CHAPTER 1
THE CHANGING FACE OF INNOVATION AND INTELLECTUAL PROPERTY

Innovation is a central driver of economic growth and development. Firms rely on innovation and related investments to improve their competitive edge in a globalizing world with shorter product life cycles. Innovation also has the potential to mitigate some of the emerging problems related to health, energy and the environment faced by both richer and poorer countries. Overcoming barriers to innovation is hence a recurring and increasingly prominent business and policy challenge.

At the same time, our understanding of innovative activity, the process of innovation itself and the role of IP within that process are in flux. Among the factors that have influenced innovation over the last two decades are structural shifts in the world economy, the steady globalization of innovative activity, the rise in new innovation actors and new ways of innovating.

This chapter assesses the changing face of innovation and the corresponding new demands on the intellectual property (IP) system. The first section sets out the central role of innovation, while the second describes what has been labeled a new "innovation paradigm". The third section discusses the implications of this for IP.

1 The Oslo Manual defines four types of innovation: product innovation (new goods or services or significant improvements to existing ones), process innovation (changes in production or delivery methods), organizational innovation (changes in business practices, workplace organization or in a firm's external relations) and marketing innovation (changes in product design, packaging, placement, promotion or pricing) (OECD & Eurostat, 2005).

2 For some examples of the classic literature in this field, see Edquist (1997); Freeman (1987); Lundvall (1992); and Fagerberg *et al.* (2006).

1.1

Innovation as the driving force behind economic growth and development

Although there is not one uniquely accepted definition, innovation is often defined as the conversion of knowledge into new commercialized technologies, products and processes, and how these are brought to market.[1] Innovation often makes existing products and processes obsolete, leading to firms' entry, exit and associated entrepreneurship.

In recent decades, economists and policymakers have increasingly focused on innovation and its diffusion as critical contributors to economic growth and development.[2] Investments meant to foster innovation, such as spending on research and development (R&D), are found to generate positive local and cross-border impacts, which play an important role in the accumulation of knowledge. In other words, thanks to these so-called "spillovers" the benefits of innovative activity are not only restricted to firms or countries that invest in innovation.

While the importance of "creative destruction" was highlighted in the early 20th century, more recent economic work stresses the role that various factors play in driving long-run growth and productivity.[3] These include not only formal investment in innovation such as R&D, but also learning-by-doing, human capital and institutions.

3 See Schumpeter (1943). The endogenous growth models and quality ladder models theorize that innovation drives long-run aggregate productivity and economic growth. See Grossman and Helpman (1994); Romer (1986); Romer (2010); Grossman and Helpman (1991); and Aghion and Howitt (1992).

A voluminous empirical literature has examined the relationship between innovative activity and productivity growth at the firm-, industry- and country-level. However, due to data limitations, earlier empirical work in this area mostly relied on two imperfect measures of innovation, namely R&D spending and patent counts. In recent years, innovation surveys and accounting exercises relating to the measurement of intangible assets have emerged as new sources of data (see Boxes 1.1 and 1.2).

Most empirical studies on the relationship between innovation and productivity have focused solely on high-income economies and the manufacturing sector. As early as the mid-1990s, the economic literature suggested that innovation accounted for 80 percent of productivity growth in high-income economies; whereas productivity growth, in turn, accounted for some 80 percent of gross domestic product (GDP) growth.[4] More recent studies at the country-level demonstrate that innovation – as measured by an increase in R&D expenditure – has a significant positive effect on output and productivity.[5]

At the firm-level, there is emerging but increasingly solid evidence that demonstrates the positive links between R&D, innovation and productivity in high-income countries.[6] Specifically, these studies imply a positive relationship between innovative activity by firms and their sales, employment and productivity.[7] Innovative firms are able to increase efficiency and overtake less efficient firms. Firms that invest in knowledge are also more likely to introduce new technological advances or processes, yielding increased labor productivity. In addition, a new stream of research stresses the role of investing in intangible assets for increased output and multifactor productivity growth (see Box 1.1).[8] While it is assumed that process innovation has a direct effect on a firm's labor productivity, this is harder to measure.[9]

Clearly, the causal factors determining the success and impact of innovation at the firm-level are still under investigation. An increase in a firm's R&D expenditure or the introduction of process innovation alone will not automatically generate greater productivity or sales. Many often connected factors inherent in the firm or its environment contribute to and interact in improving a firm's performance.

4 See Freeman (1994).
5 For an overview, see Khan and Luintel (2006) and newer studies at the firm level, such as Criscuolo *et al.* (2010).
6 See, for instance, Crepon *et al.* (1998); Griffith *et al.* (2006); Mairesse and Mohnen (2010); and OECD (2010a).
7 See Evangelista (2010); OECD (2010a); OECD (2009c); Guellec and van Pottelsberghe de la Potterie (2007); and Benavente and Lauterbach (2008).
8 See OECD (2010b).
9 See Hall (2011).

Box 1.1: Intangible assets play an important role in firm performance

Firms spend considerable amounts on intangible assets other than R&D, such as corporate reputation and advertising, organizational competence, training and know-how, new business models, software and IP (copyright, patents, trademarks and other IP forms).

Business investment in intangible assets is growing in most high-income economies and, in a number of countries, it matches or exceeds investment in tangible assets such as buildings, equipment and machinery.[10] As a result, intangible assets now account for a significant fraction of labor productivity growth in countries such as Austria, Finland, Sweden, the United Kingdom (UK) and the United States of America (US). Data for Europe show that investment in intangibles ranges from 9.1 percent of GDP in Sweden and the UK, to around 2 percent of GDP in Greece.[11] This is considerably higher than the scientific R&D investment which, for example, stands at 2.5 percent of GDP in Sweden and 0.1 percent of GDP in Greece. For the US, Corrado, Hulten & Sichel (2007) estimate investment in intangible assets at United States Dollars (USD) 1.2 trillion per year for the period 2000-2003. This represents a level of investment roughly equal to gross investment in corporate tangible assets. Depending on the depreciation rate, the stock of intangible assets may be five to ten times this level of investment. In comparison, scientific R&D makes up for only USD 230 billion.

Finally, complementary research based on market valuations of firms in Standard & Poor's 500 Index indicates that intangible assets account for about 80 percent of the average firm's value.[12] The physical and financial accountable assets reflected in a company's balance sheet account, in turn, for less than 20 percent.

Furthermore, innovation-driven growth is no longer the prerogative of high-income countries.[13] The technology gap between middle-income and high-income countries has narrowed (see Section 1.2).[14] In recent years, it has been shown that catch-up growth – and more generally the spread of technology across countries – can now happen faster than ever before. This has been exemplified by countries such as the Republic of Korea and later China.[15]

Differences in innovative activity and related technological gaps between countries are a significant factor in explaining cross-country variation in income and productivity levels.[16] According to several studies, roughly half of cross-country differences in per capita income and growth can be explained by differences in total factor productivity, a measure of an economy's long-term technological change or dynamism.[17] In addition, the variation in the growth rate of GDP per capita is shown to increase with the distance from the technology frontier. Countries with fewer technological and inventive capabilities generally see lower and more diverse economic growth than do richer countries.

As a result, reducing income gaps between economies is directly linked to improved innovation performance,[18] which is in part driven by spillovers from high-income to other economies. In other words, total factor productivity depends to a large degree on the ability of countries, industries or firms to adopt technologies and production techniques of countries and firms with higher levels of technological development.

10 See Gil and Haskell (2008); OECD (2010d); and van Ark and Hulten (2007).
11 See European Commission (2011).
12 See Ocean Tomo (2010). The S&P 500 is a free-floating, capitalization-weighted index, published since 1957, of the prices of 500 large-cap common stocks actively traded in the US. The stocks included in the S&P 500 are those of large publicly-held companies that trade on either of the two largest American stock market exchanges: the New York Stock Exchange and the NASDAQ.
13 See Soete and Arundel in UNESCO (2010) and Bogliacino and Perani (2009).
14 See World Bank (2008).
15 See Romer (1986); Long (1988); and Jones and Romer (2010).
16 See Fagerberg (1994); Hall and Jones (1999); Fagerberg *et al.* (2009); Klenow Rodríguez-Clare (1997); Griliches (1998); and Parisi *et al.* (2006).
17 See Jones and Romer (2010); Guinet *et al.* (2009); and Bresnahan and Trajtenberg (1995).
18 See Hulten and Isaksson (2007).

These spillovers are frequently driven by knowledge acquired through channels such as foreign direct investment (FDI), trade, licensing, joint ventures, the presence of multinationals, migration and/or collaboration with firms from higher-income countries.[19] Strategies for acquiring, adapting, imitating and improving technologies and existing techniques in relation to local conditions are key for innovation. Developing innovative capacity requires complementary in-house innovation activity (see Box 2.2).[20] In addition, certain framework conditions, adequate human capital and absorptive capacity are necessary at the country- and firm-level in order to benefit from innovation spillovers. The literature refers to the necessary presence of functioning "national innovation systems" with linkages between innovation actors and a government policy that underpins innovation activity.[21]

On the whole, however, too little is known about how innovation takes place in lesser developed economies, how it diffuses and what its impacts are.

That does not mean that no evidence in this area exists. Surveys confirm that innovation – understood broadly – occurs frequently in low- and middle-income economies.[22] The literature concludes that the impacts of innovation can be proportionately much greater in these economies than in high-income economies. In particular, cumulative innovation – incremental innovation where one builds on existing products, processes and knowledge (see Subsection 2.2.2) – is shown to have a significant social and economic impact.[23]

As firms in less developed economies are, at times, far from the technology frontier, they have dissimilar technological requirements and innovate differently. Process innovation and incremental product innovation play a more important role in firm performance than does product innovation. Improvements in maintenance, engineering or quality control, rather than fresh R&D investment, are often the drivers of innovation. Recent examples in Africa or other low-income economies such as Bangladesh or Rwanda show that local firms or other organizations introduce novel product or process innovation in fields such as finance (e-banking), telecommunications, medical technologies and others. In conclusion, the relationship between innovation and productivity in less developed economies is not clear-cut. Studies do not always find that technological innovation impacts on productivity, in particular where a narrow definition of product-based technological innovation is used.[24] A few studies on China and certain Asian countries conducted at the aggregate country-level even conclude that factor accumulation, rather than productivity increases, explains the majority of the recent growth.[25]

Firm-level studies conducted in lower- and middle-income economies – mainly done for Asia and Latin America – do in turn provide evidence for the strong positive relationship between innovation and productivity, or innovation and exports, as long as innovation is viewed more broadly than technological product innovation. The literature also concludes that firms in less developed economies that invest in knowledge are better able to introduce new technological advances, and that firms which innovate have higher labor productivity than those that do not.

19 In the context of developing countries, particularly for those in the early stages of development, technology transfer from foreign high-income economies and the spillover effects from foreign investment have been considered the most important sources of innovation, since most such countries lack the capital and the skills to conduct state-of-the-art research.

20 See Cohen and Levinthal (1990).

21 See Jones and Romer (2010).

22 For full references and a discussion, see Crespi and Zuñiga (2010).

23 See Fagerberg *et al.* (2010).

24 See the many country-specific studies of Micheline Goedhuys and her co-authors at *http://ideas.repec.org/f/pgo205.html.*

25 See Anton *et al.* (2006); Young (1993); and Young (1995). This might, however, have to do with measurement issues related to embodied technologies.

1.2

The shifting nature of innovation

While there is consensus on the importance of innovation, our understanding of innovative activity and the process of innovation itself continue to change.

First, the way innovation is perceived and understood has evolved over the last two decades. Previously, economists and policymakers focused on R&D-based technological product innovation, largely produced in-house and mostly in manufacturing industries. This type of innovation is performed by a highly educated labor force in R&D-intensive companies with strong ties to leading centers of excellence in the scientific world.[26]

The process leading to such innovation was conceptualized as closed, internal and localized. Technological breakthroughs were necessarily "radical" and took place at the "global knowledge frontier", without allowing for the possibility of local variations or adaptations of existing technologies. This also implied the existence of leading and lagging countries – i.e., the "periphery" versus the "core" – with low- or middle-income economies naturally catching up to more advanced ones. According to this view, firms from poorer countries were passive adopters of foreign technologies.

Today, innovation capability has been seen less in terms of the ability to discover new technological, state-of-the-art inventions. The literature now emphasizes the ability to exploit new technological combinations, the notion of incremental innovation and "innovation without research".[27] Furthermore, non-R&D-innovative expenditure, often part of later phases of development and testing, is an important and necessary component of reaping the rewards of technological innovation. Such non-technological innovation activity is often related to process, organizational, marketing, brand or design innovation, technical specifications, employee training, or logistics and distribution (see Figure 1.1, left column, and Subsection 1.2.4).

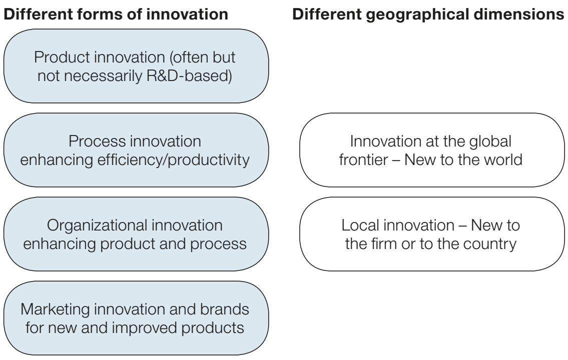
There is also greater interest in understanding how innovation takes place in low- and middle-income countries, noting that incremental forms of innovation can impact on development. This evolution in thought also recognizes that existing notions of innovation are too focused on frontier technologies and original innovation. While innovation can take place at the global frontier, local innovation that is new to a firm or a country can be equally important (see Figure 1.1, right column).

Second, the process of innovation has undergone significant change. As part of a new innovation paradigm, investment in innovation-related activity has consistently intensified at the firm, country and global level, both in terms of levels and shares of other investment, adding new innovation actors from outside high-income economies. This shift has also led to a much more complex structure of knowledge production activity, with innovative activity more dispersed geographically and collaboration on the rise, often in response to technological complexity.

26 See Fagerberg *et al.* (2010).
27 See David and Foray (2002).

Figure 1.1: Innovation takes different forms and has different geographical dimensions

Types of Innovation



Some of the numerous drivers for this gradually shifting innovation landscape are well-known:

- economies have become more knowledge-based as more countries enter the innovation-driven stage of development;
- globalization has led to new markets for innovative products as well as new production locations for them – Asia being the prime example of both;
- information and communication technologies (ICTs) have become diffused across industries and countries and have led to a fall in the cost of codifying, managing and sharing data and knowledge;
- the falling cost of travel has encouraged greater mobility; and
- the rise of common technology standards and platforms tied to de facto or industry standards – creating new innovation ecosystems on the one hand, and technological convergence on the other hand – has increased the ability to fragment innovation processes as well as the complexity of innovation.

The next subsections show that changes in the innovation landscape have happened more gradually and subtly over time than is often claimed. Trends that are often discussed, such as the increasing internationalization of innovation or wider "open" collaboration, are compared with official statistics, which time and again paint a more nuanced view. For instance, over the past two decades innovative activity has become more and more internationalized. Still, despite the shift in geographical composition of global science and technology production, R&D activity remains concentrated in only a few economies.[28]

For reasons of data availability (see Box 1.2), the next sections focus on innovation measured by quantifying knowledge and R&D inputs. However, innovation and related processes vary widely depending on the industry sector in question (see Chapter 2). The development of new drugs in the pharmaceutical sector, for instance, involves other levels and types of R&D investment and innovation activity than is the case in other sectors. This sectoral heterogeneity has to be kept in mind when studying the various degrees of collaboration, globalization and the use of IP at the aggregate level.

28 See Tether and Tajar (2008) and UNESCO (2010).

Box 1.2: Measuring innovation remains challenging

Direct official measures that quantify innovation output are extremely scarce. For example, there are no official statistics on the amount of innovative activity – as defined as the number of new products, processes, or other innovations (see Section 1.1) – for any given innovation actor or, let alone, any given country. This is particularly true when broadening the notion of innovation to include non-technological or local types of innovation. Most existing measures also struggle to appropriately capture the innovation output of a wider spectrum of innovation actors as mentioned above, for example the services sector, public entities, etc.

In the absence of such innovation metrics, science and technology (S&T) indicators or IP statistics have been used in the past as an approximate measure of innovation. These most commonly include data on R&D expenditure, R&D personnel, scientific and technical journal articles, patent-related data, and data on high-technology exports. Even these data are available for many but not all countries.[29] Moreover, these S&T indicators provide, at best, information on innovation input and throughput such as R&D expenditure, number of scientists, intermediate innovation output such as scientific publications or patents, or certain forms of technology-related commercial activity such as data on high-technology exports, or data on royalty and license fees.

In recent years the generation of data from so-called firm-level innovation surveys has improved the situation. Innovation surveys started with the European Community Innovation Survey (CIS) in the early 1990s, and are now being conducted in about 50-60 countries – mostly in Europe but also in a number of Latin American, Asian, African and other countries including, more recently, the US.[30] These surveys are a rich data source for analytical work. However, a number of problems exist: (i) innovation outside the business sector is not captured in these enterprise surveys; (ii) the quality of responses varies greatly and respondents have a tendency to overrate their innovative activity; (iii) country coverage is still limited; and (iv) survey results can only be compared to a limited extent across years and countries.

1.2.1

Globalization of production and demand for innovation

The way research and production activities are organized has changed over the last two decades. This can be partly attributed to greater integration and structural changes in the global economy; the emergence of new actors; and the ability of global firms to source scientific capabilities in different locations. The demand for innovative products and processes has also become internationalized.

Structural changes in the global economy: greater integration

Increasingly, multinational enterprises (MNEs) source input and technology from suppliers worldwide. This reflects a fragmentation of the production process in the manufacturing and services industries, with increases in task-based manufacturing, intermediate trade and outsourcing of services. As a result, a greater number of countries participate in global production and innovation networks.[31] Innovation networks have created a potential for technological and organizational learning by manufacturers and exporters, leading to industrial upgrading.[32]

29 In terms of availability, even seemingly straightforward indicators are scarcely available for more than a third of WIPO Member States. As an example, of the 214 territories/countries covered by the UNESCO Institute for Statistics, data for Gross Domestic Expenditure on Research and Development (GERD) in 2007 were only available for about 64 countries (mostly OECD or other high-income countries). For lower-income countries, these data are either unavailable or outdated (for example, for Algeria from 2005). No data are available for least developed countries (LDCs). There are typically even fewer data available for the other above-mentioned indicators. For instance, about 56 countries reported total R&D personnel for 2006.

30 Firm-level innovation surveys seek to identify the characteristics of innovative enterprise activity. After inviting firms to answer certain basic questions (on industry affiliation, turnover, R&D spending), firms were asked to identify whether they are an "innovator" and, if so, firms are asked to respond to questions regarding specific aspects of their innovation, as well as the factors that hamper their innovation. Finally, these surveys aim to assess the effect of innovation on sales, productivity, employment and other related factors.

31 For a recent overview and study, see Ivarsson and Alvstam (2010).

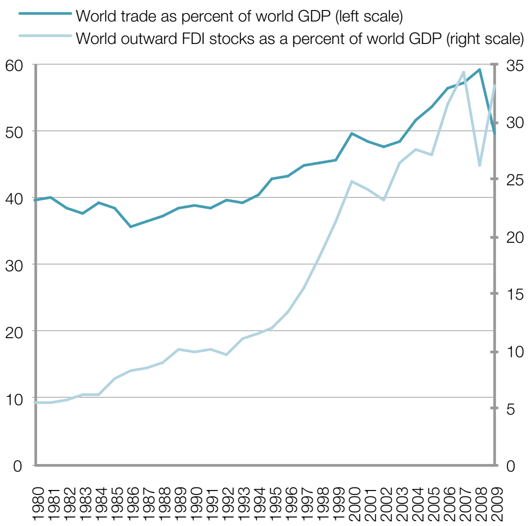
32 See UNIDO (2009).

The extent of economic integration is best exemplified in Figure 1.2 (top) which shows that world trade as percentage of GDP increased from about 40 percent in 1980 to about 50 percent in 2009; and world FDI outward stocks rose from 5.4 percent of world GDP in 1980 to about 33 percent in 2009. FDI inflows alone are expected to reach more than USD 1.5 trillion in 2011, with developing and transition countries, as defined by the United Nations (UN), now attracting more than half of FDI flows.[33] The foreign affiliates' share of global GDP has now reached a high point of about ten percent.[34] However, FDI flows to the poorest regions continue to fall.[35]

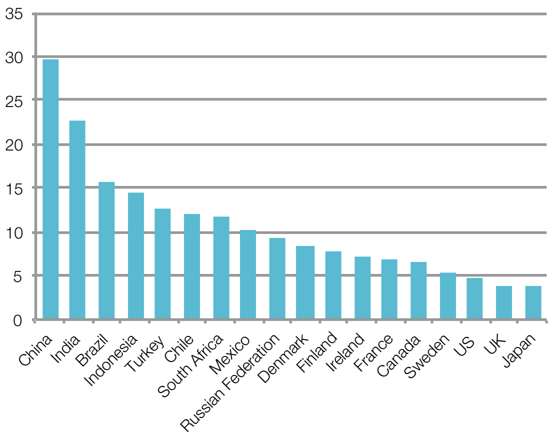
In parallel, a shift in manufacturing capacity from high-income to lower-income economies, in particular to Asia, has taken place. This shift is primarily linked to the fact that products are increasingly assembled outside of high-income economies.[36] Mirroring this trend, the share of high-technology exports of the US and Japan has constantly decreased – from 21 percent in 1995 to 14 percent in 2008 for the US, and from 18 percent in 1995 to eight percent in 2008 in the case of Japan – with the share of Europe remaining constant. In contrast, China's share increased from six percent in 1995 to 20 percent in 2008, with other economies such as Mexico and the Republic of Korea also constantly increasing their shares. In terms of the growth of high- and medium-high-technology exports, China, India, Brazil and Indonesia are in the lead (see Figure 1.2, bottom).

Figure 1.2: Economic integration and the fragmentation of value chains have been on the increase

World trade and outward FDI stocks, as a percentage of world GDP, 1980-2009



Growth of high- and medium-high-technology exports, average annual growth rate, in percent, 1998-2008



Note: In the bottom figure, data refer to 2000-08 for Brazil, Indonesia, India, China and South Africa. The underlying data for China include exports to China, Hong Kong.

Source: WIPO, based on data from the World Bank, UN Comtrade and UNCTADstat, September 2011.

33 See UNCTAD (2011).
34 *Idem.*
35 *Idem.*
36 For a discussion on the ICT industry value chain, see Wunsch-Vincent (2006).

Furthermore, the output of knowledge- and technology-intensive industries (KTI) is also increasing and becoming more geographically diffuse.[37] In particular, the global output of knowledge- and technology-intensive industries as a share of global GDP increased to close to 30 percent of global GDP in 2007, with knowledge-intensive services accounting for the greatest share at 26 percent, and high-technology manufacturing industries accounting for 4 percent. ICT industries, composed of several KTI as defined above service and high-technology manufacturing industries, accounted for seven percent of global GDP in 2007. The share is greatest in countries such as the US (38 percent), the European Union (EU) (30 percent) and Japan (28 percent). Other countries, such as China (23 percent) or regions in Africa (19 percent), have also increased their knowledge- and technology-intensive industry output as a share of GDP.

Structural changes in the global economy: more balanced world income and demand for innovation

Firms and citizens in particular middle-income economies have not only emerged as substantial contributors to technology production, but have also created significant demand for products and innovation themselves.

For the first time since the 1970s, the last decade saw a trend towards convergence in per capita income.[38] The number of converging economies increased rapidly, with growth being strongest in a few large middle-income economies but with growth also increasing more generally in, for example, Africa – averaging 4.4 percent growth between 2000 and 2007. Whereas in 1980, about 70 percent of world GDP (measured in purchasing power parities, PPP) was concentrated in high-income countries, that share fell to 56 percent in 2009, with the share of upper middle-income economies making up for the biggest increase – from about 22 percent to about 31 percent – and the low-income country group increasing only marginally (see Figure 1.3, at top). This partial convergence has been spurred further by the economic crisis, with GDP growth holding up more strongly outside of high-income economies.

37 National Science Board (2010). These data are based on calculations by the National Science Foundation following the OECD's classification of knowledge-intensive service and high-technology manufacturing industries and data provided by IHS Global Insight. The OECD has identified 10 categories of service and manufacturing industries—collectively referred to as KTI industries—that have a particularly strong link to science and technology. Five knowledge-intensive service industries incorporate high technologies either in their services or in the delivery of their services. They include financial, business, and communications services (including computer software development and R&D), which are generally commercially traded. They also include education and health services, which are primarily government provided and location bound. The five high-technology manufacturing industries include aerospace, pharmaceuticals, computers and office machinery, communications equipment, and scientific (medical, precision, and optical) instruments.

38 OECD (2010e).

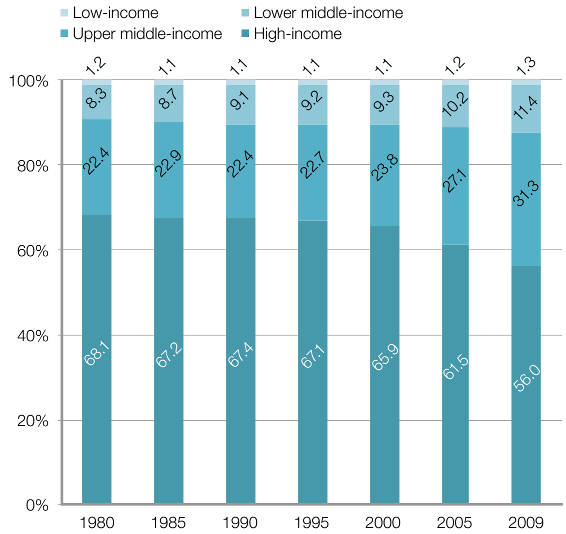
Combined with greater population growth in lower-income countries, world distribution of income has progressively shifted. Figure 1.3 (at bottom) shows that between 1970 and 2006, the absolute level and the distribution of world income have progressively increase, with more millions of people benefiting from higher incomes. Per capita income has risen, increasing household final expenditure substantially during the last decades and contributing to greater demand for innovation. Specifically, in 2009 the average per capita income in high-income economies was roughly 14 times that of a middle-income economy – compared to roughly 20 times in 1990 and 2000.

Moreover, two to three billion people are projected to enter the middle class in the coming decades. This will constitute a new source of demand for goods and services tailored to the specific needs of this middle class emerging in less developed economies. Adapting products to emerging markets will henceforth be a core activity of MNEs, including for households with fewer resources that will demand low prices for robust products with basic functionality.[39]

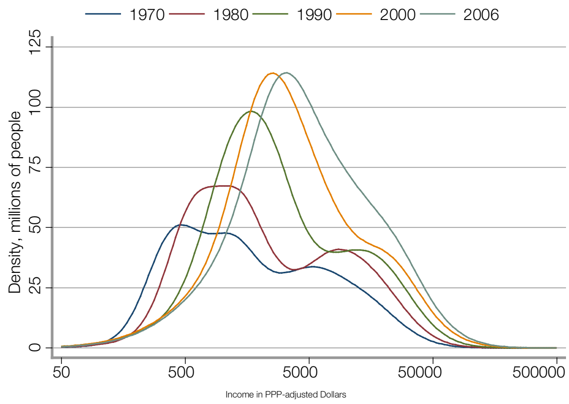
39 See Prahalad and Lieberthal (1998) and the literature building on this contribution.

Figure 1.3: World income distribution is becoming more equalized

Distribution of world GDP by income group, as a percentage of total GDP, current PPP – dollar



Distribution of world income by density (millions of people per income group), current PPP – dollar



Note: In the top graph the GDP comparisons are made using PPPs.

Source: WIPO, based on data from the World Bank (top), October 2011 and Pinkovskiy and Sala-i-Martin (2009) (bottom).

At the same time, the gap between high-income and low-income economies has increased. In particular, the income in the richest countries equaled 84 times the low-income average GDP per capita in 1990, 81 times in 2009, but only 55 times in 1974. How innovation occurs and is diffused to these countries despite this rising income gap is a matter of concern.

1.2.2

Increased investment in innovation

Investment in knowledge now makes up a significant share of GDP for most high-income and rapidly growing economies. Such investment concerns expenditure on R&D, private and public education and software.[40] These data are not yet available for low-income economies.

Israel, the Republic of Korea, the US, and the Nordic countries have the highest levels of investment in knowledge per GDP in 2008 (see Figure 1.4).[41] In terms of growth, Argentina, Brazil, Romania and Uruguay recorded double-digit growth from 2003 to 2008 with values for China unavailable for 2003. The following high-income economies have increased investment in knowledge most rapidly in the same time period: Ireland, the Czech Republic and the Republic of Korea. Investment in knowledge as a percentage of GDP declined in a number of countries – Malaysia, India, Hungary and Chile – in part due to faster GDP growth rates.

For all reported countries, education accounted for the largest share of total investment in knowledge – more than half in all cases. It accounted for more than 80 percent of total investment in knowledge for a large number of middle-income economies, including Argentina, Bolivia, Chile, Colombia, Peru, Mexico, Morocco, Thailand, and Tunisia.

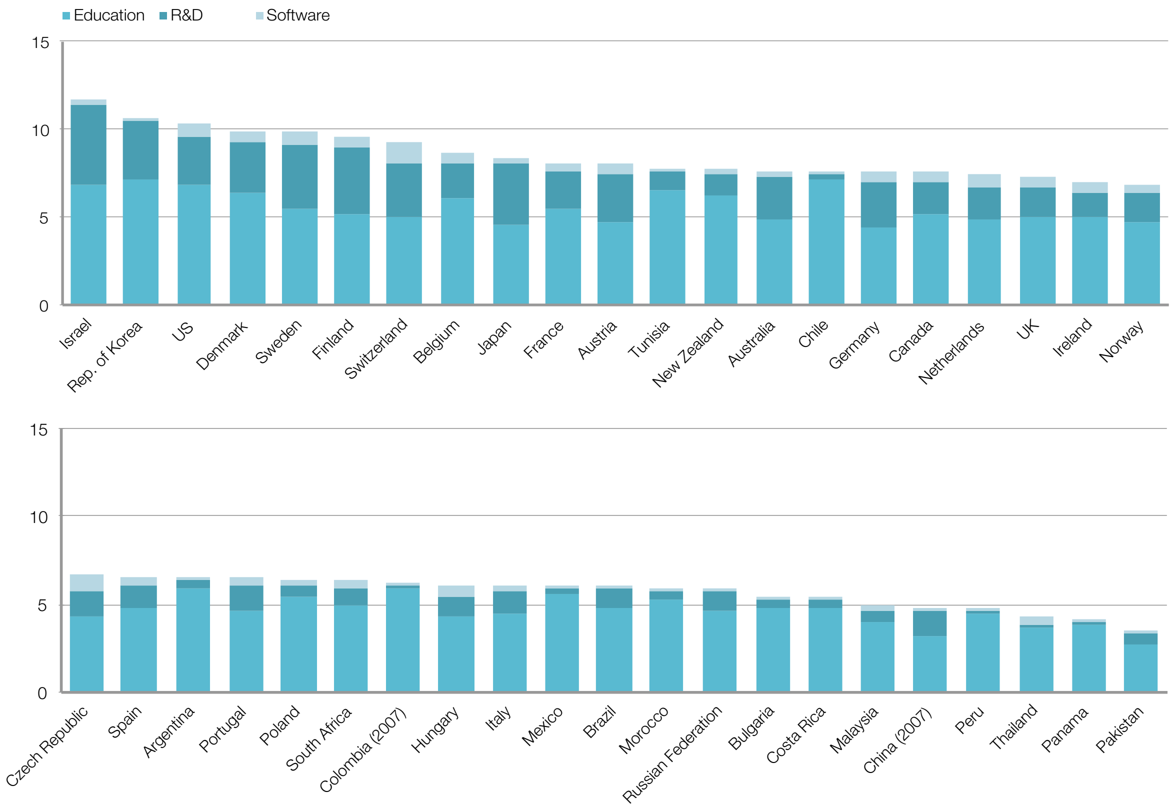
With regard to R&D expenditure, however, outside, China, only high-income economies devote to investments in R&D a share larger than 20 percent of total investment in knowledge. The share of R&D in total investment in knowledge is more than a third for Japan, Israel, Finland, Sweden, Germany and Austria in 2008, with high-income countries investing anywhere between 1 percent of GDP to R&D (Hungary) to 4.7 percent (Israel). For the majority of countries, the share of R&D in total knowledge investment increased, albeit only marginally, between 2003 and 2008.

40 Investment in knowledge is defined and calculated as the sum of expenditure on R&D, total education (public and private for all levels of education) and software. Simple summation of the three components would lead to an overestimation of investment in knowledge owing to overlaps (R&D and software, R&D and education, software and education). Data reported here have been adjusted to exclude these overlaps between components. See Khan (2005).

41 When making comparisons with regard to R&D or other knowledge-investment intensity, it makes sense to avoid direct comparisons between smaller and larger economies.

Figure 1.4: Countries are investing in knowledge

Investment in knowledge, as a percentage of GDP, 2008 or latest available year, selected countries



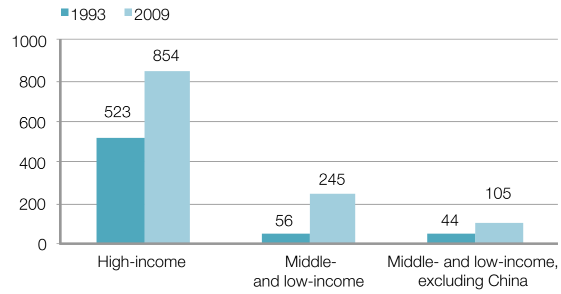
Note: For China, education expenditure refers to public expenditure only. When making comparisons to R&D-intensity it makes sense to divide countries into smaller and larger economies. R&D -intensity for small economies is often determined by one or a few companies.

Source: WIPO, based on data from UNESCO Institute for Statistics, Eurostat, OECD, World Bank and the World Information Technology and Services Alliances, September 2011.

In 2009, about USD 1.2 trillion (constant PPP 2005 USD) was spent on global R&D. This is roughly the double spent in 1993 at USD 623 billion. However, worldwide R&D spending is skewed towards high-income countries (see Figure 1.5), which still account for around 70 percent of the world total. This holds true despite the fact that their share dropped by 13 percentage points between 1993 and 2009. The share of middle- and low-income countries more than doubled between 1993 and 2008; however, almost all the increase in the world GDP share is due to China, which is now the second largest R&D spender in the world.

Figure 1.5: R&D expenditure still comes mainly from high-income countries

Worldwide R&D expenditure, by income group, in 2005 PPP Dollars, 1993 and 2009



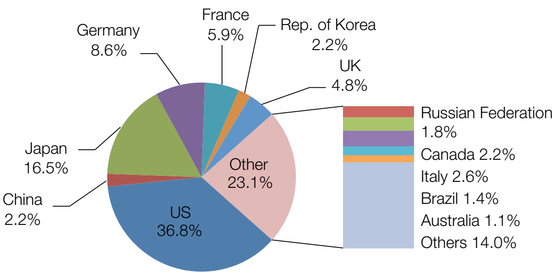
Note: R&D data refer to gross domestic expenditure on R&D (GERD). The high-income group includes 39 countries, and the middle- and low-income group includes 40 countries.

Source: WIPO estimates, based on data from UNESCO Institute for Statistics, Eurostat and OECD, September 2011.

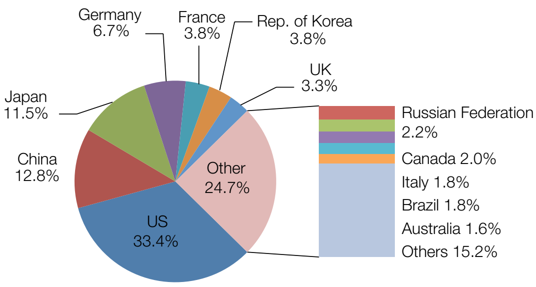
Between 1993 and 2009, the share of major spenders from the US, Canada, and all European countries declined, while the share of Brazil, China, the Republic of Korea, and countries such as the Russian Federation increased (see Figure 1.6). China is still the only middle-income country, however, that has emerged as a major R&D spender.

Figure 1.6: China has emerged as major R&D spender

Country shares in world R&D, in percent, 1993



Country shares in world R&D, in percent, 2009



Note: R&D data refer to gross domestic expenditure on R&D (GERD).

Source: WIPO estimates, based on data from UNESCO Institute for Statistics, Eurostat and OECD, September 2011.

In countries with the largest R&D expenditure, the business sector has persistently increased its share. Firms now account for the bulk of total R&D performance in these economies. In high-income countries, the share of business R&D in total R&D is around 70 percent while shares in Israel reach 80 percent, and around 75 percent in Japan and the Republic of Korea (see Figure 4.1 in Chapter 4).[42] Due to rapid growth in China, the local share of business R&D in total R&D is now similar to the US level, at around 73 percent. In a large number of Asian, Latin American and other middle- and low-income countries R&D is, however, still mainly conducted by the public sector (see Chapter 4).

New innovation actors have also emerged. For instance, the increase in contributions of philanthropic funds to the level and organization of R&D and innovation is a more recent phenomenon.

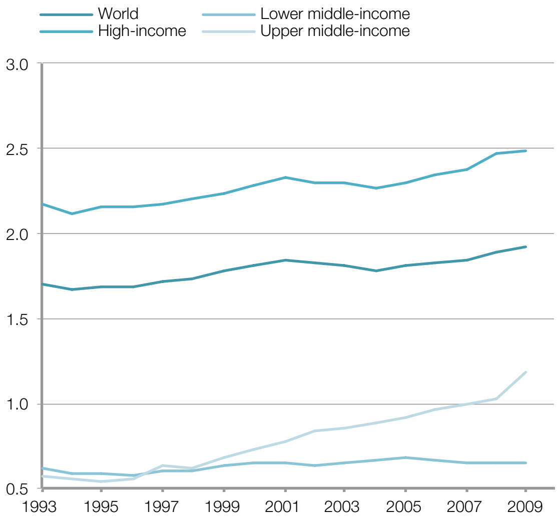
Despite rapid growth in R&D spending, the share of GDP devoted to R&D across the world, referred to as R&D-intensity, increased at a modest rate – from 1.7 percent in 1993 to 1.9 percent in 2009 (see Figure 1.7, top). However, there is considerable variation across income groups and countries. High-income economies spend around 2.5 percent of GDP on R&D activity, which is more about double the rate of the upper-middle-income groups. The sharp growth in R&D-intensity for the upper-middle-income group is mostly due to China.

R&D-intensity was highest for Israel, Finland and Sweden (see Figure 1.7, bottom). Australia, China, Finland, and the Republic of Korea are among the countries that have strongly increased R&D-intensity.

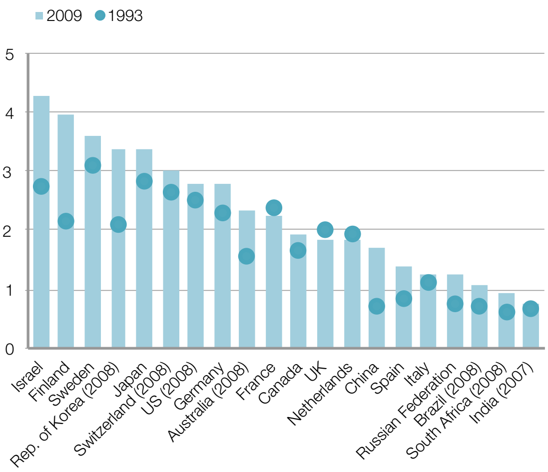
42 OECD, Main Science and Technology Indicators database (MSTI), May 2010.

Figure 1.7: R&D-intensity has increased, sometimes at a modest rate

R&D-Intensity, by income group, in percent, 1993-2009



R&D-Intensity, in percent, selected countries, 1993 and 2009



Note: R&D data refers to gross domestic expenditure on research and development. World total is based on 79 countries. High-income, upper middle-income and lower middle-income group consists of 39, 27 and ten countries respectively. R&D intensity is defined as R&D expenditure over GDP.

Source: WIPO estimates, based on data from UNESCO Institute for Statistics, Eurostat, OECD and World Bank, September 2011.

Finally, the share of software in total investment in knowledge is less than ten percent in the majority of countries (see Figure 1.4). Middle-income economies, many of which are located in Latin America, invest disproportionally in software, in order to catch up to levels similar to those in high-income economies.

1.2.3

INTERNATIONALIZATION OF SCIENCE AND INNOVATION

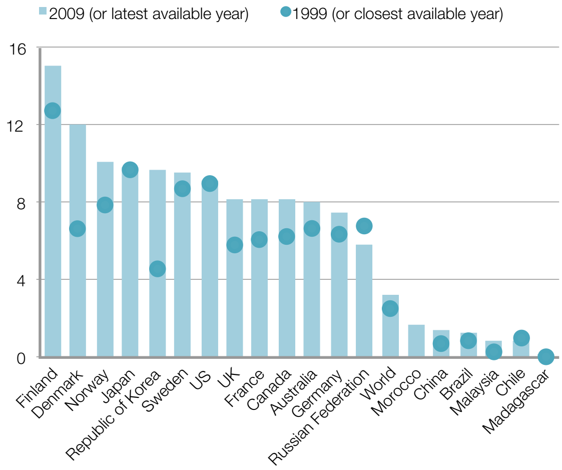
Increasing internationalization of science

Scientific research is becoming increasingly interconnected, with international collaboration on the rise. The increased importance attached to innovative activity is reflected in the growing number of researchers. In terms of worldwide distribution, the proportion of researchers in China increased from 12.3 percent in 1997 to 22.7 percent in 2008. For other major countries – the US, Japan and the Russian Federation – the share in the total has followed a downward trend.

In 2008, the average number of researchers per thousand labor force across the world was around 3.2, a considerable increase from 2.6 in 1999. In terms of researchers per labor force, the Scandinavian countries rank first, followed by Japan and the Republic of Korea (see Figure 1.8). In absolute terms, China has the largest pool of researchers but, relative to its labor force, the numbers are still small in comparison to high-income countries and the world average. Between 1999 and 2009, most countries increased the number of their researchers. The Russian Federation and Chile however experienced a drop in researcher intensity.

Figure 1.8: The number of researchers is growing in a larger number of countries

Researchers per 1,000 labor force, 1999 and 2009, or latest available



Note: Researchers data refer to full time equivalents. The world total is based on figures from 78 countries.

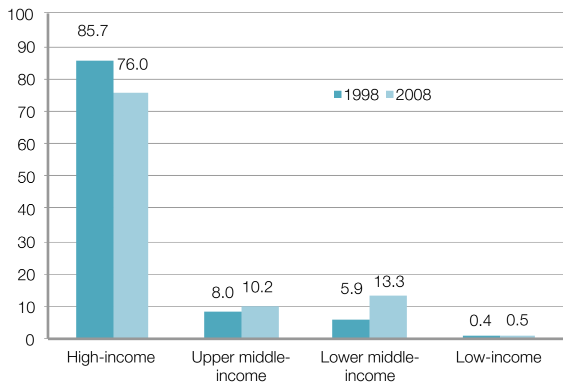
Source: WIPO based on data from UNESCO Institute for Statistics, Eurostat and OECD, September 2011.

This internationalization of skills is also mirrored in data showing the growing number of science and engineering graduates from countries such as China and India.[43] The increase in number of researchers and the S&T workforce has been accompanied by an increased mobility of students, highly-skilled workers and scientists in particular, positively influencing the international transfer of knowledge.[44]

In terms of internationalization of science, the last decades have seen a significant increase in worldwide scientific publications, to about 1.5 million peer-reviewed science and engineering articles in 2008 produced by 218 countries – up from less than one million publications in 2000.[45] Although scientific production is still far from the level in high-income economies, publication activity is increasing in middle-income economies (see Figure 1.9). This is again largely driven by a few economies such as India and China.

Figure 1.9: Science is becoming internationalized

Share of the world total of scientific and technical journal articles, by income group, in percent of total, 1998 and 2008



Source: WIPO, based on data by Thomson in National Science Board (2010).[46]

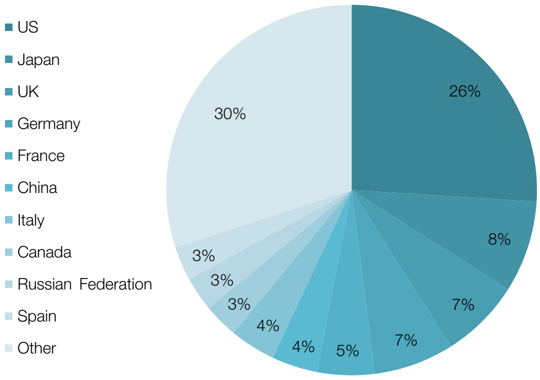
As a result, the sources of global scientific publications are changing (see Figure 1.10). The decreasing proportion of publications from the US, Japan, Germany, France and other leading high-income economies is most noteworthy. At the same time, China and India have risen to the fore, with, respectively, ten and two percent of publications in the period 2004-2008. Brazil, Malaysia, Singapore, The Republic of Korea, Thailand and Turkey also account for rising world shares of scientific publications.

Nonetheless, despite growth in journal contributions from other countries, scientific articles from high-income countries continue to attract the majority of citations.[47]

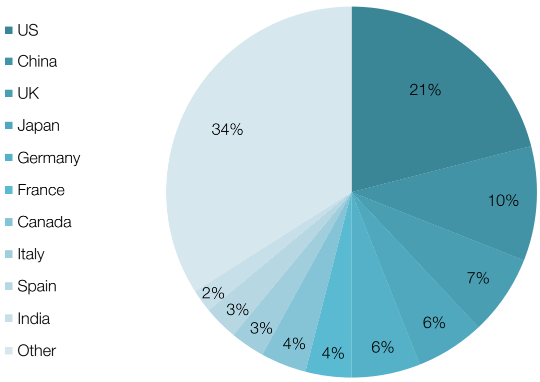
43 Based on data from UNESCO.
44 See Edler *et al.* (2011); and Filatotchev *et al.* (2011) on the positive effects of labor mobility on international knowledge spillovers.
45 See Royal Society (March 2011). Data based on Elsevier's Scopus database.
46 At *www.nsf.gov/statistics/seind10/append/c5/at05-25.xls*.
47 See Royal Society (March 2011).

Figure 1.10: Sources of global scientific publications are changing

Proportion of global publications, by country, in percent of total, 1993-2003



Proportion of global publications, by country, in percent of total, 2004-2008



Source: WIPO, based on data from Elsevier Scopus provided in Royal Society (2011).

Business R&D is becoming internationalized

Most international R&D investment is still confined to high-income economies, both in terms of investing and receiving economies. Furthermore, the largest cross-border flows of R&D continue to occur among the US, the EU and Japan. In the US, France and Germany, foreign affiliates of MNEs account for between 15 and 26 percent of total business manufacturing R&D. This figure reaches 35 percent in the UK, and more than 60-70 percent in Austria and Ireland.[48]

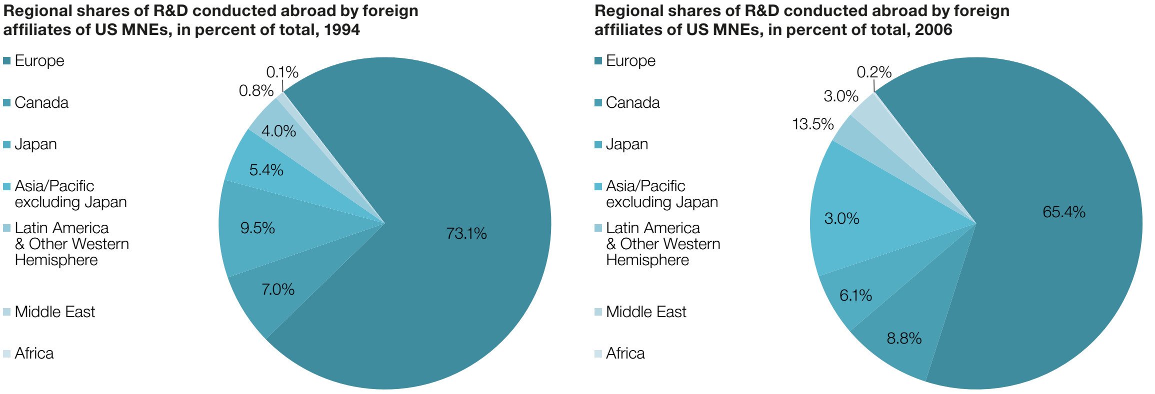
Attracted by rapidly expanding markets and the availability of lower-cost researchers and facilities, leading multinationals have nonetheless increased their R&D beyond high-income countries, in particular in large middle-income economies. The share of foreign affiliates in local R&D is higher in large middle-income countries such as China and Brazil than in high-income economies.[49]

The available evidence points to an increase in overseas R&D out of total R&D expenditure by MNEs, with a focus on a few centers of excellence. Annual overseas R&D expenditure by US MNEs, for instance, increased rapidly from almost USD 600 million in 1966 to around USD 28.5 billion in 2006.[50] High-income countries are by far the dominant location of R&D activity by US MNEs, accounting for about 80 percent of total overseas R&D expenditure (see Figure 1.11). Increases in R&D shares have occurred primarily in some high-performing East Asian economies, in particular China, Malaysia, the Republic of Korea, and Singapore. Nonetheless, they still stand at relatively modest levels, with China at about three percent and India about one percent of total overseas R&D by US MNEs.

The internationalization of business R&D is also concentrated in a few sectors. The following industries account for the bulk in US affiliates' overseas R&D: transportation equipment, including the car industry, at 29 percent of overseas R&D; chemicals, including pharmaceuticals, at 22 percent; and computer and electronic products, including software publishers, at 17 percent.[51]

48 OECD MSTI, June 2011.
49 See OECD (2010e) and Nolan (2009). In 2003, the share of foreign affiliates in total R&D was 24 percent in China, 48 percent in Brazil, 47 percent in the Czech Republic and 63 percent in Hungary.
50 At *www.nsf.gov/statistics/seind10/c4/c4s6.htm* and *www.bea.gov/scb/pdf/2010/08 percent20August/0810_mncs.pdf.*
51 See National Science Board (2010).

Figure 1.11: High-income countries are by far the dominant location of R&D activity



Note: Regions as defined by the US National Science Foundation.
Source: WIPO, based on data from the US Bureau of Economic Analysis and the US National Science Foundation.

The role of multinationals of middle-income economies in local innovation

MNEs from fast-growing middle-income economies have emerged as their revenues and innovation capacity become more similar to firms in high-income countries.

There were around 23,000 MNEs in middle- and low-income countries in 2009. This represents 28 percent of the total number of MNEs, compared to less than ten percent of firms in the early 1990s.[52] The number of firms from middle- and low-income economies that appear in company rankings by revenue, such as the Financial Times (FT) 500, has risen markedly.[53] Specifically, China has gone from zero firms in 2006 to 27 firms in 2011; Brazil from six to eleven; the Russian Federation from six to eleven; and India from eight to 14 firms in the 2011 FT500 ranking. In 2011, there were a total of 83 firms in the FT500 from middle-income countries, representing about 17.5 percent of total market capitalization, compared to 32 firms with 4.5 percent market capitalization in 2006.

Data on the top 1,000 global R&D spenders confirm that a number of multinationals from middle-income economies now conduct substantial R&D on a par with R&D-intensive multinationals of high-income countries (see Table 1.1). These MNEs come from a handful of countries only, notably China, with five firms in 2005 compared to 15 in 2009; and India, with two firms in 2005 compared to four in 2009. R&D-intensity is, however, still low. Whereas R&D expenditure over sales by US firms in the top 1,000 R&D spenders is about 4.5 percent, the average R&D-intensity of top Chinese R&D spenders included in this ranking is lower, also reflecting the sectoral affiliation of Chinese top R&D spenders.

52 See UNCTAD (2010).
53 The FT500 rankings can be gleaned from *www.ft.com/reports/ft-500-2011.*

FDI outflows from firms other than those in high-income economies are also growing, and stand at about 29 percent of total FDI in 2010. This is mainly driven by Chile, China, Egypt, Malaysia, Mexico, the Russian Federation, South Africa, Thailand and Turkey.[54] In 2010, six developing and transition economies – as defined by the UN – were among the top 20 investors. Flows of outward FDI from lower- or middle-income economies rose from about USD 6 billion in 1990 to USD 388 billion in 2010, about 29 percent of total outward flows.[55] These outward investments guarantee proximity to high-income markets and advanced innovation systems which can be exploited by cooperating with local suppliers, customers, universities and other actors.

Once more, this FDI outflow and related knowledge flows are still limited to a small group of economies with a relatively well-developed knowledge infrastructure. Apart from the rise in outward investment by China and the Russian Federation, no other low- or middle-income country has recently emerged as a significant outward FDI investor. Brazil, South Africa, India and fast-growing South-Asian economies were already outward investors by the 1980s.[56] If one eliminates a number of fast-growing middle-income countries, the percentage of outward FDI from lower- or middle-income countries as a share of global outward FDI declines to around 2.4 percent for the period 1993-2007.[57]

In relation to the growing innovation capacity of MNEs of less developed countries, discussions have recently focused on new concepts such as "frugal", "reverse" or "trickle-up" innovation. These types of innovation focus on needs and requirements for low-cost products in lower-income countries. At times, these new products or processes can also succeed in penetrating markets in high-income economies.[58] Local firms reinvent systems of production and distribution in the process, and also experiment with new business models while leveraging their familiarity with local customer needs.[59] Examples cited in this context include: the activities of Indian ICT providers in the software outsourcing market; the development by Indian firm Tata Motors of a car costing USD 2,000; and the sale by GE on the US market of an ultra-portable electrocardiograph machine originally built by GE Healthcare for doctors in India and China.

Analysis of this potential new development must move beyond anecdotal examples to better enable economists and policymakers to gauge its true economic ramifications.

54 See UNCTAD (2011).
55 See Athreye and Kapur (2009).
56 See Narula (2010).
57 *Idem.*
58 See Prahalad and Lieberthal (1998).
59 See, for instance, Ray and Ray (2010).

Table 1.1: Top R&D spenders from fast-growing middle-income countries, rank out of top 1,000 global R&D spenders, 2009

Rank	Name	Country	Industry Group	2009 R&D expenditure (USD, constant exchange rate)	Average R&D-intensity (2004-2009)	R&D-intensity (2009)
77	PetroChina Co Ltd	China	Oil & Gas	1,447	0.7%	1.0%
102	Vale SA	Brazil	Mining	996	2.5%	4.0%
123	ZTE Corp	China	Telecommunications	846	9.8%	9.6%
139	China Railway Construction Corp Ltd	China	Engineering & Construction	756	0.8%	1.5%
150	Petroleo Brasileiro SA	Brazil	Oil & Gas	690	0.8%	0.7%
186	China Petroleum & Chemical Corp	China	Oil & Gas	559	0.3%	0.3%
244	A-Power Energy Generation Systems Ltd	China	Electrical Components & Equipment	381	104.4%	122.3%
280	Dongfeng Motor Group Co Ltd	China	Auto Manufacturers	305	2.0%	2.3%
324	China Communications Construction	China	Engineering & Construction	254	0.4%	0.8%
330	China South Locomotive and Rolling Stock Corp	China	Machinery-Diversified	246	2.4%	3.7%
355	Lenovo Group Ltd	China	Computers	214	1.4%	1.3%
357	Metallurgical Corp of China Ltd	China	Engineering & Construction	212	0.6%	0.9%
401	Byd Co Ltd	China	Auto Manufacturers	188	3.1%	3.3%
426	Tencent Holdings Ltd	China	Internet	174	8.9%	9.6%
445	Shanghai Electric Group Co Ltd	China	Machinery-Diversified	162	1.2%	1.9%
446	Semiconductor Manufacturing International Corp	China	Semiconductors	161	7.7%	15.0%
517	Shanghai Zhenhua Heavy Industry	China	Machinery-Diversified	137	1.5%	3.4%
523	China CNR Corp Ltd	China	Machinery-Diversified	136	1.9%	2.3%
627	Tata Motors Ltd	India	Auto Manufacturers	105	0.4%	0.5%
683	China Railway Group Ltd	China	Engineering & Construction	95	0.2%	0.2%
696	Dongfang Electric Corp Ltd	China	Electrical Components & Equipment	93	1.8%	1.9%
699	Infosys Technologies Ltd	India	Computers	92	1.4%	1.9%
788	CPFL Energia SA	Brazil	Electric	79	0.8%	1.5%
799	Dr Reddys Laboratories Ltd	India	Pharmaceuticals	78	6.3%	5.3%
819	Lupin Ltd	India	Pharmaceuticals	75	6.6%	7.5%
846	Empresa Brasileira de Aeronautica	Brazil	Aerospace & Defense	73	1.7%	1.3%
848	Reliance Industries Ltd	India	Oil & Gas	73	0.2%	0.2%
849	Sun Pharmaceutical Industries Ltd	India	Pharmaceuticals	73	8.7%	7.8%
906	Harbin Power Equipment Co Ltd	China	Electrical Components & Equipment	68	1.6%	1.6%
921	China National Materials Co Ltd	China	Machinery & Construction & Mining	67	0.7%	1.5%
925	Weichai Power Co Ltd	China	Auto Parts & Equipment	66	1.3%	1.3%
968	Baidu Inc/China	China	Internet	62	9.0%	9.5%
976	Shanda Interactive Entertainment Ltd	China	Internet	61	7.8%	8.0%
992	Totvs SA	Brazil	Software	60	10.7%	12.0%

Note: R&D intensity as defined by R&D over revenues. The database only contains publicly-listed companies.
Large R&D spenders such as Huawei (China telecommunications) which have similarly large R&D budgets are thus not included.

Source: WIPO, based on Booz & Company Global Innovation 1,000 database.

1.2.4

The importance of non-R&D-based innovation

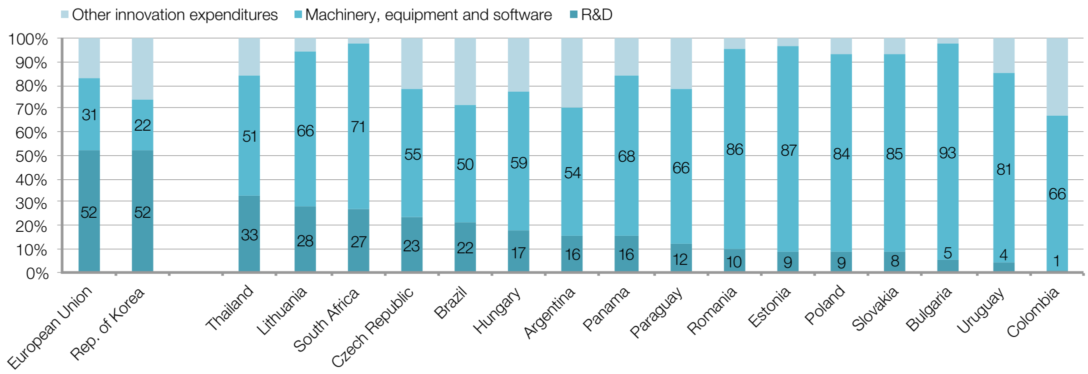
As described at the outset, the rise and globalization of R&D is not the only characteristic of the new innovation landscape. Innovation not based on R&D, including non-technological innovation, is increasingly perceived as an important contributor to economic growth and development. The service sector in particular has increased its efficiency by reorganizing business processes, in part facilitated by ICTs.

Specifically, innovation surveys find that a large share of innovative firms do not conduct any formal R&D. Specifically, almost half of innovative firms in Europe do not carry out R&D in-house.[60] Moreover, data from innovation surveys show that non-R&D innovators are relatively more prevalent in low-technology manufacturing and the service industries. Sectors with low R&D-intensity, such as textiles, clothing and paper, can be as likely to innovate as high-tech industries.[61] Surveys also find that it is small and medium-sized firms in particular which innovate without conducting formal R&D.

In the case of middle- or low-income economies, innovation expenditure by firms from the manufacturing sector often concerns machinery and equipment or related expenditure, rather than R&D (see Figure 1.12). Innovation is much more incremental. Whereas in the European Union (EU)-15, firms claim that new machinery and equipment is only responsible for about 22 percent of their innovation expenditure, in economies such as Bulgaria, Colombia, Paraguay, South Africa and Uruguay this figure can exceed 60 percent of total innovation expenditures. In these countries, investment in physical assets can increase productivity and lead to valuable organizational innovation.

Figure 1.12: Firms in middle- and lower-income countries invest in machinery and equipment to innovate

Distribution of innovation expenditure by firms in manufacturing industries, in percent of total, 2008 or last available year, selected countries



Note: Indicators refer to the manufacturing industry except for South Africa and Thailand whose indicators reported refer to manufacturing and services industries. The indicator for the European Union-15 is the average share across countries.[62]

Source: Zuñiga (2011) based on innovation Surveys.[63]

60 See the Third Community Innovation Survey.

61 See, for instance, Mendonça (2009) and the other papers in this special issue of Research Policy on Innovation in Low- and Medium-technology Industries.

62 The EU-15 figures include Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Luxembourg, the Netherlands, Portugal, Spain, Sweden, and the United Kingdom. Data for Austria and Italy which are normally EU-15 is not available.

63 Argentina: 1998-2001; Brazil: 2005; Colombia: 2003-2004; 2008; Uruguay: 2005-2006; Paraguay: 2004-2006; Thailand: 2003 and South Africa: 2002-04. Data for EU-15 countries are from Eurostat Chronos (Innovation surveys 2006).

Beyond the non-R&D innovation expenditure discussed above, research suggests that process and organizational innovation can be a prominent driver of improved firm performance. In fact, this is perhaps the most important form of non-technological innovation, particularly in the service sector.[64] Furthermore, the introduction of innovative and new technologies frequently requires enhanced skills as well as complementary organizational changes in administration and structure. Technological and organizational innovation are thus often complementary.

Nevertheless, the existing economic literature acknowledges that measuring the positive contribution of process and organizational innovation to productivity is much harder (see Section 1.1).[65] One reason for the lack of evidence in this area is that the interactions between and complementary nature of technological and non-technological innovation are hard to measure and fully assess.

64 See, for instance, Evangelista and Vezzani (2010).

65 See Hall (2011).

1.2.5

Greater collaboration in the process of innovation

Innovation has always taken place in the context of institutional and other linkages between various innovation actors.

Yet another transformation in the much discussed new innovation paradigm is the increasingly collaborative nature of innovative processes. According to this view, firms increasingly seek valuable knowledge and skills beyond their own boundaries, in order to enlarge their capabilities and enhance their assets (see Chapter 3). Joint innovation activity involves formal cooperation modes such as R&D consortia, research ventures, IP-based forms of collaboration, co-production, co-marketing or more informal modes of cooperation. Lastly, collaboration also occurs between universities, public research organizations and firms (see Chapter 4).

Such collaboration has been facilitated as innovation processes and activity have become more easily fragmented. Moreover, the expansion of markets for technologies that allow for knowledge exchange via patent licenses and other IP-based forms of exchange have been a driver of collaboration.

Collaboration is at the heart of innovation, but measurement remains difficult

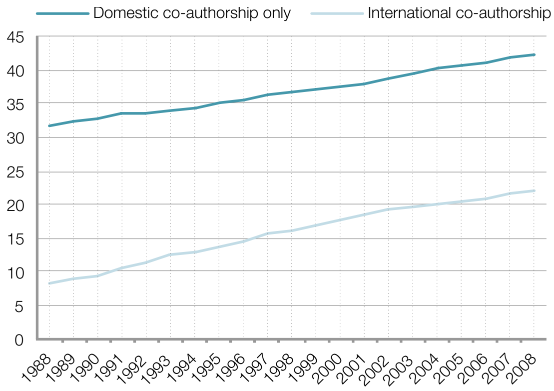
The statistics available for assessing frequency, type and impact of collaboration are limited. They are mostly based on data relating to R&D, publications, patents or innovation surveys, all of which have their limitations. A significant share of collaborative activity also remains unmeasured and/or is kept secret. Importantly, existing data say little about the quality dimension and impact of cooperation. As highlighted above, collaboration covers a wide field and involves different degrees of involvement, from sharing information through to conducting joint R&D and product development. Related impacts of cooperation might also materialize over time.

Despite these caveats, existing measures suggest that cooperation between firms and between firms and the public sector is increasing over time:

- **Increased cooperation on scientific publications:** About 22 percent of all peer-reviewed science and engineering articles in 2007 were published with international co-authorship, which is about three times higher than in 1988 (see Figure 1.13). About 42 percent of articles are co-authored domestically, up from about 32 percent in 1988.

Figure 1.13: International and domestic co-authorship are on the rise

Share of co-authored science and engineering articles, as a percentage of total global publications, 1988-2008



Source: WIPO, based on Thomson Reuters data in National Science Board (2010).

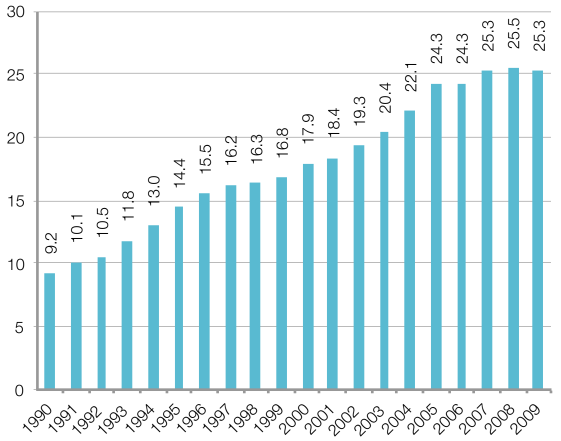
- **Prevalence of R&D partnerships in certain key sectors:** Empirical studies show that the number of R&D partnerships is particularly important in a number of industries, such as ICTs and biotechnology (see Chapter 3).[66]

- **Increased R&D outsourcing and contract research:** Outsourcing of R&D – either to other private or to public organizations such as universities – has also become an integral, albeit usually small, complement to in-house R&D. R&D contracted out by US manufacturing companies has, for instance, increased from 3.3 percent of total R&D in 1993 to 8.5 percent in 2007.[67] Data on companies that spend the most on R&D reveal that, on average, nine out of ten firms outsource 15 percent of their R&D.[68] Two-thirds of this outsourced R&D is conducted by other companies and one-third by public research organizations.[69]

- **Increased number of patent co-inventors:** An increasing number of inventors from diverse countries apply together for one and the same patent (see Figure 1.14 and Box 1.3).

Figure 1.14: International collaboration is increasing among inventors

Patent applications filed under the Patent Cooperation Treaty (PCT) with at least one foreign inventor, as a percentage of total PCT filings, 1990-2009



Note: The data reported above are based on published PCT applications.

Source: WIPO Statistical Database, July 2011.

66 See, for instance, the relevant work of John Hagedoorn on this issue at *www.merit.unu.edu/about/profile.php?id=26&stage=2*.

67 See National Science Board (2010). These figures include company-funded and company-performed R&D.

68 See OECD (2009).

69 Note that this study was only based on a non-representative sample of 59 companies.

Box 1.3: Caveats in the use of data on co-patenting as an indicator of international collaboration

Patent data showing the frequency of co-inventions, i.e., patents with several inventors listed as applicants, are frequently used to demonstrate that international collaboration among inventors is increasing.[70]

One of the advantages of patent data is their wide availability for many countries. One can use national patent data or data generated by the PCT System to showcase joint patent applicants with different national backgrounds.

To identify forms of "international" collaboration one assesses the nationality and/or residence of multiple inventors assigned to a particular patent. With increased global mobility and inventors with multiple or changed nationalities and residences, applying this procedure to identify true cross-border collaboration is not straightforward. If based solely on an inventor's nationality as shown in patent databases, the following circumstances, for instance, could lead to the erroneous conclusion that cross-border cooperation had occurred where it actually had not: intra-organizational collaboration between two inventors of different nationalities who are in the same location for the duration of the project; collaboration between two inventors who reside in two different countries but work in the same country; an inventor who moves to a different country after a project has ended with the new residence appearing on the patent due to formal administrative delays.

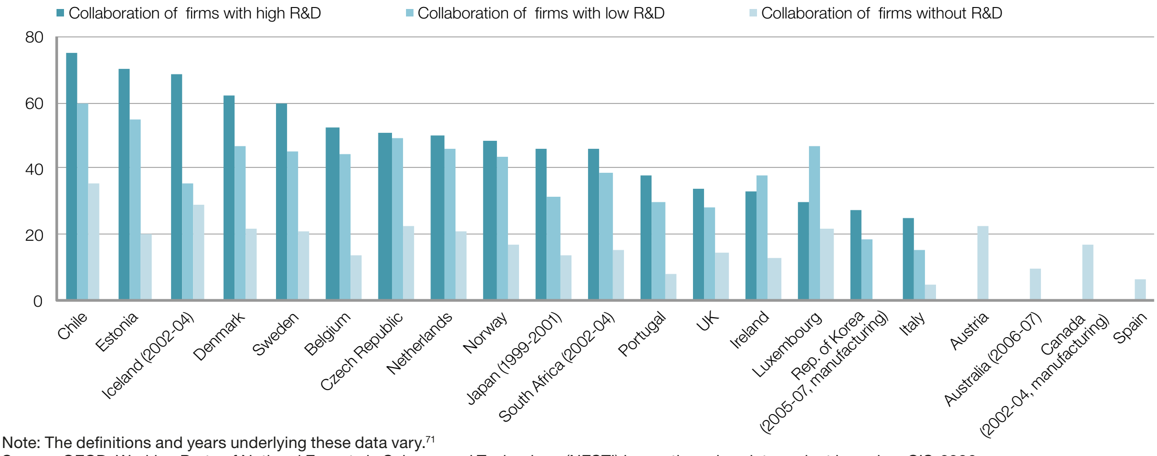
In a recent paper by Bergek and Bruzelius (2010), the relevance of considering patents with multiple inventors from different countries as an indicator of international R&D collaboration has thus been questioned. Focusing on Swiss energy and automation firm ABB, the study shows that half of this firm's patents which, according to existing methods, would be treated as if they were the result of international collaboration, are truly not. The other half would erroneously be qualified as "international collaboration" for the reasons listed above.

- Increased national and international collaboration in innovation: Innovation surveys show that more R&D-intensive firms collaborate more than those that conduct less R&D. In Chile, for instance, 74 percent of the most R&D-intensive innovative firms collaborate – defined as firms that innovate and have the highest ratio of R&D expenditure over sales – while only 60 percent of other R&D performers and only 35 percent of innovative firms that do not conduct R&D collaborate (see Figure 1.15). Collaboration in les developed economies tends to proceed on a different basis in such R&D constrained environments, such as the need to simply adapt products for local consumption. Surveys also show that the propensity to collaborate on innovation with partners abroad varies widely between countries (see Figure 1.16).

70 See, for instance, OECD (2010c) and WIPO (2010).

Figure 1.15: Increasing R&D expenditure and collaboration go hand in hand

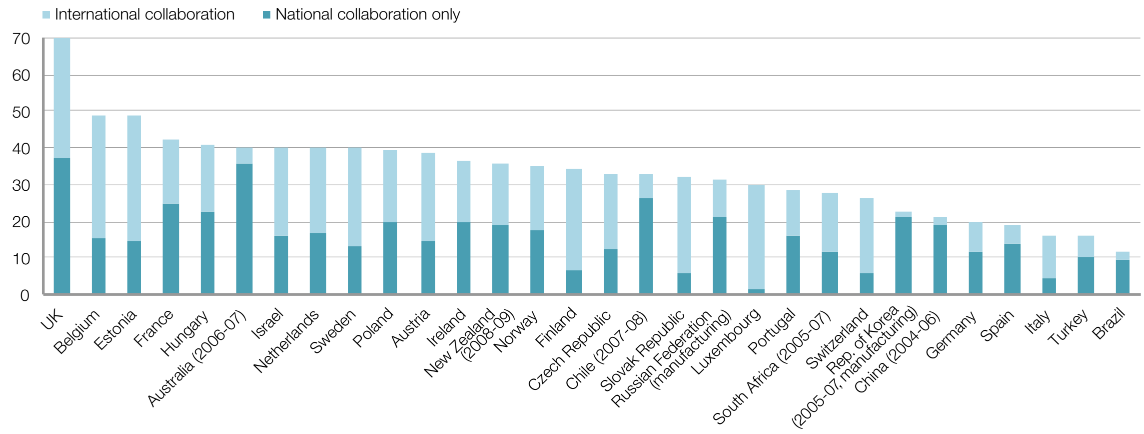
Collaboration on innovation, by R&D-intensity of firms and as a percentage of innovative firms, 2004-2006, selected countries



Note: The definitions and years underlying these data vary.[71]
Source: OECD, Working Party of National Experts in Science and Technology (NESTI) innovation microdata project based on CIS-2006, June 2009 and national data sources.

Figure 1.16: The degree and form of collaboration vary widely between countries

National and international collaboration on innovation by firms, as a percentage of innovative firms, 2006-2008, selected countries



Note: The definitions and years underlying the data vary.[72]
Source: OECD (2011), based on the Eurostat Community Innovation Survey-2008 and national data sources, June 2011.

71 For Australia, data refer to 2006-07 and innovative firms include technological and non-technological innovators; for Brazil only the following activities are included in the services sector: International Standard Industrial Classification (ISIC) Rev.4 Divisions 58, 61, 62 and 72; for Chile, data refer to 2007-08 and firms with ongoing or abandoned innovative activities are not identified. Data are based on ISIC Rev.3.1 and include a wider range of activities such as agriculture, forestry, fishing, construction, and some services; for China, data refer to 2004-06 and exclude all services. In addition, large firms are defined as firms with over 2,000 employees, over Chinese Yuan 300 million turnover and over Chinese Yuan 400 million capital. SMEs are the remaining firms with at least Yuan 5M turnover; for Korea, data refer to 2005-07 and cover only firms with more than 10 employees in the manufacturing sector. International collaboration may be underestimated; for New Zealand, data refer to 2008-09 and include firms with six or more employees. Innovative firms include technological and non-technological innovators; for the Russian Federation, data refer to manufacturing firms with 15 or more employees; for South Africa, data refer to 2005-07 and include the retail trade sector; for Switzerland, data only include R&D collaboration; for Turkey, data are based on the Classification of Economic Activities in the European Community (NACE) Rev.1.1 and exclude some activities within NACE Rev.2 Divisions J58 and J63.

72 *Idem.*

To sum up, the above and other similar statistics show that collaboration of various forms is indeed at the heart of innovation. Yet, these and other data also demonstrate that collaboration, in particular formalized forms such as R&D joint ventures or other technology alliances, are far from the norm.[73] To the contrary, there are good reasons why the extent of formal collaboration remains limited (see Chapter 3) and why other innovation strategies, for example the acquisition of other firms and their technologies, are important in practice.

Importantly, geographical proximity still matters when forming innovation-related partnerships as, despite increased internationalization, innovative activity is often conducted in clusters.

What is "open innovation" and how important is it really?

Complementing the above trend towards increased collaboration, recent contributions in the innovation literature discuss the emerging phenomenon of "open innovation".[74]

Chesbrough *et al*. (2006) defines open innovation as "the use of purposive inflows and outflows of knowledge to accelerate internal innovation and to expand the markets for external use of innovation, respectively". Increasingly, companies are said to "openly" innovate by enlarging the process to include customers, suppliers, competitors, universities and research institutes, and others, as they rely on outside ideas for new products and processes.

The business literature also refers to "crowd-sourcing", which allows firms and other organizations to find solutions to business and other challenges by seeking the expertise of a large number of potential "solvers", customers, suppliers and the like.

Table 1.2 describes four forms of open innovation, some of which involve pecuniary compensation for ideas and others that do not. Two of these forms are associated with inbound and two with outbound open innovation.

- **Inbound open innovation** is the practice of leveraging the technologies and discoveries of others. It requires the opening up to, and establishment of interorganizational relationships with, external entities. It aims to access others' technical and scientific competencies. Proprietary technologies are transferred to the initiating entity for commercial exploitation.

- **Outbound open innovation** is the practice of establishing relationships with external organizations to which proprietary technologies are transferred for commercial exploitation.

73 See Tether (2002).
74 OECD (2009); Chesbrough (2003); and Dahlander and Gann (2010).

Table 1.2 Open innovation and related practices

	Description	Opportunities	Challenges
Outbound innovation (non-pecuniary)	Internal resources are revealed to the external environment, without offering immediate financial reward, seeking indirect benefits for the focal firm. Activity: Disclose in formal & informal ways, inform and publish.	Fosters a steady stream of incremental innovation across the community of firms. Enables a marshalling of resources and a gaining of legitimacy with other innovators and firms.	Difficulty in capturing benefits that accrue. Risk of leakages.
Outbound innovation (pecuniary)	Firms commercialize their inventions and technologies by selling or licensing out resources developed in other organizations. Activity: Sell, license out, contract out.	Commercializes inventions that might otherwise have been ignored, with greater leveraging of innovative investment. Externalizes internal knowledge and inventions by communicating them to the marketplace where others might be better equipped to exploit them.	Significant transaction costs involved in transferring technologies between organizations. Difficulty in anticipating the potential and accurate value of one's own inventions.
Inbound innovation (non-pecuniary)	Firms use external sources of innovation such as competitors, suppliers, universities, etc. Activity: Learning formally and informally, crowd-sourcing, Internet solver platforms.	Allows the discoveries of others to be leveraged where complementary resources permit. Enables the discovery of new ways of solving problems.	Danger that organizations over-search by spending too much time looking for external sources of innovation and relying on them.
Inbound innovation (pecuniary)	Firms license-in and acquire expertise from outside. Activity: Buy, contract in, license in.	Ability to gain access to resources and knowledge partners. Possibility to leverage complementarities with partners.	Risk of outsourcing critical aspects of the firm's strategically important business. Effectiveness of openness hinges on resource endowments of the partnering organization. Cultural resistance within firms.

Source: WIPO adapted from Dahlander & Gann (2010) and Huizingh (2011).

All modes of collaboration shown in Table 1.2 can occur with varying degrees of openness.[75] Importantly, open innovation is almost always managed either formally, for example via contracts or firm policies, or informally, such as via community norms, trust or the implicit corporate culture.[76]

In formal settings, open innovation relies on traditional models such as licensing of various forms of IP, subcontracting, acquisitions, non-equity alliances, R&D contracts, spin-offs, joint ventures for technology commercialization, the supply of technical and scientific services, and corporate venturing investment.[77] Many of these partnership models resemble standard practices used in innovation collaboration (see Box 1.4 for examples from the biopharmaceutical industry).

Box 1.4: Open Innovation in the biopharmaceutical industry

Biopharmaceutical firms have used different organizational modes – i.e., licensing agreements, non-equity alliances, purchase and supply of technical and scientific services – to enter into relationships with different types of partners, with the aim of acquiring or commercially exploiting technologies and knowledge. These relationships can include large pharmaceutical companies, biotechnology product firms, biotechnology platform firms and universities.

A recent analysis shows at least two changes in these firms' approach to inter-organizational exchange of technologies and knowledge consistent with the open innovation paradigm: (i) biopharmaceutical firms have gradually modified their innovation network to include more and more external partners operating outside of their core areas; and (ii) alliances play an increasing role among the organizational modes implemented by these firms.

Three phases in drug development are particularly prone to the use of these innovation models:

1) **Alliances, taking place in the target identification and validation phases:** Biopharmaceutical companies establish partnerships without equity involvement in other biotech firms, pharmaceutical companies, universities or public research centers), with the aim of pursuing a common innovative objective, for example, the validation of a genetic target. Biopharmaceutical firms partner with other companies to assess certain complementary assets, for example the production capacity or distribution channels required to commercially exploit a new drug.

75 See Gassmann and Enkel (2004).
76 See Lee *et al.* (2010).
77 See Bianchi *et al.* (2011).

2) **Purchase of scientific services, related to lead identification and optimization:** Through this organizational mode, biopharmaceutical firms involve specialized players – usually biotech platform firms and, although less frequently, universities and research centers – in a specific phase of the innovation process, for example lead optimization activity, under a well-defined contractual agreement. Biopharmaceutical firms also provide technical and scientific services to third parties, which leverage the outcome of their discovery efforts.

3) **Preclinical tests and post-approval activities:** Biopharmaceutical firms acquire the rights to use a specific preclinical candidate typically from another biotech firm, a pharmaceutical company or, although less frequently, from a university.

Source: Bianchi *et al.* (2011).

Among open innovation models, new forms of inbound innovation seem particularly original. Most are Internet-enabled processes that foster customer-driven innovation such as "crowd-sourcing" and "competitions for solutions". These have taken various forms, all with the goal to generate new ideas:

- Firms or other organizations provide potential partners the possibility to submit new research projects or apply for new partnership opportunities;
- Firms solicit user feedback on new or existing products and their design;
- Firms and others host competitions and award prizes – either targeted at their own subsidiaries or suppliers, at outside professionals or the public at large.

Table 1.3 provides examples of these inbound open innovation models. While firms have already sought customer or supplier feedback in the past, the number and diversity of activity in this area is noteworthy.

Table 1.3: Open innovation platforms, selected examples

Tools or platforms to capture ideas from consumers or other contributors	• Apple's adoption of ideation software like Spigit to capture audience ideas • Portals of Starbucks, Procter & Gamble and Dell to allow customer feedback • IBM online brainstorming sessions (Jams) for employees, clients, business partners and academics
Prizes and competitions	• Tata Group Innovista competition to spur innovation among subsidiaries • Bombardier open innovation contest "You Rail", calling on designers to submit ideas for modern transportation • Peugeot Concours Design for aspiring car designers • DuPont international competition to develop surface technologies • Japanese retail chain MUJI's open innovation contests • James Dyson Award for design innovation • Seoul Cycle Design Competition 2010 for new bicycle designs • The Center for Integration of Medicine & Innovative Technology competition to improve the delivery of medical care
Co-creation platforms	• Lego Mindstorms allowing customers to create Lego designs and robots • DesignCrowd connecting clients and solvers to supply designs
Platforms connecting problems and solvers/ exchange of IP	• Various platforms for companies to post challenges: InnoCentive, Grainger, Yet2, Tynax, UTEK, NineSigma, YourEncore, Innovation Exchange, Activelinks, SparkIP • Open IDEO, a platform putting forward social challenges related to health, nutrition and education

Formal mechanisms also play a role in new Internet-based competitions and problem-solving platforms. Competitions, prizes or problem-solving platforms set up specific rules for the ideas submitted and the IP they subsequently generate (see Box 1.5). All platforms offer different IP- and other related terms of service. Yet, most if not all contain similar rules on the assignment of IP and of ownership of the ideas generated. The IP is either taken over by the initiating firm as part of the prize money, or is subject to a future licensing or other contractual arrangement.

IP and open innovation are thus often complementary. Often, the firms that file the most patent applications are – at least by their own account – the most ardent practitioners of open innovation, for example, IBM, Microsoft, Philips, Procter & Gamble.[78]

78 See Hall (2009).

Box 1.5: The attribution of ideas in open innovation contests, competitions and platforms

A review of the terms of service of InnoCentive yields the following IP-related rules:

- Individual solvers who opt to work on a specific problem featured on the platform must often sign a non-disclosure agreement before receiving the relevant information allowing them to begin searching for a solution.

- Firms already aware of a particular solver's existing IP are not obligated to pay for a solution proposing that IP. Firms should specify that "novel" solutions are required.

- Once a solver accepts the challenge award, the IP is transferred to the seeker. If the solver already holds a patent on the solution selected, the right to use that patent is transferred to the seeking entity. The solver is responsible for determining his/her ability to transfer the IP and is obligated to cooperate to ensure that the seeker obtains all rights, titles and interests in the solution and any work product related to the challenge.

- The solver must, on request, obtain a signed and notarized document from his or her employer waiving any and all rights to IP contained in the solution.

- Solutions not acquired by seekers are guaranteed not to show up in a seeker's IP portfolio at a later stage.

Source: Terms of Use, InnoCentive.[79]

Various phenomena have emerged in recent years based on Internet-enabled collaboration, sometimes without a market context, according to which individuals develop innovative solutions for the public domain. In this context, open source software, where individual software programmers invest time and resources in solving particular problems without apparent direct remuneration, has captured the most attention (see Chapter 3).

New inbound innovation models are also increasingly used for other not-for-profit objectives or to solve challenges that lie between purely commercial and non-commercial interests. Firms, universities, new entrepreneurial platforms and governments have used such contests and platforms to generate solutions to societal challenges ranging from education, access to health, access to water and other issues.

In the same spirit, collaborative efforts between the public, the non-profit and private sectors are under way which aim at inventions and innovation that the market alone might not be able to generate. New R&D funding mechanisms for solutions to rare diseases or other social challenges have attracted increasing interest.[80]

These activities have piqued the interest of scholars and practitioners alike, including in the quest to determine whether such innovative methods could be a new source of innovation.

As in the case of more traditional collaboration models, assessing the true scale and importance of open innovation is hindered by definitional and measurement challenges. Drawing a clear distinction between long-standing collaborative practices and truly new practices is difficult. Indeed, long-time existing practices, for example the identification of research partners in foreign markets, are now often relabeled by firms as part of their "open innovation" strategies.

The available data (in part discussed in the previous subsection) confirm an increased interest in leveraging external sources of knowledge to complement firms' internal activities.[81] When asked how much open innovation they are conducting, large MNEs – in particular in the IT, consumer product and, more recently, pharmaceutical sectors – claim substantial involvement in these new areas.[82] To some extent, the increased journalistic and academic attention devoted to open innovation contributes to this perceived increase. Firms are eager to portray themselves as active participants in and to show their willingness to be a part of new innovation management processes.

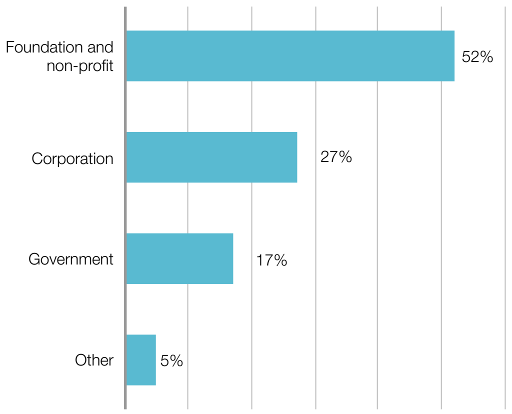
79 See *www.innocentive.com/ar/contract/view.*
80 Finally, the rise of Internet platforms is important, with attention focusing on phenomena such as user-created content on platforms such as Wikipedia and YouTube and new institutional forms such as Creative Commons, mostly relating to the production of creative works and journalism.
81 See Chesbrough and Crowther (2006).
82 See OECD (2009).

Yet, data on the actual uptake of new forms of collaborative innovation, their qualitative dimensions and effectiveness are missing. It is primarily the business management literature which has assessed the phenomenon, mostly on the basis of case studies focusing on a few sectors and firms in high-income economies. These case studies center mostly on high-technology industries, mainly the IT and to some extent the pharmaceutical sector. Follow-up studies on a more diverse set of industries, including more mature ones, are currently being undertaken to assess how fundamental this shift is across different industries.[83]

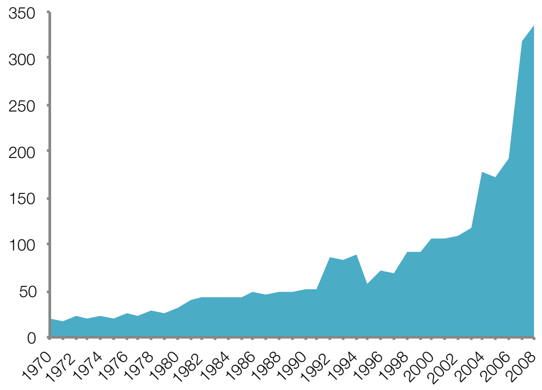
The same is true for empirical assessments of the role of prizes in the new innovation environment (see also Chapter 2 on prizes). Undeniably, their importance to innovation and policy discussions seems to be growing, albeit from a low baseline. More than 60 prizes worth at least USD 100,000 were introduced between 2000 and 2007, representing almost USD 250 million in new prize money over those seven years (see Figure 1.17).[84] The aggregate value of such large awards has more than tripled over the past decade, to USD 375 million. In comparison to total spending on business R&D in the US, however – namely USD 365 billion in 2008 alone – this figure is still exceedingly small. The source of funding for prizes has diversified (see Figure 1.17).

Figure 1.17: The sources of prizes are diversifying while the size of allocated funds is increasing from low original levels

Sources of philanthropic prizes, as a percent of total, 2000-2008



Funds allocated to prizes over USD 100,000, in USD millions, 1970-2009



Note: Based on database of 223 prizes worth USD 100,000 or more.

Source: Data obtained from Social Sector Office, McKinsey & Company, updated from McKinsey & Company (2009).

Obtaining a clear picture of the number of problems solved via competitions offering prizes or through new innovation platforms is challenging. Furthermore, assessing their contribution relative to other existing innovation channels is even harder. The related firm- or economy-wide impacts – including from the perspective of middle- or low-income countries – have not yet been seriously studied and will have to be explored further in order to demonstrate the transformative nature of these new practices.[85]

On the whole, the lack of quantitative evidence on the scope and impact of this phenomenon does mean the phenomenon should be discarded as meaningless. This holds true in particular if one accepts that most forms of innovative activity – in the present and past – have relied on some form of collaboration with varying degrees of openness.

83 See Bianchi *et al.* (2011).
84 See McKinsey & Company (2009).
85 An ongoing WIPO project on open innovation seeks to close this gap and to provide more analytical evidence. See document CDIP/6/6 on the Committee on Development and Intellectual Property's (CDIP) Open Collaborative Projects and IP-based Models at *www.wipo.int/edocs/mdocs/mdocs/en/cdip_6/cdip_6_6.pdf*.

1.3

Shifting importance of IP

IP not only drives change in the field of innovation but is itself also impacted by the changing innovation system. In the new innovation landscape, IP is a vehicle for knowledge transfer and protection, facilitating vertical disintegration of knowledge-based industries. New types of firms – and in particular new types of intermediaries – thrive as a result of their intangible IP assets. Invariably, the nature of innovation also impacts the demands on the IP system.

1.3.1

Demand and the changing geography of the IP system

A few years ago, patenting and other forms of IP activity were mostly seen as belonging to the domain of corporate legal departments, with patents used mainly in-house.

Today, an increasing number of companies treat IP as a central business asset that is managed strategically and valued and leveraged with a view to generating returns through active licensing.[86] Patents in particular are increasingly used as collateral for bank loans by patent holders, and as investment assets by financial institutions.[87] Small enterprises, newly-established or research-oriented firms depend on IP to generate revenue and use IP to obtain financing, including venture capital investments (see Chapter 2).[88] Beyond patents, business models and firm strategies tend to rely on complementary protection of trademarks, designs and copyright, although this trend and the complementarity to patent use are harder to quantify.

At the same time, there has been a shift in the IP landscape with new countries emerging as important players and greater emphasis placed on international protection of inventions. This has also invariably led to a growing demand for IP.

Growing demand for IP rights

Over the last two decades, the use of the IP system has intensified to unprecedented levels.

Demand for patents increased across the world from around 800,000 patent applications in the early 1980s to 1.8 million by 2009, with the greatest increase in demand occurring as of the mid-1990s. Growth in patent applications was stable until the 1970s, followed by acceleration, first in Japan and then in the US. Growth in fast-growing middle-income countries such as China and India picked up from the mid-1990s onwards (see Figure 1.18, at top).

86 See Arora *et al.* (2001); Gambardella *et al.* (2007); and Lichtenthaler (2009).

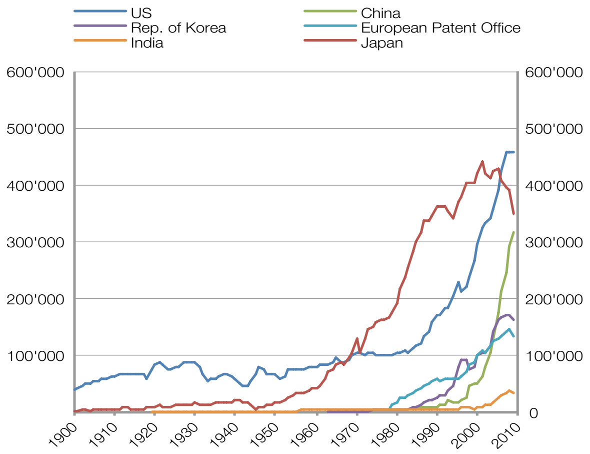
87 See Kamiyama (2005) and Otsuyama (2003).

88 See WIPO (2011d).

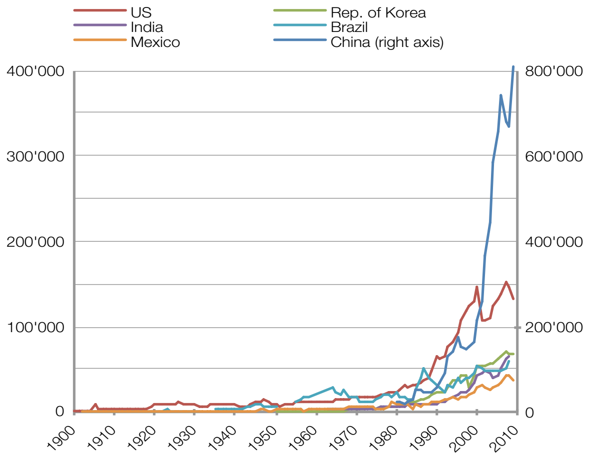
Trademark applications show a similar trend. However, accelerated activity began in the mid-1980s at the United States Patent and Trademark Office (USPTO), with trademark activity at other IP offices following during the 1990s (see Figure 1.18, at bottom). Trademark demand increased from just below one million registrations per year in the mid-1980s to 3.2 million trademark registrations by 2009.

Figure 1.18: Demand for patents and trademarks has intensified to unprecedented levels

Patent applications at selected offices, 1900-2010



Trademark applications at selected offices, 1900-2010



Note: The figures show applications data for the six top offices. Data for other large offices exhibit a similar trend. One or more classes may be specified on each trademark application, depending on whether an IP office has a single or multiclass filing system, thus complicating the comparison between countries.[89]

Source: WIPO Statistics Database, October 2011.

Other kinds of IP, such as utility models and industrial designs, have seen similar albeit smaller growth over the past decade.[90] Whereas growth in patent and trademark activity is more broad-based, increases in utility model and industrial design applications at the global level are mainly driven by China. Nonetheless, utility models have experienced substantial growth in selected countries, particularly in middle- and lower-income economies.[91] This also applies to design applications, including their international registration via the Hague System (see Box 1.6).

89 In the international trademark system and in certain IP offices, an applicant can file a trademark application specifying one or more of the 45 goods and services classes defined by the International Classification of Goods and Services under the Nice Agreement. IP offices have either a single-class or multiclass application filing system. For better international comparison of trademark application activity across offices, the multiclass system used by many national offices must be taken into consideration. For example, the offices of Japan, the Republic of Korea, the US as well as many European offices all use multiclass filing systems. The offices of Brazil, China and Mexico follow a single-class filing system, requiring a separate application for each class in which applicants seek trademark protection. This can result in much higher numbers of applications at these offices than at those that allow multiclass applications. For instance, the number of applications received by the trademark office of China is over 8.2 times that received by Germany's IP office. However, class count-based trademark application data reduce this gap to about 2.8 times. See WIPO (2010).

90 The number of worldwide utility model applications increased from around 160,000 in 2000 to approximately 310,000 in 2008, and the number of worldwide industrial design applications grew from around 225,000 in the mid-1980s to around 655,000 by 2008. The growth in utility model and industrial design applications is mostly due to the substantial increase in the level of activity in China.

91 See WIPO (2010).

Box 1.6: Design is important for product innovation

Design seems to be increasingly important in helping turn technological inventions into innovative new commercial products, i.e., facilitating the journey of technology or an invention from development through to the marketplace.[92] The latest estimates for the UK put spending on new engineering and architectural design at Great Britain Pounds (GBP) 44 billion, or 30 percent of all intangible investments.[93] This represents one and a half times the estimated expenditure by firms on training and five times the spending on R&D. A new study for the UK also shows that the majority of IP investment is on assets protected by copyright and design rights.[94]

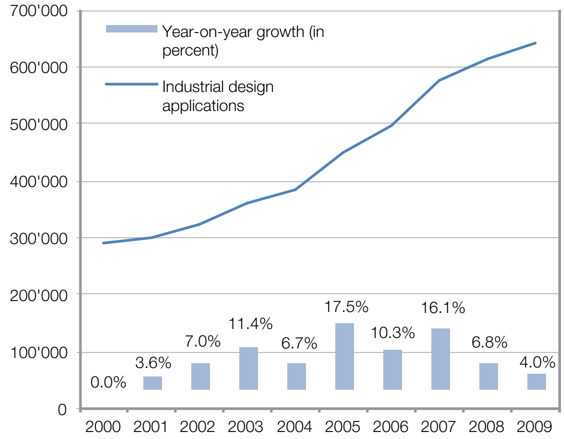
Industrial design rights can be applied to a wide variety of industrial and handicraft products, emphasizing the importance of design in innovation. The most popular industrial design classes are packages for the transport of goods and food products; clocks and watches; furniture, housewares and electrical appliances; vehicles and architectural structures; fashion and textile designs; and leisure goods. New classes for graphic logos are also increasingly filed in design registrations.

The number of industrial design applications filed worldwide in 2009 stood at approximately 640,000 (see Figure 1.19). This is the sixteenth consecutive year of growth, following a decade of stagnation. This rise in global applications can primarily be attributed to the exponential increase in industrial design applications in China. WIPO recorded 2,216 international registrations (+31.8 percent) via the Hague System in 2010, for a total of 11,238 designs (+26.7 percent).[95]

Despite these parallel increases in the importance of product design and in applications for design rights, the interaction between the two, i.e., whether the existence of design rights fosters better design, is ill-understood. Information on the share of designs covered by design rights is also not available.

Figure 1.19: Positive trend in industrial design applications after a decade of stagnation

Number of and year-on-year growth in industrial design applications, 1985-2009



Note: The world total is a WIPO estimate covering around 120 IP offices.

Source: Forthcoming World Intellectual Property Indicators Report, WIPO (2011d).

The economic literature has largely focused on understanding the surge in patent applications, which is due to a number of factors. These include a greater reliance on intangible assets and the internationalization of innovation activity. Among the factors identified as causing this surge are the following, which partly describe the same trends:

1) Increased investment in R&D and changes in the propensity to patent: The significant growth in worldwide R&D expenditure and the shift towards more applied R&D worldwide have led to more patentable inventions.[96] Furthermore, increasing levels of R&D activity in new technology fields drove increased patenting activity.

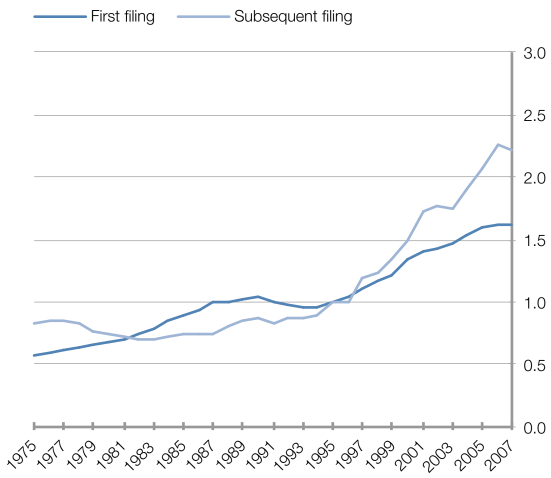
Growth in R&D expenditure and demand for patents both show an upward trend, but the growth rate of world R&D outstripped that of patent applications between 1977 and 2007. The number of patents per business R&D expenditure has thus decreased.[97] There are exceptions at the country-level, most notably in the US which has filed more patents over time per dollar spent on R&D.

92 See HM Treasury (2005).
93 See Gil and Haskell (2008).
94 See UK Intellectual Property Office (2011).
95 See WIPO (2011a).
96 See Kortum and Lerner (1999).
97 See WIPO (2011b).

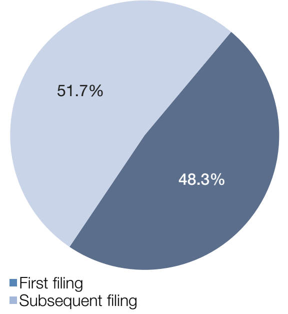
2) Growth in the number of subsequent filings: Since the mid-1990s, patenting has become increasingly internationalized. Subsequent filings reflect applicants' need to protect inventions in more than one jurisdiction. Figure 1.20 shows that subsequent filings have seen a higher growth rate compared to first filings since the mid-1990s. Patent applications grew by 83.7 percent between 1995 and 2007, and more than half of the total growth was due to subsequent filings.

Figure 1.20: Patenting in foreign jurisdictions is the main driver of growth in demand for patents

Patent applications by type of application, indexed 1995=1



Contribution of first and subsequent applications to total growth, in percent, 1995-2007



Source: WIPO (2011b).

3) Expanded technological opportunities: Computer and telecommunications technologies are some of the most important technological fields contributing to patenting growth.[98] Others are pharmaceuticals, medical technology, electrical machinery and, to a significantly lesser extent, bio- and nanotechnologies. Between 2000 and 2007, patent applications by field of technology generating the most growth were related to micro-structural and nanotechnology; digital communication and other ICT products; food chemistry; and medical technology.[99]

4) Legal and institutional changes: There have been a number of national and international legal and institutional changes to the patent system which, according to studies, have contributed to an increase in patenting activity; for example national patent reforms or the implementation of the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS).[100] Moreover, the PCT and Madrid systems and the European Patent Convention have facilitated cross-border patent applications.

5) Strategic patenting: Several researchers have attributed growth in patenting to so-called strategic patenting behaviors. These are practices aimed at blocking other firms from patenting, creating a thicket of defensive patents around a valuable invention to prevent competitive encroachment and litigation, and to enhance patent portfolios for cross-licensing negotiations (see Chapter 2). Some firms also use patents to block fellow competitors or to extract rents from other firms; non-practicing entities in particular have emerged which are said to litigate against other firms based on their patent portfolios.

The causes of growth in trademarks, utility models, industrial designs or other forms of IP remain relatively unexplored. In the case of copyright, it is difficult to document any baseline time trends due to the lack of data.

98 See WIPO (2011b). The growth in applications for new technologies has contributed to the surge in applications in the US.

99 See WIPO (2010).

100 See Hu and Jefferson (2009); and Rafiquzzaman and Whewell (1998).

As indicated above, more anecdotal evidence and documented use of the other forms of IP point to the fact that firms increasingly use bundles of IP rights to appropriate and market the products of their innovation. Popular products in areas such as technology, textiles, food and consumer products rely on the protection of technology, designs, trademarks and brands and often also on copyright, either for software or brand-related creative input. Again, the way the use of different forms of IP is incorporated within firms' strategies and how this determines filing behavior remain unexplored.

The demand for IP is expanding geographically

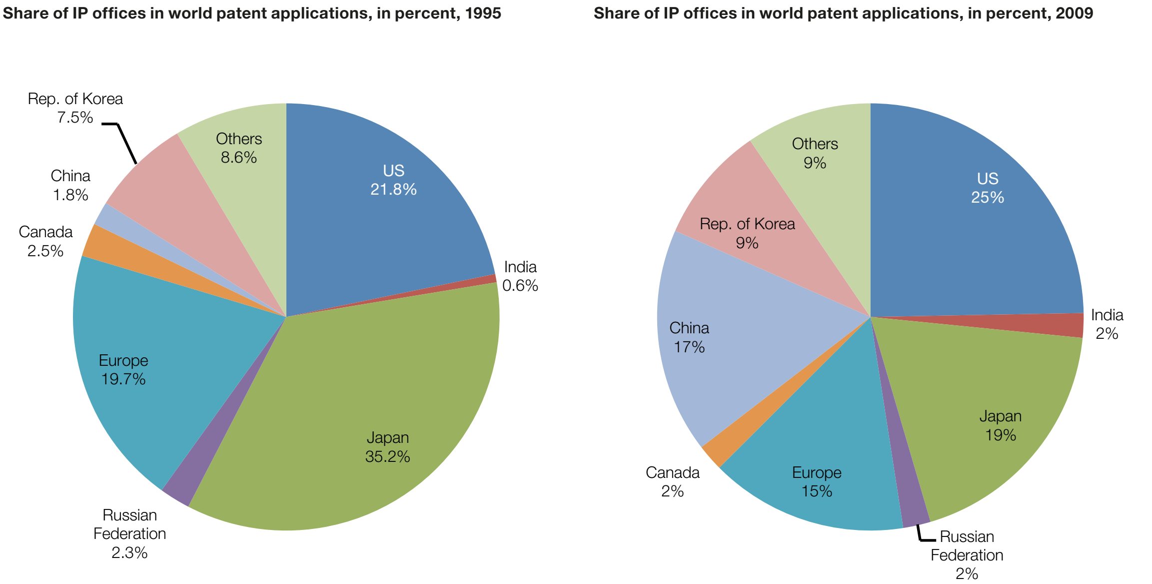
The growing demand for IP rights is also underscored by the increasing number of countries seeking IP protection.

While the demand for IP rights has come mainly from Europe, Japan and the US, over the past two decades there has been a shift to other economies, most notably Asia and in particular China and the Republic of Korea. As a result, the share of global patent applications from Europe, Japan and the US dropped from 77 percent in 1995 to 59 percent in 2009. At the same time, China's share rose by more than 15 percentage points (see Figure 1.21).

PCT international application data show a similar trend. For the first time in 2010, Asia was the largest regional bloc in terms of number of PCT applications, with the strongest showing by Japan, China and the Republic of Korea (see Figure 1.22).[101]

Trademark demand has always been less geographically concentrated. Europe, Japan and the US make up for around one-fifth of global trademark applications, in comparison to three-fifths for patents. However, the change in origin of trademark applications has followed a similar trend to that of patents, with China doubling its share while Europe and Japan see falling shares (see Figure 1.23).

Figure 1.21: Patent applications shift towards Asian countries

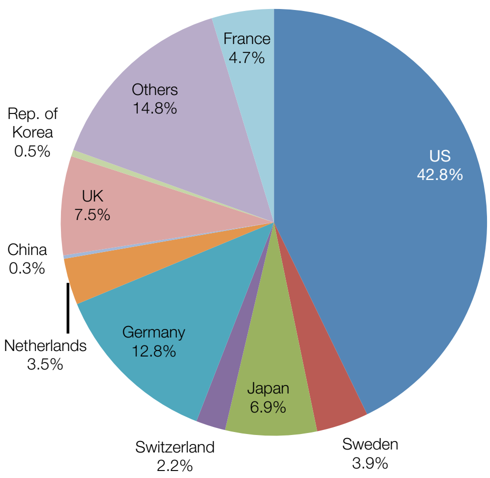


Source: WIPO Statistics Database, September 2011.

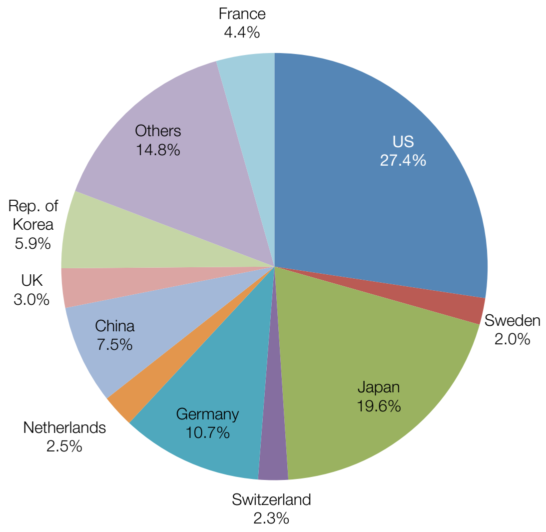
101 See WIPO (2011b).

Figure 1.22: Japan, China and the Republic of Korea become major PCT filers

Shares of PCT applications, in percent, 1995



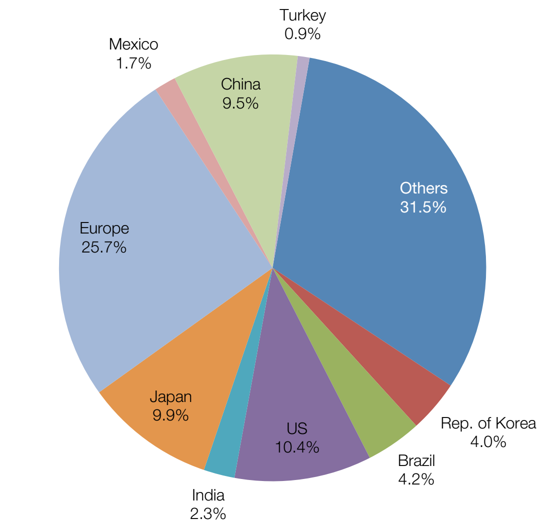
Shares of PCT applications, in percent, 2010



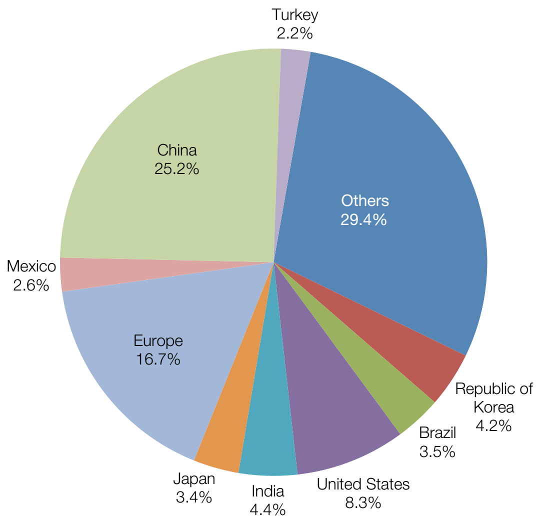
Source: WIPO Statistics Database, September 2011.

Figure 1.23: Trademark applications have followed a similar internationalization trend to that of patents

Share of trademark applications worldwide, by office, in percent, 1995



Share of trademark applications worldwide, by office, in percent, 2009



Note: Depending on whether an IP office has a single or multiclass filing system, one or more classes may be specified in each trademark application, thus complicating the comparison between countries.[102]
Source: WIPO Statistics Database, September 2011.

102 See footnote 89.

Table 1.4 shows the difference in patent and trademark use among income groups. Patent activity remains skewed towards high-income countries, while trademark activity is relatively more pronounced in less developed economies. Despite the drop in shares, the high-income group continues to account for the majority of patent applications. With about 57 percent of applications, middle-income economies account for most trademark applications. Low-income countries' share of trademark applications remains small and in line with their share of world GDP. Furthermore, that share has declined over time. The role of China in driving applications of all sorts in the middle-income and BRICS group is very pronounced (see Table 1.4).

Table 1.4: Patent, trademark and GDP share by income group (percent), 1995 and 2009

	Patent Applications		Trademark Applications		GPD	
	1995	2009	1995	2009	1995	2009
High-income	89.2	72.8	57.6	38.3	67.6	56.8
Upper-middle-income	8.4	23.8	31.9	48.6	23.4	31.4
…Upper middle-income excluding China	6.6	6.7	21.9	20.9	17.6	18.0
Lower middle-income	2.3	3.3	9.1	12.3	8.4	11.0
Low-income	0.1	0.1	1.3	0.8	0.6	0.8
BRICS	6.1	22.7	19.2	38.9	16.4	25.9
…BRICS excluding China	4.3	5.5	9.2	11.3	10.6	12.5

Note: Patents: High-income countries (43), upper-middle-income countries (35), lower-middle-income countries (25) and low-income countries (12). Trademarks: High-income countries (44), upper-middle-income countries (35), lower-middle-income countries (25) and low-income countries (10).

Source: WIPO Statistics Database, October 2011.

Protection of IP in international markets

The IP system is also becoming more internationalized due to reasons other than the rise in new countries making significant use of IP.

Specifically, IP rights are now also more intensively used by inventors and firms to protect their technologies, products, brands and processes abroad. Increasingly patents for one and the same invention are filed in multiple jurisdictions. In fact, such patent applications for one and the same invention filed in several countries accounted for more than half of all growth in patent applications worldwide between 1995 and 2007.[103]

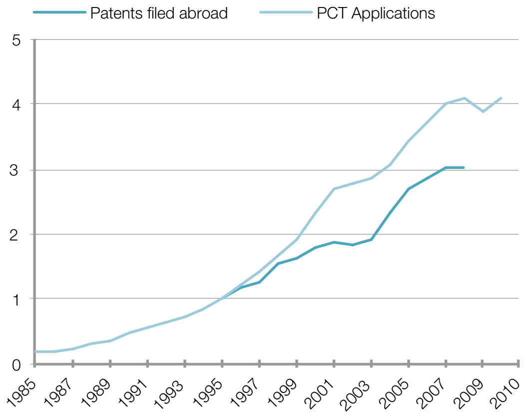
Figures 1.24 and 1.25 provide evidence of increasing levels of internationalization for both patents and trademarks. Patent applications filed abroad, including PCT applications, show an upward trend. A similar pattern is observed for trademark applications filed abroad and Madrid System registrations.[104] Non-resident patent applications account for around 43 percent of all patent applications, compared to around 30 percent for trademarks.[105]

For most countries, the ratio of filings abroad compared to total resident applications has increased over time for both patents and trademarks.[106] Nonetheless, the degree of internationalization varies across countries and among IP rights. Patent filings from European countries show a high level of internationalization (see Figure 1.24, right). Among BRICS (Brazil, the Russian Federation, India, China and South Africa) countries, only India stands out as having a level of internationalization comparable to that seen in high-income economies. In relative terms, patent applications filed by residents in China or the Russian Federation are still rarely filed in other countries.[107] The situation is similar for trademarks (see Figure 1.25, right).

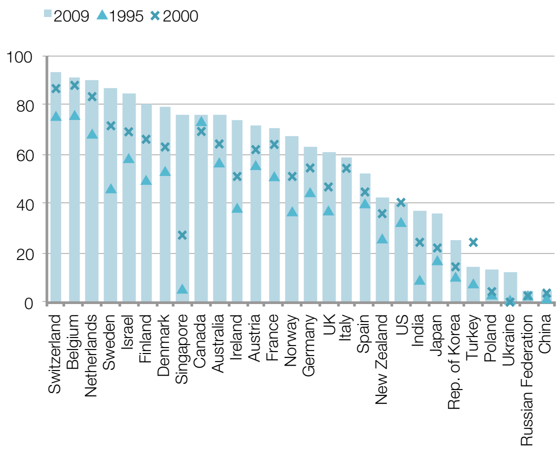
103 See WIPO (2011c).
104 The PCT facilitates the acquisition of patent rights in a large number of jurisdictions. Filing a trademark application through the Madrid System makes it possible for an applicant to apply for a trademark in a large number of countries by filing a single application.
105 See WIPO (2010).
106 However, there are a few exceptions, namely Turkey for patents, and Germany, Sweden and the UK for trademarks.
107 In absolute terms, the number of patent applications originating in China is non-trivial.

Figure 1.24: Internationalization of patent applications

Growth of patent applications abroad and PCT applications, 1995=1, 1985-2010



Filings abroad as a percentage of resident patent applications, selected countries, 1995, 2000 and 2009

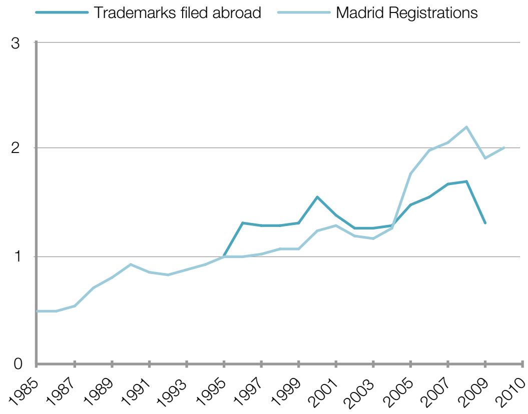


Source: WIPO Statistics Database, September 2011.

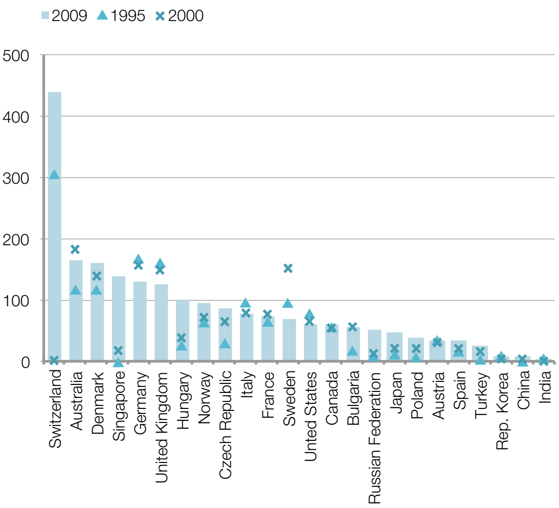
Protection of utility models and industrial designs is mostly sought for the domestic market. Compared to patents and trademarks, the non-resident share out of total applications in both these forms of IP is low and declining over time – around 3 percent for utility models and 16 percent for industrial designs in the latest available year.

Figure 1.25: Internationalization of trademark applications

Growth of trademark applications abroad and Madrid registrations,1995=1, 1985-2010



Filings abroad as a percentage of resident trademark applications, selected countries, 1995, 2000 and 2009



Source: WIPO Statistics Database, September 2011.

As technological capabilities are now more widely diffused and production more globalized, concerns relating to inadequate enforcement of IP rights, in particular patents and trademarks, have increased.

1.3.2

Increased tradability of IP

The last decades have seen an increase in licensing and other IP-based collaborative mechanisms such as patent pools. New intermediaries and IP marketplaces have also emerged.[108]

Following Arora *et al*. (2001), the literature increasingly refers to the rise in "technology markets", "knowledge markets" or "secondary markets for IP" to describe this trend. These IP-based markets are said to allow for trade in ideas and to facilitate vertical disintegration of knowledge-based industries (see Subsection 1.2.1). Firms are putting better systems in place to capture and analyze ideas both from within and without. This also enables them to capture value from IP not utilized internally. Moreover, a new type of firm has emerged which thrives solely on the creation and management of IP assets.

Increased international trade in knowledge

Existing data suggest that high-income countries make up for a large share of the international trade in knowledge and ideas, but that middle-income economies are catching up.

The most widely reported form of disembodied technology trade occurs through international receipts and payments for the use of intangible assets as measured by the payment of royalties and license fees (RLF).[109] The use of RLF data as an approximate measure of the international trade in knowledge is not without its problems. One key issue is how to isolate disembodied technology trade from transfer pricing issues (see Box 1.7). Nonetheless, RLF data are the most pertinent proxy for assessing the international trade in disembodied knowledge.

Box 1.7: The limitations of royalty and license fee data

Madeuf (1984) presents the limitations of using RLF data to infer the occurrence of technology transfer. One key problem is how to isolate technology revenue from transfer pricing. For some countries where detailed data are available, payments mostly consist of intra-firm payments, i.e., payments between subsidiaries and company headquarters – for example, 66 percent of all US receipts in 2009 and 73 percent of all US payments in 2009.[110] Given the intangible and fungible nature of IP assets between a company's headquarters and various subsidiaries, these data are subject to transfer pricing problems and related tax considerations that might be unrelated to international technology transfer between countries. Data on affiliate trade for Germany and several other European countries suggest, however, that intra-firm RLF payments made up for a lesser share, namely about 45 percent of all technology services trade from 2006-2008. Hence, for other countries this measurement problem might be a lesser one.

108 See Guellec *et al.* (2010); Howells *et al.* (2004); and Jarosz *et al.* (2010).

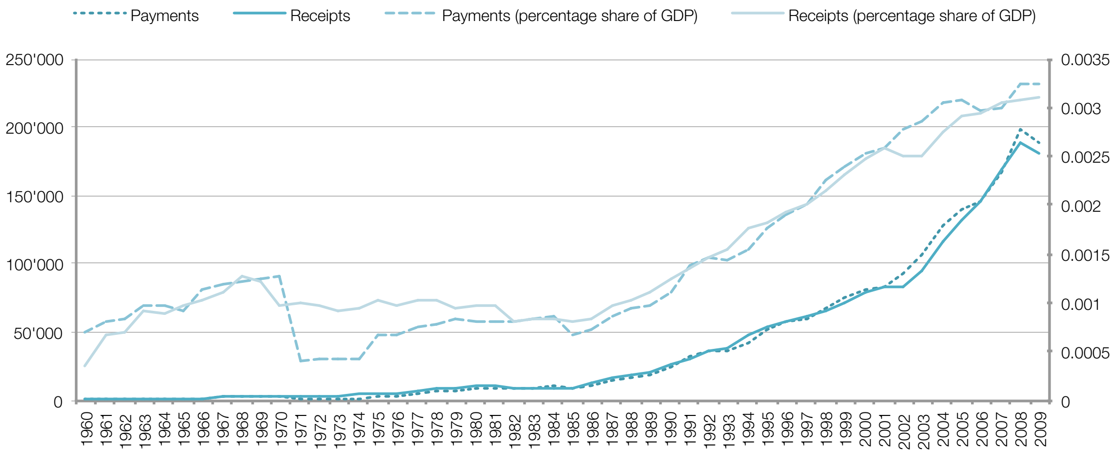
109 The International Monetary Fund (IMF) defines RLF as including "international payments and receipts for the authorized use of intangible, non-produced, non-financial assets and proprietary rights… and with the use, through licensing agreements, of produced originals or prototypes…".

110 See Koncz-Bruner and Flatness (2010); and Robbins (2009).

Figure 1.26 depicts the growth of cross-border licensing trade in the world economy and also shows the acceleration of this trade since the 1990s. In nominal terms, international RLF receipts for IP increased from USD 2.8 billion in 1970 to USD 27 billion in 1990, and to approximately USD 180 billion in 2009.[111] Over the period 1990-2009, RLF receipts and payments in the world economy grew at a fast rate – 9.9 percent per annum.[112] Even when focusing on the period since 1999, one finds a high rate of growth – about 8.8 percent per annum in nominal terms and about 7.7 percent per annum in real terms.[113] For countries where detailed data are available, it is important to note that these payments mostly consist of intra-firm payments (see Box 1.7). Although many types of activities can earn royalties, in the US, the only country with available data, industrial processes and computer software account for over 70 percent of all royalty receipts and payments.

Figure 1.26: International royalty and licensing payments and receipts are growing in absolute and relative terms

RLF payments and receipts, in USD millions (left) and as a percentage share of GDP (right), 1960-2009



Note: GDP data are from the World Bank.

Source: WIPO based on data in Athreye and Yang (2011).

111 This section relies heavily on a background report commissioned by WIPO. See Athreye and Yang (2011).

112 Some of this rise may be attributed to under-reporting or measurement issues related to the pre-1996 period.

113 The GDP deflator provided in The World Bank's World Development Indicators was used to compute the deflated values. There are numerous problems associated with finding the appropriate deflator for licensing revenue. The most commonly used deflators, GDP and consumer price index (CPI), are thought not to contain the right price indices to take into account inflation in licensing prices. A thoughtful review of the issues involved is contained in Robbins (2009), who also proposes using a deflator based on capital rentals in each country.

In 1990, 62 countries made RLF payments and, by 2007, this number had increased to 147 countries. Similarly, in 1990 only 43 countries received RLF payments but, by 2007, this number had increased to 143 countries. From 2000-2009, the BRICS economies, Ireland, the Republic of Korea, and former Eastern European nations gained in economic importance. Between 2005 and 2009, Ireland and China increased their shares of international licensing payments by 4.9 percent and 2.1 percent, respectively, while the US and UK decreased their shares by 4.1 percent and 1.9 percent.

Still today, high-income countries make up for close to 99 percent of RLF receipts – almost unchanged from ten years earlier – and for 83 percent of royalty payments – a decline from 91 percent in 1999 (see Table 1.5). Looking at US receipts one also notes little change between 2006 and 2009 in relation to their geographical composition (see Figure 1.27). The most notable transformation in the last ten years is an increased share in global payments by middle-income economies, from 9 percent in 1999 to 17 percent in 2009. Middle-income economies saw their share of receipts grow from 1 percent in 1999 to 2 percent in 2009.

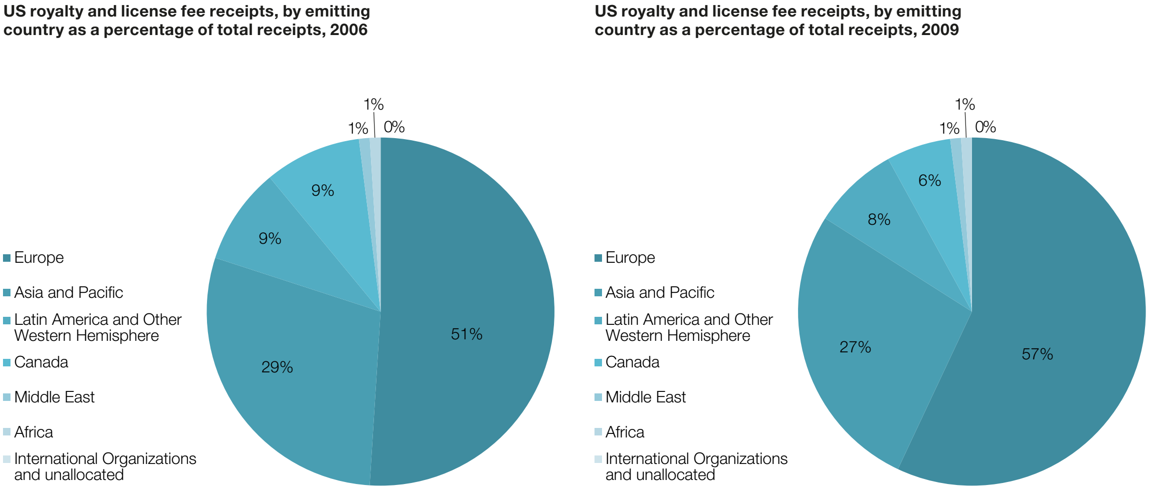
Table 1.5: Royalty and license fee receipts and payments, by income groups

Income groups	1999		2009		1999	2009		
	RLF receipts and payments, in million USD				**Share of total RLF, in percent**		**Growth, 1999 to 2009, in percent**	
	Nominal	Deflated	Nominal	Deflated			Nominal	Deflated
High-income economies								
RLF receipt values	70,587	71,959	176,716	151,119	99	98	9.6	7.7
RLF payment values	67,965	70,371	155,881	135,163	91	83	8.7	6.7
Middle-income economies								
RLF receipt values	759.883	736.771	3,765	2,055	1	2	17.4	10.8
RLF payment values	6,705	6,931	3,2428	17,942	9	17	17.1	10
Low-income economies								
RLF receipt values	16	14	34	16	0.02	0.02	7.7	1.
RLF payment values	84	72	67	34	0.1	0.04	-2.3	-7

Note: The GDP deflator provided in The World Bank's World Development Indicators is used to compute the deflated values.

Source: WIPO based on data in Athreye & Yang (2011).

Figure 1.27: The geographical composition of US RLF receipts remains relatively unchanged



Note: Regions as defined by the US Bureau of Economic Analysis.

Source: WIPO, based on data from the US Bureau of Economic Analysis.

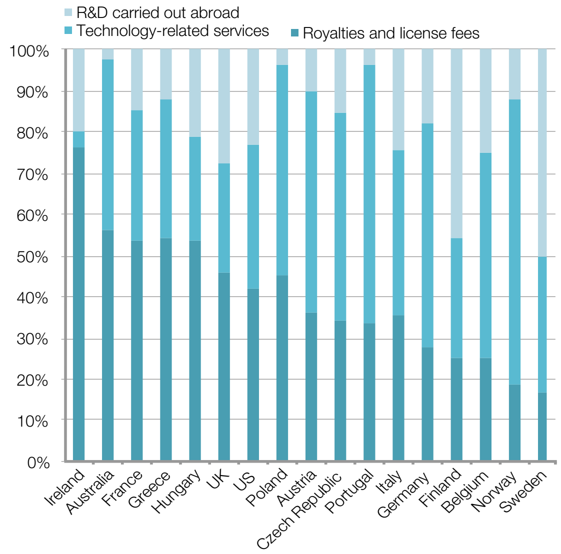
Manufacturing accounted for a large percentage of RLF payments in the six high-income countries with available data. The manufacturing sectors that dominate technology trade vary from country to country, although technology trade in chemical products, computer and office machinery and nonelectrical machinery appears to be fairly globalized.

Based on data available for high-income countries only, one can distinguish between the outright sale and purchase of patents; RLF receipts and payments for the use of intangible assets; trade in technology-related services; and receipts and payments for conducting R&D services. In the case of technology and R&D service exports, the IP rights to technology purchased usually reside with the client or buyer. This is more efficient in situations where technology transfer is likely to encounter a large tacit component requiring frequent communication or monitoring.[114]

The preferred form of disembodied technology trade differs across countries. Receipts in the UK, France and the US are mainly linked to RLFs. Ireland, Australia, France and Greece make the majority of their payments for RLF (see Figure 1.28). For other EU countries – Germany, Portugal, Norway and others – payments for technology-related services dominate. Outsourcing of R&D, captured by technology payments made for R&D services rendered abroad, accounts for only a small fraction of payments, except for Sweden and Finland, followed by Belgium, the UK and the US.

Figure 1.28: The preferred form of disembodied technology trade differs across countries

RLF payments in various high-income countries, as a percentage of the total, 2007 or last available year



Note: Purchase and sale of patents have been left out since data on theme are not consistently available. Data for France pertain to 2003; for others the reference year is 2007.

Source: WIPO based on data in Athreye and Yang (2011).

IP licensing growing from a low baseline

More disaggregated or non-trade-related data on licensing payments are harder to obtain, and complete statistics on licensing between firms do not exist. While a few private or academic sources provide aggregate figures on licensing income at the country-level, in particular for the US, these are unofficial and, most likely, imperfect estimates.[115]

114 See Athreye and Yang (2011).

115 The consulting firm IBISWorld estimates the 2010 US domestic IP licensing and franchising market to be worth around USD 25 billion, with 20.3 percent of that total attributed to patent and trademark licensing royalty income. Franchise leasing and licensing makes up more than 40 percent of that amount, and copyright licensing and leasing income more than 30 percent of total royalty income according to this source. US licensing revenue was estimated at USD 10 billion in 1990 and 110 billion in 1999, according to a different source (Rivette and Kline, 1999).

Data based on companies' annual reports as well as patenting and innovation surveys show that measurable IP-related transactions are growing but from mostly low initial levels. Better data are required to measure this phenomenon in a more timely and accurate fashion. It is also important to note that when firms enter into cross-licensing arrangements for patents, the resulting income is recorded only to the extent that cash is received. These ever-increasing transactions hence go unmeasured.

- **Annual company reports and tax filings:** In their annual reports, a minority of publicly-traded companies provide royalty revenue data (see Table 1.6 for examples). Only a few companies in the sample saw an increase in royalty revenue between 2005 and 2010. For most firms in the table, the share of RLF receipts remains between less than one to three percent of total revenue. Some firms also report other forms of IP and custom development income from technology partners. If these are taken into account, total revenue for IBM, for instance, rises to more than USD 1.1 billion in 2010, making RLF revenue 11 percent of total revenues.

Table 1.6: Shares and rates of nominal growth, selected companies, 2005 and 2010

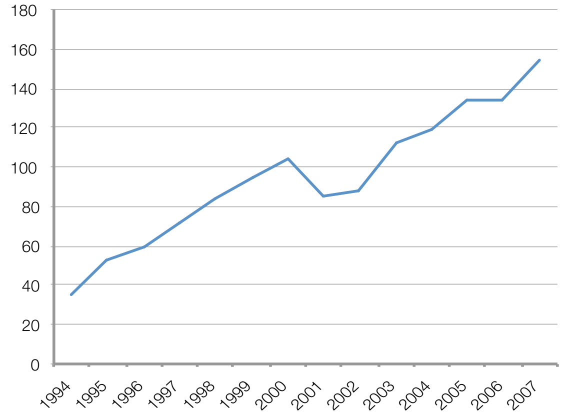
			Royalty revenue, USD millions		Royalty revenue, share of total revenue	
Company	Country	Sector	2005	2010	2005	2010
Qualcomm	US	Technology hardware & equipment	1370	4010	24.14%	36%
Philips	Netherlands	Leisure goods	665	651	1.76 %	1.86%
Ericsson	Sweden	Technology hardware & equipment	NA	638	NA	2.26%
DuPont	US	Chemicals	877	629	3.29%	1.99%
Astra Zeneca	UK	Pharmaceuticals & biotechnology	165	522	0.68%	1.61%
Merck	US	Pharmaceuticals & biotechnology	113	347	0.51%	0.75%
IBM	US	Software & computer services	367	312	0.40%	0.31%
Dow Chemical	US	Chemicals	195	191	0.42%	0.35%
Biogen Idec	US	Pharmaceuticals & biotechnology	93	137	3.84%	2.90%

Source: WIPO, based on filings at the US Security and Exchange Commission. See Gu and Lev (2004) for a more detailed but more dated analysis.

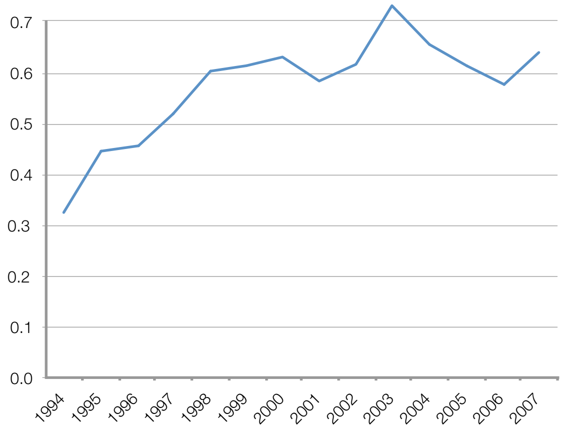
Since 1994, in the US – for which data is reported – RLF revenues have increased in nominal terms from USD 35 billion to USD 153 billion in 2007 (see Figure 1.29). The share in total company revenue remains small at 0.6 percentage points of total private sector revenue in the US. This small share can be explained by the fact that only a few US firms generate the bulk of licensing revenue. Importantly, this share has doubled since 1994.

Figure 1.29: The share of RLF receipts in company revenue remains small despite a strong increase in revenue generated by US firms

Royalties and licensing revenue, US corporations, in USD billions, 1994-2007



Royalty and licensing revenue, in percent of US corporate revenue, 1994-2007



Source: WIPO, based on data from the Internal Revenue Services (IRS) supplied by the US National Science Foundation.

- **Innovation and patenting surveys:** In Europe, around one patenting firm in five licenses patents to non-affiliated companies, whereas more than one in four does so in Japan.[116] Cross-licensing is the second most frequent motive for licensing out, both in Europe and in Japan. According to the RIETI Georgia-Tech inventor survey – conducted with US and Japanese inventors on patents with priority claims between 1995 and 2003 – licensing of patented inventions in Japan was carried out by 21 percent of firms and by 14 percent in the US.[117]

  Obtaining licensing data at the sector level is challenging. Via a survey instrument, Giuri and Torrisi (2011) identify knowledge-intensive business services as the most active in licensing their technologies (see Table 1.7), followed by pharmaceuticals and electrical and electronic equipment. The majority of licensing contracts in the sample related to ICTs (in particular semiconductors/electronics), chemicals/pharmaceuticals/biotech and engineering technological classes. Intra-industry licensing comprises a large share of total recorded licensing transactions. In other words, the largest flows of technology through licensing occur within the same technological sectors.

Table 1.7: Technology flows within and between sectors, as a percentage of total technology flows

	Pharmaceuticals	Chemicals	Computers	Electrical/electronic equipment	Transport	Instruments	KIBS
Pharmaceuticals	**64.8**	3.7	0.4	0.2	0.1	4.6	11.7
Chemicals	16.9	**42.8**	1.9	3.3	2.5	4.4	9.4
Computers	0.2	1.6	**27.1**	22.4	3.1	5.6	27.7
Electrical equipment	0.8	2.1	17	**46.4**	1	4.9	20.5
Transport	2	6.7	7.84	12.8	**27.5**	5.9	24.5
Instruments	19	2.8	6.4	10.6	1.7	**29.9**	14
KIBS	10.6	2.4	9.8	10.4	1.2	2.7	**45.6**

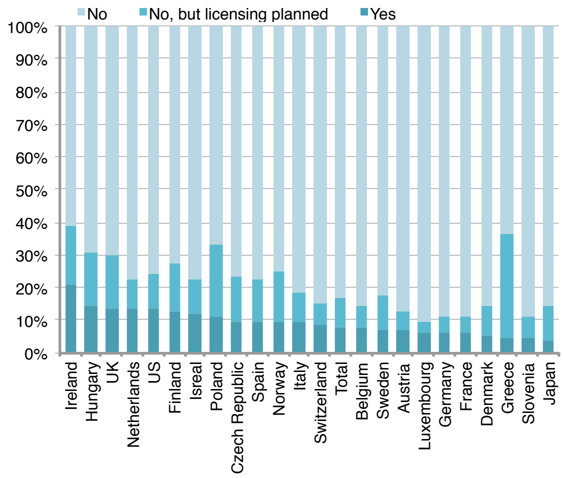
Note: KIBS stands for Knowledge-intensive business services.

Source: Gambardella *et al*. (2007).

Despite the general growth in licensing activity, only a limited share of patents is licensed out. In most countries less than ten percent of patents are subject to licensing outside the company (see Figure 1.30).[118] About 24 percent of firms in Europe declare having patents that they would be willing to license but could not. In Japan, this figure reaches 53 percent. Nonetheless, the number of firms licensing out has steadily increased over time in most countries.

Figure 1.30: The potential to license out patents is far from exhausted

Companies that license out their patents, as a percentage of total patents owned, selected high-income countries, 2003-2005



Note: Based on preliminary findings.

Source: Giuri and Torrisi (2011).

- **Universities:** Licensing out of patents by universities to firms is becoming more frequent, although the volume remains small on average and payments are mostly limited to high-income economies (see Chapter 4).

116 See Guellec and Zuñiga (2009).
117 See Michel and Bettels (2001).
118 See the PATVAL-European Union Survey.

1.3.3

New collaborative mechanisms and IP intermediaries

In Subsection 1.2.5, traditional forms of IP transactions were identified as tools for open innovation.

Technology market intermediaries have existed for a long time.[119] Already in the 1800s and early 1900s, patent agents and lawyers played an important role in matching capital-seeking inventors with investors, and in linking sellers of inventions with potential buyers.[120] Yet, beyond more traditional forms, new "collaborative mechanisms" are emerging, such as IP clearinghouses, exchanges, auctions and brokerages; model agreements; and frameworks for IP sharing.

Intermediaries are more numerous today and are equipped with novel technologies. They provide services ranging from IP management support, IP trading mechanisms, IP portfolio building to licensing, defensive patent aggregation and others. Table 1.8 describes the various actors involved and their functions.

Nonetheless, limited analysis is available on the size and scope of the actual transactions taking place. Some existing evaluations show that for some newer marketplaces, activity linked to patent auctions is only just beginning, starting from low initial levels.[121] Again, more analysis is required to determine the magnitudes and impacts of these trends.

Table 1.8: New IP intermediaries, their functions and business models

	Business models	Examples of IP intermediaries
IP management support	• IP strategy advice • Patent evaluation • Portfolio analysis • Licensing strategy advice • Patent infringement analysis, etc.	ipCapital Group; Consor; Perception partners; First Principals Inc.; Anaqua; IP strategy group; IP investments group; IPVALUE; IP Bewertungs; Analytic Capital; Blueprint Ventures; Inflexion Point; PCT Capital; Pluritas; 1790 Analytics; Intellectual Assets; IP Checkups; TAEUS; The IP exchange house; Chipworks; ThinkFire; Patent Solutions; Lambert & Lambert
IP trading mechanism	• Patent license/transfer brokerage	Fairfield Resources; Fluid Innovation General Patent; ipCapital Group; IPVALUE; TPL; Iceberg; Inflexion Point; IPotential; Ocean Tomo; PCT Capital; Pluritas; Semi. Insights; ThinkFire; Tynax; Patent Solutions; Global Technology Transfer Group; Lambert & Lambert; TAEUS
	• Online IP marketplace	InnoCentive; NineSigma; Novience; Open-IP.org; Tynax; Yet2.com; UTEK; YourEncore; Activelinks; TAEUS; Techquisition LLC; Flintbox; First Principals Inc.; MVS Solutions; Patents.com; SparkIP; Concepts community; Mayo Clinic technology; Idea trade network; Innovation Exchange
	• IP live auction/Online IP auction • IP license-right trading market	Ocean Tomo (Live auction, Patent Bid/Ask); FreePatentAuction.com; IPAuctions.com; TIPA; Intellectual Property Exchange International
	• University technology transfer	Flintbox; Stanford Office of Technology Licensing; MIT Technology Licensing Office; Caltech Office of Technology Transfer
IP portfolio building and licensing	• Patent pool administration	MPEG LA; Via Licensing Corporation; SISVEL; the Open Patent Alliance; 3G Licensing; ULDAGE
	• IP/Technology development and licensing	Qualcomm; Rambus; InterDigital; MOSAID; AmberWave; Tessera; Walker Digital; InterTrust; Wi-LAN; ARM; Intellectual Ventures; Acacia Research; NTP; Patriot Scientific RAKL TLC; TPL Group
	• IP aggregation and licensing	Intellectual Ventures; Acacia Technologies; Fergason Patent Prop.; Lemelson Foundation; Rembrandt IP Mgmt.
Defensive patent aggregation/ Framework for patent sharing	• Defensive patent aggregation funds and alliances • Initiative for free sharing of pledged patents	Open Invention Network; Allied Security Trust; RPX; Eco-Patent Commons Project; Patent Commons Project for open source software, Intellectual Discovery
IP-based financing	• IP-backed lending • Innovation investment fund • IP-structured finance • Investment in IP-intensive companies, etc.	IPEG Consultancy BV; Innovation Network Corporation of Japan; Intellectual Ventures; Royalty Pharma; DRI Capital; Cowen Healthcare Royalty Partners; Paul Capital Partners; alseT IP; Patent Finance Consulting; Analytic Capital; Blueprint Ventures; Inflexion Point; IgniteIP; New Venture Partners; Coller IP Capital; Altitude Capital; IP Finance; Rembrandt IP Mgmt.; NW Patent Funding; Oasis Legal Finance

Source: WIPO, adapted from Yanagisawa and Guellec (2009).

119 See Lamoreaux and Sokoloff (2002).
120 See Kamiyama (2005).
121 See Jarosz *et al.* (2010).

1.3.4

Emergence of new IP policies and practices

To conclude, beyond the increased use of knowledge markets and new IP intermediaries, firms and other organizations are also trialing new IP policies and practices.

For instance, firms increasingly say that they organize licensing activity and strategic alliances around an IP strategy that seeks to share technologies rather than to use IP solely as a defense mechanism. For a number of firms this represents a true change in business mentality and implies that new IP strategies are at work – moving away from the secrecy and inward-looking processes considered to be essential steps prior to applying for IP.

Companies, universities and governments are also innovating in the area of IP policy. A few select categories are listed here:

- **Publication without patenting:** Some firms opt to publish details on inventions that they do not plan to patent, often also called technical disclosures (see for example IBM's Technical Disclosure Bulletin or the IP.com Prior Art Database).[122] On the one hand, this lifts the veil of secrecy on potentially important technologies. On the other hand, it also serves the strategic aim to prevent other companies and individuals from seeking patents on the ideas, so-called defensive publishing.
- **Different forms of IP donations:** Companies can decide to release parts of their IP to the public, to fellow companies or innovators. Firms seem to have started this practice during the mid-1990s. More recently, firms have released business method patents to the public or donated IP to smaller companies. Still other firms provide royalty-free licenses for patents in the areas of food or health products. Reasons for this can be that the IP is not economically valuable to them, or that the invention requires further development efforts that the patenting firm is not willing to undertake. The extent to which these practices might be designed to preserve market share, establish or maintain standards or to crowd out competitors deserves further study.
- **Collaboration with universities:** When dealing with universities, companies are also increasingly inventive with regard to their IP policies, fostering cooperation on the one hand while ensuring control on the other (see Chapter 4). For instance, contracts often specify that the firm retains the right to require a royalty-free license on any university patent emerging from the research it has funded. University researchers are granted access to the company's internal IP, for example antibody libraries and research tools, and, in certain cases, are allowed to publish in addition to obtaining external funding (see Pfizer's new model for drug development, Philips' university partnerships, etc.). Researchers may receive extra payments if gains from developing the technology exceed original expectations.

122 www.redbooks.ibm.com

- **Contributions to patent pools:** In the last few years, a number of patent pools have been created to address health, environmental and other social challenges (see Chapter 3). The Pool for Open Innovation against Neglected Tropical Diseases, for instance, facilitates access to IP and technologies for researchers in this area.[123] Willing pharmaceutical companies or universities contribute relevant patents to the pool. The Medicines Patent Pool for AIDS medications, established with the support of UNITAID in 2010, was created to share IP through a patent pool designed to make treatments more widely affordable to the poor.[124] The Eco-Patent Commons allows ICT-related firms to make environmentally-related patents available to the public (see Box 2.4).[125] Participating firms must sign a non-assertion pledge which allows third parties royalty-free access to the protected technologies. While these patent pools are all fairly recent, so called-patent commons which support the development of open source software developers have existed for quite some time.[126]

These new IP practices can be read as a testament to firms' and other organizations' increased experimentation with new IP practices. Yet, often, firms may have recourse to these IP releases for reasons related to tax relief (as in the case of donations), overall company strategy and public relations efforts.[127] All in all, the mechanics and impacts of these IP practices require further study.

1.4

Conclusions and directions for future research

Innovation is a driver of economic growth and development. Importantly, innovative capability is no longer seen only in terms of the ability to develop new inventions. Recombining existing inventions and non-technological innovation also counts.

With increased internationalization, the way innovation activity is organized has changed. Lower- and middle-income economies contribute increasingly to technology production and innovation. Another transformation is the more collaborative nature of innovative processes. Firms are trialing different forms of "open innovation" models to leverage external sources of knowledge. That said, Chapter 1 shows that drawing a clear distinction between long-standing collaborative practices and new models – and their respective impacts – remains difficult.

In this changing context, IP both drives the changing nature of innovation and is – at the same time – impacted by these changes. Increasingly IP is treated as a central asset which is managed strategically and leveraged to generate returns. In parallel, there has been a shift in the IP landscape, with new countries emerging and greater emphasis placed on the international protection of inventions – all leading to a growing demand for the different IP forms, although patent activity remains skewed towards high-income countries, while trademark activity is relatively more pronounced in less developed economies.

123 http://ntdpool.org/.
124 www.medicinespatentpool.org/.
125 www.wbcsd.org/web/projects/ecopatent/Eco_patent_UpdatedJune2010.pdf.
126 www.patentcommons.org.
127 See Layton and Bloch (2004); and Hall and Helmers (2011).

The last decades have also seen the emergence of IP-based knowledge markets, which place greater emphasis on licensing and other IP-based collaborative mechanisms such as patent pools and new IP intermediaries. High-income countries still make up for a large share of the international trade in knowledge, but middle-income economies are catching up. Measurable IP-related transactions are growing, but from mostly low initial levels, pointing to further growth potential. Beyond traditional forms of IP licensing, new "collaborative mechanisms" have emerged. Finally, firms and other organizations are also trialing new IP policies and practices, often aimed at sharing technologies but also sometimes with a view to blocking competitors.

Areas for future research

In the light of this chapter, the following areas emerge as promising fields of research:

- Research leading to a better understanding of the role of intangible assets in firm performance and economic growth is warranted. In this context, the positive contribution of process and organizational innovation to productivity requires further study as currently the interactions between technological and non-technological innovation are ill-understood.

- The data for assessing the frequency, type, the quality dimension and impacts of collaboration for innovation remain too limited. In this context, assessing the true importance of open innovation is hindered by definitional and measurement issues. In particular, the contribution of new innovation platforms and monetary prizes – relative to other existing innovation channels – requires further research. Also this chapter points to new inbound innovation models, new IP policies and practices – for example donations to patent pools – and other public-private efforts for not-for-profit objectives which require closer scrutiny as to their scale and effectiveness.

- Too little is known about how innovation takes place in low- and middle-income countries, how it diffuses and what its impacts are. Concepts such as "frugal" and "local" innovation and associated impacts deserve further study.

- Whereas the demand for patents has become increasingly internationalized, only a few countries are responsible for the great majority of patent filings. Understanding the causes and impacts of this fragmented patenting activity deserves study. Similarly, the different propensities and motivations of firms to use different forms of IP remain ill-understood, in particular with regard to specific country income brackets. Aside from patents, other forms of IP and their role within the innovation process deserve further study. Finally, new metrics are needed for assessing the depth and range of knowledge markets, of new IP intermediaries but also to assess which barriers exist to their further development.

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