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OPEN INNOVATION IN A GLOBAL PERSPECTIVE – WHAT DO EXISTING DATA TELL US?

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OPEN INNOVATION IN A GLOBAL PERSPECTIVE – WHAT DO EXISTING DATA TELL US?

Koen De Backer (OECD), Vladimir López-Bassols (OECD) and Catalina Martínez (IPP-CSIC)*

ABSTRACT

Open innovation has received a lot of attention in the business management literature and recently also in policy discussions. Until now, most of the empirical evidence has been based on case study work offering detailed insights into some best practices of open innovation in companies' innovation strategies. While existing large-scale data may offer interesting empirical evidence on open innovation, they have surprisingly not really been analysed in great detail. Especially the increasing importance of open innovation on a global scale in so-called global innovation networks, calls for internationally comparable data on open innovation. This paper presents different indicators using existing data on R&D investments, innovation survey data, patent data and data on licensing, illustrating the increasing importance and the different characteristics of open innovation across companies, industries and countries.

L'INNOVATION OUVERTE DANS UNE PERSPECTIVE MONDIALE : QUE NOUS DISENT LES DONNÉES DISPONIBLES ?

Koen De Backer (OCDE), Vladimir López-Bassols (OCDE) et Catalina Martínez (IPP-CSIC)[*]

RÉSUMÉ

L'innovation ouverte a suscité une grande attention dans les travaux publiés sur la gestion d'entreprise, ainsi que dans le cadre des débats récents sur l'action publique. Pour l'heure, la plupart des données empiriques sur le sujet reposent sur des études de cas, offrant des indications précises sur certaines des meilleures pratiques observées en matière d'innovation ouverte dans le cadre des stratégies d'innovation des entreprises. Alors que de vastes ensembles de données pourraient offrir des éléments empiriques intéressants sur l'innovation ouverte, ils n'ont étonnamment pas vraiment été analysés de manière très poussée. Or, compte tenu de l'importance croissante que revêt en particulier l'innovation ouverte à l'échelle mondiale dans le cadre des « réseaux mondiaux d'innovation », il est nécessaire que l'on puisse disposer de données comparables au niveau international sur l'innovation ouverte. Nous présentons dans ce document différents indicateurs fondés sur des données disponibles relatives aux investissements en recherche-développement (R-D), tirées d'enquêtes sur l'innovation, relatives aux brevets et portant sur les concessions de licences, qui illustrent l'importance grandissante et les caractéristiques diverses de l'innovation ouverte dans une multitude d'entreprises, de secteurs d'activité et de pays.

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1. Introduction

Since the publication of the book "Open innovation" by UC Berkeley professor Henry Chesbrough in 2003, open innovation strategies of companies have attracted a great deal of attention. The business management literature has largely stressed the necessity of open innovation strategies today and recently open innovation has also surfaced in policy discussions because of its possible effect on national/regional innovation systems and corresponding government policies.

The discussion on open innovation could benefit a lot from more systematic empirical evidence on this form of innovation by companies. The concept of open innovation has largely been demonstrated by numerous case studies, illustrating how companies implement the open innovation model in practice. Thus far, these case studies have not been complemented by large-scale indicators showing the importance and characteristics of open innovation across companies and industries. Given that innovation has become increasingly global, giving rise to the emergence of global innovation networks, the availability of internationally comparable indicators would contribute to a better understanding of the concept and its implications for government policy.

This paper uses existing data to present several indicators that describe the importance of characteristics of open innovation across different countries. More specifically, data on R&D investments, (Community) innovation surveys, (co-) patenting data and licensing data are analysed in order to present evidence on open innovation on a global scale. Aggregate insights are obtained about the importance and the different characteristics of open innovation across countries, while the broad range of indicators presented directly shows the diversity of open innovation within companies.

This descriptive paper is only one step towards more systematically gathering data and constructing indicators on open innovation. It uses official statistics that are readily available but does not discuss data on *e.g.* alliances and joint ventures that are collected by private organisations. Further on, the paper proposes simple indicators without suggesting composite indicators that could be constructed on the basis of these existing databases. As such, in addition to presenting empirical evidence based on existing data, the added value of this paper also lies in the identification of several directions for future research.

The paper starts by introducing the concept of open innovation and directly relates this to the increasing internationalisation of R&D and innovation, thereby discussing the emergence of global innovation networks. This is followed by a discussion of the existing empirical evidence on open innovation, largely based on company case studies and some first attempts to produce more systematic evidence through national innovation surveys.

The next sections present several indicators on open innovation on a global scale, using respectively R&D investment data, innovation surveys, patenting and licensing data. For each database used, different indicators are presented and analysed, albeit without discussing the links between them in close detail given the large diversity of the different data used. The concluding section presents the main aggregate insights based on the different databases and discusses possible future research.

The different results show that suppliers and customers are the most sought-after innovation partners. Companies collaborate in innovation most frequently with suppliers and customers while the co-operation with competitors and private R&D labs and consultants seems to be somewhat less important. Secondly, larger firms innovate more openly than small firms. Thirdly, geographical proximity still matters in global innovation networks. International technology collaboration (based on innovation survey data and co-application patent data) is found to play a prominent role in the innovation process of companies, but nevertheless companies seem to privilege innovation partners that are geographically close.

This paper draws heavily on the work that has been conducted in the project "Globalisation and open innovation" within the Working Party of Technology and Innovation Policy (TIP) of the OECD. The TIP project brought together an extensive literature review on globalisation and open innovation (including empirical indicators), a large number of company case studies across 13 OECD countries and the policy implications of these new ways of innovation. The results are published in the report "Open innovation in global networks" (OECD, 2008*a*).

2. Open innovation and the emergence of global innovation networks

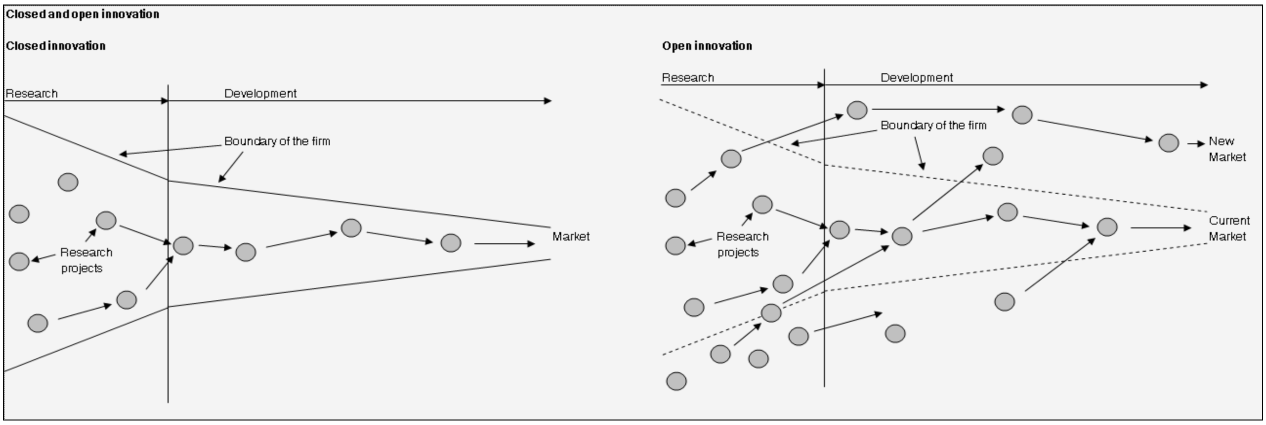
Innovation has become a key factor for the competitiveness of OECD countries as emerging countries have quickly become strong competitors in low price/cost products and services. At the same time the environment for innovation is changing: competition is increasingly global and intense resulting in shorter product life cycles, and knowledge has become more multidisciplinary and more broadly located making innovation more expensive and riskier. To meet these new challenges, companies adopt new approaches to their innovation strategies and increasingly look for partners with complementary expertise in order to get rapid access to different technologies.

A major trend in business innovation strategies is that companies open up their innovation processes, not only in industries like ICT and pharmaceuticals/biotechnology, but increasingly also in other industries. Companies "openly" innovate with customers, suppliers, competitors, universities and research institutes, etc. as they increasingly rely on outside innovation for new products and processes. Increased co-operation in technology has become an important way of sourcing knowledge in order to generate new ideas and bring them quickly to the market. Although this trend towards more open innovation is not altogether new, it takes place at a much faster pace today.

This open innovation model is typically described in contrast to the so-called traditional closed innovation model of the past, in which companies tended to innovate internally relying primarily on their own R&D departments to develop new products and processes. And if innovation projects delivered new ideas that did not match the company's strategy, the idea often stayed unused within the company. In this more traditional innovation model, R&D laboratories use inputs both from internal and external sources in inventing, evolving and perfecting technologies, but the focus is on internal development of technologies, products and processes for internal commercialisation. This is often described by the funnel analogy, as large numbers of internal concepts are narrowed down to the ones that best fit the company's needs (Figure 1). Innovations could stay (for a certain time) "on the shelf" if they did not fit into the company's strategy.

The open innovation model is a more dynamic and less linear approach whereby companies look both inside-out and outside-in (Chesbrough, 2003 and 2006). Innovation is based on knowledge assets beyond the boundaries of the company and increased co-operation has become an important way of knowledge sourcing in order to generate new ideas and bring them quickly to the market. At the same time companies exploit both their own ideas as well as innovations from other entities, in which academic research occupies a major place. Companies may also spin-out technologies and intellectual property that were internally developed but that are determined to be outside the core business of the firms and thus better developed and commercialised by others. MNEs increasingly link up with start-up firms, spin-offs and the public R&D system. Companies' solid boundaries are being transformed into a semi-permeable membrane that enables innovation to move more easily between the external environment and the companies' internal innovation process.

Figure 1. Closed versus open innovation



Source: Chesbrough, 2003.

Two major features of open innovation can be distinguished. The inbound side of open innovation relates to the sourcing of technology and knowledge from outside partners like universities, research organisations, competitors, suppliers and customers. The outbound side of open innovation is much more recent and new, as companies increasingly want to gain revenue from in-house developed knowledge that has not been commercialised yet. Companies increasingly search for alternative uses and commercialisations of their (unused) IP-portfolio, and IP is observed to evolve from Intellectual Property to Intellectual Partnering (Chesbrough, 2006). Intellectual property receipts have significantly increased (Anthreye and Cantwell, 2005), but important barriers still exist in the market for IP: only 15% of the patents are exchanged in this market, while 50% of them are used solely in-house (European Commission, 2005).

Companies use different modes for open innovation. Partnerships with external parties (alliances, joint ventures, joint development etc.); acquiring/selling knowledge (contract R&D, purchasing, licensing) are used to source external knowledge. While these modes are more common, open innovation has been increasingly realised through corporate venturing (equity investments in university spin-offs or in venture capital investment funds). Companies also increasingly use venturing to look for external partners in order to commercialise innovations that are not used internally (divestments, spinning out, spinning off).

Globalisation has significantly altered the scope for open innovation as it drastically broadens the choice of potential partners, giving rise to the development of global innovation networks. Companies increasingly build networks of distributed R&D globally in order to sense local markets' trends, to tap into local knowledge and to provide further sources of new technology. In order to match the growing demand for innovation from customers, suppliers, etc. with the worldwide supply of science and technology, (large) companies increasingly adopt so-called eco-systems of innovation across countries. Companies link in these innovation networks with people, institutions (universities, government agencies, etc.) and other companies in different countries to solve problems and find ideas (Cooke, 2005; Forrester Research, 2004).

In addition to the growing number of R&D facilities abroad, companies (and most specifically MNEs) are increasingly involved in international co-operative arrangements. Global innovation networks include own R&D facilities abroad as well as collaborations with external partners and suppliers, where, dependent on the expertise the different partners play multiple roles. Sourcing proprietary technology and know-how takes place through contractual international agreements like contract R&D, joint R&D agreements and corporate high tech venturing in addition to own R&D facilities abroad. Companies have increasingly been setting up collaborations with external parties like suppliers, customers, universities, etc. as part of their innovation strategy.

Global innovation networks influence significantly the innovation systems of countries and regions. The eco-systems or networks of innovation by MNEs often represent the nodes between regional/national systems of innovation across borders, and as such MNEs link between the several S&T actors (high technology start-ups, universities and research institutes, science and technology researchers, innovation intermediaries and government institutions) across different countries. Through their distributed networks, MNEs aim to maximise agglomeration economies across countries by combining the transfers of tacit knowledge within local knowledge residing in national innovation systems (*i.e.* among innovation actors in local communities) and of more codified knowledge through global pipelines or communication channels (Bathelt *et al.,* 2004). These international R&D activities, including the integration in local innovation networks in host countries, are expected to positively impact the competitiveness of MNEs' activities in their home country because of the existence of reverse technology transfers (UNCTAD, 2005).

3. The empirical measurement of open innovation: mainly based on case studies and surveys

The empirical evidence on (global) open innovation consists mainly of case studies, often of larger companies in technology-intensive industries (*e.g.* ICT, pharmaceuticals and biotechnology). Surprisingly, large-scale data have not really been explored notwithstanding *e.g.* innovation surveys which have already demonstrated the increasing importance of openness in R&D and technology. This may partly be due to the fact that open innovation is a very variable concept, of which the importance for companies directly depends on their strategies and structural characteristics (industry, size, life cycle, etc.).

Chesbrough *et al.* (2006) discussed the broader use of open innovation in practice and analysed whether open innovation concepts were also used in industries other than high technology. Based on a survey (albeit relatively small) he found that:

- Open innovation concepts are increasingly finding application in companies operating outside the "high-technology" industries.
- Open innovation concepts are not employed primarily as a rationale for cost reduction or outsourcing of the R&D function, since internal R&D is maintained or even increased (the importance of absorptive capacity).
- Many of the outbound-oriented concepts have not been adopted yet, mainly some inbound open innovation concepts have been used.

De Jong (2006) analysed the determinants and barriers for open innovation in SMEs in the Netherlands, as the existing empirical evidence mainly originates from case studies in larger companies. The results indicated that the trend towards more open innovation is also observable within innovating SMEs, as these companies are traditionally more open for innovating because of their limited size and resources. Market requirements such as intense competition and more demanding customers were found to be the major motivation for open innovation in these innovating SMEs. The most important bottleneck is differences in organisation and culture between the individual partners in open innovation (De Jong, 2006).

In analysing 124 companies, Gassman and Enkel (2004) found that the open innovation approach is typical for industries characterised by a high product modularity, a high industry speed (due for example to technological advances), where much explicit knowledge is required and highly complex interfaces are crucial, and where positive externalities are created (*e.g.* standard setting). Additionally they suggest that the outside-in process of open innovation is more important in rather low-technology industries that produce highly modular products, and where the competitive advantage of companies is heavily based on knowledge (companies expect spill-overs from higher technology industries). The inside-out process is found to be more prominent in research-driven companies and industries.

The survey of R&D globalisation by INSEAD, in co-operation with Booz Allen Hamilton (2006), completed by 186 companies from 19 countries and 17 industries, also included some results on the importance of external collaboration and R&D networks. Apart from the increasing importance of global and collaborative R&D (see above), the results also suggest that more global R&D companies tend to have slightly more external collaboration (with universities, customers, suppliers, alliance partners, etc.). But these external R&D collaborations are found to be still largely concentrated around the headquarters in the home country.

Gassmann and Enkel (2004) reviewed the existing empirical research using case studies to assess the importance of open innovation. Regarding the outside-in process, they refer to several studies of the role of suppliers and customers in companies' innovation process and their effects on innovation performance. The empirical literature on external knowledge sourcing is vast, and includes analysis of the importance of technology sourcing as a motive for foreign direct investment, on the appropriate choice of modes and partners in accessing external knowledge, and on the complementarity between internal and external R&D and knowledge (*i.e.* the concept of "absorptive capacity").

The empirical research on the inside-out process of open innovation is much more limited. The literature on licensing-out is scarce and often focused on special industries and even individual companies, while research on the concepts of corporate venturing (spinning-off and spinning-out) has only recently started to develop. The coupled process of open innovation as described by Gassmann and Enkel (2004) is (partially) covered by the growing literature on joint ventures, alliances and networks, although the focus in this literature seems also more on the technology sourcing and the inside-out process of open innovation.

More internationally comparable evidence on open innovation has been presented using data on (R&D)-alliances, mainly collected in private databases, on the number and types of technology collaborations between companies (*e.g.* the THOMSON and MERIT databases). Hagedoorn (2002) has reported extensively on the evolution of technology alliances between companies, as well as on the geographical, institutional and industry distribution of these collaborative agreements using the MERIT data. A drawback of these data sources is that they may be incomplete as not all alliances (on a worldwide, regional and/or national level) can be consistently identified. The variability in the number of alliances over the years suggests that the data collection process may encounter some collection problems.

Overall, the empirical evidence on open innovation is based on company case studies and private databases on (R&D-) alliances, hence the need for more systematic evidence on this phenomenon that is becoming increasingly important. Further on, the internationalisation of R&D and innovation calls for the international perspective to be taken into account in this evidence. In what follows, official large-scale databases have been exploited in order to collect empirical evidence on open innovation. It is clear that there is not one indicator of open innovation because of the diversity of open innovation practices and modes in companies. Instead, the differences and complementarity between the different information sources offer a more complete picture of open innovation. The indicators based on R&D investments, innovation surveys and patent data measure especially the outside-in part of open innovation by looking at technology collaboration between different partners. Data on licensing is also presented in order to measure the inside-out part of open innovation.

4. Data on R&D investment

Data on R&D-investment only offer rather indirect evidence on open innovation. Specific information on the public-private funding of R&D reveals to some extent insights into the interaction and collaboration between government and the business sector. While government-financed R&D seems to be merely related to the existence of direct government funds without necessarily pointing to “real” collaboration, the business funding in higher education and government sectors (*e.g.* research centres) is often an indicator of the close collaboration between public and private institutes.

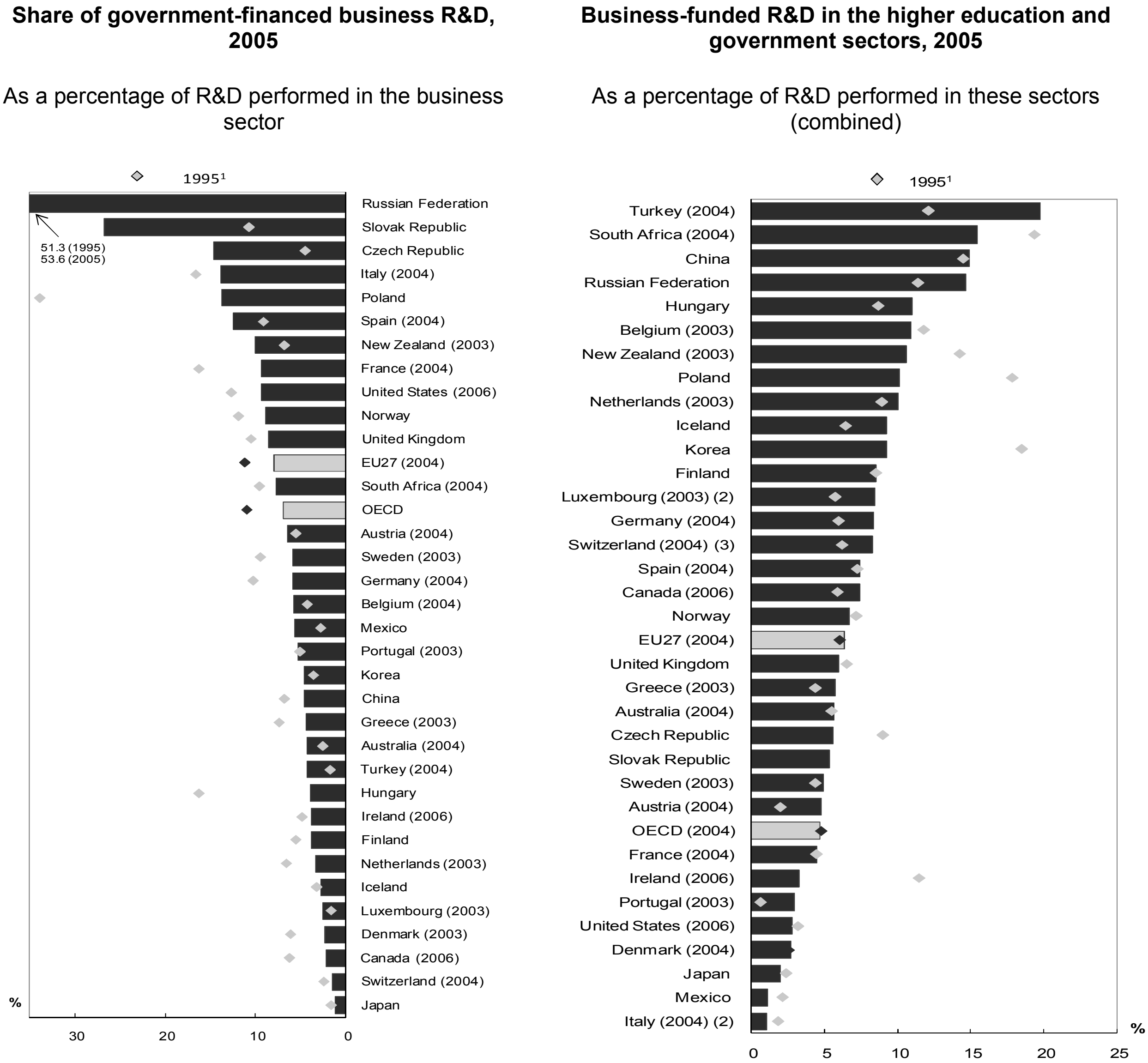
Business funded R&D in the higher education and government sector has increased in a large number of countries (Figure 2). Business funds for R&D performed in the higher education and government sector, averaged 4.7% in 2005 in the OECD area. Companies in European (27) countries are more strongly financing research in public institutions and universities, funding 6.4% of total R&D performed in these sectors, compared to companies in the United States (2.7%) or Japan (2.0%).

Information on the nationality of the funding source of business enterprise R&D may offer some evidence on the international collaboration in R&D activities, but again this is rather indirect evidence. The sources of finance of business enterprise R&D can be local or foreign and originate from other private business, public institutions (governmental and higher education) or international organisations. Figure 3 indicates that R&D sources from abroad are on average quite important in the funding of business R&D: in EU (27) countries for example finance from abroad (including other European countries) represented around 10% of total business enterprise R&D.

In most of the countries for which data are available, MNEs’ activities seem to play a large role in the international funding of business R&D. The finance of business enterprise R&D from abroad concerns basically finance by other business enterprises, and more than half of this funding from abroad concerns intra-company funding. In the Netherlands and Denmark, funding from foreign companies represented more than 80% of the total funding from abroad, and almost all of this funding comes from affiliates belonging to the same enterprise group. In Sweden and Norway, the funding by foreign companies accounted for 50% of total foreign funding, and almost one-third of this originates from non-affiliated foreign companies (Figure 4).

In summary, the empirical evidence on R&D data supports to some extent the increasing importance of open innovation on an international scale. R&D in the higher education and government sector is found to be increasingly funded by the business sector in a large number of countries. At the same time, international funding (often within MNEs) contributes significantly to business R&D.

Figure 2. Public-private cross-funding of R&D

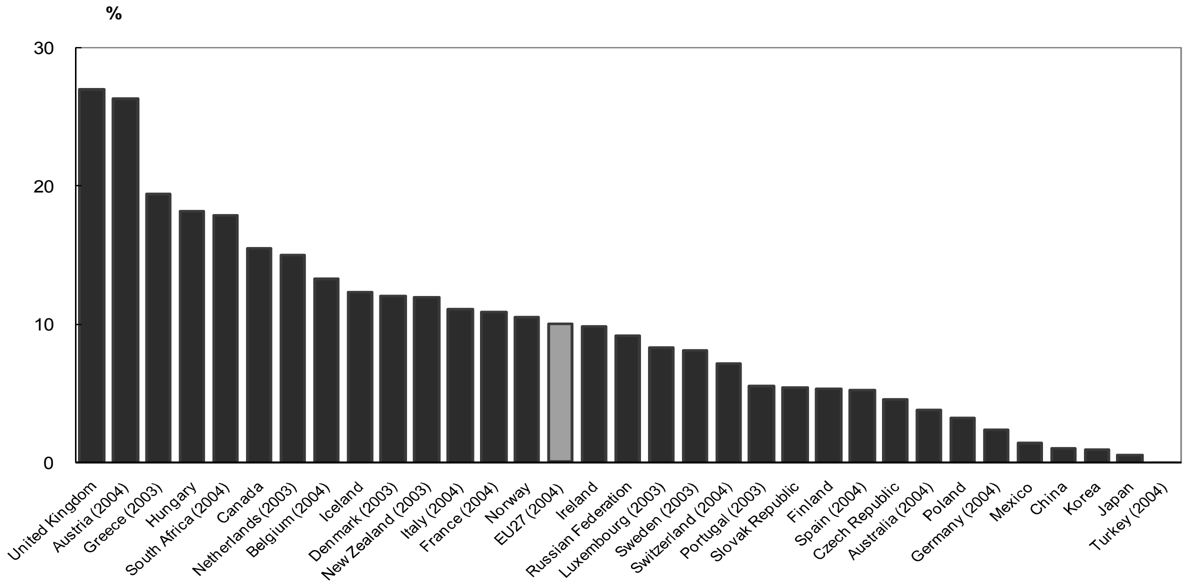


1. Data for Australia and Switzerland 1996; Luxembourg and China 2000; Austria 1998; and South Africa 2001.
2. Only in the government sector.
3. Only in the higher education sector.

Source: OECD (2007).

Figure 3. Funds for R&D from abroad

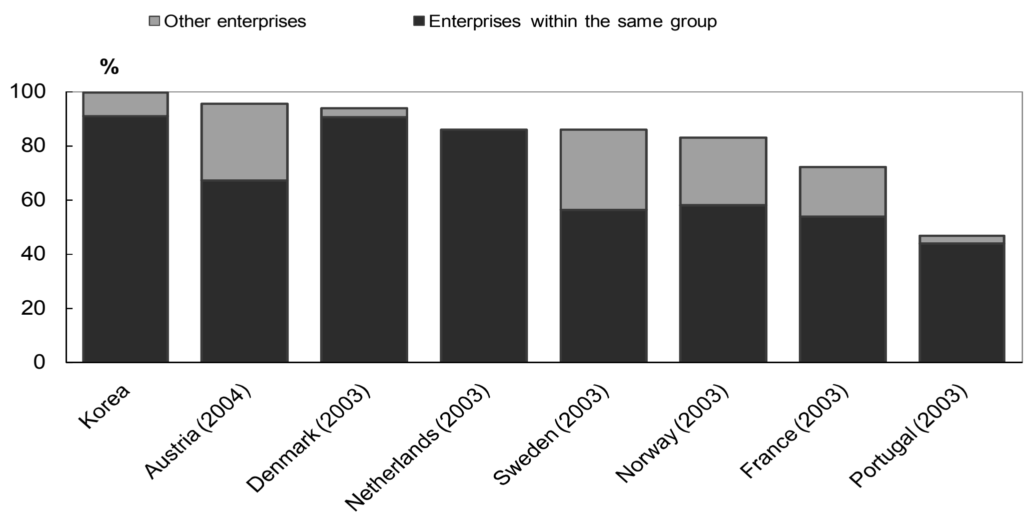
(as a percentage of business enterprise R&D, 2005)



Source: OECD (2007).

Figure 4. Funding from foreign companies

In % of total foreign funding



Source: OECD (2007).

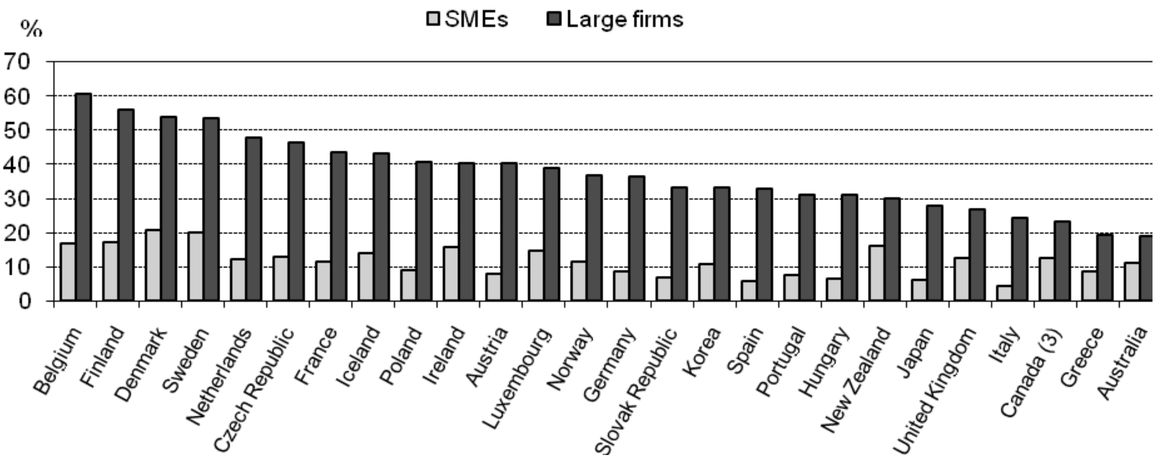
5. Innovation survey data

Innovation surveys are increasingly used in OECD and in many non-member countries to better understand the role of innovation as well as the characteristics of innovative companies. The latest editions have extended the scope to marketing and organisational innovations as well as technological innovations, and place an increasing emphasis on the role of linkages, including collaboration in innovation. Collaboration is defined as the "active participation in joint innovation projects with other organisations" (OECD/Eurostat, 2005), but excludes pure contracting out of work. Collaboration can involve the joint development of new products, processes or other innovations with customers and suppliers, as well as horizontal work with other enterprises or public research bodies. As such, more direct evidence on open innovation and specifically on the sourcing of innovation (*i.e.* the outside-in process of open innovation) can be derived from innovation surveys.

The data from the 4th Community Innovation Survey (CIS-4) show that collaboration has become an important part of the innovation activities of many companies: around one in ten of all companies (or one in four innovating companies) in Europe collaborated with a partner for their innovation activities during 2002-04. Large companies were four times more likely to collaborate in innovation than small and medium-sized enterprises (SMEs). Among SMEs, the rate of collaboration is fairly similar across countries (between 10 and 20% of all firms in more than half of the countries surveyed), but it varies widely for large companies (Figure 5). Nevertheless it should be kept in mind that the data only reveal the existence of some sort of collaboration, not its type or intensity.

Figure 5. Companies collaborating in innovation activities, by size[1], 2002-04[2]

As a percentage of all companies



1. SMEs: 10-249 employees for European countries, Australia and Japan (persons employed); 10-99 for New Zealand, 10-299 for Korea, 20-249 for Canada.
2. Or nearest available years.

Source : OECD (2007).

Table 1 gives an overview of the number of companies active in innovation collaboration across different industries and countries for which data are available (especially in specific industries in smaller countries information becomes confidential). The industry distribution shows that collaboration in innovation is important in manufacturing as well as in services, notwithstanding that there are some differences between countries. In addition to industries like chemicals and pharmaceuticals, ICT (including software) that typically show high levels of open innovation, other industries like wholesale and retail, transport and communication also display a large number of collaborations for innovation.

Table 1. Companies collaborating in innovation activities, by industry, EU-countries, 2002-04[1]

	Belgium	Denmark	Germany	Spain	France	Italy	Nether-lands	Finland	Sweden	United Kingdom	Norway
ALL	2 689	2 106	10 519	5 124	11 138	5 719	3 701	1 575	3 343	11 209	1 074
MANUFACTURING	1 529	1 176	6 949	3 278	6 093	3 646	2 076	989	1 950	4 998	636
Food and beverages (15)	173	123	325	470	771	206	231	89	116	343	89
Textiles, apparel and leather (17+18+19)	c	C	194	219	349	297	c	39	46	c	c
Wood (20)	28	13	134	83	282	74	c	38	133	114	33
Paper and printing (21+22)	95	c	334	132	518	93	218	90	188	438	32
Chemicals incl. pharmaceuticals (24)	164	84	563	296	517	342	169	48	80	347	32
Rubber and plastic (25)	105	92	432	119	396	207	108	55	114	379	17
Basic metals (27)	42	20	185	97	135	100	30	24	59	114	19
Metal products (28)	297	120	921	510	846	654	324	130	324	709	59
Machinery and equipment (29)	112	274	1 434	418	584	555	355	191	309	562	78
Office machinery and computers (30)	c	c	57	7	15	54	231	5	16	64	2
Electrical machinery (31)	39	57	398	131	225	229	c	54	91	221	26
Radio, TV and communications eq. (32)	22	24	224	56	237	121	c	21	49	139	24
Medical and optical instruments (33)	52	66	702	80	379	232	c	37	86	489	27
Motor vehicles (24)	61	c	208	142	164	90	81	16	87	172	11
Other transport equipment (35)	46	c	121	65	76	60	c	11	40	96	46
Furniture and other manufacturing (36)	59	47	387	139	213	68	192	38	101	269	34
Recycling (39)	12	c	17	12	44	26	c	1	9	40	5
Electricity, gas and water (40)	c	c	86	40	52	53	28	c	c	c	31
CONSTRUCTION	130	24	c	932	1530	c	c	c	c	c	86
SERVICES (excl. public administration)	1 725	1 197	c	2 794	9 552	3 462	1 625	c	1 830	c	454
Wholesale and retail trade (51+52+53)	794	535	c	1 176	3 615	1243	779	c	527	c	143
Horeca (55)	c	0	c	4	818	388	c	c	c	c	c
Transport, storage and communication (60)	258	48	841	305	746	448	239	139	226	838	49
Finance and insurance (61+62+63)	136	70	192	153	519	277	119	56	104	583	26
Computer and related activities (72)	151	169	1 046	293	1 206	579	219	117	316	1 904	108
Research and development (73)	64	0	c	147	326	77	c	c	101	c	17
Other business activities (74)	323	374	c	641	1 904	293	269	c	554	c	112

c: confidential; figures across industries do not sum up to total.
1. Or nearest available years .
Source : CIS-4 data.

Companies collaborate in innovation most frequently with suppliers and customers while the co-operation with competitors and private R&D labs and consultants seems to be somewhat less important. This general finding becomes clear in most countries when distinguishing collaboration in innovation by partner (Table 2). While universities and government research institutes are generally considered to be an important source of knowledge transfer for the innovation activities of companies, especially in more upstream/research activities, the collaboration with public research organisations (higher education or government research institutes) based on the CIS data however seems less important (Figure 6). Large companies are much more active in public research although there is much more cross-country variation for large firms than for SMEs.

Table 2. Companies collaborating in innovation activities, by partner, 2002-04[1]

As a percentage of all companies collaborating in innovation

	Suppliers	***Customers***	***Competitors***	**Consultants and private R&D institutes**	***Universities and other higher education***	***Government and public research***
Belgium	73%	59%	27%	42%	37%	26%
Bulgaria	74%	61%	35%	34%	27%	18%
Czech Republic	80%	68%	40%	39%	34%	19%
Denmark	66%	65%	35%	44%	32%	16%
Germany	44%	51%	27%	18%	53%	26%
Estonia	67%	66%	53%	29%	25%	17%
Ireland	72%	78%	19%	31%	31%	18%
Greece	46%	32%	47%	27%	27%	10%
Spain	52%	23%	17%	23%	26%	28%
France	65%	50%	36%	32%	26%	18%
Italy	56%	39%	37%	50%	36%	11%
Luxembourg	79%	73%	49%	36%	33%	27%
Hungary	71%	53%	37%	34%	37%	14%
Malta	70%	52%	17%	43%	13%	13%
Netherlands	75%	55%	31%	38%	31%	24%
Austria	43%	45%	22%	42%	58%	30%
Poland	67%	39%	20%	19%	15%	21%
Portugal	71%	60%	35%	45%	39%	25%
Romania	79%	57%	37%	28%	21%	25%
Slovenia	79%	70%	43%	42%	41%	28%
Slovakia	84%	80%	56%	49%	39%	30%
Finland	92%	93%	77%	74%	75%	59%
Sweden	75%	65%	25%	46%	41%	15%
United Kingdom	74%	73%	36%	41%	33%	25%
Iceland	68%	68%	48%	23%	17%	45%
Norway	70%	67%	36%	61%	45%	49%

1. Or nearest available years.

Source : CIS-4 data.

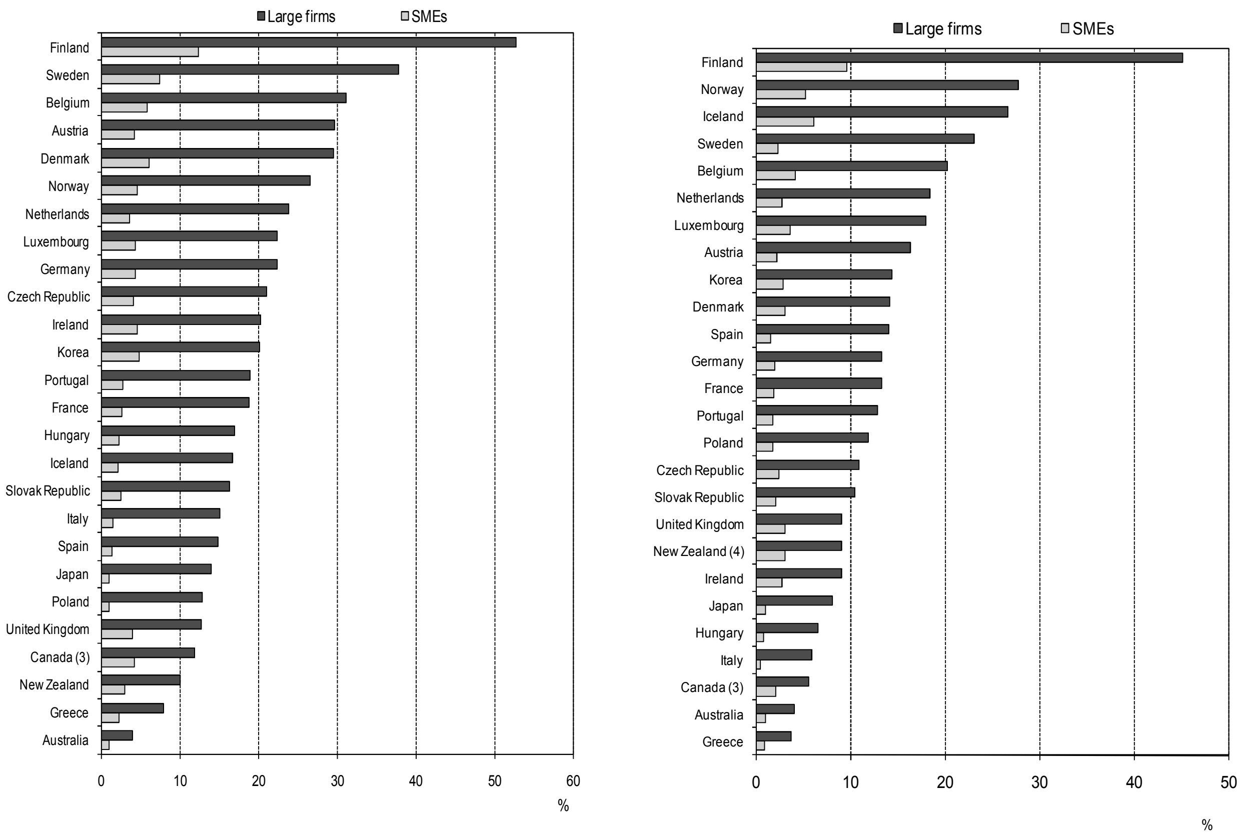
Figure 6. Collaboration with public research organisations by companies

Companies collaborating in innovation with higher education institutions, by size[1], 2002-04[2]

As a percentage of all companies

Companies collaborating in innovation with government institutions by size[1], 2002-04[2]

As a percentage of all companies



1. SMEs: 10-249 employees for European countries, Australia and Japan (persons employed); 10-99 for New Zealand, 10-299 for Korea, 20-249 for Canada.
2. Or nearest available years.
3. Manufacturing sector only.
4. Refers to firms that co-operate with Crown Research Institutes, other research institutes or research institutions.
Source : OECD (2007).

International collaboration for innovation, *i.e.* collaboration with foreign partners, is found to play a prominent role in the innovation process of companies, but nevertheless geographical proximity still seems to be important (Figure 7). The share of European companies with partners in another European country ranges between 2% and 14% (relative to the total number of companies). Collaboration with partners outside Europe is much less prevalent, concerning only between 2 and 6% of all companies in most European countries. For companies in other regions, the propensity to collaborate on innovation with partners abroad varies widely between countries, ranging from less than 2% of all firms in Korea, Japan and Australia, to more than 8% in Canada and New Zealand. Again, SMEs seem to be less active in international collaboration in innovation than larger companies.

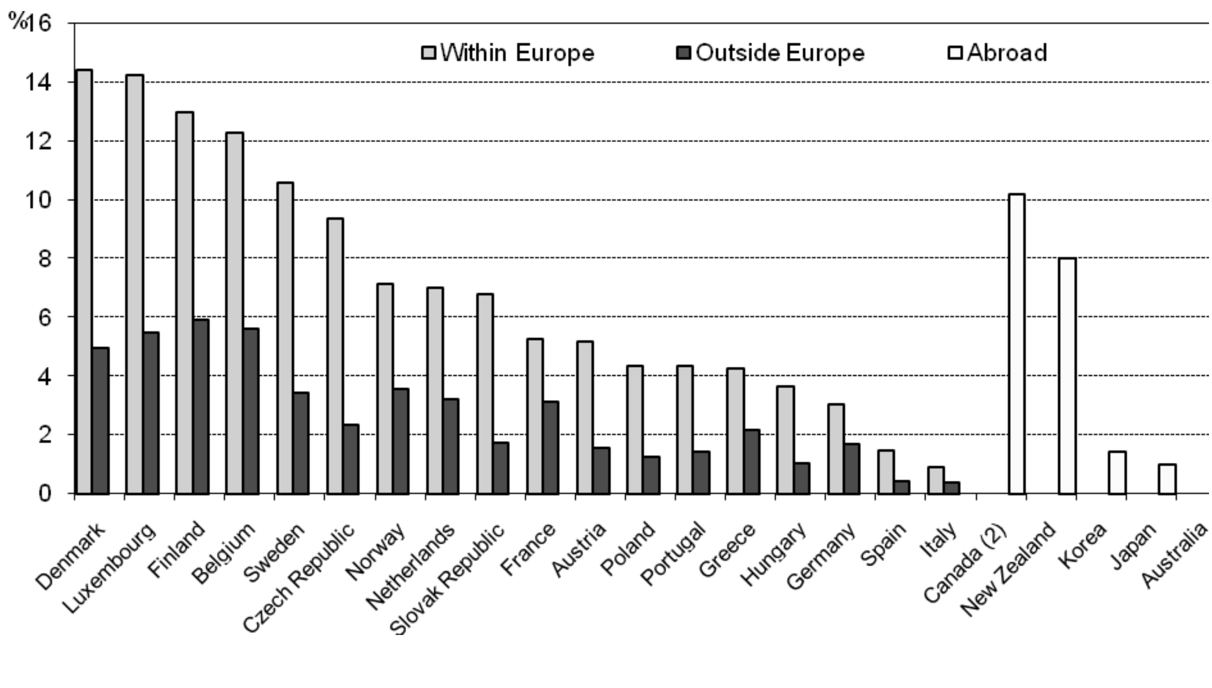
In line with other empirical evidence (INSEAD and Booz, Allen and Hamilton, 2006; Hagedoorn, 2002), these results show that the choice of innovation partners seems still to privilege those that are geographically close. Despite highly improved communication possibilities, collaboration with external partners requires extra investments and resources especially on an international level. This may explain why SMEs, which typically have less resources, display a lower intensity of collaborating with external parties, overall and internationally. Knowledge is often tacit and person-embodied and this explains why language and distance are barriers to collaboration.

It should be taken into account however that the evidence in Figure 7 only presents the (quantitative) numbers of technology collaborations without information on the qualitative importance of these collaborations. Miotti and Sachwald (2003) showed that at the end of the 1990s, French companies' transatlantic partnerships were much less numerous than domestic and European partnerships, but more focused on high tech and technology sourcing (as opposed to cost sharing and partnering within EU schemes). Since international partnerships are more costly and difficult to manage, companies enter into them if they are strongly motivated, either by market demand or excellence seeking.

In summary, CIS-data indicate in the first place that larger firms innovate more openly than smaller firms. Based on the number of innovation collaborations, suppliers and customers are the preferred partners to collaborate with; universities and government institutions account for a significantly smaller number of collaborations. Lastly, companies seem to prefer to collaborate with innovation partners which are geographically close.

Figure 7. Companies with foreign co-operation in innovation, 2002-2004[1]

As a percentage of all companies



Source : OECD (2007).

6. Data on patents

Patent data are considered a unique, broadly available source of statistical material (OECD, 2005) and are increasingly used to study different aspects of the innovation process, *e.g.* the internationalisation of innovation (OECD, 2008*b*). Patent documents report the inventor(s) and the applicant(s) – the owner of the patent at the time of application – along with their addresses and countries of residence. Furthermore, in contrast to *e.g.* CIS data, longer time series are available allowing an analysis over time. The main disadvantage of patent statistics is that they fail to capture all innovative activity as not all innovations are patented and not all patents lead to innovations.

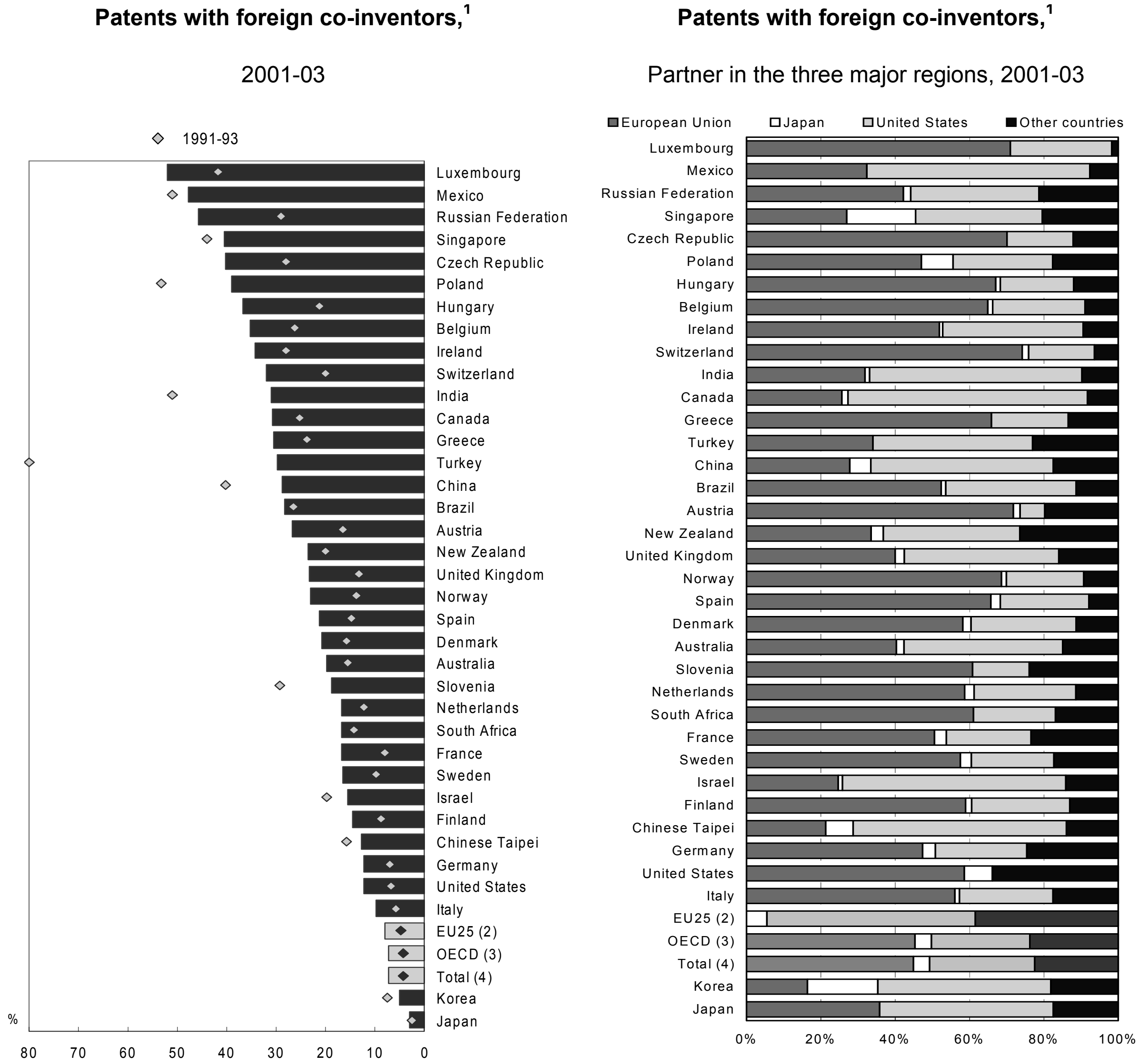
International co-invention

Several options are open to study open innovation on the basis of patents: different inventors, different co-assignees or owners, differences between inventors and assignees could all be used as indications of technology collaborations and open innovation. However results should be interpreted carefully: data on inventors typically refer to physical persons who are often employees from one company-assignee, and as such different names of inventors and assignees do not necessarily point to open innovation practices between companies. One possible indicator is the international co-invention of patents, as this indicator is not only based on multiple inventor names but also on different countries of residence of these inventors. As such, this indicator can be considered as a proxy measure of formal R&D co-operation and knowledge exchange between inventors located in different countries. However, it should be noted that different inventors may still be employees of one MNE with affiliates in different countries and that this indicator may be biased against the international R&D activities and patenting strategies of MNEs.

The degree of international co-invention of a country refers to the number of patents invented by a country with at least one foreign inventor in the total number of patents invented domestically. The world total share of patents involving international co-invention increased from 4% in 1991-93 to 7% in 2001-03. Small and less-developed economies typically engage more actively in international collaboration while larger countries such as the United States, the United Kingdom, Germany or France, have shares between 12 and 23% (in 2001-03).

The breakdown of collaboration by main partner country confirms the importance of geographical proximity also in international co-invention. EU countries are found to collaborate essentially with other EU countries, whereas countries such as Canada, Mexico, India, China, Israel, Korea and Japan, collaborate more frequently with the United States. For instance, more than 20% of inventions made in India, Canada and Mexico involved collaboration with a US inventor (Figure 8). Just as in the case of the Community Innovation Survey, these results may be due to the geographical proximity of affiliates of MNEs (intra-firm collaboration in innovation).

Figure 8. International co-invention in patents



Note: Patent counts are based on the priority date, the inventor's country of residence, using simple counts.

1. Share of patent applications to the European Patent Office (EPO) with at least one foreign co-inventor in total patents invented domestically. This graph only covers countries/economies with more than 200 EPO applications over 2001-2003.
2. The EU is treated as one country; intra-EU co-operation is excluded.
3. Patents of OECD residents that involve international co-operation.
4. All EPO patents that involve international co-operation.

Source: OECD (2007).

Co-applications: geographical dimension

In addition to indicators based on co-invention information, data on co-applications (*i.e.* patent applications with more than one applicant-owner of the patent) may offer alternative indicators on open innovation. Again, this indicator is not a perfect measure of innovative collaboration as some companies may opt to form a joint-venture for doing the collaborative R&D and apply for the corresponding patents (and have joint venture as the only applicant-owner). Patent applications to the European Patent Office

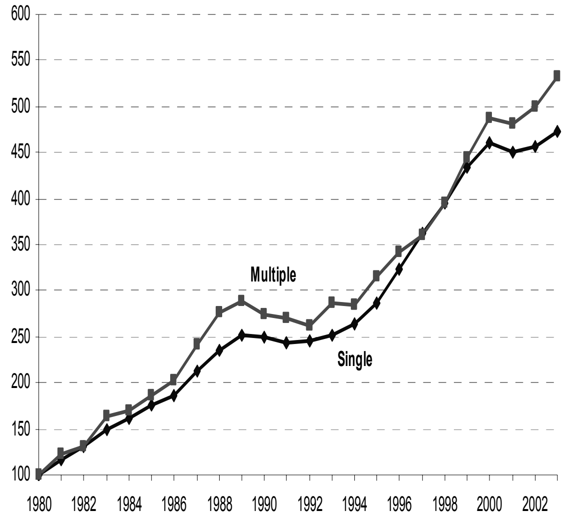
(EPO) with priority years 1980-2003 have been analysed based on information from the April 2007 version of the EPO Worldwide Patent Statistics Database (PATSTAT).

Reflecting the strong increase in the total number of EPO patent applications over the last two decades, the number of applications with multiple applicants has grown significantly and somewhat more strong than those with single applicants. The share of patent applications with multiple assignees in the total number of patent applications has nevertheless remained relatively stable around (only) 6% during 1980-2003 (Figure 9). The most common form of co-assignment is observed to be two applicants from the same country, representing around 3% of all EPO filings, followed by two applicants from different countries with almost 2%. Patent applications with more than two applicants (national and international) are rather limited.

Figure 9. EPO patent applications, single and multiple applicants, priority years 1980-2003

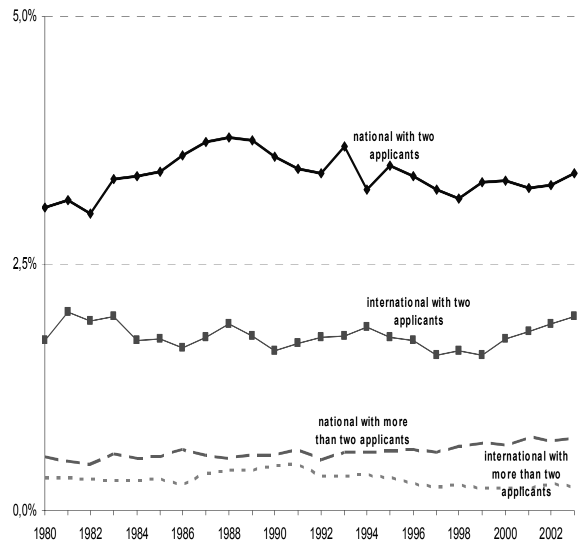
EPO patent applications with single and multiple applicants,1980-2003

1980=100



EPO patent applications with multiple applicants 1980-2003

in % of total applications



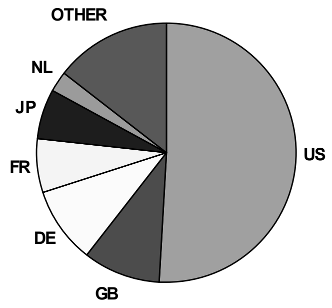
Source : OECD patent database.

In order to analyse co-application between countries, Figures 10 to 12 present shares of applications with multiple assignees in more detail by showing the nationality of the co-applicants of specifically US, Japanese and German applicants. The results show that the co-applicants of US and German applicants are national (*i.e.* US and German respectively) as well as international, and both groups are more or less equally important. In contrast, national co-filings to EPO are by far more frequent for Japanese applicants than international co-filings and this difference seems to have broadened in the past few years. This is consistent with empirical evidence that Japanese companies have internationalised their R&D activities to a smaller extent than US and European companies (OECD, 2008*b*).

The figures show further that US applicants file patents at EPO most frequently with UK and German co-applicants. Japanese applicants tend to co-file patents at EPO most frequently with US and German co-applicants while German applicants tend to co-file patents at EPO with Dutch and French co-applicants.

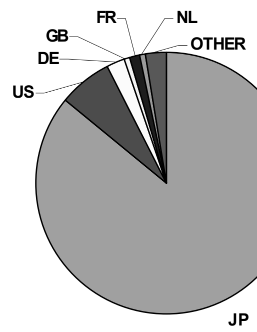
This last observation especially points again to the importance of geographical proximity in collaborating in innovation.

Figure 10. Country of origin of US co-applicants in EPO filings with multiple applicants and at least one of them from the United States, priority years 1980-2003



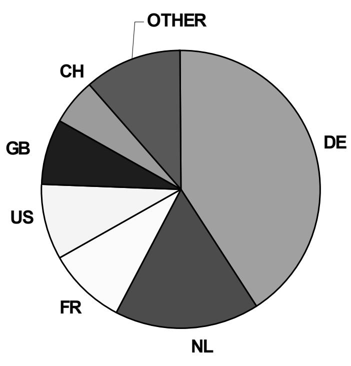
Source: OECD patent database.

Figure 11. Country of origin of Japanese co-applicants in EPO filings with multiple applicants and at least one of them from Japan, priority years 1980-2003



Source: OECD patent database.

Figure 12. Country of origin of German co-applicants in EPO filings with multiple applicants and at least one of them from Germany, priority years 1980-2003

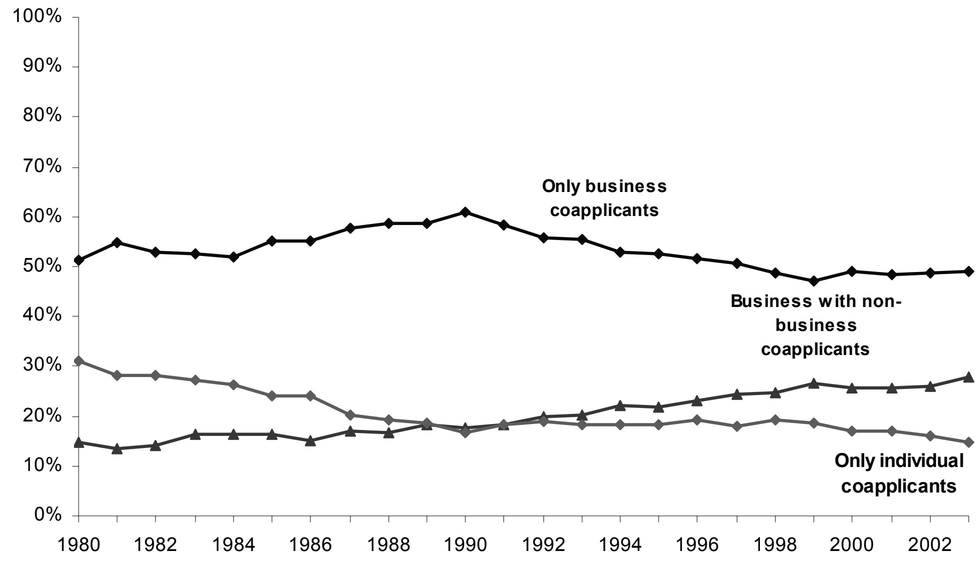


Source: OECD patent database.

Co-applications: institutional dimension

In order to analyse the institutional dimension of co-application (which type of partners co-patent witheach other), the applicants have been allocated to different institutional sectors (companies, government, higher education, individuals, etc.)[1]. The majority of joint filings at EPO have business co-applicants (Figure 13): companies file most frequently with other companies. Joint filings by individual inventors also account for a large part of filings with multiple applicants at EPO, although they have not grown as much as business joint filings within recent years.

Figure 13. EPO applications with multiple applicants, by institutional sector, priority years 1980-2003



Note: Non-business institutions are government, higher education, private non-profit, hospitals, individuals and others, according to the EUROSTAT algorithm.

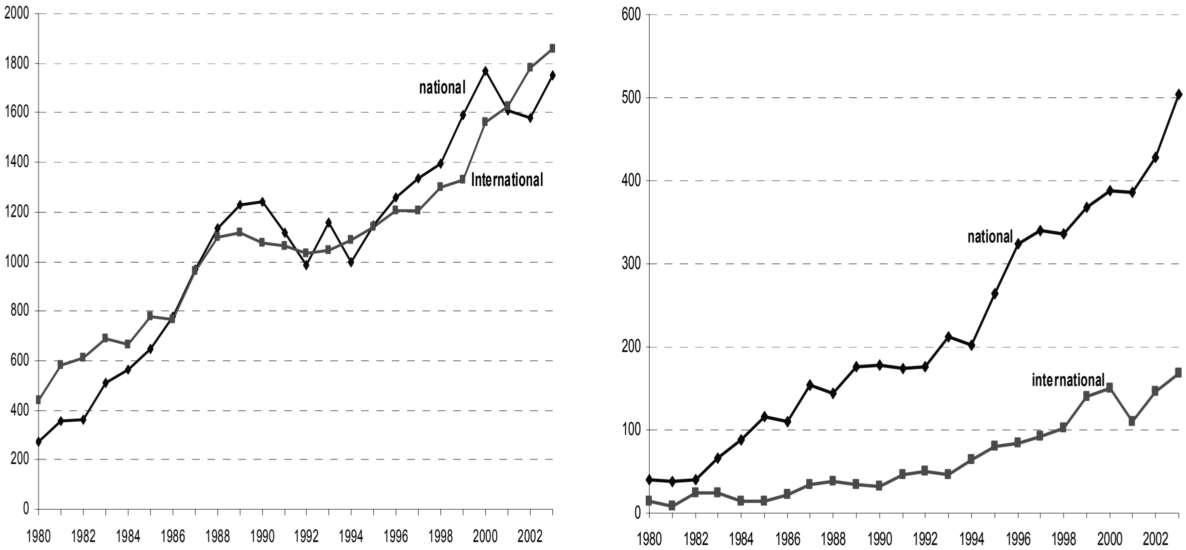
Source: OECD patent database.

The number of national and international joint filings at EPO within the business sector has grown more or less at the same pace since 1980 and reached similar levels (Figure 14). Consistent with the results based on CIS-data, technology collaboration measured by co-assignments between companies and public research institutions (universities and public research organisations) seems to be less important. EPO co-applications between business and public research predominantly involve institutions from the same country (national joint filings) although both national and international joint filings have grown significantly in recent years.

1. This has been done by applying the EUROSTAT-algorithm on the OECD patent database. The algorithm for the allocation of patentees to different institutional sectors is not 100% accurate. For more information see Van Looy, B., M. du Plessis and T. Magerman (2006), "Data Production Methods for Harmonised Patent Indicators: Assignee Sector Allocation", EUROSTAT Working Paper and Studies.

Figure 14. EPO applications with multiple applicants and at least one of them from the business sector, priority years 1980-2003

Only business co-applicants **Business joint filings with universities and PROs**



Note: Public research institutions include universities and public research organisations.

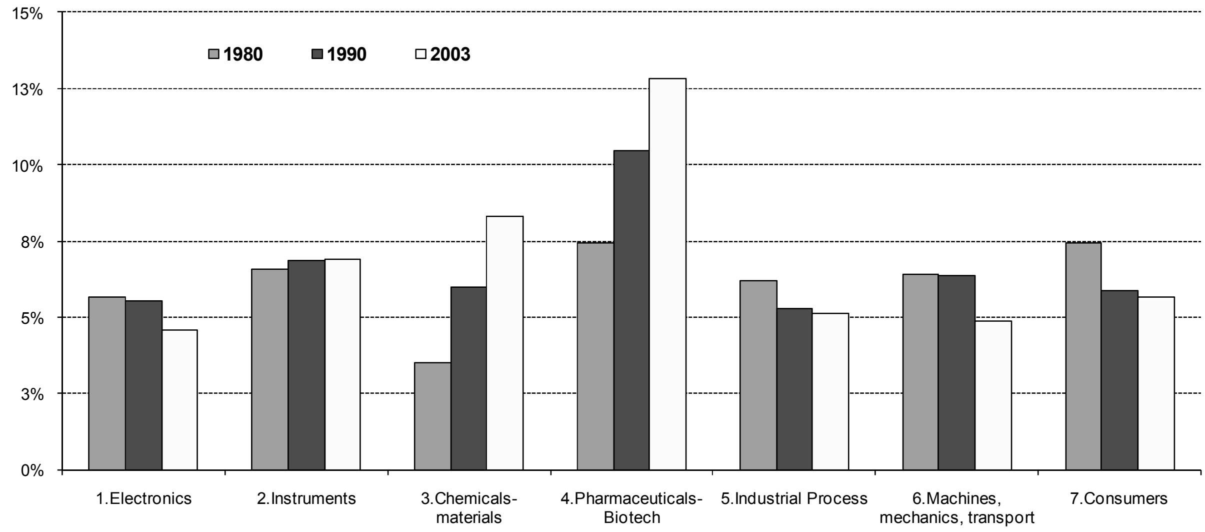
Source: OECD patent database of EPO applications by type of institution, based on the EUROSTAT algorithm.

Co-applications: the technology dimension

The correspondence between technology areas (based on the Fraunhofer/INPI/OST classification) and the main IPC class of EPO applications allows an analysis of the importance of co-applications across technologies. In line with the increase in the total number of patent applications, the number of EPO filings with multiple applicants has grown in all technology areas, with the strongest growth observed in electronics, instruments and pharmaceutical-biotech. Relative to the total number of EPO patent applications in each technology however, the share of filings with multiple applicants has substantially increased for pharmaceuticals-biotech and chemicals-materials. In all other technology areas including electronics the relative importance of co-applications has decreased (Figure 15).

Figure 15. EPO applications with multiple applicants, by technology area, priority years: 1980, 1990, 2003

in % of all EPO applications



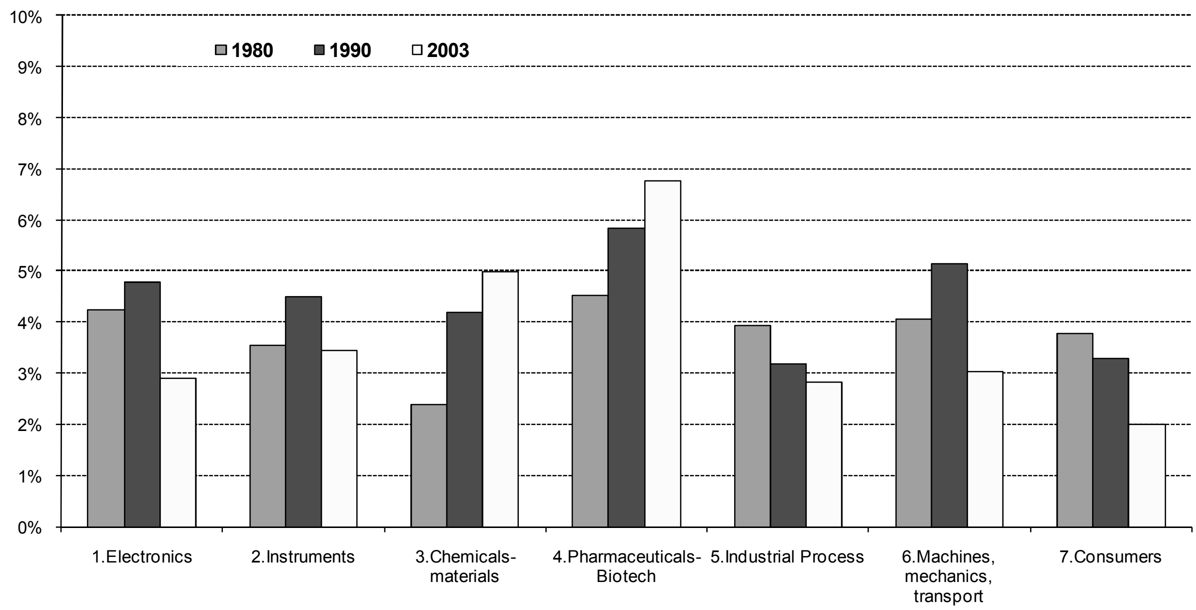
Note: Based on the correspondence between the seven broad technology areas of the revised Fraunhofer/INPI/OST and the main IPC class of EPO applications.

Source: Calculations based on PATSTAT-data.

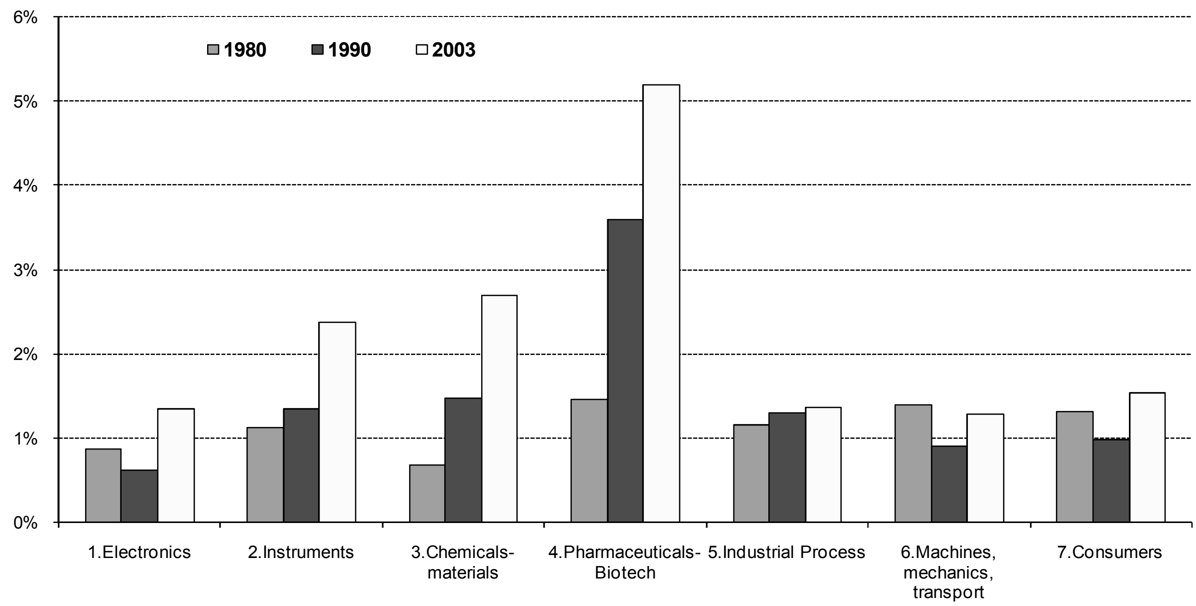
Business joint filings at EPO have significantly grown in pharmaceuticals-biotechnology, chemicals-materials and electronics. The share of joint filings at EPO between businesses and other types of institutions (with respect to all EPO filings with at least one business applicant) has substantially increased in three technological areas in the past years: pharmaceuticals-biotechnology, chemicals-materials and instruments (Figure 16).

Figure 16. EPO applications with multiple applicants and at least one from the business sector, broken down by institutional dimension and technology class, priority years: 1980, 1990, 2003

EPO applications with multiple applicants, having all co-applicants from the business sector, in % of all EPO applications in the technology area



EPO applications with multiple applicants, having business and non-business institutions as co-applicants, in % of all EPO applications in the technology area



Note: Based on the correspondence between the seven broad technology areas of the revised Fraunhofer/INPI and the main IPC class of EPO applications.

Source: Calculations based on PATSTAT-data.

Co-applications and large European firms

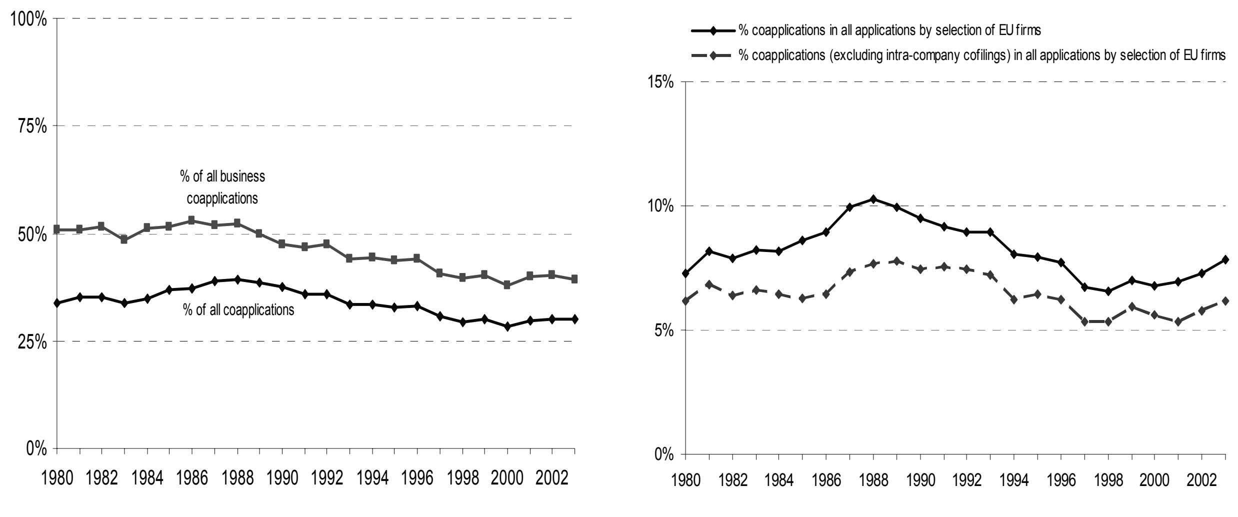
Given the central role of large firms in general and MNEs more specifically in global innovation networks, co-applications by a set of European large firms have been analysed in closer detail in order to identify differences in co-applying behaviour between them and other companies. For this an experimental dataset has been used that was recently developed by Thoma and Torrisi (2007), including all EPO applications filed by 1 433 European publicly listed firms that have disclosed information on their R&D investments in their company books. This database is unique, as it provides consolidated information on patents at the group level based on information about the ownership structure of the applicant[2].

These 1 433 companies accounted for around 90% of total intramural business R&D expenditures in European countries in 2000 (Thoma and Torrisi, 2007) and represented, on average, 45% of the annual business patent filings to EPO between 1980 and 2003. Name inspection showed that the largest firms within the set are MNEs active in Europe.

The group of 1 433 large/MNE companies have increased their co-applications at the EPO between 1980 and 2003 but to a lesser extent than other applicants, since their share in all business co-applications has decreased from 50% in 1980 to 39% in 2003 (Figure 17). Notwithstanding this negative trend, their propensity to co-apply for EPO-patents is slightly higher than for other firms (8% versus 5% for all companies together). In addition, it is worth noting that intra-group co-applications represented on average 20% of the co-filings of the firms in our selection, which supports our observation that a large share of them are multinationals (Figure 17).

Figure 17. EPO-applications with multiple applicants by 1 433 European publicly listed firms disclosing R&D in Europe, priority years 1980-2003

as % of EPO applications with multiple applicants and at least one from the business sector | **as % of all EPO-applications by European publicly listed firms disclosing R&D**



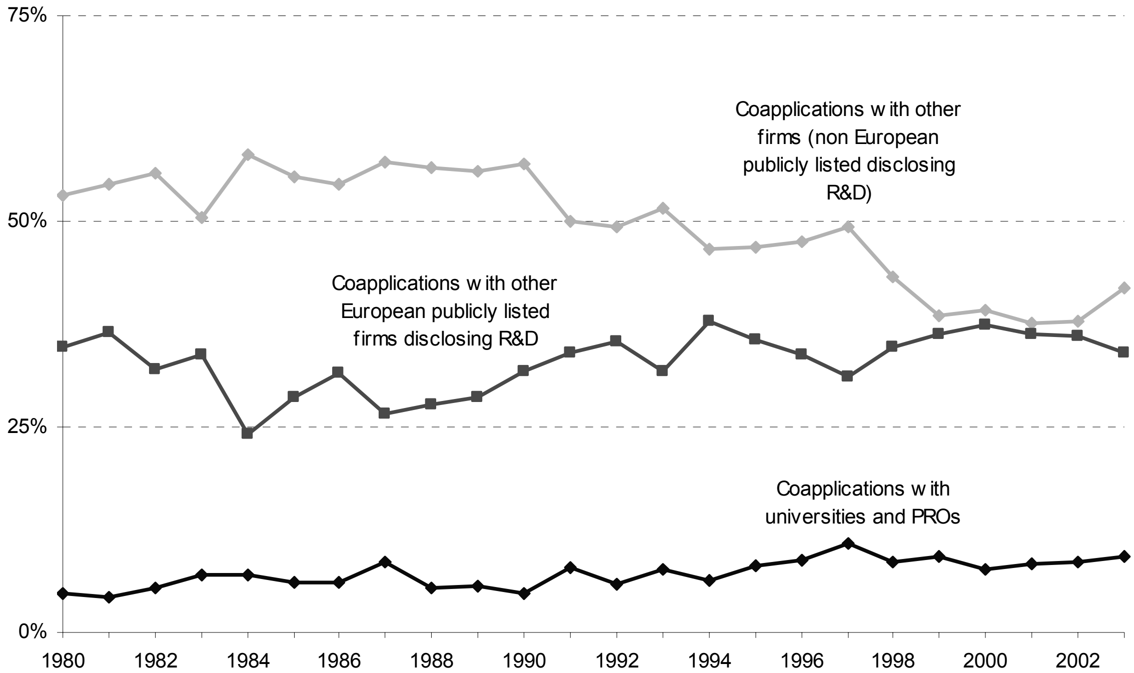
Source: Calculations based on PATSTAT-data and HAN-EPO-PCT database.

2. This HAN-EPO-PCT database mainly relies on two main data sources: the Amadeus database of Bureau van Dijk for company information, and PATSTAT for patent data.

EPO co-applications among the 1 433 companies have grown stronger than with other firms and now represent more than 30% of all their co-filings with third parties (it is excluding intra-group co-applications). Joint filings of this selection of 1 433 companies with universities or public research organisations have increased in recent years, but have remained relatively low on average, at around 7% of all their co-filings with third parties between 1980 and 2003 (Figure 18).

Figure 18. EPO-applications with multiple applicants by European publicly listed firms disclosing R&D in Europe, by institutional sector, priority years 1980-2003

As % of non-intra group EPO-applications with multiple applications by 1 433 European publicly listed firms disclosing R&D

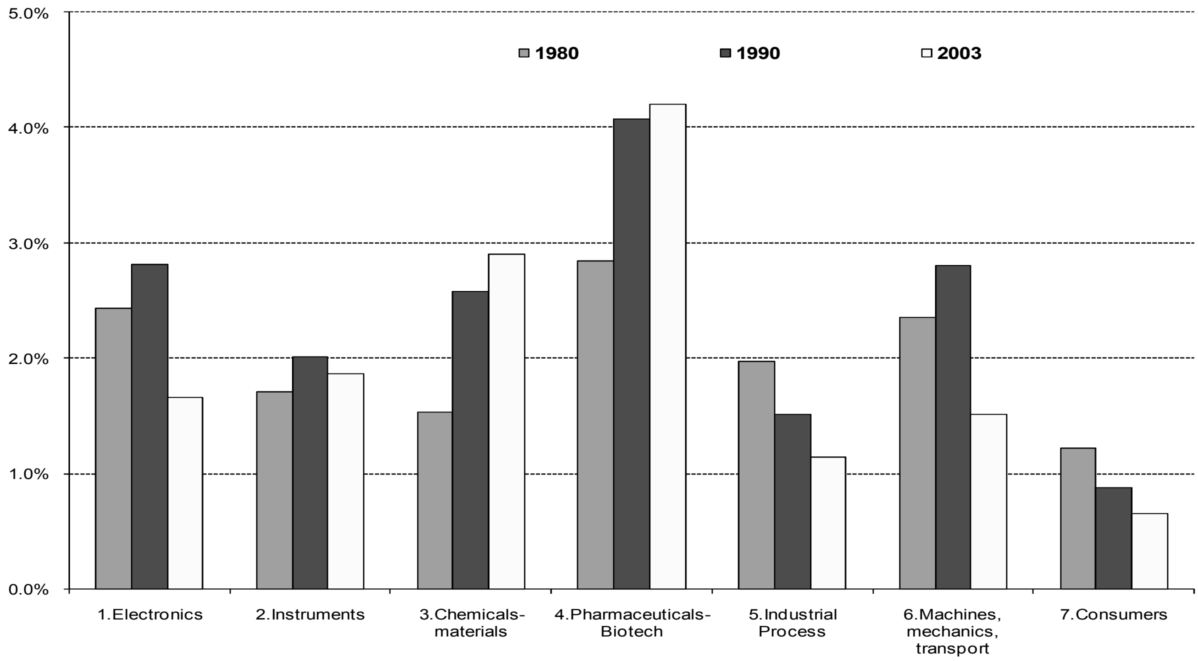


Source: Calculations based on PATSTAT-data and HAN-EPO-PCT database.

Distributing the co-applications of the 1 433 European publicly listed firms disclosing R&D across technology areas shows they tend to co-apply with third parties (universities, PROs, and other firms, European multinationals or not) especially in the field of chemicals-materials (Figure 19). Co-applications with universities, PROs and other European multinationals also appear in pharmaceuticals-biotechnology, while with other firms (*i.e.* not belonging to the group of 1 433 companies) in electronics and machines-mechanics-transport. The bulk of intra-group joint filings is found in the technology area of electronics.

Figure 19. EPO applications with multiple applicants by 1 433 European publicly listed firms disclosing R&D, by technology class, priority years: 1980, 1990, 2003

as % of all EPO applications in the technology area



Source: Calculations based on PATSTAT-data and HAN-EPO-PCT database.

7. Data on licensing

Data on licensing also offer a good indication of open innovation, as they not only measure the outside-in side of open innovation (by licensing in) but also the inside-out aspect (by licensing out). Patent licensing provides an alternative channel for unlocking the economic value of unused patents by making the rights available to organisations that may have a greater interest in – or ability to – exploit the invention. However, most patent licensing is based on private contracts that are subject to confidentiality agreements resulting in a lack of robust statistics on technology licensing. Furthermore, accounting rules do not require firms to disclose patent licensing revenues as a separate item in corporate reports, and while most OECD countries have regulatory requirements for reporting licensing contracts, these are mostly related to cross-border transactions, and data are published only at aggregate level. While available data on patent licensing are limited, scattered and lacking in uniformity, some general observations can be drawn (OECD, 2006).

Different studies have suggested that markets for technology licensing are large and growing. Patent licensing revenues have been estimated to have risen in the United States from USD 15 billion in 1990 to more than USD 100 billion in 1998, while experts estimate that revenue could top USD 500 billion annually by the middle of the next decade (Rivette and Kline, 2000). A recent Japanese survey indicates that inward licensing revenues increased from JPY 230 billion in 1994 to JPY 360 billion in 2001, while outward licensing jumped from JPY 170 billion in 1994 to JPY 420 billion in 2002 (Motohashi, 2005).

Markets for technology licensing display an important degree of diversity because of significant regional differences. A 2004 survey conducted by the European Patent Office reported that spending on inward licensing was equivalent to 5.6% of R&D spending for US firms, 22% for Japanese firms and 0.8% for European firms. Royalty receipts amounted to 6.0%, 5.7% and 3.1% of R&D spending in the United States, Japan and Europe, respectively. These findings are generally consistent with results of an earlier survey by BTG, which found that spending on inward licensing during the 1990s was equivalent to 12% of R&D spending in the United States, 10% in Japan and 5% in Europe (Gambardella, 2005). A more recent study, however, found that total inward licensing in Japan remained at about 3% to 4% of R&D spending between 1994 and 2002, and outward licensing expenditures increased from 0.06% to 0.14% of total sales revenues (Motohashi, 2005).

Patent licensing practices also differ between industries reflecting differences in technological regimes, *e.g.* in the dynamics of innovation and the role of patenting in innovation processes (OECD, 2006). Anand and Khanna (2000) attempt to identify industry differences with respect to patent licensing based on information from the SDC strategic alliances database:

- Licensing is concentrated in selected industries. About 80% of licensing deals occur in three industries: 46% in the chemical industry, including drugs; 22% in the electronic and electrical equipment industry, including semiconductors; and 12% in the industrial machinery and equipment industry, including computers.
- Prior relationship is important for engaging in licensing contracts. About 30% of licensing deals are signed between parties having a prior relationship. This tendency is stronger in computer and electronics firms than in chemicals.
- Exclusivity and restriction clauses are more common in chemical firms. More than half of the deals in chemicals involve some exclusivity clauses, which are less common in computers (18%) and electronics (16%). Restrictions such as field of use, geographical domain and contract length are more common in chemicals (40%) than computers and electronics (30%).
- Cross-licensing is frequent in electronics. Cross-licensing is more common in electronics (20%) than in other industries (10%). It is more common for transfers of technology that have not yet been developed than for *ex-post* transfers.

Similar sectoral differences have been reported in more recent surveys as well. In the OECD/BIAC survey, respondents from the ICT sector were the most likely to report increases in outward licensing (about 80% of respondents), suggesting that licensing out has become important as a source of revenue for ICT firms. In contrast, respondents from the pharmaceutical industry were most likely to report increases in inward licensing (about 80% of respondents), reflecting the trend of licensing in from small biotechnology firms. Across all sectors, around 70% of respondents expected the importance of inward and outward patent licensing to rise in the next five years (OECD, 2006).

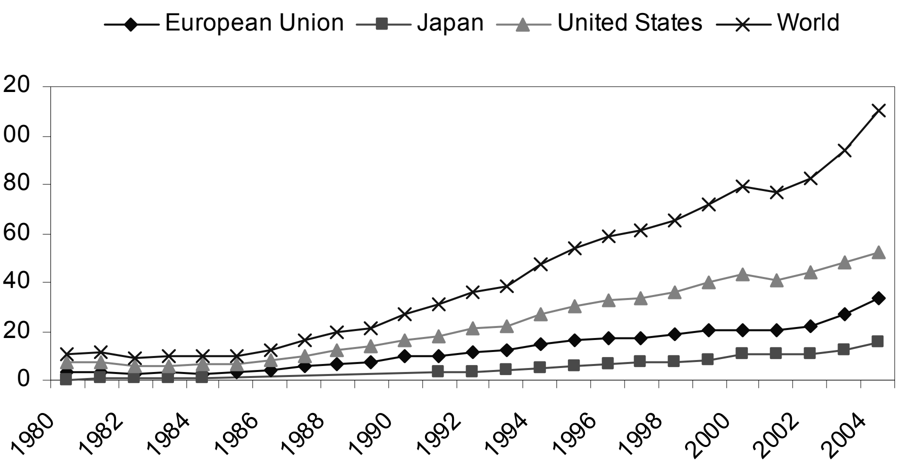
Differences exist also between smaller and large firms, as data show that smaller firms are more likely to license. This is related to their lack of complementary downstream assets and the smaller risk of the licensee becoming a potential competitor (Arora et al., 2001). Another study, also based on information from the SDC database on strategic alliances but using more recent data (1985-2002) has identified several factors that affect firms' propensity to engage in licensing agreements positively (Vonortas and Kim, 2004). Companies will tend to engage in licensing agreements: the closer their technological profiles; the closer their market profiles; the more familiar they are with each other through prior agreements; the higher their prior independent experience with licensing; and the stronger the intellectual property protection in the licensor's primary line of business. All these factors affect licensing transaction costs and indicate that reducing transaction costs may be more important when licensing occurs across sectors, whereas strategic and competition-related factors may be more important when licensing occurs between firms in the same industry (OECD, 2006).

International licensing appears to be on the rise and accounts for a significant share of total patent licensing (Figure 17). International receipts for intellectual property (including patents, copyrights, trademarks, etc.) increased from USD 10 billion in 1985 to approximately USD 110 billion in 2004, with more than 90% of the receipts going to the three major OECD regions: the European Union, Japan and the United States. Total payments climbed to approximately USD 120 billion in 2004, up from USD 8.3 billion in 1985.[3] While receipts remain considerably higher in the United States than in the EU or Japan, growth rates in the latter have been equal or higher over the past 20-year period.

Much international licensing reflects transactions among affiliated businesses. In Japan, for example, transactions among affiliated firms accounted for approximately 60% of international royalty receipts and 14% of royalty payments in 2002. Nevertheless, there are indications that the share of transactions among unaffiliated firms is growing. In the United States, the share of transactions among unaffiliated firms in the international trade balance of intellectual property (royalties and fees) almost doubled from about 20% in 1996 to more than 40% in 2001. The share of German trade income from international intellectual property transactions with unaffiliated foreign firms doubled from about 5% in 2002 to 10% in 2003 (Wurzer, 2005).

Figure 20. Receipts from international licensing in major OECD regions

Billions of USD



Source : OECD (2006).

Future work will analyse the importance of licensing for open innovation in more detail. A pilot survey co-ordinated by the OECD on the use of patents by business and public research organisations may offer more insights on licensing and the inside-outside of open innovation. The survey will be carried out in Europe by the EPO, in Japan by the University of Tokyo with support of the JTO, and possibly in the United States; the questionnaire was dispatched to respondents in the summer of 2007.

3. The definition of payments and receipts from licensing used by the World Development Indicators (WDI) of the World Bank is as follows: "Royalty and license fees are payments and receipts between residents and non-residents for the authorized use of intangible, non-produced, nonfinancial assets and proprietary rights (such as patents, copyrights, trademarks, industrial processes, and franchises) and for the use, through licensing agreements, of produced originals of prototypes (such as films and manuscripts)."

8. Some first conclusions and directions for future research

This paper has presented new indicators for open innovation based on existing official data that allow for the comparison across companies, industries and countries. As such, the increasing international orientation of open innovation was taken into account. Overall, the longitudinal data suggest that open innovation is on the rise: companies increasingly innovate together with external partners (R&D-investment data, co-invention patent data and licensing data) although in terms of co-applications open innovation is found to be rather limited and stable. This last observation may be due to the fact that co-applications may be less accurate to assess open innovation; nevertheless more evidence is needed to study the increasing importance of open innovation (especially on a longer time horizon).

The industry distribution shows that collaboration in innovation is important in manufacturing as well as in services, notwithstanding that industries like chemicals and pharmaceuticals, ICT (including software) typically show higher levels of open innovation. The data coming from innovation surveys clearly show that larger firms innovate more openly than SMEs. These results therefore suggest that limited resources may prevent SMEs from deploying open innovation practices more broadly, and on an international scale. Large companies are much more active in public research although there is a larger degree of cross-country variation for large firms than for SMEs.

Companies are found to collaborate in innovation especially with suppliers and customers, while co-operation with universities and research institutions was found to be less important. Different data sources lead to this observation: R&D-investments (especially R&D-investments coming from abroad), innovation surveys and patent data on co-applications). The collaboration with public research organisations (higher education or government research institutes) seems less important at least in numbers, which may be explained by the fact that public research is focused more on upstream research and exploration activities that may represent only a small part of overall innovation.

The empirical data further show that despite globalisation, geographic proximity still matters in open innovation (innovation survey data, patent data). Companies were found to collaborate more with geographically close external partners, although it should be taken into account again that the data measure only the number of interactions and not the intensity and quality of collaboration. Furthermore, additional evidence suggests that it may not be proximity *per se*, but rather good connectivity with external partners.

The evidence presented in this paper concerns simple indicators based on existing official data. While the large number and diversity of indicators contributes to a better understanding of the broad and complex phenomenon of open innovation, several gaps can be identified, directly suggesting some directions for future research. Especially more complete and systematic gathering of data on alliances, joint ventures, etc. may be rewarding since open innovation is really about collaborating and connecting different innovation partners. Likewise, more specific information on venture capital, spinning in/off/out, etc. is needed given that corporate venturing is increasingly used for open innovation.

Another direction for future research is the construction of composite indicators allowing for the analysis of more complex issues in open innovation. Some research activities have already been undertaken along this line: in recent OECD work *e.g.* innovation survey micro-data have been analysed in order to identify different types of innovating firms combining information on so-called formal innovation (*i.e.* in-house activities through R&D) and collaboration activities for individual companies (OECD, 2008*c* forthcoming).

Other promising research underway is a project within the European ERANET-VISION group that again uses innovation surveys to construct composite indicators for open innovation (Herstad, 2008). Using the framework developed by Laursen and Salter (2006) on the breadth (range of external sources) and depth (importance of sources) in open innovation practices, the research combines different firm-level data in the innovation survey data in order to analyse different dimensions of open innovation in four countries (Norway, Denmark, Belgium and Austria). Subsequently, these composite indicators are then used to analyse the impact of open innovation on the innovative performance of companies. As such this research goes one step further and tries to undertake more analytical work in addition to presenting descriptive indicators.

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