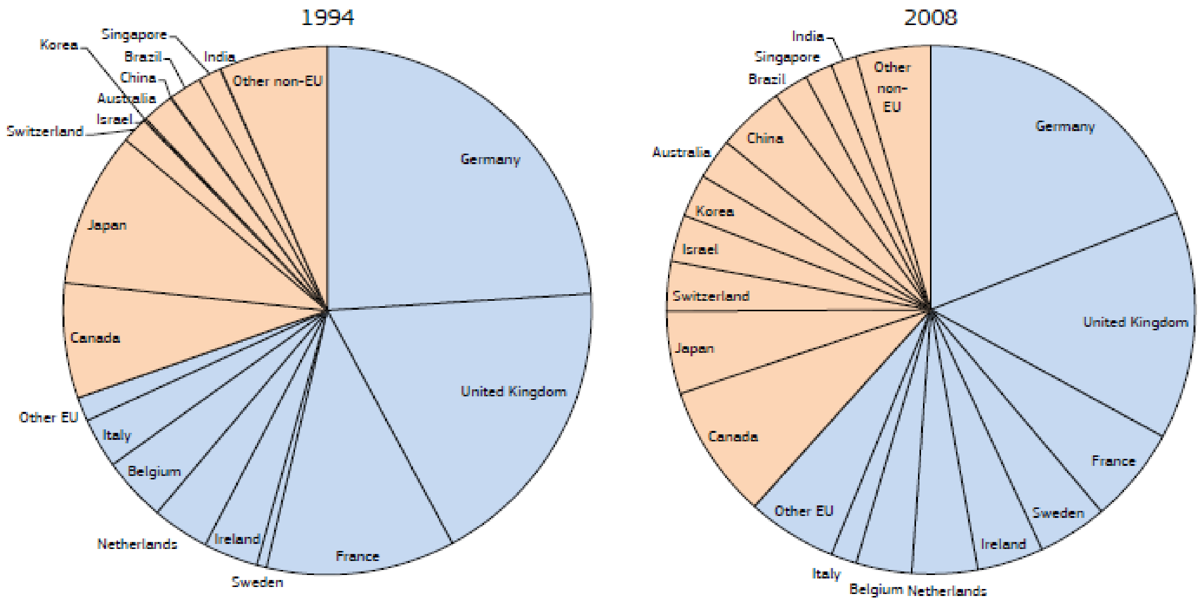
Between 1994 and 2008, outward R&D by US companies strongly increased from 8$bn to 23$bn. Increased internationalisation was unevenly distributed across countries. In particular, emerging countries experienced stronger rates of increase of R&D investment from US companies. As a result, the share of OECD countries in US business R&D abroad has decreased somewhat (figure 1). The combined share of Germany, the UK and France decreased from over 50% in 1994 to less than 40% in 2008. The share of some European countries increased on the contrary. In the case of Sweden and Switzerland, this may be due to large acquisitions by US companies, which typically result in R&D facilities changing hands. The share of Japan decreased substantially, while the share of Korea increased. In 2008, the share of China was equivalent to that of Japan.

Overall, the large majority of US R&D investment abroad remains in the largest markets and most advanced economies, but the geography of foreign R&D has substantially changed and remains dynamic.

Figure 2 based on available data shows the distribution of inward business R&D. Chinese data is incomplete and difficult to compare with data from other countries. Among OECD countries, figure 2 shows that the US is very attractive for both EU and Japanese companies R&D investment.

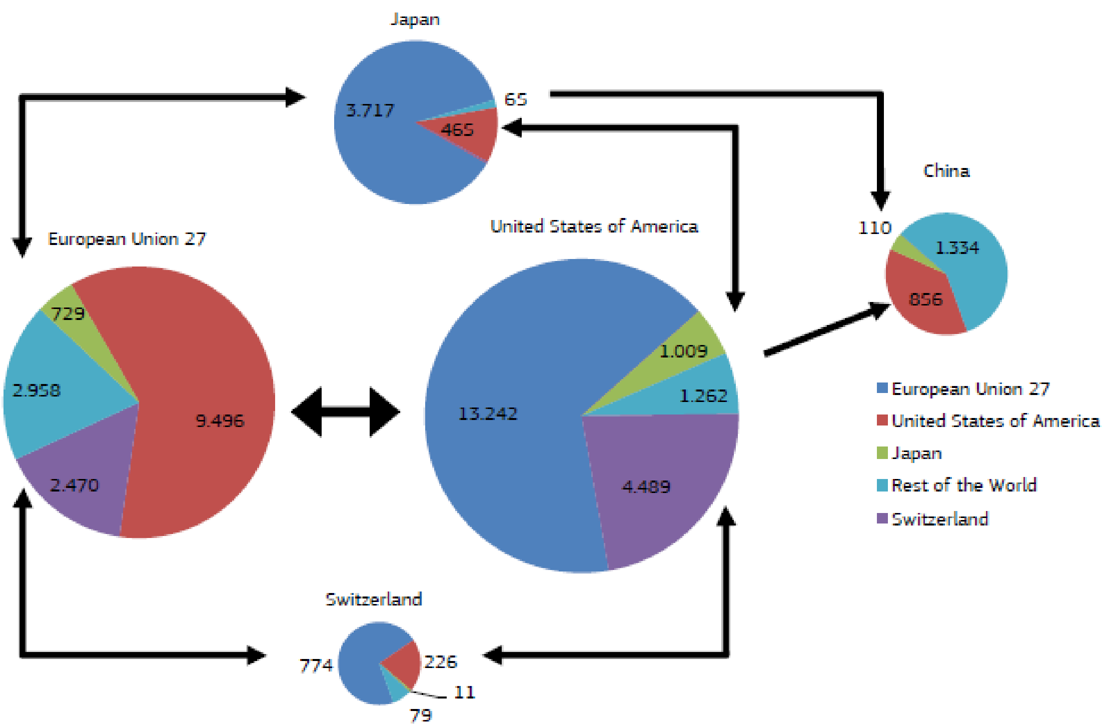
Pharmaceuticals is a major sector of foreign R&D investment in the US, with 24% of the total. France, Germany and Switzerland in particular have strongly invested in pharmaceutical and biotechnology R&D units in the US. This may be related both to the large US market and to technology sourcing (see below). Strong US R&D investment in the automobile and machinery industries in Germany can be related to the country specialisation in these sectors. These observations have to be related to the determinants of foreign R&D location, which is analysed in the next section.

**Figure 1. Distribution of outward US Business R&D**




Source: EU (2012)

**Figure 2. Distribution of inward Business R&D**




*Notes. For China, only R&D expenditure of wholly foreign-owned companies is included. For the EU, intra-regional flows are not included*

Source: EU (2012)

## 2. Typology of foreign R&D centres

Firms' R&D location decisions are complex and subject to a number of underlying factors. In their survey of MNEs, Thursby and Thursby (2006) found four outstanding determinants of R&D location in general: output market potential, quality of R&D personnel, university collaboration and intellectual property protection. In the case of companies locating in emerging economies, the growth potential in the market and the quality of R&D personnel were the most important factors. For companies locating in high wage countries (at home or in another country), the quality of R&D personnel and intellectual property protection were the most important ones. This survey was quite careful and interestingly distinguished location in different types of countries. Its results are similar to those of other surveys, either older or more recent. Cincera *et al*. (2010) for example also identified different determinants for location of R&D in emerging countries.

One methodological difficulty with these surveys is that strongly interdependent motives are analysed as separate. As a result the market potential tends to be underestimated as a determinant of R&D location. For example, in some surveys, the size or growth of the local market is proposed as one factor of attraction along with proximity to production facilities. But market access draws local production, which in turn requires technical support and R&D. Similarly, a skilled workforce is often mentioned as a determinant of R&D location, but it is a quite general term and necessary qualifications depend on the type of R&D activities being considered, from fundamental research to experimental development, from frontier research or exploration to adaptation to local conditions or routine analyses. A recent empirical study by the European Commission identifies the share of the workforce with a tertiary education as a major determinant of foreign R&D in EU12 countries, but not in the EU15, where the size of the market is the major determinant (EU 2012). This suggests that the type of R&D activities in these two groups of countries are different (see below). A recent study shows that patents generated in China and India very often involve mutinational companies (Branstetter *et al.* 2013). Moreover, patents with a multinational assignee receive 45% more citations than the ones under the sponsorship of Indian enterprises. Results are similar for patents involving Chinese inventors. Indian and Chinese R&D locations do involve high skilled personnel, but not necessarily the required experience in conducting frontier research or radical innovation projects.

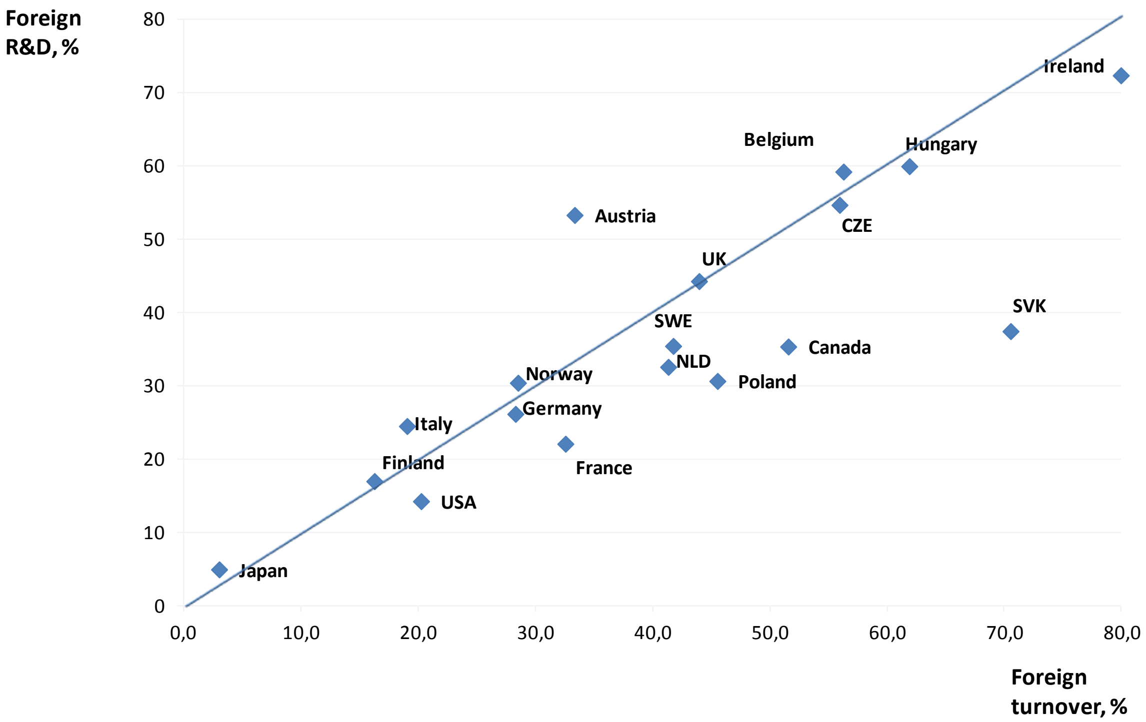
Figure 3 shows that in OECD countries, the share of foreign R&D is correlated with the share of foreign production. This correlation has not changed since the mid-1990s (OECD 1999) despite large increases of foreign production for some countries (Ireland, Sweden, UK). In general, penetration by foreign production is higher than penetration by foreign R&D[1]. The share of foreign R&D compared to foreign turnover is relatively high in Japan, Italy and Austria. These outliers should probably be related to the sector composition of foreign investment compared to domestic business.

Figure 3 confirms that support to foreign production is a major determinant of R&D location abroad. Since the early 2000s, increased foreign R&D has been following FDI growth in emerging countries. As a result, a large share of foreign R&D in emerging countries

[1] Foreign value added is on the contrary lower than foreign R&D for some countries (EU 2012), but data is available for less countries and it should not be interpreted as production being less internationalised than R&D, which is not true.

corresponds to an expansion of R&D operations rather than a substitute for existing R&D activities in high wage countries. Surveys as well as empirical studies have nevertheless identified labour costs as a one of the important determinants of R&D location in emerging countries (Thursby and Thursby 2006, Meyer and Dyck 2011, EU 2012).

**Figure 3. Correlation between the shares of foreign production and foreign R&D, 2009**




*Source*: Data from OECD STI Scoreboard 2011

Technology sourcing in OECD countries has also been increasing since the late 1980s. Besides, cross-border M&A have been used by firms from emerging countries in order to upgrade their position in global value chains, resulting in their acquisition of R&D activities in developed countries. Examples include Korean firms in the 1990s (Sachwald 2001) and more recently Chinese and Indian firms (OECD 2013).

Overall, as foreign R&D increased and reached new locations, it became more diverse. Three types of R&D foreign centres may be identified. Figure 4 identifies the factors of attractiveness of each of these types of R&D centre by distinguishing the factors of supply and demand in the host country. For each type of centre it indicates the main determinant in the choice of location (bold face) together with secondary factors of attractiveness.

Local Development Centres (LDC) are designed to provide support for production and sales in the foreign country by helping to tailor supply to local demand. These centres are therefore logically located close to production plants. In Europe, however, some development centres are not aimed solely at one local market but at a region that can encompass more than one country. The deployment of LDCs will tend to follow the development of markets and production abroad. Most LDCs are thus still located in high-income countries, although a growing number have been attracted to emerging countries with dynamic markets.

Global Research Laboratories (GRL), in contrast, are attracted by top-tier scientific and technological resources concentrated in countries and regions in which leading consumers, firms at the leading edge of their fields and world-renowned research institutions interact with one another (Figure 4). Excellent academic research is a determinant factor to attract this type of foreign R&D activities (Belderbos *et al*. 2009).

Global Development/service Centres (GDC) perform studies and R&D services. They are therefore located in countries where it is possible to employ efficient engineers and technicians at relatively low cost compared with the home country (Figure 4). This type of choice of location seems to be particularly common in IT and telecommunications sectors, notably in Asia. India in particular has attracted many software development centres, as well as sub-contracted R&D activities in other sectors. New EU Member States and Russia have also attracted this type of R&D centre. In contrast, foreign R&D centres in China appear to have located there mainly in response to the rapid expansion of production plants. This distinction among emerging countries is consistent with the motivations of French firms when offshoring activities more generally[2].

**Figure 4. Determinants of location for different types of R&D activity abroad***

| Type of R&D unit | Attractive local characteristics: of the supply of scientific and technological expertise | Attractive local characteristics: of demand |
|---|---|---|
| Local development centre (**LDC**) | **Quality of training (engineers, technicians)**<br>Local technogical infrastructure | **Large local market (size, purchasing power)** |
| Global research laboratory (**GRL**) | **Centres of excellence**<br>**Good relationship between research and industry** | Market leader |
| Global development centre(**GDC**) | **Good cost benefits of labour for R&D activities**<br>Protection of intellectual property | - |

*Source* : Sachwald (2008)

Empirical support for this typology was found using a database of R&D investment projects in Europe which indicates the precise location of the project and the intended activity (Sachwald and Chassagneux 2007, Sachwald 2008). A recent study on the determinants of foreign R&D location confirms that they are different for the EU 15 and EU 12 (EU 2012). The

[2] Based on the French results of the Survey on activity chains (Fontagné and D'Isanto 2013) and the presentation by A. D'Isanto at the i4g-OECD workshop on GVCs (Sept. 9-10 2013).

four variables found influencing positively and significantly R&D location in the EU 15 are GDP, FDI intensity, the ratio of labour cost over value added and R&D intensity. The first two could correspond to the location of LDCs and the last two to the location of GRLs. The location of foreign R&D in the EU 12 depend positively on the share of tertiary graduates, the share of public research spending in GDP and FDI intensity, but also negatively on the ratio of labour cost over value added. This corresponds to favourable conditions for GDLs in the car and equipment industries. Based on the description of foreign R&D projects, Sachwald (2008) had identified a number of GDLs in the car industry in the EU12.

A recent detailed analysis of patents involving Chinese and Indian inventors also suggests that multinationals develop a global division of their innovation processes (Branstetter *et al.* 2013). It shows that patents generated MNEs in India get fewer non-self citations than those generated in the MNEs home countries. The gap hardly fades overtime, suggesting that Indian locations could be GDCs as described above. The pattern is different in China, where there has been a rapid relative improvement in the measured quality of the MNEs inventions (Branstetter *et al.* 2013). This may be due to the size of the Chinese market and the location of both numerous LDCs and some GRLs.

More generally, besides the determinants initial location, each R&D centre has its own dynamics and can progressively upgrade and play one or several role within the global R&D network of its parent company. Foreign R&D centres interact with their local environment and based on the characteristics of the latter may develop their own innovation capability. As a result, even if the initial location has been motivated by market access, further developments will depend on the local scientific and technological capabilities. This has been confirmed by an empirical study of foreign R&D subsidiaries of US companies between 1991 and 2002 (Hegde and Hicks 2008). The probability to locate an R&D activity in a given country depends on the importance of the local market, but the probability that it then generates patents depends more strongly on the local technological capabilities. Moreover, the number of patents of a subsidiary depends mainly of the local scientific production as measured by publications in science and engineering. In India and even more in China, in the context of increasingly substantial "(re)-engineering products for the local market" local engineers often take a leading role and local R&D centers may evolve to contribute to the global R&D agenda (Branstetter et al. 2013).

## 3. Impact of the internationalisation of R&D on performance

Empirical studies have tried to measure the impact of the foreign location of R&D on the innovation and on the performance of the mother companies. A number of empirical studies measure positive impacts of foreign R&D on the performance of home country firms.

Using patent data, a number of studies have shown that European and Japanese multinationals succeed in sourcing technology in the United States. Their R&D locations in the US have a positive impact on the generation of innovation (Almeida 1996, Iwasa and Odagiri 2004, Griffith *et al.* 2006).

In their analysis, Iwasa and Odagiri (2004) distinguish among Japanese R&D centres in the

U.S., research locations from development locations in a similar way as the typology above. Only the research locations have an impact on the production of patents by the Japanese parent.

Using panels of UK and US firms matched to patent data Griffith et al. (2006) show that UK firms who had established a high proportion of US-based inventors by 1990 benefited disproportionately from the growth of the US R&D stock over the next decade. According to their estimates, UK firms' total factor productivity (TFP) was positively impacted by the growth of US R&D investment during the 1990s. The benefits of technology sourcing were larger in industries whose TFP gap with the US was greater. Griffith et al; (2006) did not measure a similar benefit for US firms who located R&D labs in the UK. Technology sourcing between the UK and the US thus appears asymmetric.

A recent empirical study based on German data measures the impact of transatlantic technology sourcing on the parent company (Harhoff *et al*. 2012). It shows that co-patenting with American inventors, placing inventors in the US and to a lesser extent cooperating with US suppliers have a positive impact on German companies' productivity. Cooperation with American customers may increase sales in the US, but do not generate a productivity effect on the German parent. This confirms that cooperation with customers generally aims at market adaptation.

D'Agostino *et al*. (2013) focus on the impact of foreign R&D in emerging countries. They show that R&D expenditures in emerging countries are complementary to home regions' R&D expenditures in the case of mid-technology sectors. This means that R&D in emerging countries has an additional effect on the knowledge production of the home region. This is not the case in high-technology sectors, despite high FDI in emerging countries in these sectors. It would be interesting to conduct a similar test using firm data rather than regional data.

This result is compatible with the case of the German car industry as studied by Gary Herrigel (2013). The car industry in China is a case of market-led GVCs. German car manufacturers' are developing global monitoring and exchange systems that both support disparate local technical and organizational experimentation processes and capture and distribute promising developments from those locations to other operations that could profit from them. Corporate production systems and the cultivation of a globally circulating engineer and technician cohort facilitate these learning and innovation oriented governance practices.

Germany's centrality for future oriented R&D has been solidifying because of its comparative advantage for engineering talent and contact with R&D infrastructure and support: German R&D competence is drawn in to a support role for foreign technical experimentation processes. Globally mobile cohorts of engineers, based in Germany with close ties to R&D engineering expertise, cooperate with and monitor the progress and needs of subsidiary product development processes. Such activities are growing along with the expansion of competence and production sophistication abroad. Production operations in Germany are also changing as a result of offshore upgrading.  Competence and capacity development in emerging markets has not resulted in a loss of either competence or capacity in home market locations. Instead, home production location profiles are being recomposed. Because home country R&D operations have expanded, the need for prototyping, small batch and quick turnaround manufacturing capacity has expanded accordingly

The available data and studies suggests that foreign R&D adapts to the development of GVCs. GVCs locate segments of value chains or activities in different countries and regions based on their comparative advantage. One multinational company can operate a number of different value chains to optimize costs and market adaptation. Some GVCs are market-led, aiming at market adaptation. This is the case for example of a number of the GVCs of cars assembled in China using some foreign components. Other GVCs are cost-led, aiming at reducing costs of products and services. These GVCs may be be more complex and involve inputs from a large number of suppliers and sub-contractors. The activities of foreign R&D depend on the type of GVCs in which they are involved. Using the typology developed above, market-led GVCs should mostly generate LDCs, while cost-led GVCs may generate GDCs. Of course large multinationals with a global reach will use both market-led and cost-led GVCs, as well as the different types of foreign R&D centres, including GRLs, which conduct research for the company as a whole.

## 2. The development of global innovation networks

As foreign R&D locations have developed, they have become more geographically and functionally diversified. Some of the foreign R&D centres have local functions while others have global missions for the company. Besides, both foreign and home R&D centres are involved in open innovation practices. They increasingly contract out R&D services (Meyer and Dick 2011) and cooperate with both academic research and other firms. Since the late 1980s, an increasing number of multinational companies have developed and refined global innovation networks (GINs) including both the set of their R&D centres and the related networks of cooperation. The international business literature has examined the development and management of these networks aiming at maximising the production and transfer of knowledge within each multinational[3].

As GVCs have become ubiquitous, multinational companies have organised their GINs in close connexion with their GVCs. This section discusses how GINs are designed in relation with GVCs. It studies how the different types of R&D centres are located and how cooperation with various partners is organised in order to take advantage of the local knowledge resources.

### 1. The dynamics of open innovation and internationalisation of R&D

Interactions that develop as a result of openness and internationalisation of innovation processes assist in the formation of global open innovation networks. These networks reach more globally and are more integrated than previous R&D activities by multinationals.

While openness remains easier and more frequent with well-known partners that supply more certain inputs than sources that are less known, firms nevertheless try to reach for

[3] See for example Bartlett and Ghoshal (1989), Kogut and Zander (1992), Doz *et al.* (2001).

new partners whenever they seek specific knowledge inputs or need to cooperate on attractive markets.

Figure 6 summarises the drivers of open innovation and internationalisation of R&D. It points out that both trends depend on a number of common features of the business environment. Firstly, both trends correspond to an increasing demand for innovation in more competitive business environments, both at the local and international levels. This more pressing demand for innovation exerts a growing pressure on firms' capabilities. As a result firms seek complementary resources through various partnerships to innovate.

The increasingly multi-disciplinary nature of innovation provides one reason for the opening-up of the innovation process, and also for its internationalisation insofar as adequate competences and market drivers can be better found abroad. R&D centres located in leading markets can increase the firm's capacity to monitor future demand trends. Such centres can be more fruitful for companies with open innovation practices.

**Figure 6. Factors of openness of the innovation process and of internationalisation of R&D activities**

| Incentive to: | Demand side | Scientific and technological supply |
|---|---|---|
| **Develop open innovation practices at the local, national or international level** | 1. Acceleration of the innovation cycle; increasing demand for innovation<br><br>2. Hybrid or complex innovations, including interactions between products and service<br><br>3. Evolution of the business model.<br><br>4. Growing attention to demand or customer driven innovation, including in services | 1. Increasing supply of technologies, in particular from new firms and knowledge intensive services, nationally or internationally<br><br>2. Incentives from public policies to develop cooperation with academic research.<br><br>3. Internal focus on defendable core competencies in face of growing external competition; limited R&D resources<br><br>4. New practices and methods of exchange of data, of simulation… |
| **Establish or increase research and/or development capabilities outside the home base** | 1. Importance of the foreign market (size, purchasing power) and implications for differentiation of products/services<br><br>2. World leading local market | 1. Increased global availability of high quality S&T human resources and infrastructures<br><br>2. Excellence centres and good relations between academic research and firms in foreign countries<br><br>3. Good cost-efficiency ratio for some R&D activities in foreign countries<br><br>4. Increased capacities, qualities and cost-effectiveness of supporting ICT services |

On the supply side, the emergence of new specialised firms reinforces the development of new technologies. These trends stimulate R&D outsourcing or the substitution of in-house capabilities with efficient third-party facilities and software. This tendency has been particularly significant for performing certain tests and advanced simulations. Increasing foreign R&D capabilities means that some of the externalisation can take place abroad, particularly when the centre(s) of excellence in a research field are located there. The shortage of in-house resources has also strengthened the trend toward externalisation and specialisation of the firms' R&D operations, but also the relocation of some operations. Similarly, cost optimisation has encouraged sub-contracting and relocation of certain activities into centres that can offer greater cost-efficiency (e.g. where salaries are relatively low but performance is sufficient to achieve high-quality results and good integration into the firm's global operations).

## 2. Typology of innovators and patterns of cooperation

Patent data can be used to identify different types of innovators. Forward citations are used to measure the degree to which a patent contributes to further develop technology. The number of forward citations is considered as an indicator of novelty or technological significance of a patent. The number of backward citations is rather used as an indicator of technological breadth or scope of a patent. Patents with numerous backward citations build on a large pool of existing knowledge. Dornbusch and Neuhäusler (2013) have proposed to use the ratio of forward to backward citations to measure the "technological impulse" (TI) of a patent that takes into account both its originality and its significance. The authors have used the TI of their patents to compare the inventions filed by MNEs, SMEs and academic institutions. Figure 7 is adapted from the empirical analysis of the components of the TI in the case of Germany (Dornbusch and Neuhäusler 2013).

**Figure 7. Typology of innovators**

*Forward citations*

| | |
|---|---|
| **Pioneers**<br>Academics, TI = 0.53 | **Enablers**<br>MNEs, TI = 0.39 |
| **Mavericks**<br>SMEs, TI = 0.36<br>and some academics | **Adopters**<br>Some SMEs |

*Backward citations*

*Source*: adapted from Dornbusch and Neuhäusler (2013).

Academic researchers aim at advancing the frontier of knowledge. They generate patents from a focused stock of knowledge with a high potential for further technological development, but some patents from academics show a low connectivity. SMEs are in a symmetrical position: based on a narrow range of expertise, they build on the existing stock of knowledge and focus on incremental innovation. MNEs both draw on a broad technological base and generate patents that have more technological impact than those of SMEs (but less than those of academic researchers). Dornbusch and Neuhäusler (2013) show that differences between the three profiles are statistically significant[4].

[4] They calculate the forward and backward citations from German EPO patents.

Given their innovative profiles, SMEs, MNEs and academic researchers have different motivations to cooperate for innovation. Firstly, SMEs having a low capacity of absorption tend to cooperate much less for innovation than larger enterprises[5]. Secondly, as explained below, and for similar reasons, they generally cooperate much less with public research institutions.

International studies as well as country studies indicate that firms that cooperate to innovate tend to do so first with their customers and suppliers (OECD 2013b). Collaboration with competitors is less frequent. Collaboration with public research organisations, universities or institutes, also tends to be less frequent. From this point of view, Germany appears as an exception, with a high propensity to cooperate with public research institutions relative to cooperation with other firms (OECD 2013b, Robin and Schubert 2013). The generally lower propensity to collaborate with academic research institutions can in part be explained by the nature of such collaborations. Firstly, academic collaborations tend to focus on the upstream or exploration phases of the innovation process (Bercovitz and Feldman 2007), which represents a relatively low share of the firms' innovation activities. Secondly, firms that cooperate with public research have a specific profile. In France, they have a relatively large portfolio of partners (Dhont-Peltrault and Pfister 2008). Conversely, more than one third of the companies cooperating with their suppliers have no other type of cooperation. Firms cooperating with public research tend to externalise a high share of their R&D work, yet they also more often conduct in-house R&D activities, resulting in a strong absorption capacity. French and British firms that cooperate with public research have a similar profile: they are few, originate from R&D or knowledge intensive sectors, have in-house research capabilities and have adopted open innovation practices (Laursen and Salter 2004).

Cooperation with public research seems more important for radical innovation, while cooperation with suppliers and customers are often an integral part of incremental innovation processes. An empirical study based on CIS survey shows that patenting is positively influenced by cooperation with public institutions, but not by other types of cooperation. At the same time, the share of innovative products in turnover is only increased by vertical cooperation with suppliers or customers (Miotti and Sachwald 2003). Another study on French data shows that, cooperation with a partner from public research significantly increases the likelihood to introduce new products to the market and to have a high share of new products in sales (Dhont-Peltrault and Pfister 2008). A recent empirical study of collaboration between firms and universities in Japan showed that resulting patents had a higher quality than those flowing from firms' internal R&D (Motohashi and Muramatsu 2012).

Generally, SMEs have a lower propensity to cooperate for innovation, in particular with academic research (OECD 2013b). Dornbusch and Neuhäusler (2013) have found that when SMEs do cooperate, the impact on the TI of their patents is greater than for MNEs. This may be due to the profile of the SMEs cooperating with academic research, which are often spin

[5] Larger firms tend to interact more with academic research in general, including through publications and conferences.

off from universities or large companies belonging to high tech sectors.

At a regional or local level, various studies suggest that academic research has a positive influence on innovation performance and firm creation. Several studies examine patent data and do not necessarily identify the channels through which the local universities influence firms' innovation performance. Throughout OECD countries, the number of patents invented by companies in a region is positively related to the stock of patents from other companies, and above all to the stock of public patents in this same region (Guellec and Thoma 2008). The influence of the most-frequently cited public patents is particularly strong. These results suggesting that companies conduct more intense inventive activities in regions hosting academic organisations filing quality patents have been confirmed in the case of the UK (Huggins *et al*. 2010) and the U.S. (Hausman 2012).

The correlation between excellent academic research and firms' innovation seems to have increased from the beginning of the 1990s to the beginning of the 2000s (Guellec and Thoma 2008). This evolution coincides with the development of public policies that favour both technology transfer and clusters. It is however also compatible with the spontaneous development of the open innovation practices by companies that locate or relocate towards favourable environments where academic organisations producing inventions are attractive. Working on US data, Hausman (2012) measures a positive impact of university patents on the local creation of new establishments and the increase of total employment. The impact increased after the implementation of the Bayh Dole act and the creation of numerous technology transfer offices. The impact has been strongest in technology fields corresponding to increased federal research budgets (NIH and DOD). Numerous new firms have been created, but most new jobs have been generated by new establishments from existing companies coming close to the university. Such examples include a Novartis research centre in Cambridge (MA) or other pharmaceutical subsidiaries located close to the University of Pennsylvania and related hospitals.

Empirical studies focusing on formal cooperation between academic research and firms measure a positive impact of cooperation. However, they suggest that national and local conditions are important to explain the size of this impact of public-private cooperation in terms of innovation. In Japan, cluster participants apply for more patents than others without reducing patent quality when they collaborate with national (ie excellent) universities, but not when they simply cooperate with universities in the same cluster (Hishimura and Okamuro 2011).

In both Germany and France, public-private cooperation has a positive impact on the share of new products in turnover, but that impact is substantially stronger in Germany. In both countries public-private cooperations to innovate have increased during the 2000s, but the performance of these cooperations has remained higher in Germany (Robin and Schubert 2013).

Overall, the available empirical studies suggest that large firms, including in particular MNEs, systematically identify partners for their open innovation practices. With respect to exploration activities, they carefully identify the most relevant academic partners. When local academic partners generate high impact research, they can easily benefit from a close relationship. Otherwise, they have the resources to identify better academic sources and to cooperate with them. The following section discusses the case of international cooperation.

## 3. International cooperation for innovation: rare and efficient

As a number of contributions on the economics of innovation have shown, geography matters. Cooperation for innovation is no exception. The higher propensity to cooperate with national rather than foreign partners is very general, even if the overall propensity to collaborate varies substantially across countries (OECD 2013b). For EU companies, the share of the extra-European collaborations is lower than the share of the intra-European collaborations (OECD 2008a). Indeed, the international economic relationships are always more costly and uncertain, and even more so when they are distant. However, cross-border R&D collaborations, including distant ones, tend to have a high impact on firms' innovative performance.

Herstad. e*t al* (2008) measures a positive impact of international collaborations with customers or suppliers on the propensity to innovate for firms from Northern Europe. This impact is stronger and more constant than that of the national collaborations and of the international collaborations with competitors.

At the end of the 1990s, while French companies had relatively few transatlantic R&D collaborations, these were concentrated in high-tech sectors and often aimed at accessing new resources in order to remove technological obstacles (Miotti and Sachwald 2003). Conversely, according to firms' answers in the CIS survey, collaboration with EU partners seemed rather aimed at sharing R&D costs. Insofar as international partnerships are more costly and difficult to manage, companies that use them are strongly motivated and demanding with the distant partner. On average, French firms with international partnerships to innovate tend to have more extensive cooperation networks than other firms (Dhont-Peltrault 2005). They are more concentrated in high-tech sectors. The motivations that most consistently explain the choice of a foreign partner are complementarity in terms of competence and reputation, market access being a weaker determinant (Thévenot 2007).

An evaluation of the impact of the Japanese cluster policy provides symmetrical findings (Hishimura and Okamuro 2012). Their results suggest that participation in a cluster project alone does not affect R&D productivity. Moreover, research collaboration with a partner in the same cluster region decreases R&D productivity both in terms of the quantity and quality of patents. The authors concluded that in order to improve the R&D efficiency of local firms, it was necessary go beyond clusters, which tend to focus on the network at a narrowly defined local level.

The case of Norway illustrates the effectiveness of innovation through long-distance knowledge exchange in the case of isolated areas (Fitjar and Rodriguez-Pose 2011). The level of innovation of enterprises in this country has managed to remain high, despite a number of evident disadvantages. The Norwegian context is characterised by the presence of relatively small cities, distant between each other and located far from the economic core of Europe. The concentration of enterprises in these urban centres is not sufficient to give rise to externalities and knowledge circulation typical of large agglomerations. However, Norwegian cities have been able to maintain their innovativeness through the development of international connections between the local industry and foreign firms. The number of enterprises' international partners is positively associated with their innovative capacity, and process, product and radical innovations have tended to come especially from those firms which have set up connections outside their clusters and immediate geographical surroundings. On the contrary, regional cooperation does not impact radical innovation. Thus, international collaborations have helped businesses to acquire new knowledge, which has been in turn diffused within Norwegian clusters and local innovation systems.

The positive impact of geographical distance may be related to technological distance and quality. Based on more than 900 alliances from 116 companies between 1986 and 1997, Nooteboom *et al*. (2007) showed that innovation performance as measured by patents increases with the technological distance between partner companies up to a point and then decreases (in an inverted U-shaped relationship). This positive relationship was found stronger for firms engaging in more radical exploratory alliances than in exploitative alliances. In other words, companies engaging in more radical innovation projects benefit more strongly from alliances with partners with a very different technological profile.

Distant knowledge may be superior to that available locally either because it is different and complementary or because it is of better quality. As a result, academics and innovative firms, in particular MNEs, tend to search and exchange knowledge on and international scale. They develop cognitive, organisational or institutional proximity that can at least partially substitute for geographical proximity as a facilitator of knowledge interactions (Boschma 2005).

GINs are precisely designed by companies to tap into distant knowledge pools and to exploit knowledge around the world. Given the global configuration of academic communities their involvement in GINs improves the performance of international cooperations. Dornbusch and Neuhäusler (2013) have shown that cooperation with academic researchers is particularly efficient in the context of international cooperation.

## 3. Policy implications of GINs

This paper focuses on the internationalisation of R&D and the development of GINs. It shows that GINs interact with GVCs as both types of network organise a global division of production processes. As a result, policy implications of GVCs and GINs are partially related.

A recent European study identify "multiple mode firms", which organise complex GVCs, combining importing of components, offshoring to subsidiaries or internationally outsourcing certain parts of the value chain and exporting finished or semi-finished goods (Veugelers *et al*. 2013). These multiple mode firms are relatively few, but they are among the largest and are trade intensive. As a result, they drive total trade flows in most sectors. Based on a large sample of firms from European countries, the study shows that multiple mode firms also display the highest productivity premia and are significantly more likely to introduce product innovations. It provides evidence that the firms that take on the opportunities of global market access, and which source resources globally, are well placed to be the engines of Europe's innovation-based growth and to drive its external competitiveness on the basis of globally sustainable comparative advantage.

Our analysis also suggests that multinationals with complex GVCs are also those with the most sophisticated GINs and high innovation performance. Results from recent studies on these firms' global networks of innovation and production suggest a number of policy implications. In particular, they suggest that policy makers have to take into account the position of the local innovation system they aim at upgrading within GINs.

1. **Improve the knowledge of GVCs and GINs**

Given the role of GVCs and GINs in contemporary economies and in the dynamics of innovation and growth, it matters for policy makers to better understand the firms involved and their interactions with home economies.

Firstly, knowledge on GVCs and GINs is still hampered by data problems. In the case of GINs, data on foreign R&D location by multinationals is missing in most national statistics. Data are particularly scarce for service sectors and insufficiently reliable for emerging countries, despite their increasing role in GINs (EU 2012).

Secondly, more firm-level analysis is needed, particularly to trace the performance of GVC-involved firms over time in order to better identify the causal relationship between internationalisation and performance: do firms need to be strong before they can benefit from the opportunities offered by engagement in GVCs and GINs, or does international engagement make firms stronger and more innovative? Or both, resulting in a virtuous circle? Beyond these broad questions, more detailed studies should be able to examine better the different types of GINs and their dynamics. Empirical work on the different types of R&D centres and their relationships to local innovation systems should go beyond the typology presented in this paper. From a policy point of view such more precise typologies should allow countries and regions to clearly identify their positions in GVCs and GINs so as to best take advantage of their engagement in global networks. In the case of EU policies, such better knowledge of GVCs and GINs is important for example to implement smart specialisation.

2. **Strengthen internal capabilities and promote relevant partnerships**

Companies that build GINs and open innovation practices nurture their in-house R&D capabilities in which they continue to invest in a selective but sustained way. In particular, companies that cooperate with academic research also invest in internal R&D capabilities and maintain a broad portfolio of partners to innovate.

The success of open innovation also depends on the quality of the firms' partners, including academic research. Openness of the innovation process to academic research represents an asset for companies, which have progressively identified and selected partners to conduct exploration activities. Open innovation has contributed to elaborate comparisons of academic research organisations including abroad. Cross-border public-private partnerships and the increased knowledge about foreign organisations contribute to reinforcing the selection process at the national level and to promoting the quality and the relevance of public research.

As an answer to companies' need for cooperation to innovate, policies have fostered various types of partnerships, including with financial incentives. The objective however should not be to promote partnerships as such but rather as a tool to stimulate innovation. As a consequence, policies should promote the right partnerships. For example, collaboration with academic research does not seem efficient for process innovation.

In the case of exploration partnerships aiming at radical innovation funding criteria should be centred on scientific excellence and innovative character. Conversely, conditionality based on institutional characteristics or on the geographic origin of partners may lead to the choice of projects of lesser quality. Such considerations are important both national and EU policies.

### 3. Develop local attractiveness for R&D activities

Attractiveness has moved up the public policy agenda, but like competitiveness, it has several facets and doesn't depend on one single public policy. Strengthening a country's or region's attractiveness for R&D activities implies first to understand the determinants of their location. The typology developed above suggests that countries should try to attract different types of R&D units depending on their more general position within GVCs.

Emerging countries attract a large number of the new R&D centres of multinational companies as their markets are expanding. The growth differential between emerging and more advanced countries will persist during the catch-up period. However, European countries can improve their attractiveness for LDCs in some high-tech sectors or niches. In this perspective, policies should stimulate the dynamism of local markets of these industries, which does not only depend on research or innovation policy in a narrow sense. Countries that develop leading markets for new products or services, become attractive for production and R&D capabilities in these sectors, including for foreign firms.

As for technology sourcing, the United States appears more attractive than the EU as a whole. European countries can increase their attractiveness for GRLs by strengthening their research capabilities and the efficiency of open innovation practices, at the national and European level. As seen above, this largely depends on the quality of the scientific and technological supply. In turn, this implies that European researchers and centres of excellence are connected to international networks. Similarly, local companies can upgrade their innovative capabilities by developing GINs and participating to international R&D projects.

In this context, attractiveness policies are facing a paradox: they have been designed to promote a national territory, but their full success may also depend on measures in favour of the internationalisation of some local companies. Indeed, insofar as GINs and technology sourcing benefit local companies, governments could consider supporting some of these strategies. GINs should also be taken into consideration for the promotion of start ups. R&D intensive start-ups are being supported as part of strategies to upgrade local ecosystems. But they often need global connexions and are part of an attractive environment for foreign companies.

### 4. Connect clusters through pipelines

Knowledge and technological capabilities are not evenly distributed, but globalisation and efforts of the emerging countries diversify the competence centres and create various links between poles of excellence. The latter are both clusters of knowledge accumulation and nodes of exchange.

Agglomeration effects coexist with firms' growing capability to identify and use knowledge from distant origins. As we have seen, firms may resort to various channels of international technology transfer and sourcing. International knowledge transfers take place within multinationals' GINs, but also generate spillovers. Griffith *et al*. (2007) have showed that the home bias of international knowledge spillovers as measured by the speed of patent citations across international boundaries has been decreasing during the 1980s and 1990s. At the end of the 1990s, they estimated that there was practically no home bias for the more modern sectors such as pharmaceuticals and information/communication technologies

In this context, public action must adapt some of its tools and, more fundamentally, modify some of its perspectives. Since the 1990s, analyses in term of national innovation systems have strongly influenced public policies. This influence is particularly visible in a growing interest for the interactions between public research and private research, as well as for the innovation eco-systems and the promotion of research and innovation clusters. Cluster policies emphasise the promotion of the interactions within local innovation ecosystems. They are part of a more general policy trend in favour of multi-actor and multi-sector projects, aiming at strengthening technology transfer and innovation capability. They also tend to be modelled after the success of large urban agglomerations as major as major catalysts for innovation and productivity.

In small and/or peripheral areas, policies aimed at generating industrial clusters among local actors may foster resource concentration and an increased visibility of the local innovation systems. However, excellence and international visibility also depend on connections to global networks that must be developed both by the cluster and by individual actors. Clusters that focus on local cooperation may be most efficient at supporting incremental innovation. They also can to lead to short-living networks incapable of guaranteeing long-run upgrading. In these contexts knowledge exchange at large distance through the creation of external connections and bridges to GINs is likely to be at least complementary to cluster policy in order to overcome the lack of diversity and the risk of lock in. The best performing eco-systems are connected to the right actors and networks around the globe. Clusters should in particular offer efficient interfaces with international partners. This role may be particularly important for SMEs, which face more difficulties to cooperate for innovation, including internationally.

## References

Almeida P., 1996, « Knowledge sourcing by foreign multinationals : patent citation analysis in the U.S. semiconductor industry », *Strategic Management Journal*, vol. 17.

Branstetter, L., L. Guangwei and F. Veloso, "The rise of International Co-invention", The Changing Frontier: Rethinking Science and Innovation Policy, NBER conference, 2-3 August.

Bartlett, C. and S. Ghoshal, 1989, *Managing Across Borders*, Harvard Business School Press.

Belderbos, R., B. Leten and S. Suzuki, 2009, "Does Excellence in Academic Research Attract Foreign R&D?", UNU-MERIT Working Paper Series 066, United Nations University

Bercovitz, J. and M. Feldman, 2007, "Fishing upstream: Firm innovation strategy and university research alliances", *Research Policy*, Vol. 36, p. 930-48

Boschma, R., 2005, "Proximity and Innovation: A Critical Assessment", *Regional Studies,* 39, 61-74.

Cincera, M., C. Cozza and A. Tübke,.2010, *Drivers and policies for increasing and internationalising R&D activities of EU MNEs*, JRC-IPTS Working Papers on Corporate R&D and Innovation.

D'Agostino, L., K. Laursen and G. Santangelo, 2013, "The impact of R&D offshoring on the home knowledge production of OECD investin regions" *Journal of Economic Geography*, 13(1): 145-175.

Dhont Peltrault, E. and T. Pfister, 2008, *Les coopérations public-privé pour innover en France*, Note d'Information, DEPP-MESR.

Dornbusch, F. and P. Neuhäusler, 2013, *Academic knowledge as a dirver for technological innovation, Comparing universities, small and large firms in knowledge production and dissemination*, Fraunhofer ISI Discussion paper 37.

Doz, Y., Santos, J., Williamson, P., 2001, *From Global to Metanational: How Companies Win in the Knowldege Economy*, Boston: Harvard Business School Press

EU, 2012, *Internationalisation of business investments in R&D and analysis of their economic impact*, European Commission.

EFI, 2013, *Research, Innovation and Technological performance in Germany*, Commission of experts for Research and Innovation, www.e-fi.de

Fitjar, R. D. & Rodríguez-Pose, A. (2011) When local interaction does not suffice: Sources of firm innovation in urban Norway, *Environment and Planning A*, 43(6), pp. 1248–1267

Fontagné, L, and A. D'Isanto, 2013, « Chaînes d'activité mondiales : des délocalisations d'abord vers l'Union européenne », *Insee Première,* INSEE*,* June*.*

Griffith, R., R. Harrison and J. Van Reenen, 2006, "How special is the special relationship? Using the impact of US R&D spillovers on UK firms as a test of technology sourcing" *American Economic Review*, 76 (5), pp. 1859-1875

Griffith, R., S. Lee and J. Van Reenen, 2007, *Is Distance Dying at Last? Falling Home Bias in Fixed Effects Models of Patent Citations*, Centre for Economic Performance Discussion Paper 818.

Guellec, D. and G. Thoma, 2008, *The regional impact of university inventions on industry*, OECD report to the French Ministry of Economy, Draft.

Hausman, N., 2012, University innovation, local economic growth, and entrepreneurship, Center for Economic Studies, U.S. Census Bureau

Harhoff, D., E. Müller and J. Van Reenen, 2012, What are the Channels for Technology Sourcing? Panel Data Evidence from German Companies**.**

Hedge, D. and Hicks, D., 2008, 'The maturation of global corporate R&D: Evidence from the activity of U.S.foreign subsidiaries', *Research Policy*, 37(3), pp. 390-406.

Herrigel, G., 2013, *Recent Trends in Manufacturing Globalization and Their Effects on the Distribution of R&D, Design, and Production within US, German and Japanese Automobile, Electro-Mechanical, Machinery and related Component MNC*s, Report to the European Commission

Hishimura, J. and H Okamuro, 2011, "Subsidy and networking: The effects of direct and indirect support programs of the cluster policy," *Research Policy*, vol. 40(5), pages 714-727

Huggins, R, H. Izushi and D. Prokop, 2010, University-industry networks: Interactions with large R&D performers, DRUID 2010

Iwasa T. and Odagiri H., 2004, « Overseas R&D, knowledge sourcing and patenting: an empirical study of Japanese R&D investment in the US », *Research Policy*, vol. 33, n° 5.

Kogut, B. and U. Zander, 1992, *Knowledge of the firm, combinative capabilities and the replication of technology*, *Organization Science*, 3, p. 383-97

Laursen, K. and A. Salter, 2004, "Searching high and low: what types of firms use universities as a source of innovation?" *Research Policy*, vol. 33, p. 1201-15.

Motohashi, K. and S. Muramatsu, 2012, "Examining the university industry collaboration policy in Japan: Patent analysis", *Research Policy*

Miotti, L. and F. Sachwald, 2003, "Cooperative R&D: why and with Whom? An Integrated Framework of Analysis, » *Research Policy* 32, 1481–99.

Nooteboom, B., W. Van Haverbeke, G. Duysters, V. Gilsing and A. Van den Oord, 2007, "Optimal cognitive distance and absorptive capacity", *Research Policy* 36, 1016-34.

OECD, 1999, *STI Scoreboard 1999*

OCDE, 2007, *Competitive Regional Clusters National Policy Approaches,* OECD Reviews of Regional Innovation

OCDE, 2008, *Open Innovation in Global Networks*

OECD, 2011, *STI Scoreboard 2011*

OECD, 2013, *Take advantage of interconnected economies*

OECD, 2013b, *STI Scoreboard 2013*

Robin, S. and T. Schubert, 2013. "Cooperation with public research institutions and success in innovation: Evidence from France and Germany", *Research Policy*, vol. 42(1), 149-166.

Sachwald, F, 2001, *Going multinational. The experience of Korea with direct investment*, (ed.), Routledge

Sachwald, F. and E. Chassagneux, 2007, «Les facteurs de localisation des centres de R&D à l'étranger : le cas de l'Europe», *Economie et société*.

Sachwald, F., 2008, *Location choices within global innovation networks: the case of Europe*, *Journal of Technology Transfer*, 33: 364-78.

Sachwald, F., 2011, « Internationalisation des activités de R & D et politiques publiques », *Les Cahiers Français*, La Documentation Française, pp. 50-55.

Thévenot, C., 2007, « Internationalisation des réseaux de R&D: une approche par les relations d'entreprises », *Economie et Statistique*, 405/406, p. 141-62.

Thursby, J., M. Thursby, 2006, *Here or There? A Survey on the Factors in Multinational R&D Location*, National Acacdemies Press, Wahsington D.C.

Veugelers, R., 2013, *Manufacturing Europe's future*, ed., Bruegel Blueprint Series.

UNCTAD, 2005, *World Investment Report 2005*.