Open Innovation in Global Networks



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Open Innovation in Global Networks



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Foreword

As global competition intensifies and innovation becomes riskier and more costly, the business sector has been internationalising knowledge-intensive corporate functions, including R&D. At the same time, companies are increasingly opening their innovation processes and collaborating on innovation with external partners (suppliers, customers, universities, etc.). This clearly has important implications for policy making, given the important role of innovation in OECD countries' economic growth. This issue has recently been addressed in an OECD project on "globalisation and open innovation" undertaken by the OECD Working Party on Innovation and Technology Policy (TIP).

This report presents the project's findings. It expands upon work carried out by the OECD following the March 2005 OECD Forum on the Internationalisation of R&D. It also builds on information in a chapter of the OECD Science, Technology and Industry Outlook 2006 *on the internationalisation of R&D as well as a volume entitled* The Internationalisation of Business R&D: Evidence, Impacts and Implications, *published by the OECD in June 2008. Presentations and discussions at a symposium on open innovation in global networks, held in Copenhagen in February 2008, were another source of important input to this publication.*

This volume was prepared by Koen De Backer and Mario Cervantes of the OECD Directorate for Science, Technology and Industry, together with Els van de Velde (Vlerick Leuven Gent Management School, Belgium) who co-ordinated the company case studies across countries. The empirical work on patent data was prepared by Catalina Martinez (Institute of Public Goods and Policies, Spain).

This report draws heavily on a large number of company case studies in various countries that were undertaken by national experts (see below). Their important contributions, not only to the case studies but to the overall report, are gratefully acknowledged. Special thanks go to Wim Vanhaverbeke and Paul Beije for designing the case study questionnaire.

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Executive Summary

Globalisation increasingly affects how companies in OECD countries operate, compete and innovate, both at home and abroad. Global competition drastically shortens product life cycles, while the growing integration of different technologies makes innovation riskier and more costly. Companies more and more internationalise knowledge-intensive corporate functions, including R&D, and simultaneously open up their innovation process to collaborate with external partners (suppliers, customers, universities, etc.). This clearly has important implications for policy making, given the contribution of (business) innovation to economic growth.

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 "ecosystems of innovation" across countries. They link into these global innovation networks with people, institutions (universities, government agencies, etc.) and other companies in their own or different countries to solve problems, source knowledge and generate ideas. These global innovation networks include own R&D facilities abroad as well as collaborative arrangements with external partners and suppliers, in which firms depend in various ways on the expertise of the different partners.

While open innovation is not totally new, the organisation of innovative activities (technological as well as non-technological) across firm boundaries is clearly on the increase, with more balance between internal and external sources of innovation. Other terms have also been used to describe this trend, and all stress to some extent the openness of innovation activities: open source, open standard, open research, user-driven innovation, etc. The fact that the term "open" is usually thought of as cost-free creates confusion; however, in contrast to open source, for example, open innovation typically implies the payment of licence fees as well as other financial arrangements. In this context, therefore, open does not mean free.

New evidence on global innovation networks based on case studies as well as on large-scale data sets shows that:

- The main reason for locating research and/or development facilities abroad is the proximity of large and growing markets. Other important factors are

the availability of engineers and researchers, and the company's proximity to other activities (production, sales).

- Suppliers and customers are the most sought-after innovation partners. While universities and public research institutes are generally considered an important source of knowledge for companies' innovation activities, especially in more upstream research and exploration activities, they represent only a small share of innovation collaborations.
- Larger firms innovate more openly than small firms. Innovation survey data indicate that large companies are four times more likely than small and medium-sized enterprises (SMEs) to collaborate on innovation.
- Geographical proximity matters in global innovation networks. Companies seem to prefer innovation partners that are geographically close. As the only information available concerns the number of collaborations, however, the fact that companies may enter collaborations with more distant partners only if they are strongly motivated by market demand or excellence seeking may be masked.
- Differences among industries are significant. Collaboration on innovation is important in manufacturing as well as in services, notwithstanding some differences among countries. Industries such as chemicals, pharmaceuticals and information and communication technology (ICT) typically show high levels of open innovation.

The degree of openness in innovation models differs, depending on factors such as the importance of the technology, the strategy of the firm, the characteristics of the industry, etc. Companies traditionally seek to retain their core capabilities and determine what to outsource or with whom to collaborate. Their core competencies (in technology and markets) are developed internally to the greatest extent possible, but open innovation may be a faster, less risky alternative to internal development in order to diversify (in terms of technology and/or markets).

In industries characterised by rather short technology life cycles, *e.g.* the ICT, electronics and telecommunications industry, companies have sought external partners in order to keep up with new developments in and around their industry. In industries characterised by rather long technology life cycles and strong protection of intellectual property rights (IPR) (*e.g.* pharmaceutical, chemical and materials industries), companies mainly look outside the firm to keep up with research. In industries in which patents are important but can be more easily circumvented (*e.g.* the transport equipment industry and the fast-moving consumer goods industry), companies set up collaborations to keep pace with new developments. They seek technologies or products that have proven their market potential, which they can improve, scale up and commercialise.

The largest benefit of open innovation is a much larger base of ideas and technologies. Companies source external knowledge in various ways: partnerships with external parties (alliances, joint ventures, joint development, etc.); or acquisition or sale of knowledge (contract R&D, purchasing, licensing). In addition to these common modes, open innovation is increasingly realised through corporate venturing (equity investments in university spin-offs or in venture capital investment funds).

Open innovation is not only about sourcing external knowledge ("outside-in") as companies look for ways to generate additional revenue from in-house innovations ("inside-out") especially when the technology has future potential but is not part of the firm's core strategy. Companies also increasingly use venturing to find external partners for commercialising innovations that are not used internally (divestment, spin-out, spin-off).

Theft of intellectual property (IP) is seen as the most important risk to global innovation networks. Unique knowledge may be revealed to external partners that may later become competitors. Working closely with external partners can create uncertainty about the appropriation of the benefits of technology collaboration. When collaborating with larger companies, SMEs especially may face larger risks because they typically have fewer resources and limited expertise in IPR issues. The effective management of IP is crucial for identifying useful external knowledge and particularly for capturing the value of a firm's own intellectual property rights (IPR).

Successful open innovation also depends on the open character of the business model. As knowledge has become companies' key resource, open innovation needs to be embedded in an overall business strategy that explicitly acknowledges the potential use of external ideas, knowledge and technology in value creation. Owing to the integration of different technologies, industry borders are shifting or even disappearing, necessitating new business models and organisational structures, including the effective management of human capital (open culture, diversity, etc.).

Global innovation networks significantly influence national and regional innovation systems. The ecosystems or networks of innovation of multinational enterprises (MNEs) create cross-border nodes between regional/national systems of innovation. MNEs also link S&T actors in different countries, and their ecosystems often span clusters and industrial districts in specific industries across countries. In this context, geographical proximity permits localised learning.

Science, technology and innovation policies can no longer be designed solely in a national context. As a country's attractiveness as a location for R&D and innovation activity becomes a priority, framework conditions that affect

the location of production as well as costs (production, labour, tax) become critical. Appropriate structural policies, such as labour market and competition policies, as well as the public infrastructure for innovation and a highly skilled workforce, are essential.

In addition, global innovation networks have some more specific policy implications:

- Universities and public research organisations increasingly play a significant role in the open innovation strategies of firms both as a source of basic knowledge and as potential partners. Support for basic research must therefore continue. Given the scarcity of public resources and competition to attract R&D-related foreign direct investment (FDI), countries must balance their research efforts and investments in specific fields with the need to be open and develop sufficient absorptive capacity in a range of fields.
- World-class clusters and networks remain important but integration across fields and borders may require different interfaces and competencies. The potential for innovation depends on how well knowledge flows and how well the system is connected: policies to foster or enable the development of world-class clusters and networks.
- Sharing intellectual property may require different kinds of management tools in firms and public research organisations. Companies participating in national R&D programmes may need to share IP with foreign subsidiaries/partners or seek to commercialise it in foreign markets, but may be constrained by national regulations.
- Investing in people and fostering cross-functionality and mobility and a "culture of innovation" is crucial, as open innovation implies that people must be able to work in networks and across borders, sectors and at the interface of converging technologies. It also requires openness to a geographically mobile workforce.
- Open innovation stresses the broad characteristics of innovation. Much public support for innovation still focuses on R&D and technological innovation and less on non-technological innovation or other forms of user-driven innovation. While open innovation involves service firms, much public support for innovation still targets manufacturing firms. Policy attention focuses more on the supply side of innovation and less on building market demand for innovation (*e.g.* through public procurement).
- National R&D programmes need to be more open while ensuring benefits via reciprocity and cost-sharing agreements. Also arising from open innovation is the question of capturing national benefits from cross-border

spillovers of the ecosystems of innovative firms. Potential national benefits must be communicated and demonstrated to public stakeholders.

- Building a strong knowledge base is necessary to develop next-generation innovation policies and best practices. A strong knowledge base will be necessary to identify policy implications and develop next-generation innovation policies and best practices. OECD work over the coming years will seek to address these issues.

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Introduction

Globalisation increasingly affects how companies in OECD countries operate, compete and innovate, both at home and abroad. Companies now face an environment in which competition is global, in which knowledge is spread more widely, in which R&D investments are increasing and in which product life cycles are shortening. In addition, the integration of large emerging economies such as China and India has more than doubled the world's supply of labour. To meet these new challenges, companies need to adopt new approaches to innovation processes, organisational models, finance and decision making.

Innovation has become a key to succeeding in the competitive struggle for market share and a prerequisite for sustainable development in a globalised world. It increasingly requires the utilisation of multiple sources of knowledge, both explicit and tacit, and the overall management of intangible assets. Owing to the emergence of global value chains, companies have shifted their production and distribution activities abroad. R&D activities are also increasingly undertaken abroad as companies seek to access knowledge globally.

Over the past decades the amount and intensity of cross-border economic transactions have accelerated, leading to changes in companies' innovation processes:

- Firms are turning to a more open model of innovation that makes more extensive use of research results from external sources in the public or private sectors.
- Innovation is being "democratised" and users of products and services, both firms and individual consumers, are increasingly able to innovate themselves.
- The globalisation of R&D and innovation (especially by multinationals), industry structure and value chains is increasing. Innovation is extending beyond national boundaries, R&D is becoming more internationally mobile, industry-science relationships are globalising, and new global players are emerging, challenging OECD economies to remain competitive.

- R&D and innovation are increasingly linked to business strategy. Business R&D investments no longer play a supporting role that is only indirectly linked to business objectives, but are increasingly directed to the development of new products, processes and services. Firms now actively seek financial returns from their R&D investments.

This volume analyses these trends and identifies the implications for innovation policy, based on extensive analysis and 59 company case studies from various countries. As globalisation and open innovation increasingly affect the linkages within national/regional innovation systems, governments face new challenges. This study highlights best practice business strategies for adapting innovation strategies to globalisation and internationalisation and analyses the role played by open innovation. It aims to provide a sound basis for policies to strengthen growth, employment and productivity in a context of increased outsourcing and globalisation.

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Chapter 1

Open Innovation in Global Networks

This chapter reviews the trends and drivers of open innovation and the advantages and disadvantages of greater openness. It analyses open innovation in relation to other factors, such as user-driven innovation, open source innovation, the role of lead markets, intellectual property rights, and the broader national innovation system framework. It discusses the link between globalisation and open innovation in light of the emergence of global innovation networks. Companies increasingly set up R&D facilities in other countries and initiate technology collaborations abroad to get access to knowledge in local centres of excellence. The diversity of global innovation networks, differences not only between industries but also between modes of open innovation, is also discussed.

The concept of open innovation

Companies' innovation strategies have recently become more open, a phenomenon described by Chesbrough (2003) as "open innovation". Companies increasingly rely on outside innovation for new products and processes and have become more active in licensing and selling results of their own innovation to third parties. The open innovation model is typically contrasted with the so-called traditional closed model, in which companies innovated internally, relying primarily on their own R&D departments to develop new products and processes. If innovation projects resulted in ideas that did not match the company's strategy, the idea often remained, unused, in the company.

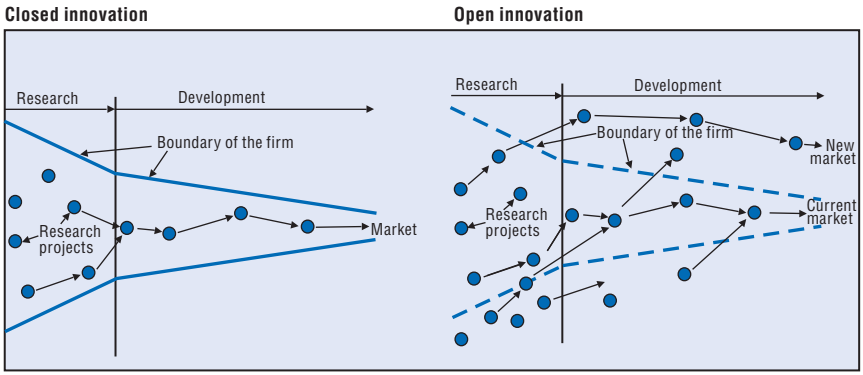
In this more traditional innovation model, R&D laboratories use inputs from internal and external sources to invent, develop and perfect technologies, with a focus on internal development of technologies, products and processes for own commercialisation. This is often described, by analogy, to a funnel, with concepts narrowed down to those that best fit the company's needs (Figure 1.1). Innovations remain (for a time) "on the shelf" if they do not fit in the company's strategy.

The open innovation model is a more dynamic and less linear approach in which companies look both "inside-out" and "outside-in". Innovation is based on knowledge assets outside the company and co-operation is a way to source knowledge in order to generate new ideas and bring them quickly to market. At the same time companies exploit their own ideas as well as innovations of other entities, with academic research occupying a major place. Companies spin out internally developed technologies and intellectual property that are not part of their core business and thus better developed and commercialised by others. Multinational enterprises (MNEs) increasingly link up with start-ups, spin-offs and the public R&D system. Companies' boundaries are becoming a semi-permeable membrane that enables innovation to move more easily between the external environment and the companies' internal innovation process.

The meaning attached to the term "open innovation" varies somewhat, according to the different research streams that have contributed to the concept: insights emerging from analysis of the globalisation of innovation, outsourcing of R&D, user innovation, supplier integration and external commercialisation of technology (Gassmann, 2006). Table 1.1 gives a rapid overview of some of the definitions proposed.

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Figure 1.1. **Closed versus open innovation**



Source: Chesbrough, 2003.

Table 1.1. **Definitions of open innovation**

Author	Reference	Definition
Henry Chesbrough	*Open Innovation: New Imperative for Creating and Profiting from Technology*, Harvard Business Press, Boston (2003)	Open innovation is a paradigm that assumes that firms can and should use external ideas as well as internal ideas, and internal and external paths to markets, as the firms look to advance their technology. Open innovation combines internal and external ideas into architectures and systems whose requirements are defined by a business model.
Henry Chesbrough	*Open Business Models: How to Thrive in the New Innovation Landscape*, Harvard Business Press, Boston (2006)	Open innovation is the purposive inflows and outflows of knowledge to accelerate internal innovation and expand the markets for external use of innovation Open innovation means that companies should make much greater use of external ideas and technologies in their own business, while letting their unused ideas be used by other companies. This requires each company to open up its business model to let more external ideas and technologies flow in from the outside and let more internal knowledge flow to the outside.
Joel West, Wim Vanhaverbeke and Henry Chesbrough	*Open Innovation: Researching a New Paradigm*, Oxford University Press (2006)	Open innovation is both a set of practices for profiting from innovation, and also a cognitive model for creating, interpreting and researching these practices.
Joel West and Scott Gallagher	"Challenges of Open Innovation: The Paradox of Firms' Investment in Open Source Software", *R&D Management* (2006), Vol. 36, No. 3, pp. 319-331	Open innovation systematically encourages and explores a wide range of internal and external sources for innovation opportunities, consciously integrates that exploration with firm capabilities and resources, and broadly exploits those opportunities through multiple channels.

Table 1.1. **Definitions of open innovation** *(cont.)*

Author	Reference	Definition
Joakim Henkel	"Selective Revealing on Open Innovation Process: The Case of Embedded Linux", *Research Policy* (2006), Vol. 35, pp. 953-969	Openness in innovation processes reaches far beyond the market-mediated exchange, where technology is treated as a tradable good to be bought and sold on the market under suitable circumstances. Firms may make their technology available to the public in order to elicit development collaboration.
Charles Leadbeater	*Open Business* (2007), "Open Platform to Develop and Share Innovative New Business Ideas. *www.openbusiness.cc/2007/03/14/two-faces-of-open-innovation/*	There are two faces of open innovation: Open Innovation IN is the basic model where ideas flow into companies from different sources (crowdsourcing). Open Innovation OUT is where a group of people, a movement, sometimes a company, create a kernel or a platform, with some tools, onto which people can add their ideas and contributions. Open Innovation IN narrows down a wider set of contributions into a funnel of corporate development. Open Innovation OUT is designed to allow a process of evolutionary innovation that accretes and grows as each new person adds their piece of information, code or module.
Michael Docherty	"Primer on 'Open Innovation': Principles and Practice", *Visions Magazine*, April 2006	Popularised by Chesbrough's book "Open Innovation", this term refers to the broad concepts of leveraging external sources of technology and innovation to drive internal growth. Also entails the spin-off and outsourcing of unused intellectual property.
Rick Harwig, CEO Philips Research	*Philips Research: Password*, Issue 19, 2004	At Philips we have adopted Open Innovation as our method of working. We team up with academic and industrial partners who have competencies and interests complementary to our own, join forces with industry peers on standardisation and create momentum in the future directions of technology we jointly aspire to, and are active in establishing strong local networks of leading industries and research institutes that help top technology regions to grow.
Procter & Gamble: Innovation Strategy	*www.scienceinthebox.com/en_UK/research/innovation-strategy_en.html*	Our innovation strategy is an approach we call Connect + Develop through which Procter & Gamble is seeking to build a global innovation network. While we invent most of our products in our own labs, we want half of the new ideas to come from outside… Connect + Develop is our way to encourage more open innovation. It is a way of leveraging internally and externally developed innovation assets. We are developing mutually beneficial relationships with the talents and technologies of today's most inspired minds and capabilities.

Source: Finnish contribution to OECD project.

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The inbound aspect of open innovation relates to the sourcing of technology and knowledge from outside partners – suppliers, customers, competitors, universities and research organisations. The more recent outbound aspect relates to companies' increasing wish to gain revenue from knowledge they have developed but not commercialised (*e.g.* patents that remain "on the shelf"). As companies increasingly seek alternative uses for their (unused) IP portfolio, it has been remarked that IP also means intellectual partnering (Chesbrough, 2006). However, while intellectual property receipts have indeed significantly increased (Athreye and Cantwell, 2005), important barriers still exist in the market for IP: only 15% of patents are exchanged while 50% are used solely in house (European Commission, 2005b).

Other classifications of open innovation have been proposed, which generally reflect these inbound and outbound aspects. Gassmann and Enkel (2004) distinguish three archetypes or core processes:

- *The outside-in process*: sourcing and integrating the external knowledge of customers, suppliers, universities and research organisations, competitors, etc.
- *The inside-out process*: bringing ideas to market, selling/licensing intellectual property and multiplying technology.
- *The coupled process*: the outside-in and inside-out processes combined, working in alliances with complementary knowledge.

They reviewed the empirical research in order to assess the importance of these three subtypes. For 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 discussions of the importance of technology sourcing as a motive for foreign direct investment (FDI), of the appropriate choice of modes and partners in accessing external knowledge, and of the complementarity between internal and external R&D and knowledge (*i.e.* absorptive capacity).

The empirical research on the inside-out process is much more limited. The scarce literature on licensing out often focuses on certain industries and even individual companies, while research on 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 this literature seems to focus more on technology sourcing and the outside-in process. The literature review suggests that the novelty of the open innovation concept resides especially in the outbound side or inside-out process.

The Netherlands Advisory Council for Science and Technology (AWT, 2006) developed a slightly different typology, distinguishing between purchasing-based open innovation, collaborative (open) innovation and open access innovation. These dimensions differ mainly in terms of co-ordination mechanisms between economic actors. In so-called purchasing-based innovation, companies interact with other parties as they purchase inputs for their innovation process. Collaborative innovation implies that companies set up partnerships to innovate together in view of a common goal. Companies in open access innovation allow anyone to contribute to the innovative process – users, employees, suppliers, etc.

Applications of open innovation: user innovation, lead markets and open source

Several of the other terms recently used all stress to a greater or lesser extent the openness of innovation activities: open source, open standard, open research, user-driven innovation, etc. Because of the different meanings assigned to "open innovation", differences between these terms are not always clear. The fact that the term "open" is usually associated with royalty-free technologies adds to the confusion. In contrast to open source, open innovation may still imply payment of (significant) licence fees (see below).

The term "user innovation" (Von Hippel, 2005) has also become prominent in recent years. While not identical to open innovation, user innovation is similar in that it concerns innovations developed elsewhere, specifically by customers. "Innovation is being democratised" since users of products and services are increasingly able to innovate on their own, owing to their access to easy-to-use tools and components. These users are firms or individual consumers that expect to benefit from using a product or a service (user-centric innovation), whereas manufacturers expect to benefit from selling a product or service (manufacturer-centric innovation). Users and manufacturers develop different types of innovation, with user innovation resulting in more functionally novel developments (requiring "sticky" user-need and use-context information) while manufacturer innovations are more generally developments and improvements on well-known needs.

Users innovate if they want something that is not available on the market and if they prefer to innovate themselves instead of hiring a custom manufacturer because of the cost but also because of the pleasure of learning (Von Hippel, 2005). In general, their motivations are of three types: direct utility, intrinsic benefits such as learning skills and personal fulfilment, and reputation effects (signalling capabilities to others). Some companies have implemented incentive mechanisms such as financial rewards, IP co-

ownership, co-branding, etc., in order to ensure the continued involvement of users and customers in their innovation process.

Empirical studies show that from 10 to 40% of users engage in developing and/or modifying products and services (Von Hippel, 2005). These innovating users are typically "lead users", *i.e.* they are ahead of the majority of users with respect to an important market trend and expect to benefit significantly from a solution to their specific needs. As lead users are at the leading edge of the market, the novel products they develop for their own use may appeal to other (follower) users, and this provides a rationale for manufacturers to commercialise these innovations. A number of studies have shown that many innovations of lead users are judged to be commercially attractive and/or have actually been commercialised by manufacturers.

Individual users do not have to develop everything they need on their own as they may gain by learning from one another and can often benefit from innovations developed and freely shared by others. Users may freely reveal their innovations and give access to all interested parties; they may voluntarily give up their intellectual property rights. Moreover, it may be of no use to hide their innovation, since other users generally know similar things. Other reasons for freely diffusing user innovations include enhancement of reputation among peers and network partners and the expected (mutual) benefits of improvements of the innovation by others. Innovation by users is often widely distributed rather than concentrated, with the result that innovations are combined and leveraged in so-called innovation communities. In these very direct, informal user-to-user co-operation networks users help each other to solve problems and innovate.

Free and open source software projects are examples of relatively well-developed and very successful forms of Internet-based innovation communities, in which innovations are freely disclosed. They involve a copyright-based licence to keep private intellectual property claims out of the way of both software innovators and software adopters, while preserving a commons of software code that everyone can access (O'Mahony, 2003). Open source can be defined as a set of principles and practices on how to write software, the most important of which is that the source code is openly available. It is not only the source code that is important but also the right to use it (Open Source Initiative).

Open source software started without any enterprise involvement (often university-based research) with enhancements to the code available to everyone on an equal basis. It is a collaborative, community model based on a process that does not allow any contributor to claim ownership to intellectual property on any portion of the code developed within the open source framework. More recently, professional companies have also become active in

open source software since they can create value from their IP over and above what they give away. Companies use strategies that combine the benefits of open source software with the control of (some) proprietary knowledge by sharing rights for using technology and collaboratively developing new technology (West, 2003). Companies may profit from open source software by selling installation, service and support with the software, by versioning the software, by integrating the software with other parts of the IT infrastructure and by providing proprietary complements (Chesbrough, 2003). Different business models can be developed: for example, making portions of intellectual property freely accessible in order to stimulate innovative activity around input and/or complementary technologies.

Open innovation in the innovation literature

The trend towards more openness in innovation has become more prominent but it is not new. The innovation literature has long recognised that companies do not innovate in isolation but co-operate with external partners throughout the innovation process. The emphasis on open innovation primarily reflects greater awareness of the organisation of innovative activities (technological as well as non-technological) across firm boundaries with a more equal balance of internal and external sources (Acha, 2007). The novelty of the concept of "open innovation", coined by Chesbrough (2003), lies especially in the fact that the open innovation process has become an integral part of companies' innovation strategy and business model. Additionally, the concept draws attention not only to the importance of knowledge sourcing but also to the exploitation of internal innovation together with external partners (the so-called inside-out process).

Innovation models have evolved from simple linear models like the technology-push model (up to the second half of the 1960s) and the market-pull model (in the 1970s), towards more complex models. More recent innovation models try to build more complexity and interaction into the framework and explicitly stress the need for openness towards external partners in innovation and R&D. The "third-generation" innovation model (Rothwell, 1991, 1993) combines the technology-push and need-pull models by stressing linkages and feedback loops between R&D and marketing. The subsequent integrated model of the 1980s ("fourth-generation") emphasised innovation as a broadly parallel process with cross-functional integration and parallel development within the company and with external collaborators. Rothwell proposed a "fifth-generation" system and integration networking model as an ideal, based on multi-institutional networking with strong links to leading-edge customers and strategic integration of primary suppliers and horizontal linkages (Table 1.2).

Table 1.2. **Rothwell's five generations of innovation models**

Generation	Key features
First and second	The linear models – need-pull and technology-push
Third	Interaction between different elements and feedback loops among them – the coupling model
Fourth	The parallel lines model, integration with the firm, upstream with key suppliers and downstream with demanding and active customers, emphasis on linkages and alliances
Fifth	Systems integration and extensive networking, flexible and customised response, continuous innovation

Source: Tidd (2006).

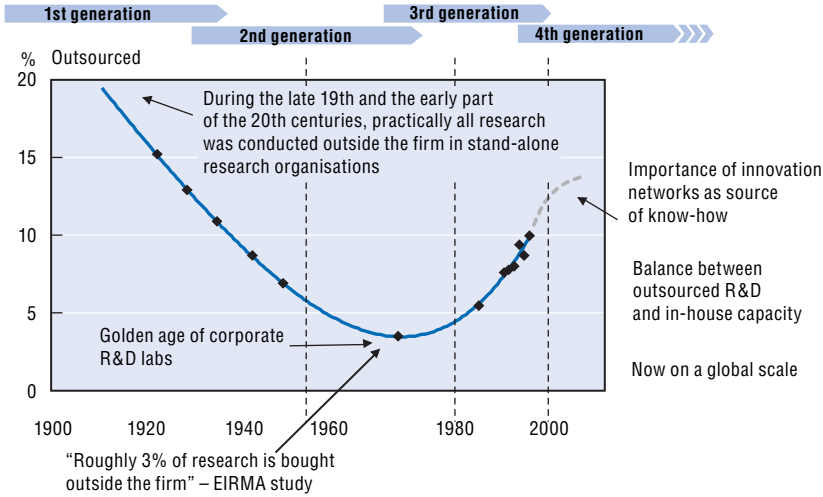
The centralised closed organisation of R&D was the dominant model at a time (1950-70) when innovation management was shaped by the technology-pull view. R&D, with strong specialisation and autonomous R&D professionals, was assumed to be the main driving force for innovation. Innovation activities took place in R&D laboratories that were relatively isolated from business problems and other corporate activities (Roussel *et al.*, 1991; Coombs and Richards, 1993; Lam, 2000).

From the 1980s firms tended to outsource a larger part of their R&D, reflecting the market-pull view of innovation. Decentralisation of R&D to business units and the formation of a market relationship between R&D (as supplier) and business divisions (as customer) are characteristics of this kind of organisation. Innovation is no longer an autonomous activity driven primarily by R&D experts but is increasingly integrated in the firm's business and organisational context. Furthermore, to develop new technologies and knowledge beyond the firm's core competencies, networks of interaction, both internal and external, are set up. Innovation is perceived to be cross-functional and transdisciplinary; as such, access to a wide variety of external knowledge sources is regarded as crucial for generating (radical) innovations.

Information on the top R&D spending companies revealed that in 2000, on average, nine out of ten outsourced 15% of their R&D (Figure 1.2), two-thirds of which to other companies and one-third to public research organisations (European Commission, 2005a). However, open innovation is broader than pure outsourcing of innovation activities to external partners; joint ventures, acquisitions and venture capital are increasingly used for innovation purposes and are not necessarily taken into account in R&D budgets. Companies increasingly innovate within so-called innovation networks in which links and connections between innovation partners have become as important as the actual ownership of knowledge, but investment in own R&D is still necessary because of the importance of absorptive capacity (Cohen and Levinthal, 1990).

The concept of open innovation is also closely related to the literature on national/regional innovation systems. However, while open innovation looks at

Figure 1.2. **Towards greater sourcing of innovation**



Source: European Commission (2005a).

the innovation system from within the company, the literature on innovation systems looks at companies as black boxes. The concept of "innovation system" (including customers, suppliers, competitors, universities, government organisations, etc.) was first launched by Lundvall in 1985; it viewed innovation as a "social" process involving a multitude of interactions among various parties. Shared practices, attitudes, expectations, norms and values, which facilitate the flow and sharing of tacit and other forms of proprietary knowledge, are considered to be crucial for the innovation system. Innovations result from interactive processes of development and learning across organisational boundaries since scientific and technological developments largely arise through the interplay with other sources of knowledge.

National/regional systems of innovation emphasise these inter-organisational linkages as the basis for knowledge creation and diffusion and have been highly influential as a basis for policy development (Lundvall, 1992; Nelson, 1993). For policy makers, the creation and sustainability of a national/regional innovation system implies not only creating the necessary nodes of the system but also ensuring a continuous flow of ideas and facilitating the linkages that will favour an interactive environment. These may be user-producer interactions but may also be shared knowledge among potential competitors or between entities that generate knowledge (researchers) and those that adopt knowledge (firms). When industry, university and government work effectively together in such a system, the term "triple helix" is commonly applied.

Drivers of open innovation: demand and supply factors

Changes in the marketplace – globalisation among them – require companies to be open to external ideas that supplement internal R&D in order to remain competitive. Owing to more intense and global competition and technological progress, product life cycles have been drastically shortened, forcing companies to innovate more quickly and develop products and services more efficiently. Moreover, the growing integration of different technologies has made innovation more costly and riskier. The greater the need for interdisciplinary cross-border and cross-sector research, the less a single company has the capability to innovate successfully. Companies increasingly look for partners with complementary expertise to obtain access to different technologies and knowledge quickly.

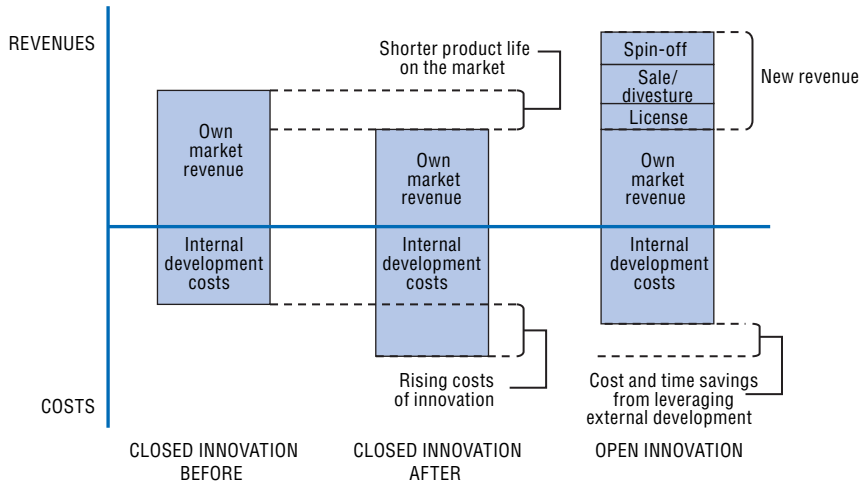
Among the so-called erosion factors, Chesbrough (2003) mentions – in addition to global competition, shortened product life cycles, increased complexity of new technologies and knowledge and increasing costs and risks of innovation – the supply and mobility of researchers and engineers, the supply of venture capital specifically for innovation purposes, and the capabilities of actors in the (global) value chain ("not all smart people in the industry work for you"). More competition and other demand factors have decreased the income of innovating companies, while more supply-related factors have raised the costs of innovation in the closed model. A more open innovation model generates revenues from knowledge developed in house that is largely unused by the firm and generates cost and time savings by leveraging external development (Figure 1.3).

A Dutch report (AWT, 2006) highlighted the need for speed because global competition forces companies to innovate more quickly and more efficiently. The greater complexity of products and services, better educated and more demanding consumers, the convergence of technologies and the dispersion of knowledge are all factors that strengthen the drive for more rapid innovation, while technological advances, notably in information and communication technology (ICT), have facilitated co-operation among actors in the innovation process.

Globalisation is a major driver of more open innovation processes not only because it means more intense and global competition but also because it creates a more global landscape for innovation. A growing number of countries, including emerging countries, have developed important S&T capabilities and resources very rapidly and the internationalisation of R&D and of science as well as the international mobility of researchers have created an increasingly global supply of S&T (OECD, 2008).

While R&D investments are still concentrated in the United States, the European Union and Japan, non-OECD economies account for a growing share

Figure 1.3. **The changed business environment: closed versus open innovation**



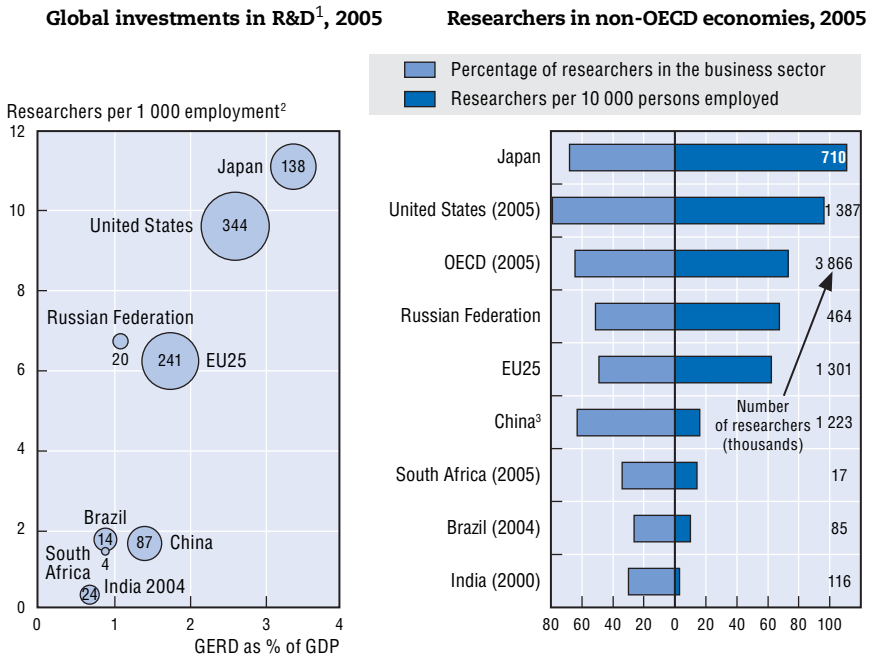
Source: Source: Chesbrough (2006).

of the world's R&D (Figure 1.4). In 2005, non-OECD countries for which data are available accounted for 18.4% of R&D expenditure (expressed in current USD PPP) of OECD and non-OECD economies combined, up from 11.7% in 1996. China made by far the largest contribution, accounting for 41% of the non-OECD share[1].

The growing number of countries with scientific publications and patents illustrates the internationalisation of science. Data on triadic patents[2] show that while the differences are considerable in absolute numbers, the surge in innovative activities is especially strong in Asia. China gained 16 positions since 1995 and entered the top 15 countries in 2005 and India, Korea and Chinese Taipei also rose significantly in the ranking. Patent families from these economies increased notably in the late 1990s and after 2000. Similarly, while scientific publications are concentrated in a few countries (almost 84% of the 699 000 articles in science and engineering [S&E] published worldwide in 2003 were from the OECD area), growth has recently been faster in emerging economies. Scientific articles from Latin America have more than tripled since 1993 and those from south-east Asian economies (Indonesia, Malaysia, the Philippines, Thailand and Vietnam) expanded almost three times over the period (OECD, 2007a).

The availability of qualified human resources is also becoming a more global phenomenon, and supplies from emerging countries are rising

Figure 1.4. **Global supply of S&T capabilities**



1. The size of the bubble represents R&D expenditure in billions of current USD in purchasing power parities (PPP).
2. For researchers per 1 000 persons employed: India (2000); Brazil, United States and South Africa (2005).
3. Data are for scientists and engineers rather than researchers. Overstimation possible.

Source: OECD Main Science and Technology Indicators (MSTI) database (2008).

(Figure 1.4). Expressed as a proportion of employment, the figures indicate that China, with 1.6 researchers per 1 000 persons employed, is still far behind the OECD average of 7.3 (in 2005). The same can be said of Brazil (1.0 in 2004) and India (0.3 in 2000). But while the number of R&D personnel in non-OECD economies is small in relative terms, absolute numbers give a completely different picture for some emerging countries. The number of researchers in China has increased tremendously, from 695 000 in 2000 to 1.2 million in 2006. In absolute numbers China ranks third behind the United States (estimated by the OECD at more than 1.4 million in 2005) and the EU (an estimated 1.3 million in 2006), and ahead of Japan (710 000) and Russia (465 000).[3]

In parallel to this global supply of S&T resources, innovation strategies increasingly depend on global sourcing in order to sense new market and technology trends worldwide. International sourcing of technology and

knowledge has become an important reason for MNEs to internationalise their R&D activities. As markets have opened up, MNEs have become more mobile and increasingly shift activities in their global value chains (OECD, 2007b), including R&D, across borders in reaction to differences in location factors (including costs of innovation). Recent empirical evidence shows that the top 700 R&D spending MNEs[4] increasingly invest in R&D outside their home country in line with the growth in the global supply of S&T resources (OECD, 2008). A survey of the largest R&D investors, undertaken by UNCTAD from November 2004 to March 2005, suggests that the pace of internationalisation in R&D may be accelerating (UNCTAD, 2005): as many as 69% of responding firms stated that their share of foreign R&D is set to increase (only 2% indicated a decline and the remaining 29% expected no change). The average firm in the UNCTAD survey spent 28% of its R&D budget abroad in 2003, including in-house expenditure by foreign affiliates and extramural spending on R&D contracted to other countries.[5]

Technology sourcing has become a major consideration for locating R&D outside the home country, and the geographic dispersion of MNEs is increasingly a means of knowledge creation rather than knowledge diffusion. Their decentralised R&D activities have been defined as "home-base augmenting" (Kuemmerle, 1997) or "asset-seeking" (Dunning and Narula, 1995). Pearce and Singh (1992) describe "internationally interdependent labs" that participate in the group's long-term basic research and collaborate closely with similar labs.

Location decisions for R&D facilities that augment those of the home base are typically supply-oriented, based not only on the host country's technological infrastructure, but also on the presence of other firms and institutions from which investing firms can benefit: spillovers from other R&D units, access to trained personnel, links with universities or government institutions, the existence of an appropriate infrastructure for specific kinds of research, etc. The R&D of these affiliates is more innovative and/or aimed at technology monitoring, and is largely determined by the quality of the components of the regional or national innovation systems. The features of a host country that attract such innovative R&D vary depending on the industry and the activity.

This new motivation complements the traditional demand-oriented reasons for R&D abroad: market proximity to "lead users" and adaptation of products and processes to local conditions. R&D activities have also been undertaken in affiliates abroad to support the MNE's local manufacturing operations and often follow in the wake of FDI in manufacturing. This type of R&D site has been termed "home-base exploiting" (Kuemmerle, 1997), or "asset-exploiting" (Dunning and Narula, 1995). In this case, technological knowledge tends to flow from the parent firm's laboratory to the foreign-based

facility so that the technological advantages of the affiliate primarily reflect those of the home country (where the core of innovation activities is concentrated) and foreign R&D units exploit the parent company's technology.

While "home-base augmenting" activities are increasing, "home-base exploiting" motivations remain important. The empirical evidence showing that companies offshore R&D activities in which they are strong at home suggests that asset-exploiting activities are mostly undertaken abroad (see also below). Moreover, the distinction between adaptive and innovative R&D centres may seem clear in theory, but it is less so in the real world. Criscuolo *et al*. (2005) found that although most FDI in R&D still falls into the home-base exploiting category, it most often tends to be simultaneous with home-base augmenting R&D.

Most internationalisation of R&D by MNEs still takes place within the main OECD regions. However, with the increasingly global supply of S&T resources, emerging countries are attracting more R&D (OECD, 2008). UNCTAD (2005) explains the increasing attractiveness of emerging countries for R&D investments by the low cost and availability of researchers. Some emerging economies with a good education system have a large body of well-trained researchers at low wages. In China, for example, a small proportion, but a very large absolute number, of the population has a tertiary degree. Like the internationalisation of manufacturing, the internationalisation of R&D is also motivated to some extent by cost advantages. However, an available pool of skilled scientists and engineers seems to matter more than lower wages. Schwaag (2006) indicates the presence of an stronger and more competitively priced human capital base near to markets and production facilities as the most important reason for locating R&D in China.

Global networks and innovation ecosystems

Companies increasingly build distributed global networks of R&D to sense local markets trends, to tap into local knowledge and to provide further sources of new technology. To match the growing demand for innovation from customers, suppliers, etc., with the worldwide supply of science and technology, (large) companies increasingly adopt ecosystems of innovation[6] which link networks of people, institutions (universities, government agencies, etc.) and other companies in different countries to solve problems and find ideas (Cooke, 2005; Forrester Research, 2004).

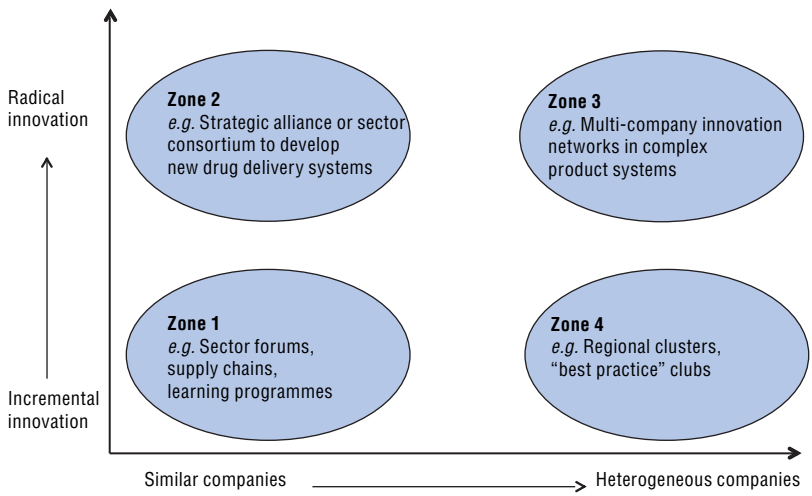
In addition to the growing number of their R&D facilities abroad, companies (specifically MNEs) are more involved in international co-operative arrangements. They source proprietary technology and know-how abroad both through their own R&D facilities and through contractual agreements (contract R&D, joint R&D agreements and corporate high-technology

venturing). They set up more collaborations with suppliers, customers, universities, etc., as part of their innovation strategy. The entire system of collaborative innovation activities stimulates innovation: the whole is greater than the sum of its parts (Tidd, 2006).

In surveying 186 companies, INSEAD and Booz, Allen & Hamilton (2006) concluded that the R&D footprint of most companies was becoming more global, with significant growth in China and India, and that collaborative innovation was also becoming somewhat more frequent. The most cited reason for establishing a new foreign site was access to qualified staff, followed by access to technology clusters and academic institutes. The survey also offered some evidence that external partners have started to play a greater role, with collaboration firmly rooted in relationships with universities and research institutes and with customers. However, the survey found that most companies possessed limited expertise for managing innovation with external partners across borders. Other surveys (*e.g.* Thursby and Thursby, 2006) also find these factors important for internationalisation of R&D, next to size and growth of the host markets.

Tidd (2006) looks at differences in global innovation networks in terms of how radical the innovation is and how similar the participating companies are (Figure 1.5). A first group of global innovation networks is formed by similar companies that focus on tactical innovation issues (zone 1). The success of

Figure 1.5. **Different types of innovation networks**



Source: Tidd (2006).

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these innovation networks depends on their ability to share experience, disclose information and develop trust and transparency. Zone 2 innovation networks involve collaboration between companies from a single industry or adjacent industries (*e.g.* biotechnology and pharmaceuticals) that co-operate to explore and create new products and processes. Since these networks are exploratory in nature and challenge existing boundaries, the sharing of information and risk is often formalised in joint ventures and strategic alliances. Innovation networks in zones 3 and 4 include more heterogeneous companies that typically bring different technology and knowledge to the network. This requires effective IP management and agreements on sharing the benefits and risks.

The internationalisation of innovation requires a level of investments and resources that smaller companies typically do not possess. Previous research has indicated that the most valuable knowledge is hard to codify and that knowledge transfer is typically very sticky, often requiring the establishment of R&D subsidiaries abroad. SMEs may be constrained by the high and increasing costs of search and negotiation because of their weaker and smaller international networks. Open innovation may however provide an answer to the challenge of globalisation (of innovation) for smaller companies. It may offer (especially on the inbound side, *i.e.* the sourcing of knowledge and technology) a less costly alternative to local R&D facilities for obtaining rapid access to local centres of knowledge across the world. Open innovation may speed up the internationalisation of innovation in smaller (high-technology) companies if they do not need to set up full-scale R&D facilities locally. New "infrastructure" in the form of innovation intermediaries (some of them government-sponsored) may help SMEs to develop and integrate global innovation networks.

Globalisation alters the scope of open innovation as it drastically broadens the array of potential partners. Global innovation networks include own R&D facilities abroad as well as collaboration with external partners and suppliers in which the different partners play multiple roles depending on the nature of their expertise. This complex and more open way of innovating (in ecosystems) requires cross-functional co-operation and interaction throughout companies – not only R&D units, but also manufacturing, marketing, sales and services – and enhanced interaction with external parties, both public and private. This embeds R&D activities in a company's global value chain with important implications for the role of (some) subsidiaries in recognising and exploiting the potential for innovation.

The role that companies, and specifically their foreign R&D facilities, play in global ecosystems depends on the technological capabilities and the strategic importance of the host market. At one extreme, foreign R&D subsidiaries can play a purely implementing role for projects in markets

with little strategic importance and with low levels of technological expertise. This corresponds to the traditional "home-base exploiting" motivation for foreign R&D in which adaptation to local needs is primordial. However, if the location has a high level of technological capability for a particular innovative project, it can be assigned a role in developing generic know-how or even play a leading role as a "centre of excellence" with a "global product mandate" (Rugman and Poynter, 1982). In these "home-base augmenting" or "asset-seeking" situations, there are significant transfers of know-how, and the subsidiary is responsible for sourcing know-how from other units of the MNE (including headquarters) but also for accessing external sources. For an effective global innovative strategy, know-how needs to flow throughout the MNE's units and locations. This requires effective linking of R&D units, mobility of staff, the existence of long-distance interpersonal communication and adequate reward systems and responsibilities.

The larger the role that companies' foreign R&D facilities play in global ecosystems, the more intense and more diverse their transfers of know-how will be, since they are responsible for sourcing know-how in other units of the companies (including MNE headquarters) but also for accessing external sources. Frost (2001) argues that this requires a "dual embeddedness" on the part of the foreign R&D facility, *i.e.* its embeddedness in the firm's external and internal networks. In practice, few MNEs operate truly global R&D collaboration systems among dispersed sites working on common projects. Instead, their laboratories abroad specialise in particular technological fields.

Global innovation networks influence national and regional innovation systems. MNEs' ecosystems or networks of innovation often represent "nodes" linking regional/national systems of innovation across borders and therefore various S&T actors in different countries: high-technology start-ups, universities and research institutes, S&T researchers, innovation intermediaries and government institutions. Through their distributed networks, MNEs aim to maximise transfers of tacit 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). MNEs' ecosystems often span clusters and industrial districts in their search for new knowledge because they recognise that spillovers often occur because of geographical proximity. International R&D activities, which include integration in local innovation networks in host countries, are expected to have a positive impact on the competitiveness of MNEs' activities in their home country because of the existence of reverse technology transfers (UNCTAD, 2005).

Open innovation across industries

In their discussion of different types of innovation, Chesbrough and Teece (1996) conclude that open innovation is more attractive for "autonomous" innovation because the necessary sharing of (codified) information and co-ordination of activities among different parties is easier for innovations that can be pursued independently. In contrast, it is less attractive for "systemic" innovations, *i.e.* those for which the benefits are only realised in conjunction with complementary innovations, which often imply the exchange of tacit knowledge and parties that are heavily dependent on each other. Industries like chemicals, steel, railroads and petroleum, which are characterised by long product life cycles and high capital intensities, are among industries with systemic innovations.

The attractiveness of (global) open innovation thus depends on the technological and industrial context (Chesbrough, 2006). The model is perhaps most prevalent in the ICT sector, as it enables companies to cope with accelerating innovation cycles, global competition, complex products and services that incorporate multiple technologies, and the difficulty of controlling all the intellectual assets and qualified people needed for innovation. Yet, open innovation is also found in industries such as pharmaceuticals, with active technology in-sourcing from biotechnology start-ups. While large pharmaceutical companies maintain significant in-house research capabilities, they increasingly rely on externally sourced compounds to widen their product lines (OECD, 2006).

Evidence on openness in innovation can also be observed in industries such as automotives and aerospace where first- and second-tier suppliers play a growing part in the innovation process. Manufacturers in these industries (often MNEs) have shifted many innovative activities to their supplier companies over the years, and these have leveraged the upgrading of their activities to carry out more activities on an international scale.

Gassmann (2006) discusses different determinants of open innovation and uses them to identify industries that appear more prone to open innovation. The more an industry's structural characteristics correspond to these developments and trends, the more appropriate the open innovation model seems to be:

- Globalisation: open innovation in global industries results in economies of scale, powerful standards and dominant designs (Anderson and Tushman, 1990).
- Technological intensity: even the largest companies in high-technology industries lack all the necessary capabilities to cope with emerging technology, hence the need for co-operation with external parties (Miotti and Sachwald, 2003).

- Technology fusion: the more interdisciplinary cross-border research is required, the less a single company's capabilities are sufficient for innovation.
- New business models: with the rapid shift of industry and technology borders, new business opportunities arise, hence the need for new business models to exploit these opportunities.
- Knowledge leveraging: knowledge has become the most important resource for companies and directly determines their competitive advantage.

(Global) open innovation may also be directly related to the concept of technological regimes (Nelson and Winter, 1982), which are determined by differences in knowledge conditions (Malerba and Orsenigo, 1993). Differences in appropriability, opportunity, cumulativeness and knowledge give rise to significant differences among companies, industries and countries with respect to open innovation (Acha, 2007; Herstad, 2007). Although further analysis is needed owing to the interdependence of various knowledge conditions, some relationships may be hypothesised:

- Opportunity determines how easy it is to innovate, radically or incrementally; more opportunities can be expected to favour open innovation. For example, faster and more pervasive technological change (*i.e.* knowledge can be applied to a variety of products and markets) increases the number of external parties with which firms can innovate.
- Appropriability conditions determine how easy it is to protect innovation. Better appropriability conditions may favour open innovation as companies can better protect their innovations from typical strategic hazards such as imitation or the extraction of profits from innovative activities by collaborating parties.
- Cumulativeness determines the degree to which innovation today forms the basis for innovation tomorrow. High cumulativeness means that subsequent innovations are serially correlated and follow specific trajectories; this path dependency and knowledge accumulation (within technologies, organisations and companies) can be expected to make open innovation less attractive.
- The knowledge base determines the degree of multidisciplinarity and cross-functional complexity as well as the tacitness of the knowledge involved. A knowledge base that is characterised by a high degree of tacitness hampers open innovation (because of a stronger tendency towards internal codes and communication channels given the high costs of interacting with external partners), while a high degree of complexity may favour open innovation as some of the required competencies may only be available outside the company.

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Modes of open innovation

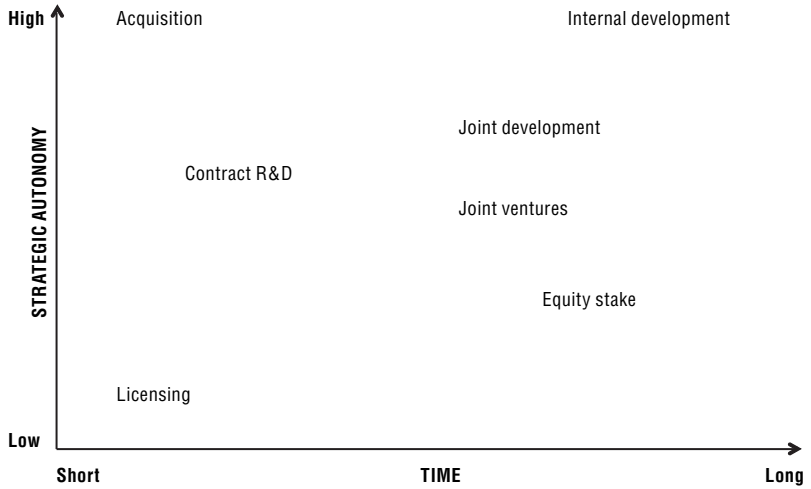
The "old" closed and "new" open models of innovation are typically presented as two extremes of a spectrum ranging from doing everything in house (vertical integration) to outsourcing everything to external partners. However, Dahlander and Gann (2007) explore different degrees and types of openness and convincingly argue that the dichotomy is artificial. Chesbrough and Teece (1996) reported that most companies use a mix of approaches: they purchase some technologies from other companies, acquire others through licences, partnerships and alliances, and develop still other critical technologies internally. Companies' innovation strategies combine characteristics of both innovation models and the degree of openness depends on factors such as the importance of the technology, the firm's business strategy, the industry's characteristics, etc. Companies traditionally seek to retain their core capabilities and decide what to outsource or with whom to collaborate on innovation on that basis.

Laursen and Salter (2006) distinguish between breadth (range of external sources) and depth (importance of sources) in open innovation practices. The former depends on the number of search channels a company draws on in its innovative activities. The latter refers to the extent to which companies draw intensively on different search channels or sources of innovative ideas. Laursen and Salter show the variety of open innovation practices and also show that companies with open search strategies (those that search widely and deeply) tend to be more innovative (however with decreasing returns).

In recent years, open innovation has been extensively discussed by referring to some best practices, such as P&G's Connect + Develop, DSM and Nokia Venturing, Philips' campus, but open innovation encompasses a much wider variety of practices. In accessing and sourcing external technologies and knowledge (*i.e.* the outside-in process of open innovation), EIRMA (2004) distinguished the following modes: purchase of technology; joint venturing and alliances; joint development; contract R&D; licensing; collaborations with universities; equity in university spin-offs; equity in venture capital investment funds.

A choice of one or more of these options depends first on a company's (innovation) strategy as they affect the company's resources and strategic directions differently. Figure 1.6 presents the options for accessing technology/knowledge in terms of the company's strategic autonomy and the corresponding time horizon. The use of licensing for example means that the company can source technology rather quickly but with quite significant dependency on other (external) parties. At the other extreme is internal development ("make the technology") which typically will take a long time but

Figure 1.6. **Open innovation modes: strategic autonomy versus time**



Source: Adapted from EIRMA (2004).

implies much more strategic autonomy. Alternatives such as joint venture, joint development, equity stakes, etc., have intermediary positions in the matrix.

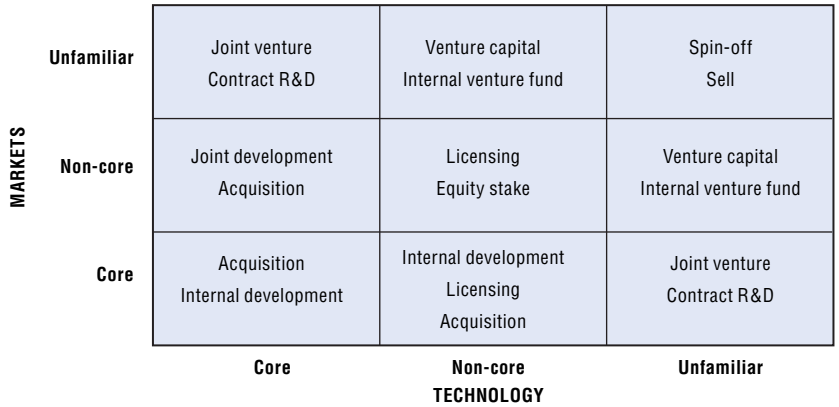
Another matrix presents these different modes according to their suitability for core, non-core and unfamiliar markets and technologies (EIRMA, 2004). Figure 1.7 thus displays not only different options for gaining access to new technology/knowledge (*i.e.* the outside-in of open innovation) but also some alternatives to market technology and knowledge (*i.e.* the inside-out of open innovation). Modes such as joint ventures and venture capital are typically used for sourcing knowledge from outside as well for commercialising in-house innovations.

Internal development and (full-scale) acquisition are typically implemented in core technologies for core markets: open innovation and collaborating with external partners may be too risky for the company's long-term success. Spin-offs and selling appear more appropriate for step-out technologies marketed in step-out markets. Licensing appears more appropriate for dealing with non-core technologies when sourcing them externally or when commercialising those developed internally.

Figure 1.7 clearly shows the importance of choosing the appropriate modes of open innovation in relation to a company's technology and market portfolio. It directly links open innovation to diversification, indicating that core competencies (in technology and markets) should be developed internally as much as possible. In contrast, open innovation may be a faster

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Figure 1.7. **Open innovation modes: technology and markets**



Source: Adapted from EIRMA (2004).

and less risky alternative to internal development for diversification motives (in non-core technology and/or markets). These observations are confirmed by the case studies (see Chapter 3). If technologies and markets are considered too unfamiliar, companies may decide to step out by selling or spinning off the activity. As long as the technology and/or the market may be of importance, companies will try to be involved to some extent (*e.g.* by corporate venturing). Overall, Figure 1.7 shows the diversity of open innovation, *i.e.* companies can choose an appropriate balance and use different modes of open innovation in sourcing and marketing innovations, depending on the core of their technologies and markets.

Partnerships with external parties (alliances, joint ventures, joint development) and acquisition and sale of technology and knowledge (contract R&D, purchasing, licensing) are already common practices, and openness in innovation is increasingly realised through corporate venturing (EIRMA, 2003). Until recently, venture investing was almost exclusively the purview of specialised venture capital funds, but large companies have started to use this technique to create a window on new technology developments and to market more quickly and efficiently innovations that are not directly related to their core competencies.

Spinning in implies investing in technology start-ups (*e.g.* university spin-offs) that lack the scale and financial resources to further develop and market their innovations themselves. By leveraging the structural advantages of small entrepreneurial companies and investing in future technologies, the investing companies try to ensure their future growth. Spinning in is expected to allow the companies to increase their market penetration in the future, to enter new

markets and to respond to competitive threats related to their existing business and technology portfolio. Furthermore, spinning in may increase the rate of innovation and shorten the time to market as companies may obtain emerging technologies with the corresponding entrepreneurial talent.

Spinning out or divesting internally developed technologies relates to the inside-out aspect of open innovation, and is typically done in order to offer the project a better chance to succeed away from corporate influence. The company typically keeps a stake in the project/company that is spun out, and may later buy the whole company back (spinning in again). Spinning off differs somewhat from spinning out, as the company no longer maintains a stake in the project/company. The motives for spinning off are financial instead of strategic; the technology developed in house does not fit well with the company's business/technology portfolio but can earn revenue by being sold to a third party.

Spinning in, spinning out and spinning off are generally considered external corporate venturing; internal corporate venturing concerns the sponsoring of R&D activities within the company itself. Other terms used are new business development or incubation; basically small structures are created within the company to support ideas and projects before the stage at which they can stand alone. In biotechnology, this practice is well-established.

The advantages and disadvantages of global innovation networks

One of the most obvious benefits of open innovation is the much larger base of ideas and technologies from which to derive internal innovation and growth. Beyond that, companies also recognise open innovation as a strategic tool to explore new growth opportunities with less risk. Open technology sourcing offers companies more flexibility and responsiveness without necessarily implying huge costs. Companies not only increase the speed of exploitation and capture economic value through inward licensing or spinning out unused ideas, they also create a sense of urgency about internally available technologies (use it or lose it) among internal groups. Overall the main benefits of open innovation are (Docherty, 2006):

- Ability to leverage R&D developed outside.
- Extended reach and capability for new ideas and technologies.
- Opportunity to refocus some internal resources on finding, screening and managing implementation.
- Improved payback on internal R&D through sales or licensing of otherwise unused intellectual property.
- A greater sense of urgency for internal groups to act on ideas or technology.

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- Ability to conduct strategic experiments with less risk and fewer resources in order to extend core business and create new sources of growth.
- Over time, the opportunity to create a more innovative culture from the "outside in" through continued exposure and relationships with external innovators.

Open innovation also has disadvantages, especially since technology and innovation have often become the basis for companies' competitive advantage. The academic literature on co-operation, collaboration and alliances has discussed various disadvantages: the extra costs of managing co-operation with external partners, the lack of control, the adverse impact on flexibility, the (over)dependence on external parties and the potentially opportunistic behaviour of partners. The growth in outsourcing of R&D and open innovation also make the management of innovation more complex and may result in the loss of (some) technological competencies and greater dependency on external actors. In addition, the increased risk of leakage of proprietary knowledge and involuntary spillovers means that unique knowledge may be revealed to external partners that may later become competitors or may make better use of the results of the venture or the know-how. The effective management of IP is crucial, not only to identify useful external knowledge but especially to capture the value of a firm's own IP rights.

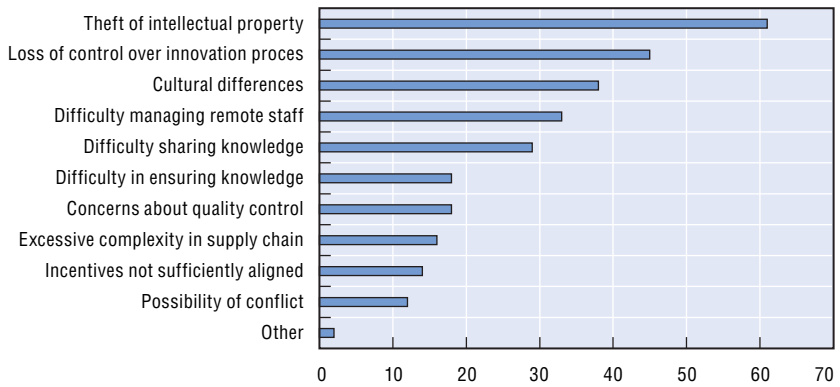
Because open innovation has a significant impact on capabilities and resources, on funding and budgeting, its success depends on the company's business model. Open innovation needs to be embedded in an overall business strategy that explicitly acknowledges the potential value of external ideas, knowledge and technology for creating value. Chesbrough (2006) discussed the need for such open business models, not only to access and use external knowledge but also to exploit internal knowledge (in R&D, marketing). The integration of various technologies means that industry borders are shifting or even disappearing (*e.g.* between telecommunications, information, entertainment and multimedia industries). This in turn requires new business models and organisational structures. The main reasons for companies to join forces are to seize new business opportunities, to share risks, to pool complementary resources and to realise synergies. To achieve these objectives, barriers and resistance (especially within the company) may have to be overcome before it is possible to implement open innovation strategies effectively and efficiently.

Global innovation networks and intellectual property

The growing interaction with external parties raises important issues regarding the protection and safeguarding of intellectual assets and intellectual property (patents, trademarks, trade secrets, etc.). It can create

uncertainty about how to appropriate or share the benefits of the collaboration. A survey by the Economist Intelligence Unit identified intellectual property theft as the most important risk in global innovation networks (Figure 1.8). More than 60% of the 300 senior executives questioned indicated IP as the most acute problem in collaborating on innovation with international partners.

Figure 1.8. **Risks of global innovation networks**
"What do you see as being the most significant risks to developing global innovation networks?"
Percentage of respondents



Source: The Economist Intelligence Unit 2007.

Protection of intellectual property rights attracts much attention, especially in emerging countries, because of weak enforcement of intellectual property rights (IPR) in some countries. The risk of dissipation of know-how to local competitors has been a traditional reason for the centralisation of R&D at home. Empirical studies on the impact of IPR on foreign R&D have generally provided evidence that IPR protection has a positive impact on inward R&D, although studies of specific host and home countries have not found a clear relationship (for an overview see OECD, 2007c). In trying to explain why MNEs set up foreign R&D affiliates in emerging countries with weak IPR regimes UNCTAD (2005) indicated that such R&D activities often focus on technologies that are typically used in combination with complementary technologies. In the absence of the related technologies, local technology leakage does not pose a major threat. In a related point, Thursby and Thursby (2006) reported that companies use familiar rather than new frontier technologies in emerging countries.

Since knowledge has become increasingly important for competitiveness and innovation, companies seek the most appropriate protection of their interests when collaborating with external partners. They usually adopt both

formal methods (such as patent, trademark or copyright protection) and informal ones (lead time, first mover advantage, lock-in). SMEs especially may face greater risks in collaborations with larger companies because they typically have fewer resources and limited expertise in IPR issues. The choice of specific IP strategies will depend on the chosen modes of open innovation: when companies collaborate more upstream, co-development may result in co-patenting, while in more downstream (technology) collaborations licensing may be preferred.

In the past, IP management was often relatively closed since intellectual property was mainly created and used internally, and protection of intellectual property was used to prevent or block competitive moves. A survey of business patenting and innovation patterns in the United States and Japan (Cohen *et al.*, 2002) clearly illustrates the important role played by patents in protecting companies' inventions from imitation. The reasons for defensive patenting most cited by US and Japanese respondents were preventing copying, preventing other companies from patenting (*i.e.* blocking) and preventing lawsuits. A smaller share of firms indicated that patenting was important for strategic reasons as well: for use in negotiations (*e.g.* cross-licensing), to enhance reputation, to generate licensing revenue and to measure performance (Table 1.3).

Table 1.3. **Reasons for patenting product innovation**
Share of respondents and ordinal rank

	United States	Japan
Prevent copying	98.9 (1)	95.5 (1)
Prevent blocking	80.3 (2)	92.6 (2)
Prevent lawsuits	72.3 (3)	90.0 (3)
Use for negotiations	55.2 (4)	85.8 (4)
Enhance reputation	38.8 (5)	57.9 (7)
Licensing revenue	29.5 (6)	66.7 (5)
Measure performance	7.8 (7)	60.1 (6)

Source: Cohen *et al.* (2002).

The sometimes low utilisation rate of IP assets in the commercialisation of products and services was a direct consequence of closed IP management. Most patents do not directly generate revenue for patent owners via their incorporation into products, processes and services or through licensing revenues (OECD, 2006). To illustrate:

- Gambardella (2005) reports that roughly one-third of European patents are not used for any commercial or economic purpose and at least half are not even held for strategic or other reasons but are simply "sleeping" patents.

- A 2003 survey of EPO patent applicants (about 700 responses) showed that the share of licensed patents in respondents' patent portfolios averaged 8% among Japanese firms, 11% among European firms and 15% among US firms (Roland Berger, 2005).
- A large-scale comprehensive survey conducted by the Japan Patent Office (JPO) (about 6 700 responses) found that only 30% of Japanese patents were being exploited internally, less than 10% were being licensed out to other parties, and more than 60% were unused (JPO, 2004).
- A large-scale survey of European inventors shows that the share of European patents that are licensed to a third party is about 5%, that cross-licensed patents cover another 5% and that patents licensed to another party and also used internally by the owner are about 3.5% (Ceccagnoli *et al.*, 2005).
- A survey by the British Technology Group (BTG) of 150 technology-intensive firms and research universities in the United States, western Europe and Japan found that 24% had more than 100 unutilised patents, 12% had more than 1 000 and only 15% reported having none. Approximately 30% of Japanese firms reported having more than 2 000 unused patents (BTG, 1998).

The shift towards open innovation has however resulted in more open IP management, with companies licensing in from external parties to access complementary technology and also creating value by licensing unused technologies or by selling the patents. Many researchers and business executives have reported that the use of patenting has evolved from a focus on defensive applications to exploitation as part of business and management strategy (*e.g.* licensing, building a patent portfolio) to exploitation as a financial asset (*i.e.* attracting external sources of financing). Patent licensing has been found to generate significant financial benefits for patent holders, *e.g.* Dow Chemical, IBM, Merck, Amgen, Thomson, etc. (OECD, 2006).

The rise in patenting over the past decade, especially in ICT and biotechnology, has resulted in areas that are densely populated with patents and consequently with significant overlapping ("patent thickets"). In such situations even unintentional patent infringement may be unavoidable and can constrain collaboration. Companies have tried to circumvent this situation by the creation of cross-licensing and patent pools (Shapiro, 2001). Cross-licensing agreements involve the exchange of two or more patent portfolios and are typically used to allow mutual use of patents by multiple patent holders in order to secure freedom of operation and access to complementary technologies and to avoid running the risk of patent infringement litigation with other companies in similar product markets. Patent pools typically consist of the collection of patents required to offer a products or service. To maximise the benefits of a

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patent pool, as many of the required patents as possible should be collected, while keeping total royalty payments reasonable.

The emergence of intermediary markets for ideas and technologies may facilitate the mutually beneficial exchange of IP between different parties. Differences in technological regimes and more specifically in appropriability between industries directly determine the efficiency of these intermediary markets for ideas and technologies. When these markets are inefficient because of prohibitive transaction costs for technology transfer, innovation and intellectual property may not be exchanged at all or only exchanged by takeovers, mergers or spin-offs or divestment of divisions. However, a new innovation market is emerging in which companies increasingly act as innovation intermediaries or technology brokers by bringing together those seeking a solution to a problem with problem solvers (including academia, company workers, students, retirees) in a global network. Other intermediaries specialise in helping companies buy and sell intellectual property on an open market, for example through licensing.

Notes

1. However, the conversion from national currency into USD PPP may overestimate China's R&D effort.
2. Triadic patent families are defined at the OECD as a set of patents taken at the European Patent Office (EPO), the Japan Patent Office (JPO) and US Patent & Trademark Office (USPTO) that protect the same invention.
3. However, the number of researchers for China may be overestimated owing to problems of definition.
4. More than 95% of the 700 firms with the largest R&D expenditure are MNEs and they account for close to half of the world's total R&D expenditure and more than two-thirds of the world's business R&D (UNCTAD, 2005). The top R&D-performing MNEs often spend more on R&D than many countries and their presence is felt not only through activities in their home countries but also increasingly abroad.
5. However, some authors have qualified this view of the internationalisation of R&D, since R&D establishments may be acquired incidentally through mergers and acquisitions (M&A). Ronstadt (1978) and Håkanson and Nobel (1993) noted that many R&D investments were due to M&A activity of the parent company, which did not have as the primary objective gaining access to the organisation's R&D. It is difficult to assess the importance of this "incidental" internationalisation of R&D as data on R&D facilities abroad that distinguish between M&A and greenfield investment are not readily available.
6. Forrester calls this dynamic structure "innovation networks", in which firms seamlessly weave internally and externally available invention and innovation services to optimise the profitability of their products, services and business models (Forrester Research, June 2004).

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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.

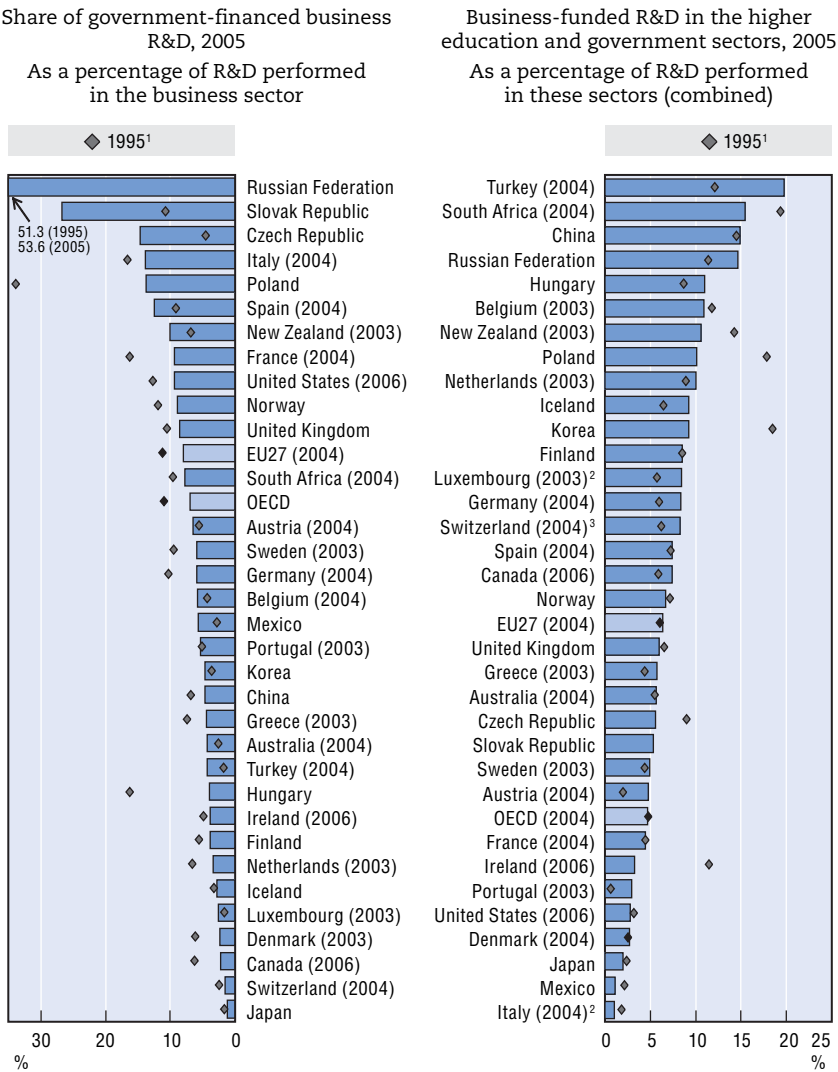
Trends in R&D collaboration

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.

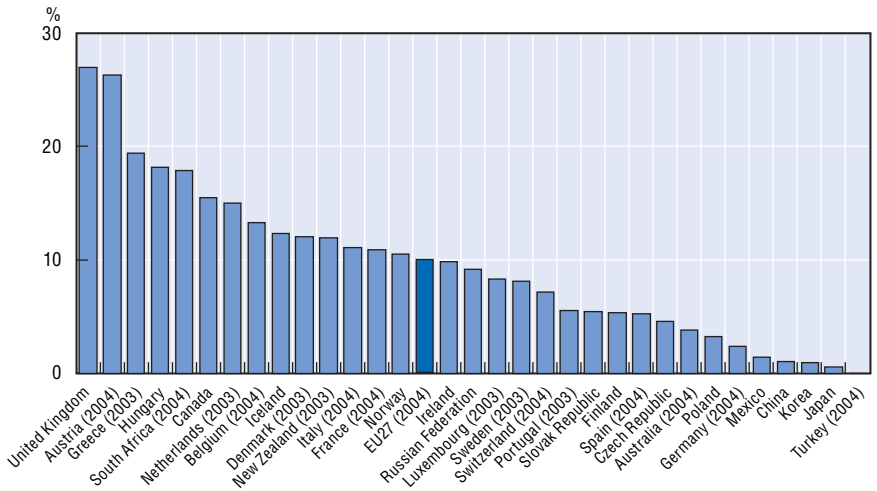
Source: OECD (2007).

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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.

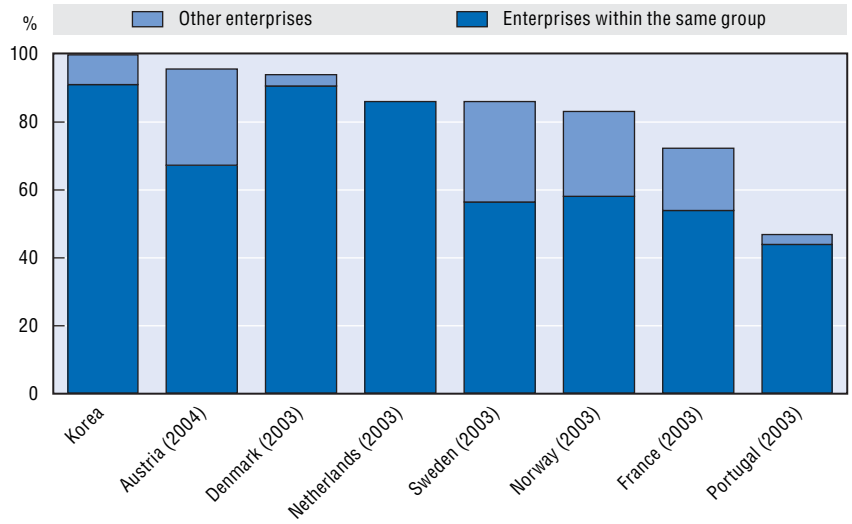
Figure 2.2. **Funds from abroad**
As a percentage of business enterprise R&D, 2005



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).

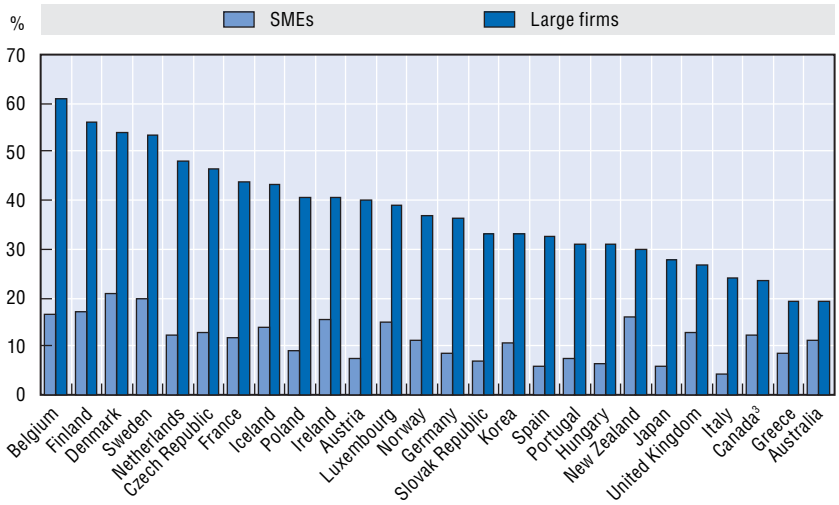
Innovation surveys: the role of networks and collaboration

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

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.

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Table 2.2. **Companies collaborating on innovation activities, by partner**
As a percentage of all companies collaborating on innovation, 2002-04[1]

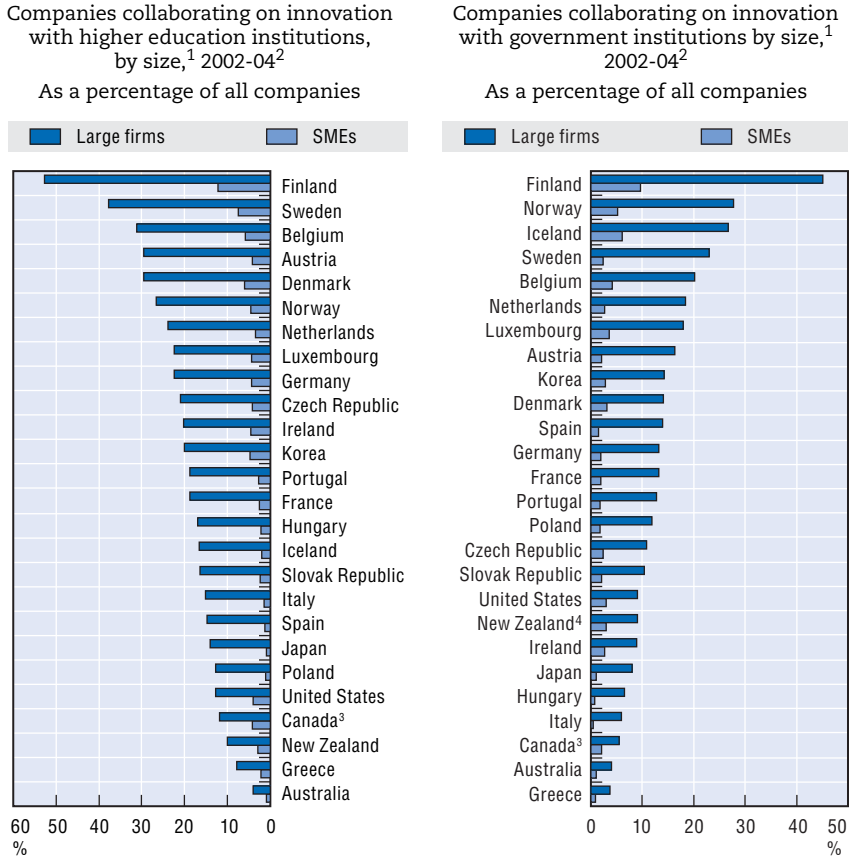
	Suppliers	Customers	Competitors	Consultants and private R&D institutes	Universities and other higher education	Government and public research
Belgium	73	59	27	42	37	26
Bulgaria	74	61	35	34	27	18
Czech Republic	80	68	40	39	34	19
Denmark	66	65	35	44	32	16
Germany	44	51	27	18	53	26
Estonia	67	66	53	29	25	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.

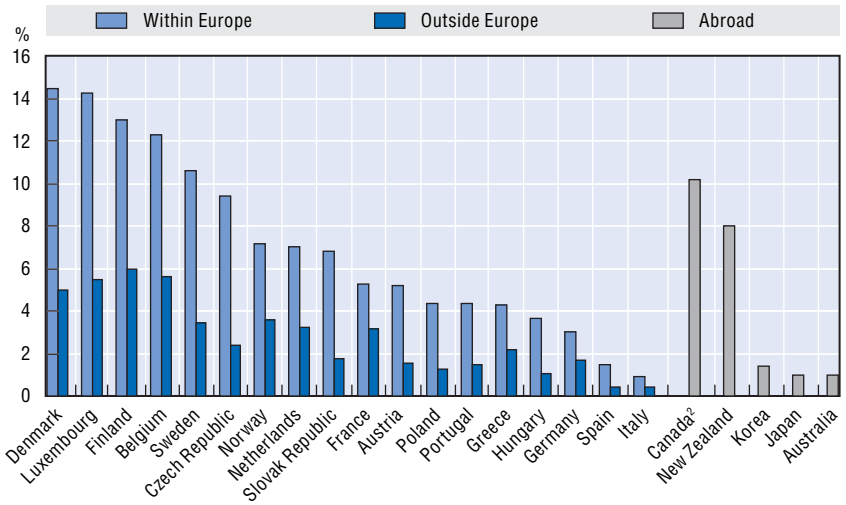
Source: OECD (2007).

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.

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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.

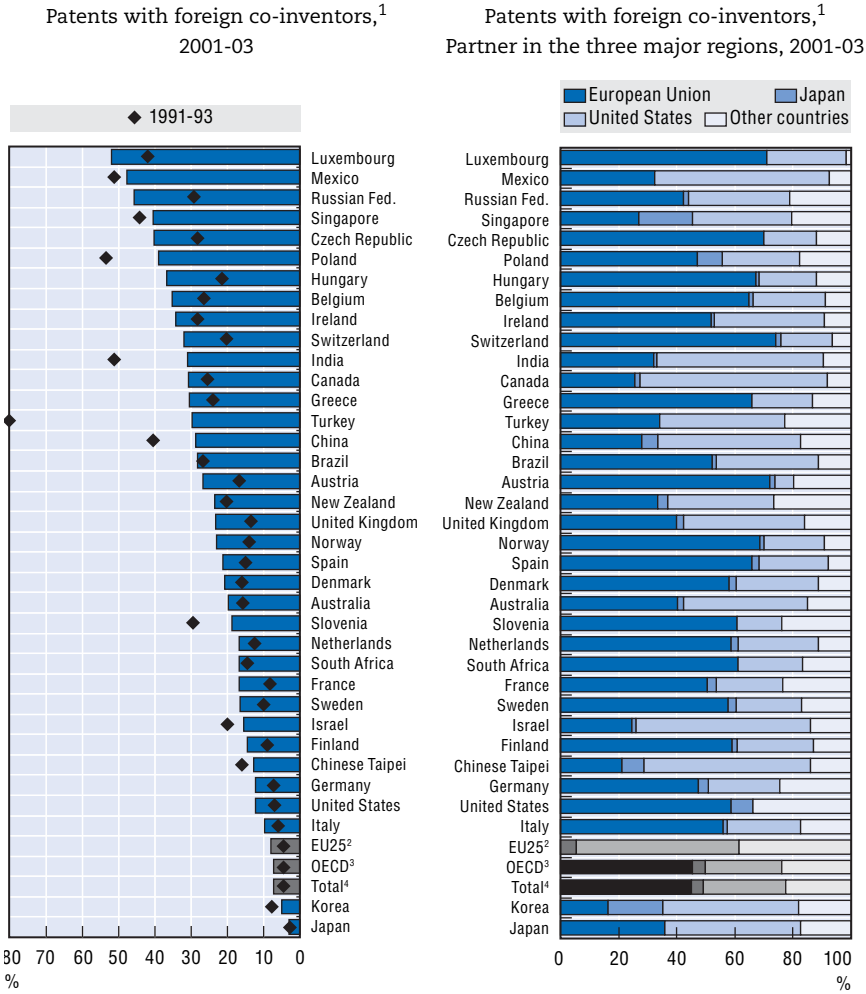
International co-invention

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.

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)

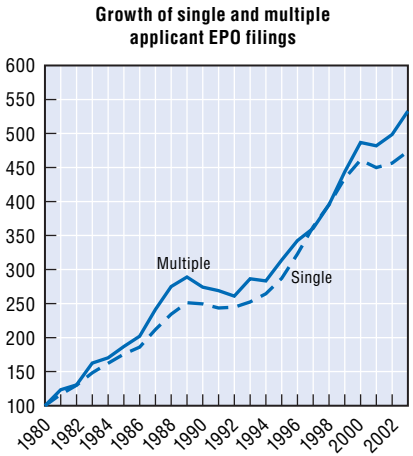
may also offer indicators on open innovation. Again, these are not perfect measures of technology collaboration as some companies may opt to form a joint venture for the collaborative R&D and apply for the corresponding patents (with the joint venture as the only applicant-owner). Patent applications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

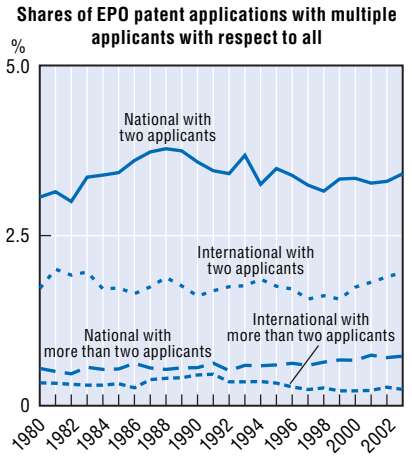
In order to further analyse co-application, Table 2.3 shows, for EPO patent applications with multiple assignees, the nationality of the co-applicants of US, Japanese and German applicants. The results show that the co-applicants

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.

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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

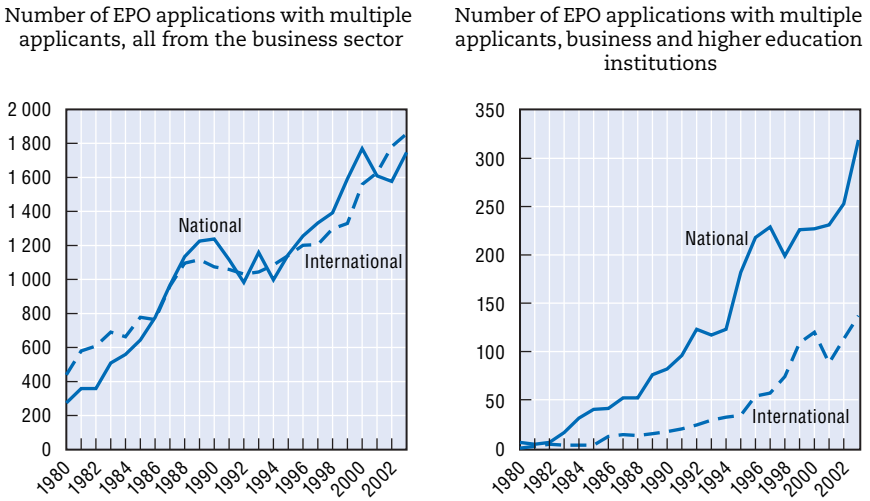
Table 2.4. **Number of EPO applications with multiple applicants, by institutional sector, priority years 1980-2003**

	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.

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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.

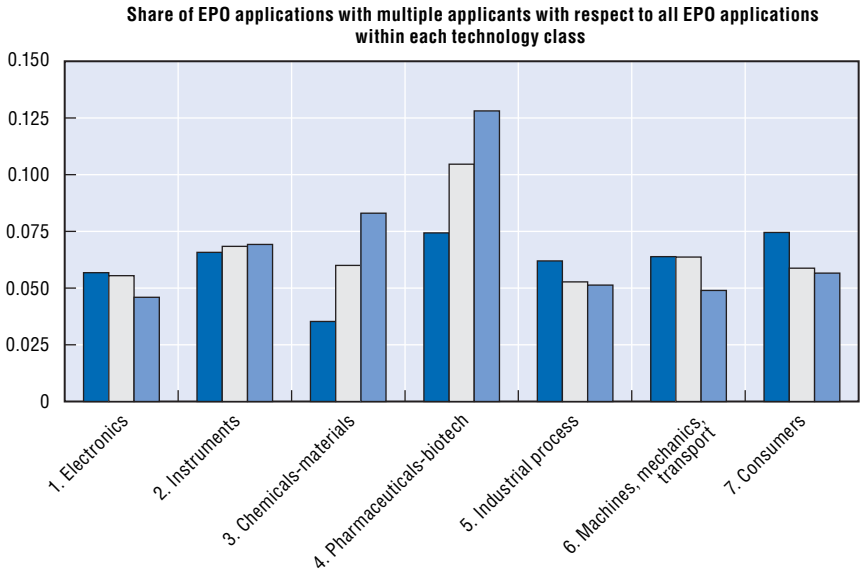
Co-applications: the technology dimension

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.

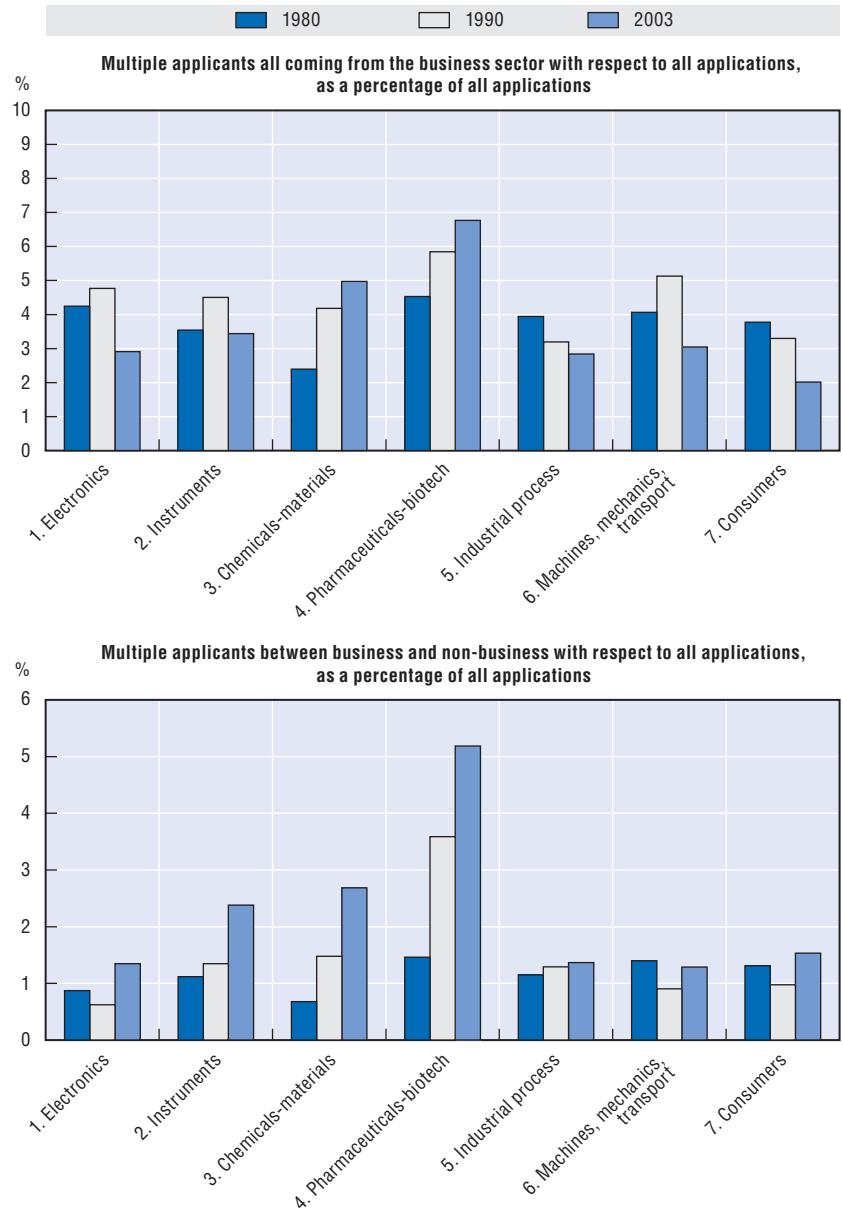
substantially in three technological areas in the past years: pharmaceuticals-biotechnology, chemicals-materials and instruments (Figure 2.11).

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**



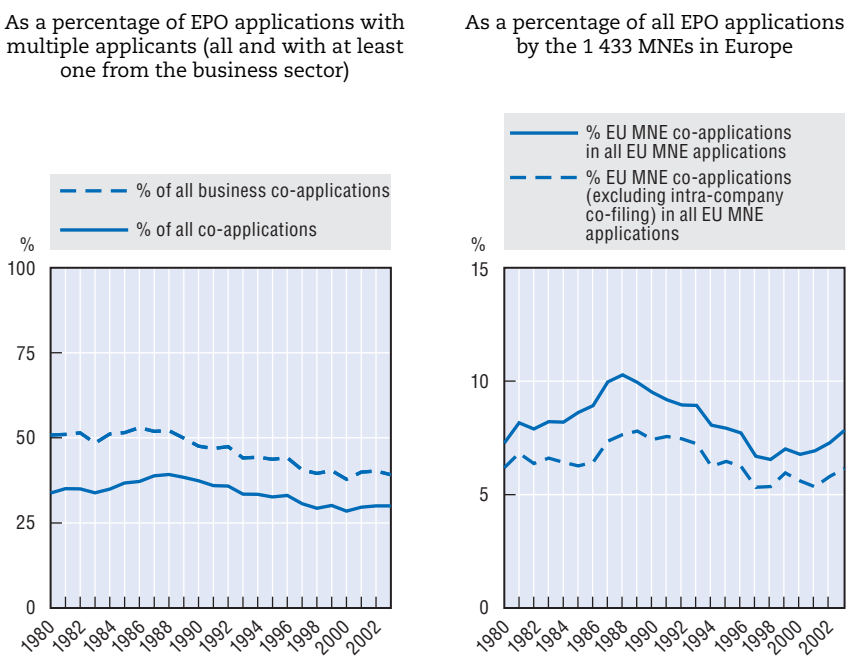
Note: Based on the correspondence between the seven broad technology areas of the revised Fraunhofer/INPI and the main IPC class of EPO applications.

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**



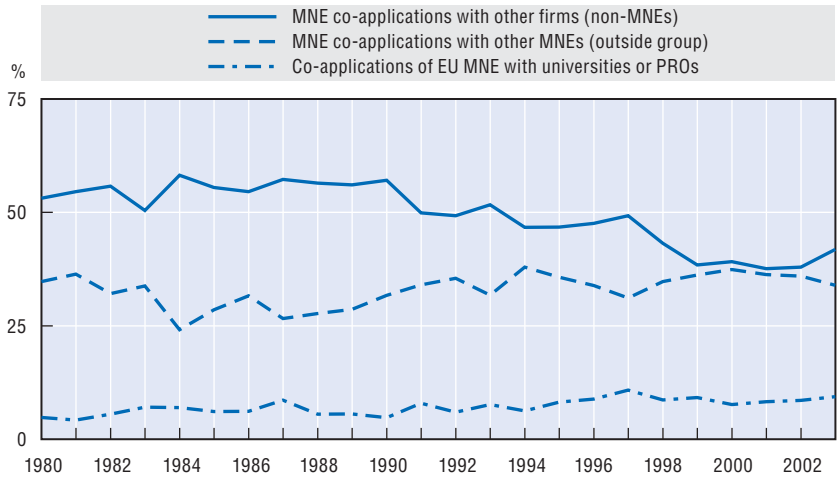
Source: OECD patent database.

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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

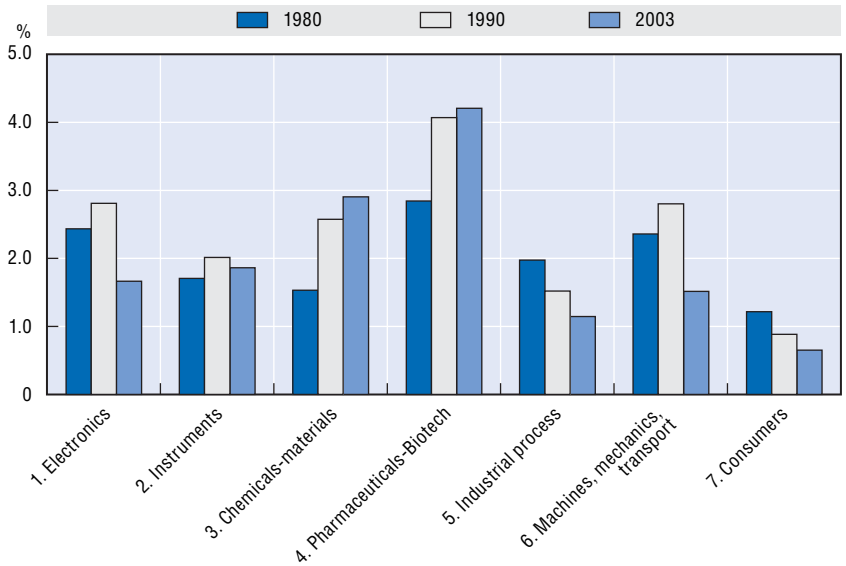


Source: OECD patent database and HAN-EPO-PCT database.

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

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).

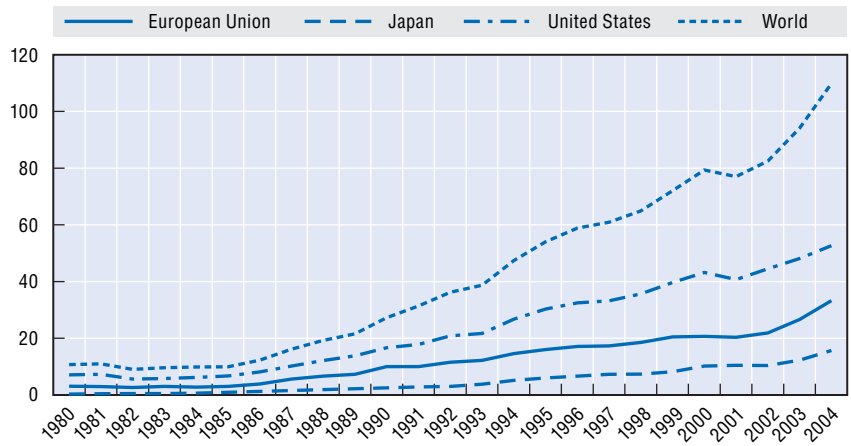
Differences also exist between smaller and large firms, as data show that smaller firms are more likely to license. This is related to their lack of complementary downstream assets and the smaller risk of the licensee becoming a potential competitor (Arora *et al.*, 2001). Another study, also based on 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

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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Chapter 3

Insights from the Company Case Studies

Chapter 3 complements the "academic" analysis with insights from the 59 company case studies undertaken for this project. Their number and variety (manufacturing and services, high and low technology, MNEs and SMEs) enable an informed discussion of the diversity of open innovation in various contexts. In addition to the aggregate information drawn from the case studies, examples of how companies organise open innovation are presented.

General overview

Company case studies were undertaken in several countries to assess how open innovation is implemented in practice in different sectors and types of firms. The aim was to understand the extent to which open innovation is helping firms respond to the challenges of globalisation. A standard questionnaire was distributed to companies and followed by interviews. In selecting the companies for the case studies, attention was paid to choosing a diversity of firms across countries.

Most companies covered by the case studies implement open innovation through innovation networks as an integral part of their strategic development. By innovating in an open framework, companies co-operate with the best in their business and take advantage of the expertise that these partners have built over many years. Companies look at open innovation as close collaboration with external partners, *i.e.* customers, consumers, researchers or others that may have an impact on the future of their company.

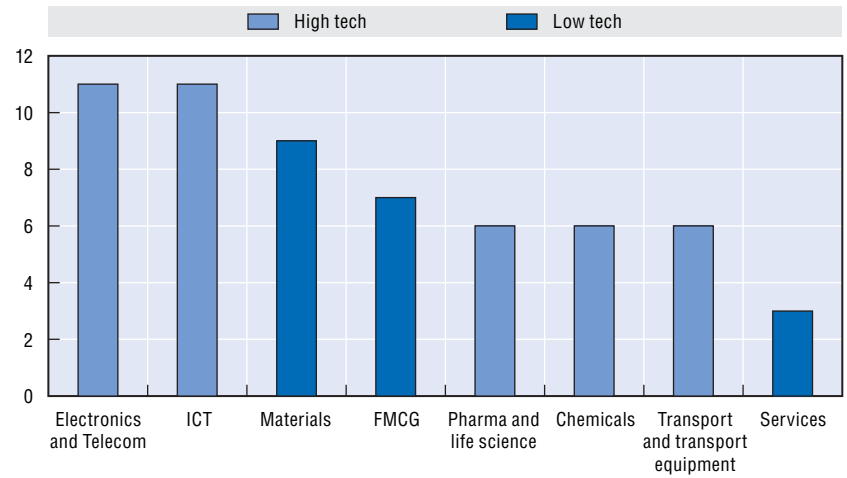
The 59 case studies were conducted in 12 countries: Belgium, Denmark, Finland, France, Germany, Greece, Japan, the Netherlands, Norway, Spain, Switzerland and the Russian Federation. The companies are listed in Table 3.1. They include manufacturing and service companies, large firms and SMEs, high-technology and low-technology industries. They are classified according their NACE code into eight major industries: pharmaceuticals and life sciences, chemicals, electronics and telecommunications, ICT, transport equipment, materials, fast-moving consumer goods (FMCG) and services.

High-technology[1] industries are well represented: the ICT industry and the electronics and telecommunication industry each account for 11 case studies, while the pharmaceutical and life sciences industry has six (Figure 3.1). Chemicals and transport equipment (automotive, aerospace and shipbuilding industry) are also represented. Lower-technology industries include the fast-moving consumer goods (FMCG) industry (seven companies) and the materials industry, including wire drawing, textiles and glass (nine companies). Nevertheless, even in these lower-technology industries, companies often perform "high-technology" activities, including R&D. In total the manufacturing sector has 46 case studies, while the broad services sector (including some ICT and electronics and telecommunications companies) have 13.

Table 3.1. **Company case studies**

Country	Companies
Belgium	Bekaert, Herstal Group, J&J, MACQ Electronique, Numeca International, P&G, TWIN Development,
Denmark	Danisco Ltd., Exiqon Ltd., Gabriel Ltd., IBM Denmark Ltd., Quilts of Denmark Ltd.
Finland	Nokia
France	Air Liquide, Alcatel Lucent, ArcelorMittal, Dassault Systèmes, Danone, Saint-Gobain SEB, SNECMA, Valeo
Germany	Siemens AG Transportation Systems, Case Germany 2, Case Germany 3
Greece	Eurobend, S&B Industrial Minerals, Velti, Case Greece 4, Case Greece 5
Japan	NEC, Omron, Toray Industries
Netherlands	Philips, Case Netherlands 2, Case Netherlands 3
Norway	Aker ASA, Ewos Innovation eZ Systems, Q-Free,
Russia	Biological Research & Systems, Biopharm, Stack Group, Case Russia 4
Spain	Case Spain 1, Case Spain 2, Case Spain 3, Case Spain 4, Case Spain 5
Switzerland	ABB, Alcan Engineered Products, Clariant, IBM Zurich Research Laboratory, Microsoft Suisse, Nestlé, Novartis, Siemens Building Technologies, Swiss Reinsurance Company, UBS

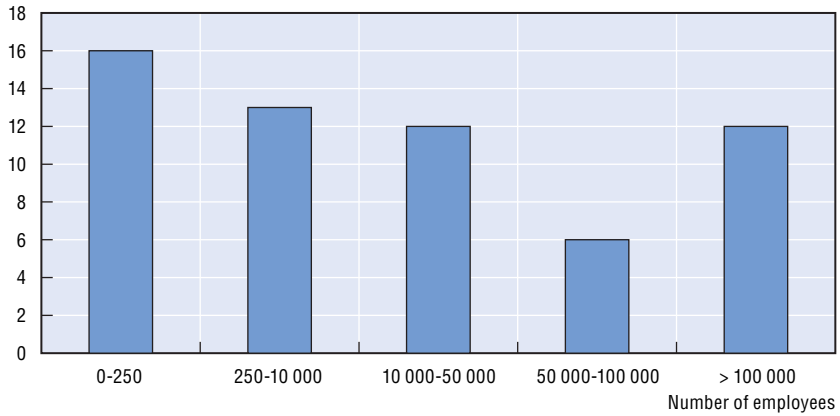
Figure 3.1. **Number of company case studies, by industry**



Source: OECD case studies.

Larger firms are over-represented in the case studies (Figure 3.2). Only 16 can be considered SMEs, *i.e.* companies with fewer than 250 employees. Within the group of larger firms, 13 have between 250 and 10 000 employees, 12 have between 10 000 and 50 000 employees, six have more than 50 000 employees and 12 very large companies report more than 100 000 employees.

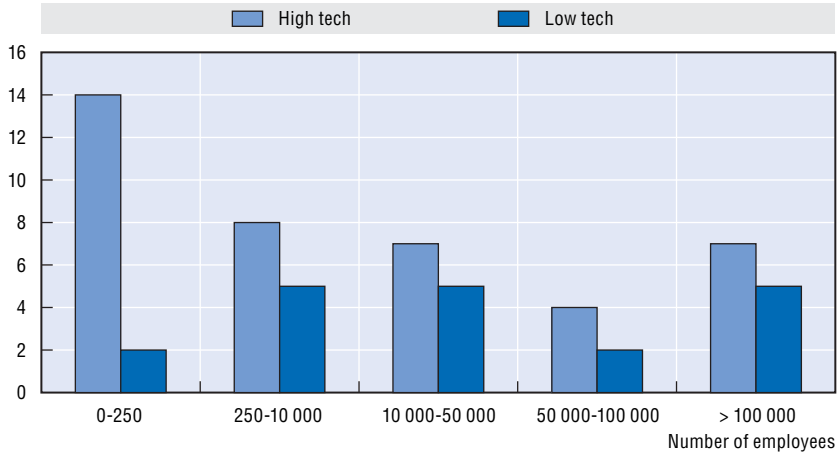
Figure 3.2. **Number of company case studies, by employment**



Source: OECD case studies.

Numbers of employees are used to show the diversity of firms covered by the case studies. Most SMEs in the sample are in high-technology industries (Figure 3.3). There are also somewhat more large companies in high-technology industries (the overall sample had more case studies in high-technology than in low-technology industries). Companies in the services sector tend to be smaller; There is no service company with more than 100 000 employees, while there are 12 manufacturing firms (Figure 3.4).

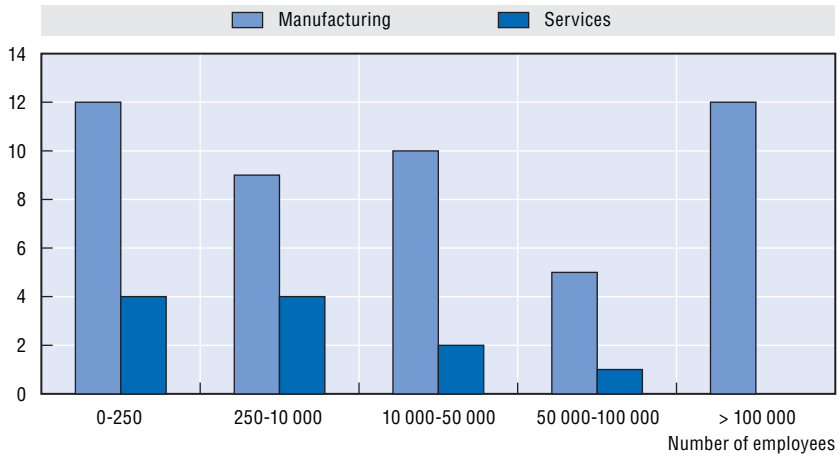
Figure 3.3. **Number of company case studies, by industry and employment**



Source: OECD case studies.

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Figure 3.4. **Number of company case studies, manufacturing and services, by employment**



Source: OECD case studies.

Quantitative findings on the globalisation of innovation

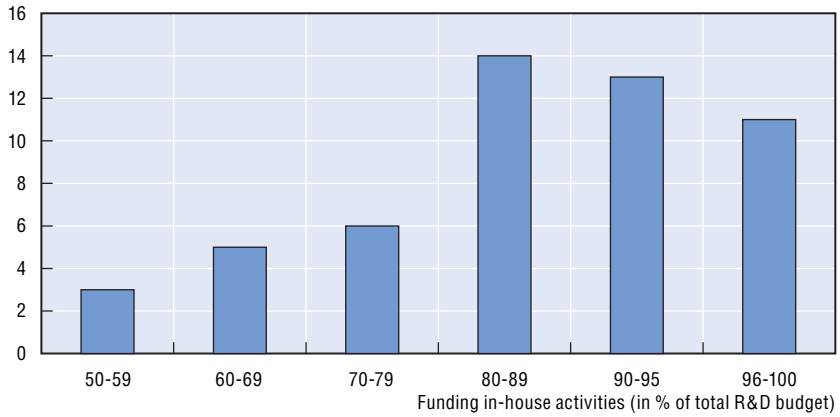
In order to structure the interview process, a standardised questionnaire was designed to collect information from innovative companies in the various countries. The quantitative part of the questionnaire focused on the globalisation of innovation, *i.e.* how companies reacted to the ongoing globalisation process, and the information presented here is based on the case studies. Some of the graphs are based on fewer case studies owing to missing values.

Basic information on innovation and R&D

The case study material shows that 67% of the companies reported R&D expenditures of between 1 and 10% of sales, while 18% of the companies reported 20% or more. The percentage remained quite stable over a five-year period, with half of the companies reporting no change, while the other half reported minor changes of 1 to 10%.

Almost three-quarters of the companies indicated that 80% or more of their R&D budget is spent on in-house R&D (Figure 3.5). Nevertheless, most are actively involved in open innovation practices: 51% of the companies allocate from 0 to 5% of their R&D budgets to research in other companies, while 31% allocate more than 10%. They fund less research in public research organisations (Figure 3.6). These percentages also remained relatively constant over a five-year period. Best practices in open innovation are therefore likely to have been in place during the last five years since their implementation typically takes some time.

Figure 3.5. **Importance of in-house innovation activities**



Source: OECD case studies.

In terms of the output of companies' innovation activities, 33% introduced one to ten new products or services on the market during the previous five years. Almost 55% introduced from ten to 30, and only 15% introduced more than 30. In almost 50% of the companies, sales of new products or services only represented up to 20% of total sales. However, four companies reported that more than 80% of total sales was due to new products and services.

Activities other than R&D found to be very important are research on market trends and co-ordination with customers (Figure 3.7). Other activities include working with third parties, development of new business, as well as production, manufacturing, sale and procurement.

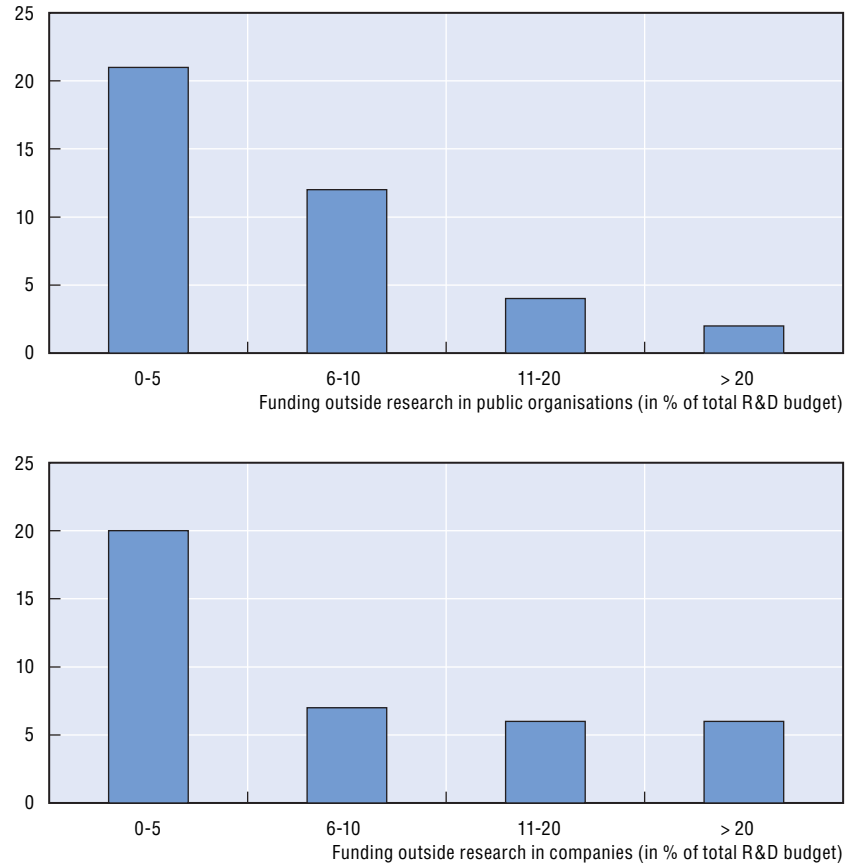
Changing business strategies owing to globalisation

When asked to select the three most important aspects of globalisation for their company during the last five to ten years, most companies mentioned possibilities for exporting existing products to new countries/markets (Figure 3.8). Other important aspects cited were the need to introduce new products or services immediately at global scale and investing in new manufacturing facilities abroad in order to adjust products to local needs. Relocating R&D facilities to countries with relatively low wages was less important. These results concur with the findings that companies base their decisions to locate R&D on market potential and quality of R&D staff rather than on the lower costs of R&D staff in developing countries (Thursby and Thursby, 2006) (see also OECD, 2008).

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Figure 3.6. **Importance of research in public research organisations and companies**

Number of companies



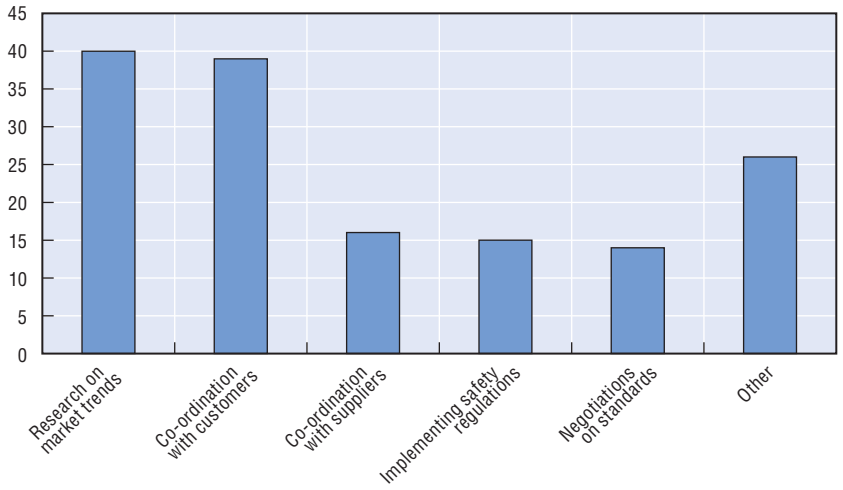
Source: OECD case studies.

Companies pointed to the globalisation of R&D units, and the exploitation of public research results as the most important changes in their business strategy. Foreign lead users and suppliers for new product development proved to be of minor importance.

Globalisation of R&D

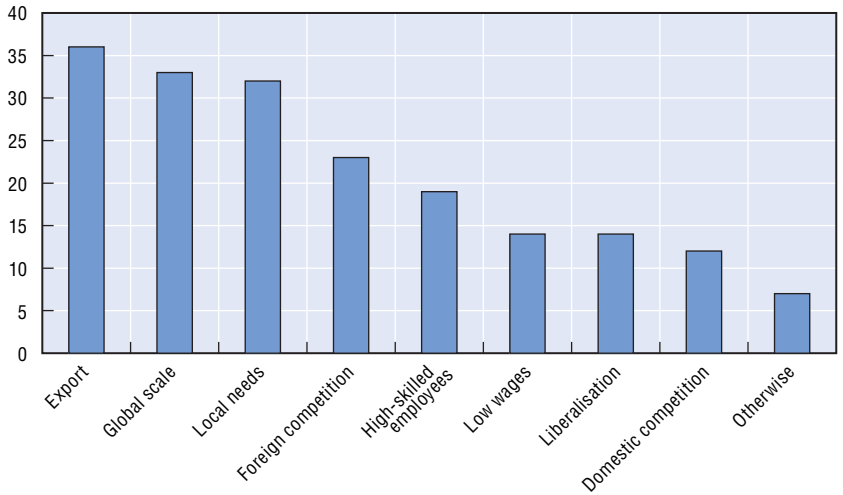
In analysing the geographic dispersion of R&D activities, 74% of the companies indicated having R&D facilities in one to ten countries; the most global company had R&D facilities in 26 countries. There was a clear difference between European and Japanese companies for the location of R&D abroad: European companies located most of their R&D facilities in Europe or in the United States

Figure 3.7. **Activities other than R&D that are important in innovation**
Number of companies



Source: OECD case studies.

Figure 3.8. **Importance of different aspects of globalisation**
Number of companies

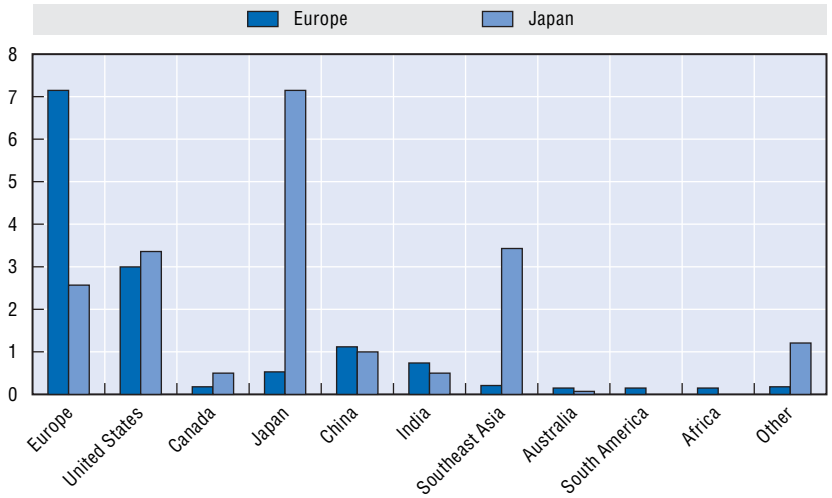


Source: OECD case studies.

(Figure 3.9). More than 70% of their total R&D investment still took place within the European Union, but China and India have become more prominent. Japanese companies have located their R&D facilities mainly in south-east Asia,

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Figure 3.9. **Location of R&D facilities**
Scale from 1 (less attractive) to 10 (very attractive)



Source: OECD case studies.

although the United States and Europe are becoming more popular. Very few companies have R&D facilities in South America, Africa or Australia.

These results are largely in accordance with the 2005 EU survey on R&D investments and business trends in ten sectors which looked at the location of R&D facilities (in the survey all companies are based in the EU). It was reported that:

> "Germany, the United Kingdom and France form a group of the three most favoured countries, followed by the Netherlands, Italy and Sweden. In more than 60% of the cases, the firms stated their home country as one of the three most attractive locations. Underlying reasons for the preference of the home country may be geographic proximity to other company sites or familiarity with the national socioeconomic environment. When eliminating the home base as a possible choice, the new member states of the EU gain over-proportionally in weight but do not enter the top five. It seems that, while companies prefer to choose an R&D location within their country, this location is then subject to the same R&D strategy as any other company site outside the home country. By sector, the figure reveals that many countries are strong in all sectors. Often, the preferred choice is a country with sector-specific clusters such as Germany and France for automobiles and parts. Electronics and electrical equipment prefer the United Kingdom and Sweden. Engineering and machinery is relatively well distributed over all

countries. However, it should be re-emphasised that the statements are related to the home country in the majority of the cases. Regarding the preferred location outside the EU, a group of three countries can be distinguished. The United States, China and India had the highest popularity index. For the United States, drivers of R&D investment are mostly a combination of technology clusters/academic institutes and markets/customers. For China, the main drivers are markets/customers and a low-cost skill base. The latter is also a main driver in India, together with the qualification of workers."

In general, companies are found to have three types of R&D facilities: local development centres, global research labs or global development centres (Sachwald, 2007). Close to 60% of companies had local development centres. Local development centres traditionally support production at the home base. Some 20% of companies had global research labs that extend the home-base R&D units and contribute to the global innovation process of multinationals by generating applications for different countries. They may be organised as part of a global network of laboratories, in which the core R&D unit in the country of origin has a less central role, or be a small specialised laboratory with a very specific research area in relation with a local university. Some companies have set up global development centres (21%). These are in charge of R&D tasks that can be separated and plugged back into the MNE's innovation process; these include back-office tasks, such as specific studies, tests or software writing.

The main reason to locate research and/or development facilities abroad is the proximity of large and growing markets. Other important factors are the availability of engineers and researchers and proximity to other activities of the company (production, sales). Factors such as proximity to suppliers, low labour costs for researchers, the low degree of regulation of product markets or the presence of lead users were viewed as unimportant. Figure 3.10 shows the number of companies stating that a particular reason was critically important for them. The 2005 EU Survey found very similar results:

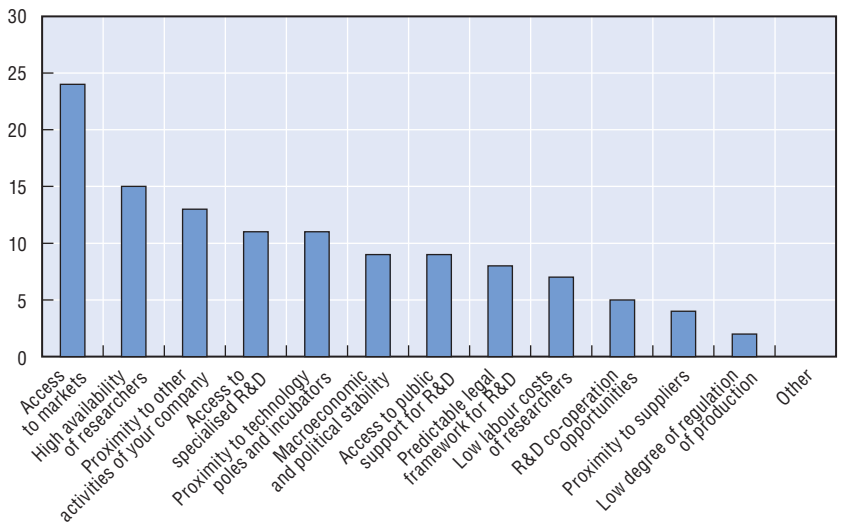
"The respondents made statements about twelve factors for locating or increasing some of the company's R&D investment in a country other than its home country. The answers can be split into three groups. The first group consists of market access as the most important factor with more than two-thirds of the respondents rating it very or crucially important in all sectors. The second group contains seven other factors which have some importance[2] for the choice of the R&D investment location: high availability of researchers, access to specialised R&D knowledge and results, macroeconomic and political stability, R&D co-operation opportunities, proximity to other company activities, a predictable legal framework for R&D and proximity to technology poles and incubators. The factors in the

third group have less importance:[3] low labour costs of researchers, public procurement for innovative products, proximity to suppliers and a low degree of regulation of the company's product markets. It stands out that the often mentioned labour costs of researchers seem to be less significant compared to many other factors. A sector-by-sector analysis shows that market access as a location factor for R&D investment is less important for IT hardware than for the other sectors. A high availability of researchers and access to specialised R&D knowledge and results are very or crucially important for more than two-thirds of the respondents in IT hardware as well as pharmaceuticals and biotechnology, which suggests that these sectors are hungry for knowledge."

The main barrier to internationalisation of R&D was the risk of leakages of information and proprietary knowledge. Other factors inhibiting international R&D were the need for close supervision and control of R&D, and higher co-ordination and communication costs (Doz *et al.*, 2001).

Figure 3.10. **Critically important reasons for the location of R&D facilities**

Number of companies



Source: OECD case studies.

Qualitative findings: open innovation on a global scale

The second, more qualitative part of the questionnaire focused on open innovation as a strategic reaction to the ongoing globalisation process. It

concentrated on certain topics in order to structure the subsequent interviews. The questions under each topic were indicative and were intended to facilitate discussion. In some countries, the qualitative part of the questionnaire was supplemented by in-depth case studies. This section brings out the main findings on these topics.

The use of external sources of innovation

The major motivation for engaging with external sources of innovation was to speed up innovation by tapping into knowledge from research institutes, companies and adjacent markets. When companies look for external sources of innovation, they tend to focus on specific technologies or products, rather than to seek to collaborate with specific companies. Other motivations were to find ideas for new projects, to attract and retain talent and to increase external funding of ideas and technology development.

External sources of innovation also present some pitfalls. Companies pay particular attention to the fact that partners' expectations, time schedules and interests in the project need to be aligned. The drivers and rewards need to be the same for all in order to achieve a fruitful, long-term collaboration.

Both MNEs and SMEs use external sources of innovation. MNEs in particular implement open innovation on two levels. First, they co-operate closely with external partners. Customers were found to be important determinants of the innovation process, especially for radical innovations. Second, they view open innovation as openness between business units *e.g.* mechanisms that make it possible for each unit to draw on knowledge available in other units. In order to establish this kind of openness, strong person-based networks and intranet sites for connecting people from different departments within the company are essential.

For SMEs, open innovation has a slightly different meaning as the type of external information mainly concerns market developments, new trends and customer requirements, in addition to scientific and technological information (new developments or techniques in relation to the technologies underlying the applications that the company develops). Lead users are an important source of information, as their needs often signal future market developments and changes in technologies and know-how.

Open innovation is reported to involve close interaction among people and to create an ecosystem within and beyond the company's boundaries. This is true of the SMEs studied and may be related to the fact that most are active in higher-technology industries. An SME's networks are often very valuable and when the SME is acquired by another company, it is crucial to

Box 3.1. **Saint-Gobain**

Saint-Gobain reaches out internally by creating multi-sector/multi-centre programmes on technological topics of strategic interest that are shared by its different businesses. The objectives are to leverage cross-disciplinary expertise and to identify and satisfy common needs such as upstream competencies (academia, consultants) and downstream competencies (market knowledge, contacts). Saint-Gobain has set up several horizontal R&D centres *e.g.* in Northboro (United States), Aubervilliers (France), Cavaillon (France), and Shanghai (China) which are in charge of developing the company's key competencies. These R&D centres possess the critical mass necessary to carry out breakthrough projects; they also act as hubs for academic contacts and are attractive to talented young scientists. These programmes help Saint-Gobain to reach out externally by developing partnerships.

Saint-Gobain has also developed a techno-marketing team, an external venturing team and the Saint-Gobain University Network (SUN). The role of the techno-marketing team is to identify new applications for existing technologies, to assess emerging markets and technologies, and to propose new approaches for new/existing markets. The external venturing team combines ideas from innovative start-ups with the industrial strength and assets of Saint-Gobain. The Saint-Gobain University Network develops long-term interactions with the best research teams in their domains to keep an eye on technological developments. It also helps in hiring students from top universities in countries of strategic importance for Saint-Gobain.

integrate these networks. However, some of these partnerships may end if the knowledge is already available in the acquiring company. The acquiring company has advantages if it has internalised the open innovation model, since this makes it easier to manage IP. The management of IP in a true open innovation model (*i.e.* with external partners) is more difficult since it requires managing the IP interests of different partners, with different cultures and processes.

MNEs actively create ecosystems, as illustrated by the high-technology campuses and networks set up by some of the companies studied. The objective is to generate opportunities for co-operation and joint ventures, create valuable partnerships and turn ideas into business ventures. In most cases, one large company is the main investor, as this maximises the company's support and allows its researchers to be actively engaged in the

Box 3.2. **Quilts of Denmark**

Quilts of Denmark collaborated with NASA in order to optimise in-house innovation that was not entirely successful. The quilts made by Quilts of Denmark are based on knowledge provided by sleep researchers who tell Quilts of Denmark about the real needs for quilts, *e.g.* temperature regulation in relation to insomnia. Quilts of Denmark worked on a technology for regulating the temperature in quilts but it was not completely successful.

Quilts of Denmark then learned in a scientific journal that NASA had solved this problem and invented a technology called TempraKON®. NASA sells rights to some technologies that can be used for peaceful purposes. NASA receives public funding for research, but in return the technologies must be used to improve the quality of life on earth. The company Outlast had bought the rights to this technology for use in materials for house insulation. Quilts of Denmark contacted Outlast and they agreed on a joint development. Basically Outlast kept the rights for insulation materials and Quilts of Denmark received the rights for down quilts and pillows. However, NASA's technology could not be transferred directly to the company's quilts, since quilts are soft and the technology invented by NASA was very stiff. The technology was modified in a lengthy development project with Outlast. A producer of winter jackets now has a licence to use the technology owned by Quilts of Denmark.

high-technology campuses and networks. This may lead to interesting spillover effects between this company and the other companies present at the campus.

In creating an ecosystem, the company's focus is mostly not geographical but technological. However, most companies indicate that geographical proximity creates fewer problems of confidentiality. Some ecosystems are therefore local, while others have a more global focus.

External sources of innovation are used by MNEs at the corporate level and at the business unit level. Several companies have set up units to look for and identify external sources of innovation: to find interesting research at universities and other research institutes (focus on science); to seek partners (focus on potential opportunities); and to identify key technology trends and new business development. At the business unit level, companies set up business development departments for each unit, mainly with a market-oriented focus *e.g.* co-marketing or co-manufacturing.

Box 3.3. **Philips: High-technology Campus Eindhoven**

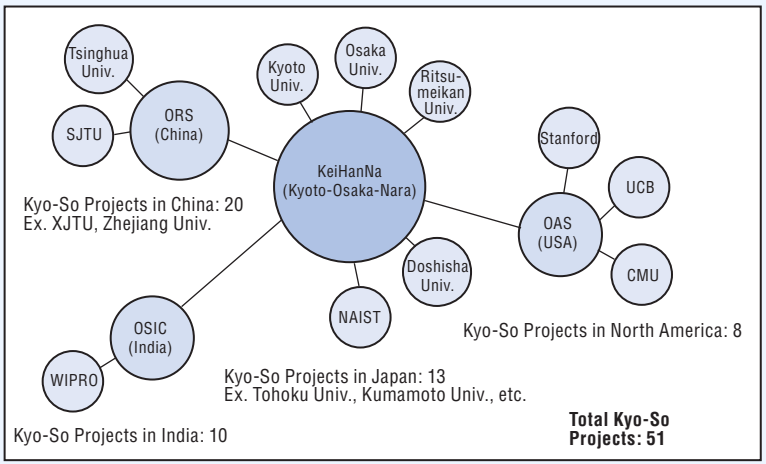
The High-technology Campus Eindhoven is a technology centre which houses thousands of engineers and advanced facilities. It focuses on crucial technological areas such as microsystems, infotainment, high-technology systems, embedded systems, life technology and nanotechnology. With "Open Innovation" as its motto, technological breakthroughs are facilitated by the emphasis on sharing equipment, services and knowledge. Technologically advanced companies, including Philips Research, IBM, Atos Origin, FluXXion, ASML, Cytocentrics, Philips Semiconductors, Handshake Solutions, and Dalsa, are already in residence. Others are nearby, such as FEI Company and TNO Industrial Technology, as is the renowned TU Eindhoven, one of Europe's leading universities in science, engineering and technology. The campus is a dynamic environment which is attracting new high-technology companies and research groups. It is a place where industry and research institutes/ universities meet to work on the future.

The Holst Centre is one of the initiatives located at the campus. It aims to be an internationally recognised and leading R&D centre in the fields of wireless autonomous transducer solutions and system-in-foil, with strong industrial participation (see also Box 4.3). The planned structure of the centre is an open one: other participants will be sought out and welcomed in a healthy balance between industry and knowledge institutions. The available research infrastructure at the campus (*i.e.* MiPlaza cleanrooms and associated facilities) is very attractive for the programme lines envisaged by the Holst Centre, which will work intensively with innovative SMEs.

External sources of innovation also differ depending on whether they are for research or for development. At the research level, companies build privileged relations with certain universities; at the development level, they build research platforms around certain technologies and group actors such as clients, suppliers and industrial partners. In some companies, each R&D centre has a university relationship. The idea is that proximity and close relations between individuals in the university and in the company lead to better results owing to similarities of language and culture. For example, in France several *pôles de compétitivité* have been created in which large companies and several research institutes work together. The sample of case studies also includes companies that have built reality centres to test their applications, *e.g.* Air Liquide.

Box 3.4. **Omron: Kyo-So**

Omron has organised its global R&D in Kyo-So (collaborative innovation) networks in Japan, China, India and the United States using its local subsidiaries as a hub. Most human resources are employed locally. The Kyo-So area is an innovation-incubating area located next to Omron's research laboratories. The partners for collaboration from outside (including from abroad) are invited to have their own pilot offices in the Kyo-So area. This facilitates an open and creative atmosphere. Special promenades are installed in the office building as cross-over/encounter/fusion zones to allow people with various functions to meet.



Some companies use IT tools, such as innovation portals or online technology intermediaries, to enhance the use of external sources of innovation. Others have developed an open source model to connect to user communities so as to tap into users' knowledge and get feedback from them. User communities help to develop the software, which is thus developed better and faster.

Companies' may engage in strategic partnerships, frequent non-strategic partnerships, and *ad hoc* partnerships. Criteria used to assess the value of partnerships are complementary skills and reputation. Other companies organise days with universities to present their competencies and long-term strategies. This helps to create valuable partnerships with universities. Most companies in the case studies collaborate with universities on particular projects.

Box 3.5. **UBS: Looking for new partners**

In engaging in open innovation practices, UBS found that too many new ideas were created internally or by consultants who were too close to the industry's existing practices. Therefore, new concepts were created:

- 13 "extreme" customers were interviewed to identify lead customer needs.
- Other customers were invited to "brown bag" lunches and UBS management meetings to share their views.
- "Best practice client-centric" service organisations were analysed for approaches and implementation, including Starbucks, Ritz Carlton, Singapore Airlines and Disneyland.
- Teams of the internal "talent development programme" analysed topics such as "client experience in other industries" and "exchange platform for innovations".

Box 3.6. **PERA: Innovation portals**

PERA is an international network of technology development and industry support centres that helps companies to develop innovative new products, improve business performance and enhance management and leadership skills. It helps its clients to become truly innovative through its ability to add value to all disciplines across the business cycle and uses it international presence to source best practice technological and business solutions across the globe. It has created a unique international infrastructure which acts as a gateway to knowledge, opportunities and partnering. It has made world-class innovation affordable for over 1 200 companies in the last five years and brought new business opportunities to thousands of companies. It has a network of over 30 offices and partners across Europe, the United States and Asia-Pacific and has created an independent pan-European association for supporting innovation – iNet – an innovation solutions network with 25 000 scientists and technologists.

Alternative ways of generating revenue with in-house innovations/ external innovations

Companies increasingly seek alternative ways to generate additional revenue from in-house innovations if the technology has future potential but is not part of their core strategy. If the technology is perceived as having only

Box 3.7. **P&G: Connect + Develop**

A well-known example of the use of external sources of innovation is P&G's Connect + Develop model. In using external sources of innovation, P&G seeks ideas that already have some degree of success in areas specified by the company. To focus its search, P&G limits itself to the following: *i)* top ten consumer needs: each business division has such a list and there is also a list for the company as a whole; *ii)* adjacencies: products or concepts that help P&G leverage its existing brand equity; *iii)* technology game boards: this is a tool that maps the evolution of different technologies and how these developments affect products in other categories.

In order to make the Connect + Develop model work, P&G needs effective networks. The company taps into closed proprietary networks and open networks of individuals and organisations available to any company. The two largest proprietary networks are "technology entrepreneurs" and suppliers. The former is a network of 70 senior P&G people who aggressively scan the market for opportunities. They map consumer needs and create so-called adjacencies maps and technology game boards. It is their task to scan the scientific literature, patent databases, local stores, etc. P&G also closely collaborates with its suppliers and has created a secure IT platform that allows P&G to post technical problems and suppliers to propose a solution.

Next to these proprietary networks, P&G also disposes of a number of open networks:

- NineSigma: a technology intermediary that helps companies solves their science and technology problems. Companies such as P&G can post their technology problem on line. If a company or research institute is able to solve the problem, NineSigma connects the parties.
- Innocentive: this technology intermediary works like NineSigma, but offers solutions to more narrowly defined problems.
- YourEncore: a network of 800 retired scientists and engineers that makes their knowledge and experience available to others.
- Yet2.com: an online market place for IP exchange.

limited potential, the technology/idea is often abandoned. In order to decide to start and finance a new business development or internal corporate venture project, companies first analyse the core business activity involved to identify the innovative potential, to determine how sustainable it will be in the market,

the level of existing competition, etc. They then consider their complementarity with the company's existing activities: the potential economies of scale and scope, innovation potential through collaboration, exploitation of common resources, etc.

Spin-off companies are increasingly used as a way to externalise projects; the timing depends on the preferences and understanding of markets. If these appear insufficient, the spin-off may not be launched until relatively mature; however, if market-pull forces are important, the spin-off may occur rapidly because of the chances of raising external capital appear good. In creating spin-off companies, one company reported paying particular attention to the possibility of raising external capital in order to diminish the costs and risks of spinning off. Spinning-off processes are mostly supported by internal management skills and may be accompanied by venture capital financing. Some companies explicitly encourage employees to start ventures from promising research projects and technologies that are not directly suitable for core businesses.

Some case study companies have set up a corporate venture capital fund to develop new projects or companies based on ideas originating within the company; these corporate venture capital groups are often subsidiaries with a legal status. The company's main tasks are the financing of the venture and the development of managerial competencies to guide spin-offs within the company. After spinning off, the parent company usually enters the ownership structure of the spin-off, with the intention to gradually reduce its stake through a sale or initial public offering. Other companies use corporate venture capital funds to access competencies they lack.

Box 3.8. **Aker: spinning off**

Aker ASA is an active industrial company in the Norwegian petro-maritime technology cluster. Its core activities span a wide range, from fisheries (Aker Seafoods) through shipbuilding (Aker Philadelphia Shipyard in the United States) and into advanced offshore engineering and processing (Aker Kvaerner). During the past few years, Aker has developed and spun off a range of new companies such as Aker BioMarine, Aker Floating Production, Aker Oilfield Services and most recently Aker Exploration. Aker Clean Carbon was launched early in 2007 and is still wholly owned by Aker. The predominant strategy is to retain a controlling share in the spin-off companies, while using capital markets to fund and distribute the risk (Herstad, 2007).

Box 3.8. **Aker: spinning off** *(cont.)*

Aker plays a key role as a "gravitation point" in Norwegian industry and has credibility and a good track record in what is a small and highly specialised financial community. The establishment of Aker BioMarine to commercialise dietary supplements and pharmaceuticals based on certain marine fatty acids show that its gravitational pull extends beyond petro-maritime financial networks to include marine and biotechnology research and NGOs concerned with securing sustainable fisheries These external communities voluntarily contacted Aker in the wake of the announcement of the BioMarine venture. Aker BioMarine existed for almost ten years as a project internal to Aker ASA and was based on the merger between a novel technology developed in house for harvesting Antarctic shrimp "krill" and the in-house competencies necessary for immediate on-board processing of the catch. (The high quality fatty acids are destroyed within 30 minutes after the "krill" is dead, so that it must be caught and brought on board alive and processed immediately.) The company was established as a formal entity owing to the need to access complementary competencies and capital. A biotechnology actor was acquired and merged into BioMarine to provide competencies on lipid-based dietary supplements, food and feed additives. Superba™ is Aker BioMarine's name for krill oil products for the human market, and Qrill™ is the brand name for its krill meal and krill oil products for aquaculture and animal feed markets.

Other possibilities for generating revenue include postings on websites of technological brokers such as Yet2.com. These brokers bring buyers and sellers of technologies together to maximise the return on their investments. Yet2.com's principal services are to help their clients realise a return on their IP investments or to acquire IP and access technology solutions. ODIS (On Demand Innovation Services) is yet another way to generate revenues from in-house and external innovation.

Assessing the value of "external" projects or companies

In order to assess the value of external projects, companies in the case studies have developed assessment units with different objectives:

- Business development groups to screen the market.
- Financing funds, *e.g.* venture capital initiatives and corporate venture capital funds.

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Box 3.9. **ODIS and Thinkplace**

With ODIS (On Demand Innovation Services) IBM has created teams of researchers and consultants to explore cutting-edge ways to increase competitive advantage and business value and provide solutions, strategies and processes for business transformation. The primary capabilities of ODIS come from the expertise and knowledge of IBM Research's industry-leading scientists and engineers combined with IBM's world-class consultant teams. To better match those capabilities with clients' needs, solutions have been organised into cross-industry interest areas. ODIS mixes research and consulting competencies, and sells innovation projects and patents to customers.

"Thinkplace" is an intranet site to which all IBM employees have access and can submit proposals for new products and processes. People can be catalysts and rate the incoming proposals in their area (as on YouTube). The product or process may then move on to the next level, and managers can sponsor an idea and take ownership of it. A team can be formed, typically of three or four people from all over the world with the right competencies. One day a week might be allocated to working on and developing this technology or business model.

- Emerging business opportunities units to identify potential business growth areas.
- Business group for scouting.
- Research centres in which other firms are invited to co-operate.

The main difficulties associated with assessing the value of external projects is that once an interesting opportunity has been identified, it is often difficult to acquire it and integrate it into the company culture. IPR and contract conditions are also reported to cause difficulties.

Several companies have created a corporate venturing programme to invest in start-ups to keep an eye on potential opportunities. The success of corporate venturing depends on the strategic fit between the (mother) company and the start-up and is often based on mutual trust. This is not without problems, however, since employees' expertise is often needed to detect useful applications of the technology developed in the start-up. Additionally, the venturing unit needs to convince other stakeholders of the added value the investment brings to the firm's portfolio.

Spinning-in activities are generally motivated by a strategic reorientation of the company towards key (technological) competencies. The spin-ins typically possess competencies that are lacking in the company. The reason for internal venture capital units to spin in companies seems to be primarily

Box 3.10. **Nestlé's venture capital fund**

Nestlé has set up a venture capital initiative for medium-term developments. The objectives are to provide Nestlé with better access to new science, technology and know-how, through acquisitions, minority stakes, licensing and joint ventures. The fund looks especially at life sciences (food and nutrition in general, health-enhancing food, agricultural biotechnology), as well as at commercial applications, such as management of consumer relations, food processing and packaging technologies. A venture board, with the head of Nestlé Nutrition as president and the Chief Technology Officer as vice-president, co-ordinates all new investments. EUR 880 million are committed for such investments; a portion has been invested in approximately 70 companies to date and investments have only been made in areas not yet covered by Nestlé units. These investments are usually based on minority stakes with rights to use results and managed on an "arm's length" basis.

technological rather than financial, with a focus on the potential market success of innovations. Most companies in the case studies are aware that the entrepreneurial structure or spirit of the spin-in can be endangered by full organisational integration. Hence, depending on the individual case, loose structural solutions may be favoured.

Box 3.11. **Novartis Venture Fund**

The Novartis Venture Fund has established itself as an "evergreen fund" with a balanced portfolio ranging from early start-ups to fully operational companies ready to go public. The Novartis Venture Fund is committed to investing in companies that develop innovative life science concepts for the benefit of patients. Since its inception, it has supported 137 businesses of which 92 are equity companies. Companies helped by this fund plan to bring new medicines to patients and because of the improving economic conditions in 2005 six of these companies went public, thereby providing substantial returns for the fund. One of these success stories is Sirtris. In May 2007, Sirtris Pharmaceuticals, Inc., made a public offering and was listed on the American NASDAQ. Sirtris focuses on discovering and developing small molecule drugs to treat diseases associated with ageing, including metabolic diseases such as Type 2 diabetes. The purpose of the fund is to stimulate outstanding innovation. In addition to funding, Novartis also provides advice and strategic input to the companies. As the companies grow, they often develop collaborations and business deals with Novartis; this further enhances the potential for discovering novel therapies. In 2007, a total investment of CHF 68 million was made.

Box 3.12. **VCI: spinning in**

VCI (Velti Centre for Innovation) is one of the most important business initiatives of Velti. It is partly funded by the General Secretariat for Research and Technology under the "ELEFTHO" programme which aims to promote innovation and the introduction of new technologies in the Greek market. VCI's main objective is to finance and support new business ventures that operate mainly in the information, telecommunications, new media and services sectors. The incubated companies are hosted in VCI's state-of-the-art facilities and have the opportunity to take advantage of VCI's technology infrastructure, its professional staff, consultants as well as Velti's large network of investors, in order to establish and promote their innovative business idea. Services offered by VCI to the incubators include:

- Strategic guidance and network access.
- Sales and business development services.
- Legal and financial services.
- Marketing, public relations and human resources services.
- Accounting services.
- Information technology and telecommunication support.
- Software development, quality control and project management services.

All companies incubated in VCI can benefit from Velti's network of professionals and their work experience in Greece and abroad.

Companies may also use joint ventures and other forms of collaboration agreements to explore new technology domains as an alternative to spinning in. Alliances with strong partners (in technologies that may or may not be new to the company) may be an important source of information. A specific mode of collaboration applied by some companies in the case studies is open source software, which allows sharing and benefiting from software code developed by others. In some cases, commercial companies are able to develop proprietary products that are based on and complementary to open source products. Linux is the best known example of open source and has been a major competitor to proprietary products for a long period.

Examples of ways to assess the value of external projects or companies include Innovation Jam, Second Life, a virtual place to facilitate open innovation where everyone can comment, or so-called "open rooms" where people meet to exchange ideas and insights.

Box 3.13. **Nokia: open source software**

Nokia has taken steps towards greater openness with its 770 Internet Tablet based on the Linux operating system. It is the first open source (OS), Linux-based consumer handheld from Nokia, and it allows everyone to share the code. This is Nokia's first major attempt to connect a commercial company and non-commercial communities via a handset. On the market, the product is situated between cellular phones and notebooks.

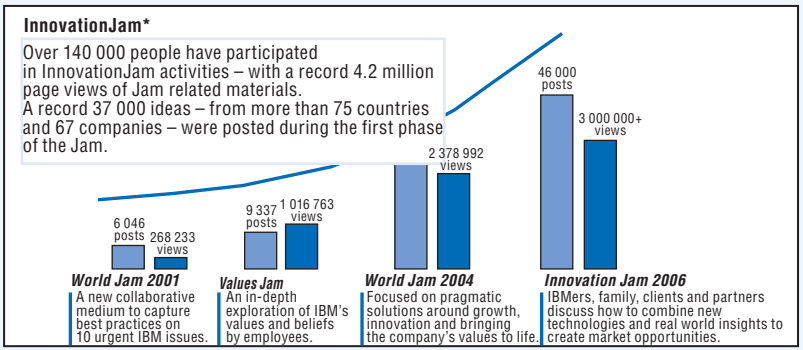
Historically, Nokia has relied on Symbian for the operating system for smartphones, and it has now used a Linux-based operating system for a browser-type device. Nokia has developed the company's main products (smartphones) in house using Symbian, because the market in smartphones is mature with strict operator and server requirements. The new Tablet is placed on new markets. By using Linux as an operating system, Nokia has chosen a flexible and mature technology that gives access to PC technologies, such as Internet Protocol. To speed the development of this open source product, Nokia published an open development platform, which is a Linux software toolset available to developers. The new development platform is targeted to open source developers and innovation houses to ensure the most effective development of a product and its applications. The idea is that developers have an opportunity to develop and share their own applications for Nokia 770 (enable application and technology development for the OS software and the commercial community). The company's goal is to work closely with technology experts and the OS community. These actions signal that Nokia is actively embracing the open source movement and the Linux operating system for future non-phone products. The 770 is not Nokia's first use of open source, but it had limited its open source efforts to its server-based networking products and internal development tools. In the handset market, this is its first major use of open source.

Human resource management

Most companies in the case studies believe that the creation of an open innovative culture is very important and that it should be present and operative at every level of the organisation; this means encouraging all employees to look for opportunities for improvement and innovation. It implies giving autonomy to employees and establishing a decentralised management structure that allows the different business units to preserve their own culture. Employees who are entrusted with more autonomy tend to become more involved. A culture of diversity is also beneficial as it leads to new views and insights. Several research departments in the case study

Box 3.14. **IBM: InnovationJam**

The largest on-line brainstorming session ever, InnovationJam 2006 brought together more than 140 000 people from 104 countries, including IBM employees, family members, universities, business partners and clients from 67 companies. Over two 72-hour sessions, participants posted more than 37 000 ideas as they explored IBM's most advanced research technologies and considered their application to real-world problems and emerging business opportunities. In July global issues were raised, such as environment, health care and traffic, and this started discussions that ran over 72 hours. People and software analysed the incoming data: What is the trend? What is especially discussed? What suggestions are made? In the second round in September ten areas were specified for identifying needs and interest. Then resources were allocated for related innovation processes with funding of approximately USD 100 million.



Source: IBM presentation.

companies employ researchers from over 20 countries to have a better view of the outside world. In addition, it allows for variety in the company's informal networks.

Trust, exchange of knowledge and clear communication are essential since innovation depends heavily on interaction among individuals: "We can accomplish everything if we are open, work as a team and share information." Companies profit from sharing knowledge, embracing ideas from outside and fighting the "not invented here" syndrome. Mobility (internal and external) of human resources is important since it increases knowledge development and exchange.

Box 3.15. **Credo of J&J**

"We are responsible to our employees, the men and women who work with us throughout the world.

Everyone must be considered as an individual.

We must respect their dignity and recognise their merit.

They must have a sense of security in their jobs.

Compensation must be fair and adequate, and working conditions clean, orderly and safe.

We must be mindful of ways to help our employees fulfil their family responsibilities.

Employees must feel free to make suggestions and complaints.

There must be equal opportunity for employment, development and advancement for those qualified.

We must provide competent management, and their actions must be just and ethical."

The creation of an innovative culture is often supported by a reward system that creates the right incentives. Few of the companies studied give financial rewards to employees who engage in open innovation practices. They are more likely to give appreciation awards to compensate extraordinary achievements, although in one case, engaging in open innovation was part of the bonus system applicable to all employees. In another case, rewards for team members in research and innovation projects are based on a specific model which includes, aside from salary and additional benefits, a stock option plan that provided researchers with the opportunity to share the risk and profits in new ventures.

To keep people motivated if new initiatives ultimately fail, some companies have a system that rewards employees for a decision to stop a particular project, which is justified by extensive documentation of the reasons so that the whole company can learn from the failure.

An important aspect of human resource management is the management of partners since the success of open innovation often depends on involving external partners in the company's innovation activities. The rewards for employees and for partners need some alignment if the collaboration is to be effective. It is important to screen potential partners' competencies and culture in view of what needs to be developed, including the alignment of mutual expectations.

Senior researchers may possess very valuable knowledge and excellent networks that may be partly lost when they move to management functions. Several companies noted difficulties in finding technical staff, which highlights the need to establish good career paths for technical staff. Companies often collaborate with universities for recruitment purposes, since university researchers often possess the expertise companies need and through collaboration they are already familiar with the company. Other companies keep more creative and complex R&D work nearer home to keep employees motivated, while outsourcing the more codified work to labs in Asia.

Intellectual property rights

Intellectual property rights have become vital in almost all industries and the number of non-disclosure agreements has grown exponentially since companies have started to engage in open innovation practices. Confidentiality and exclusivity agreements are central to partnerships: most companies sign a confidentiality agreement with partners so as to be able to work freely. Also brands, designs and models have received increasing attention.

Companies sometimes find it difficult to patent since filing a patent may allow competitors access to useful information about the new technology. They may therefore choose to maintain the secrecy of new technology in house. Patents play a key role in sectors such as pharmaceuticals, but may hinder innovation in sectors such as ICT. Some of the IT companies felt that patents hinder open innovation and particularly open source software developments. However, others are in favour of patents since they support their activities. Companies may also collaborate to create and/or exploit open standards.

Although patents are very important in the pharmaceuticals sector, most value is created at the end of the patent's lifetime. A typical pharmaceutical company applies for a patent when the potential of a drug has been established, so that the company faces huge development and testing costs to bring the drug to the market over a period of 10-15 years. Pharmaceutical companies have increasingly bought biotechnology SMEs specialised in drug discovery in recent years, as this reduces the development process and ensures a much longer period of patent protection.

Several companies from the case studies still mainly use IPR defensively, to protect the business and to prevent others from taking out a related patent. However, companies engaged in open innovation practices often organise licensing activities and strategic alliances as part of a proactive intellectual property strategy that aims at sharing technologies rather than keeping IP as a defence mechanism, *e.g.* IBM, Philips.

Box 3.16. **Alcatel-Lucent: open standards**

Alcatel-Lucent has set up a joint initiative about multimedia content delivery over DSL with Thomson multimedia. Both companies are global leaders in broadband access and entertainment and have demonstrated multimedia content delivery in the portable mobile space with a demonstration of streaming video content over a 3G cellular infrastructure. The novelty of this demonstration at the 3GSM World Congress was the use of a more efficient video compression format based on MPEG4-Part10, an open standard, which promises improved efficiency for bandwidth on cellular networks. Both companies consider that this breakthrough will unleash the potential of video delivery of entertainment over a broadband wireless network infrastructure. With their demonstration of an end-to-end delivery system, Thomson and Alcatel enable the mobile industry to deliver value-added services based on encoders and video servers from Nextream (a Thomson/Alcatel joint venture), with network infrastructure from Alcatel and end user equipment from Thomson. Both Thomson and Alcatel will be leveraging their mutual know-how in the delivery of multimedia entertainment content with differentiating features, including efficient power and bandwidth audio/video codec technology. Nextream will capitalise on vast experience in the area of digital video processing and delivery to serve this new market segment.

Box 3.17. **IBM: licensing out**

The US leader in patenting, IBM, received approximately USD 1.9 billion in royalty payments for its licensing in 2001; this represents roughly 30% of total profits. The value of licensing is even higher when cross-licensing is added. Given its licensing strategy, which includes aggressive patent licensing with increased royalties, manufacturing joint ventures, strategic joint development alliances and leverage and returns to technology, IBM also aims at leveraging its hardware and software brands in new commercial products developed by its partners.

IBM is making 500 of its software patents freely available to anyone working on open source projects, such as the popular Linux operating system, on which programmers collaborate and share code. The patents will be available to individuals as well as to small companies. IBM is hoping to begin a "patent commons", which it hopes other companies will join. The patents fall into 14 categories, including those for managing electronic commerce, storage, image processing, data handling and Internet communications. IBM will continue to hold the patents but has pledged not to seek royalties from or to place restrictions on companies, groups or individuals who use them in open source projects, as defined by the Open Source Initiative, a non-profit education and advocacy group.

IPR problems may arise in public-private partnerships because of the different objectives and characteristics of the partners, For example, companies experience difficulties when collaborating with universities, since university researchers tend to publish their technological findings, while companies usually prefer to protect their new knowledge (although universities have become more interested in patenting in recent years). Technology brokers seem to represent a very promising approach, but they have as yet no stable strategy.

Towards an integrated model of open innovation

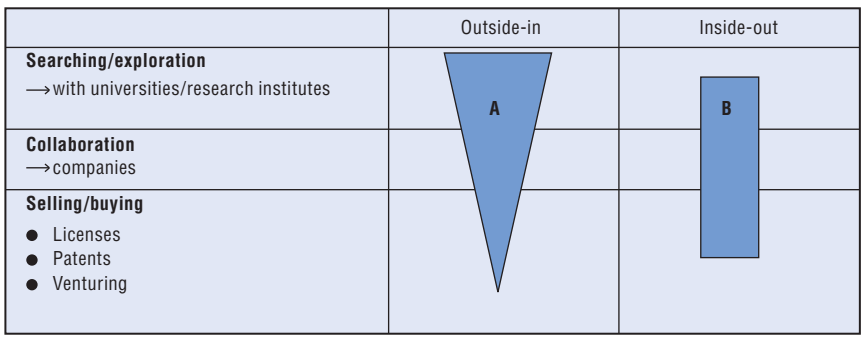
Exploration and exploitation phases in innovation

Based on insights gained from the case studies, Figure 3.11 proposes a tentative model of the dynamics of companies' innovation processes. It shows the outside-in and inside-out sides of open innovation in relation to the exploration and exploitation phases of innovation that are traditionally distinguished. Exploration in innovation involves experimenting with new alternatives while exploitation involves refining and extending existing knowledge (Beckman *et al.*, 2004).

In developing a technology, companies seem to distinguish three phases, the first of which concerns the search and exploration phase, during which companies look for new opportunities and new technologies with the potential to strengthen the company's core technology and products. Some may prove very valuable, while others may eventually be abandoned. Universities and research institutes are a valuable source in this phase, since they typically focus on research and technology that is ten to five years ahead of the market.

If the value of the technology or product becomes (more) apparent, companies tend to collaborate, mostly with other companies, to start to

Figure 3.11. **Open innovation: exploration and exploitation phases**



Source: OECD case studies.

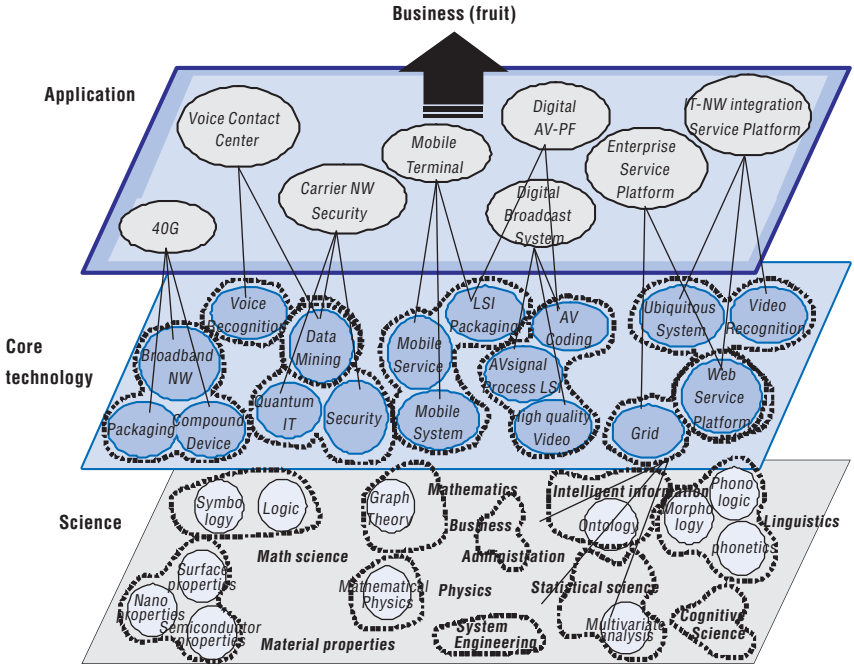
realise the commercial potential of the new technology or product. Collaboration can take place through partnerships, alliances, joint ventures, etc. Overall, the choice of mode of collaboration depends on the risk of losing control over the technology, the benefits of owning the technology or product, the implied resources, etc. In the collaboration phase, companies tend to shift from exploring technologies or products to exploiting them.

In a third phase, when the technology or product is approaching the commercialisation phase, companies need to decide if they want to commercialise the technology or product themselves or if they prefer to sell it. The sale can take several forms, *e.g.* sale to another company, sale of a licence to other companies, a spin-off, etc. To obtain complementary technologies may require buying and subsequently integrating a unit of another company that is working around the technology; it may mean buying an exclusive licence, taking a patent on the technology/product, etc. In the selling/buying phase, the company tries to exploit its technology or product commercially.

The companies covered by the case studies tend to use outside-in processes to strengthen the core technologies of the company and look for external opportunities that fit their business strategy. At NEC, open innovation for core technologies is clearly distinguished from open innovation practices for non-core technologies (Figure 3.12). Companies that engage in outside-in processes are very active in the search/exploration phase; they approach universities and research centres for interesting opportunities and screen the market for promising upcoming technologies or products. Once the value of a technology or product becomes apparent, most companies become less open and tend look for the most promising partnerships and focus on collaborating with these preferred partners. In the third phase, they become even less open as they work to achieve the competitive advantage associated with the new technology or product.

The case study companies use inside-out processes instead to search for new technologies and applications that are not part of the company's current portfolio. They use this process to look for new technologies and products with the potential to create new lines of business in new or adjacent markets. In the search/exploration phase, they seek out promising technologies or products, and in the collaboration phase they set up partnerships to explore the potential of these technologies or products. In contrast to the outside-in process, they do not become less open, since they generally do not possess all the required knowledge in house. In the selling/buying phase as well, they are likely to be quite open in order to gather all the expertise needed to bring the new technology or product to market and achieve a competitive advantage. If, for example, a company decides not to commercialise an in-house innovation itself, the inside-out process may begin by being very closed and become very

Figure 3.12. **Creating technology innovation within NEC**



Source: OECD case studies.

open in later stages. Compared to the outside-in process, the inside-out process will typically start later and end earlier.

Inside-out processes are also used to offer alternatives to researchers with an idea that does not fit the company's current strategy. In order to keep researchers motivated to look for alternative technologies, some companies have corporate venturing programmes to help these researchers create their own company and commercialise their ideas.

Most case study companies engage in outside-in processes; only a few engage in inside-out processes. The choice seems to depend on company size. Large companies are well placed to engage in outside-in processes to make collaboration agreements in order to speed up the development and commercialisation of new technologies by partnering with universities, research organisations, customers and suppliers. Few large companies engage in inside-out processes. SMEs tend to set up collaboration agreements with several actors in an attempt to speed up the development process by getting access to external knowledge. However, in general, SMEs have fewer possibilities to engage in open innovation practices owing to resource constraints.

Technological regimes and open innovation

The use of outside-in processes is also linked to companies' industry and technological environment. The literature on technological regimes (Nelson and Winter, 1982; Malerba and Orsenigo, 1993) argues that companies in an industry behave in similar ways, because they share sources of information and technology (suppliers, universities, other industries) and opportunities for innovation (Leiponen and Drejer, 2007). Their users are also likely to be the source of similar demand and ideas for innovation. Technological regimes are characterised by opportunity, appropriability and cumulativeness conditions and by the complexity of the knowledge base (Malerba and Orsenigo, 1993).

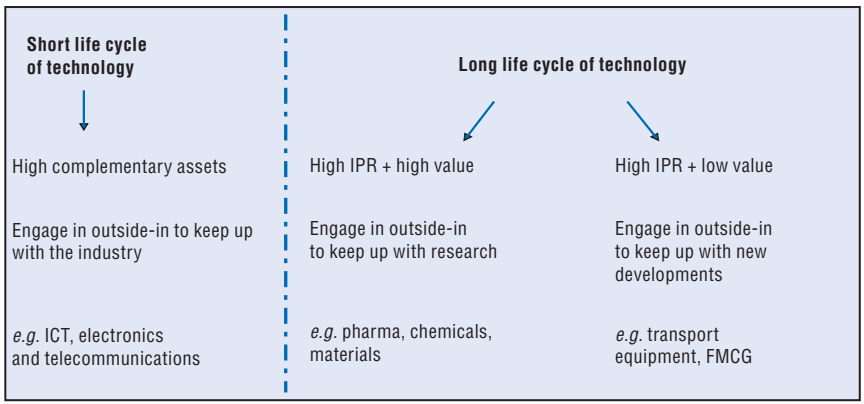
Opportunity conditions reflect the ease of innovating and depend among other things on the stage of the technology life cycle: introduction, growth or maturity (Abernathy and Utterback, 1978; Utterback, 1994). Initially, new technology makes slow progress because the technology is not well known and important bottlenecks must be overcome before it can be translated into practical and meaningful products. As work on the technology continues, the technology crosses a threshold and enters the growth stage, in which rapid progress leads to increases in sales of products based on the technology. Then, after a period of rapid improvement in performance, the technology reaches maturity and progress slows or reaches a ceiling (Utterback, 1994). Maturity occurs when there is less incentive for incumbent firms to innovate because of fears of obsolescence or cannibalisation from a rival platform (Sood and Tellis, 2005).

Appropriability conditions refer to the possibility of protecting innovations from imitation and of extracting profits from innovative activities. Companies use a variety of means to protect innovations, ranging from formal intellectual property rights such as patents, to informal mechanisms such as secrecy. If the level of appropriability is high, companies generally have time to develop their ideas and experiment to find dominant designs, while reaping the fruits of the technology's success. If not, the innovative firm must vertically integrate to build a complete solution or hope to create an enforceable contract with the suppliers of complementary products and capabilities needed to commercialise the innovation (Teece, 1986).

Cumulativeness of technological knowledge means that today's innovations form the basis and building blocks of tomorrow's innovations. Successful commercialisation of an innovation requires using it in conjunction with other capabilities or assets (Teece, 1986). Services such as marketing, manufacturing and after-sales support are almost always needed and are often obtained from specialised complementary assets.

Figure 3.13 combines the insights from the literature on technological regimes and the technology life cycle with the insights from the case studies.

Figure 3.13. **Open innovation and technological regimes**



Source: OECD case studies.

In industries characterised by rather short technology life cycles (*e.g.* ICT and electronics and telecommunications), complementary assets are increasingly important. The case study material indicates that companies in these industries engage in outside-in processes in order to keep up with new developments in and around their industry. The use of external sources of information allows them to be informed about changes within and outside the industry and to act rapidly so as not to lose their competitive advantage.

In industries characterised by longer technology life cycles, strong IPR protection may be of vital importance (*e.g.* some blockbusters in the pharmaceutical industry have reaped enormous profits). The case study material suggests a distinction between industries in which it is difficult to get around patents (strong IPR, high value) and industries in which patents are important but can be more easily circumvented (strong IPR, low value). Industries in the first category include pharmaceuticals, chemicals and materials. Companies in these industries mainly engage in outside-in processes to keep up with research and open innovation seems to be concentrated in the upstream search/exploration phase, with limited downstream collaboration in the selling/buying phase.

In the first phase of the technology life cycle, companies develop technologies that may become the next breakthrough and because these technologies are in or related to their core technology, companies prefer to develop them completely in house. However, if diverse technologies are involved (because of increasing multidisciplinarity) and if R&D expenditures are high, open innovation becomes a valuable way to get access to a broad range of technologies (Beije and Dittrich, 2008). In the pharmaceutical

industry, for example, very high R&D expenditures for developing new medicines stimulate companies to collaborate with universities, research centres and biotechnology start-ups.

In some industries, patents and IPR protection are important, but competitors may develop products that circumvent the patent. Typically, they find different manufacturing methods or modify (slightly) product characteristics. In the transport equipment industry and the fast moving consumer goods industry (FMCG), companies set up outside-in collaborations to keep up with new developments. They look for technologies or products that have proven their market potential which they can improve, scale up and commercialise. If the collaboration is successful, companies tend to buy the technology or product.

Notes

1. High-technology industries are defined as high- and medium-high-technology industries, ISIC Rev.3: 24,29-35; while low-technology industries are defined as medium-low and low-technology industries, ISIC Rev.3: 15-23,25-28,36-37).
2. Some importance means that the factor is very or crucially important for more than 40% but less than 60% of the respondents.
3. Less importance means that the factor is very or crucially important for more than 20% but less than 40% of the respondents.

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Chapter 4

Policy Implications

Chapter 4 discusses the policy implications of global and open innovation for national and regional innovation systems. The impact on different domains of innovation is discussed, with examples of how countries are responding to the changing innovation environment.

The goal of the third module in the globalisation and open innovation project is to draw out the implications for science, technology and innovation policies that arise from the case studies on open innovation as well as from the analysis of the main drivers behind globalisation and open innovation. This chapter therefore first presents some of the policy issues raised by globalisation and open innovation, discusses the policy implications of the case studies and empirical evidence on open innovation, and, on the basis of the existing evidence and information, reviews the main policy responses.

Policy issues related to globalisation and open innovation

Before discussing some of the potential policy implications of globalisation and open innovation, it is worth recalling some of the related policy concerns. While the phenomena of R&D internationalisation and open innovation are related and raise similar policy issues, the implications vary depending on the policy area and the level of government policy.

While OECD countries are still the most active investors in and performers of R&D, globalisation has reduced barriers to entry and created opportunities for new players in emerging economies – and also at home – to tap into global networks. The emergence of global players such as China and India as new markets but also as platforms for research and talent have raised concerns about the off-shoring of R&D and related high-skill jobs and/or erosion of existing national R&D infrastructure and capacity. For smaller and catching-up OECD economies, the emergence of global players increases competition for R&D-related foreign direct investment (FDI) and for research talent, making the catching-up process more difficult.[1]

The emergence of open innovation also raises policy issues. While open innovation is essentially business-driven, it has implications for science, technology and innovation policies. Insofar as open innovation is about "open" business models for innovation, countries' framework conditions (*i.e.* product and labour markets, IPR and competition policies, a strong public research base, etc.) are extremely important policy levers. At the same time, because open innovation involves going beyond firms' and nations' boundaries, it may create issues for government research and innovation policies. Most OECD countries' S&T policies are predominately national in

Box 4.1. **Policy lessons from the case studies on globalisation and open innovation**

The case studies on open innovation have provided a better understanding of the impact of globalisation and open innovation at the level of firms. This understanding is critical to improve the design of innovation policies and instruments. Among the policy-relevant findings that emerged are the following:

- ***The technology life cycle matters.*** The case studies on firms in a broad range of sectors and industries have shown that the incidence of open innovation is related not only to the size of the company but also to its position in the technology life cycle. When the technology is rather new and explorative, companies and other research organisations actively collaborate to find solutions in the market. This has implications for public research institutes.
- ***Open innovation requires a differentiated approach to knowledge sourcing and development.*** The emphasis on external co-operation and in-house knowledge diffusion varies. With regard to external linkages, the nature of knowledge and customer bases is important for shaping structure and strategy. Consequently, openness towards various external actors also varies.
- ***University knowledge plays a key role in the exploration phase of open innovation.*** Large firms in the case studies were especially concerned by access to public research upstream. CIS-4 data on collaboration show that collaboration between universities and small firms remains weak.
- ***A pro-active strategy towards management and use of intellectual property rights (IPR) is important*** for open innovation. Universities tend to be less well equipped in this area, however, making collaboration with firms difficult.
- ***Trust matters.*** The case study exercise identified trust and commitment as especially important for the success of open innovation strategies.
- ***There are organisational limitations to open innovation*** and there are often trade-offs between different approaches, resulting in experimentation through trial and error. Increased networking also generates greater costs.
- ***Building a culture of open innovation in companies requires rewarding teamwork and organisational changes that foster internal and external collaboration.*** This requires work arrangements that encourage and reward risk taking.
- ***Small firms' participation in open innovation is limited owing to internal resource constraints.***
- ***Technology markets matter in helping foster open innovation.*** The ability to use inside-out and outside-in strategies is facilitated by frameworks that allow for the purchase or sale of intellectual assets that can create value and opportunities for firms inside or outside their core businesses.

scope, but it is becoming clear that policies designed for geographically circumscribed knowledge-based activities or for vertically integrated value chains of firms need to be reviewed.

For example, policies to promote (national) networking and clusters may have to be adapted to take account of the globalisation of R&D and production networks. Clusters are not necessarily constrained by geography or technology. For example, the Biovalley is a cluster of biotechnology companies that straddled the borders of France, Germany and Switzerland. Policy measures to promote in-house R&D and innovation are important but may no longer be adapted to firms' innovation practices (*e.g.* insourcing or outsourcing R&D and innovation processes through corporate venturing strategies). Policies to foster industry-science relations are also affected by the cross-border linkages of public research institutes and firms. One may ask, to what extent are measures to promote internal R&D capacity still relevant or are they in fact more important given the complementarities needed to use external R&D? Should networking initiatives be strengthened, and if so how? Can and should governments target innovation support at specific points in the value chain?

The globalisation of R&D and the emergence of open innovation strategies in firms clearly raise intellectual property issues. The shift towards "IPR sharing" in open innovation strategies may require different kinds of management tools in universities and public research organisations. Indeed, open does not mean "free". The case studies have shown that a pro-active strategy towards management and use of IPR is important for open innovation but that universities tend to be less well equipped in this area. Universities have learned the value of protecting IP generated with public research funds but the management of IP in an open innovation context – as opposed to the technology transfer approach of licensing patents – remains a challenge, especially in their interactions with firms. Universities may also tend to overvalue or undervalue their IP, which can lead to difficulties in collaborating with industry.

IPR issues also play a role in the location decisions of multinational firms. While strong IP protection can attract R&D-related FDI, excessively strong protection can act as a barrier to open innovation strategies that rely on knowledge sharing and access. It can lead to abuses, block access to public and private research and ultimately stifle innovation. Access to IP allows innovators to create new IP that can in turn be made available to other users. This requires platforms and repositories for the "intellectual commons" which can be facilitated by government regulations and investment in a strong ICT infrastructure.

Policy responses

Findings from OECD questionnaires on the internationalisation of R&D

How are OECD countries responding to the policy concerns or challenges raised by globalisation and open innovation? Three main sources of information were used to gather information on policy responses: the OECD 2005 questionnaire on national policies on the internationnalisation of R&D; the responses to the 2006 *OECD Science, Technology and Industry Outlook* questionnaire; and country responses to the request for updates in the form of "policy notes" for the project on globalisation and open innovation.

The responses indicate that OECD countries have been reviewing their internationalisation strategies by bringing them in line with more general policies to strengthen economic competitiveness, and by adopting policies to address certain key aspects of the globalisation of R&D. Countries such as Denmark have explicitly developed an integrated strategy by considering internationalisation as a central dimension of all elements of an innovation system. Four broad categories of policies are identified:

- General economic framework conditions including those that play a role in the attractiveness of foreign R&D.
- R&D and innovation policies, including instruments to support business R&D and to promote linkages between industry and the public research sector.
- IPR and related policies.
- Human resource capacity building, including policies to promote the mobility of human resources.

Science and technology policies aimed at attracting R&D activities from abroad closely follow policies to attract FDI in general, notably by improving economic framework conditions. Crucial to attracting R&D investments is the establishment of a world-class science system including high-performance research units, a highly developed infrastructure and a supply of excellent human resources. Given that countries are not able to excel in all technological domains, a quality domestic knowledge base goes hand in hand with specialisation. In order to foster clusters and networks and enhance research and learning, industry-science linkages around centres of competence are being reinforced. In addition, more specific S&T policy instruments and measures are applied in (some) countries. Examples are public support for (new) investment in R&D, often involving the regional level of governments; opening up national public (support) programmes in the area of S&T according to the non-discrimination principle for foreign-owned domiciled firms; and facilitating the mobility of S&T personnel. For the second of these, the concept of reciprocity is an important consideration in order to demonstrate that national benefits can

flow back to the taxpayers that fund public programmes. For mobility, policies will have to balance brain drain with brain circulation.

A second broad category of policy measures envisages linking domestic firms with foreign knowledge and stimulating spillovers from foreign sources of R&D to local R&D units and the local economy at large. This is done by increasing the absorptive capacity of local firms, by raising the educational level of the local labour force and by stimulating the development of own technological and innovative capacities. The creation of platforms for co-operation and linkages between companies and public research organisations through cluster and network initiatives, competence centres and their transfer offices also aims to maximise spillovers. Countries also implement more direct and active policies for linking to "international" knowledge by providing information and consultancy services, by supporting participation in international R&D programmes and in international S&T co-operation in general.

Third, many countries have made substantial efforts to lower barriers to the mobility of highly skilled personnel through more favourable immigration regimes and the simplification of immigration procedures. Immigration policy targeted towards highly skilled and temporary immigrant workers/students provides incentives, such as preferential income taxation for certain groups among the highly skilled. In some countries specific policies for repatriation (of nationals working abroad), retention and networking of talent have been set up.

Policy responses in general appear to be adapting to the challenges of open innovation and globalisation. However, some gaps remain:

- **Globalisation is putting pressure on upgrading framework conditions (including competition and fiscal policies).** Many countries recognise the importance of framework conditions but upgrading takes time and governments encounter political and public resistance to accelerating reforms in difficult areas (*e.g.* labour market policies).
- **Open innovation and global value chains drive efforts to improve framework conditions that affect the location of production (FDI) as well as costs (production, labour, tax).** Common responses include reforms to reduce corporate and/or labour social tax rates (France, Japan, the Netherlands) as well as helping to link firms to global production networks (*e.g.* industry productivity centres in Australia for trade-exposed small and medium-sized enterprises [SMEs]).
- **Globalisation and open innovation also require changes in the governance of S&T policies.** This is reflected in new national plans; national strategies that involve a cross-government approach (*e.g.* Denmark's Globalisation Strategy), as well as greater involvement of industry in public research priorities and policy development (the Netherlands).

- **A broader definition of innovation is necessary – innovation is more than R&D and more than technological innovation.** This is increasingly recognised, as seen in changes to existing support instruments such as R&D tax credit schemes which include service firms as well as incentives for collaboration with public research.
- **Upgrading and internationalising public research organisations.** Enhancing the ability of public research organisations to compete at world level as well as to join research and innovation networks and supply chains is reflected in efforts to renew infrastructure, to reform university systems and to foster critical mass in research fields. However, most universities continue to seek their collaboration partners nationally. Changes to regulations and new incentive mechanisms may be needed to encourage more internationalisation of research at universities and public research organisations.
- **Networks and clusters remain important** but globalisation and open innovation have created a trend towards focusing and rationalising cluster initiatives to create world-class "nodes" in global innovation networks. Some countries are increasing support to intermediaries that can help link public and private research (France, Ireland, the Netherlands, Spain).
- **Evaluation of innovation policy is also becoming important,** not only in a national context (*e.g.* across the EU).
- **New initiatives for human resources in science and technology (HRST).** Strengthening domestic human capital as well as attracting foreign talent and return migration are policies pursued to support human capital for innovation. However, beyond stimulating supply, attracting and retaining quality HRST in companies and public research institutes will require changes in training and in employment/workplace conditions that foster autonomy and teamwork and that reward entrepreneurial risk taking.
- **Reforms to intellectual property rights (IPR) to support open innovation.** Efforts to promote knowledge sharing involve legal changes such as clarification of the research exemption for patented inventions (Australia); or extension of the protection of non-exclusive licensees (Japan) and limits on "evergreening" patent strategies (Canada). Another trend is the simplification of patent procedures (France) and use of the tax system to promote IPR (*e.g.* reduced taxation on royalties in the Netherlands). Outreach to public research and SMEs is also important for encouraging their participation in open innovation networks.

Implications for government support to R&D and innovation

As the preceding shows, traditional policies and instruments for stimulating research and innovation are under pressure to adapt to the global context for innovation. For one, the globalisation of R&D implies that the

leverage effect of public instruments may become less effective if national firms can readily shift R&D or expand it in offshore markets with greater growth potential. Another possible implication is the need for greater coherence in policy making across government ministries and departments to increase the leverage of existing mechanisms. However, this is often not the case, and considerable overlap and duplication persist. Against the background of globalisation many OECD countries are adapting their institutions for the governance of research and innovation policy, and this can go a long way towards ensuring that public support schemes meet their targets. In EU countries, greater policy coherence is also being achieved by the effect of the Framework Programmes on the design and implementation of national research policies in member states.

At the same time, while it is clear that national innovation policies must look beyond geographically circumscribed knowledge-based activities and vertically integrated value chains, it is not altogether clear that the effects are the same for large countries with large internal markets for R&D and innovation as for small countries that are more dependent on international flows of knowledge and capital. For larger countries, nationally focused innovation policies may still matter and they may not necessarily be at odds with globalisation. Indeed, for larger countries it may be more important to ensure that regional and local initiatives have a global dimension. Similarly, "policy coherence" is becoming more important, but it is arguably more so – and easier – for smaller countries. It is therefore not surprising that smaller economies have taken the lead in opening up national programmes for R&D to firms across the borders irrespective of the location of their production capacities. The Nordic countries, owing in part to the regional integration of their economies and labour markets, have adopted "globalisation strategies" to ensure that policy making across the whole of government is responsive to the challenges of globalisation. Some policy implications for government support to R&D and innovation include:

- **Integrating the global dimension in business R&D and innovation schemes.** Public schemes to support business R&D and innovation, whether via grants or indirect schemes (*e.g.* R&D tax credits, networks) may need to be adjusted to encourage greater participation by firms whose main production base is located abroad.

- **Streamlining and simplifying access to business R&D and innovation schemes.** Another implication of globalisation and open innovation is that firms, especially large firms, can "forum shop" for the best conditions and schemes available in different countries. For them, but also for SMEs which are less internationalised, improving access to and "ease of use" of government support becomes more important.

- **Promoting open innovation practices in the public sector.** Government can also become an enabler of open innovation by promoting open source platforms and practices in its procurement strategies as well as for government services.
- **Fostering technology foresight and road-mapping.** Working with firms to set priorities for research, but also to help companies identify and scout technology trends can help bridge the information gaps inherent in knowledge markets.
- **Networks and clusters.** As open innovation requires the flow and exchange of knowledge between the public and private sectors, governments have a role in ensuring that the market and non-market sectors can facilitate knowledge flows through regulation but also through infrastructure. Networking with public research allows firms to internalise knowledge spillovers. Consequently, many countries have fostered research and innovation clusters and networks. As networks proliferate, however, there is growing demand for integrating different networks across fields, sectors and technologies. This requires very different types of skills, management and organisational structures from those currently found in many universities and public research organisations.
- **Linking national and regional/local policies for R&D and innovation.** For R&D, agglomeration economies are now often more important than economies of scale. As a result, regional or local initiatives may play a greater role in helping central governments influence innovation performance of firms at home and abroad. Strengthening the ability of public research institutes and smaller firms to internationalise through national or regional innovation policies will be critical to helping OECD countries compete globally.

Implications for public research organisations

The OECD project has focused mainly on businesses and their use of open innovation strategies in a global context. It has highlighted as well the important role of universities and public research organisations in firms' knowledge sourcing and innovation strategies. This "sourcing role" is driven by the development of global innovation networks, in which companies tap into knowledge sources worldwide in the wake of the globalisation of production networks, but it is also a response to changes in the ways firms innovate in house. Anecdotal evidence has shown that in response to competition and shorter product cycles, firms have reduced their focus on longer-term and basic research. This increases the need for basic research in public labs and in universities, whether or not the results from basic research are channelled directly into the value chain (as in biotechnology) or into the

Box 4.2. **France's Passerelle programme**

France maintains a range of policies to foster open innovation and networking, ranging from clusters to promoting collaboration between industry and public research. One example is the "SME pact" to mobilise large entities (private or public) to promote the development of innovative SMEs. Large entities (*i.e.* firms) agree with government agencies (based more on willingness than on obligation) to strengthen relations with innovative SMEs through procurement and research and industrial development contracts. Under the SME pact, the Passerelle programme fosters R&D collaboration between innovative SMEs and large enterprises. If a large enterprise is interested in an SME's innovative products or services that require further development, the Passerelle programme supports the R&D projects for testing and adaptation of the products and services to the specific needs of the large enterprise. One-third of the funding comes from the large enterprise (cash and/or in-kind contributions), one-third from public subsidies (Oseo Innovation grant) and one-third from the SME. The intellectual property stays with the SME but the large enterprise has privileged access to the results for application in its specific business domain.

public domain via scientific publications. Another trend that is making open innovation more relevant and necessary is the growing convergence of technologies (nanotechnology, biotechnology, ICT) which generates new fields for research and innovation at the interface of existing fields and requires cross-functional, multidisciplinary approaches to research and innovation.

The OECD project on open innovation highlighted the importance of collaborating upstream in the research and innovation process. This points to the need for public research organisations to develop interfaces for linking up with business. At the same time, public research cannot simply react to business strategies or act merely as a provider of knowledge on demand. Indeed, changes in the governance of public research over the past decade – in particular the move towards greater autonomy, the shift towards competitive funding and in some cases privatisation, and the deregulation of academic labour markets – have allowed universities and public research organisations to play a more active and central role in the innovation process itself. In some cases, public research organisations have become "knowledge hubs" that help firms, small and large, source and jointly develop new knowledge.

The following are policy areas in which globalisation and open innovation may be affecting universities and public research organisations and their ability to respond to new demands, but also to play a more central role:

- **Public research.** As the business sectors has less time and fewer resources for carrying out longer-term research, continued support for basic research is of the utmost importance, even if the boundary between basic and applied research is ever more blurred. A key issue is not only to promote research but also to improve its diffusion and accessibility to firms and to society at large. Here, changes in the mission, priorities and governance of public research and new platforms (*e.g.* the development of competence centres) may be needed to encourage the production and diffusion of high-quality research. Open science initiatives and ICT-enabled platforms can also help improve the quality and diffusion of public research across sectors and borders.
- **Joint knowledge development.** Efforts to strengthen links between universities/public research organisations and firms have long been based on a knowledge-transfer or "technology push" model. One implication of open innovation is that the public research sector must be better equipped to develop knowledge *jointly* with firms. This may sometimes imply changing the mission of technology transfer offices and enabling them to expand into different areas.
- **Knowledge exploitation.** IPR and their management have been identified as crucial in open innovation strategies, especially in the upstream phase. The shift towards "IPR sharing" in open innovation strategies may require different kinds of management tools in universities and public research organisations. The case studies have shown that a proactive strategy towards the management and use of IPR is important for open innovation but that universities tend to be less well equipped in this respect. Universities may also overvalue or undervalue their IP, which can lead to difficulties in collaborations with industry.
- **Mobility of the highly skilled.** In spite of reforms in many countries, mobility between the public and private research sectors remains a challenge. In some cases, the university sector in particular lacks the legal and regulatory framework and the financial incentives to encourage the mobility of highly skilled personnel between universities and the private sector as well as to other parts of the public research sector (*e.g.* government labs).

Implications for the broader environment: getting the framework conditions right

Governments influence the broader business environment for innovation through macroeconomic as well as structural policies (labour policy, fiscal policy, capital markets). In addition, framework conditions (competition policy, antitrust rules, IPR regime) and the public infrastructure

Box 4.3. **The Holst Centre and Point One in the Netherlands**

The Dutch government stresses specialisation for innovation in order to become a front runner in an economy in which R&D internationalisation and open innovation are increasingly important. Innovation involves not only R&D, but also SME policy, human capital, etc. Implementation of these project- or programme-oriented policies requires a clear commitment from industry. The Holst Centre and Point One are two new initiatives.

The Holst Centre at the Eindhoven Campus is an Open Innovation Centre for Autonomous Microsystems and Systems-in-Foil created in 2005. This joint centre of TNO (Netherlands) and IMEC (Belgium) is funded by government as well as industry, and has clearly international ambition with partners worldwide and employment involving 18 nationalities. The Host Centre creates generic technologies with a time to market of between three and ten years, co-operates with industry and universities through pre-competitive shared programmes (creating focus and mass), with the results shared among the partners. Industrial partners of Holst Centre take part in the research programmes to enable rapid transfer of results to industrial partners. In the case of co-invention, industrial partners become co-owners of IP.

Point One is a pole of innovative technology in nano-electronics and embedded systems which began in 2006. It has an ambitious and coherent strategic agenda and the key success factors are considered to be its international recognition, (scientific) strengths, commitment of key industry players and an integrated approach (human capital, SMEs). A range of public incentives are foreseen: grants, feasibility studies, vouchers, brokerages (national and international), trade missions, knowledge transfer activities, education (vocational training), stimulation of spin-off companies, joint research institutes, exchange of researchers, R&D subsidies, etc.

for education and public research also play a major role. The OECD project has highlighted the importance of "building trust" in the marketplace as well as at the interface between the public and private sectors. Stable framework conditions and government policies therefore seem to be important. Many countries recognise their importance for innovation and for economic growth more generally, but reform takes time and governments can encounter political and public resistance to reforms in difficult areas (*e.g.* labour market policies). Other areas in which governments can act are:

- **Competition policy.** Insofar as competition between firms has put pressure on firms to innovate, competition policy is a key framework condition.

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However, co-operation is also part of open innovation. Designing competition policy that does not preclude co-operation is an important challenge, especially in industries where excessive competition can slow innovation.

- **Infrastructure for ICT.** Open innovation and global value chains rely on information and telecommunications networks, especially in certain industries or sectors. Public investment but also regulations and standards are important for the development of a communications infrastructure that allows firms, consumers, users and other players to collaborate on user-driven and open innovation.
- **Services and innovation.** Services are part of global value chains. Policies to foster competition and innovation in services can expand opportunities for firms and countries to participate in the global production and trade of services.
- **Dynamic capital markets.** Insofar as corporate venturing is one channel through which firms add value internally and externally, capital markets that allow for corporate venturing and exit to secondary markets are important for open innovation strategies.
- **Business regulations and corporate tax policies,** including those on initial public offerings and mergers and acquisitions, can facilitate corporate venturing strategies.
- **Entrepreneurship and firm start-ups.** Many countries encourage entrepreneurship and firm creation by reducing barriers to entry and regulations on start-ups. In public research, too, academic entrepreneurship can be promoted through regulations that foster faculty exchange and mobility.
- **Consumer policy.** User-driven innovation is an important element of open innovation. Consumer policy therefore plays a role in providing a framework through which consumers, users and suppliers can participate in the innovation process.
- **Technology markets.** Most companies source knowledge in various ways but licensing and purchasing technology and knowledge embodied in patents or other forms of IP are important. Creating rules and conditions that facilitate the development of technology can facilitate open innovation.

Ultimately, however, open innovation and the globalisation of R&D are, in the first place, business strategies of firms in response to market opportunities and challenges raised by the globalisation process itself and by technological change. Globalisation creates new market opportunities which imply new innovation strategies in response to (new or unmet) market

needs. The response builds on technological progress and international trade, including global value chains, generating further acceleration of the internationalisation of R&D and globalisation more generally.

The challenge for governments is to help firms adjust their innovation strategies to a changing environment. As mentioned, framework conditions are a clear area for policy action, but there are other areas in which policies have a role to play. However, if they are isolated from other measures, they may not succeed in encouraging innovative behaviour. For example, extending networking policies or improving industry-science relationships alone may not be enough to attract foreign R&D or to promote more collaborative research and open innovation. However, if such initiatives are integrated with other policy measures such as those to promote entrepreneurship and new firm creation, they may stimulate capacity in the overall innovation system.

Towards a different innovation policy?

Policy responses in OECD countries appear to be gradually addressing the challenges posed by open innovation and globalisation. However, among those still to be addressed are the need for a "coherent" cross-government approach to policies for research and innovation, the importance of non-technological forms of innovation, especially in services, the need to internationalise science-industry relations, in particular in public research; and the issue of how to open up access to national R&D programmes to foreign firms and institutions while ensuring that benefits flow to the host country.

A question on the minds of policy makers is whether new or radically different policies are needed to meet these challenges. The answer is probably somewhere in the middle but there is no single recipe. As countries have different economic structures and resource endowments, policies will have to be differentiated according to the national context. Small countries with a weak research base will need to focus on strengthening research in order to participate in global innovation networks. Other countries may need to focus on improving policy coherence. In sectors in which global value chains are extremely fragmented, the ICT infrastructure will be especially important. And in countries where multinationals play a large role, the focus may need to be on designing policies to help local firms capture spillovers from global innovation networks.

Some of the policies areas of particular relevance in light of our current understanding of the effects of globalisation and open innovation are:

- Reinforcing framework conditions, including a strong education and research infrastructure.
- Strengthening policy coherence and co-ordination at national and at supranational levels to avoid duplication of efforts.

- Financing of networks instead of individual companies.
- Integrating support for non-technological and technological innovation.
- Opening up access to the national public research and innovation infrastructure through cost sharing and reciprocity agreements but also joint development and public/private partnerships.
- Finding a balance in IPR between protection and dissemination.
- Balancing stronger competition with co-operation.
- Investing in human resources in S&T, and encouraging cross-disciplinary, cross-functional and entrepreneurial research and innovation.

Ultimately however, policy making must be guided to the extent possible by evidence and facts. Much of our understanding of how innovation works and how policies can affect performance is constrained by a statistical infrastructure based more on traditional R&D activities and more on inputs than on outputs, outcomes or impacts. Building a strong knowledge base will be necessary to identify policy implications and develop a new generation of innovation policies and best practices. The OECD work over the coming years will seek to address these issues.

Note

1. There is also a north-south dimension: globalisation and open innovation provide opportunities for developing countries to access research and innovation networks to accelerate their own development but it also creates a risk that national resources may be shifted away from country needs to meet the short-term objectives of foreign-based platforms.

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Open Innovation in Global Networks

Confronted with increasing global competition and rising R&D costs and risks, companies are reverting to new modes of innovation. To match the global demand and supply of innovation, businesses increasingly internationalise their innovation activities while opening their innovation process by collaborating with external partners (*e.g.*, suppliers, customers, universities). What drives these global innovation networks across different industries? How are they related to companies' overall strategies? Are they accessible for small and medium-sized enterprises (SMEs)? Finally, what are the consequences?

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