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Global networks of open innovation, national systems and public policies

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This study is made available to the public as part of a programme of work aimed at improving knowledge of firms' innovation practices, which are evolving rapidly in response to technological and business dynamics and increasing global R&D capabilities. A good understanding of these phenomena is important for those in charge of public policies, for researchers themselves and for other actors in the French research and innovation system.

The sequence of this study is described in an annex. Its publication implies no commitment by the French State to the detailed analyses. Comments will be welcomed by the author, Frédérique Sachwald, Head of Business R&D unit at the French Ministry of Higher Education and Research, (frederique.sachwald@recherche.gouv.fr).

Summary

Open innovation, a new paradigm that makes R&D investments by companies and society more profitable.

The concept of open innovation places emphasis on the growing importance of external innovation resources, as opposed to resources that are internal to the company, in particular its own R&D capabilities. As a new paradigm, open innovation treats openness as a strategic response to the evolving constraints on innovation. Through more systematic and organised “openness,” the company aims to maximise the effective use of its internal innovation capabilities by taking greater advantage of external inputs. It also aims to gain greater benefits externally from internal projects that no longer reflect the company’s strategy. From the company’s standpoint, in-house capabilities such as R&D are put to better use. From society’s standpoint, open innovation offers a vector for valorising research investments, through an increased diffusion of knowledge between academia and companies, but also between companies.

Companies use different tools and different types of partners to access these external competencies along the innovation process. During the phase of exploration, research partnerships complement in-house R&D capabilities. When they identify patents corresponding to their needs, firms can buy licenses to complement their technology portfolio. Companies put in place processes to monitor and identify external projects of potential interest and they can follow their growth through venture capital investments. They can then take control of a newly-created company after the interest is confirmed.

Open innovation allows firms to access a much wider range of knowledge and ideas than the in-house capabilities can generate. Openness to external inputs can reduce the cost, and accelerate the process, of innovation. More fundamentally, openness may allow firms with established markets and technologies to achieve successful radical innovation when incremental innovation is insufficient to keep up with the competition. It is indispensable in situations where firms must review their strategy, particularly when this leads to much more intimate integration of products and services.

The globalisation of open innovation networks increases firms’ ability to access different knowledge sources and environments. Global networks can thereby become powerful vehicles for knowledge hybridisation or for reducing the cost of innovation.

Dissemination of open innovation practices

After declining up to the 1960s, when large companies were developing their central laboratories, R&D outsourcing started to increase again in the mid 1970s. However, there are no official statistical series that precisely document long-term trends across different countries.

The available data do show growth of outsourced R&D, but the phenomenon varies widely according to the sector and size of the company. Large companies and high-tech companies tend to outsource a larger share of their spending, but individual strategies play a role too. In the mid-2000s, taken at the national level, the average share of R&D spending that was outsourced was

generally less than 10%, but slightly higher in some countries. This relatively low figure for R&D outsourcing does not adequately account for all aspects of open innovation. Firstly, this is because openness relates to the innovation process as a whole and not just R&D. Secondly, the openness of the innovation process is larger during the exploratory phases, when research activities are less costly, than during the applied research or development phases.

The numerous types of R&D cooperation and external sources of information that firms use to innovate also illustrate the development of open innovation practices. Firms can develop capabilities to access technologies through start-ups, through various forms of venture capital operations, and through expanding markets for technology.

The opening up, particularly towards academic research, stimulates firms' innovation capability

Various surveys in European countries on firms' innovation practices suggest that firms that have adopted open innovation processes achieve better results, both in term of new products and in term of the turnover achieved by these products. The best results seem to come from firms that collaborate with many partners and use diverse channels of information to support innovation.

Firms' most frequent innovation partners are their own customers and suppliers. Academic research organisations are much less frequent partners, although various indicators and case studies show that they play a specific and important role during the exploratory phase. Only a small number of firms cooperate extensively with academic research. They are concentrated in a few industrial sectors: chemistry, pharmaceuticals, machinery, transport and electrical and electronic equipment. The companies that cooperate most with universities also tend to nurture substantial in-house R&D capabilities and have adopted open innovation practices. Thus, companies that cooperate with universities are those having the more ambitious innovation strategies and are the more likely to obtain radical innovations. They combine internal and a diversified range of external resources to innovate.

Internationalisation of innovation networks is largely driven by market access and increasingly by access to scientific and technological resources

Since the 1990s, the trend towards the internationalisation of R&D activities has accelerated and companies have set up R&D centres within a growing number of countries. Since the start of the millennium, these installations have been particularly numerous in the emerging economies as these became more attractive for R&D.

Many surveys and company case studies suggest the same general hierarchy of criteria for setting up R&D centres, namely access to market as first factor, followed by access to human and technological resources, then access to low cost resources. Detailed analyses show that each of these criteria has particular importance for certain types of R&D centres: local market for development and product adaptation centres, scientific and technological resources for global research laboratories and low salaries for testing centres or other operations with a strong need for technical personnel.

The dynamics of innovation networks becomes more and more comparable to that of production networks, with units having differentiated and evolutionary functions. R&D centres that are located abroad are combined with international collaborations, including with foreign academia, to establish global open innovation networks.

Exploratory activities are open and global, development activities are internal and local

The degree of openness and internationalisation varies along the innovation process. Those R&D centres that focus on exploration and research activities adopt a global and open perspective. Conversely, local development centres are close to markets and production units in order to adapt the company's supply to local specificity. These centres are largely supported by the technological capabilities of the parent company and are less open to the local scientific environment.

French companies develop global open innovation networks

Although they were not the first in the field, French companies have adopted open innovation practices in recent years. They had already begun the internationalisation of their R&D activities by the 1990s. French companies have thus been developing towards global open innovation networks for some years. While these networks remained largely centred on Europe and, to a lesser extent, the USA until the beginning of the 2000s, they now include emerging economies.

The motivations for, and the shape of, the innovation networks of French companies are similar to those of their counterparts, with in particular the strong attraction of dynamic markets on the one hand and a presence in certain global clusters of excellence on the other hand. As a result, the innovation networks of French companies are now more internationally spread and more flexible.

The innovation networks of French companies include the same types of partners as their foreign counterparts. The ease with which they cooperate in order to innovate is nevertheless rather modest compared to those in other countries, and there is a large gap between SMEs and large corporations. Furthermore, among firms that cooperate to innovate, relatively few do so with academic research. Yet, although cooperations with public research are relatively limited, the positive impact of these collaborations on firms' innovation performance is the same as in other countries. In particular, companies that cooperate with academic research typically introduce more new products onto the market and draw significant turnover from these products.

Implications for research and innovation policies

Since the 1980s, research and innovation policies have evolved progressively in response to a changing environment. The adoption of a "national innovation systems" perspective resulted in a growing interest for interactions between public and private research, for eco-systems of innovation and for the promotion of clusters. The internationalisation of companies' R&D has also resulted in the introduction of a range of measures aimed at increasing individual countries' attractiveness for such activities.

While the advent of the open innovation paradigm does not fundamentally change public policy recommendations, it points out more clearly any weak points in the national systems. Open innovation thus represents an additional incentive to develop effective national research and innovation strategies. The analysis of the global open innovation networks allows the formulation of six recommendations in this perspective.

First, the success of open innovation practices relies on strong actors. In other words, the success of collaborations and exchanges along the innovation chain depends primarily on partners' qualities and strengths. Companies with the most sophisticated cooperation practices are also those which nurture strong capabilities in-house. The same companies seek the best

global partners, in particular for their exploratory activities and their radical innovation projects. Thus, public policies should simultaneously and efficiently support business R&D and promote excellent academic research.

Second public policies can stimulate the development of openness infrastructures. Technology transfer should be considered as a major component of these openness infrastructures.

Third, since firms spontaneously collaborate to innovate, public policies target the more efficient types of collaborations for addressing these policies' objectives. The dynamics of open innovation networks emphasise the extent to which companies seek cooperations and make efforts to identify the right partners and find the right forms of collaboration for each of their objectives. For example, some companies have reorganised their relationships with academic research by selecting institutions on a global basis in order to explore fundamental issues. As an answer to companies' need for cooperation, 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.

Fourth, cluster policies must take into account the development of open innovation networks. Clusters emphasise the effects of agglomeration and local interactions between innovation actors. Clusters that stimulate local cooperation can efficiently support incremental innovation, which typically represents a very significant share of the innovation activity. Those that promote research excellence and international visibility need to be connected to relevant global networks.

Fifth, supply policies supporting firms' innovation capability could be complemented by policies aiming at stimulating demand for innovation. Companies' practices stress the importance of market demand in the organisation of the innovation processes as well as in the choice of location for R&D activities. In high wage countries, companies' R&D activities will partly depend on the development perspectives of new markets, particularly to face the challenges of ageing and environment.

Debates on the stagnation of R&D intensity in Europe have suggested that production structures should evolve. It is not plausible to expect that a country's R&D intensity will increase significantly solely through increases in the R&D spending of mature firms, because their investments already reflect the sectors in which they operate. New R&D investments and the most promising innovations often come from young firms showing strong growth within new markets. Open innovation can help large companies to make radical innovations and succeed on new markets. But the development of these depends largely on new innovative firms, for which access to markets are vital.

Finally, a national research and innovation strategy must be based on a good knowledge of firms' innovation networks and of the impact that policies can have on their organisation and efficiency. Since the local and global context of innovation will continue to change, increased observation capabilities will be required in order to design and evaluate public policies.

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Introduction

As globalisation and acceleration of technological progress have strengthened competition, innovation has become one of the key determinants of companies' competitiveness, particularly for those based in high wage countries. In the last twenty years, innovation has thus become more necessary, more demanding and more constrained. At the same time, formidable advances in information and communication technologies, combined with the evolutions that underlie globalisation, offer more and more opportunities to access the ideas and resources that help generate innovations. As a result and despite a number of difficulties, the international dissemination of knowledge seems to accelerate, particularly in high-tech sectors (Griffith *et al.* 2007).

Companies have gradually responded to these combined challenges and opportunities by re-engineering their innovation process. Firms have developed various types of cooperation agreements in research since the late 1980s. The internationalisation of R&D activities gathered speed in the 1990s onwards, and, since the mid-2000s, the development of scientific and technological capabilities in the emerging economies has resulted in the development of truly global networks of innovation.

Beyond these general tendencies, companies have reacted according to their strategic position, to the intensity of competition they faced, and to their specific histories. Nevertheless, since the beginning of the century, the organisation of innovation process of a large number of companies has evolved dramatically. The concept of *open innovation* encapsulates a number of these developments and has been presented by its promoters as a paradigm change (Chesbrough 2003, Chesbrough *et al.* 2006). It emphasises the fact that companies now complement their in-house R&D capabilities with various, carefully selected external sources.

Access to new resources can accelerate the innovation cycle and reduce its cost. The adoption of an open innovation strategy can also allow companies to launch new markets where they would be in leading positions. Combined with the internationalisation of R&D, this trend can generate efficient global networks of open innovation. From the point of view of the countries concerned, the development of open innovation can improve the process of technology transfer from those parts of academic research on which companies rely more systematically during the exploration phase of their R&D.

This report draws on recent statistical studies and analysis of firms' experiences to assess the dissemination of open innovation practices, their impact on firms' performance and the implications for public policies¹. Open innovation requires a better integration of both internal and external components of the firms' innovation processes – both for the individual company and for the national research and innovation system.

¹ Appendix 1 explains the process of information gathering in the companies approached.

1 The development of global networks of open innovation

The concept of open innovation provides a consistent framework for analysing a series of recent developments in firms' innovation processes. It suggests that the combination of these developments results in a paradigm change in the organisation of innovation.

This first section explains the concept of open innovation (1.1) and draws on recent empirical studies to assess its diffusion and its impact on firms' performances (1.2). Open innovation interacts with the internationalisation of R&D activities to generate global innovation networks (1.3). As in the case of global production chains, firms tend to develop specific innovation processes according to their sector and strategic positioning. Radical innovations tend to require both a more open and a more global organisation than incremental innovations (1.4).

1.1 Open innovation as a new paradigm

Outsourcing of certain R&D operations and cooperating in order to innovate are not new phenomena, but they have become more important and more sophisticated over the last twenty years. Central laboratories conducting research for an entire company began to emerge at the end of the XIXth century. They underwent a period of dissemination and expansion up to the 1960s, with a result that, at the beginning of the 1970s, the level of sub-contracted R&D by large companies had become very low (EIRMA 2005). During the next two decades, the share of externalised R&D increased noticeably, including through various types of cooperations. R&D partnerships can be bilateral, but broader networks have developed progressively, first in information and communication technologies (Gomes-Casseres 1996) and then in other sectors.

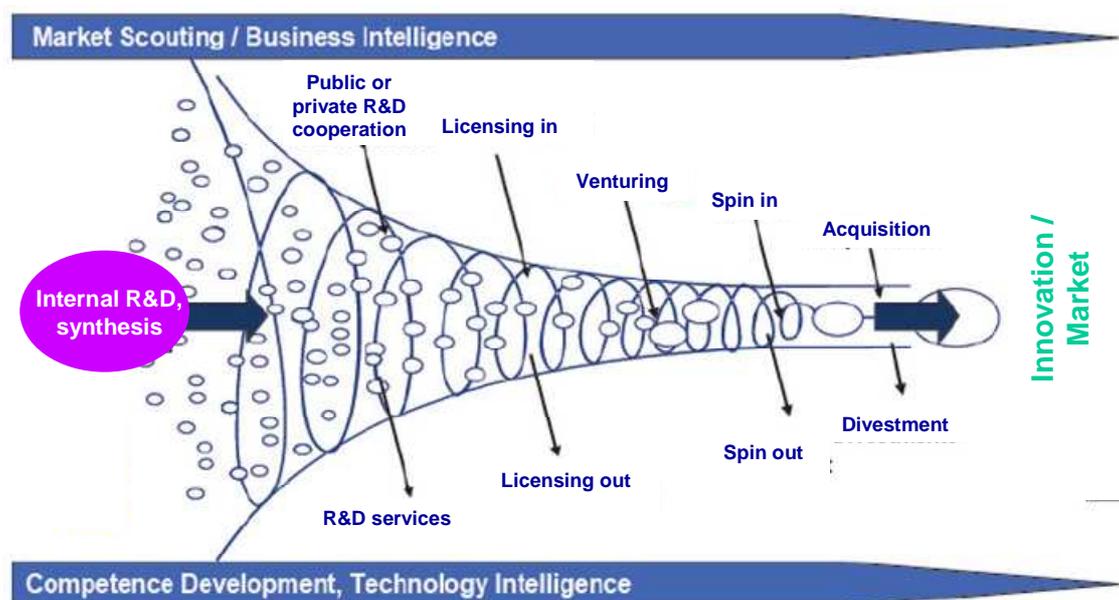
New knowledge is generated through the combination of disciplines and the reconfiguration of fields of expertise. Companies draw on the synthetic knowledge bases provided by generic technologies, and on specialist knowledge acquired from experience and interactions with customers and suppliers. As the relevant knowledge bases have become more complex and dynamic, companies have increasingly turned to external sources of information and ideas.

The emphasis that the concept of open innovation puts on the open nature of the R&D process can be interpreted as recognition of the growing importance of external sources of innovation, as opposed to firms' internal capabilities. But the concept goes much further, by making openness a strategic response to changes occurring in the economic and technological context of innovation (Chesbrough 2003). Openness is now an integral part of these firms' approach to innovation. Their frontiers have become more permeable to both the import of new concepts from outside and the export of technologies to partners with business models that are better suited to commercialise a given technology. Open innovation aims to optimise the use of internal innovation capabilities by complementing them with external inputs, but also by finding returns outside for those projects that no longer correspond to the firm's strategy. Investment in R&D capabilities could thereby become more profitable, even when the capabilities have not generated new products or services for the firm's existing markets.

As illustrated in figure 1, firms use a range of tools to access a broad array of knowledge sources. In some situations, research partnerships are used to complement in-house R&D capabilities

with specific competences. In other cases, collaboration is aiming at cost and risk sharing. Partners are selected depending on the precise objectives pertaining to the firms' needs (Miotti and Sachwald 2003). Firms also buy licenses during the process when they identify patents corresponding to their needs. A company can also identify potentially-interesting external projects and follow closely their evolution through venture capital investments. Finally, companies can buy a more mature firm when they consider that its competences are necessary or particularly promising.

Figure 1. Open innovation tools in the innovation process



Source: Adapted from de Jong (2007)

Figure 1 highlights the two directions of open innovation practices. Inbound open innovation can be measured by examining the extent of R&D collaboration (private-private and public-private), licensing in, venturing and acquisitions. Outbound open innovation may include licensing-out, the provision of R&D services, spinouts and divestments.

The profitable practice of these outside-in and inside-out transactions implies an appropriate internal organisation and a favourable environment. For example, Chesbrough (2003) emphasised the role played by the large venture capital market in the United States for the development of open innovation. This active market has generated a continuously-renewed stock of start-ups available for acquisition; and their very existence has influenced the way large companies envisage their own technological renewal and their entry on new markets. Similarly, the systematic use of licensing-in and -out depends on the development of the markets for technology, which in turn requires a favourable environment in terms of intellectual property and information. These interactions between the firms' organisation and the characteristics of the ecosystem are particularly important for public policies². The characteristics of the ecosystem can explain the extent of the diffusion of open innovation practices, either among large companies or SMEs. The latter are affected due to their relationships with their customers, but

² See part 3 of the report.

also as they adopt open innovation strategies themselves³.

Figure 2 suggests that companies should also choose modes of open innovation in relation to their competences and absorption capacities. For a well-known technological field or market, the company can depend upon its in-house capabilities or acquire a sizeable company. It will indeed have the capacities to integrate the new entity. Conversely, as the company ventures into markets for which it lacks technological or marketing skills, it must turn to partnerships. If a company ventures in fields where it has few resources, it must accept that it is dealing with partners that remain independent. They will take on their share of the risk attached to the project, but will also share the potential profits. In the case of venture capital, companies can choose to create an internal unit, or to invest through external funds. Both potential risks and potential profits are higher in the first case.

In those cases where a firm seeks to develop through radical innovation or by moving into a very different field, partnerships with public research can be necessary to provide the scientific and technical component of the project. The precise choice of the partners in these types of cases (right column in figure 2) will depend on the time horizon of the project but also on the environment, particularly the existence of potential targets or the capability to negotiate a good relationship with the public research. In extreme cases (North-east box of the figure), the firm will probably have to invent a new business model involving multiple partnerships upstream and downstream.

Figure 2. Modes of development and innovation in relation to the firm’s knowledge portfolio

Market knowledge	<i>Unknown market</i>	Joint Venture Cooperation agreement	Venture capital Start-up acquisition	Venture capital Start-up acquisition Agreement with academic research
	<i>New but familiar market</i>	In-house R&D Acquisition Joint Venture	Internal incubation Acquisition Licensing-in	Venture capital Start-up acquisition Agreement with academic research
	<i>Original market</i>	Internal R&D Acquisition	Internal R&D Acquisition Licensing-in	Joint venture Cooperation agreement Agreement with academic research
		<i>Core technologies</i>	<i>New but familiar technologies</i>	<i>Entirely new technologies</i>
Technological knowledge				

Source: adapted from Roberts and Berry (1985)

In certain intermediary situations, the company can attempt to keep control through acquisitions, for which integration may nevertheless be risky. Symmetrically, an internal venture created to develop a radical innovation risks lacking sufficient independence within a large company. Certain companies thus implement specific structures, first for incubation and then for integration into a business unit. For example, at the beginning of the 2000s, Degussa

³ A recent study outlines the development of Dutch SMEs’ open innovation practices – particularly those with more than one hundred employees (van de Vrande *et al.* 2008).

progressively generated innovations in the field of nanomaterials, which eventually allowed the company to renew part of its portfolio (Maine 2008).

Open innovation allows firms to access a much broader scope of knowledge and ideas than could be generated by its in-house R&D capabilities. It can also substantially reduce the cost of innovation, whilst accelerating the process. Lastly, it can enable companies with mature markets and technologies to succeed in radical innovations rather than focusing exclusively on incremental innovations.

Open innovation however imposes exacting implementation conditions. In particular, firms must identify the right partners for each objective along the innovation cycle. Upstream, as suggested in figures 1 and 2, firms should open wide windows on the external world. As projects get through the different selection barriers, investment tends to increase, partners are less numerous and transaction modes become more formal. The ability to benefit from openness implies identifying the right partners and negotiating the right mode of cooperation. Finally, interactions with partners and absorption of external inputs require an appropriate internal organisation. These success criteria may explain why open innovation has only developed progressively and remains unevenly disseminated across sectors and countries.

1.2 Open innovation diffusion and impact

The share of R&D outsourcing provides a simple indicator of inbound open innovation. After a decrease until the early 1970s, outsourcing increased perceptibly (EIRMA 2005). However, there are no comprehensive statistical series that follows its evolution long term and across different countries. Surveys among the top EU R&D-investing companies measured an increasing outsourcing rate⁴. An exceptional figure of 30% was recorded in 2007, although this value was sample-dependent and 18% seems a better estimate of the situation during the late 2000s. Companies from sectors such as pharmaceuticals and ICT tend to outsource more R&D. Two-thirds of outsourced R&D goes to other companies and one-third to public research organisations. An OECD survey (2008) completed by sixty companies indicates that 80% of them outsource less than 20% of their R&D expenses. Fewer than one in three outsources more than 10% of its R&D budget. Companies have generally reported little change over the last five years, but outsourcing has increased in some cases.

Surveys among representative samples of firms indicate lower outsourcing rates. At the beginning of the decade, outsourced R&D spending was 5% in Austria, 8% in Belgium, 10% in Denmark and 12% in Norway (Herstad *et al.* 2008). Such figures are close to the share of R&D expenses outsourced to non affiliated companies in national statistics (DERDE). Indeed, outsourcing to independent local or foreign subcontractors and to academic research represent generally less than 10% of the business R&D spending. These lower outsourcing rates for the entire population may be explained by the fact that limited surveys tend to focus on rather large companies and/or high-tech sectors. A German survey of 1663 firms reported that 3.6% outsourced part of their R&D activities between 2004 and 2006 (Fhg-ISI 2008). Among firms with more than 500 employees the share was 13.8% while it was only 2.9% among firms with 20-99 employees.

⁴ Weighted average by R&D spending among surveyed companies. The sample is different from one year to the other (EU 2006 to 2009).

A relatively low share of R&D outsourcing should not be interpreted as indicating an absence of open innovation practices. First of all, open innovation encompasses a broader set of activities than those that factor into R&D spending. In particular, open innovation includes sophisticated technological watch and the identification of start-ups developing interesting technologies or larger acquisition targets. Second, the innovation process is particularly open upstream, where research activities are exploratory in nature and typically less costly than in the applied research or development phases.

It is thus necessary to complement the R&D outsourcing indicator with more direct measurements of open innovation practices. Various indicators suggest that companies develop open innovation practices with a positive impact on their performance. Also, if public research bodies are not the primary partners for companies, they play a specific and important role in the exploratory phase of the innovation process.

The propensity to collaborate for innovation with different partners

Innovation surveys in different countries (Box 1) can be used to study R&D collaboration in more detail. In these surveys, collaboration is defined as an active participation to common innovation projects with other organisations and does not include R&D sub-contracting. Collaboration can involve the development of new products or processes with customers or suppliers, as well as common R&D projects with competitors or academic laboratories.

Box 1. Surveys on the business innovation practices: the case of France

CIS

CIS surveys (*Community Innovation Survey*) are conducted in the European Union countries and are based on harmonised definitions (OECD Oslo Manual). In France, for the CIS4 about 25 000 companies were surveyed on their innovation activities between 2002 and 2004.

CIS describes the innovation process in business companies with 10 employees or more. It measures the economic weight of innovation, evaluates its impact and appreciates its mechanisms (cooperations to innovate, resources implemented, hindrances, etc).

One quarter of companies operating in industry, commerce and services with ten employees or more have innovated at least once between 2002 and 2004 by introducing new products or implementing new processes. With a broader definition, including innovations in organisation and commercialisation (marketing), almost half the companies in France claim to be innovative.

ERIE

The survey on the relationships between companies was launched in 2003 and a similar survey was conducted by other EU countries, coordinated by Eurostat.

The first objective of ERIE was to establish an overview of the various relationships between two or several companies, whatever their sector, the domain in which these relationships exist, the nature of these relationships, etc... The second objective was to provide quantitative data on the importance and the intensity of these relationships. A distinction was made between the intra-group relationships and external relationships.

ERIE concerns firms with more than 20 employees or more than €5 million turnover and with a principal industrial activity, ie about 22 000 companies.

Table 1 shows that the propensity to collaborate varies substantially across countries. Companies from small countries in the north of Europe collaborate more than those from the larger European countries. It also clearly indicates that larger companies collaborate much more to

innovate than SMEs. This observation was confirmed by empirical studies, which found that R&D collaboration is correlated with size, whatever the sector⁵. This lower propensity to collaborate may be explained by SMEs' scarce human and management resources. They can also be less motivated due to their weaker absorption capacity.

Table 1. Companies collaborating on innovation activities
As a percentage of all companies, 2002-04

	All population	Industry	Services	SMEs	Large companies
Denmark	22.2	24.6	20.0	20.8	53.9
Sweden	21.4	26.0	18.6	20.0	53.5
Finland	19.2	23.4	14.8	17.3	56.1
Belgium	18.3	22.0	14.9	16.6	60.9
United Kingdom	15.8	14.7	16.7	15.3	27.7
France	12.9	14.1	11.7	11.6	43.6
Netherlands	12.8	18.4	8.4	11.6	45.3
Norway	12.3	15.8	9.3	11.3	36.9
Germany	10.4	14.2	7.0	8.6	36.3
Switzerland	9.9	16.6	5.9	9.4	22.2
Austria	9.1	10.8	7.6	7.7	40.2
Japan	7.4	8.4	6.2	6.5	27.9

Source: OECD (2008a)

Firms from manufacturing sectors tend to collaborate more to innovate than firms from service sectors such as distribution, transport or communication (table 1). Studies have indicated that collaboration is more intense in high-tech sectors (Hagedoorn 2002, Miotti and Sachwald 2003). The extent of collaboration also varies by country. On average, companies collaborate more in France than in Germany. Manufacturing firms nevertheless collaborate as much in Germany as in France. In the United Kingdom, SMEs collaborate more than in France and in Germany, but large companies collaborate less. Service companies collaborate relatively strongly in the United Kingdom.

Table 2 shows that those firms that cooperate to innovate tend to do so first with their suppliers and their customers. Collaboration with competitors is less frequent. Collaboration with public research organisations, universities or institutes, is also less frequent. In Germany and Austria, companies have a strong relative propensity to collaborate with universities and a low propensity to collaborate with their suppliers. Conversely, French and Spanish companies have a lower propensity to cooperate with universities. In France there is a low propensity to cooperate with public research institutions in general. In Finland, companies tend to collaborate intensely with all types of partners.

Such national differences may partly be explained by sector distribution. For example, Finland has specialised in ICT, where collaboration to innovate is very frequent. Size may be an additional explanation: the low propensity to collaborate in Austria, Denmark and Italy could be

⁵ See, Miotti and Sachwald (2003), Laursen and Salter 2004, Dhont-Peltrault (2005), Herstad *et al.* (2008).

related to the high share of SMEs in the population of companies. Characteristics of the national innovation system may also contribute to these differences. The quality of academic research as well as its openness to business vary noticeably between countries and could explain the variable diffusion of partnerships between public research and companies.

Table 2. Companies collaborating on innovation activities, by partner

As a percentage of all companies collaborating on innovation, 2002-04

	Suppliers	Customers	Universities	Public institutes, government	Competitors
Finland	92	93	75	59	77
Czech Republic	80	68	37	26	40
Sweden	75	65	41	15	25
Netherlands	75	55	31	24	31
United Kingdom	74	73	33	25	36
Belgium	73	59	37	26	27
Hungary	71	53	37	14	37
Denmark	66	65	32	16	35
France	65	50	26	18	36
Italy	56	39	36	11	37
Spain	52	23	26	28	17
Germany	44	51	53	26	27
Austria	43	45	58	30	22

Source: adapted from OECD (2008a)

While there are also other explanations, including prevailing incentive structures as influenced by the regulatory and financial policy frameworks, the lower propensity of companies to collaborate with academic research institutions can in part be explained by the nature of such collaborations. Firstly, upstream collaboration focus primarily on the exploration phases of the innovation process (Bercovitz and Feldman 2007). Secondly, upstream research generally represents a relatively low share of the total innovation activities in companies.

Impact of open innovation practices

Drawing on results from national innovation surveys, Herstad *et al.* (2008) designed a synthetic indicator of open innovation. It aims to summarise the intensity of various open innovation practices: R&D outsourcing and licensing-in, collaboration, search for information from external resources and the use of instruments to protect intellectual property. For the first three practices, the indicator includes both an intensity factor and a diversity factor, which depends of the variety of the partners or sources of information. Computations have been harmonised for four countries, Austria, Belgium, Denmark and Norway. If Denmark has a higher synthetic indicator, the gap with the other countries is relatively small. The study found a positive impact of the synthetic indicator of open innovation on the probability to bring new products to the market and on the share of sales of new products in the turnover. It concluded that *it is primarily the overall openness of organizations which impact positively on innovation performance...* (Herstad *et al.* 2008).

An estimate based on the results of the UK innovation survey showed that companies with the more active information search strategies exhibit a stronger innovation performance (Laursen and Salter 2006). Companies that resort to various information channels and use them intensely

have a higher probability to produce radical innovations. This study further suggests that the extension of firms' information channels has a cost. For example, beyond a certain number of channels, the return in terms of innovation diminishes. Similar conclusions have been drawn from innovation surveys in Northern European countries (Herstad *et al.* 2008).

These studies do find a positive contribution of in-house R&D expenses to innovation, but clearly identify the additional contribution provided by open innovation practices.

A study based on British data (Laursen and Salter 2004) contributes towards explaining the apparent paradox of the low propensity of companies to cooperate with public research mentioned above (table 2). The main sources of external knowledge for British companies are in-house R&D, customers and suppliers. Universities are used to source knowledge to innovate by a small number of companies that operate in a limited number of industrial sectors (pharmaceuticals, chemicals, machinery, automobile, electrical and electronic equipment). Furthermore, the companies that collaborate intensely with universities invest in both their own internal R&D capabilities and the development of open innovation practices. This result confirms the explanation suggested above: companies that cooperate with universities develop ambitious innovation strategies and are the most likely to generate radical innovations. They allocate diversified internal and external resources to innovation. These companies are relatively few and focus their collaboration with academic research upstream. As a result, this public-private collaboration may be limited in volume but qualitatively very important. This can be illustrated using the case of Microsoft Research, which focuses on exploration activities and devotes a substantial share of its budget to collaborations with public research (Anandan 2006). IBM is also emblematic of a company which devotes important resources to in-house R&D, whilst developing open innovation practices and collaborative research along the innovation life cycle. In particular, it maintains partnerships in basic research with large universities. At the world level, "IBM's global technology ecosystem" includes various types of partners (Ruetsche 2008).

The role of academic research for company R&D can also be measured through patent data. A recent study uses the OECD patent data base to measure the degree of co-location of the inventors of the patents⁶ filed by companies on one hand and by academic research organisations on the other hand (Guellec and Thoma 2008). It shows that the number of patents from academic origin invented in a region has a positive correlation with the number of patents invented by companies in the same region⁷. The importance of academic patents is stronger at the intra-regional level. It is also stronger at the industry level, which suggests that intra-regional interactions are concentrated in specific fields. Besides, the correlation is stronger in sectors that rely more directly on scientific activities, such as pharmacy, chemistry and instruments⁸. Finally, the correlation has increased between the beginning of the 1990s and the beginning of the 2000s. This evolution coincides with the development in different countries of public policies that favour concentration in clusters. It is however also compatible with the spontaneous development of the open innovation practices by companies which give priority to favourable environments where academic organisations producing inventions are sufficiently concentrated.

⁶ Demands submitted to OEB and PCT. Inventors' addresses are filed in 330 regions of OECD countries, or in 1700 zones of the type French 'département'.

⁷ The estimate includes control variables for the year of filing, the sector and the country of origin.

⁸ The patents can also play a role in the strategies of protection.

1.3 Internationalisation and open innovation networks

Another dimension of open innovation comes from the internationalisation of companies' R&D and innovation activities. Since the 1990s, the trend towards internationalisation has accelerated, and companies have set up and expanded their R&D centres in a growing number of countries. Foreign R&D activities have also become more diverse and companies develop global networks through their own research locations and international partnerships.

The extent and determinants of foreign R&D centres

Since the 1990s, as during the two previous decades, the establishment of R&D capacities abroad is explained by the international expansion of the production activities and the need for technical support and adaptation to markets which they generate. The recent trend is also explained by the burst of mergers-acquisitions observed since the 1990s and by the construction of global networks of innovation by companies.

Since the 2000s, establishments have been particularly numerous in emerging countries, which became more attractive for R&D activities. In various surveys, companies indicate that these countries have better and better trained human resources and a young population, and often place cost factors behind. It nevertheless seems difficult to disentangle arguments concerning access to talent and concerning access to cheap R&D resources. In particular, India has attracted many foreign companies at the beginning of the 2000s because it offered a very good quality-price ratio for some scientific and technological activities. Foreign R&D investments have strongly increased to destination of OECD countries between the mi-1990s and the mid-2000s (OECD 2008b). Still, countries which have had the stronger incoming flows are Japan, Ireland and some Eastern European countries – in other words, destinations historically new for the establishment of R&D. In this context, it is important to identify more precisely the criteria of the geographic distribution of R&D activities.

Patent data provide additional information in identifying foreign inventors – a priori employees of subsidiaries located outside the countries of origin – of the patents filed by multinational companies. The cross-comparison of patent databases with information on filers, including the ultimate owner of the foreign subsidiaries, enables an appreciation of the importance of the foreign inventors to companies from a given country. Between the beginning of the 1990s and the beginning of the 2000s, European companies placed a growing share of their innovative activity outside their country of origin. However, the propensity to conduct these activities abroad varies noticeably from country to country. At the beginning of the 2000s, about half of patents filed by Belgian, Dutch and British companies originated in R&D work done in foreign subsidiaries (Abramovsky *et al.* 2008). German multinational companies showed the opposite trend, placing abroad a low proportion of their patent-generating R&D work. French companies were in an intermediary situation: 39% of their patents have inventors located in units set up abroad. Symmetrically, many inventors based in certain countries⁹ work for foreign companies. At the beginning of the 2000s, this was the case for more than 30% of inventors based in France, for almost 60% of inventors based in Belgium, but about 15% only of inventors based in Germany or in Denmark (Abramovsky *et al.* 2008).

The largest share of foreign innovative activity of multinational companies from European

⁹ Identified as such in patents.

countries is located in the United States (table 3). The importance of the United States is however noticeably stronger for French multinational firms and even more so for British ones. Germany is the second country of location of innovative activities by French multinational companies (12% in 2000-04). The reverse is not true: German multinational firms conduct little innovative activities in France, and not more in the 2000s than in the 1990s. The share of “other EU countries” has strongly increased. This evolution corresponds in particular to the dynamic investments these firms made in the new member countries during the period (Sachwald and Chassagneux 2007).

Table 3. Location of multinationals’innovative activity¹, in %

Country of origin	Location of innovative activity						Total
	France	Germany	UK	Other UE	USA	Others	
1990-1994							
France	66.19	8.98	4.05	6.66	12.46	1.56	100
Germany	1.47	88.34	1.26	2.25	5.42	1.26	100
United Kingdom	1.73	3.29	64.9	6.36	21.55	2.17	100
1995-1999							
France	63.02	12.13	2.62	6.07	14.01	2.15	100
Germany	1.4	86.04	1.11	2.99	6.64	1.82	100
United Kingdom	2.68	5.56	51.62	9.76	27.53	2.85	100
2000-2004							
France	61.42	12.39	1.79	6.63	13.98	3.80	100
Germany	1.43	86.08	0.85	3.85	5.17	2.61	100
United Kingdom	2.98	7.05	53.43	12.62	19.46	4.46	100

1. The level of inventive activity is measured by the number of inventors listed in the patents owned by the multinational firms. These inventors can be located.

Source: Abramovsky *et al.*(2008).

The stock of a country’s investments abroad¹⁰ influences the share of foreign inventors in the patents controlled by domestic companies. For example, an important share of Swiss patents is invented in foreign subsidiaries of Swiss multinational companies. Conversely, Japanese laboratories abroad represent a relatively low share of Japanese groups R&D and there are logically not many patents from these establishments. The United States and Germany have a share of foreign inventors slightly inferior to the global average, which is logical for large economies (OECD 2008c).

To the growing internationalisation of R&D activities is added a diversification of operations conducted abroad. The internationalisation of R&D continues largely to follow the development of production in new areas, which leads to the need to adapt to local markets (CNUCED 2005, OECD 2008a). Yet the relationship between production abroad and R&D abroad depends on the country of origin of the parent company. For example, Japanese multinational companies maintain relatively centralised R&D capacities, whilst European companies, which have rapidly internationalised their production in the 1990s, have also strongly increased the share of their

¹⁰ Direct investments abroad.

foreign R&D. This is particularly the case for German and French companies¹¹. Yet, access to local scientific and technological resources has motivated a growing number of installations of R&D centres abroad. In the last twenty years, European and Japanese companies have used their subsidiaries in the United States to draw upon the resources of the American innovation system in high-tech sectors. Different studies have thus shown that the establishment of R&D in the United States had a positive impact on their production of patents in these sectors (Almeida 1996, Frost 2001, Sachwald 2003, Iwasa and Odagiri 2004). A study has also shown that R&D investments of British companies in the United States in the 1990s resulted in higher productivity (Griffith *et al.* 2004). The study suggests that these transatlantic investments might have been more efficient in terms of productivity than the R&D expenses of the same companies in the United Kingdom.

The behaviour in term of access to technology through investment abroad has progressively developed and increased in sophistication. In particular, companies have tried to better integrate these various R&D units into their innovation strategies. The relative importance of these different trends varies, depending on companies' sectors and countries of origin, and this makes the identification of the different motivations of R&D internationalisation more complex. The identification problem is particularly obvious in understanding the more recent motivation of R&D internationalisation, cost reduction versus increased innovation process productivity. The analysis of the location criteria of R&D activities can be clarified in taking into account the growing diversity of these activities. For example, a typology identifying three types of foreign R&D centres is presented in box 2.

Box 2. Typology of R&D centres abroad

The local development centre (LDC)

Traditionally, the local development centre draws on the parent company's technological resources to support production abroad and enable the adaptation of supply to local market (Frost 2001, Iwasa and Odagiri 2004). The location of the LDC tends to follow that of the production sites (Sachwald and Chassagneux 2007).

The global research laboratory (GRL)

A global research laboratory contributes to the innovation process of the company worldwide. GRLs are destined to increase the parent company's innovation capabilities and must generate ideas and applications adaptable in different countries. They can be organised in a network, in which the historical laboratory of the country of origin plays a less central role than in the past. Global laboratories rely partially on the parent company's R&D resources in the framework of common projects. Yet their objective is to take advantage of the scientific and technological resources of the country where they are established.¹² Some have a "watching" function, and this can vary in importance. A GRL can be small if specialised in a very specific field and if its location is commanded by the proximity with a local university with excellent capabilities in that field.

During the 1990s, the burst of mergers-acquisitions has been a factor of acceleration of the internationalisation of R&D. After a series of acquisitions, a company usually restructures its R&D activities and some centres abroad can become GRLs. In some cases, companies have also invested in new laboratories in order to locate R&D activities in centres of excellence.

GRLs conduct applied research work and are much less numerous than the LDCs. A survey among Japanese groups indicates that in 1998, out of 700 subsidiaries in the United States, 137 had R&D activities, from which only 23%

¹¹ See particularly Cantwell and Harding (1998), Larédo and Mustar (2001), Sachwald (2003), Ambos (2005), Belitz *et al.* (2006).

¹² Studies, specially based on the examination of patents filed by European or Japanese companies, have showed that they really benefited from their establishment in centres of excellence in the United States (Almeida 1996, Gerybadze and Reger 1999, Florida 1997, Iwasa and Odagiri 2004).

was research work (Iwasa and Odagiri 2004). From a survey done in 2000 in 130 of German companies' foreign R&D centres, 30% had research activities (Ambos 2005). During the first half of the years 2000 decade, GRLs represented 23% of the establishment projects of foreign R&D centres in European countries (Sachwald 2008).

The global development centre (GDC)

A global development centre is in charge of tasks that can be separated then re-injected in the company's innovation process. It ensures the internal sub-contracting of R&D work. GDCs are generally in charge of *back-office* tasks, such as specific studies, tests or writing of softwares or sub-group softwares. The development of this type of setting-up abroad follows the growing pressure on the costs of R&D activities, which have tended to increase as innovation was becoming a factor of competitiveness. In certain cases the establishment of a GDC can be justified by the availability of specific natural resources in the local environment (fauna, flora...), or by specific physical conditions (climatic, for example).

Originally, the GDC corresponds to the relocation of a subgroup of R&D activities in a country where costs are lower than in the country of origin. But its contribution may not be limited to cost reduction. The centre can gradually gain in autonomy and take in charge more sophisticated tasks. The increase of human resources, facilitated by the cost reduction, and the presence of teams working 24 hours on 24 around the world on the same project, enable in particular to accelerate the development of new products.

Source: adapted from Sachwald (2008)

The determinants of the R&D centres' location vary according to their precise functions and activities. For example, if LDCs are first attracted by the proximity to a market and to local production capabilities, GRLs tend to seek the proximity of first rate scientific and technological capabilities. An empirical analysis of projects designed to set up new R&D centres in Europe between 2002 and 2005 showed that the establishment of the three types of centres obeys different factors (Sachwald and Chassagneux 2007). LDCs are established as a function of the attractiveness of the regional and national markets, the scientific and technological supply, as labour costs, being secondary choice factors. GRLs are located as a function of the quality of the scientific and technological supply, both national and regional. Cost factors have hardly any impact. Conversely, GDCs are attracted to the countries where manpower costs are relatively low, even if the national system of innovation is not very sophisticated.

Empirical analysis of the characteristics of foreign countries in which Japanese R&D centres have been established also shows that choice criteria depend on the specific activities of the different centres (Shimizutani and Todo 2008). In particular, the centres where all the R&D operations are carried out are based in countries where the R&D intensity¹³ is higher than in the countries where the development centres are based.

A survey among European companies shows a general hierarchy of the establishment criteria of the R&D centres similar to the studies already quoted, namely the access to the market first, then the access to the human and technological resources, finally the access to low cost resources (EU 2006). These three groups of criteria are partially in line with the three types of centres identified above (box 1). The survey indicates also that the criteria of access to the scientific and technological resources are relatively more important for high-tech sectors, and this corresponds to the importance of the research and innovation activities for companies from these sectors. This point was also stated in a global study that differentiated between location criteria of the R&D centres in high wages countries and in emerging countries (Thursby and Thursby 2006).

These general results are confirmed by the way individual companies explain the location of their different types of R&D centres. For example, Air Liquide identifies a different criteria hierarchy

¹³ Ratio R&D / GNP.

for research centres and for development centres. For the former, the primary criteria is the presence of talents, then the quality of academic research, market proximity and lastly costs – the questions of intellectual property being one of the important elements of the business environment. For development centres, market attractiveness is the main criteria. Then come low costs, available talents and the academic environment.

Table 4 shows the location of the inventive activities of the French, German and British multinational companies by sector. The distribution reflects at the same time the motivation of the adaptation to the market and the motivation of access to technology.

Table 4. Location of the inventive activity of multinationals by industry 2000-04, % by sector¹

Country of origin	Location of inventive activity					
	France	Germany	UK	Other EU	USA	Others
France						
Total	61.4	12.4	6.6	1.8	14.0	3.8
Chemicals	68.8	5.7	6.9	3.1	13.8	1.9
Communications	50.8	13.3	9.3	1.4	19.5	5.8
Computing	50.6	17.0	7.5	1.4	17.4	6.4
Disinfectants and detergents	75.1	7.0	3.8	3.5	9.0	1.6
Electric power	71.3	14.5	5.0	1.8	5.6	1.8
Electronics	54.0	13.2	6.0	1.8	21.1	3.9
Mechanical engineering	67.7	14.5	6.0	2.0	8.7	1.2
Pharmaceuticals	67.0	9.8	3.3	2.4	7.9	9.5
Plastics	60.4	7.1	12.2	1.5	16.4	2.4
Semiconductors and circuitry	56.9	15	7.4	1.5	15.5	3.7
Germany						
Total	1.4	86.1	3.9	0.9	5.2	2.6
Chemicals	2.7	87.2	1.9	0.7	5.1	2.5
Communications	0.7	83.7	8.4	2.0	3.4	1.8
Computing	1.2	84.4	4.0	1.1	6.8	2.5
Disinfectants and detergents	1.3	81.7	4.3	0.8	8.3	3.6
Electric power	0.6	91.4	3.0	0.6	2.7	1.7
Electronics	0.5	88.0	4.9	0.6	2.8	3.2
Mechanical engineering	1.6	90.0	4.0	1.0	2.3	1.2
Pharmaceuticals	0.9	70.5	4.7	1.3	13.9	8.7
Plastics	1.4	86.9	2.7	0.5	6.1	2.4
Semiconductors and circuitry	1.2	77.3	8.7	0.6	8.9	3.5
United Kingdom						
Total	3.0	7.1	53.4	12.6	19.5	4.5
Chemicals	2.8	6.2	55.5	12.4	19,9	3.3
Communications	3.4	12.9	56.8	12.4	8,0	6.5
Computing	3.7	5.9	68.2	3.9	13,8	4.5
Disinfectants and detergents	1.2	3.5	38.4	20.8	31,3	4.8
Electric power	4.0	14.5	63.7	5.8	10,3	1.7
Electronics	0.9	16.5	67.0	4.8	9,1	1.6
Mechanical engineering	5.5	16.4	57.4	7.8	11,1	1.8
Pharmaceuticals	2.3	1.0	45.4	15.7	29,3	6.2
Plastics	2.8	6.8	53.4	14.1	19,5	3.4
Semiconductors and circuitry	1.5	20.9	48.5	8.6	15,3	5.1

1. Classification by Derwent section, the total in line is equal to 100%

Source: Abramovsky et al. (2008)

First, when a country is specialised in a sector, companies tend to locate their inventive activities in their country of origin. As a result, German multinational companies establish 90% of their inventive activities in mechanical engineering in their home country. Conversely, French multinational companies establish relatively few of their inventive activities in the data processing, communication, electronics or semi-conductor sectors in their home country.

Then, firms seek to access to the technological resources of the more specialised countries. The German and British multinational companies from the pharmaceutical industry establish a relatively high share of their inventive activities in the United States. French and German multinational companies in the data processing sector behave in the same way. In the sectors of plastics and detergents, location decisions seem to be motivated by market access, particularly in the United States or in the new UE member countries. The relative importance of “other” countries for pharmaceuticals could correspond to the realisation of clinical tests.

More generally, the 2008 EU Survey on R&D investments trends (EU 2009) indicates that European multinationals are particularly attracted to the US for the location of R&D activities in high tech sectors. This recent result confirms previous work on the attractiveness of the US for the location of R&D in high tech sectors (Florida 1997, Serapio and Dalton 1999).

The activities R&D centres located abroad evolve in time. Centres develop relationships with their local environment and, depending on the latter’s characteristics, can thereby enhance their own innovation capability. So, even if the establishment of an R&D centre depended initially largely of the importance of the local market, its subsequent development may depend on the local scientific or technological capabilities. This sequence has been verified in the case of the foreign subsidiaries of American companies between 1991 and 2002 (Hegde and Hicks 2008). The likelihood of establishing an R&D activity in a specific country depends first on the local market. On the other hand, the likelihood that the local R&D centre files patents depends more on the local technological capabilities, measured by the number of U.S. patents attributed to the inventors of the country¹⁴. Finally, the number of patents filed by a subsidiary, representative of its innovation capability, depends essentially on the scientific production of the host country, measured by the articles published in sciences and engineering¹⁵. Besides, the number of patents filed by American subsidiaries increased between 1998 and 2002, which suggests that the U.S. multinational companies benefit more and more or better and better from their foreign R&D capabilities to innovate.

Symmetrically, studies based on patent data have shown that the European and Japanese multinational companies benefit effectively from the American scientific and technological capabilities, thanks to their R&D centres in the United States (Almeida 1996, Iwasa and Odagiri 2004, Griffith *et al.* 2004).

¹⁴ The authors have subtracted patents attributed by the American office (USPTO) to inventors from a given country, those that have been attributed to U.S. multinational companies. They use fractional accounts for the patents with multiple inventors.

¹⁵ The article distinguishes between 9 industrial sectors, for which the nomenclature differs from that in scientific articles. The authors calculate a relevance ratio for each scientific field in each sector based on quotations from articles in the patents of the sector. The local publications in a given field are weighed by this ratio.

International partnerships to innovate

Cross-border R&D collaborations have tended to increase since the 1980s¹⁶. Data from innovation surveys indicate that European companies have a substantial share of their collaborations with foreign partners, particularly in industry (table 5). For example, 19% of the Finnish companies collaborate to innovate (table 1) and 13% do so with foreign partners. Logically, the relative propensity to collaborate with foreign partners is weaker for the larger countries, but this is also the case in Switzerland. Table 5 shows again national disparities.

**Table 5. Companies with transnational partnerships to innovate in 2002-04¹,
% of all companies**

	Companies			
	Industry	All	Large	SMEs
Finland	16.9	13.3	51.6	11.2
Denmark	16.5	14.8	44.2	13.5
Belgium	15.7	13.5	51.0	11.3
Sweden	14.2	11.4	45.3	9.9
Netherlands	11.8	7.6	35.6	6.6
Switzerland	11.0	6.4	19.1	6.0
Norway	10.1	7.9	27.4	7.1
United Kingdom	7.8	7.7	19.7	7.2
Germany	7.6	4.8	32.4	2.9
France	7.4	6.2	31.9	5.0
Austria	6.1	5.3	30.2	4.2
Japan	1.6	1.2	9.9	0.9

Source: OECD

Collaborations with foreign, including distant, partners have a positive impact on the propensity to innovate. The cited empirical analysis of Northern Europe countries (Herstad. *et al* 2008) measures a positive impact of the international collaborations with customers or suppliers on the propensity to innovate. This impact is stronger and more constant than that of the national collaborations and of the international collaborations with competitors.

For EU companies, the share of the extra-European collaborations is logically weaker 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. Still, the geographic distribution of collaborations does not provide information on the qualitative aspects and the respective importance of different types of collaboration. For example, 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, following the companies' declarations in the innovation survey, the collaboration with UE partners seemed rather aimed at sharing R&D costs. Insofar as international partnerships are more costly and

¹⁶ It is as difficult to measure this as the increased establishment of foreign R&D centres, because no official statistics are available.

difficult to manage, companies which agree on them are strongly motivated and demanding with the distant partner.

1.4 Summing up: the dynamics of global open innovation networks

Interactions that develop as a result of openness and internationalisation of firms' innovation process 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. These networks are flexible, depending on the evolution of the local capabilities and the ambition of the innovation strategy of each company. In particular, the degree of openness and global reach tend to be higher for radical innovation.

Interactions between openness and internationalisation

While openness remains easier and more frequent with well-known partners that supply more certain inputs into the innovation process than sources that are less known by the company, a distant partner can still be well-known and reliable. Companies nevertheless try to reach for new partners whenever they seek specific knowledge inputs or need to cooperate on attractive markets.

Figure 3. Factors of openness of the innovation process and factors of internationalisation of R&D activities

Incentive to:	Demand side	Scientific and technological supply
Develop open innovation practices	<ol style="list-style-type: none"> 1. Acceleration of the innovation cycle; increasing demand for innovation 2. Hybrid or complex innovations, including interactions between products and service 3. Evolution of the business model. 4. Growing attention to demand or customer driven innovation, including in services 	<ol style="list-style-type: none"> 1. Increasing supply of technologies, in particular from new firms and knowledge intensive services 2. Internal focus on defendable core competencies in face of growing external competition; limited R&D resources 3. New practices and methods of exchange of data, of simulation...
Establish or increase research and/or development capabilities outside the home base	<ol style="list-style-type: none"> 1. Importance of the local market (size, purchasing power) and implications for differentiation of products/services 2. World leading local market 	<ol style="list-style-type: none"> 1. Increased global availability of high quality S&T human resources and infrastructures 2. Excellence centres and good relations between academic research and firms in foreign countries 3. Good cost-efficiency ratio for some R&D activities in foreign countries 4. Increased capacities, qualities and cost-effectiveness of supporting ICT services

Figure 3 summarises the drivers of open innovation and internationalisation of R&D. It points out that both trends depend simultaneously on supply and demand factors as well as changing preferences in respect of business model and corporate management.

Figure 3 first underscores the fact that the development of open innovation, like the internationalisation of R&D, corresponds to market evolutions and demand for innovation. The demand for innovation has increased, quantitatively and qualitatively, exerting a growing pressure on companies' R&D capabilities.

The increasingly multi-disciplinary nature of innovation (involving multiple scientific disciplines as well as greater interaction between traditional R&D and activities such as marketing and design that have their roots in the social sciences) provide 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 the evolution of global demand. Such centres can be more fruitful for companies with open innovation practices.

On *the supply side*, the emergence of new specialised firms reinforces the development of new technologies as the market grows. 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).

The efficiency of innovation networks depends partially on the innovation process integration, and on the company's ability to combine this process with a relevant and timely perception of demand. At the same time, one of the major challenges is to maintain the in-house R&D activities that help to sustain the firm's absorption and anticipation capacities.

Radical vs. Incremental innovation

Combining the available empirical results indicate that the degree of both openness and internationalisation varies along the innovation process.

Based on numerous case studies, the OECD (2008a) concluded that outside-in openness is at its highest upstream and diminishes as projects progress and applications are being developed. This result corresponds to the general practice of companies, for which development tends to be internalised, whilst exploration activities are more frequently externalised through various partnerships. Empirical studies further suggest that partnerships with academia tend to focus on this upstream end and the most R&D intensive sectors. The French companies interviewed as part of this study confirmed both their wider openness upstream and the focus of partnerships with universities on exploration. For example Valeo has largely developed partnerships and chooses to partner with the best specialists in their sector. But the company focuses partnerships with universities on upstream steps of the R&D process. For Saint-Gobain, *«the main source of new technological evolutions must come from outside: the upstream research is done outside the group»*.

As for the degree of internationalisation, our discussion of the different types of R&D centres (box 2) clearly shows that global laboratories, which concentrate on exploration activities, adopt a global and open perspective: they are located in clusters of excellence and nurture relationships

with the global scientific community. As for the local development centres, they are established near markets and production units in order to adapt the company's supply to the local specificities. These centres rely very much on the technological capabilities and on the innovations issued from the parent company. On the other side, they are relatively closed to the local scientific environment. In other words, exploration activities are both open and global, whilst development activities tend to be more internal and more local.

Figure 4 summarises this relationship between the exploratory nature of an R&D activity and its degree of openness. Exploration and research activities tend to draw more on external knowledge, which the company seeks to identify worldwide. Conversely, development activities close to the market are largely conducted in ways that can ensure appropriability. Hence, in general, as the process gets closer to the market, it is likely that the degree of openness will decrease.

Figure 4. Degree of openness along the innovation process and by type of innovation

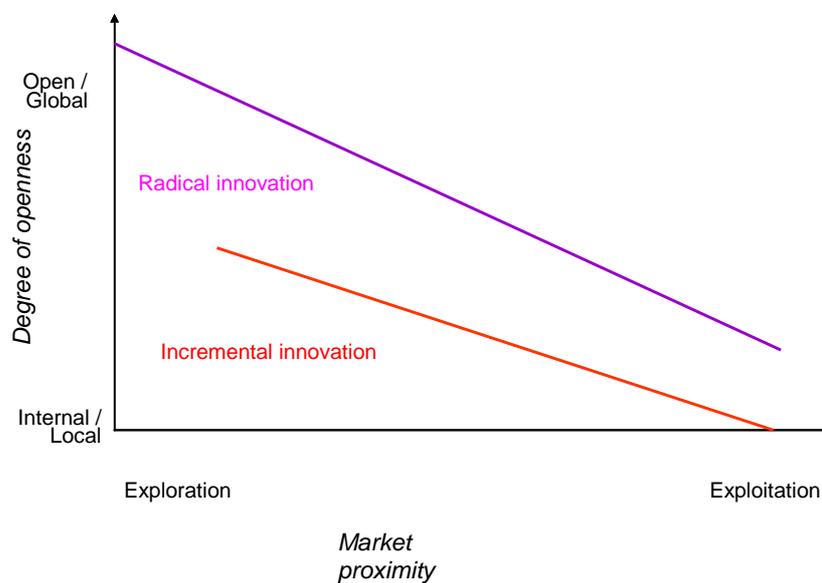


Figure 4 also summarises the conclusions from empirical studies which indicate that radical innovation processes tend to be more open, from partnerships with academic research during the exploratory phase to partnerships during the development or even into the production and commercialisation phases.

A recent paper based on more than 900 alliances from 116 companies between 1986 and 1997 tests complementary hypotheses (Nooteboom *et al.* 2007). It shows 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). It further shows that the positive relationship between technological distance and innovation performance is much stronger when firms engage 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.

To sum up, companies more often conduct incremental innovation projects, but some companies will also concentrate on potentially radical innovations. Increasing competition on the various markets leads larger firms to develop the complex innovation networks required to

support each type of projects. These networks become more reactive to the evolution of the environment, and the locations and the tasks allocated to various R&D units are likely to change following the shifting of the markets on one hand and of the competences on the other.

The dynamics of innovation networks becomes progressively more comparable to that of the production networks, with units having differentiated and evolutionary functions. The efficiency of these networks depends partially on the innovation process integration, and especially on the company's ability to "plug" this process into a good perception of demand. At the same time, one of the major challenges is to maintain in-house R&D competences and activities, ensuring that the firm's absorption and anticipation capacity is maintained.

Open innovation represents a similar challenge for public policies that must increase the integration of the national innovation system. The challenge here is also to better take into account the role of demand, whilst ensuring the excellence of basic research.

2 Evolution of the innovation networks of French companies

If they were not the pioneers in the field, French companies have adopted the practices of open innovation in the last years. They had already engaged in internationalising their R&D activities since the end of the 1980s, first in Europe and in the United States, then, from 2000 onwards, in some emerging economies.

The motivations and the configuration of the innovation networks of the French companies are similar to those of their counterparts, with in particular the strong attraction of the dynamic markets on one hand and presence in certain clusters on the other. Altogether, the innovation networks of the French companies have become more internationally distributed and more adaptable to technological and market evolutions.

2.1 Innovation networks of French companies

Some of the indicators defined in the first part can be calculated for the French companies and give a first image of the adoption of the open innovation practices. So, the propensity to cooperate to innovate of the French companies looks rather modest compared to other countries, with a strong gap between SMEs and large companies. Besides, among companies which cooperate to innovate, relatively few do so with public research. Finally, if French companies cooperate relatively little with foreign partners, distant partnerships seem motivated by access to technologies rather than to markets or by the will to reduce R&D costs. The frequent cooperation with close partners would then correspond to more frequent and less ambitious needs than the cooperation with more distant partners. Altogether, companies which cooperate with many partners, foreign partners and academic partners are also those which tend to invest the more in their in-house R&D capabilities.

French firms' collaborations to innovate

At the beginning of the 2000s, about 40% of the French innovative companies cooperated to innovate¹⁷. This proportion is logically higher than the propensity to cooperate to innovate of the whole population (table 1). Yet, table 1 rightly indicates the relative position of French firms in Europe: they cooperate less than Scandinavian firms, but more than British or German firms. French SMEs' propensity to cooperate is relatively low.

In France, collaboration between firms and public research organisations is relatively low. Between 2002 and 2004, 10% of innovative companies cooperated with academic research, which is much less than in Finland or Sweden and equivalent to the United Kingdom (Dhont-

¹⁷Data are from the French CIS Survey for years 2002-04 that was presented in box 1 (Dhont-Peltrault and Pfister 2008). The complementary survey on intercompany relations conducted in 2003, 48% of companies have at least one R&D partnership (Dhont Peltrault 2005).

Peltrault and Pfister 2008). Among companies that cooperate to innovate, one quarter only have public research among their partners, compared to more than half in Germany (table 2).

Few companies cooperate with public research and they have a specific profile. They more often belong to a high-tech sector than the average cooperating firm. They also have a relatively large portfolio of partners: more than half have at least three other innovation partners, while more than one third of the companies cooperating with their suppliers have no other type of cooperation (Dhont-Peltrault and Pfister 2008). Firms that cooperate with public research often externalise part of their R&D activities (58% as opposed to 36% for all firms cooperating to innovate). Yet they also more often conduct in-house R&D activities and so have a large absorption capacity.

French companies cooperating with public research have a similar profile as British companies that use academic research as a source of information (Laursen and Salter 2004): they are few, originate from specific sectors, strongly invest in-house R&D capabilities and have adopted open innovation practices. The low propensity of French companies to cooperate with public research could then be partly the result of its weak specialisation in high-tech.¹⁸ These high-tech companies indeed tend to have the “right profile”: strong in-house R&D capabilities and sophisticated practices of open innovation. This suggests interactions within the French innovation system between low specialisation in high tech and the overall low level of technology transfer between public research and companies.

Cooperations with public research are relatively rare in France, but their impact on innovation performance is positive, as in other countries. These cooperations seem more important for radical innovations, while cooperation with suppliers and customers are often an integral part of the incremental innovation process. An empirical study shows that, whatever the level of internal R&D spending and other firm’s characteristics (size, industry, belonging to a group...), 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).

From a geographic point of view, whatever the type of R&D partner, companies mostly cooperate at the national rather than regional level (Dhont-Peltrault and Pfister 2008). Geographical proximity is nevertheless more important for SMEs.

Europeanisation and internationalisation of R&D activities

Up to the mid-2000s, R&D French firms’ cross-border R&D investment and collaborations were located within the EU and, increasingly, in the United States. Since then, French firms have further developed their foreign R&D activities, especially in emerging economies.

Foreign R&D expenses of French groups tend to be concentrated in Europe. Up to recently, French companies had a lower share of their foreign R&D in the United States than German or British companies (OECD 2008b). French groups execute a relatively high share of their foreign R&D spending in Germany and in the United Kingdom. Nonetheless, a substantial share of the inventive activities of French multinationals is located in the United States¹⁹. Besides, this share

¹⁸ Specialisation can be measured from the distribution of added value or exports. For comparisons, see for example Miotti and Sachwald (2007). For the link with R&D intensity, see van Pottelsberghe (2008).

¹⁹ This can be measured in particular with the location of patents’ inventors as in table 4 above.

is larger in high-tech sectors (Sachwald 2003). This pattern suggests that French R&D centers located in the United States are more often motivated by access to technology than those located in European countries.

On average, companies located in France collaborate to innovate first with French partners, less frequently with European ones, and much less frequently with American ones (Miotti and Sachwald 2003, Dhont-Peltrault and Pfister 2008). These proportions substantially differ according to the ownership of the capital. French groups choose domestic partners in three cases out of four. Foreign groups with a location in France tend to engage in European partnerships, which is probably related to intra-group cooperation. Similarly, U.S. groups tend to cooperate more frequently than average with American partners. Interestingly, European groups located in France cooperate more with American partners than French groups (Thévenot 2007).

On average, companies with international partnerships to innovate tend to have extensive cooperation networks, with 13 partners against 6 for all cooperating companies (Dhont-Peltrault 2005). These companies are more concentrated in high-tech sectors. The motivations that most consistently explain the choice of a foreign rather than a French partner are complementarity in terms of competence and reputation, market access being a weaker determinant (Thévenot 2007). The choice of an American partner is more strongly influenced by its reputation.

These different results support the conclusions of previous analyses: geographical proximity makes partnerships simple and affordable, but firms are strongly attracted by partners with strong competences. As a result, whenever firms are looking for specific competences or a strong reputation, the location of the potential partner matters little. Transatlantic partnerships for example are relatively few and often motivated by access to technology (Miotti and Sachwald 2003).

2.2 Re-engineering of firms' innovation processes

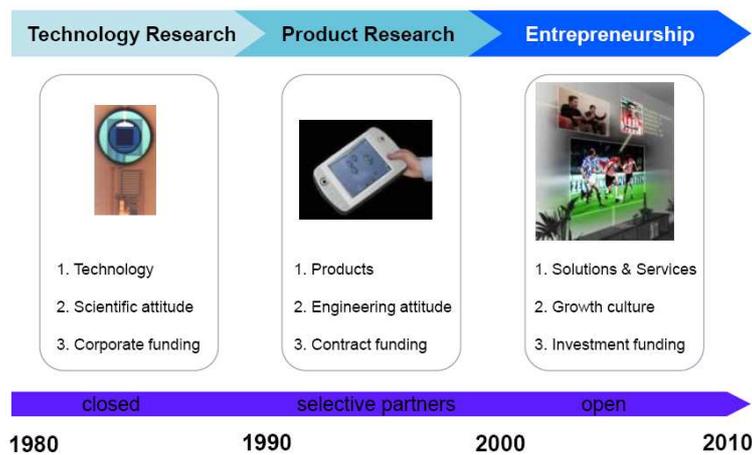
“Openness” calls for a strong absorption capacity that enables firms to benefit from external information and from cooperation with various partners. The absorption of new ideas and their contribution to innovation depend on the number and quality of the interfaces between firms and their external environment (Ebert *et al.* 2008, Herstad *et al.* 2008). More generally, the opening of the innovation process calls for its reorganisation, involving in particular more interactions between the R&D capabilities and the firms' other functions. It implies more fundamentally an organisation that is able to identify, select and absorb appropriate knowledge for its development. For example, marketing is often tightly involved with open innovation processes.

As a consequence, the organisation of an open innovation process implies important changes for the companies that used to rely mainly on internal capabilities. Figure 5 illustrates the evolution of the characteristics of the innovation process at Philips. It relates the more or less open character of innovation, its objectives, its funding and the company culture to which it corresponds. In the closed process, the objective of the R&D process was to increase in-house technological resources. As the outcome of research, the company fostered a scientific attitude in its laboratories, which were operated with corporate funds. The innovation process was then centered on the R&D process and depended on the resources the company devoted to it.

In accordance with the general trend, from the 1990s, partnerships have played a growing role in Philips' innovation process. This first type of openness responded to an acceleration of

innovation cycles and to objectives to generate products rather than technologies. Since 2000, Philips has been convinced of the abundance of technologies around the world and promotes an open innovation process. The company aims at getting more directly to solutions for customers, which involves an evolution of the dominant culture of managers (Figure 5). Finally, funding methods get closer to those of investors and venture capital. The company may use acquisitions to assemble the necessary competences, or support start-ups, possibly coming from its in-house R&D.

Figure 5. Evolution of the innovation process and culture at Philips



Source: Philips (van der Biesen 2008)

This case illustrates the scope of the changes that are necessary to genuinely develop open innovation practices. As a matter of fact, open innovation pioneers and the companies which undertook a radical opening of their innovation process, have generally experienced either a weakening capability to innovate or slow growth of their traditional markets. Such difficulties represent a strong incentive to embark on a paradigm shift, which implies going beyond the adoption of a few tools to develop a new organisation and a new conception of the innovation process. The literature on innovation management often mentions the Not Invented Here (NIH) syndrome to illustrate the importance of cultural attitudes. Many companies now struggle to overcome this syndrome, but the successful implementation of an open innovation strategy implies an in-depth and sometimes lengthy reorganisation.

Open innovation to accelerate creation

Procter & Gamble was one of the pioneers of open innovation (Chesbrough 2003, Dodgson *et al.* 2006). It operates in a very competitive sector, where innovation and brands are basic determinants of competitiveness. During the 1990s, interpreted its undynamic to their inability to respond to the evolution of their customers' expectations. In order to increase significantly increased its innovation capability, Procter & Gamble launched the "*Connect and Develop*" concept. The aim was to draw the organisational consequences of the need to combine ideas as well as technologies to stimulate and speed-up innovation. This new approach was only possible because the company admitted that it could find the solutions to many questions outside its own labs. At the end of the 1990s, Procter & Gamble had a 75,000 strong R&D staff working in 150 scientific fields (Dodgson *et al.* 2006). It calculated that around the world 1.5 million

researchers and experts were active in these same fields. The *Connect and Develop* strategy aimed at drawing on this external expertise by dramatically increasing collaborative innovation projects.

Some French companies have also adopted open innovation practices after they felt a weakening innovation capability. In this case, open innovation goes with a strategic reorientation.

In 2005, after a period of growth based on M&A, Saint-Gobain strengthened its innovation capability as part of a strategic shift towards organic growth. In this context, breakthrough innovation had become necessary to create new markets. Besides, Saint-Gobain wanted to ensure that they would benefit from fast-growing new markets - contrary to the 1990s when the group had not entered the market for glass for liquid crystal screens. In the mid-2000s, Saint-Gobain thus simultaneously increased its investments in R&D and reorganised its innovation process and promoted openness, with the hope to generate breakthrough innovations.

Valeo has also sought to increase its breakthrough innovation capability as a result of the increasing share of development work attributed by carmakers to suppliers. In 2004 the company adopted a new organisation, aimed at promoting the exploration of new transversal innovation paths (Ben Mahmoud Jouini *et al.* 2007). The implementation of transverse “domains of innovation” has been an openness factor. The “domains” coordinate the search for innovative solutions, which are then “adopted” by business units in order to finalise their development.

These examples illustrate the fact that open innovation practices are not exclusively for high-tech companies. However, they suggest that in the more traditional sectors, which had developed internal processes and large laboratories, the switch to open innovation represents a radical choice in relation with the of the firm’s strategy. In high-tech sectors, where international competition is strong, open innovation practices have spread more quickly. Alcatel-Lucent uses a broad range of open innovation tools, with many partnerships on a global scale but also a strategy of *start-up* acquisitions (Behague 2007). This opening has been, as in other firms, partially dictated by the need to identify and quickly implement promising technologies. In software where the evolutions are particularly fast, partnerships and acquisition of small firms to integrate their technology seem more spontaneous.

The case of France Télécom is particularly interesting to study the causes of the switch to open innovation. Indeed, France Télécom is a company whose core trade has evolved considerably, involving an increasing demand for innovation from its market. Over the last decade, innovation in the telecom sector has followed a double evolution: firstly towards the service dimension, i.e. value propositions based on technical artefacts, but only partially determined by the underlying technology; and secondly towards software. France Télécom has an impressive portfolio of technologies, but has not always been able to exploit it efficiently in this new context to create markets and take leadership positions. It needed to switch from an R&D capability generating technological solutions to an innovation capability generating profitable services in a context of increased competition. In other words, France Télécom needs to follow an evolution similar to that of Figure 5.

The difficulties France Télécom faced to generate service innovations has been a central motivation for the reorganisation of its innovation process launched in 2005 as part of a new strategy. This case confirms the importance of the adequacy between the organisation of the innovation process and the firm’s *business model*. French groups that have not faced comparable challenges have felt weaker incentives to radically reorganise and adopt new a innovation culture.

Nevertheless, many groups adopt some open innovation practices, particularly to identify promising technologies and start-ups. Certain companies with a strong internal R&D tradition have progressively out-sourced more activities. Michelin for example, which had developed teams in all relevant fields, including applied mathematics or statistics, has progressively adopted a more strategic approach. Thus, whilst the company had developed its own CAD tools, it decided to use outside tools while maintaining a capacity to adapt them to its specific needs. In this case, the development of specialised companies and a market for such services has been a necessary prerequisite.

Re-engineering and opening of the innovation process

When Procter & Gamble turned to open innovation, it adapted its internal organisation, particularly with the creation of the *Technology Acquisition Group*, which identifies technologies to acquire. More generally, the opening of the innovation process can only succeed if the company's organisation allows for fruitful interactions with the outside. The necessary evolutions often involve a cultural shift for R&D teams.

Saint-Gobain's R&D must simultaneously contribute to ensuring the company's leadership on the construction markets and offer solutions to global challenges, such as energy saving and the environment. As a consequence, R&D ensures first the support of the firm's existing activities with incremental product and process innovations. It must also enable the implementation of new strategies and the penetration of new markets with breakthrough innovations. The first mission requires a strong integration of the innovation process with the product divisions, which each have an R&D organisation. In the mid 2000s, Saint-Gobain reorganised its R&D activities in order to also develop a capability for breakthrough innovation. Beside the capabilities of the product divisions, Saint-Gobain established strategic R&D projects, aiming at entering new markets. These projects are costly and risky. They are validated by the board of management and receive the support from central R&D, whilst being "hosted" by a division. Saint-Gobain conducts transverse projects, involving several R&D centres and several divisions.

The group has strengthened its central R&D capability with four transverse centres, which develop key competences to ensure a critical mass for strategic projects, constitute platforms for interacting with academic research and poles of attraction for young talented researchers. Three historical centres have been strengthened (Aubervilliers and Cavaillon in France, Northboro in the United States). The fourth centre was opened in Shanghai in 2007.

The reorganisation of Saint-Gobain's in-house R&D capabilities comes with a cultural change which promotes partnerships²⁰ and the ability to anticipate market needs. The 'techno-marketing' team, which is based near Boston, is composed of some twenty engineers and marketing specialists of different nationalities to observe market trends and emerging technologies. The aim is to propose new approaches to markets. Nova External Venturing was created in 2006 to spot start-ups and interesting technologies which could be combined with Saint-Gobain's in-house capabilities. Nova has access to venture capital funds, as well as to internal resources (R&D and marketing). Eventually, developments are transferred to divisions.

At Valeo, the reorganisation of the innovation process was motivated by the need to propose radical or "architectural" innovations, i.e. which could affect new functions, without necessarily

²⁰ The structuration in network of academic cooperations will be touched upon later (2.2.3).

respecting the company product line organisation. The identification of car drivers' needs implies upstream exchanges with the manufacturers, beyond what existed at the level of each component (Reilhac 2008).

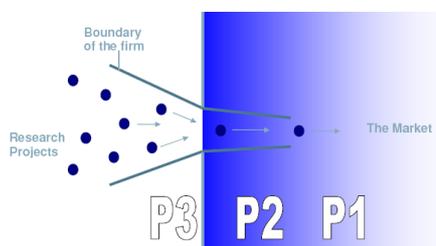
The new organisation adopted in 2004 created three new organisational entities, the “domains”. They are innovation platforms which complement the R&D capabilities of product divisions (Ben Mahmoud Jouini *et al.* 2007). Their objective is to offer car manufacturers innovative products drawing on cross fertilisation between divisions and exploiting the synergies between them. The *powertrain* domain for example covers a set of systems surrounding the engine and contributing to its global performance: the starting system, alternators, other accessories driven by the engine like the air-conditioning compressor or the turbo, the engine's cooling system, the calculator which controls the engine... Only part of the related components are produced by Valeo's own divisions.

The *domains* have to stimulate innovation-based growth and they are evaluated on their capacity to identify innovative value propositions. Each has a small team, a dedicated manager with a strong statute, a structure incorporated on the same hierarchical level as the divisions, and its own budget. Projects explore and test new solutions drawing on both internal and external expertise.

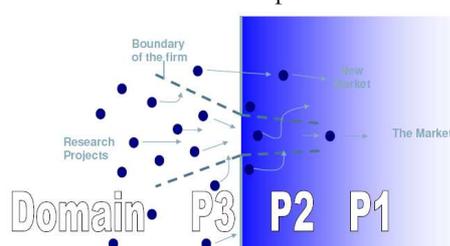
The *domains* constitute major channels of interactions with the ambient ecosystem and constitute an open innovation feature of Valeo's innovation process (Reilhac 2008). Figure 7 places the role of the domain upstream of the milestones traditionally used to characterise the innovation process in the automotive industry.

Figure 6. The ‘domain’ in the innovation process of Valeo

The model of internal innovation in car industry



The domain as channel of implementation of OI



P3, test of new ideas and advanced technologies; P2, establishment of concept and standards; P1, development of applications.
 Source: Valeo (Reilhac 2008)

The identification of missing competences necessary to develop certain particularly promising innovations leads *domains* to take part to the analysis of opportunities for partnerships or acquisitions (Ben Mahmoud Jouini and Charue-Duboc 2007). *Domains* constitute an organisational innovation at Valeo, enabling the generation of transverse ideas and projects (Reilhac 2008).

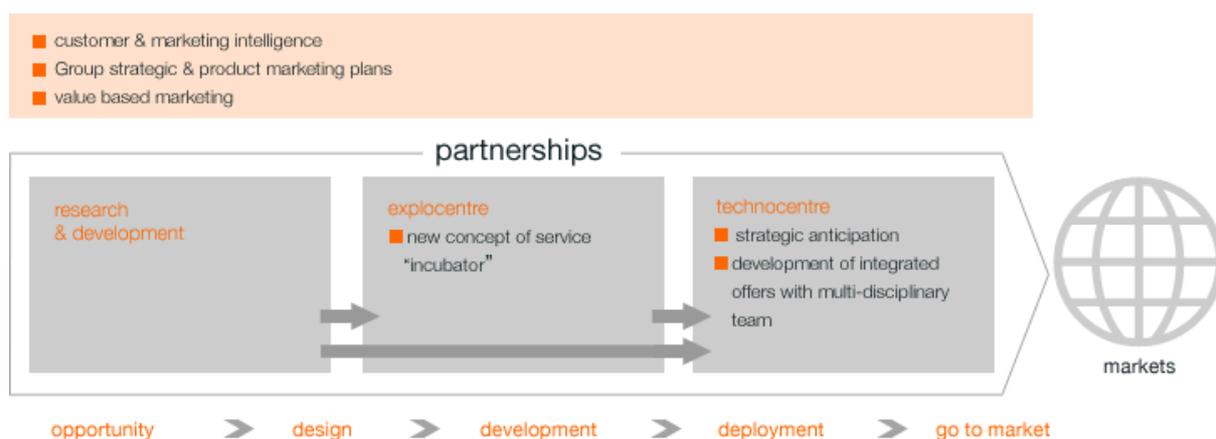
France Télécom has reorganised its R&D to improve its capacity to generate innovative services and accelerate the marketing of new ideas, including from outside the group. In 2005, the group started to refocus its research on market needs. Strategic Marketing aims at better integrating the group's orientations and market knowledge in the innovation process (Figure 7). The innovation process relies on ideas from the group, but also, in an open innovation logic, from

different partners and certain overseas laboratories.²¹

Ideas with a high development potential are transferred to the *Explocentre*, an incubator, which has implemented new methods of co-creation with customers and partners. The incubated projects are managed like in-house start-ups. Each project has a small multidisciplinary team which works in collaboration with contributors coming from the whole group. Decisions are taken by a governing committee of the investor kind; at each step of the project, it can be decided to stop it, to accelerate development or to go on with the exploration.

The Committee of strategic marketing then decides on the projects that will be challenged to the Technocentre, which is a bridge between R&D, networks and information systems, and marketing. The Technocentre, established in 2006, industrialises the launch of innovative services to accelerate development and market responsiveness. This kind of organisation was previously implemented by the automotive industry as it felt the same type of constraint. The Technocentre has been organised around some thirty co-located teams.

Figure 7. The innovation process at France Télécom



Source: site Orange (http://www.francetelecom.com/fr_FR/innovation/creer/chaine_innovation/), 30/08/08

The integration of the innovation process and the driving role of strategic marketing should build a more efficient link between R&D and market needs. For France Télécom, as for other companies, the elimination of the cultural barriers between the marketing and development teams aims at accelerating the innovation process. In companies where these reorganisations are recent, they must still prove their efficiency. Success depends on the convergence of the organisation of the innovation process and cultural changes in favour to open innovation.²²

Degree of openness to the various types of partners

The French companies in our sample have R&D cooperation and externalisation practices comparable to companies from other OECD countries (OECD 2008a). However, the case studies emphasise the role of both sectoral features and individual companies' strategies in the adoption of open innovation practices.

²¹ This point is developed later (2.2.4).

²² See also Ebert *et al.* (2008).

On average, the companies in our sample outsource less than 10% of their R&D activity, with significant exceptions. One company never uses external research, whilst another completely externalises its upstream research, which represents 30% of its R&D budget. Our sample also exhibits a typical pattern of partnership: R&D is firstly outsourced to private contractors and much less to academic research. Those companies that outsource more their upstream R&D choose academic partners more often. The type of research being externalised may thus have a stronger influence on the types of partners than the industry of origin of the company.

The French CIS4 survey, shows that R&D intensive sectors have a stronger propensity to cooperate with public research than the whole manufacturing industry (Dhont-Peltrault and Pfister 2008), but firms' individual strategies also play a role. The strong propensity to cooperate with public research of the R&D intensive sectors could be largely due to the importance of their research activities – including upstream – rather than to the proportion of these activities outsourced to the public actors. The strategy of some companies deciding to outsource their upstream research could thus play a fundamental role, whatever the sector.

Upstream research is often less costly than downstream developments. Even within cooperations with academic researchers, costs can vary depending on the type of programme. As a consequence, firms' specific choices in their cooperation strategy have an important impact on the share of their R&D budget that is allocated to cooperations with academic research. Substantial and fruitful cooperations may not represent the largest budgets, particularly as some collaborative projects are partially financed by public funds (French and European). Public laboratories typically receive direct funding as part of such project, which does not appear in the private partner's R&D budget.

The measurement of the propensity to cooperate with academic research echoes the more general debate of the degree of openness along the innovation process. French companies exhibit a quite typical pattern with more outside-in openness upstream (Figures 4). According to Jean-Luc Schuppiser, scientific director at Essilor International, the firm is always seeking *external competences and partnerships with public research are key*.²³ Essilor has a common research unit with CNRS in Toulouse, which works on new technologies of surface treatment and a common center with CEA LETI in Grenoble. In 2007, it also created a common laboratory with Shanghai University to work on nanoparticles for the optics industry. Finally, Essilor participates, together with other firms, to the “Institut de la vision” located in the Quinze-Vingt national ophthalmology hospital in Paris, where public and private researchers study eye disorders.

In France as in foreign countries, firms' relationships with public research, through subcontracting and partnerships, are thus more important than one can assume from available quantitative indicators. These relations are not new, but the companies that open more systematically their innovation process build networks of partners with whom they commit themselves on the medium-long term. They identify the best academic teams to contribute to their global networks. The *Saint-Gobain University Network* (SUN) for example has been selecting academic partners worldwide to develop long term relationships with the best research teams in their field, ensure a technological watch and contribute to the recruitment of students from the best universities.

When companies seek partners, public or private, for their expertise, they now do so on a very broad basis. French companies have historical partnerships with French universities and research

²³ Cited in « Les partenariats public-privé stimulent l'innovation », *Les Echos* 14/10/08.

centres. At Arcelor Mittal for example, partnerships are decentralised under the responsibility of the various research centres of the company. Still, there is a trend among strategic partnerships toward centralisation and selectivity. For these, proximity is getting relatively less important. At Michelin, the role of proximity in the choice of R&D partners has been perceptibly reduced since 2000. For Dassault Systems, if competitiveness clusters provoke interest, they are not considered necessary to establish cooperations. A meeting with a German company at a conference may be sufficient to engage a fruitful partnership. The collaborative work itself can be conducted partly virtually. The recent agreement between ST Microelectronics and IBM offers another illustration of the utmost importance of competences for engaging research and technological partnerships, including for companies participating to local clusters.

In conclusion, the relatively low level of cooperation between firms and academic research in France could have several sources. The stronger propensity to cooperate with public laboratories in Germany or Scandinavian countries could be related to the higher quality or relevance of academic research. Academic research in those countries could also be more open to firms' problems and better equipped to relate to their innovation processes. Companies for example often signal intellectual property issues as an obstacle to cooperations with public research in France.

International networks

The internationalisation of French companies' R&D developed earlier than the opening of their innovation process, in the 1990s. The global configuration of their innovation network varies, but tends to deploy beyond Europe, in the United States, in Japan.

The interviewed companies consider that their innovation process is now organised on a worldwide basis. Furthermore, they progressively organise their innovation process in networks, supported by centres with complementary competences. Here, internationalisation combines its effects with research of transverse and open innovation processes to encourage the pooling of resources on kingpin sites. These sites are *global research laboratories* of the companies, which are typically located in France on one or two historical sites, in the United States and possibly in Japan or in another Asian country. For example, two of the four global laboratories of Saint-Gobain are in France, one in the United States and the more recent was opened in Shanghai in 2007. The American, Japanese, or Korean laboratories of French companies, even those that are relatively recent, can play leading roles depending on the local eco-system. France Télécom's laboratories in San Francisco, Tokyo and Seoul thus constitute important sources of new ideas for the group²⁴. Drawing on the Japanese advances in mobile services particularly due to optic fibres infrastructures, the Tokyo R&D centre has allowed an acceleration of the experimental phase for certain projects of the group. Since 2006, Tokyo and Seoul centres have been working on specific projects like the 4th generation of mobile phone, to which French laboratories have contributed.

The configuration of the R&D centres can be more complex in companies which have gone through many mergers-acquisitions in a recent period, like ArcelorMittal. Eventually, a rationalisation process takes place, as at Schneider's for example with the pooling of resources on the Grenoble site. Some integrators - of mechanical, electronic or software systems - can

²⁴ France Télécom R&D, Orange Labs, involves 18 centres: French laboratories plus centres in China, South Korea, United States, Japan, Poland and the United Kingdom, as well as recent openings in Jordan and Egypt.

maintain more centralised capabilities whilst serving international markets. Finally, some companies have small scattered branches for specific technologies, either in universities or close to partners and customers.

Development centres keep a more classic role of adaptation to the different countries' local conditions.²⁵ As a consequence, the location of these centres follows the dynamics of the markets and will continue to develop in emerging countries. They are logically embedded in each local environment.

In sectors where the R&D costs represent an important issue, companies have deployed centres for technical support, for studies or for software in emerging countries. It is the case in particular for Alcatel, Schneider, Valeo or STMicroelectronics. Valeo differentiates among its R&D centres, between the *front-office* centres, in contact with customers, the *back office* centres, which produce the studies, and the core business of each craft (Devauchelle 2006). This typology tallies with the one proposed above (box 1). In the mid-2000s, Alcatel also distinguished three types of functions for its R&D centre: proximity with the customer, access to innovation clusters and cost optimisation (Beylat 2006).

Overall our French case studies suggest, as do other analyses (Christensen *et al.* 2004, OECD 2008a), that the scope and the terms of R&D internationalisation depend on the sectors and on the specific constraints encountered by the innovation processes.

Beside, French companies notice, as do others, that foreign R&D centres tend to progressively develop their capabilities, and thus claim more sophisticated functions. It is particularly the case for the Indian centres. They have often first been opened by companies to develop software under the supervision of French units. But the functions filled by staffs and the missions of the Indian units tend to become more complex, and this changes their role in the company network. It is the case at Faurecia for example, where the Pune centre's activities have been able to evolve relatively soon after opening²⁶.

In a more general way, when the firms' innovation networks have more dispersed establishments and partnerships, they tend to establish specialisations and organise coordination more efficiently. Thus, the evolution of innovation networks is comparable to that of the production networks. It is for example the evolution experienced by Michelin: its foreign R&D centres have been specialised as a function of the strengths present in the various establishments. As for companies at large, French firms' innovation networks follow an evolution comparable to that of their production networks.

²⁵ Section 1.3 above.

²⁶ Presentation at a *France 2025* meeting, Conseil d'Analyse Stratégique, 2nd September 2008.

3 Policy implications of open innovation networks

Companies evolve from innovation processes centred on their in-house R&D capability to open and globally distributed innovation networks. Open innovation practices enable companies to organise efficient relationships with their environment: to understand new market demands, imagine innovative solutions and draw from the external scientific and technological resources. Open innovation seems to be particularly well adapted to companies which adopt breakthrough innovation strategies. In such cases, the relevant environment includes the national innovation system, but also all the markets of the company and various clusters of excellence where it is involved through its global network.

As a consequence, public policies seek to improve the efficiency of the interactions within national innovation systems, but also open up those systems to external inputs. The knowledge and the technological capabilities are certainly not evenly distributed, but globalisation and the efforts of the emerging countries diversify competence centres and create various links between more or less specialised poles of excellence. These poles become platforms for exchanges between local and distant actors. They are simultaneously poles of knowledge accumulation and exchange nodes. They are not closed systems and their attractiveness depends partly on their openness to the world through international networks.

Thus, open innovation implies cooperation with local actors, with whom interactions can be simple and immediate, but also with more distant partners. The innovation process is now open to the world. Similarly, while the quest for excellence leads to concentration of knowledge and creative capabilities within clusters, it also generates connections between clusters around the world. As a consequence, firms and territories must learn how to simultaneously nurture in-house competences and develop efficient networks.

In this context, public action must adapt some of its tools and, more fundamentally, modify some of its perspectives. Since the 1980s, research and innovation policies have evolved in response to the development of firms' practices, but the changes have not reflected a strategic analysis of global networks. However, since the 1990s, analyses in term of national innovation systems have more and more clearly influenced public policies. This influence is especially visible in a growing interest for the interactions between public research and private research, as well as for innovation eco-systems and the promotion of clusters.

The development of global innovation networks actually reinforces the role of local eco-systems. It emphasises in particular the attractiveness of global clusters of excellence. This third part discusses the impact of open innovation on major policy issues and considers more specifically the case of cluster policies and attractiveness policies.

3.1 Strengthening internal capabilities and promoting relevant connexions

The development of open innovation practices draws attention to the importance of networks and to the infrastructures supporting openness. The success of open innovation nevertheless also depends on the strength of firms' and academic research institutions' internal capabilities. The key to the evolution of public policies may lie in the resolution of this apparent paradox.

Promote internal investment and select partnerships

Companies that succeed in open innovation 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 in-house R&D capabilities and maintain a broad portfolio of partners to innovate. The reduction of the size of in-house research, particularly within the exploratory phases, must not endanger firms' absorption capacity and their ability to fruitfully interact with public research.

The rationale for public support to business R&D remains quite strong in a context of open innovation. The bases for specific aids to SMEs are not questioned either. However, their role in the open innovation dynamics and emerging sectors suggest emphasising specific profiles of small and young firms, either to accompany them with an easier access to (public and private) R&D services, or to ensure their access to markets.

The success of open innovation 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 established processes of identification and selection of partners to conduct exploration activities. Open innovation has stimulated national and international comparisons between academic research organisations. These comparisons have generated indicators and rankings to assess the scientific production of research organisations. Cross-border public-private partnerships and the increased knowledge about foreign organisations thus now contribute to 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, policies have fostered various types of partnerships along the innovation chain, including with financial incentives. The objective however should not be to promote partnerships as such but rather as a tool to stimulate innovation. In the case of exploration partnerships, which tend to contribute to radical innovation, funding criteria should be centred on scientific excellence and innovative character.

Open innovation infrastructures

The dissemination of open innovation practices also depends on the development of the infrastructures that support openness. Public policies can reduce transaction costs, without necessarily generating pernicious effects in terms of quality of research and incentives to innovate. Technology transfer should be considered as a major component of these open innovation infrastructures. From this perspective, technology transfer must be developed by taking into account the various interactions between research supply and demand that are reinforced by open innovation practices. Universities' capacity to negotiate their patents and to use them for the creation of new firms depends in particular on the incentives they have to develop efficient technology transfer services and to involve researchers. A comparison between the United States and Sweden suggests that, beyond the issue of patent property, competition between universities and their flexibility in different fields are important points to stimulate technology transfer (Svensson 2008). In Sweden, the relatively low capacity of university patent owners (generally researchers) to conduct technology transfers results in a preference for consulting in the relationships between university research and firms.

Systems of intellectual property protection contribute to the infrastructures supporting openness. The practices of open innovation give rise to the emergence of markets for

technology. Their development depends on the quality of industrial property rights, which must not however be reinforced to the point where they would hinder subsequent research (Amendola *et al.* 2001, Guellec and Van Pottelsberghe 2007). The experience of the United States suggests that companies have been making more use of the knowledge generated by university patents since the 1980s, representing a greater dissemination of the results of the academic research (Fabrizio 2006). However, this trend was accompanied by a concentration of the use of university patents for the benefit of those companies most engaged in research, and by a longer delay between patent filing and citation. These observations suggest that the IPR system influences the dissemination of public research results via complex circuits, which in turn call for carefully designed policies.

Besides, the development of markets for technologies implies the intervention of go-betweens that act as facilitators. It could be useful to accompany the reflection on the role of these technology brokers in order to both promote their development and prevent potential pernicious effects.

The mobility of researchers is one of the fundamental infrastructures supporting openness. This has already given rise to the development of public policy tools, which should be systematically assessed and further strengthened, at the national and EU levels. As for public-private research partnerships, it may be useful to remember that mobility and excellence tend to reinforce each other.

Finally, innovation policies can disseminate a culture of openness and foster cooperation practices. In particular, public authorities can play a role in the development of trust between public and private organisations, leading companies and new entrants, customers and suppliers. Different countries have developed exchange forums and guidelines for promote best practices. Such efforts could be increased at the national and European levels (EIRMA 2005). In France, efforts are being made to develop a better knowledge of R&D laboratories associating public institutions and private companies²⁷. Recent programmes associating academic research and business R&D on interdisciplinary issues could be examined in this context. For example the « *Institut de la vision* » opened in 2008 seeks to ensure a continuum between basic research, clinical tests and technologies in the field of eye disorders.

This review suggests that the development of open innovation practices calls for a more systematic evaluation of public policies in the light of recent evolutions. Public policies have evolved over the last decade and governments should ensure that they result in a consistent policy mix. Moreover, innovation policies have to balance competing requirements (De Jong *et al.* 2008): between the promotion of excellence in research and the will to include specific partners in collaborative projects, between intellectual property protection, opportunities to conduct further research and dissemination of knowledge, and between the creation of clusters relying on proximity benefits and international openness. Public policies must also make sure that they promote at the same time a better reactivity of the national system to the perceptions of demand and excellence in curiosity-driven research.

²⁷ To take up one of the proposals (no. 10) of an official report on technology transfer (Guillaume *et al.* 2007).

3.2 Developing 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 France's attractiveness for R&D activities should rely on a clear understanding of the determinants of their location. The analyses that distinguish R&D units according to their role in innovation processes thus suggest that France should concentrate on attracting certain types of R&D units.

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, and particularly France, can improve their attractiveness for local development centres (box 1) 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 will develop leading markets, where demand will be strong, will become attractive for production and R&D capabilities.

Besides, European countries can increase their attractiveness for global research laboratories (box 1) by strengthening their research capabilities and the efficiency of open innovation practices, at the national or European level. As seen above, it largely depends on the quality of the local scientific and technological supply. The most attractive R&D locations include well trained researchers and global centres of excellence. But these will only be the best and recognised as such if they are connected to international networks. Similarly, local companies tend to be more innovative when they participate to international R&D projects and have connexions with different foreign clusters. In other words, local excellence and attractiveness feed on global openness.

In this context, attractiveness policies are facing a paradox: they were generally conceived to promote a national territory, but their full success may also depend on the internationalisation of some of the local companies and research facilities. Indeed, insofar as strategies of access to technology through foreign establishments benefit to local companies (Griffith *et al.* 2004), governments could consider supporting some of these strategies. Various measures to support business R&D are now open to foreign companies, for the sake of the local R&D's attractiveness and efficiency. In the same way, some offshored R&D activities could be eligible for support by the country of origin if they generated spillovers at home. Certain countries, particularly the smaller ones, are already considering these questions. Such a reflexion could be conducted in parallel with the analysis of the issue of competition that countries have engaged to support R&D, including with tax measures.

Attractiveness for R&D depends on the quality of the entire local eco-system of innovation. R&D intensive start-ups belong to it and for a country like France, it is important to stimulate their development. As such start-ups are part of an attractive environment for foreign companies, the capacity of the latter to contract with them or to acquire them should not be restricted. Such acquisitions are sometimes considered as a problem, while a recent empirical study shows that foreign acquisitions raise the R&D budget of target firms (both internal and external expenses). Moreover, the share of R&D contracted out to local public research institutions tends to increase²⁸.

²⁸ The study covers the evolution of French target firms between 1994 and 2004 (Bertrand 2009).

Available surveys and studies on the determinants of R&D location generally find a secondary role for cost considerations – except in the case of Global Development Centres (box 1). Cost considerations however play an increasing role as the global supply of scientific and technological capabilities increases. According to firms, the location of R&D projects is decided first on the basis of strategic considerations and then as a function of local capabilities. Cost considerations can have an impact on the final choice of a site. As a consequence, public funding may usefully complement a local strong innovation ecosystem.

3.3 Connecting clusters

Policies intended to support, or even to create, clusters of economic development have gathered momentum over the last decade. Their objectives, their scope and the specific tools used by local and national authorities vary. Some policies aim first at promoting local development, others concentrate on the stimulation of industry and jobs, yet others focus on the stimulation of innovation (OECD 2007). Cluster policies in favour of innovation generally aim at stimulating the interactions within the knowledge triangle. 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. Cluster policies resort to various tools and modes of funding. In France, ‘competitiveness clusters’ mainly support collaborative R&D projects²⁹.

Cluster policies promote collaborative R&D and should thus contribute to the development of open innovation. In order to do so, cluster policies should however promote open clusters.

Cluster policies aim at reaping the benefits of both agglomeration effects that foster local specialisation and of proximity that stimulates exchanges of tacit knowledge³⁰. Yet, the development of global innovation networks has contrasted effects on the role of proximity in firms’ innovation performance. Insofar as it tends to increase the need for cooperation, open innovation can encourage partnerships, and thus strengthen clusters if companies find appropriate partners locally. Conversely, finding complementary partners and accessing the best researchers imply national and international openness. This is particularly important in the case of radical innovation (see Figure 5).

Sector-based agglomeration may be weakened in environments where innovation comes from horizontal rather than vertical interactions within the value chain. Companies seek to establish horizontal cooperation between their divisions and with external partners. This leads to the development of knowledge exchange platforms (Herstad *et al.* 2008). Cluster policies must take these evolutions into account in order to maximise their contribution to the innovation performance of firms.

Cluster policies must also take into account the reduction of the distances resulting from the diffusion of information and communication technologies and the broader context of globalisation. Various empirical studies have shown that the dissemination of knowledge tends to diminish when the distance between the transmitter and the receiver increases. Companies have developed specific transfer channels to nevertheless exchange complex knowledge across borders³¹. Moreover, a recent analysis of patent citations suggests that the international

²⁹ Through the *Fond Unique Interministeriel* (FUI).

³⁰ OECD (2007) presents more completely the various backgrounds of policies of clusters.

³¹ In addition to the foreign locations and the internal mechanisms of the multinational groups (Bartlett and

dissemination of knowledge has accelerated, particularly in high-tech sectors (Griffith *et al.* 2007). This result based on a broad sample is consistent with the interviews we conducted as part of this study and which suggest that geographical proximity plays an uneven role as a determinant of cooperations.

Local agglomeration effects nevertheless persist. Throughout OECD countries, the number of patents invented by companies in a given region³² is positively related to the stock of patents from other companies, and above all to the stock of patents from public research in the same region (Guellec and Thoma 2008). The influence of the most-frequently cited public patents is particularly strong. These results suggest that companies conduct more intense inventive activities in regions hosting academic organisations filing quality patents. These various effects are also significant for the patents issued by companies filing for the first time, which are often young companies. Thus, companies, including young ones, seem to benefit from the presence of local inventive activities to produce the patents. The same study shows that academic organisations' patents are more likely to be cited by patents originating from other regions or from other countries than firms' patents. Altogether, the academic organisations that produce patents contribute at the same time to the effects of agglomeration at the regional level and to the effects of dissemination at the national and international levels.

Agglomeration effects coexist with firms' increasing capability to know and to use knowledge from distant origins. Various results suggest that knowledge that is exchanged at the local level have a different role than knowledge exchanged at the national or international levels. Radical innovation may need partnerships and extra-regional knowledge exchanges, whilst incremental innovation can be successfully completed with regional resources. Incremental innovation being more frequent, efficient local microsystems are essential even as global networks are developing.

As companies search partners worldwide and successfully conduct distant cooperations suggests, clusters must provide more than connection with local actors. In doing so, clusters could strengthen the networking of large companies and SMEs. 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 to innovate, including internationally.

Ghoshal 1989, Weil 1999, Doz *et al.* 2001), the intercompany cooperations take forms adapted to the complexity of the knowledge exchanged between the partners (Kogut and Zander 1992).

³² Inventors' addresses.

Conclusion

The diffusion of open innovation practices and the development of international networks represent opportunities for companies to adapt to both the growing demands for new products and services, and to increasing cost constraints. Companies are not equally exposed to the competitive and technological pressures and to the need to reengineer their innovation process. However, international competition and the use of new technologies in mature sectors have widely disseminated open innovation processes. In this context, the adoption of open innovation practices appears as a competitive asset. The diffusion of these practices can also represent an important channel for technology transfer from academic research.

Open innovation can enable established companies, whose markets had long been secure, to engage in breakthrough projects. Success depends on the adoption of an appropriate organisation of the innovation process and related cultural changes within the company. It also depends on a favourable eco-system, including access to a rich pool of public and private partners. At the same time, open innovation networks enable firms to overcome deficiencies in their local environment since they increase their ability to access resources globally.

National strategies of adaptation to open innovation

Public policies often aim at revitalising the product portfolio of large incumbents and to maintain local jobs when demand weakens in mature sectors. In the present context, it becomes necessary to accompany breakthrough innovation with approaches that enable them to face tougher price competition and create new markets. But public policies that seek to promote radical innovation must build upon the whole domestic eco-system, with a good understanding of the role played by academic organisations on one hand and new firms on the other. The first ones act as important sources of innovation and train future researchers. The second ones can generate radical innovations and new market opportunities.

The development of open innovation does not call for a fundamental change in public policies. However, open innovation practices reveal the weak points of national eco-systems more clearly. As a consequence, open innovation constitutes an additional incentive for the adoption of strategies of research and innovation.

The analysis of the dynamics of global networks of innovation emphasises the importance of interactions between investment in research, perceptions of demand and those additional competences that the company must engage to innovate. The establishment of R&D centres in emerging countries is thus predominantly motivated by the need to innovate for the specific needs of their markets. In high wage countries, business R&D partly depends on the development of new markets, particularly to face the challenges of ageing and the environment. The stagnation of R&D intensity in Europe largely results from an insufficient evolution of production structures³³. European countries' R&D intensity will not increase significantly and reach the 3% target solely through increases in the spending of existing firms, because their

³³ See particularly Guellec and Sachwald (2008), Van Pottelsberghe (2008).

research investments correspond to the characteristics of the sectors in which they operate. New investments in R&D and the more promising innovations often originate from young companies experiencing strong growth in new markets. The economic environment of these young firms and their capacity to win market shares are thus key to stimulate national demand for innovation – and thus for research. Here, some demand-side policies can complement supply-side policies: ensure access to markets, including public ones, for young firms.

The open innovation paradigm gives increased importance to the ability of the academic research system to generate new relevant ideas. Excellence may be reached in all disciplines, but from the point of view of innovation and growth, it seems particularly important for a country like France to develop talent in emerging fields. Globalisation and expansion of the scientific capabilities worldwide give rise simultaneously to pressures in favour of more specialisation and to a race for excellence and visibility. In this context, most countries have to choose those emerging disciplines or interdisciplinary fields in which they want to specialise and ensure that adequate resources are effectively allocated to them.

The analysis of the determinants of attractiveness for R&D activities underscores the importance of talent. Investments by certain emerging countries in this field, even if their curricula are not yet equivalent to those of the high wage countries, provoke international comparisons that tend to increase the quality of universities worldwide. International comparisons highlight the importance to strengthen universities as part of a national strategy in favour of innovation. This effort must go along with an increased mobility of students and researchers – within countries as well as across borders.

Networks of open innovation and clusters

In the context of more open innovation practices, companies seek cooperations and deploy efforts to identify the right partners and find appropriate modes of collaboration. Public policies promoting collaborative research between different types of partners should take this reality into account and focus on specific types of collaborations. The analysis of firms' practices shows that collaborations with academic research organisations have a quite different profile from collaborations with suppliers and customers. Public-private R&D partnerships tend to correspond to radical innovation strategies, which are adopted by companies with a specific profile. A better knowledge of firms' practices and the development of typologies of cooperation could allow public policies to focus their support on partnerships that contribute most to the objectives they want to promote.

Public policies have sought to stimulate cooperation through networks and through support to clusters. Cluster policies emphasise agglomeration effects and interactions between local actors. They may foster resource concentration and an increased visibility of local research and innovation systems if clusters develop competences renowned on the national or even international level. However, excellence and international visibility also depend on connections to global networks, which must be developed both by the cluster and by individual actors. Conversely, clusters that focus on local cooperation may be most efficient at supporting incremental innovation.

Evidence-based innovation policies

Various indicators have been developed to observe and qualify open innovation practices. However, knowledge on innovation networks should be improved, especially as the environment keeps changing. For example, the role of the emerging economies in global innovation networks will continue to develop and will become more complex, as it has been the case for production networks. Besides, the importance of emerging markets will open new innovation paths, as has already been the case with the development of *low-cost* products. The growing importance of emerging markets and the larger pool of researchers based in these countries are going to give an advantage to companies that will be able to call up crossbreeding capabilities to innovate.

The context in which innovation takes place will continue to change and this calls for increased observation capabilities. In parallel, the definition of a strategy of research and innovation aiming at adapting public policies must go along with an evaluation of the policy mix.

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Appendix: Preparation of the report

This report presents the results of a study conducted by the Directorate of Research and Innovation of the French Ministry of Higher Education and Research in order to improve knowledge of companies' R&D processes and their interactions with the innovation ecosystems, in France and abroad. The study is an extension of an OECD project on open innovation and on companies' R&D internationalisation (OCDE 2008a). The author was in charge of France's contribution to the OECD study and then extended this first work with a specific exploration of the French case.

Nine companies accepted to participate in the OECD study. Each has on one hand completed a written questionnaire on the international distribution of its R&D activities and on the other hand answered a series of questions on the organisation of its innovation activity during an interview.

The questionnaires of the French companies were handled with those from some sixty companies which participated in the OECD study. This allowed the establishment of statistics on the practices of internationalisation and openness. The answers to the interviews were also analysed to understand the dissemination of the open innovation practices and the sectoral or geographic specificities. The OECD report does not mention individual cases of companies and only quotes a few examples in boxes, drawing largely on public data for the companies in question. This satisfies the confidentiality commitment agreed upon with the participating companies in the various countries.

French companies involved in the OECD project: Air Liquide, Alcatel-Lucent, Arcelor-Mittal, Danone, Saint-Gobain, SEB, SNECMA, Valeo and company X.

For the preparation of this report, additional interviews have been done with other companies: France Télécom, L'Oréal, Michelin.

The report draws also on presentations at meetings attended by the author. These presentations were prepared either within the OECD project, or during a conference organised in the framework of the French presidency of the UE (*Pour une croissance intensive en connaissance*, 7-9 July 2008), or also at a *Repères* seminar conducted by the Directorate of evaluation, prospective and performance (DEPP) of the French Ministry of Higher Education and Research. The following list includes all the contributions; the full title of the presentations is indicated in the reference list above in case the text refers to it precisely: Alcatel-Lucent (F. Behague); Baracoda (T. Serval); France Télécom (C. Roche); General Electric (J. Shei); Philips (J. van der Biesen); Microsoft (A. Hagehülsmann); Saint-Gobain (A. Ajdari); Solvay (L. Demiddeleer); Thales (E. Lansard); Valeo (P. Reilhac).

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This report was designed as an extension of the OECD project on open innovation (Innovation in global networks). The aim was to deepen the analysis and to explore the case of France through statistical data and the gathering of information on the practices in French companies. The participation to the OECD project constituted an important step and I thank the team in charge of this project with whom I worked in a very fruitful way, namely Koen de Backer, Mario Cervantes, Dirk Pilat and Els van der Velde. I thank also the contributors from the countries participating in the OECD study whom I exchanged with. Dominique Guellec gave me access to OECD data and studies, which I have used with profit.

Yves Doz took charge of interviews with some companies within the framework of a collaboration with the French Ministry of Higher Education and Research. In this collaboration, Edwige Chassagneux and Marie-Aude Dalsace have contributed to the preparation and the exploitation of these interviews. Yves Doz also contributed to one of the conferences organised within the OECD project by drawing from his work on the internationalisation of companies R&D.

The exchanges with companies have been an essential source of information and reflection to understand the evolution of their innovation practices. This is why I insist to thank all the participants who have accepted to devote time to this project.

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