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Open Innovation in Global Networks

Chapter 2

Empirical Measures of Open Innovation

Chapter 2 develops new empirical indicators that help to show the importance and the evolution of open innovation across companies, industries and countries. Until now open innovation has been mainly discussed in terms of case studies, largely in high-technology sectors. Different indicators based on R&D data, patent data, innovation surveys and data on licensing are presented.

Case studies and surveys

The empirical evidence on (global) open innovation consists mainly of case studies, often of large companies in technology-intensive industries (*e.g.* information and communication technology [ICT], pharmaceuticals, biotechnology). Surprisingly, large-scale data have not really been systematically explored even though innovation surveys have demonstrated the increasing importance of openness in R&D and technology. This may be related to the fact that open innovation is a very variable concept and its 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 went beyond high-technology industries. Based on a (relatively small) survey he found that:

- Open innovation concepts increasingly find application in companies operating outside the high-technology industries.
- Open innovation concepts are not employed primarily to reduce costs or the outsourcing of R&D, since internal R&D is maintained or even increased (owing to the importance of absorptive capacity).
- Many outbound-oriented concepts have not yet been adopted; inbound open innovation concepts have mainly been used.

De Jong (2006) analysed determinants and barriers with respect to open innovation in SMEs in the Netherlands (the empirical evidence comes mainly from case studies of larger companies). The results indicate that the trend towards more open innovation is also observable in innovating SMEs; these are traditionally more open because of their limited size and resources. Intense competition and more demanding customers were found to be the major motivation for open innovation in these SMEs. The most important bottleneck for open innovation is differences in organisation and culture between the individual partners.

In analysing 124 companies, Gassman and Enkel (2004) found that the open innovation approach is used by industries characterised by high product modularity and high speed (*e.g.* due to technological advances), in which much explicit knowledge is required, highly complex interfaces are crucial and positive externalities are created (*e.g.* standard setting). Additionally they suggest that the outside-in process of open innovation is more important in low-technology industries that produce highly modular products, and where companies' competitive advantage is heavily based on knowledge (they expect spillovers 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 growing degree of global and collaborative R&D (see above), the results suggest that more global R&D companies tend to have slightly more collaborations (with universities, customers, suppliers, alliance partners, etc.). However, their external R&D collaborations are still largely concentrated around their headquarters at home.

Data on (R&D) alliances between different companies and organisations are another valuable source of information for the empirical measurement of open innovation, as they reveal the number and types of companies' technology collaborations (*e.g.* the Thomson and MERIT databases). Hagedoorn (2002) has used the MERIT data to report extensively on the evolution of technology alliances, as well as on the geographical, institutional and industry distribution of these collaborative agreements. However, these data sources are somewhat incomplete as not all alliances (on a worldwide, regional and/or national level) can be identified. The fluctuation in the number of alliances over the years suggests that the data collection process may be problematic.

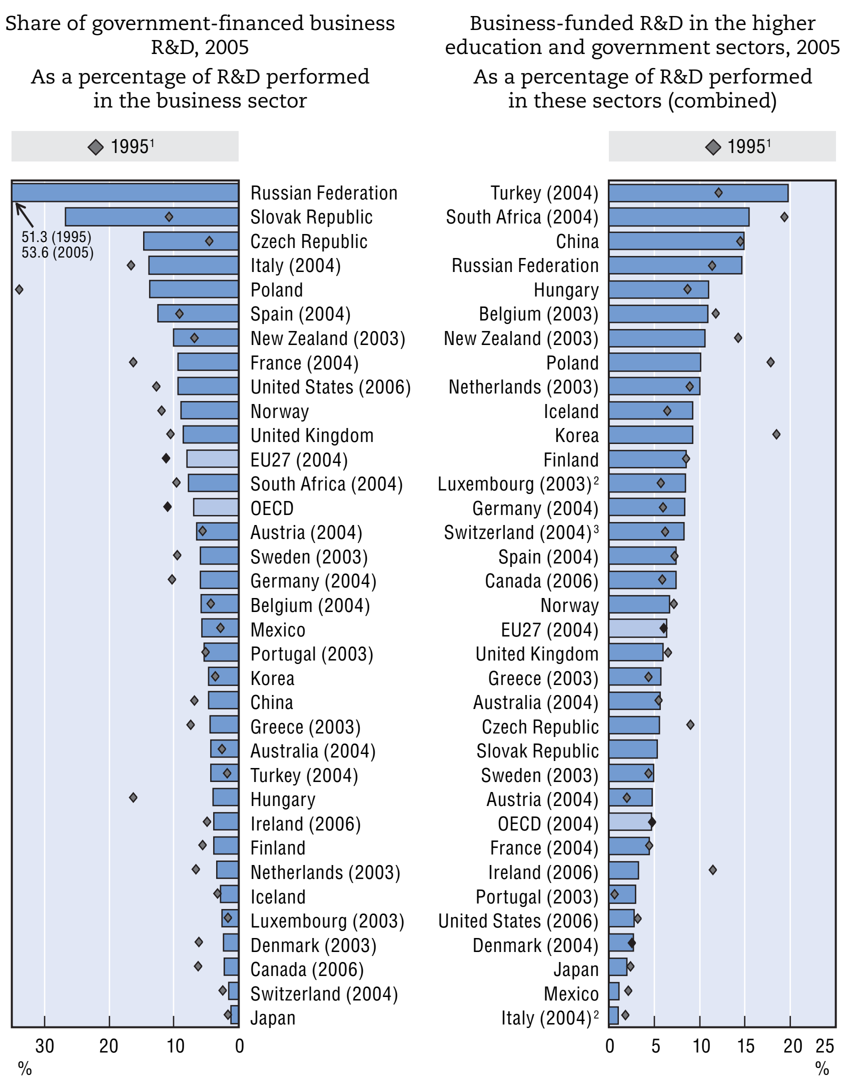
In what follows, various large-scale databases have been exploited for empirical evidence on open innovation. There is clearly no single indicator of open innovation given the diversity of open innovation practices and modes in companies. The differences and complementarities between the various information sources create a more complete picture of open innovation. The indicators based on R&D investments, innovation surveys and patent data measure especially the outside-in side of open innovation by looking at technology collaborations. Data on licensing is also presented in order to measure the inside-out of open innovation.

Trends in R&D collaboration

Data on R&D investments are a first source of information and offer some large-scale data and internationally comparable, albeit indirect, evidence on open innovation. Specific information on public-private funding of R&D reveals some of the interaction and collaboration between government and the business sector. While government-financed R&D seems related to direct government funding, without necessarily pointing to actual collaboration, business funding in the higher education and government sectors (*e.g.* research centres) often indicates close collaboration between public and private entities.

Business-funded R&D in the higher education and government sector has increased in several countries (Figure 2.1). Business funds for R&D

Figure 2.1. **Public-private cross funding of R&D**



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

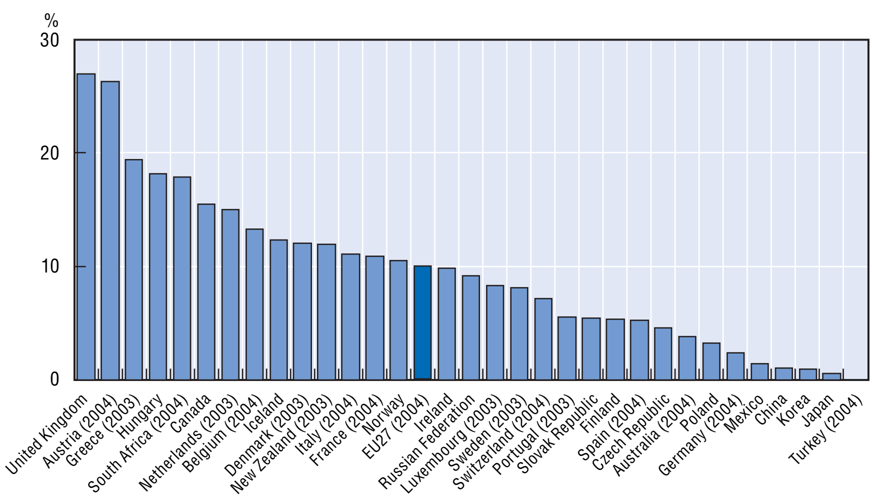
Source: OECD (2007).

performed in the higher education and government sectors averaged 4.7% in 2005 in the OECD area. European companies (EU27) finance more research in public institutions and universities (6.4% of total R&D performed in these sectors) than 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, albeit rather indirect, evidence on international collaboration on R&D. The sources of finance of business enterprise R&D may be local or foreign and originate from other private businesses, public institutions (governmental and higher education) or international organisations. Figure 2.2 indicates that R&D sources from abroad are on average quite significant in the funding of business R&D: in the EU27, finance from abroad represented around 10% of total business enterprise R&D.

Figure 2.2. **Funds from abroad**

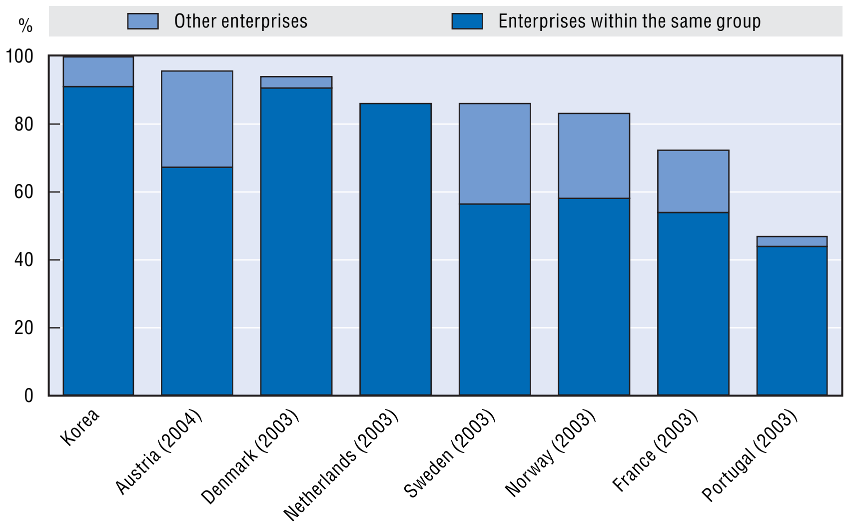
As a percentage of business enterprise R&D, 2005



Source: OECD (2007).

In most countries for which data are available, MNEs' activities seems to play a large role in the international funding of business R&D. Financing of business enterprise R&D from abroad basically concerns financing by other business enterprises, and more than half is intra-company funding. In Netherlands and Denmark, it represented more than 80% and in Sweden and Norway 50%, with 20% of funding from abroad originating from non-affiliated foreign companies (Figure 2.3).

Figure 2.3. **Funding from foreign companies as a percentage of funds from abroad, 2005**



Source: OECD (2007).

Innovation surveys: the role of networks and collaboration

Innovation surveys are increasingly used in OECD and in many non-member countries to better understand the role of innovation and the characteristics of innovative companies. The latest surveys have extended their scope to cover marketing and organisational innovations as well as technological innovations and place more emphasis on linkages, including collaboration on innovation. Collaboration is defined as the "active participation in joint innovation projects with other organisations" (OECD, 2007a) 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. Therefore, 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 fourth Community Innovation Survey (CIS-4) show that collaboration is an noteworthy 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 than small and medium-sized enterprises (SMEs). Among the latter, the rate of collaboration is fairly similar across countries (between 10

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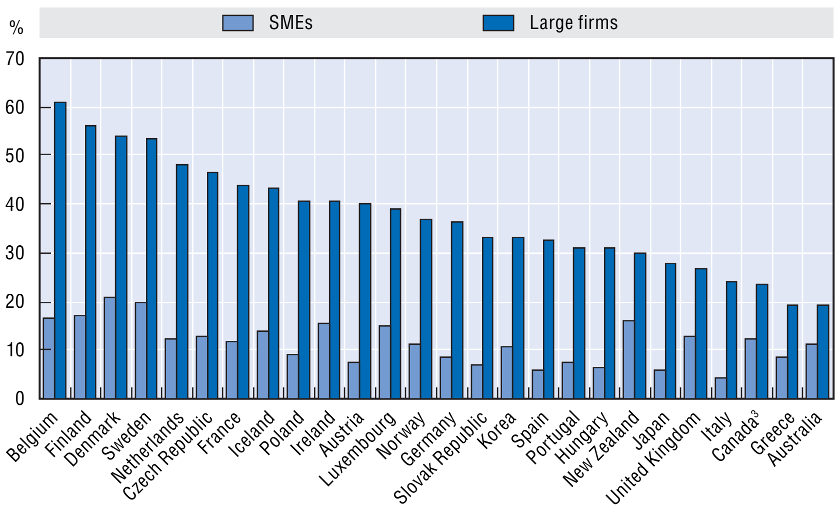
and 20% of all firms in more than half of the countries surveyed), but it varies widely for large companies (Figure 2.4). It should be kept in mind that the data reveal the existence of some sort of collaboration but not its type or intensity.

Figure 2.4. **Companies collaborating on innovation activities, by size**[1]

As a percentage of all companies, 2002-04[2]



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.

Source: OECD (2007).

Table 2.1 gives an overview of the number of technology collaborations for most industries and countries for which data are available (in specific industries in smaller countries this information tends to be confidential). The industry distribution shows significant collaboration on innovation in manufacturing as well as in services, with some differences among countries. In addition to industries such as chemicals, pharmaceuticals and ICT (including software) which typically have high levels of open innovation, industries such as wholesale and retail, transport and communication also display a large number of technology collaborations.

Companies collaborate on innovation most frequently with suppliers and customers; 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 collaboration on innovation is broken down by partners (Table 2.2). While universities and government research institutes are generally

Table 2.1. **Companies collaborating on innovation activities, by industry, selected EU countries, 2002-04**[1]

	Belgium	Denmark	Germany	Spain	France	Italy	Netherlands	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	1 530	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	1 243	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.

Table 2.2. **Companies collaborating on innovation activities, by partner**

As a percentage of all companies collaborating on innovation, 2002-04[1]

	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

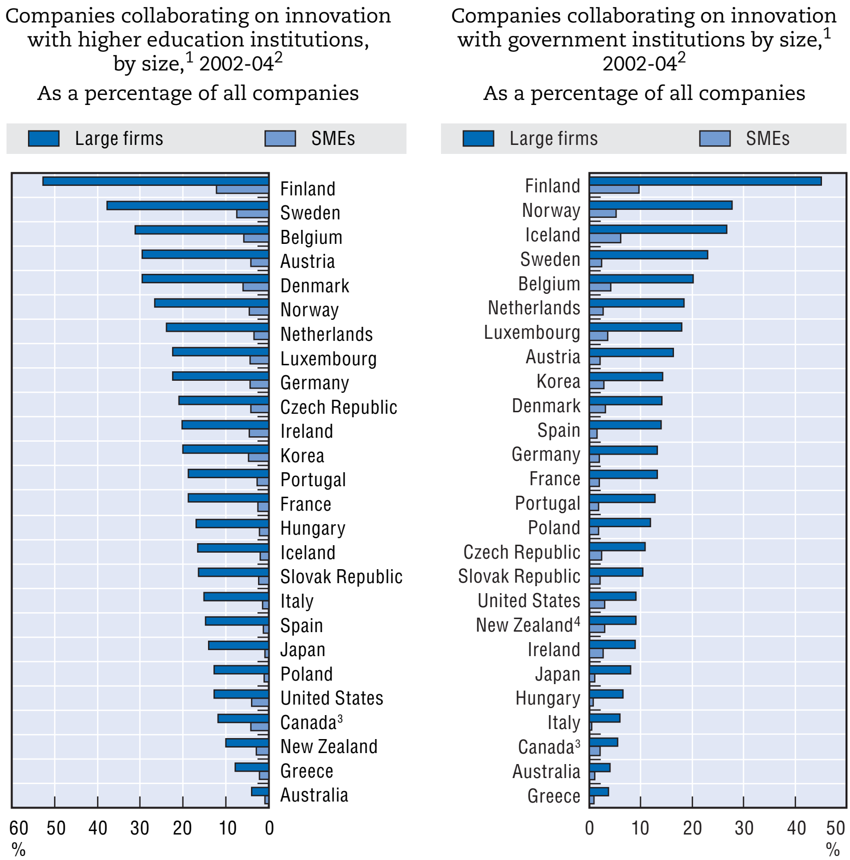
1. Or nearest available years.

Source: CIS-4 data.

considered a major source of knowledge transfer for the innovation activities of companies, especially in more upstream research and exploration activities, the CIS data indicate that collaboration with public research organisations (higher education or government research institutes) is less frequent (Figure 2.5). Large companies are much more active in public research although there is much more cross-country variation for large firms than for SMEs.

International technology collaboration, *i.e.* collaboration with foreign partners, is found to play a prominent role in companies' innovation process, but geographical proximity still seems to be valued (Figure 2.6). The share of European companies with partners in another European country

Figure 2.5. **Collaboration with public research organisations by companies**



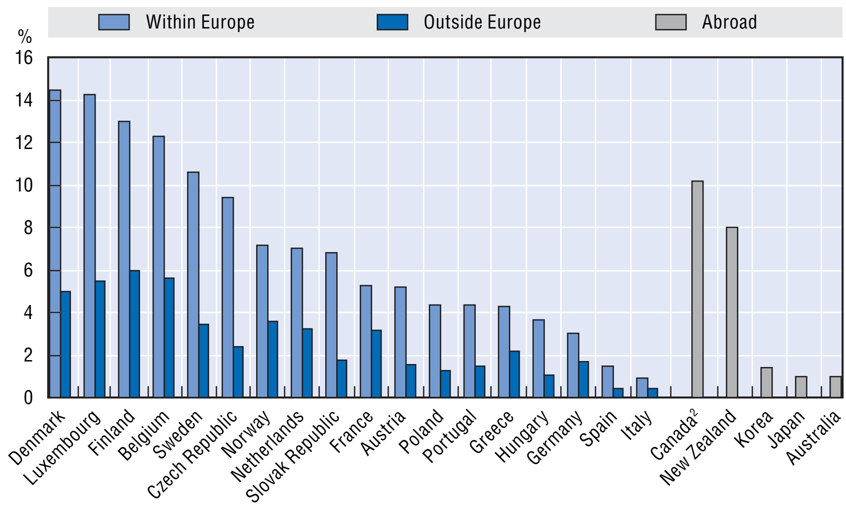
1. SMEs: 10-249 employees for European countries, Australia and Japan (persons employed); 10-99 for New Zealand, 10-299 for Korea, 20-249 for Canada.
2. Or nearest available years.
3. Manufacturing sector only.
4. Refers to firms that co-operate with Crown Research Institutes, other research institutes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

Source: OECD (2007).

ranges between 2 and 14% (of 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, ranging from less than 2% of all firms in Korea, Japan and Australia, to more than 8% in Canada and New Zealand. Again, SMEs seems to be less active in international collaboration on innovation than larger companies.

Figure 2.6. **Companies with foreign co-operation on innovation, 2002-04**[1]

As a percentage of all companies



1. Or nearest available year.
2. Manufacturing sector only.

Source: OECD (2007).

In line with other empirical evidence (INSEAD and Booz, Allen & Hamilton, 2006; Hagedoorn, 2002), these results show that innovation partners that are geographically nearby are still preferred. Despite vastly improved communication possibilities, collaboration with external partners on the international level requires extra investment and resources. This also explains why SMEs, with their typically fewer resources, display less tendency to collaborate with external parties, overall and internationally. The fact that knowledge is often tacit and person-embodied helps to explain why language and distance are barriers to collaboration.

Figure 2.6 shows numbers of technology collaborations but gives no information on their qualitative aspects. 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 technology and technology sourcing (as opposed to the cost sharing partnering that characterised their EU schemes). Since international partnerships are more costly and difficult to manage, companies enter them if they are strongly motivated by market demand or the search for excellence.

Patents: co-inventions and co-applications

Patent data are considered a unique and broadly available source of statistical material and are increasingly used to study different aspects of the innovation process, *e.g.* the internationalisation of innovation (OECD, 2008). 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, time series allow 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

There are several options for studying patents to learn about open innovation: different inventors, different co-assignees or owners, differences between inventors and assignees may all be indications of technology collaborations and open innovation. The problem with the data on inventors overall is that inventors are physical persons who are often employees of one company-assignee, so that the data do not necessarily contain information on open innovation practices between companies. The international co-invention of patents is a possible indicator, as it is not only based on multiple inventor names but also on their countries of residence. This indicator can thus be considered a proxy for formal R&D co-operation and knowledge exchange between inventors located in different countries. However, it should be noted that these inventors may still be employees of an MNE with affiliates in different countries, so that the indicator may be biased against the international R&D activities and patenting strategies of MNEs.

A country's degree of international co-invention is measured as the number of patents invented by a country with at least one foreign inventor in the total number of patents invented domestically. The total share of patents involving international co-invention worldwide 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 to some extent the importance of geographical proximity in international co-invention. EU countries collaborate essentially with other EU countries, while countries such as Canada and Mexico collaborate more frequently with the United States. For instance, more than 20% of inventions in Canada and Mexico involved collaboration with a US inventor (Figure 2.7). China, India, Israel, Japan and Korea also appear to co-operate significantly with the United States, although good connections rather than proximity may be more important in explaining these patterns.

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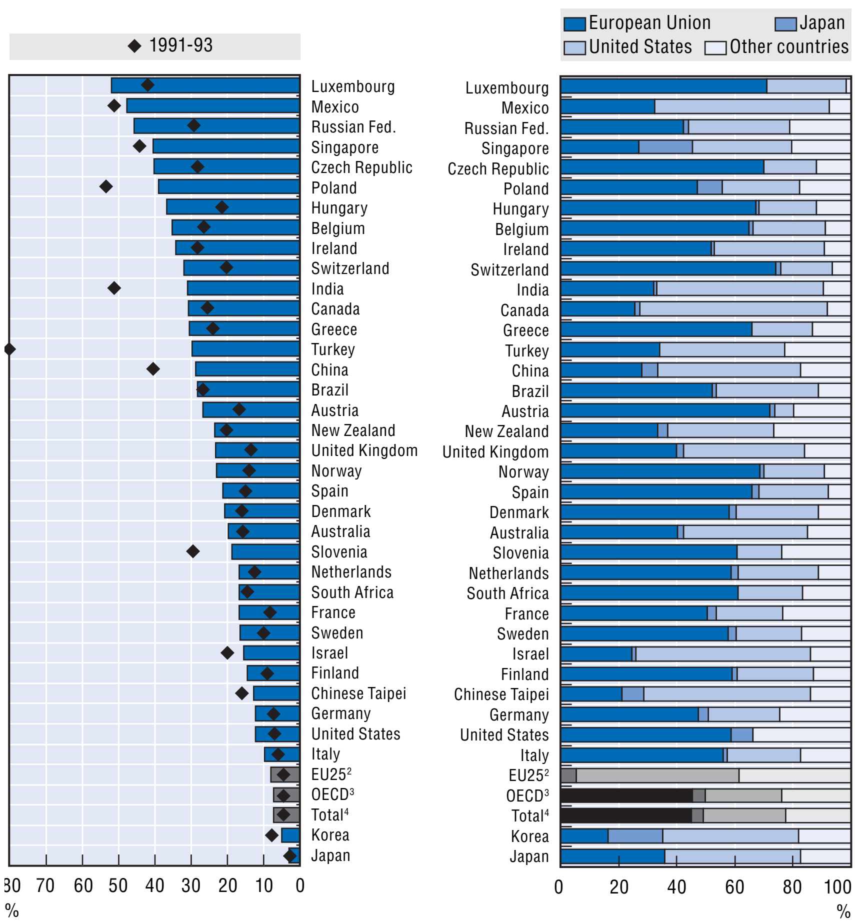
Figure 2.7. **International co-invention in patents**



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) may also offer indicators on open innovation. Again, these are not perfect measures of technology collaboration as some companies may opt to form a joint venture for the collaborative R&D and apply for the corresponding patents (with the 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).

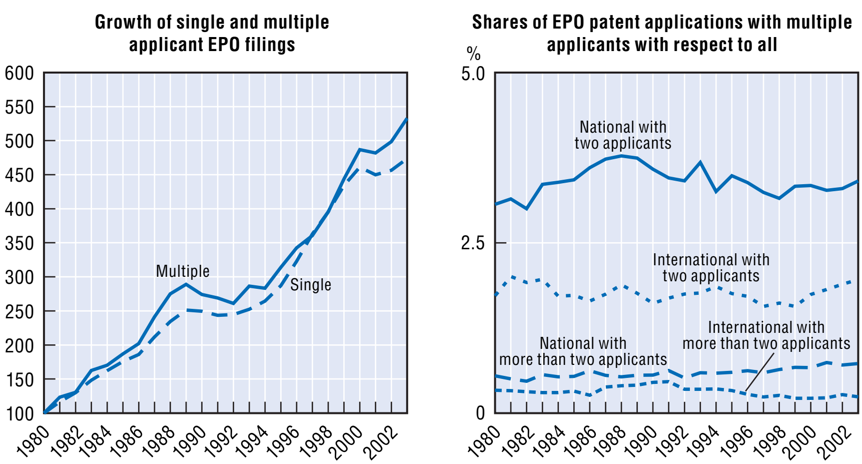
Over the last two decades, the number of applications with multiple applicants has risen significantly and somewhat faster than those with single applicants. The share of patent applications with multiple assignees in the total number of patent applications has nevertheless remained relatively stable at around 6% from 1980 to 2003 (Figure 2.8). The most common form of co-assignment involves two applicants from the same country (around 3% of all EPO filings), followed by two applicants from different countries (almost 2%). There are relatively few patent applications with more than two applicants (national and international).

In order to further analyse co-application, Table 2.3 shows, for EPO patent applications with multiple assignees, the nationality of the co-applicants of US, Japanese and German applicants. The results show that the co-applicants

Figure 2.8. **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
Percentage of total applications



Source: OECD patent database.

Table 2.3. **EPO applications with multiple applicants and at least one from United States, Japan and Germany, priority years 1980-2003**

United States			Japan			Germany		
Number of EPO applications with multiple applicants and at least one US			Number of EPO applications with multiple applicants and at least one Japanese			Number of EPO applications with multiple applicants and at least one German		
US national	11 934		Japanese national	19 456		German national	10 192	
US international	10 239		Japanese international	3 132		German international	11 627	
Countries of co-applicants of US international applicants			Countries of co-applicants of Japanese international applicants			Countries of co-applicants of German international applicants		
Country of co-applicant/s	*Number of international applications*	*% US international*	*Country of co-applicant/s*	*Number of international applications*	*% Japanese international*	*Country of co-applicant/s*	*Number of international applications*	*% German international*
United Kingdom	2 286	22	United States	1 513	48	Netherlands	4 125	35
Germany	2 175	21	Germany	471	15	France	2 308	20
France	1 572	15	United Kingdom	233	7	United States	2 175	19
Japan	1 513	15	France	220	7	United Kingdom	1 896	16
Netherlands	601	6	Netherlands	195	6	Switzerland	1 353	12
Canada	553	5	Switzerland	92	3	Austria	806	7
Switzerland	414	4	Canada	59	2	Japan	471	4
Italy	258	3	Australia	48	2	Belgium	367	3
Belgium	247	2	Korea	43	1	Italy	287	2
Israel	234	2	Italy	41	1	Sweden	223	2
Other	1 664	16	Other	286	9	Other	684	6

Note: The sum of the number of international applications broken down by country of co-applicants is greater than the total number of international applications because a single international patent application can have co-applicants from several countries. For this reason the sum of the shares of international applications by country of co-applicants with respect to the total number of international applications exceeds 100.

Source: OECD patent database.

of German and US applicants are national (*i.e.* German and US, respectively) as well as international, with both groups more or less equal. In contrast, national co-filings are by far more frequent than international co-filings for Japanese applicants, a difference that seems to have increased 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).

Table 2.3 shows further that US applicants file patents at the EPO most frequently with UK and German co-applicants. Japanese applicants tend to co-file patents at EPO 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 points again to the importance of geographical proximity in collaborating on innovation.

Co-applications: institutional dimension

To analyse the institutional dimension of co-application (which type of partners co-patent with which type of partners), applicants are allocated to different institutional sectors (companies, government, higher education, individuals, etc.).[1] The majority of joint filings at the EPO have business co-applicants (Table 2.4): companies file most frequently with other companies. Joint filings by individual inventors also represent a large share of filings with multiple applicants at the EPO, although they have not grown as much as business joint filings in recent years.

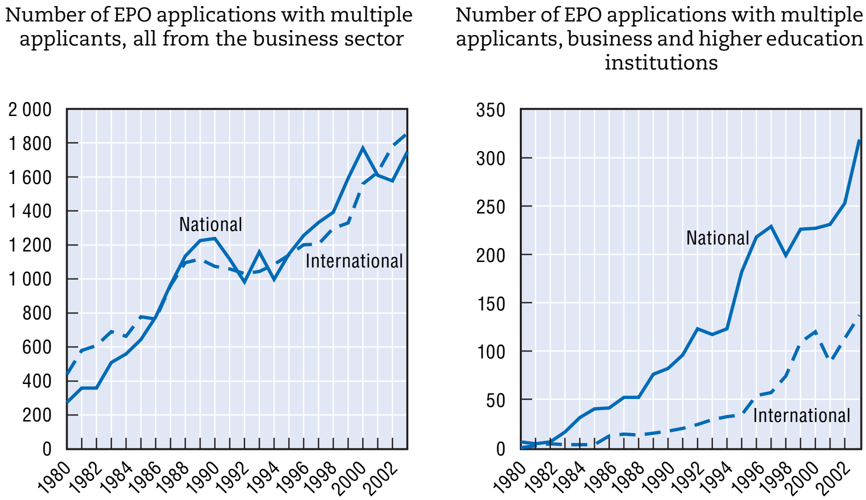
The number of national and international joint filings at the EPO by the business sector has grown more or less at the same pace since 1980 to reach similar levels (Figure 2.9). As for the results based on CIS data, technology collaboration measured by co-assignments between companies and higher

Table 2.4. **Number of EPO applications with multiple applicants, by institutional sector, priority years 1980-2003**

	Companies	Government	Higher education	Private non-profit	Hospitals	Individuals	Other
Companies	51 751						
Government	2 754	242					
Higher education	3 926	670	1 129				
Private non-profit	2 633	391	655	186			
Hospitals	345	38	282	59	48		
Individuals	8 886	228	408	274	30	18 879	
Other	2 195	179	192	141	15	1 935	259

Source: OECD patent database.

Figure 2.9. **EPO applications with multiple applicants from the business sector, priority years 1980-2003**



Note: Type of institution based on the EUROSTAT algorithm

Source: OECD patent database.

education seem less frequent. EPO co-applications between companies and higher education institutions mainly involve institutions from the same country (national joint filings) although both national and international joint filings have grown significantly in recent years.

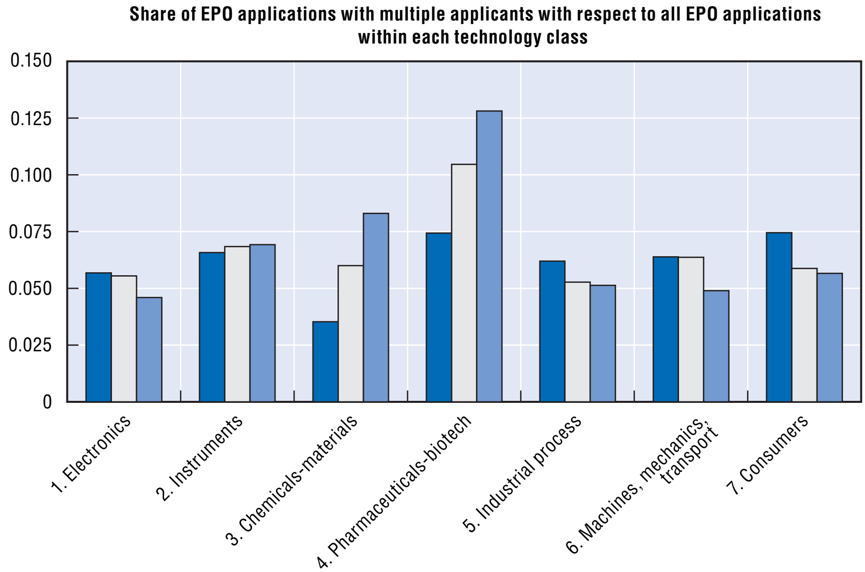
Co-applications: the technology dimension

The correspondence between technology areas (based on the Fraunhofer/ INPI/OST classification) and the main IPC class of EPO applications allows analysis of co-applications across technologies. In line with the rise in the total number of patent applications, the number of EPO filings with multiple applicants has grown in all technology areas, most strongly in electronics, instruments and pharmaceuticals-biotechnology. 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-biotechnology and chemicals-materials. In all other technology areas, including electronics, the relative importance of these co-applications has decreased (Figure 2.10).

Business joint filings at the EPO have risen significantly in pharmaceuticals-biotechnology, chemicals-materials and electronics. The share of joint filings between businesses and other types of institutions (as a share of all EPO filings with at least one business applicant) has risen

Figure 2.10. **EPO applications with multiple applicants, by technology area, priority years: 1980, 1990, 2003**

Percentage of all EPO applications



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: OECD patent database.

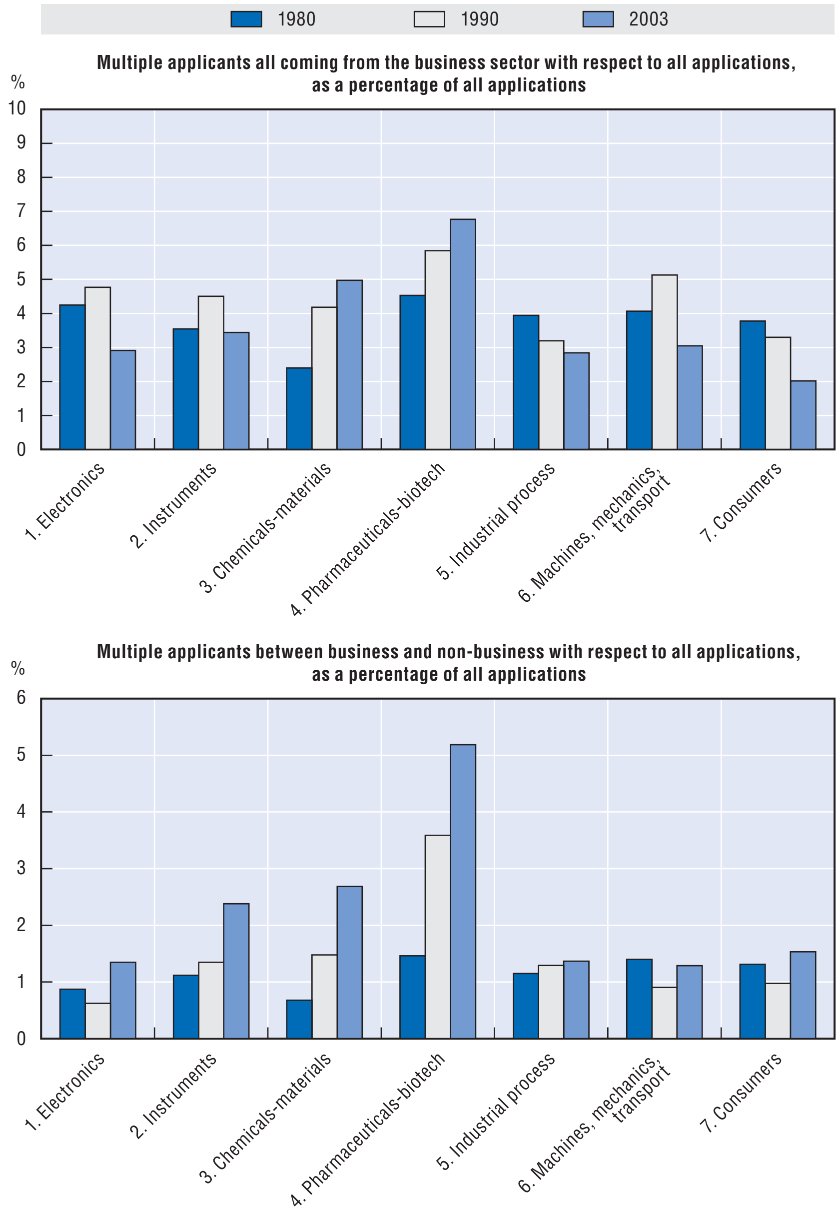
substantially in three technological areas in the past years: pharmaceuticals-biotechnology, chemicals-materials and instruments (Figure 2.11).

Co-applications and MNEs (in Europe)

Given the central role of MNEs in global innovation networks, co-applications have been analysed in greater detail in order to assess the importance of MNEs' co-applications and to identify differences between their behaviour and that of other companies. An experimental data set recently developed by Thoma and Torrisi (2007) is used: it includes all EPO applications filed by 1 433 publicly listed European firms that disclose information on their R&D investments in their company books. This unique database 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,

Figure 2.11. **EPO applications with multiple applicants (at least one from the business sector), by institutional sector and technology class, priority years: 1980, 1990, 2003**



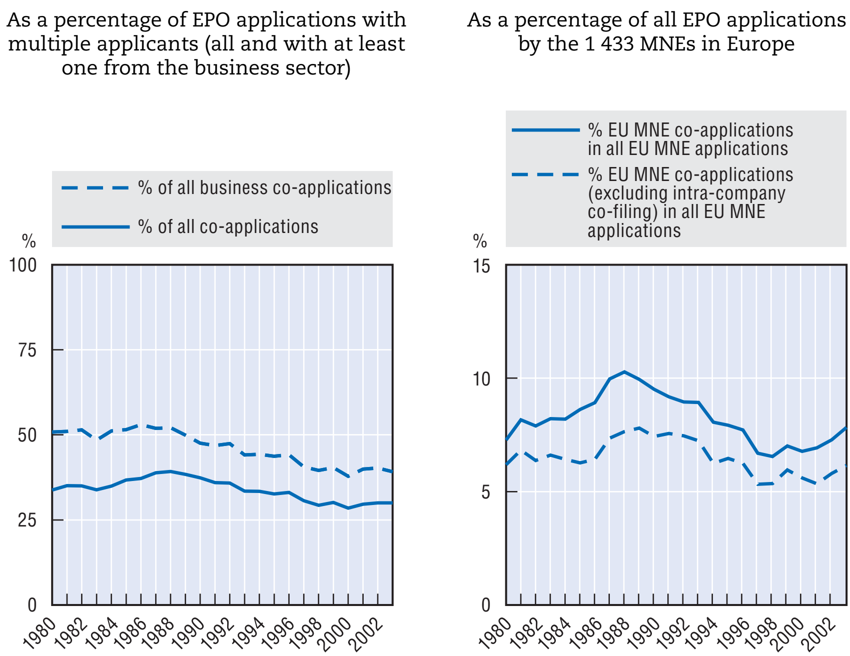
Note: Based on the correspondence between the seven broad technology areas of the revised Fraunhofer/INPI and the main IPC class of EPO applications.

Source: OECD patent database.

2007) and represented, on average, 45% of the annual business patent filings to the EPO between 1980 and 2003. While the selection criterion is not the multinational character of the company *per se* (and thus non-MNEs may be part of the database), name inspection showed a large majority to be MNEs active in Europe. However, since the database only includes 1 433 firms, the results provide an underestimation of the importance of MNEs in EPO co-applications. Given that this is an experimental data set, the results should be interpreted accordingly.

MNEs in Europe (*i.e.* the 1 433 publicly listed European firms) increased their co-applications at the EPO between 1980 and 2003 to a lesser extent than other applicants, since their share in all business co-applications decreased from 50% in 1980 to 39% in 2003 (Figure 2.12). However, their propensity to co-apply for EPO patents is slightly greater than that of other firms (8% for these MNEs versus 5% for all companies together). Intra-group co-applications represented on average 20% of the co-filings of European multinationals (Figure 2.12).

Figure 2.12. **EPO applications with multiple applicants by 1 433 MNEs in Europe, priority years 1980-2003**

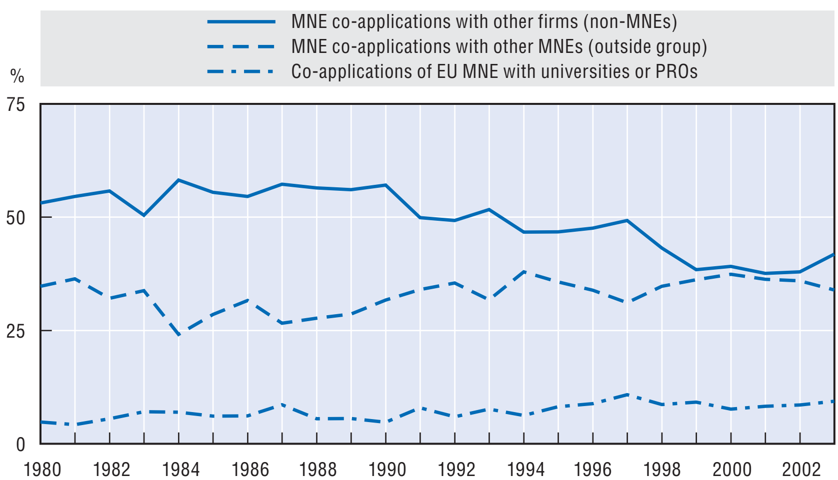


Source: OECD patent database.

Co-applications of MNEs in Europe with other firms (outside the group of 1 433 MNEs) represent on average 50% of the co-applications with third parties. EPO co-applications among the 1 433 MNEs in Europe have grown faster than those with other firms and now represent more than 30% of all their co-filings with third parties. Joint filings of European multinationals with universities or public research organisations have increased in recent years, but have remained at around 7% of all their co-filings with third parties between 1980 and 2003 (Figure 2.13).

Figure 2.13. **EPO-applications with multiple applicants by 1 433 MNEs in Europe, by institutional sector, priority years 1980-2003**

As a percentage of non-intra group EPO-applications with multiple applications by the 1 433 MNEs in Europe

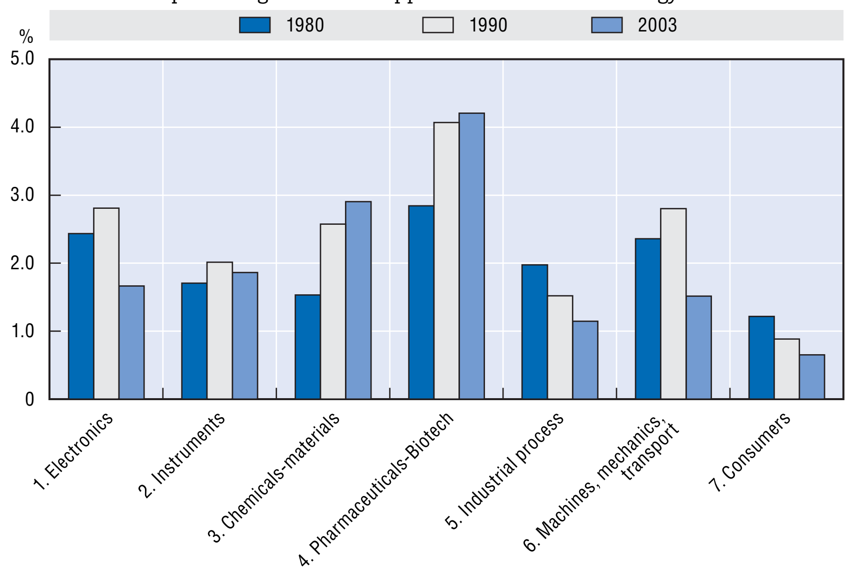


Source: OECD patent database and HAN-EPO-PCT database.

Distributing the co-applications of the 1 433 firms in the database across technology areas shows that MNEs in Europe tend to co-apply with third parties (universities, public research organisations and other firms, European multinationals or not) especially in the field of chemicals-materials (Figure 2.14). Co-applications with universities, public research organisations and other European multinationals also appear in pharmaceuticals-biotechnology, while co-applications with other firms (not in the database of 1 433 MNEs) appear in electronics and machines-mechanics-transport. Most intra-group joint filings are found in the technology area of electronics.

Figure 2.14. **EPO applications with multiple applicants by 1 433 MNEs in Europe, by technology class, priority years: 1980, 1990, 2003**

As a percentage of all EPO applications in the technology area



Source: OECD patent database and HAN-EPO-PCT database.

Trends in licensing

Data on licensing may 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, as most patent licensing is based on private contracts that are subject to confidentiality agreements, robust statistics on technology licensing are not available. 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 relate mostly 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).

Various studies have suggested that markets for technology licensing are large and growing. Patent licensing revenues were estimated to have risen in the United States from USD 15 billion in 1990 to more than USD 100 billion in

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1998, and some experts estimate that revenue could top USD 500 billion annually by 2015 (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 are very diverse owing to significant regional differences. A 2004 survey conducted by the EPO reported that spending on inward licensing was equivalent to 5.6% of R&D spending for US firms, 22.0% 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 the 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 among industries owing to 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.
- A 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 in computers and electronics (30%).
- Cross-licensing is more frequent in electronics (20%) than in other industries (10%). It is more common for transfers of technology that have not yet been developed.

Similar sectoral differences have been reported in more recent surveys as well. In the OECD survey (OECD, 2004), respondents in the ICT sector were 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 in the pharmaceutical industry were most likely to report increases in inward licensing (about 80% of respondents), reflecting the 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 (Sheehan *et al.*, 2004).

Differences also exist 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 when: their technological profiles are similar; when their market profiles are similar; when they are familiar with each other through prior agreements; when they have more prior independent experience with licensing; and when intellectual property protection is stronger 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 2.15). International receipts for intellectual property (including patents, copyright, 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 EU, 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 two have been equal or faster over the past 20 years.

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, their

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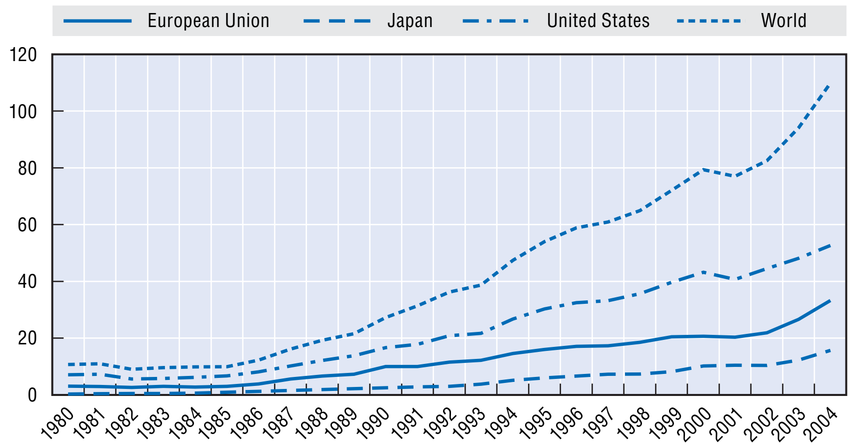
Figure 2.15. **Receipts from international licensing in major OECD regions**

Billions of USD



Source: OECD (2006).

share in the international trade balance of intellectual property (royalties and fees) 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).

Some tentative conclusions

Some new indicators on open innovation based on large-scale data suggest that companies increasingly innovate together with external and international partners. The industry distribution shows that collaboration on innovation is significant in manufacturing as well as in services, although certain industries (chemicals, pharmaceuticals, ICT, including software) typically have higher levels of open innovation. While open innovation is on the rise, the data show clearly that larger firms innovate more openly than SMEs. These results suggest that limited resources may prevent SMEs to deploy open innovation practices more broadly and on an international scale. Large companies are much more active in public research although there is much more cross-country variation for large firms than for SMEs.

Companies collaborate on innovation with suppliers and customers more than with universities and government research institutions, at least in terms of numbers of collaborations. This may be because public research focuses more on upstream research and exploration activities which may be a small part of overall innovation.

The empirical data also show that despite globalisation, geographic proximity still matters in open innovation. Companies were found to collaborate more with geographically close external partners, although it should be recalled that the data measure the number of interactions and not the intensity and quality of collaboration. Additional evidence suggests that proximity may matter somewhat less than good connectivity with external partners.

Notes

1. This is done by applying the Eurostat algorithm to 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 *et al.* (2006).
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.
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 authorised use of intangible, non-produced, non-financial 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)."

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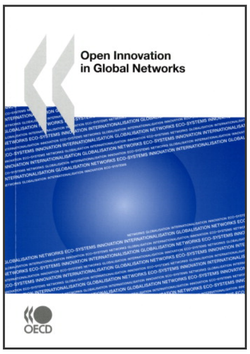

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