CHAPTER 2
THE ECONOMICS OF INTELLECTUAL PROPERTY – OLD INSIGHTS AND NEW EVIDENCE

Innovation holds the potential to improve human well-being and generate economic prosperity. Understanding why individuals and organizations innovate and how government policies affect innovative behavior are therefore important. Throughout history, economists have studied these questions and devised different theories to explain incentives for innovation.

This chapter focuses on the role of the intellectual property (IP) system in the innovation process and has two main objectives. It first seeks to convey, from the standpoint of economists, the key ideas behind the IP system, including the main rationales for protecting IP rights as well as their pros and cons compared to other innovation policy instruments (Section 2.1).

The second objective is to explore how economists' understanding of the IP system has changed, by taking a closer look at the patent system which has received, by far, the most scrutiny by researchers (Section 2.2). While many old insights still apply, economists have gained new empirical perspectives which have led to a more refined view of how patent protection affects innovation. These new perspectives partly reflect real world developments – as reviewed in Chapter 1 – and also better data, which enable richer investigations.

One important theme that emerges from the recent literature is the key role patent institutions play in determining innovation outcomes. Since this theme is of special relevance for IP policymaking, the chapter elaborates on some of the challenges facing these institutions (Section 2.3). The concluding remarks summarize some of the key messages emanating from the economic literature and point to areas where more research could usefully guide policymakers (Section 2.4).

2.1

Understanding IP rights and their role in the innovation process

The importance of innovation in economic thinking can be traced as far back as 1776. In his famous treatise on the Wealth of Nations, Adam Smith notes that "the invention of all those machines by which labour is so much facilitated and abridged seems to have been originally owing to the division of labour." He further observes that "[a] great part of the machines […] were originally the inventions of common workmen, who, being each of them employed in some very simple operation, naturally turned their thoughts towards finding out easier and readier methods of performing it."[1]

1 See Smith (1776).

But it was not until the second half of the 20th century that scholars started to scrutinize the circumstances of inventive activity more closely, rather than simply viewing it as a "natural turn of thought". In 1962, Nobel-prize winning economist Kenneth J. Arrow helped galvanize economic thinking in this area by arguing that the inventive process – viewed as the production of problem-solving information – faces two fundamental difficulties.[2] First, it is a risky process: when embarking on a problem-solving exercise, it is uncertain whether a solution can really be found. Second, information related to problem-solving possesses characteristics of what economists call a public good: many people can simultaneously use it, and the problem solver often cannot prevent reproduction of the information. The latter characteristic is also known as the *appropriability dilemma* of inventive activity.

In view of these two fundamental difficulties, Arrow concluded that, left alone, markets would underinvest in inventive activity relative to what would be socially desirable. To avoid wasting resources should a problem-solving effort fail, firms operating in competitive markets may forgo inventive opportunities; and, if competitors can immediately free ride on a successful solution, the inventing firm may reap little financial reward.

In view of the innovative behavior observed in markets, these conclusions may seem overly pessimistic. Much invention occurs due to innate curiosity. Some inventors thrive on inventive challenges that carry a high risk of failure. Recognition from peers or society at large for solving a complex problem is another important factor driving creativity and inventiveness. In some cases, such recognition may ultimately lead to a tangible reward in the form of future job offers or access to the venture capital market. Lerner and Tirole (2005), for example, find that reputational benefits are a key factor motivating software programmers to participate in open source software projects.

There are also mechanisms for reducing risks and appropriating inventive efforts in private markets. The pooling of inventive activity within larger firms diminishes the uncertainty of inventive outcomes, as successes make up for failures. Pooling can also be achieved through financial markets, notably through venture capital funds. In addition, firms can often overcome appropriability problems by being first to introduce a new good or service on the market; even a short lead time may be sufficient to generate enough profits to make inventive investment worthwhile. Creating consumer goodwill through extensive marketing of new products can also give firms a competitive edge, allowing them to finance inventive activity. Indeed, surveys of firms over the past decades have shown that, in many sectors, lead time and marketing are some of the most important ways of appropriating returns on inventive activity.[3]

However, problems of appropriability and risk in innovative activity persist even where private markets offer certain innovation incentives. To begin with, although individuals may invent purely out of curiosity, they also need to earn a living. Pushing the limits of the world's knowledge frontier requires talent, but often it also demands years of experience, collaboration within larger research teams and expensive equipment. In addition, successful innovation in modern economies not only requires smart inventions, but also substantial investment in the subsequent development and commercialization of new products. In many cases, market mechanisms are bound to be insufficient for inducing innovation that is in society's best interest, thus providing a rationale for government intervention.

2 See Arrow (1962). In the 1930s, Joseph Schumpeter (1937, 1943) had already recognized that firms with market power were in a better position to innovate. However, his analysis focused primarily on how firm size affects innovative behavior and entrepreneurship; he had not yet explored the special economic attributes of information goods as was later done by Arrow.

3 Subsection 2.3.1 summarizes the results of these surveys.

Against this background, this section looks at the IP system as one form of government intervention to promote innovation. It explores how the IP system shapes innovation incentives (Subsection 2.1.1), which considerations go into designing IP rights (Subsection 2.1.2) and how those rights compare to other innovation policy instruments (Subsection 2.1.3).

Before proceeding, one caveat is in order. Most economic research on IP protection has focused on patents, but many insights also apply to other forms of IP. For that reason, this section refers to "IP rights" generically. Where relevant, the discussion points to important differences between the various forms of IP. Trademark rights are, however, excluded from the discussion. While their enabling of firms to appropriate innovative efforts through marketing makes them indirectly relevant to innovation, the economics of trademark protection involves fundamentally different considerations which, for space constraints, are not discussed here.[4]

2.1.1

How IP protection shapes innovation incentives

IP protection is a policy initiative that provides incentive for undertaking creative and innovative activity. IP laws enable individuals and organizations to obtain exclusive rights to their inventive and creative output. Ownership of intellectual assets limits the extent to which competitors can free ride on problem-solving and related information, enabling owners to profit from their efforts and addressing the appropriability dilemma at its heart.

Table 2.1 describes the five forms of IP most relevant to innovation – patents and utility models, industrial designs, copyright, plant variety rights and trade secrets. These IP forms have emerged historically to accommodate different forms of innovative and creative output.

Table 2.1: Main forms of IP rights available to innovators

IP right	Subject matter	Acquisition of right	Nature of right: prevent others from…
Patents and utility models	Inventions that are new, non-obvious and industrially applicable	Granted by government authority, typically following substantive examination	… making, using, selling, offering for sale or importing
Industrial designs	Industrial designs that are new and/or original	Granted by government authority upon registration, with or without substantive examination	… making, selling or importing
Copyright	Creative expressions	Automatically, upon creation	… reproducing and related acts
Plant variety rights	Plant varieties that are new, distinct, uniform and stable	Granted by government authority following substantive examination	… using and multiplying propagating materials
Trade secrets	Any valuable confidential business information	Automatically, upon creation	… unlawfully disclosing

Note: This table offers an intuitive overview of the main forms of IP and, only incompletely, describes the legal character of these rights, as established through national laws and international treaties. For a detailed legal introduction, see Abbott *et al*. (2007). Trademarks are not included here, as explained in the text.

4 The main economic rationale for protecting trademark rights is to resolve problems of asymmetric information between buyers and sellers. There is a similar rationale behind the protection of geographical indications. See, for example, Fink *et al*. (2005).

IP rights are an elegant means for governments to mobilize market forces to guide innovative and creative activity. They allow decisions on which innovative opportunities to pursue to be taken in a decentralized way. To the extent that individuals and firms operating at the knowledge frontier are best-informed about the likely success of innovative projects, the IP system promotes an efficient allocation of resources for inventive and creative activity.

This has traditionally been the key economic rationale for protecting IP rights. However, there are a number of additional considerations, some of which strengthen the case for exclusive rights, while others weaken it.

First, while IP rights do not directly solve the problem of risk associated with inventive activity, they can improve the functioning of financial markets in mobilizing resources for risky innovation. In particular, the grant of a patent at an early stage in the innovation process can serve to reassure investors that a start-up firm is in a position to generate profits if the invention is successfully commercialized. In addition, it provides an independent certification that an invention pushes the limits of the knowledge frontier – something that investors may not be able to assess on their own.[5]

Second, inventing sometimes means finding solutions to stand-alone problems. More often, however, it is a cumulative process, whereby researchers build on existing knowledge to develop new technologies or products. The IP system plays an important role in the process of cumulative innovation.[6]

Patent applicants must disclose the problem-solving information underlying an invention in return for being granted exclusive rights. This promotes timely disclosure of new technological knowledge, and allows follow-on inventors to build on that knowledge. In some cases, problem-solving information can easily be discerned from a new product on the market – as is naturally the case for new designs and most creative expressions.[7] In other cases, however, reverse engineering may take substantial time and effort, or it may be altogether impossible. In the absence of patent rights, inventors would have every incentive to keep their inventions secret. At the extreme, valuable inventions would die with their inventors.

Even though patent laws provide for express exceptions on using patented technologies for research purposes, patents may nonetheless create a barrier for follow-on innovators. Notably, certain technology fields are characterized by complex patent landscapes, generating uncertainty about whether potential new inventive output could clash with existing proprietary rights. A related problem arises where the commercialization of an invention requires use of third-party proprietary technology. Other right holders may refuse to license their technologies or may demand royalties that render the innovation unprofitable – leading to the so-called holdup problem. Even where they are willing to license, coordinating the participation of a large number of right holders may be too costly.[8]

5 See, for example, Greenberg (2010) and Dushnitski and Klueter (2011).

6 See, for example, Scotchmer (1991).

7 Computer software is an important exception. The source code for a particular software can be technologically protected from disclosure. Copyright protection does not oblige the owner to disclose the source code.

8 See, for example, Eisenberg (1996) and Shapiro (2001).

Third, the IP system facilitates firm specialization in different stages of the innovation process. As argued in Chapter 1, the traditional view of research, development and commercialization undertaken by a single firm does not reflect innovation processes in modern economies. For example, while a given firm may find it is particularly good at figuring out how to extend the life of batteries, other companies might be better at turning the underlying inventions into components for different consumer electronics. Similarly, a firm may know how best to market a new kitchen utensil in its home market, but prefer to partner with another firm in an unfamiliar foreign market. Specialization allows firms to maximize an inherent advantage, ultimately enhancing the economy-wide productivity of the innovation process.

Economic theory holds that specialization occurs wherever the transaction cost of providing specific goods or services through the market is lower than the costs of coordination within a single organization.[9] Specialization in the innovation process relies on markets for technology. Compared to markets for standardized commodities, technology markets face especially high transaction costs – in the form of information, search, bargaining, enforcement and related costs.[10]

To some extent, IP rights can reduce these costs. In the absence of patent rights, for instance, firms would be reluctant to disclose secret but easy-to-copy technologies to other firms when negotiating licensing contracts.[11] As a result, licensing agreements from which all parties stand to benefit might never materialize. In addition, while inventive and creative assets can, in principle, be transferred through private contracts independent of any IP right, IP titles offer a delineation of these assets combined with an assurance of market exclusivity. IP rights thus convey important information that can facilitate the drawing up of contracts and reduce the uncertainty of contracting parties as to the commercial value of the licensed assets.

Fourth, the grant of exclusive IP rights affords firms market power, viewed by economists as the ability to set prices above marginal production costs. In many cases, market power emanating from an IP right is limited, as companies face competition from similar products or technologies. However, for radical innovation – say, a pharmaceutical product treating a disease for which no alternative treatment exists – market power can be substantial. The ability of companies to generate profits above competitive levels – also called economic rents – is part of the economic logic of the IP system. Economic rents allow companies to recoup their initial investment in research and development (R&D). In other words, economic rents are at the core of the solution to the appropriability problem.

However, market power also implies a non-optimal allocation of resources, moving markets away from the economic ideal of perfect competition. Above-marginal cost pricing can raise social concerns, as witnessed by the debate on patents and access to medicines. It can also slow the adoption of new technologies, with follow-on effects on economic productivity. Finally, scholars have long recognized that the existence of economic rents may promote rent-seeking behavior with wasteful or outright harmful consequences.[12]

9 See, for example, Coase (1937) and Alchian and Demsetz (1972).
10 See Arora *et al.* (2001b) and Arora and Gambardella (2010).
11 See Williamson (1981) and Arrow (1971).
12 See Tullock (1987) for a discussion of the economics of rent-seeking.

The foregoing discussion reveals that IP rights have multiple effects on innovative behavior. Understanding their net effect ultimately requires empirical insight. Generating credible empirical evidence is a difficult task, however. Unlike in the natural sciences, economists usually cannot conduct experiments, say, by randomly assigning IP rights to companies or IP laws to countries. Historical experience sometimes offers quasinatural experiments, allowing for important insights – as illustrated by research on innovation in the 19th century (see Box 2.1). However, it is not clear whether these insights still apply to today's more evolved innovation systems and economic structures.

Box 2.1: How did patent laws affect innovation in the 19th century?

In the mid-19th century, countries in northern Europe protected patents to varying degrees. A few – such as Denmark, the Netherlands and Switzerland – did not provide for patent protection during certain periods. Where protection was available, it varied from 3 to 15 years. Countries adopted patent laws in a relatively ad hoc manner, influenced more by legal traditions than economic considerations.

Economic historian Petra Moser (2005) analyzed whether this variation in national patent laws influenced innovation outcomes. In particular, she collected data on close to 15,000 inventions presented at the Crystal Palace World's Fair in 1851 and the Centennial Exhibition in 1876; her dataset covered inventions from 13 northern European countries across 7 industries. She then asked whether patterns of innovation in countries that provided for patent protection differed from those that did not.

Her findings suggest that innovators in countries without patent laws focused on a small set of industries where innovation could be appropriated through secrecy or other means – most notably, scientific instruments. By contrast, innovation in countries with patent laws appeared to be more diversified. These findings suggest that innovation takes place even in the absence of patent protection; however, the existence of patent laws affects the direction of technical change and thus determines countries' industrial specialization.

Notwithstanding these difficulties, economic research has generated useful empirical evidence for evaluating the impact of IP rights on innovation. Section 2.2 – as well as Chapters 3 and 4 – will further review this evidence. However, before doing so, it is instructive to explore the implications of the above considerations for the design of IP rights and how these rights compare with other public policies aimed at promoting innovation.

2.1.2

Trade-offs in designing IP rights

IP rights are not discrete policy instruments. National policymakers face far-reaching choices on what can be protected by different IP instruments, which rights are conferred and the exceptions that may apply.[13]

As a first consideration, the effectiveness of different IP instruments depends on firms' absorptive and innovative capacity (see Box 2.2). Economic research has further shown that a firm's ability to profit from its innovation depends on access to complementary assets – such as manufacturing capability, organizational know-how and marketing skills.[14] These factors vary considerably across countries at different levels of economic development.

The design of IP rights needs to respond to the innovative potential of local firms. For firms in countries at an early stage of development, utility models may be more relevant than patents for protecting inventive output.[15] Several East Asian countries relied heavily on utility models in their early development stages – often protecting incremental, non-patentable modifications of imported products.[16] One study on the historical experience of the Republic of Korea found that the experience firms gained by using the utility model system prepared them for effectively using the patent system, both nationally and internationally.[17] However, other low- and middle-income countries with utility model systems in place have not seen a similar reliance on this form of IP. No systematic evidence is available to guide policymakers on the circumstances under which utility models work best.

13 As will be further discussed in Section 2.3, policymakers also face important choices in the design of institutions that administer and enforce patent rights.
14 See Teece (1986).
15 Utility models are sometimes also known as petty patents.
16 See Suthersanen (2006).
17 See Lee (2010).

Box 2.2: Absorptive and innovative capacity

The terms absorptive and innovative capacity refer to the set of conditions that enable firms to learn about existing innovation from external sources and to generate innovation themselves. The factors that determine a firm's capacity to absorb external information and to produce new ideas are related, but the concepts explain the different capabilities that firms require in order to successfully innovate.

Absorptive capacity was first used by economists Wesley Cohen and Daniel Levinthal in their seminal articles in 1989 and 1990 on the importance of firms undertaking R&D. They argue that conducting R&D generates two useful outcomes: new information and enhanced ability to assimilate and exploit existing information. When firms conduct R&D, they learn from the process and build technical skills. This, in turn, enables them to identify and assimilate R&D outcomes developed elsewhere, improve their technical knowledge and, later, their innovative capability, the ability to create new innovation.[18]

The ability to assimilate and learn from new knowledge is also relevant at the economy-wide level. Economies that are able to build sufficient absorptive capacity are more likely to benefit from exposure to foreign technologies and may, eventually, develop the ability to generate new technologies on their own.[19]

In economic theory, the design of IP rights has been treated as an optimization problem: governments adjust IP policy in order to maximize the net benefit that accrues to society from new inventions, taking into account the possibly adverse effects exclusive rights have on competition and follow-on innovation. Economist William Nordhaus first applied the optimization approach to setting the term of patent protection.[20] It can also be applied to the breadth of IP protection – as determined by the claims set out in IP titles and their interpretation by courts.[21]

In the actual design of IP rights, economic optimization arguably has played little direct role. This partly reflects the difficulty of empirically implementing an optimization model. The societal value of inventions is typically unknown before policies are set. In addition, fully capturing all the benefits and costs, as outlined in Subsection 2.1.1, seems elusive, even for the best-equipped economists.

Nonetheless, economic theory offers some useful guidance for policymakers. First is that IP protection standards should be differentiated according to the specific environment in which innovation takes place. This is partly reflected in actual IP policy by the fact that different IP instruments exist for different subject matters (see Table 2.1). For example, while a new tablet computer may be protected by patents, industrial designs and copyright, each IP right protects a distinct innovative element – whether it is the technology for operating a touch screen, the aesthetic feature of the tablet's design or the software running on it.

There is also important scope for fine-tuning the breadth of IP rights across different technology fields – partly through laws and partly through the actions of IP offices and courts. Economists have argued, for example, for differentiated patent breadth depending on the extent to which patented inventions in particular industries build on each other.[22] While some differentiation does indeed occur in practice, it is not clear whether it always follows economic considerations.[23]

18 See Cohen and Levinthal (1989, 1990).
19 See the works of Nelson (1993), Kim (1997), Yu (1998), the World Bank (2001) and Lall (2003).
20 See Nordhaus (1969).
21 See Scotchmer (2004) and Gilbert and Shapiro (1990).
22 For example, Jaffe (2000) argues that broader patent protection should be afforded to the initial invention in a line of cumulative inventions. See also Green and Scotchmer (1995), Scotchmer (1996) and O'Donoghue *et al.* (1998).
23 Lemley and Burk (2003) discuss how US patenting standards differ across industries and what motivates these differences.

The changing nature of innovation has challenged established norms on what subject matters can be protected by different IP instruments, especially in the area of patents. Historically, patents have been associated with technological inventions; the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS Agreement), for example, refers to inventions "in all fields of technology". However, the rise of non-technological inventions has raised questions about whether patents should also be granted for software, business methods or financial trading strategies, to name a few examples. From an economic perspective, arguably it matters less whether an invention is of a technological nature; what is more important is whether patent rights make a difference in resolving appropriability problems and contribute to the disclosure of knowledge that would otherwise remain secret.

Finally, in designing differentiated IP standards, certain trade-offs exist. Policymakers may not be sufficiently informed about innovation conditions to optimally differentiate IP policies. In addition, uniform IP standards are easier to operate, and political economy pressures to favor certain sectors are less likely to arise.

Moreover, policymakers need to be aware of how certain forms of IP may be chosen over others. In particular, firms face the choice of protecting inventions by patent rights or through trade secrecy. Surveys suggest that weak patent rights may prompt firms to rely more often on secrecy.[24] This enlarges opportunities for legitimate imitation and technology diffusion; however, where imitation is not possible, it may forestall the disclosure of valuable knowledge.[25]

2.1.3

How IP protection compares to other innovation policies

IP rights are a useful incentive mechanism when private motivation to innovate aligns with society's preferences with regard to new technologies. But such an alignment does not always exist. In addition, it is unclear whether the IP system can incentivize invention that is far from market application, for example basic science research. So, what other means do governments have to promote innovation, and how do they compare with the IP system?

In general, one can broadly distinguish three mechanisms for promoting innovation. First, there is publicly-funded innovation carried out by academic institutions and public research organizations. Second, governments can fund research undertaken by private firms – notably through public procurement, research subsidies, soft loans, R&D tax credits and innovation prizes. Third, the IP system is the one mechanism that promotes privately executed R&D which is financed through the marketplace rather than government revenues.[26]

24 See Mansfield (1986), Levin *et al.* (1987) and Graham and Sichelman (2008). These surveys show that firms – across many industrial sectors, except for the chemical and pharmaceutical sectors – relied more heavily on trade secrets than on patents to protect their innovation from rivals. They also show that firms producing process – rather than product – innovation rank trade secrets as more effective than patents in protecting innovation. This preference is also expressed where the likelihood of imitation is higher, such as where patent protection is perceived to be weak or the perceived value of innovation is high.

25 Lerner and Zhu (2007) show that a weakening of copyright protection in the US has prompted software developers increasingly to rely on patent rights. However, it is not clear from their study how this substitution of IP forms has affected innovation.

26 See, for example, David (1993).

It is important to recognize that the various instruments of innovation policy can be complementary. For instance, academic research sometimes results in patents and subsequent licensing for commercial development. Similarly, government support of privately undertaken research may result in IP ownership. However, it is useful to independently analyze and compare each policy instrument.

Table 2.2 offers an overview of the different mechanisms and compares them along several dimensions. It shows that the choice of policy instrument depends on the circumstances in which R&D is conducted. To begin with, basic research that does not immediately lead to commercial application is largely undertaken by academia and public research organizations. These institutions also invest in more generic research aimed at advancing specific societal interests – for example in the area of health. Other policy instruments can also spur such generic research, although they typically place a stronger emphasis on applied research.

Important differences exist in how R&D is financed. Certain policy instruments – notably, prizes, R&D tax credits and IP rights – require firms to initially fund R&D activity on their own or through financial markets. These instruments may therefore be less effective for large and highly risky R&D projects and in economies with underdeveloped financial markets (see Box 2.3). The other instruments provide upfront public financing of R&D, reducing ex-ante risk and avoiding the problems of imperfect credit markets.[27]

Box 2.3: Barriers to innovation in Chile

Chile is a small open economy that mainly exports raw materials and agricultural commodities – such as copper, wine, fruits and fish. Nonetheless, the country has incipient technological capabilities in certain industries, notably those linked to the processing of natural resources. Indeed, responses to Chile's national innovation survey reveal that 24.8 percent of firms had introduced some kind of innovation in the 2007-2008 period.

What barriers do Chilean firms encounter when they innovate? According to the same survey, high costs of innovative activity and difficulties in obtaining financing rank among the most important barriers. Firms also indicate "ease of copying by other firms" as a problem, but it only ranks 11th on the list of barriers. Accordingly, only 4.8 percent of innovating firms indicated that they had applied for patents – a figure far below similar shares for the United States (US) and European countries.

In response to these key barriers to innovation, one central element of Chile's innovation policy has been the provision of innovation subsidies. Two innovation funds – the *Fondo Nacional de Desarrollo Científico y Tecnológico* and the *Fondo de Fomento al Desarrollo Científico y Tecnológico* – offer support to basic scientific research and early stage R&D activity.

Source: Benavente (2011).

A closely related consideration is whether a policy instrument functions mainly as a "push" or a "pull" mechanism. The key difference is that, in the case of a "push" mechanism innovators are rewarded at the outset, whereas in the latter case, the reward depends on the innovation's success. "Pull" mechanisms such as IP rights and prizes may thus entail stronger performance incentives, as innovators face the pressure – or lure – of success when engaging in R&D.

27 For a literature survey, see Hall and Lerner (2010).

As mentioned earlier, one attraction of the IP system is that companies likely to be well-informed about technological opportunities select R&D projects themselves. This is also the case for tax credits. In order to obtain subsidies and soft loans, companies may initiate an R&D project, but it is a government agency that ultimately decides whether to support the project. In the case of procurement and innovation prizes, governments initiate and select R&D projects. This may give rise to so-called information failures. First, governments may be imperfectly informed about the success potential of competing R&D projects, possibly leading to less than ideal choices. Second, problems related to incomplete contracting may arise; in particular, it may be difficult at the outset to fully enumerate the conditions that determine whether a procurement contract or prize objective has been fulfilled.

The categorization presented in Table 2.2 ignores important choices in the design of individual policy instruments that affect innovation performance. However, it points to some of the key advantages and drawbacks of the IP system relative to other innovation policies. First, for governments, the IP system is cheap; it does not require government spending to finance R&D. Second, R&D decisions based on IP rights are decentralized, reducing information failures. Tax credits offer the same advantage, but do not by themselves solve the appropriability problem. In fact, for tax credits to be effective, firms need to be able to appropriate innovation investment – including through IP rights.

One drawback of the IP system is that it leads to exclusive rights over research outcomes; this may reduce competition and slow cumulative innovation. Innovation prizes that result in public ownership of research results are superior in this respect, and they preserve the "pull" property of the IP system. However, they can suffer from information failures, notably the difficulty of writing complete contracts. This may explain why innovation prizes have mainly been used for relatively small-scale problems for which solutions are within reach, and mainly by firms rather than governments (see subsection 1.2.5). Nonetheless, prizes may be especially suitable for incentivizing socially desirable innovation for which no or only small markets exist, precisely because of the lack of market signals that may otherwise guide R&D decisions.[28]

A second drawback of IP rights – and prizes – is that they require *ex-ante* private financing of R&D. In environments where such financing is hard to come by, "push" instruments such as subsidies and soft loans may be needed to encourage innovation, especially where risk is involved.

In sum, no single policy instrument works best in all circumstances. In considering which instrument to employ, policymakers need to take into account financing conditions, risk levels, possible information failures, performance incentives and other variables. Indeed, since each policy instrument has both advantages and drawbacks, the key challenge for policymakers is to mix policies so that they effectively complement each other.

28 Much thought has been given in recent years to designing innovation prizes in a way that maximizes their effectiveness, especially in the pharmaceutical sector. For example, see Love and Hubbard (2009) and Sussex *et al.* (2011).

Table 2.2: Overview of innovation policy instruments

	Main features	Research direction	Financing of R&D	Push versus pull	Selecting entity	Selection criteria	Ownership of results	Main advantages	Main drawbacks
Publicly funded and executed									
Public research organizations	• Public goods such as defense and health • Does not undertake commercialization of knowledge	• Basic • Generic	• *Ex-ante* financing of project cost	• Push	• Government	• Public interest • Peer review	• Public • Institution	• Advance fundamental scientific knowledge	• Uncertain impact
Academic research	• Aimed at increasing basic scientific knowledge • Does not undertake commercialization of knowledge	• Basic • Generic	• *Ex-ante* financing of project cost	• Push	• Government • University • Philanthropy	• Public need • Peer review	• Public • Institution	• Advance fundamental scientific knowledge	• Uncertain impact
Publicly funded and privately executed									
Procurement	• Government purchases of well-defined innovative goods – for example, military equipment	• Generic • Applied	• Financing of project cost • Timing depends on contract	• Combination of push and pull depending on design	• Government	• *Ex-ante* competition	• Depends on contract	• Mobilizes competitive market forces for the provision of public good	• Difficult to write perfect contracts
Research subsidies and direct government funding	• Public support for targeted research	• Generic • Applied	• *Ex-ante* financing based on estimated project cost	• Push	• Government • Firm	• Competition • Administrative decision	• Usually firm	• Mobilizes competitive market forces for public benefit	• Governments are imperfectly informed about success potential of R&D projects
Prizes	• Prizes for targeted solutions to specific problems	• Generic • Applied	• *Ex-post* financing based on ex-ante estimated project cost	• Pull	• Government	• Competition	• Usually public	• Mobilizes competitive market forces for public benefit • Subsequent competitive provision of technology	• Difficult to write perfect contracts • Requires private *ex-ante* financing of R&D
Soft loans	• Subsidized provision of credit through below-market interest rates, government guarantees and flexible reimbursement provisions	• Applied	• *Ex-ante* financing based on estimated project cost	• Push • Some pull depending on design	• Government • Firm	• Administrative decision	• Firm	• Reduces risks associated with large R&D undertakings	• Governments are asymmetrically informed about success potential of R&D projects • Does not address firms' appropriability problem
R&D tax credits and related fiscal incentives	• Reduced taxation of profits linked to investment in R&D	• Generic • Applied	• *Ex-post* financing dependent on actual investment expenditure	• Push • Some pull depending on design	• Firm	• Proof of R&D investment	• Firm	• Decisions on R&D decentralized	• Does not address firms' appropriability problem • Requires private *ex-ante* financing of R&D
Privately funded and executed									
IP rights	• Market exclusivity	• Generic • Applied	• *Ex-post* financing based on market value of innovation	• Pull	• Firm	• As specified in IP laws	• IP owner (firm or institution)	• Decisions on R&D decentralized	• Static misallocation of resources • Requires private *ex-ante* financing of R&D

Source: WIPO, extending on Guellec and van Pottelsberghe de la Potterie (2007) and Granstrand (1999, 2011).

2.2

Taking a closer look at the patent system

The last three decades have seen use of the patent system increase to historically unprecedented levels (see Figure 1.18). They have also seen substantial increases in real R&D investment and remarkable progress in many areas of technology – most spectacularly in the information and communications technology (ICT) field. While these trends indicate that patenting has become more central to strategies of innovative firms, they alone do not reveal how effective the patent system has been in promoting innovation and improving welfare.

Prompted by the increase in patenting activity, economists have scrutinized the role that patents play in the innovation process. In addition, the construction of new databases – often combining unit record data on patents with firm-level information on innovative behavior and economic performance – has enabled richer investigations into the effects of patent protection.

This section takes a closer look at the economics of the patent system, focusing on more recent research. It expands on several concepts and ideas introduced in the previous section and confronts them with empirical evidence. In particular, it discusses how effective the patent system is as an appropriation mechanism in different sectors of the economy (Subsection 2.2.1), how more widespread patenting affects the process of cumulative innovation (Subsection 2.2.2), how patent rights shape the interplay between competition and innovation (Subsection 2.2.3) and the role patents play in modern technology markets and open innovation strategies (Subsection 2.2.4). The insights gained through more recent research have led economists to refine their views on the role the patent system plays in the innovation process.

2.2.1

How patent protection affects firm performance

As a first step, it is helpful to review the evidence on how patent protection affects the performance of firms. Subsection 2.1.1 pointed to one key difficulty in generating empirical evidence: since patent systems have been in place in most countries throughout recent history, no obvious benchmarks exist against which the performance of patenting firms can be compared. One way around this problem is to directly survey firms about the importance they place on patents as an appropriation mechanism for innovative activity. Several such surveys have been conducted, and Table 2.3 summarizes their main results.

As pointed out in Section 2.1, both lead time and sales and service activities emerge as the most important appropriation mechanisms. The importance of patents varies across industries. In industries with short product life cycles – for example, electronics – patents appear to be of lesser importance; indeed, technologies may be obsolete by the time patents are granted. By contrast, patent protection is critically important in the chemical and pharmaceutical industries. This results from the long R&D process in these industries, combined with the fact that chemical and pharmaceutical products are easily imitated once introduced to the market. The surveys summarized in Table 2.3 provide useful insights into the role of patent protection, but the evidence is qualitative in nature.

Table 2.3: Summary of survey evidence

Survey	Year	Country	Survey sample	Product innovation					Process innovation				
				1	2	3	4	5	1	2	3	4	5
Yale	1982	US	Firms (publicly traded), performing R&D in the manufacturing sector	Sales or service efforts	Lead time	Fast learning curve	Patents	Secrecy	Lead time	Fast learning curve	Sales or service efforts	Secrecy	Patents
Harabi	1988	Switzerland	Firms engaging in R&D, mainly in manufacturing sector	Sales or service efforts	Lead time	Fast learning	Secrecy	Patent	Lead time	Sales or service efforts	Fast learning	Secrecy	Patents
Dutch CIS	1992	Netherlands	Firms (≥10 employees) that developed or introduced new or improved products, services or processes during the last three years in the manufacturing sector	Lead time	Retain skilled labor	Secrecy	Patent	Complex-ity of design	Lead time	Retain skilled labor	Secrecy	Complex-ity of design	Certifi-cation
Carnegie Mellon	1994	US	Firms (≥ 20 employees and ≥ USD 5 million in sales) performing R&D in the manufacturing sector	Lead time	Secrecy	Comple-mentary assets	Sales or service efforts	Patent	Secrecy	Comple-mentary assets	Lead time	Sales or service efforts	Patents
Japan Carnegie Mellon	1994	Japan	Firms performing R&D (≥ JPY 1 billion capitalization) in the manufacturing sector	Lead time	Patents	Comple-mentary assets	Sales or service efforts	Secrecy	Comple-mentary assets	Secrecy	Lead time	Patents	Sales or services assets
RIETI-Georgia Tech	2007	Japan	Inventors who applied for triadic patents with priority years 2000-2003	Lead time	Comple-mentary assets	Secrecy	Comple-mentary assets	Patents	Survey does not distinguish between product and process innovation				
Berkeley	2008	US	Small manufacturing firms focusing on biotechnology, medical devices and software	Lead time	Secrecy	Comple-mentary assets	Patents	Reverse engi-neering difficult	Survey does not distinguish between product and process innovation				

Source: WIPO extending on Hall (2009). Results of the surveys were collected for Yale (Levin *et al*., 1987), Switzerland (Harabi, 1995), Dutch CIS (Brouwer and Kleinknecht, 1999), Carnegie Mellon (Cohen *et al*., 2000), Japan Carnegie Mellon (Cohen *et al*., 2002), RIETI-Georgia Tech (Nagaoka and Walsh, 2008), Berkeley (Graham *et al*., 2009).

Several studies have sought to generate quantitative evidence on the importance of patent protection. One study by Arora and his co-authors (2008) employs detailed data on firms' innovative activity and patenting behavior to estimate a so-called patent premium – defined as the increment to the value of an invention due to having it patented. The study's methodology takes into account that patenting decisions are not random: firms only seek to patent inventions that can be expected to yield a net benefit. The results indicate a premium of almost 50 percent for patented inventions.[29] Confirming the earlier survey evidence, patent premia are highest in the fields of medical instruments, pharmaceuticals and biotechnology and lowest in the food and electronics sectors. The results also show that patent premia are higher for larger firms; one likely explanation for this finding is that larger firms are better equipped to exploit and enforce patents than smaller firms.[30]

29 Arora *et al.* (2008) estimate a negative patent premium for all innovation – including innovative technologies that firms do not actually patent. This suggests that the costs of patenting – in the form of the possible disclosure of knowledge that would otherwise be kept secret – exceed its benefits for many innovations.

30 Patent renewal models also offer insight into the private value firms derive from having their inventions protected by patents. Important studies in this field include Pakes (1986), Schankerman and Pakes (1986), Lanjouw *et al.* (1998) and Schankerman (1998). However, these studies do not offer a direct estimate of the R&D-incentive effect associated with patent protection.

Studies have also investigated whether the prospect of securing patent rights leads firms to invest more in R&D. A study by Qian (2007) focuses on the experience of 26 countries that introduced pharmaceutical patent protection in the period 1978-2002. The pharmaceutical sector is especially suited for analyzing how patent protection affects R&D behavior. The survey evidence summarized in Table 2.3 reveals the importance of patent protection in this sector, and the establishment of pharmaceutical product patent protection typically represents a major policy shift. The study finds no effect for patent protection across all countries, but a positive effect in countries that are more developed and have higher levels of education. This finding highlights the fact that pre-existing innovative capacity is an important factor in whether patent rights matter (see Subsection 2.2.2).

A closely related study by Kyle and McGahan (2011) draws similar conclusions. In addition, it finds that the introduction of patent protection in lower-income countries has not created incentives for R&D related to diseases primarily affecting those countries. The study argues that this result is due to the small size of these countries and calls for complementary innovation policies to incentivize R&D specific to the needs of poorer societies (see Subsection 2.2.3).[31]

A related question concerns whether differences in the level of patent protection across countries affect firms' decisions on where to locate R&D. Such differences may be of minor importance for R&D directed at global markets. However, R&D often has a local component – for example, where firms adapt technologies to local markets or focus on the preferences and needs of local consumers.

Thursby and Thursby (2006) studied the importance of IP protection in the decision-making process of R&D-intensive multinational firms. In a survey of 250 such firms, respondents identified IP protection as an important factor in determining where to conduct R&D. However, they still established R&D facilities in markets where IP protection was perceived to be weak. Indeed, other factors – notably, the potential for market growth and the quality of R&D personnel – emerge as important drivers of location decisions. Further research work by Thursby and Thursby (2011) highlights the fact that most "new-to-the-world" research is conducted either in the US or in other high-income countries where IP protection tends to be strong. Again, however, IP protection does not appear to be the main driver of this outcome; university faculty expertise and ease of collaboration with universities emerge as the key factors which explain where firms carry out cutting-edge research.

31 The evidence from other studies is more ambiguous, although many use a less convincing policy counterfactual. Park and Ginarte (1997) and Kanwar and Evenson (2003) use an index that measures overall strength of a country's IP rights. They also find that patent protection leads to greater R&D expenditure for countries above certain levels of development. Sakakibara and Branstetter (2001) studied the effects on R&D of Japan's 1988 patent reform and find only a small impact on R&D activity.

Recognizing that patents can convey information about the commercial potential of inventions, economists have studied their role in mobilizing financial resources for innovative firms. Indeed, studies have found that firms that own patents are more likely to receive financing from venture capitalists than those that do not. Recent surveys conducted in the US show that this is the case for small rather than large firms.[32] Two important studies on venture capital financing of US semiconductor firms show that not only do patent applications convey important information to investors about the quality of inventions, they also help firms to attract funds in the earlier stages of financing.[33] At the same time, the importance of patents in facilitating access to finance differs by industry, with, for example, patents playing a more prominent role in health care-related technologies than ICTs.[34]

32 See Lemley (2000), Hsu and Ziedonis (2008), Harhoff (2009), Graham and Sichelman (2008) and Sichelman and Graham (2010).

33 Cockburn and MacGarvie (2009) examine how US legislation enabling the patentability of software in the mid-1990s has affected market entry of new competitors. They use data on the financing of entrants in 27 narrowly defined software markets. One of their findings is that firms with patents are more likely to be funded by venture capitalists. See also Greenberg (2010).

34 See Graham *et al.* (2009). This study also suggests that the role of patents differs according to financing source.

2.2.2

How patent strategies shift where innovation is cumulative

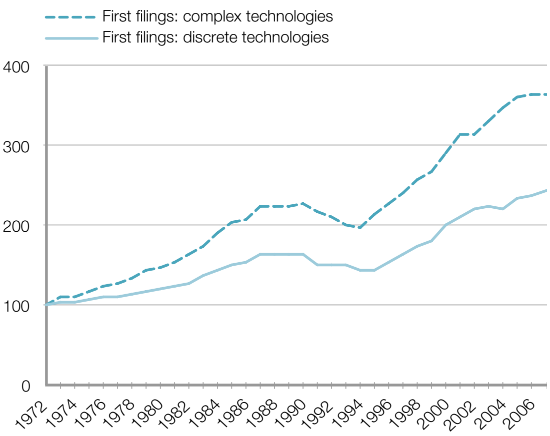
To understand how patent protection affects innovation, it is essential to look beyond the individual firm. Innovative activity seldom happens in isolation; one firm's solution to a problem typically relies on insights gained from previous innovation. Similarly, in competitive markets, firms innovate simultaneously and develop technologies that may complement each other. As pointed out in Subsection 2.1.1, patent rights influence how prior or complementary knowledge can be accessed and commercialized.

The rapid increase in the number of patent filings has raised concerns about patents hindering cumulative innovation. Indeed, patenting activity has grown especially fast for so-called complex technologies. Economists define complex technologies as those that consist of numerous separately patentable inventions with possibly widespread patent ownership; discrete technologies, by contrast, describe products or processes made up of only a few patentable inventions. Figure 2.1 depicts the growth in patent applications worldwide for these two technology categories. The top figure compares patenting growth for first filings, approximating new inventions; it shows consistently faster filing growth for complex technologies since the early 1970s. The bottom figure focuses on subsequent filings, made up mostly of filings outside the applicants' home country; it reveals equally faster filing growth for complex technologies, though only starting from the mid-1990s.

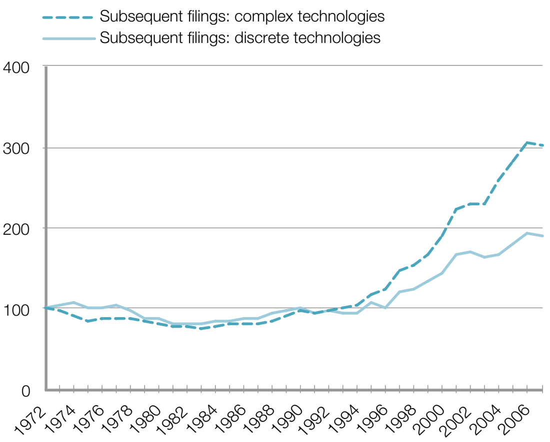
Figure 2.1: Complex technologies see faster patenting growth

Patent filings for complex versus discrete technologies, 1972=100, 1972-2007

First filings



Subsequent filings



Note: WIPO's IPC-Technology Concordance Table is used to classify the data by field of technology. The classification of complex and discrete technologies follows von Graevenitz *et al.* (2008).

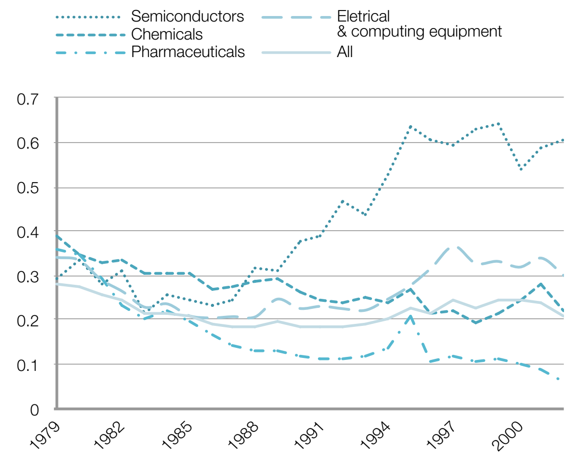
Source: WIPO Statistics Database, March 2011.

What accounts for the difference in growth rates? The difference may partly reflect the nature of technological change. For example, complex technologies include most ICTs which have experienced rapid advances over the past three decades. However, economic research suggests that faster growth in complex technologies is also due to a shift in patenting strategies.

Hall and Ziedonis (2001) convincingly made this point in their study of patenting behavior in the US semiconductor industry. Firm surveys such as the ones outlined in Table 2.3 show that patents are among the less effective mechanisms for appropriating returns on R&D in this sector; because of short product life cycles, semiconductor firms mainly rely on lead time advantage and trade secrets to recoup their investment in innovation. Paradoxically, however, the US saw a sharp increase in semiconductor patenting from the mid-1980s to the mid-1990s. Moreover, semiconductor patenting grew at a faster pace than real R&D investment, leading to a doubling of the so-called patent yield (see Figure 2.2).

Figure 2.2: Semiconductor patenting grows faster than R&D investment

Patent yield in selected US manufacturing industries, 1979-2002



Note: Patent yield is defined as the ratio of patents granted to constant dollar R&D investment. It is based on a sample of publicly listed firms for which R&D data are available through Compustat. Chemicals exclude pharmaceuticals and electrical and computing equipment excludes semiconductors.

Source: Updated from Hall and Ziedonis (2001).

Hall and Ziedonis relate the increase in semiconductor patenting to shifts in the US legal environment that proved favorable to patent owners. Relying on econometric analysis of firm-level data and interviews with semiconductor firms, they conclude that these shifts prompted firms to proactively build up large patent portfolios. One motivation for such portfolios is to ensure a firm's freedom to operate in its innovation space and preempt litigation. In fact, the study finds that the large-scale and capital-intensive manufacturers most vulnerable to holdup – for example, through preliminary injunctions – invested most aggressively in securing patent rights. A second motivation for creating these portfolios is to strengthen a firm's bargaining position vis-à-vis its competitors. In particular, a firm owning many patents in a crowded technology space can preempt litigation by credibly threatening to countersue competitors. In addition, it is in a better position to negotiate favorable cross-licensing arrangements that are often needed to commercialize new technologies.[35]

How widespread is strategic patenting beyond the US semiconductor industry? Clearly, patent portfolio races have been documented for other complex technologies – ICTs in general and, in particular, telecommunications, software, audiovisual technology, optics and, more recently, smartphones and tablet computers.[36] While the Hall-Ziedonis study focused on the US, evidence suggests that electronics firms in other countries – especially in East Asia – have also built up large patent portfolios for strategic purposes.[37] According to one study, a 1986 lawsuit by semiconductor firm Texas Instruments against Samsung – which led to a settlement worth more than USD 1 billion – proved to be a catalyst for Korean firms to proactively build up their patent portfolios.[38] Still, looking at trends in patent filings and real R&D expenditure, the US stands out as the only major jurisdiction that has seen a consistent increase in the economy-wide patent yield since the mid-1980s.[39] While other factors may account for this diverging trend, it is consistent with the conclusion of Hall and Ziedonis that patent portfolio races were prompted by changes in the US legal environment.[40]

What is the ultimate effect of strategic patenting behavior on welfare and innovation? On the one hand, such behavior has not obviously prevented rapid progress in semiconductors and many other complex technologies – though the counterfactual scenario remains, of course, unclear.[41] In addition, the study by Hall and Ziedonis points out that patent protection fostered specialization in semiconductor innovation; in particular, patent rights facilitated the entry of specialized semiconductor design firms which initially had relied on venture capital finance.[42]

35 For survey evidence on the importance of patent ownership for negotiating cross-licensing arrangements, see Cohen *et al.* (2000) and Sichelman and Graham (2010).
36 See Harhoff *et al.* (2007) and, for software, Noel and Schankerman (2006). In the case of smartphones, evidence is still anecdotal in nature – see "Apple and Microsoft Beat Google for Nortel Patents" in The New York Times (Nicholson, 2011).
37 See Cohen *et al.* (2002).
38 See Lee and Kim (2010).
39 See WIPO (2011a), measuring patent yield as first filings over real R&D expenditure. Similarly, Switzerland and the Netherlands have seen a rise in patent yield since the early 1990s. The Republic of Korea experienced a rising patent yield from 1994 to 2000, but that measure has since fallen.
40 However, survey evidence suggests that strategic use of patents is more prevalent in Japan than in the US (Cohen *et al.*, 2002).
41 To the extent that large patent portfolios can be said to "neutralize" each other, the costs of acquiring and administering them may, from an economy-wide perspective, be considered wasteful.
42 See also Arora *et al.* (2001a) and Arora and Ceccagnoli (2006) for similar evidence beyond the semiconductor industry.

On the other hand, econometric evidence suggests that dense webs of overlapping patent rights – so-called patent thickets – can indeed slow or even forestall cumulative innovation processes.[43] High transaction costs have made it difficult for some – especially small – firms to obtain the licenses necessary for prior and complementary technologies; the latter include patented research tools that, for example, are of special relevance to biotechnology research.[44] As will be further discussed in Chapter 3, private collaborative arrangements can, to some extent, preempt such adverse outcomes.

Finally, strategic patenting affects the nature and intensity of competition in product markets, in turn affecting innovation incentives. To understand precisely how first requires a broader discussion of the interaction between the forces of competition and innovation.

2.2.3

How patent rights shape the interplay between competition and innovation

Competition in product markets affects innovative behavior in different ways. Subsection 2.1.1 discussed one such way: if firms cannot generate profits above competitive levels, they cannot recoup their initial R&D investment. Too much competition harms innovation. Indeed, this relationship appears to hold empirically; studies show that, across industries, more intense competition is associated with less innovation. However, this correlation only holds above a certain threshold of competition. Below that level, more intense competition is actually associated with increasing innovation.[45] This latter finding has an intuitive explanation: if firms generate large economic rents and face little competition that threatens these rents, market pressure to innovate is weak. If, by contrast, firms' economic rents are threatened by rival innovative efforts, their incentive to innovate on their own is stronger.

Overall, there is thus an inverted-U-shaped relationship between competition and innovation, whereby investment in innovation first increases with the level of competition, and then declines as competition intensifies beyond that level. Although intuitive, formally incorporating these relationships into theoretical models of industrial organization has turned out to be difficult. Only recently have economists developed models that generate the inverted-U relationship observed in the data.[46]

How do patent rights influence the competition-innovation relationship? On the one hand, one may argue that patent rights foster a healthy competitive balance. They prevent competition of the free-riding type that undermines the appropriation of R&D investment. But they permit competition between substitute products each of which may be protected by different patent rights. In addition, certain features of the patent system directly promote competitive market forces: the disclosure requirement enables firms to learn from the inventions of rivals; and

43 See Cockburn *et al.* (2010) for econometric evidence.
44 See Eisenberg (1996), Heller and Eisenberg (1998), Murray and Stern (2006, 2007) and Verbuere *et al.* (2006).
45 See Aghion *et al.* (2005).
46 *Idem.*

the limited protection term ensures that the economic rent associated with a patent is time-bound, inducing firms to stay ahead by constantly innovating.

On the other hand, patent ownership can, in certain situations, significantly curtail competition. While rare, patent rights to key technologies for which few substitutes exist can lead to concentrated market structures. In addition, the emergence of patent thickets, as outlined in the previous subsection, can negatively affect competition by marginalizing those firms that do not have a sufficiently large patent portfolio as a bargaining tool. Where patent rights overly restrict competition, society loses twice: through higher prices and less choice in product markets; and through insufficient competitive pressure on firms to innovate. In practice, it is difficult for policymakers to assess when such a situation arises. There is little empirical guidance on what "dose" of competition is optimal for innovation. Indeed, this will differ across industries and depends on the characteristics of markets and technologies.

Nonetheless, policymakers should be especially concerned about two types of patenting practices. First, certain patenting strategies primarily serve to slow the innovative efforts of rival firms. For example, a firm may seek a patent for a technology that it does not commercialize, but may then sue rivals on the basis of that patent to block entry into product markets.[47] Indeed, a recent inventor survey revealed that, for nearly one-fifth of patents filed at the European Patent Office (EPO), "blocking competitors" was an important motivation for patenting.[48]

A related strategy involves filing patents with broad claims for trivial inventions and threatening competitors with litigation; even if the patent office eventually rejects those patents, they may generate uncertainty among rival firms who fear that their own innovative activity may clash with future patent rights. Small firms and new market entrants – often thought to be an especially important source of innovation in the economy – may be especially vulnerable to these types of blocking strategy, because they may not have a large enough patent portfolio to deter litigious rivals.

The rise in patenting of complex technologies has arguably widened the scope for using patents anticompetitively. Identifying such practices is difficult. Patent documents alone do not offer any insight into the strategic use of patent rights.[49] In addition, the line between a patent that aims to ensure freedom-to-operate versus a predatory patent may not be easily drawn, especially in industries with dense patent thickets. As will be further explained in Section 2.3, sound patent institutions can reduce the potential for patents to be used anti-competitively. In addition, there is an important role for competition policy to play in containing outright predatory behavior by patent owners.[50]

A second area of emerging concern relates to the activities of so-called non-practicing entities (NPEs). These entities are either individuals or firms that build up portfolios of patent rights, but do not seek to develop or commercialize any products based on technologies they own. Instead, they monitor markets for potentially infringing products and then enforce their patent rights by approaching firms to negotiate licenses or by initiating litigation. Many larger NPEs do not file patents themselves, but buy unused patents from firms that do not actively use them or that are forced by bankruptcy to auction them.

47 See Gilbert and Newbery (1982) for a theoretical exposition.

48 See Giuri *et al.* (2007).

49 However, Harhoff *et al.* (2007) argue that acts of predation will leave traces in patent data if those acts involve patent opposition or outright litigation.

50 See Harhoff *et al.* (2007).

NPEs can be beneficial to society by helping to create secondary markets for technology (see also the discussion in Subsection 2.2.4). Such markets can foster innovation incentives as they enable firms to reap a return on research activity, even if the resulting research output is not further developed and commercialized. Selling non-essential patents may be especially attractive for small companies or individual inventors that lack the resources to effectively use or enforce them.[51]

Yet, critics of at least some NPEs argue that their activities are primarily rent-seeking and that any benefit to the original patent owners is more than offset by the costs to the innovators targeted by NPEs' enforcement actions.[52] A firm threatened with costly litigation may prefer to settle and agree to pay a royalty, even if it feels that it has not infringed a patent. Since NPEs do not manufacture and thus do not risk infringing someone else's patent, they face no chance of counter-lawsuits. According to critics, NPEs are thus harmful to society, as they increase the risks associated with and cost of innovation.

Empirical research on NPEs is still in its infancy. One recent study on litigation of financial patents in the US finds that parties other than the inventor or the original patent applicant play a significant role in litigation. Patent owners initiating litigation fitted the profile of NPEs; they were overwhelmingly individuals or small companies – unlike the larger financial institutions that commercialize most financial innovations. Indeed, the latter were disproportionately targeted in litigation. The study also finds that financial patents were litigated at a rate of 27 to 39 times greater than that of US patents as a whole.[53] These findings are specific to the US financial service industry and do not shed light on how litigation has affected financial innovation. However, they point to NPEs as a rising force that innovating companies need to take into account.

As in the case of anti-competitive patenting strategies, sound patent institutions can make a difference in containing the possibly abusive behavior of NPEs that is detrimental to innovation – as will be further discussed in Section 2.3.[54]

2.2.4

The role patents play in technology markets and open innovation strategies

Chapter 1 discussed the rise of so-called technology markets, as reflected, for example, in more frequent patent licensing. At first, the existence of such markets may seem surprising. Technologies are highly specialized and non-standardized goods; matching sellers and buyers can be difficult – not least because many firms keep their technologies secret. Even where there is a match, strategic behavior and high transaction costs can prevent firms from entering into licensing contracts.[55] What then motivates firms to participate in technology markets and why are they increasingly doing so?

Subsection 2.1.1 pointed to one important reason: technology markets allow firms to specialize. Firms may be both more innovative and efficient by focusing on selected research, development or manufacturing tasks – outweighing the difficulties related to participating in technology markets. In addition, so-called general purpose technologies (GPTs) – technologies that find application in a large number of product markets – are often best developed by specialized firms who can sell them to many downstream firms, thereby recovering large upfront R&D outlays.[56]

51 See, for example, Geradin *et al.* (2011).
52 See, for example, Lemley and Shapiro (2007).
53 See Lerner (2010).
54 Some governments have also launched special initiatives aimed at limiting the exposure of innovating companies to NPE lawsuits. For example, in 2010 the Korean government helped launch a firm called Intellectual Discovery, which buys out patents that might be asserted against Korean firms. See "The Rise of the NPE" in Managing Intellectual Property (Park and Hwang, 2010).
55 See, for example, Nelson and Winter (1982), Teece (1988), Arora *et al.* (2001b) and Arora and Gambardella (2010).
56 See Bresnahan and Gambardella (1998) and Gambardella and McGahan (2010).

As discussed in Chapter 1, specialization is one important element of open innovation strategies: firms license out those technologies that are outside their core business; and they license in technologies that amplify their competitive advantage. Evidence confirms that firms that do not have the complementary assets needed to bring their inventions to market tend to license them to others for commercialization.[57] In addition, survey studies reveal that licensing is one of the main reasons for seeking patents in the US.[58] In Europe, one in five companies licenses patents to non-affiliated partners, while in Japan more than one in four companies do so.[59] Studies on GPTs, in turn, have shown that licensing is more likely to occur where downstream product markets are fragmented.[60] There is also evidence that certain industries – notably, the biotechnology, semiconductor and software sectors – have seen an increase in specialized firms.[61]

Little is known, however, about the fundamental factors that have driven greater specialization in more recent history. One possible explanation is that smaller companies with fewer bureaucratic structures may be better positioned to find solutions to increasingly complex technological problems. Another reason may be that ICTs and new business models have made it easier for specialized firms to participate in technology markets. Subsection 1.3.3 described, for example, the entry of new intermediaries with novel approaches to matching technology sellers and buyers.

A second reason why firms participate in technology markets is to tap these markets for valuable knowledge. In-house research is an essential element of innovation, but firms advance their knowledge and draw inspiration from the ideas of others. Economists have devised the concept of knowledge spillovers to describe situations in which knowledge flows from one firm or individual to another, without the originator receiving any direct compensation. From society's viewpoint, knowledge spillovers are desirable, because they lead to the wide dissemination of new ideas. However, if knowledge spills over to everyone as soon as it is created, the classic appropriability dilemma arises. A trade-off exists, for policymakers and firms.

Policymakers must balance incentives for creating knowledge against the rapid diffusion of knowledge. The patent system helps to strike this balance by granting limited exclusive rights to inventors while, at the same time, mandating the disclosure of information on inventions to society. Inventor surveys reveal that published patents are indeed an important knowledge source for firms conducting R&D – more so in Japan than in the US and Europe.[62] No study has attempted to quantify the associated knowledge spillovers and their economic benefits. Such an exercise might indeed be elusive. Yet, the patent literature represents a valuable source of knowledge for creative minds anywhere in the world. In addition, the easy availability of millions of patent documents to anyone connected to the Internet has arguably created new catch-up opportunities for technologically less developed economies.

Firms face a similar trade-off between guarding and sharing knowledge. On the one hand, they need to earn a return on their R&D investment, which calls for preventing knowledge from leaking to competitors. On the other hand, absolute protection of ideas is not possible and, more important, it may not even be desirable. Spillovers are often a two-way street, involving give and take. For example, economic research shows that innovating firms have found it beneficial to collocate; being close to firms operating in the same field brings learning benefits even if it means sharing one's own knowledge.[63]

57 Using the 1994 Carnegie Mellon survey on industrial R&D in the US, Arora and Ceccagnoli (2006) found that firms that do not have specialized complementary assets for commercializing their inventions are more likely to license out their inventions than those who do.
58 See Cohen *et al.* (2000) and Sichelman and Graham (2010).
59 See Zuniga and Guellec (2009).
60 See Gambardella and Giarratana (2011) and Arora and Gambardella (2010).
61 See Arora *et al.* (2001a), Hall and Ziedonis (2001) and Harhoff *et al.* (2007).
62 See Nagaoka (2011) and Gambardella *et al.* (2011).
63 See Krugman (1991).

Generating spillovers is a second important element of open innovation strategies: firms can be better innovators by engaging with others – even if that involves some sharing of proprietary knowledge. Indeed, patent rights are at the heart of the trade-off between guarding and sharing knowledge. They allow firms to flexibly control which technologies to share, with whom and on what terms. Economic research provides only limited guidance on how different patent-based knowledge sharing activities – especially those associated with more recent open innovation strategies – affect spillovers and innovation. As described in Subsection 1.3.2, this is partly the result of insufficient data; in particular, patent licenses are often confidential and escape statistical measurement. Box 2.4 summarizes evidence on one open innovation initiative in the area of green technologies, and finds systematic differences between the technologies that firms are willing to share and those they keep in-house.

Box 2.4: Open Innovation and the Eco-Patent Commons

Recognizing the need for promoting innovation and the diffusion of green technologies, in 2008 a number of multinational companies – including IBM, Sony and Nokia – created an "Eco-Patent Commons". This initiative allows third parties royalty-free access to patented technologies, voluntarily pledged by firms from around the world. One key aim of the Commons is to encourage cooperation and collaboration between pledging firms and potential users to foster further joint innovation.

A recent study by Hall and Helmers (2011) analyzed the characteristics of the 238 patents pledged to the Commons. In particular, it compared patents pledged to: i) patents held by pledging firms that are not donated to the Commons; and ii) a randomly drawn set of patents in the same technology field.

Approximating patent value by indicators such as patent family size and patent citations received, the study finds that patents in the Commons are more valuable than the average patent held by pledging firms and than comparable patents protecting similar technologies. However, patents pledged do not seem to cover firms' most radical inventions. In addition, they do not appear to be at the core of firms' patent portfolios, possibly explaining their willingness to place them in the Commons. While these findings offer interesting insights into firms' open innovation strategies, it is too early to assess how successful the Commons is at promoting further green innovation.

Finally, a third important reason why firms participate in technology markets and adopt open innovation strategies is to access complementary skills and technologies. A firm may find that it stands to gain by collaborating with another firm or a university in developing a particular technology. In other cases, a firm may require access to proprietary technologies held by other firms in order to commercialize a product – a frequent scenario in technology fields in which patent thickets proliferate (see Subsection 2.2.2). How technology markets operate when firms cooperate with each other or with universities will be discussed more fully in Chapters 3 and 4.

2.3

Appreciating the role of patent institutions

Patent laws set the basic rules on what can be patented, for how long and under what conditions. However, the incentives created by the patent system are critically dependent on how these rules are implemented. This is largely the responsibility of patent offices and courts. For a long time, economic research paid little attention to these patent institutions. This, arguably, has changed – partly because unprecedented levels of patenting have put these institutions under considerable pressure.

This section seeks to highlight the important role played by patent institutions. It first discusses the characteristics of sound patent institutions. It then focuses on how patenting trends over the past decades have challenged many patent offices and what choices they face.

2.3.1

What makes for sound patent institutions

Patent institutions best serve innovation when they promote two broad principles: rigorous examination leading to the grant of quality patents and balanced dispute resolution.

Promoting the first principle has two important elements. First, patent offices should grant patents only for those inventions that strictly meet the standards of patentability – namely, novelty, inventive step and industrial applicability. This sounds straightforward, but for patent offices it is not: the complexity of technology is constantly on the rise and many entities in different parts of the world create new knowledge that may be relevant prior art. Second, patent documents should clearly delineate the patent's inventive claims and describe the invention in a transparent way. Patents granted which meet both criteria can be considered quality patents.[64]

The second principle recognizes that disputes over patent rights invariably occur. But when they do, they should be resolved in a way that balances the interests of all parties involved. In particular, the parties should have easy access to dispute resolution mechanisms, but those mechanisms should minimize bad faith initiation of disputes and remedies should be proportionate to any damage suffered.

Why do these two principles matter? Poor-quality patents – including patents for trivial inventions or those with overly broad or ambiguously drafted claims – can harm innovation. At worst, they may lead firms to refrain from certain research activities or from commercializing a new technology for fear of violating patent rights; at best, they burden innovating companies by leading to extra royalty payments and legal costs.[65] Poor-quality patents may also increase the risk of anticompetitive uses of patent rights (see Subsection 2.2.3). Vague descriptions of inventions in patent documents, in turn, may curtail the spillover benefits of patent disclosure.

64 Quality is here defined in terms of the rigor of the examination process, not in terms of the technical or commercial value of the invention.

65 See Choi (1998), Jaffe and Lerner (2004), Lemley and Shapiro (2005) and Harhoff (2006).

Imbalanced dispute resolution can have more varied effects on innovative behavior. For example, if dispute resolution is overly costly, it may bias the system against smaller firms – whether they are claimants or defendants. Smaller firms may thus innovate less, either because they have difficulty enforcing their patent rights or they are more exposed to infringement accusations from competitors.[66] Enforcement costs may be an especially binding constraint for firms in more resource-constrained low- and middle-income countries, which explains why many of them do not apply for patent rights in the first place.

Promoting patent quality is bound to reinforce more balanced dispute resolution and vice-versa. Quality patents that have undergone rigorous examination are less likely to be challenged in court. Conversely, effective dispute settlement preempts the filing of poor-quality patents, as the prospect of enforcing them is low.

66 A study of IP enforcement in smaller UK firms confirms that the financial costs of litigation deter enforcement. See Greenhalgh and Rogers (2010). See also Lemley (2001) and Lanjouw and Schankerman (2004).

67 This estimate is based on pending applications data from 70 patent offices, which include the top 20 offices except for China, India, and Singapore. Care is required in comparing backlog figures across offices. In some patent offices – notably, the Japanese and German offices – applicants can delay patent examination for several years. The JPO recently revised its statistics on unprocessed patent applications downward.

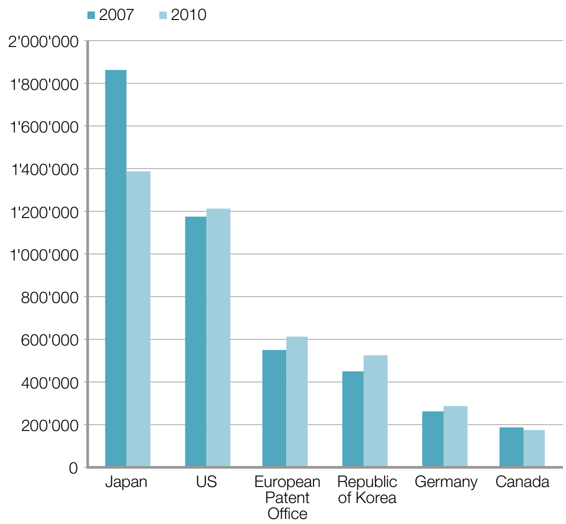
2.3.2

How patenting trends have challenged patent offices

Over the last 15 years, many patent offices have seen a rise in their application backlogs. While there is no unique metric of office backlogs, WIPO estimates that the number of unprocessed applications worldwide stood at 5.17 million in 2010.[67] In absolute terms, the Japan Patent Office (JPO), the United States Patent and Trademark Office (USPTO) and the EPO account for the largest office backlogs (see Figure 2.3, left). However, relative to annual application flows, patenting backlogs are substantial in many other offices, including those in low- and middle-income countries (See WIPO, 2011b).

Figure 2.3: Workload in many patent offices is piling up

Unprocessed patent applications in selected large offices, 2007 and 2010



Source: WIPO Statistics Database, October 2011.

Many offices have also seen a lengthening of patent pendency times. For example, between 1996 and 2007, average pendency times increased from 21.5 to 32 months at the USPTO and from 24.4 to 45.3 months at the EPO.[68]

Rising office backlogs and lengthening pendency times have coincided with rapid growth in the number of patent applications (see Subsection 1.3.1). However, fast patenting growth is only one factor behind increased office strain. Indeed, some offices have managed to reduce backlogs and shorten pendency times despite rapid patenting growth – mainly by expanding examination capacity.[69]

In addition, in those offices that have experienced growing backlogs and longer pendency times, other factors have played a role, especially an increase in the size of patent applications. At the EPO, for example, average application size jumped from 14 to 30 pages between 1988 and 2005, while the average number of claims per patent increased from 12 to 21.[70] Growing technological complexity appears to be one important driver of larger patent applications.[71] Examining more complex patents takes longer – not least because patent examiners need to learn about new technologies and the corresponding legal rules. Such patents may also require more frequent communication between applicants and examiners, further prolonging examination.

What is the effect of longer pendency times? At least some innovating companies are bound to suffer from long delays in the patenting process. Subsection 2.2.1 discussed evidence that, for some entrepreneurs, the grant of a patent makes a difference in attracting financing from venture capitalists, especially in early financing stages. However, for more established firms, patenting delays may be less problematic and could even be beneficial. Indeed, many patent offices allow applicants to request accelerated examination of patents, but few applicants actually do so.[72]

Some firms – especially in industries with long product life cycles and high uncertainty about market developments – might welcome a longer patenting process to collect more information about an invention's technological and commercial potential. Applicants can thus avoid paying grant and renewal fee payments in case they decide to drop the application. In addition, longer examination enables applicants to submit new or amended patent claims based on what they learn while developing an invention.

Even if some applicants gain, longer pendency times are problematic for society as a whole, because they prolong the period of uncertainty about which technologies may in the future be proprietary. In addition, longer examination may invite anticompetitive and rent-seeking behavior. In particular, it creates incentives to file low-quality patents specifically intended to create uncertainty among competitors. It may also encourage applicants to insert claims that map onto the uses of technology they see developing in the marketplace.

68 For the JPO, data are only available starting in 2000, but the trend is the same: pendency times increased from 26.9 months in 2000 to 32.4 months in 2007. As with backlog figures, care is required in directly comparing pendency times across offices. See WIPO (2011a).

69 See WIPO (2011a).

70 See van Zeebroeck *et al.* (2008) and van Zeebroeck *et al.* (2009).

71 See Lanjouw and Schankerman (2001) and van Zeebroeck *et al.* (2008).

72 To some extent, high costs and procedural requirements may discourage the use of accelerated examination.

Realizing their possible harmful effects, many patent offices have sought to reduce pendency times. However, this is not always easy. Offices only partly control the length of examination. Applicants decide how to draft applications and how they communicate with offices.[73] To the extent that they benefit from longer examination – whatever the underlying reasons may be – applicants may seek to strategically delay the process; for example, they may introduce ambiguities in patent claims that prompt future examiner enquiries.[74]

In addition, confronted with large, growing backlogs, patent offices face the risk that quicker examination may compromise patent quality. Numerous commentators have argued that the pressure created by rising workloads has caused deteriorating patent quality in some offices, especially in the US.[75] Indeed, improving the quality of patents granted was a key objective behind the patent reform legislation recently enacted in the US.[76] More generally, given the difficulty of objectively measuring patent quality, it is hard to empirically assess how systemic quality problems are and how quality differs across offices. Finally, how backlogs affect patent quality is not only important in high-income countries. As pointed out above, many offices in low- and middle-income countries have accumulated substantial backlogs in recent years. They also typically have fewer resources to support thorough examination, increasing the risk of granting low-quality patents.[77]

73 For example, van Zeebroeck *et al*. (2008) argue that countries that follow US drafting styles tend to have more voluminous patent applications compared to filings at the EPO.
74 Mejer and van Pottelsberghe de la Potterie (2011) conjecture that applicants who delay the patenting process are the root cause of backlogs at the EPO.
75 See, for example, Jaffe and Lerner (2004) and Guellec and van Pottelsberghe de la Potterie (2007).
76 See the statement of USPTO Director David Kappos before the US House of Representatives, available at *www.uspto.gov/news/speeches/2011/kappos_house_testimony.jsp*.
77 Sampat (2010) discusses how resource constraints might have affected pharmaceutical patents granted in India.
78 Using a panel dataset, Rassenfosse and van Pottelsberghe de la Potterie (2011) estimate a demand elasticity for patents of -0.3, implying that a 10 percent increase in the patenting fee leads to a 3 percent fall in patent volumes.

2.3.3

The choices patent institutions face

The choices facing patent institutions determine how the system promotes the principles of patent quality and balanced dispute resolution. What may seem like a minor change in procedural rules or a management response to operational demands may have far-reaching consequences for patent system use. Relevant institutional choices are often specific to countries' legal systems and their level of development. However, a number of common choices exist. This final subsection points to some of the most important ones.

First, to ensure quality examination, patent offices need to be properly resourced. This raises the question of how their operations should be funded. The two prevailing models are: financing them out of general government spending; or through the fees they collect. Difficult trade-offs exist. Fee-based financing can establish incentives for operational efficiency and insulates patent offices from the ups and downs of public budgets. However, patent offices that seek to maximize fee income may adjust their operations in a way that conflicts with society's best interest. Above all, quickly processing patent applications may maximize fee revenue, but that might come at the expense of patent quality. In fee-financed offices, it is therefore important to establish complementary performance incentives that promote patent quality.

A closely related second institutional choice concerns the level and structure of patenting fees. While fees charged by offices are only one – and usually a small – component of the legal costs applicants face, studies have clearly shown that higher fees lead to lower patenting activity.[78] Fees are thus an important regulatory instrument. As a rule of thumb, fees should be sufficiently low to ensure equitable access to the system, but not so low as to encourage speculative applications.

One dilemma in establishing a fee policy is that it can only serve one purpose. In particular, a set of fees that ensures office cost recovery may not coincide with society's best interest – and vice-versa. For example, cost recovery would call for high filing fees to support labor-intensive examination work and low fees for renewing patents that involve very little work for offices. However, low renewal fees may not be in society's best interest, as they prolong protection for patents inventors no longer highly value.[79] In fact, for the latter reason, economists have argued for an escalating renewal fee structure.[80]

A third important institutional choice concerns the interests of third parties in the patenting process. Third parties may provide useful information on relevant prior art that bears on the patentability of an invention. In addition, if the grant of a patent affects them, they may want to challenge its validity before it leaves the patent office, preempting more expensive court litigation down the road. Many patent offices have therefore adopted mechanisms allowing for third party information submission and patent opposition (see Box 2.5 for one example).[81] Such mechanisms can usefully promote patent quality.[82] However, building on the principle of balanced dispute resolution, they should be designed in such a way that they open the door to legitimate third party interests, but minimize the risk of bad faith challenges that unduly burden patent applicants.

Box 2.5: Crowd-sourcing patent examination

No matter how qualified and dedicated patent examiners are, they may miss out on important prior art. For example, there are instances where the state of the art progresses at a faster pace than examiners can match. In addition, examiners may only have incomplete access to non-patented prior art, especially in new areas of patenting. In such cases, it is useful to enlist the help of the public to identify information related to inventions under review. A new crowd-sourcing initiative – called Peer-to-Patent – makes use of social networking software to assist patent offices in their examination work.

The original Peer-to-Patent initiative – launched by the New York Law School and the USPTO as a pilot program in June 2007 – focused on using members of the open source community to help identify relevant prior art in the areas of computer architecture, software and information security. Community members were able to review and rate documents they considered important in determining the patentability of particular inventions. Patent examiners could later use these documents in examination if they were deemed relevant. A review of the pilot program was positive, and the project has now been extended to cover subject areas beyond the initial three technology areas.

Given the success of the pilot program in the US, patent offices in Australia, Japan, the Republic of Korea and the United Kingdom (UK) have each launched similar initiatives to assess the feasibility of this mechanism in their countries.

Source: Wong and Kreps (2009).

Strategic use of ICTs by patent offices is an increasingly important fourth institutional choice. Most patent office operations consist of the processing of information. Modern ICTs can not only improve operational efficiency, but also promote patent quality. This is especially the case for prior art searches. Digital access to patent and non-patent literature, combined with sophisticated search algorithms – and, increasingly, automated translation – can reduce the risk that examiners might miss important prior art.[83] In addition, the timely provision of patent information in digital form enlarges the potential for knowledge spillovers, as discussed in Subsection 2.2.4.

79 Gans *et al.* (2004) provide a theoretical exposition of this argument.

80 See Schankerman and Pakes (1986), Lanjouw, Pakes and Putnam (1998), Scotchmer (1999) and Cornelli and Schankerman (1999).

81 See WIPO (2009) for an overview of the patent opposition system and a summary of some countries' laws and practices. Rotstein and Dent (2009) and Graham *et al.* (2003) compare the third party opposition systems of the EPO, USPTO and JPO.

82 Hall *et al.* (2004), for example, discuss the quality benefits of post-grant opposition.

83 Michels and Bertels (2001) show significant differences in the results of prior art searches across the major offices, partly attributable to language barriers.

A fifth important institutional choice concerns international cooperation. As noted in Subsection 1.3.1, around one-half of the increase in patent filings worldwide from 1995 to 2007 was due to subsequent patent filings, most of which represented international filings. In practice, this means that national patent offices increasingly look at the same patents. International cooperation – as already practiced through the Patent Cooperation Treaty (PCT) – can help in reducing duplication of work. In addition, combining the resources of more than one office can help promote patent quality.

International cooperation can take place at different levels of ambition – from the simple exchange of information to the recognition of foreign grant decisions. In between, there are many options. Deciding on the appropriate level of cooperation involves many considerations – including how offices trust the work of their foreign counterparts, how compatible domestic patenting standards are with those abroad, how cooperation affects filing behavior and office workload, and the learning benefits that may be lost by not examining patents domestically.

Finally, one of the most challenging choices is the design of enforcement institutions. Litigation is invariably a costly activity – for litigants and courts. Balanced and timely dispute resolution requires substantial resources and skilled judges. Specialized patent courts can improve efficiency and promote consistent rulings, but they may not be an option in smaller and less developed economies. Institutional innovation that provides for alternative dispute resolution short of outright litigation may be helpful in preempting costly litigation. For example, some patent offices offer administrative dispute resolution, mediation or advice on questions of patent validity and infringement – including some offices in middle-income countries.[84] Patent opposition – as outlined above – is another form of early dispute resolution.

There are other important considerations in designing enforcement institutions – for example, whether judges should decide on patent infringement and validity at the same time or in separate cases, and how courts should be financed. No comparative research exists that offers general guidance on which approaches work best. A better understanding of enforcement institutions and their effects on patenting behavior are, arguably, priority areas for future research.

84 The UK Intellectual Property Office offers a patent validity search service that provides firms with information on whether a patent granted is vulnerable to legal challenge see *www.ipo.gov.uk/types/patent/p-other/p-infringe/p-validity.htm.*

2.4

Conclusions and directions for future research

Understanding how IP protection affects innovative behavior has been a fertile field in economic research. Important insights gained long ago arguably still shape how economists view the IP system today. Above all, compared to other innovation policies, IP protection stands out in that it mobilizes decentralized market forces to guide R&D investment. This works especially well where private motivation to innovate aligns with society's technological needs, where solutions to technological problems are within sight, and where firms can finance upfront R&D investment.

However, difficult trade-offs exist in designing IP rights, not least because IP protection has multifaceted effects on innovative behavior and market competition. As technologies advance and business models shift, optimally balancing these trade-offs represents a continual high-stakes challenge.

In more recent history, economists have refined their view of the IP system – partly as a result of new research and partly due to real world developments. The patent system has received special attention, in at least two ways:

- The build-up of strategic patenting portfolios in complex technologies has raised concerns about patent rights slowing or even forestalling cumulative innovation processes. Entrepreneurs facing dense webs of overlapping patent rights – or patent thickets – may forgo research activities or shelve plans for commercializing promising technologies.

- Patents play an important role in modern technology markets. They enable firms to specialize, allowing them to be more innovative and efficient at the same time. In addition, they allow firms to flexibly control which knowledge to guard and which to share so as to maximize knowledge spillovers – a key element of open innovation strategies. Finally, the widespread availability of patent information has created vast opportunities for technological learning and catch-up by less developed economies.

The effectiveness of the patent system in promoting innovation is critically dependent on how the rules set by laws are implemented in practice. Patent institutions have moved to the center stage of the modern innovation system. They perform the essential tasks of ensuring the quality of patents granted and providing balanced dispute resolution. Unprecedented levels of patenting in many high- and middle-income countries have put these institutions under considerable pressure. The choices they make have far-reaching consequences on incentives to innovate.

Areas for future research

Even though economic research has come a long way since the galvanizing work by Kenneth Arrow some 50 years ago, there are many questions for which future research could offer better guidance to policymakers:

- Most academic studies have focused on high-income countries. While they can in many ways inform policymakers throughout the world, the varying innovative and absorptive capacity of middle- and low-income countries suggests that IP protection operates differently in these economies. A better understanding of the conditions under which different IP forms can incentivize R&D and promote the formation of technology markets is therefore crucial.

- Only limited guidance is available on how the different patent-based knowledge sharing activities – especially those associated with more recent open innovation models – affect knowledge spillovers and innovation outcomes. A related question concerns the extent to which greater openness in the innovation process has created greater opportunities for technological catch-up by firms in less developed economies.

- Further research is needed on how the choices of patent institutions affect innovation incentives, especially in the area of rights enforcement.

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