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Open Innovation in Global Networks

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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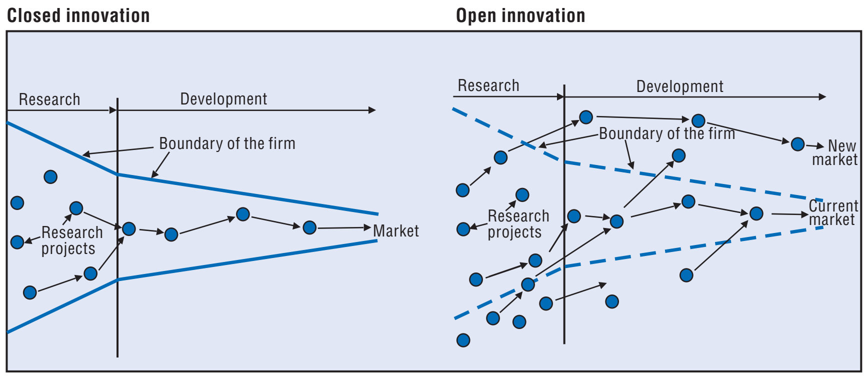
Figure 1.1. **Closed versus open innovation**



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.

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 coownership, 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).

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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).

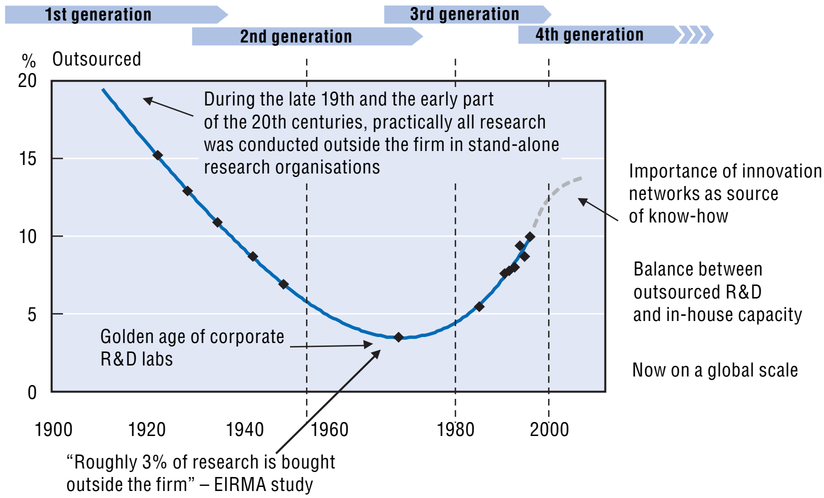
The centralised closed organisation of R&D was the dominant model at a time (1950-70) when innovation management was shaped by the technology-pull view. R&D, with strong specialisation and autonomous R&D professionals, was assumed to be the main driving force for innovation. Innovation activities took 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.

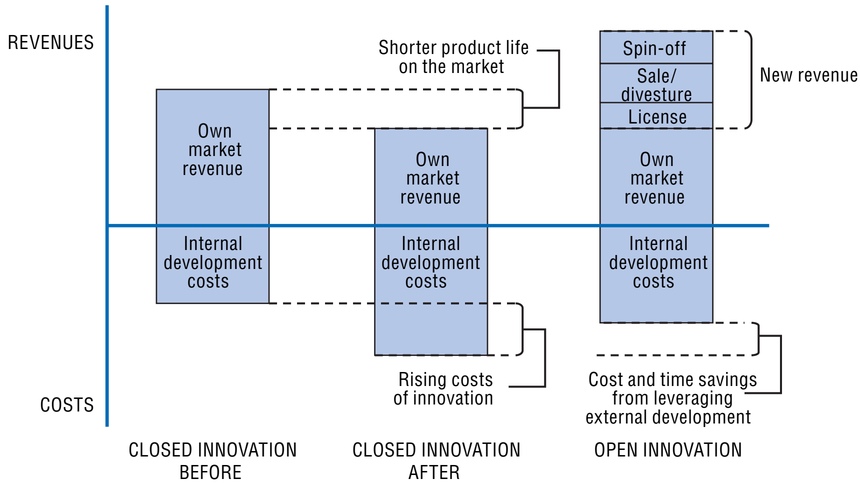
Among the so-called erosion factors, Chesbrough (2003) mentions – in addition to global competition, shortened product life cycles, increased complexity of new technologies and knowledge and increasing costs and risks of innovation – the supply and mobility of researchers and engineers, the supply of 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

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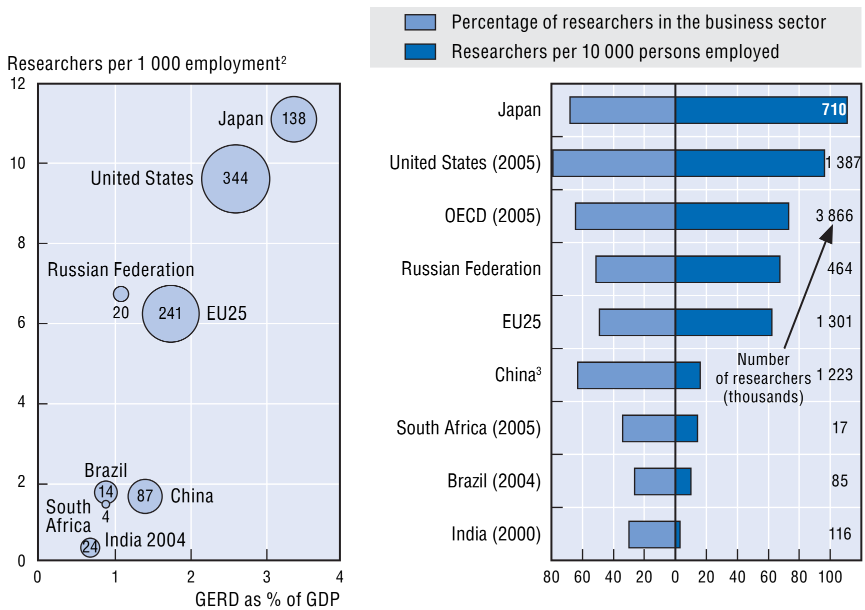
Figure 1.4. **Global supply of S&T capabilities**

Global investments in R&D[1], 2005 | **Researchers in non-OECD economies, 2005**



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

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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

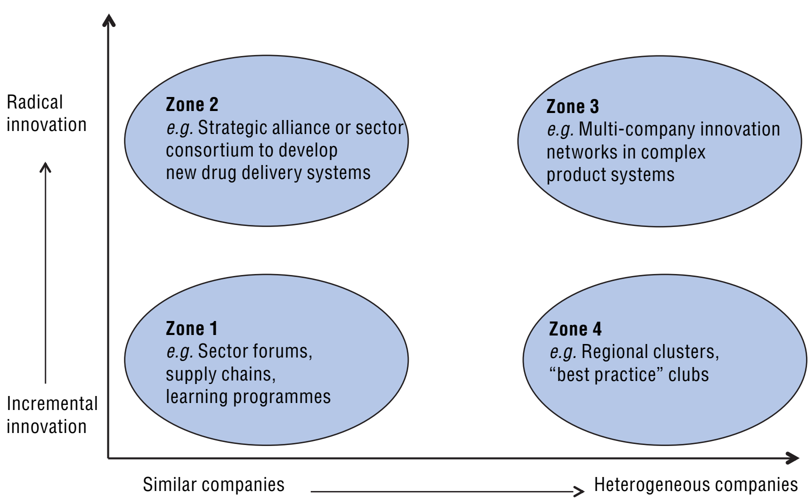
Companies increasingly build distributed global networks of R&D to sense local markets trends, to tap into local knowledge and to provide further sources of new technology. To match the growing demand for innovation from customers, suppliers, etc., with the worldwide supply of science and technology, (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).

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).

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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

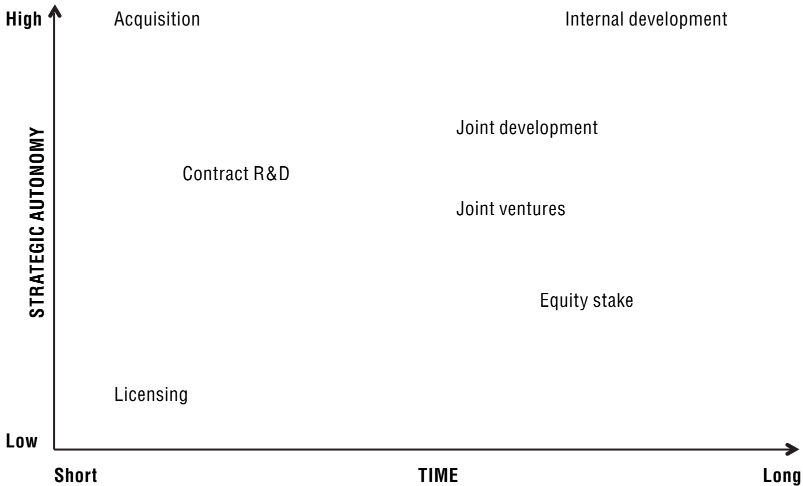
The "old" closed and "new" open models of innovation are typically presented as two extremes of a spectrum ranging from doing everything in house (vertical integration) to outsourcing everything to external partners. However, Dahlander and Gann (2007) explore different degrees and types of openness and 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**

MARKETS \ TECHNOLOGY	Core	Non-core	Unfamiliar
Unfamiliar	Joint venture Contract R&D	Venture capital Internal venture fund	Spin-off Sell
Non-core	Joint development Acquisition	Licensing Equity stake	Venture capital Internal venture fund
Core	Acquisition Internal development	Internal development Licensing Acquisition	Joint venture Contract R&D

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.

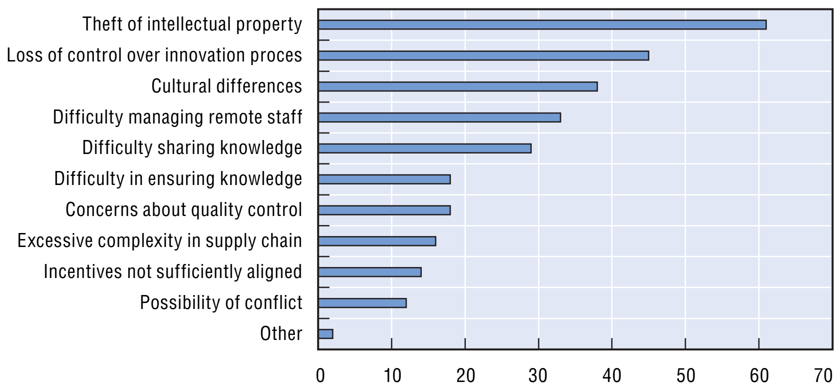
Global innovation networks and intellectual property

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 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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Table of Contents

List of boxes

List of tables

List of figures

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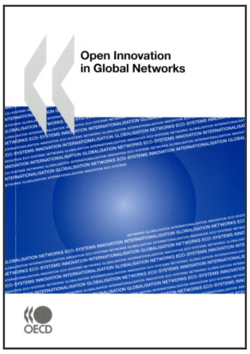

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