PATENTS AND INNOVATION: TRENDS AND POLICY CHALLENGES

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

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EXECUTIVE SUMMARY

Patents play an increasingly important role in innovation and economic performance. Between 1992 and 2002, the number of patent applications filed in Europe, Japan and the United States increased by more than 40%. The increasing use of patents to protect inventions by businesses and public research organisations is closely connected to recent evolutions in innovation processes, the economy and patent regimes. Scientific and technological advances have created new waves of innovation, notably in information and communications technology (ICT) and biotechnology, and innovation processes themselves have become centred less on individual firms and more dependent on interactions among global networks of actors in the public and private sectors. Shifts in the legal and regulatory framework of patent regimes have resulted in more expansive domains of patentable subject matter (patent regimes in many countries now include biotechnology and software), and more robust and more valuable patents.

Changes in patent policy in OECD countries over the past two decades have fostered the use and enforcement of patents with the aim of encouraging investments in innovation and enhancing the dissemination of knowledge. Despite these reforms, few systematic economic evaluations have been carried out to better inform policy choices. To what extent have changes in patent policies over the past two decades been beneficial to innovation and technology diffusion? What particular aspects of patent policy in OECD countries can be seen as successful, or have failures occurred? These questions are central to this report, which covers a range of areas, and highlights some unresolved issues that policy makers should address in the near future:

- *Markets for technology* are increasingly important for the circulation of knowledge. Patents play a pivotal role in the development of technology transactions. Governments need to improve their knowledge of the functioning of markets for technology and the effect of such markets on economic performance in order to support their development in the most socially beneficial directions.

- Encouraging patenting by *public research organisations* (PROs) has led to increased commercialisation of inventions derived from publicly funded research - hence generating greater benefits to society - but may have made it more difficult for researchers to access certain types of basic science. Governments should ensure access to basic inventions, for instance by monitoring patenting and licensing practices at PROs, and by reinstating and clarifying the exemption for research use, which is now being restricted.

- In *biotechnology,* the surge in innovation, notably by start-ups, benefited greatly from the possibility of obtaining patent protection, which attracted the capital needed in this area. In certain upstream fields, such as genetic material or genetic testing, there are cases where patents might still impede access to technology. The quality (novelty) and breadth of patents in these areas need to be reviewed. Governments should explore ways to encourage alternative means of disseminating knowledge, such as the public domain, and to improve the diffusion of patented inventions, *e.g.* through the promotion of patent pools and the publication of licensing guidelines.

- *Software and services* are new subject matter for patents, although to a different extent across countries. The impact of patents on innovation and diffusion in this area has yet to be systematically evaluated, and such evaluation is sorely needed. The quality and breadth of software patents also need to be monitored, and patent offices should keep up their efforts to systematise their experience and knowledge base. The role of patents in the expanding world of open source software also needs to be evaluated.

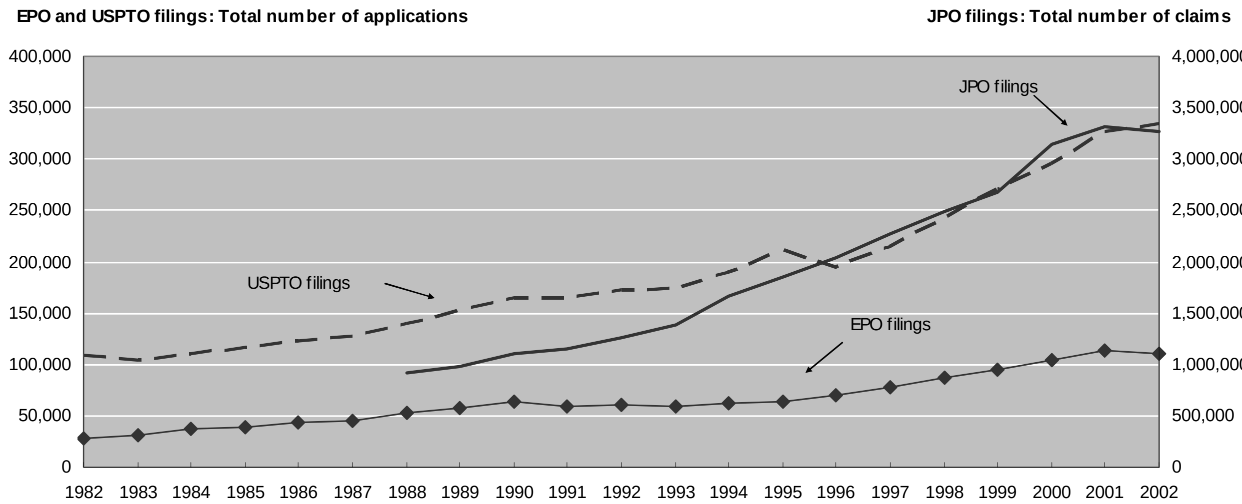
Economic evaluation suggests that there are further possible directions of change for patent regimes that are worth exploring. Possible avenues for economic-based reforms of patent regimes include introducing a more differentiated approach to patent protection that depends on specific characteristics of the inventions, such as their life cycle or their value (as opposed to the current uniform system); making patent fees commensurate to the degree of protection provided; and developing alternatives to patenting, such as the public domain. In the near future, the patent system will be facing even greater challenges than those it has confronted in the past two decades, including increased globalisation, the overwhelming use of Internet as a vehicle of diffusion, and expanded innovation in services. Well-informed and more global policies will be needed to prepare the patent system to meet these new challenges, so that it can continue to fulfil its role of encouraging innovation and technology diffusion.

1. Introduction

Patenting experienced a sizeable boom in the last decade. More than 850 000 patent applications were filed in Europe, Japan and the United States in 2002, against about 600 000 in 1992. These figures reflect the growing importance of patents in the economy. Business and public research increasingly use patents to protect their inventions, and fostering this trend has been the objective of patent policy in OECD countries over the past two decades, with a view to encouraging investments in innovation and fostering the dissemination of knowledge. To what extent has this been the case? What particular aspects of patent policy in OECD countries can be seen as successful in this regard, or have there been mainly failures? These questions are central to this report.

Figure 1. Patent filings at EPO, USPTO and JPO[1]

Filing years: 1982-2002



1. EPO and USPTO filings correspond to total number of applications. JPO filings correspond to total number of claims (number of claims per application multiplied by total number of applications) to account for the effect of the 1988 law reform allowing more than one claim per patent application at JPO.
Source: OECD Patent Database and USPTO, EPO and JPO Annual reports. JPO figures for 2001 and 2002 are OECD estimates.

Growth in patenting corresponds to a new organisation of research that is less centred on the individual firm and more based on knowledge networks and markets: innovation processes throughout the OECD area have become increasingly competitive, co-operative, globalised, and more reliant on new entrants and technology-based firms. Market mechanisms play a more central role in technology diffusion. Businesses have been demanding more and more patents to accommodate these new conditions.

At the same time, patent regimes themselves have experienced major changes that have encouraged an increase in patenting. Not only have new types of inventions – software, genetic, and business methods – been deemed patentable by some patent offices, but the ability of patent holders to protect and enforce their rights has also increased, leading many to call the past two decades a pro-patent policy era. There is little doubt that many of these policy changes have helped the patent system to cope with changes in innovation systems by attracting more private-sector funding for R&D and supporting the development of markets for technology to help diffuse patented knowledge. In that sense, the patent system has been instrumental in the recent waves of innovation which have occurred in the fields of biotechnology and ICT.

This strengthening of patent systems in the European Union, Japan and the United States has, however, raised new concerns and exacerbated old ones. There have been numerous claims that patents of little novelty or excessive breadth have been granted, allowing their holders to extract undue rents from other inventors and from customers. This has been of particular concern in software, biotechnology and business methods, where patent offices and courts have had most difficulties in responding to rapid change, building up institutional expertise, evaluating prior art and determining correct standards for the breadth of granted patents. More basically, it has also been asked whether patentability might hamper the diffusion of knowledge, and therefore innovation, notably in these new areas. Other concerns have been raised about access to basic technologies, and research tools, which seems to have been hindered sometimes by patent holders exercising their right to exclude. As universities are becoming more likely to patent and commercialise their own inventions, exemptions for research use of existing inventions are under threat, with the danger of public research being faced with rising costs and difficulties of access.

Addressing these concerns and ensuring that patent systems continue to fulfil their mission of both stimulating invention and promoting diffusion of knowledge requires careful examination of broader issues. This report summarises OECD work to date on the relationships between patents, innovation and economic performance. It aims to place major changes in patenting patterns and patent regimes in the economic context, and to review the evidence regarding the links between patenting, innovation and diffusion in areas of particular interest (PROs, biotechnology, software and services). It provides policy-relevant conclusions based on existing analysis, and identifies policy issues and options for further consideration.

Box 1. Patents and the patent system

A patent is an exclusive right to exploit (make, use, sell, or import) an invention over a limited period of time (20 years from filing) within the country where the application is made. Patents are granted for inventions which are novel, inventive (non-obvious) and have an industrial application (useful). There are other types of exclusive rights over intangible assets, notably copyright, design protection and trademarks, but patents provide a broader protection that extends beyond the specific expression of an invention to the invention itself. Due to this control over the technology, the patent holder is in a position to set a higher-than-competitive price for the corresponding good or service, which allows recovery of innovation costs. In return, the applicant must disclose the invention in the text of the application, which is published 18 months after application.

As a patent is valid only within the country in which it is granted, it is subject to national laws and litigation settled in national courts. The forthcoming community patent in Europe will be an exception, as it will provide protection in all EU member countries, and litigation will be centralised in a specialised court. International agreements such as the agreement on Trade Related Aspects of Intellectual Property Rights (TRIPS), signed in 1994 and overseen by the World Trade Organisation (WTO), tend to place restrictions on what national laws and policies can do. TRIPS introduced intellectual property rules into the multilateral trading system for the first time, in an attempt to guarantee the same minimum standards of protection across countries.

2. Economic issues raised by patents

Viewed from the angle of innovation policy, patents aim to foster innovation in the private sector by allowing inventors to profit from their inventions. The positive effect of patents on innovation as incentive mechanisms has been traditionally contrasted with their negative effect on competition and technology diffusion. Patents have long been considered to represent a trade-off between incentives to innovate on one hand, and competition in the market and diffusion of technology on the other. However, recent evolutions in science and technology and patent policy and progress in the economic analysis of patents have nuanced this view: patents can hamper innovation under certain conditions and encourage diffusion under others. The impact of patents on innovation and economic performance is complex, and fine tuning of patent design is crucial if they are to become an effective policy instrument.

Empirical evidence tends to support the effectiveness of patents in *encouraging innovation*, subject to some cross-industry variation. In a series of surveys conducted in the United States, Europe and Japan in the mid-1980s and 1990s, respondent companies reported patents as being extremely important in protecting their competitive advantage in a few industries, notably biotechnology, drugs, chemicals and, to a certain extent, machinery and computers. Companies in other industries reported that patents play a secondary, if not negligible, role as a means of protection for their inventions, as they tend to rely more on alternative means such as secrecy, market lead, advance on the learning curve, technological complexity and control of complementary assets (Levin, Klevorick, Nelson and Winter, 1987; Cohen, Nelson and Walsh, 2000).

However, patent protection may also *hamper further innovation*, especially when it limits access to essential knowledge, as may be the case in emerging technological areas when innovation has a marked cumulative character and patents protect foundational inventions. In this context, too broad a protection on basic inventions can discourage follow-on inventors if the holder of a patent for an essential technology refuses access to others under reasonable conditions. This concern has often been raised for new technologies, most recently for genetic inventions (Bar-Shalom and Cook-Deegan, 2002; Nuffield Council on Bioethics, 2002; OECD, 2003*a*) and software (Bessen and Maskin, 2000; Bessen and Hunt, 2003).

In addition, as has long been recognised, the main drawback of patents is their negative effect on *diffusion and competition*. As patents are an exclusive right that creates a temporary monopoly, the patent holder can set a market price higher than the competitive price and limit the total volume of sales. This negative impact on competition could be magnified as patent holders try to strengthen their position in negotiations with other firms, in an attempt to block access by competitors to a key technology, or inversely, to avoid being blocked by them (Shapiro, 2002). Such *strategic patenting* seems to have developed over the past 15 years, notably in the electronics industry (Hall and Ziedonis, 2001).

Nevertheless, patents can also have a positive impact on competition when they *enhance market entry and firm creation*. Not only is there evidence of small companies being able to assert their right in front of larger ones thanks to their patent portfolio, but patents may also be a decisive condition for entrepreneurs to obtain funds from venture capitalists (Gans, Hsu and Stern, 2002). Moreover, patents may *enhance technology diffusion*. Patenting means disclosing inventions which might otherwise be kept secret. Industrial surveys show that the reluctance of firms to patent their inventions is primarily due to the fear of providing information to competitors. This has been confirmed in the OECD/BIAC survey on the use and perception of patents in the business community, sent to firms in OECD countries in 2003 and in which respondents indicated their intensive use of patents as a source of information (Box 2; Sheehan, Guellec and Martinez, 2003). Patents also facilitate transactions in markets for technology: they can be bought and sold as property titles or, more frequently, be subject to licensing agreements which allow the licensee to use the patented invention in return for payment of a fee or royalty (Arora, Fosfuri and Gambardella, 2001; Vonortas, 2003). Finally, enhancing technology diffusion has been the goal put forward by governments to encourage universities to patent their inventions, with the objective of licensing them to businesses that will further develop and commercialise them (OECD, 2003*b*).

In summary, the traditional view of patents as a compromise between incentives to innovate and barriers to technology diffusion, if not incorrect, presents a rather partial picture, as patents can either encourage or deter innovation and diffusion, depending on certain conditions. In fact, the effect of patents on innovation and diffusion depends on particular features of the *patent regime*. Patent subject matter, patenting requirements and patent breadth are three basic tools for policy makers involved in the design of patent regimes that could be used to enhance both innovation and diffusion (Encaoua, Guellec and Martinez, 2003):

- *Patent subject matter* is the domain of knowledge that can be patented, if the patenting criteria of novelty, non-obviousness and usefulness are also met. For instance, scientific discoveries and abstract ideas are generally excluded. Its definition must be based on a careful examination of when it is efficient for society to offer patent protection in addition to other legal or market-based means of protection.

- *Patenting requirement* is the height of the inventive step required for a patent application to be granted. It is understood as the extent of the contribution made by an invention to the state of the art in a particular technology field. The higher that contribution, the more selective the process, thus the lower the number of patents granted. The lower it is, the larger the likelihood of finding many inventions with no significant social value. Conversely, too high a requirement would discourage innovations which, while not being radical, are still necessary for technological breakthrough to translate into actual products and processes.

- The *breadth of a patent* is the extent of protection granted to patent holders against imitators and follow-on inventors. Not only do patentees obtain exclusive rights on their own invention but also on other inventions which are deemed "functionally equivalent", and to a certain extent on improvements of their inventions. Patents that are too broad allow their holders to "pre-empt the future", while patents that are too narrow discourage research that feeds into follow-on inventions.

Other policy or legal aspects have an impact on the patent system, including the amount of damages attributed by courts in case of infringement, the conditions for exemptions for research use, etc. Taken together, these aspects determine the strength of patents. Overall, excessively weak and narrow patents might deter business investment in R&D, as it becomes too easy for an imitator to undercut the inventor's market price. Weak and narrow patents may also encourage secrecy at the expense of publicity, and harm markets for technology, hence hindering diffusion of technology. Conversely, excessively strong and broad patents may open the door to undesired strategic behaviour by patent holders, who may use their titles to appropriate revenue from existing inventions marketed by other companies. For instance, a broad patent on a basic invention with no substitutes may be equivalent to having an exclusive right of exploitation over an essential facility, allowing its holder to bar follow-on inventors who would be willing to invest in R&D to create socially useful applications. By carefully balancing these multiple instruments, policy makers can design patent regimes that are favourable to both innovation and diffusion.

Box 2. OECD/BIAC Survey

The OECD and the Business and Industry Advisory Committee to the OECD (BIAC) collaborated in 2003 on the development and implementation of a questionnaire on the use and perception of patents in the business community. The purpose of the questionnaire was to gather qualitative information about business patent and licensing practices and provide insight into evolving business strategies for managing intellectual property.

An electronic questionnaire was developed and tested on a sample of BIAC member companies and a revised version was made available to firms through BIAC and its affiliated industry associations across OECD countries, and several OECD country delegations. Responses were sent directly to BIAC so that identifying information could be removed before the results were forwarded to the OECD for analysis.

A total of 107 responses were received, predominantly from large firms (only 20% had fewer than 1 000 employees or less than USD 10 million in annual R&D spending) and firms based in Europe. More than half of the respondents were in the chemical and pharmaceutical sectors, with the rest coming mostly from the ICT and machinery sectors. Figures presented in this report are raw results from the survey (no grossing up was performed on the data).

Source: Sheehan, Guellec and Martinez (2003).

3. Recent trends in patenting in OECD countries

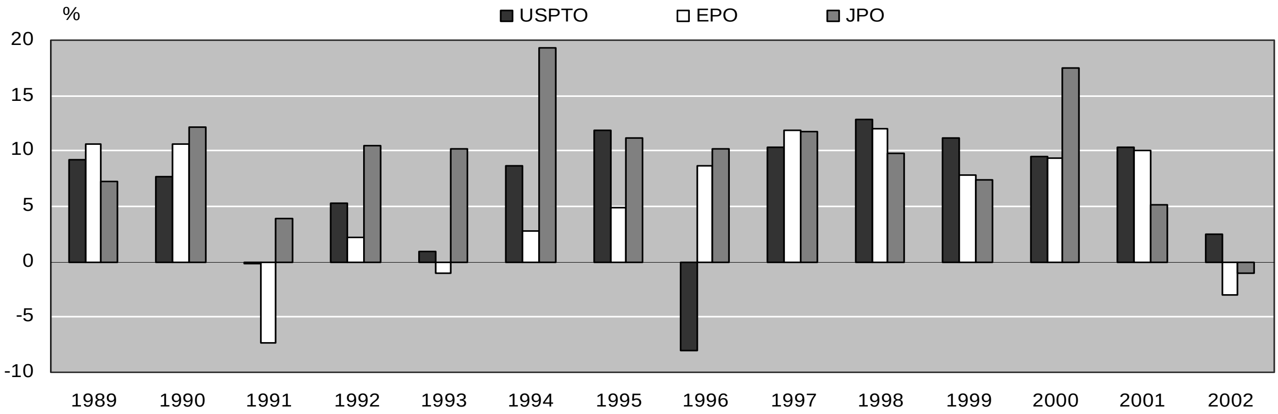
Most patent offices have experienced a surge in patent applications in the past two decades, with the largest contribution to growth being made by new technologies (ICT, biotechnology) and to some extent originating in economies which have recently gained a significant position in the international technological landscape, such as Korea and Chinese Taipei (OECD*c*, 2003).

The number of applications in the three major patent offices increased by 40% between 1992 and 2002, which corresponds to a doubling of the number of applications at EPO and USPTO, and to a 15% increase at the JPO (when adjusted for the increase in the number of claims allowed by law in 1988). The growth rate of applications at the USPTO, which was as high as 9% per year at the end of the 1980s, slowed at the beginning of the 1990s and again reached a 10% annual growth rate at the end of the 1990s[1]. The EPO has also experienced high growth since it received its first application in 1978. Growth rates at EPO were relatively high throughout the 1980s, mainly due to its progressive installation as a central patent office in Europe, stagnated in the first half of the 1990s, and resumed growth in 1995-2001, averaging almost 10% a year.

1. The spectacular drop of USPTO filings in 1996 corresponds to the change in patent term from 17 years from grant to 20 years from application due to the implementation of the TRIPS agreement in the United States in 1996, as many companies preferred to apply before the change (hence the higher growth in 1995).

Figure 2. Annual growth rates of filings at USPTO, EPO and JPO[1]

Filing years: 1989-2002



1. EPO and USPTO filings correspond to the total number of applications. JPO filings correspond to the total number of claims (number of claims per application multiplied by total number of applications) to account for the effect of the 1988 law reform allowing more than one claim per patent application at JPO.
Source: OECD, Patent Database, September 2003, and USPTO, EPO and JPO Annual reports. 2001 and 2002 Japanese figures are OECD estimates.

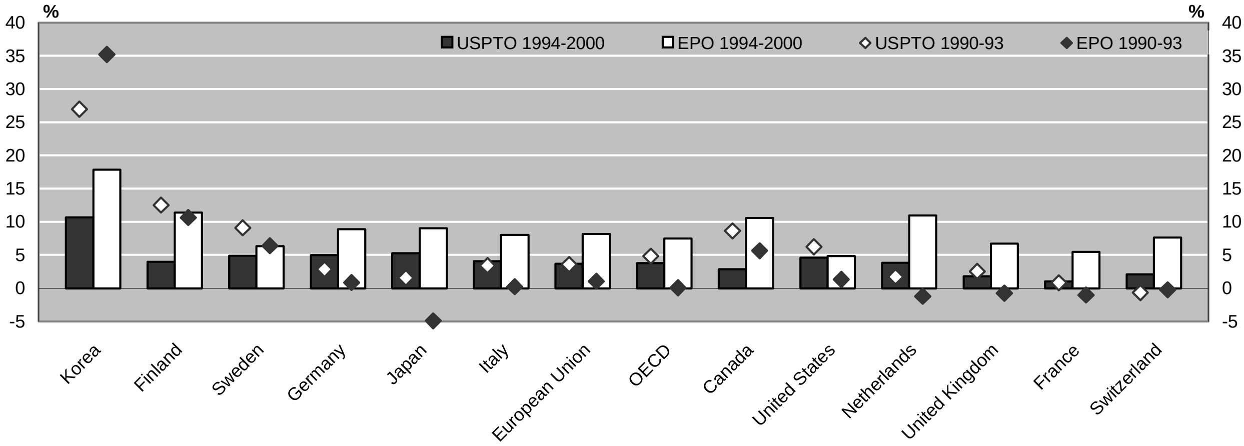
Even though the growth rate of patent applications at JPO was not as high as at EPO or USPTO in those years, JPO appears to have experienced similarly high growth rates in patent protection when filings are adjusted by the growth in the number of claims[2]. The total number of claims in applications filed at JPO more than doubled over the period 1995-2001. Nevertheless, as the economic situation has deteriorated in OECD countries since the beginning of the 21st century, patent numbers have fallen at the EPO and JPO in 2002 while they were sharply slowing down at the USPTO.

As regards the origin of inventions, US inventors largely contributed to the first surge in patents, in the late 1980s, when their share of USPTO grants to OECD countries jumped from 50% to 55-57% and from 27% to 30-31% of EPO filings, levels that have stabilised since. Nevertheless, a significant share of the surge in patenting over the second half of the 1990s can be attributed to new arrivals on the world technology stage, notably Korea and Chinese Taipei, and, to a lesser extent, China, India and Israel. Among European countries, the number of patents filed by inventors from Germany, Finland and Sweden contributed significantly to the rise in EPO filings after 1995.

2. Following a change in law in 1988, JPO has accepted patents including several claims. The number of claims per patent has continued to rise since this change, reflecting the increased breadth of any single patent in Japan. Hence, in order to fully capture the broadening scope of patent protection in the Japanese economy, patent numbers need to be corrected for this factor.

Figure 3. Average annual growth rates of USPTO grants and EPO applications

Selected countries, priority years: 1994-2000[1]

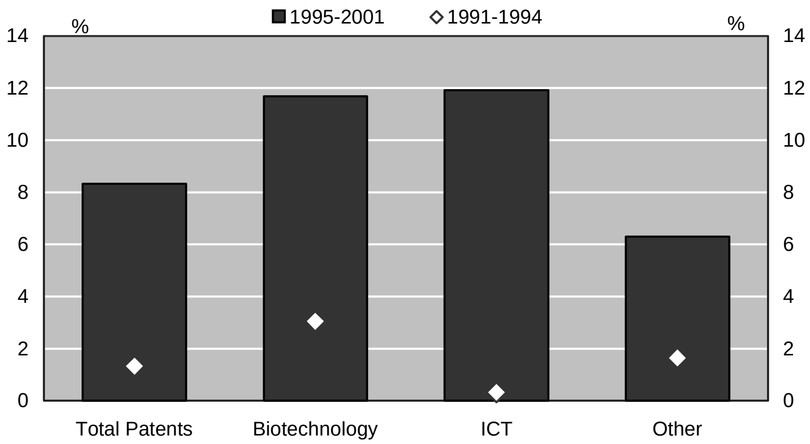


1. Based on the residence of the inventors and priority date. Selected countries are among the top 15 countries in both USPTO grants and EPO applications. Priority year corresponds to the initial date of filing of a patent application worldwide, regardless of subsequent filings in other countries; it normally corresponds to the date of filing in the applicant's domestic patent office.
Source: OECD, Patent Database, November 2003.

Although nearly all technology fields experienced growth in patenting over the 1990s, two contributed disproportionately to the overall surge in patenting: biotechnology and ICT. The share of biotechnology in EPO filings climbed from 4.3% in 1994 to 5.5% in 2001 (filing years). During the same period, the share of ICT climbed from 28% to 35%. Nearly half of the growth of patenting in the EPO over this period is due to these two technology areas, even though initially they accounted for only one-third of patents. Patterns in the USPTO are similar. USPTO data from previous years show that the share of ICT increased slowly but consistently throughout the 1980s, started accelerating in 1989 and grew at an even faster pace after 1995. The increase in the EPO share of certain countries such as Finland and Sweden can be traced essentially to ICT. To some extent, this is also the case for Germany, which had a 16.9% growth per year in ICT patents in 1995-2001 (compared to 11.9% for all OECD countries) compared with 7.5% for other technology areas (6.7% in OECD).

Figure 4. Average annual growth rates of EPO applications

Selected technologies, OECD inventors, filing years: 1995-2001

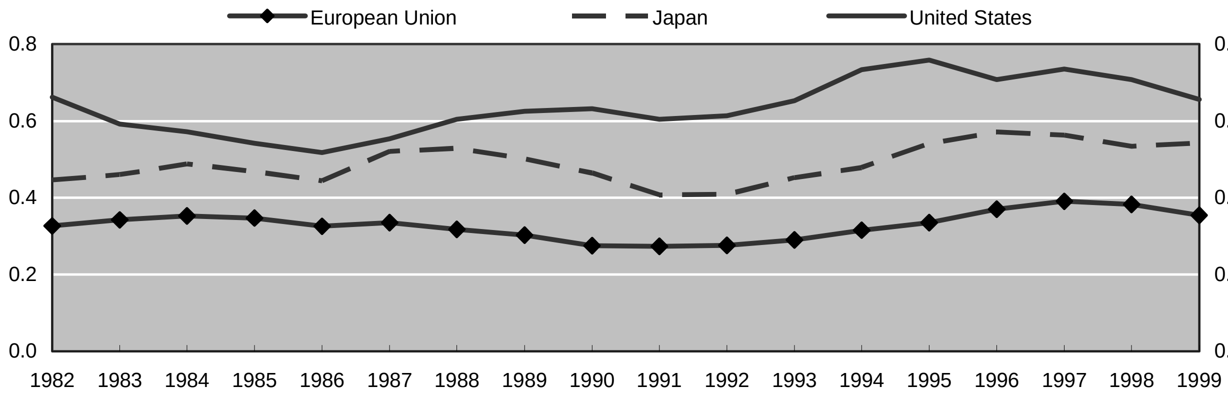


Source: OECD, Patent Database, November 2003.

The fact that the surge in patenting occurred mainly in new technology areas, where inventions have been more vivid over the past decade, suggests that patent numbers reflect trends in invention. This is supported by responses to the 2003 OECD/BIAC survey, in response to which firms assigned part of their increased patenting to growing numbers of inventions (Sheehan, Guellec and Martinez, 2003). The picture is somewhat blurred when one looks at the ratio of patents to business-funded R&D (patents per dollar of R&D). This ratio, for US patentees at USPTO, increased firstly after 1986, and again after 1993, interrupting a very long-term declining trend prior to the 1980s. The most spectacular evolution is the 50% increase in this ratio for European patentees at the EPO between 1994 and 2000, which was notably driven by Germany as country of inventor, and by ICT as an industry.

Figure 5. Ratio of USPTO grants to industry-financed R&D[1]

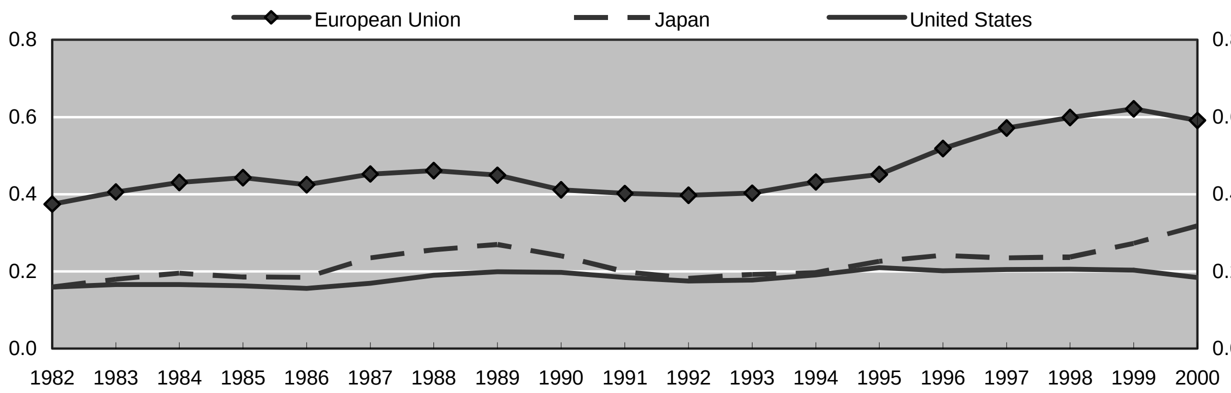
By residence of inventors, priority years: 1982-99



1. R&D is measured as gross domestic expenditure on research and development (GERD), expressed in millions of 1995 USD using purchasing power parities and lagged one year. Priority year corresponds to the initial date of filing of a patent application worldwide, regardless of subsequent filings in other countries; it normally corresponds to the date of filing in the applicant's domestic patent office.
Source: OECD, Patent Database, November 2003.

Figure 6. Ratio of EPO applications to industry-financed R&D[1]

By residence of inventors, priority years: 1982-2000



1. R&D is measured as gross domestic expenditure on research and development (GERD), expressed in millions of 1995 USD using purchasing power parities and lagged one year. Priority year corresponds to the initial date of filing of a patent application worldwide, regardless of subsequent filings in other countries; it normally corresponds to the date of filing in the applicant's domestic patent office.
Source: OECD, Patent Database, November 2003.

The increase in R&D expenditures has contributed to the surge in patent applications, but cannot fully explain it. Changes in competition seem to have played a key role in growing patenting trends in ICT industries. Some studies have reported the relevance of building patent portfolios and strategic patenting behaviour for firms in the US semi-conductor industry and the European mobile phone industry. Changes in patent regimes might have also contributed to the increase by making patents more valuable and easier or less costly to obtain. The surge in patenting in the United States, notably in ICT, started after important court decisions increased damage awards to plaintiffs in infringement litigation, hence increasing the value of patents (*e.g.* the Kodak-Polaroid case in 1986). The extension of the subject matter, notably in the United States, resulted in a greater number of patents for software and genetic inventions. In addition, high grant rates in the United States may have attracted more applications which in turn have generated more grants, and part of the surge in EPO might have come from a sharp reduction in patent fees (effective in July 1997). Overall, a mixed picture emerges, with part of the surge in patenting being explained by growth in inventions, notably in new areas, part being contingent upon changes in the economic environment and in patent regimes (Kortum and Lerner, 1999; Kortum, Eaton and Lerner, 2003).

4. The changing context: evolving innovation processes and markets for technology

Changes in patenting and licensing behaviour occur against a backdrop of changes in industrial innovation processes. Over the last decade, the importance of innovation as a driver of competitive advantage in OECD economies has grown. Innovation has also become more globalised, with small and medium-sized enterprises (SMEs) playing an increasingly important role. These changes have contributed to more collaborative innovation processes that involve a larger number of more diverse actors and inter-linkages among them. Growing levels of business patenting have helped inventors appropriate the returns from their investments and facilitated co-operation via market-based transactions of knowledge.

- *Innovation is central to business strategy*. Firms in a wide range of industry sectors see innovation and R&D as means of improving their competitive advantage. Between 1990 and 2001 industry-financed R&D in the OECD region rose 51% in real terms from USD 244 billion to USD 368 billion, or from 1.31% to 1.48% of GDP. Much of this growth was driven by high-technology manufacturing and knowledge-intensive service sectors, in particular ICT and pharmaceuticals – the same sectors that have seen the most rapid increases in patenting (Mairesse and Mohnen, 2003).

- *Globalisation of innovation processes.* Foreign affiliates of multinational enterprises accounted for between 15% and 17% of total business manufacturing R&D in the United States, France and Germany in 1998, more than 30% in the United Kingdom, and more than 65% in Ireland and Hungary. These investments increased by more than 50% in the OECD area between 1991 and 1998 as firms located R&D closer to foreign markets (in order to adapt products to local needs) and, increasingly, closer to sources of scientific and technological excellence. The globalisation of R&D contributes to international patenting.

- *The expansion of ICT and the Internet* has accelerated the availability of information on new technologies, making secrecy a less viable strategy. Such codified information can be more easily accessed by competitors who can imitate in a shorter period of time, thus reducing the efficiency of market-based strategies of appropriation. As the number and variety of potential competitors has increased notably due to globalisation, innovative companies have been demanding enhanced legal protection, including patents.

- *New technology-based firms play an important role*. In the United States, R&D in SMEs grew at almost twice the rate of R&D in large firms during the 1990s, with the smallest firms increasing the most rapidly. This trend was supported in part by increased venture capital funding to the advantage of the activities for new technology-based firms. Patents are especially important to new technology-based firms because such firms often have few assets other than their intellectual property, and need patent protection to attract venture capital. The ability to license intellectual property further enables their participation in the innovation networks of other firms.

- *Greater collaboration*. The growing technological complexity of products and processes, increased technological opportunities created by recent scientific advances (*e.g.* life sciences, ICT, nanotechnology), rapid technological change, more competition and higher costs and risks of innovation are forcing firms to work in greater collaboration. Firms are focusing a larger share of their R&D on activities that are linked to their specific competencies, and are acquiring complementary technologies from other firms, universities and government labs. This trend has been facilitated by the expansion of ICT, which reduces communication costs. The result has been a rapid rise in virtually all forms of collaboration, from sponsored and collaborative research to strategic alliances, mergers and acquisitions, and, notably, technology licensing.

Collaboration has been facilitated by the expansion of *markets for technology* that allow for formal, market-based exchanges of knowledge via patent licences. Licensing provides another channel by which patented technology can be disseminated and utilised – at a price negotiated by buyer and seller. In the OECD/BIAC survey, 60% of responding firms reported increased inward and outward licensing over the past decade, and 40% reported increased cross-licensing. While good statistics on inter-firm licensing are lacking, estimates in the United States suggest an increase in licensing revenues from USD 10 billion in 1990 to more than USD 100 billion in 2000.

Markets for technology affect economic performance and structure in many ways. They provide a means for the diffusion of patented technologies among a larger number of innovating organisations. In addition, they allow firms to concentrate their R&D resources in areas in which they have relative strength and allow them to rely on others for complementary technologies, possibly improving the overall efficiency of industrial R&D and innovation. Technology markets can also provide a channel through which firms sell or license technologies they cannot use themselves, encouraging additional investments in innovation. A growing number of firms report significant revenues from outward licensing of technologies they have developed, but do not intend to commercialise. IBM alone has reported revenues of more than USD 1.5 billion in recent years from technology licences, mostly on a non-exclusive basis.

Markets for technology also influence industry and market structures. Technology markets create niches for new types of firms, such as intermediaries that broker matches between potential buyers and sellers of technology and R&D service firms. The number of such firms has grown in recent years, as has R&D performed by technical service firms. Markets for technology are also important to so-called fab-less semiconductor firms that design chips and license them to other manufacturers, and to small biotechnology firms that identify drug targets that are then licensed to larger pharmaceutical firms for clinical trials, manufacturing and marketing. These firms lack the complementary assets, such as marketing and manufacturing, which are necessary to successfully commercialise their inventions.

However, the full economic effects of markets for technology are not well understood. It is not clear, for example, how such formalised, market-based transactions complement rather than substitute for the more informal exchanges of technical knowledge that are recognised as drivers of innovation performance. Nor is it clear how markets for technology compare with other formalised channels of technology transfer, such as strategic alliances, mergers and acquisitions and collaborative research, in transferring codified and tacit knowledge.

Numerous questions remain about the role of public policy in facilitating and sustaining technology markets. What role can and should governments play in linking buyers and sellers of technology or in creating technology markets? Can changes in accounting standards to highlight the value of intangible assets and revenues associated with licensing encourage the development of technology markets? There is some evidence to show that the strengthening of patent rights in Japan has stimulated greater inward and outward licensing of technology, but does this also apply elsewhere? Other countries, including the United Kingdom and France, have established licences of right that offer patentees a discount on certain fees in exchange for a commitment to license their inventions; however, their effectiveness has not been evaluated. How effective are mechanisms such as licenses of right in encouraging technology licensing? Additional work is needed to answer these questions.

5. Recent changes in patent regimes

Patent regimes have gone through important changes in the past two decades, most in the direction of strengthening patent rights, in the sense of reinforcing the exclusive rights conferred to patent holders, expanding their coverage and easing their enforcement. This upward shift in most countries coincided with upward international harmonisation of patent regimes. It was based on the view that stronger patents would boost innovation (Jaffe, 2000; Gallini, 2002; Schatz, 2003; Martinez and Guellec, 2003).

The design and enforcement of patent policies is increasingly the responsibility of new and more powerful governing bodies. Reforms were initiated in the United States in the late 1970s, and the centralised court system set up in 1982 (Court of Appeal of the Federal Circuit, CAFC) has been instrumental in strengthening the rights of patent holders in the United States. The EPO, with Europe-wide coverage and a centralised examination system, was also set up in the late 1970s. In 2002, the Japanese government created the Strategic Council on Intellectual Property under the Prime Minister’s Cabinet with the aims to establish a national strategy for intellectual property (IP) and to implement the corresponding policies (an IP strategic programme was issued in July 2003). At the global level, IPRs were included in international trade negotiations, and WTO was given enforcement power at the Uruguay Round in 1986-1994, resulting in the signature of TRIPS in 1994, which is considered as an important milestone in international harmonisation efforts. Negotiations are currently taking place at WIPO to increase international harmonisation of substantive patent law across countries, and some efforts have been initiated at the trilateral level to increase co-ordination among the three major patent offices in the world: the USPTO, JPO and EPO.

Major changes experienced by patent regimes in the United States, Japan and Europe in the past two decades can be summarised as follows:

- *Extended coverage of intellectual property protection.* Areas that used to fall outside the patent subject matter are now partially or totally included, notably software, business methods and some inventions close to basic science, although differences remain across jurisdictions (which are significant in the case of business methods).

- *Patents confer broader protection, especially in new areas.* Patent claims in new areas often cover far more than what the inventor actually discovered or invented. Some of the current patenting practices in new areas may extend protection to a broad range of applications unknown at the time of patenting (*e.g*. uses of genes).

- *Filing procedures are increasingly flexible and less costly, notably at the international level.* Several mechanisms to defer filing and examination procedures at patent offices, such as the system introduced by the Patent Cooperation Treaty (PCT), have transformed the initial application into a sort of option to patent that allows inventors to retain the right to patent in foreign countries for longer periods of time.

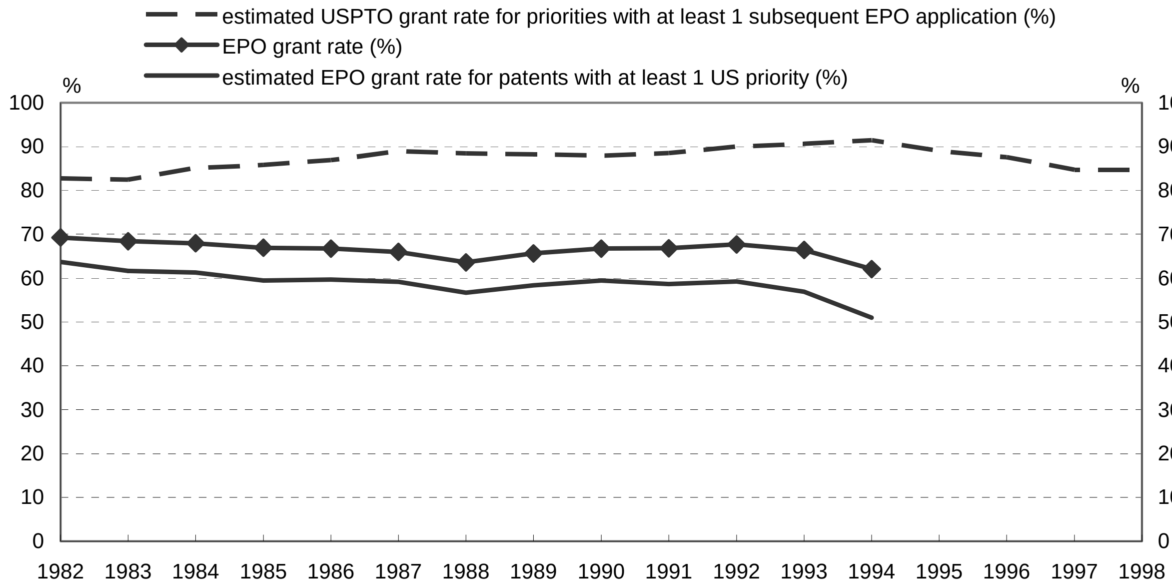
- *The rights of patent holders are more frequently and strongly enforced in court.* Since the creation of the CAFC in 1982, the rate of invalidation of patents by courts has substantially decreased in the United States. Efforts to create specialised courts are ongoing in other jurisdictions: legislation is expected to be passed next year in Japan in order to create a high court specialised in IPRs, and the implementation of a centralised patent litigation system is currently under discussion in Europe. Moreover, damage awards in patent litigation trials have substantially increased in recent years.

- *Restrictions on the exemption for research use*. Recent developments indicate that the conditions to apply research exemptions may become increasingly restrictive in the future. In 2002, the CAFC held that research exemptions would be granted in the United States when research is solely for amusement, to satisfy idle curiosity, or for strict philosophical inquiry.

Despite trends towards harmonisation, differences remain in patenting requirements across jurisdictions. A comparison between USPTO and EPO estimated grant rates for patents applied in both jurisdictions (see Figure 7) reflects those differences and suggests that the patenting requirement may have been lower in the United States than in Europe during the 1980s and 1990s: *i)* the difference between USPTO and EPO grant rates for patents with US priorities also applied at EPO was around 30 percentage points; and *ii)* the estimated EPO grant rate for patents first filed in the United States (US priority) has remained about 6-8 percentage points below the average grant rate at EPO. Differences in granting procedures in the United States and at the EPO might have contributed to these differences (Quillen and Webster, 2001). Notably, the US system seems to be more flexible, allowing the final grant to be different (usually narrower) than from the initial application. In fact, concerns about low patenting requirements, especially in new patenting areas, have prompted some reforms at USPTO in recent years, such as the introduction of a second examination for business methods in 2000, and the explicit requirement of a "specific, substantial and credible utility" for biotechnological inventions to be patentable in 2001.

Figure 7. USPTO and EPO estimated grant rates

Priority years: 1982-98



Note: EPO grant rates are defined as number of applications with grant date divided by total number of applications, sorted by year of priority (data on EPO grants is still partial for recent years). The methodology to estimate the grant rate at USPTO for US priorities also applied at EPO consists of the following steps: 1. Select all EPO applications with at least one US priority in the EPO database; 2. Track the corresponding patent number in the USPTO database on grants; 3. Divide the number of US priorities in EPO applications with a grant date at USPTO by the total number of US priorities in EPO applications, sorted by year of priority. Priority year corresponds to the initial date of filing of a patent application worldwide, regardless of subsequent filings in other countries; it normally corresponds to the date of filing in the applicant's domestic patent office.
Source: OECD Patent Database, November 2003.

Recent changes in patent regimes have contributed to the rapid growth in patenting activity in most countries by making patents a more attractive strategy for inventors. Reinforcing and broadening the rights provided by patents have resulted in increasing their value to firms, while the opening of new fields to patents has had a direct effect on filing numbers.

6. Intellectual property at public research organisations

Academic patenting – the patenting of inventions resulting from university and public research, whether supported fully or in part by public funds – has emerged as a new arena for the expansion of intellectual property policies in OECD countries and beyond (OECD, 2003*b*). The rise of academic patenting is to a large extent founded in the notion that it encourages the commercialisation of research results, with significant private and social benefits. It is part of a broader policy framework aimed at fostering the impact of public research on the economy through various means such as public/private partnerships, incubators, etc.

In 1980, the United States passed what is widely considered landmark legislation, the Bayh-Dole Act, which granted recipients of federal R&D funds the right to patent inventions and license them to firms. The main motivation for this legislation was to facilitate the exploitation of government-funded research results by transferring ownership from the government to universities and other contractors. Although academic patenting did occur prior to Bayh-Dole, it was far from systematic.

Taking inspiration from the United States, nearly all other OECD countries have reformed research funding regulations or employment laws to allow research institutions to file, own and license the IP generated with public research funds. The main focus of the legal and policy changes has been to transfer title from governments or individual researchers to PROs, and to give academic inventors a share of royalty revenue in exchange. The rationale is that ownership by the PROs, as opposed to individual researchers (or to not patenting), provides greater legal certainty, lowers transaction costs and fosters more formal and efficient channels for technology transfer. In addition to reforming legal and regulatory frameworks for the ownership and exploitation of academic IP, governments are encouraging the development of academic patenting by other means, such as reduced patent application fees for universities and support, often on a time-limited basis, for the creation of technology transfer offices or the prosecution of academic patents.

Results from the recent OECD/PRO survey on patenting and licensing, sent to PROs in OECD countries in 2002 show that the United States has a huge lead over other OECD countries in academic patenting: universities and federal labs received over 8 000 patents in 2000 (5% of total patenting, rising to 15% in biotechnology). Academic patenting in other countries, as measured by the number of patents granted to public research institutions, ranged from the low hundreds in Japan, the Netherlands and Switzerland, to close to 1 000 at German public labs and Korean research institutions in 2000-2001. Not all academic patents are licensed and not all patents earn income, however. Most public research organisations negotiate a very small number of licences per year (often fewer than ten). Even in the United States, the average number per university is 24 per year. A few leading research organisations in countries such as the United States, Germany and Switzerland may earn millions of dollars or euros in licensing revenue, but the gains are highly skewed as a few blockbuster inventions account for the greater share of revenue. Licensing income, even at the best performing institutions, is an extra benefit for research and education and rarely represents more than 10% of research budgets. A fact frequently missed, however, is that in several countries most licences are for non-patented intellectual property, such as biological research material or copyrighted works.

Box 3. OECD/PRO Survey

The OECD undertook a survey on patenting and licensing in public research organisations in 2001/2002. The survey collected information from technology transfer offices at three types of organizations: *i)* research-performing universities, both public and private; *ii)* research laboratories and agencies operated and fully funded by the government; and *iii)* other research organisations that receive a significant share of their total funding from public sources. It inquired about the organisational structure, size and funding of technology transfer offices, the size and scope of the intellectual property portfolio (*e.g.* number of patent applications and grants, filing jurisdiction), licensing practices and licensing income.

The survey was administered by government ministries or their consultants in Belgium (Flanders), Denmark, Germany (non-university PROs only), Italy, Japan (universities only), Korea, the Netherlands, Norway, Spain, Switzerland and Russia. Australia and the United States provided aggregate data based on existing surveys of universities and non-university PROs. Response rates varied across countries and between universities and other PROs, ranging from 52% to 90%. Results of the survey were published in the report *Turning Science into Business: Patenting and Licensing at Public Research Organisations* (OECD, 2003*b*). Several questions, such as R&D expenditure or patenting expenses, however, had low response rates and were eliminated in the tabulations. Because the questionnaire focused on patents that were assigned to or applied for by the institutions surveyed, it is possible that the results under-estimate the total amount of academic patenting in some countries, especially those in which PROs do not automatically claim title to inventions or cede them to industry or individual inventors.

Source: OECD (2003*b*).

Despite the small amount of (formal) academic patenting activity that takes place outside the United States, the increased focus on protecting academic inventions and licensing them to companies has raised a number of concerns common to countries throughout the OECD area and beyond. These concerns range from the impact of patenting on the traditional missions of universities, the effect on the direction of research, the actual costs and benefits of patenting and licensing, to the effects on the diffusion of and access to publicly funded research results.

What has been the impact of IP and technology transfer activities on the direction of research? Quantitative studies tend to show that patenting has led universities to conduct more applied research. By making university research more responsive to the economy, is there a danger that basic research will suffer? On the one hand, several studies in the United States have found that universities and individual researchers that have seen the largest increases in patenting are also those which experienced the greatest gains in academic publications. On the other hand, the rate at which academic patents are cited in other patents fell (relative to the average) between the early 1980s and late 1990s in the United States and is now lower than the citation rate of patents granted to business. This suggests a possible drop in the quality of public research – or at least of its patented component.

Should all patentable academic inventions be patented? As academic inventions arise in areas closer to basic research, scientists and policy makers are concerned that choosing to patent certain inventions could block downstream research. One example is that of research tools, in which granting a patent could inhibit diffusion by increasing the costs and difficulty of using such tools in applied research. In response, the National Institutes of Health in the United States (NIH) have espoused a policy to not knowingly apply for patents on research tools and to discourage their grantees from doing so. Such guidelines are being emulated by funding agencies and research institutions in other countries.

What is the impact of patenting on the diffusion of public research? There has been some debate about whether PROs should grant *exclusive licences* to the private sector for discoveries that have benefited from public funds. Licensees often require exclusive licences as they offer more protection for the necessary development to be conducted before a university-provided invention can become a marketed product. The issue is particularly crucial for start-ups which have no other asset than the licence. On the other hand, by definition, exclusive licences limit the diffusion of technologies. The OECD/PRO survey shows that the mix of exclusive and non-exclusive licences granted by PROs is fairly balanced, and that exclusivity is often granted with restrictions on the licensee side. Research institutions often include clauses in licence agreements to protect public interest and access to the IP for future research and discovery. Licensing agreements in many institutions include a commitment to exploit the invention on the part of the licensee, particularly if the licence is exclusive, and to agree on milestones in order to assure that commercialisation will take place. Hence these patents cannot be used simply to block competitors.

Another area of debate concerns the use of the so-called exemption for research use that has been in use in universities in both the United States and in EU countries, either formally or informally. Traditionally, universities have been exempted for paying fees for patented inventions they use in their own research. The rationale is that universities fulfil a public mission. As more public research is carried out with business and generates monetary rewards, the rationale becomes less clear. The extent and status of this exemption differs across countries and is often ill defined. This research exemption – or rather its interpretation – has recently been the subject of policy debate and litigation: recent court decisions in the United States have tended to restrict its meaning. There is now growing pressure on governments to clarify the scope of the research exemption in relation to the research missions of universities. This issue also relates to the management of IPR for international co-operative projects.

Many of these concerns or issues will take time to resolve. The growing reliance of public research institutions on various sources of funding, including from industry and contract research, as well as demands by society for greater economic and social returns on investment in public R&D, have made academic patenting a reality that is more likely to increase than decrease. While research institutions and firms are working to find solutions to problems as they arise, governments and research funding agencies have a role to play in providing guidelines on academic patenting and licensing and in fostering debate. More information on the amount of patenting and licensing, and the costs and benefit of patenting for universities, would also help inform policy makers and institutions alike. Data are needed on the costs of managing IP, inter-university licensing activity, and the amount of additional industry-sponsored research generated as a result of academic patents. Greater effort should be made to repeat the OECD/PRO survey in order to build time-series data and improve international comparability of data.

7. Biotechnology, patents and diffusion

The biological sciences are yielding an impressive array of inventions which involve the manipulation and use of genes and genetic elements, and there has been a surge in patenting in this area in recent years. Patents have emerged as the most important form of intellectual property protection for much of the biotechnology industry, in particular the biopharmaceutical sector.

Patent protection for biotechnology inventions has been available for over 20 years. Each year, thousands of biotechnology patents are issued worldwide, leading to the successful development of new products, services, and tools in fields as diverse as agriculture, pharmaceuticals, environmental clean-up, and industrial products and processes. An important early legal landmark was the 1980 US Supreme Court *Diamond vs. Chakrabarty* decision on the patentability of a genetically modified bacterium, after which inventions involving life forms were deemed patentable in the United States. Over time, court decisions, legislation (such as the 1998 EC Biotechnology Directive), multilateral trade agreements and examination guidelines at the major patent offices have confirmed the patentability of biotechnology-based inventions. The categories of patentable biotechnology inventions in many OECD countries have expanded over the years to include genes, gene fragments and genetic-based tools and diagnostics, genetically modified plants and animals, and a host of inventions derived from the revolutions in genomics, proteomics and pathway engineering.

Biotechnology patent statistics show some special characteristics. First, there has been a rapid rise in patent grants. From 1990 to 2000, the number of patents granted in biotechnology rose by 15% a year at the USPTO, and by 10.5% at the EPO, compared with a 5% increase in overall patents. Second, the share of US organisations granted patents is much higher in this sector than in other sectors. Third, the public sector has played an important role in the growth of patents for biotechnological inventions. For example, US and European PROs own 30% of all the patents for DNA sequences filed between 1996 and 1999. Finally, start-up companies have a higher share of biotechnology patents than do large, established pharmaceutical companies.

Industrial surveys on the effectiveness of patents in protecting inventions across sectors show that pharmaceutical firms traditionally place a high value on patents for protecting intellectual property – more so than do other industries (Levin *et al*, 1987; Cohen *et al.*, 2000). In the pharmaceutical sector, where innovation costs are very high, regulatory approval substantially increases time-to-market, and few R&D projects result in marketed drugs, patents are considered an essential factor in protecting competitive advantage. Patents are also very important to start-ups and university spin-offs in the biomedical field because both rely on protected intellectual property as their main asset in raising capital for development. The importance of patent protection for public sector research is more controversial. Commercial innovations are generally considered a by-product of government-funded basic research. Whether patent protection helps or hinders the development and use of these innovations by others is still unclear.

In public debates about patent protection for biotechnology, there are some concerns related to adequate access to patented inventions, and the quality of issued patents. By definition patent holders are granted the right to restrict others from using their inventions. In some cases, it is felt that this restricted access can have negative effects on upstream research or downstream clinical use. For example, patents over research tools may increase the difficulty of obtaining the necessary tools and materials for basic research and increase its cost. There is also some concern about the quality and breadth of patents issued by patent offices, notably some DNA patents. Some believe that in a number of cases the criteria of novelty and inventive step are not being met, and that broad patents are issued that could give the patent holders an overly-strong negotiating position *vis-à-vis* possible licensees (Nuffield Council on Bioethics, 2002; Walsh, Arora and Cohen, 2003; OECD*c*, 2003).

Despite these concerns, recent empirical surveys conclude that, on the whole, the patent system as applied to biotechnology inventions is doing what it is intended to do and that there is no widespread breakdown in the licensing of biotechnology patents. Examples of licence stacking, restricted access, and poor quality patents do exist, but in the majority of cases industry and universities have found workable solutions to mitigate their effects. Diffusion occurs through licence negotiations, inventing around and alternative access solutions, such as the creation of public databases. Nevertheless, continued vigilance is necessary to ensure that licensing practices do not overtly restrict access.

Meanwhile, there is room to improve access and market penetration without undermining the patent system. Given the important role of PROs in biotechnology patenting and licensing, many of the problems highlighted here were mentioned in the previous section; in particular OECD countries should consider:

- *Encouraging good licensing practices in the public and private sectors.* The licensing of patented technologies can provide financial rewards to inventors while encouraging the dissemination and use of inventions by others. Licensing guidelines or model contracts are self-regulatory solutions to some of the perceived problems associated with the patenting of biotechnology. OECD governments are working towards good practice guidelines that should encourage their development and use.
- *Clarifying and reinforcing research exemptions.* There is a consensus in favour of defining a space in which basic research inquiries could be free of overly burdensome IP restrictions. Many observers are concerned that the present patchwork of national research exemptions is both ill defined and may be breaking down due to legal challenges. OECD countries may wish to clarify how research exemptions are used in practice and consider how better research exemptions that would permit limited use of patented technologies, while offering adequate protection for those who create novel research tools, might be crafted.
- *Exploring alternative access arrangements*. The private and public sectors are beginning to experiment with alternative institutional solutions to access problems, in some cases agreeing to place certain inventions in the public domain, in others creating mechanisms for sharing bundles of IP. Understanding how patent pools, patent clearinghouses and public databases can be used in biotechnology, and what peculiarities of the technology or industries will require different solutions than in, for example, electronics, would help move these access arrangements closer to reality.

- *Economic analyses of knowledge transfer mechanisms*. Technology diffusion occurs within an increasingly complex web of relationships involving industries, universities, and small and large firms. Patents allow these informal and *ad hoc* forms of interaction to occur. It is important to develop methodologies that can explain how technology transfer occurs in these structures, and how market and non-market transactions are affected by various features of the patent system.
- *Improving the quality of patents issued.* Some observers are of the view that the administration of the patent system could be improved so that fewer patents, of less expansive scope are issued, which in their view would increase certainty about the validity of granted patents. Governments could compare how examiners in different jurisdictions interpret the criteria of patentability for biotechnology inventions, and whether these criteria are applied with sufficient rigour.
- *Monitoring emerging access challenges.* New challenges for access and high transaction costs are likely to emerge as different types of intellectual property – patents, copyrights, and database rights – are brought together by firms exploiting interdisciplinary fields such as nanotechnology. Governments need to anticipate where the next generation of challenges are likely to emerge.

8. Software and services

The patentability of software-related inventions is currently one of the most heated areas of debate. Software has become patentable in recent years in most jurisdictions (although with restrictions in certain countries, notably those signatories of the European Patent Convention) and the number of software patents has risen rapidly. However, there remain fundamental questions about whether software should be patentable and, if so, whether specific characteristics of software demand that different rules be applied to ensure that patenting provides true incentives for innovation, allows follow-on or incremental innovation and facilitates knowledge diffusion. The patentability of business methods – often software-based – has further fuelled the debate, especially as concerns the possibility that low quality patents might block or impede the fledgling electronic commerce sector.

Since 1998, software-related inventions (and mathematical algorithms in general) are patentable in the United States as long as they produce a "useful, concrete and tangible" result, in addition to the usual criteria (novelty, non-obviousness and industrial application). However, in Europe and to some extent in Japan, they are only patentable if "sufficiently technical in nature" (which excludes business methods in particular), a position which has been recently confirmed in Europe, although the legislative process is still ongoing (Hall, 2003; Motohashi, 2003).

Following permissive patentability trends, patents for software and business method inventions have increased rapidly in recent years in the United States. Various estimates indicate that the number of software patents granted by the USPTO grew from fewer than 5 000 per year in 1990 to approximately 20 000 in 2000, or approximately 15% of all US patents granted in that year (Hunt and Bessen, 2003). In contrast, business methods patents represent a very low share of the total number of grants, with around 1 000 grants per year in the US since 1998. Interestingly, software publishers account for only a fraction of software patents – only 6% of software patents according to one recent study – with the majority of software patents owned by large firms in the ICT manufacturing and electrical machinery sectors. Large software consultancies and other service-sector firms also account for a small, but growing, number of patents to date. This pattern reflects the increasing role of software and services business units within large ICT firms, as well as the growing pervasiveness of embedded software in a range of electrical and electronic devices.

Growth in software and business methods reflects both increased innovative activity and changes in patenting behaviours. R&D spending by software and ICT firms has grown rapidly over the past decade. Microsoft's R&D expenditures alone grew from USD 270 million in 1991 to USD 4.4 billion in 2002. More than three-quarters of ICT firms responding to the OECD/BIAC survey reported that they were generating more inventions now than ten years ago (Sheehan, Guellec and Martinez, 2003). Nevertheless, the patenting strategies of these firms have also changed. More than three-quarters of ICT firms in the survey reported that they now patent technologies they would not have patented a decade ago – even if the technology had been patentable then. Software and ICT firms see patents as an important bargaining chip in negotiating alliances with other firms and as a means of generating additional revenue via licensing. Indeed, more firms in the ICT sector than in other sectors reported increases in outward licensing and cross-licensing over the past decade. Other research has also demonstrated the key role of strategic patenting in the semi-conductor industry (Hall and Ziedonis, 2001).

Does increased patenting for software and business methods stifle innovation and facilitate anti-competitive behaviour? Software programmes tend to be complex, modular products that combine multiple functions, each of which may be the subject of a different patent. Increased patenting may therefore inhibit follow-on innovation or the assembly of complex programmes as it increases transaction costs. Interoperability also needs to be high, meaning that open standards and interfaces are critical to ensuring innovation and market entry. On the other hand, if patents give more protection, they also could require more disclosure, which can be helpful for reducing the exclusion effect generated by patents. Network effects are also strong in the software sector, and switching costs can be high, locking-in customers to dominant products, especially if interoperability cannot be assured. In this context, patents might contribute to enhancing competition and innovation by allowing new market entrants to defend their technological position against incumbents.

In summary, when addressing the issue of software protection, the following points should be considered:

- *As in other areas, patent offices should ensure the quality of software-related patents.* Patents with extremely broad, abstract claims have sometimes been granted, notably in the field of Internet-related business methods. Not only should patented inventions be novel and not excessively broad, but patent documents should also disclose all the information necessary for a person skilled in the art to be able to replicate the invention in a reasonable period of time. The information disclosure requirement should be subject to the same standards prevalent in other fields of technology, which stress the importance of publicising patented source code for software-related inventions.
- The interaction of patents and copyright may be an obstacle to the diffusion of technology in this area, and thus further innovation, as patents protect the invention whereas copyright forbids the publicity of the way in which the invention is implemented by forbidding reverse engineering (Graham and Somaya, 2003). In addition, as copyright forbids reverse engineering (closed source code is protected as such), and as software patents do not have to reveal their source code, disclosure of software knowledge is clearly hampered in the current IPR setting. This calls for government attention focusing particularly on the cross effects of copyright and patent, and on insufficient disclosure requirements in software patents.
- *Software is pervasive*. Less than 10% of software patents in the US are granted to software companies. Actually, according to survey data, between 25 and 40% of business expenditure R&D in all industry has a software-like outcome, reflecting the fact that many operations which used to be monitored by mechanical means are now mediated by software. Hence, a

special treatment of software *in general* regarding IP might affect patterns of innovation beyond the software industry, and create unintended effects on the R&D industry-wide.

- *Important segments of the software market are moving towards an open-source approach,* which clearly helps disclosure and follow-on innovation, but the viability of the economic model for open source software is uncertain. In current open source approaches, attracting financing for innovation is not as straightforward as with proprietary, closed source software that is sold in the marketplace. To date, rewards to open source innovation have been essentially non-monetary (*e.g.* reputation) or based on the provision of complementary services (*e.g.* customisation, support). It would be worth exploring whether patent protection could be useful to open source software developers in creating sustainable business models and markets for technology, while guaranteeing the disclosure of source code. One aspect of this question is that patents might provide, as in other fields, the protection that inventors require to fully disclose their inventions – a necessary condition for an open source approach.

9. Conclusion: Policy issues and options

The analyses presented in this report suggest a series of policy issues and options, and recommended topics for more in-depth analysis in the future. These concern the development of markets for technology and the access to basic inventions, as well as the patent system itself, its principles and the way it works.

The paucity of economic evaluation of the patent system is striking. Most of the changes to patent regimes implemented over the past two decades were not based on hard evidence or economic analysis. It is necessary to develop economic analysis in this domain that would inform the policy debate, giving governments a clearer view beyond the arguments put forward by pressure groups. Such analysis should rely notably on quantitative evidence: an effort to build and make available to analysts the corresponding databases has been initiated notably by the OECD, but this work needs to be broadened. In addition, more information is needed on the ways in which patents are used by their holders, for instance as regards in-house implementation, licensing contracts and business strategies.

In parallel to this analytical effort, policy makers might encourage experience-sharing across countries: there are significant differences in patent regimes and many countries have experimented with various policy mechanisms, but there have been few attempts to systematise this experience and disseminate best practices across countries.

Analysis and policy messages presented in this report also apply to a certain extent to developing countries with significant national innovation capacity. These countries need a patent system strong enough to attract foreign direct investment, to ensure inward licensing and to encourage local investment in research. However, these countries also need to protect their ability to access and digest existing foreign technology, just as developed countries used to do in their development stage (Barton, 2003). The specific features that these countries might build into their patent systems to address these various objectives is a topic for future research.

9.1. Encourage the development of markets for technology

The expansion of markets for technology is a major achievement of a well-functioning patent system, as these markets enhance the circulation of technology. Our knowledge of technology markets remains insufficient, and future studies should be devoted to improving it and addressing many of the questions that have not been yet fully investigated: How do they work? How does information circulate between the various actors? How are agreements settled? What is the role of intermediaries?

What is the impact of technology markets on technology diffusion and competition? To what extent, and in which areas if any, do market transactions on technology substitute for non-market spillovers?

As technology markets interact with important government concerns - notably competition - there is a need for further reflection on the economic impact of certain instruments such as cross-licensing and patent pools. In addition, governments are potentially important actors in technology markets as they sponsor most basic research that is then licensed by PROs. Government policies on patenting and licensing practices at PROs affect certain segments of the market, such as users of basic science. More broadly, one might wonder whether these markets are confronted with certain failures that might justify some kind of government intervention, especially as regards SMEs. On this basis, policies could be designed to support the development of markets for technology and remove barriers which could hamper their development.

9.2. Ensure access to basic inventions

Patenting of basic research and patenting by PROs (which perform most basic research) have contributed substantially to increasing investment, achievements and commercialisation in the research areas concerned, notably biotechnology. This practice raises new issues, mainly regarding the conditions of access to the outcome of that research. Although there is no sign of a global failure here, there have been cases of restricted access (*e.g.* genetic tests) and proliferation of rights slowing down research and raising its cost (tragedy of the anticommons). New entrants and future developments could upset the delicate balance between protection and diffusion. In order to avoid future problems in this regard, governments may consider taking two steps:

- *Protect and clarify the exemption for research use.* This is needed to ensure that the conditions and cost of basic research remain manageable while preserving incentives for business to invest in certain upstream areas of research. The statute and extension of research exemption differ across countries. An international comparative study analysing its evolution across time and how it is currently used by universities and businesses is necessary to clarify the current debate.

- *Ensure that patenting does not reduce incentives to disseminate inventions by universities.* There have been publicised examples of academic publications being delayed due to patent filing, licensing terms reducing diffusion, etc. The extent of these phenomena is unknown, and needs to be monitored. As market signals are increasingly and efficiently used for orienting university research and linking it to the needs of the economy, governments should take measures to safeguard the public mission of universities which is a major factor of innovation in the long run.

Based on a broad review of the evidence, governments might consider a series of policy measures aimed at fostering the diffusion of university research. Such policy measures may include the following: *i) grace period*: the possibility given to the inventor to file for a patent in a given period of time *after* publishing the invention; *ii) provisional patents*: one-year option for possible future filing; *iii)* elaborating and promoting *guidelines for licensing of basic research* that support the broad diffusion of basic research. Governments might also explore policies for promoting the diffusion of non-patented inventions made by PROs. More generally, policies for promoting the use of public domain knowledge and information, notably through the Internet, need to be made more systematic in order to provide the appropriate conditions and incentives for public knowledge to actually be accessed and used by the public.

9.3. Revisiting the working of the patent system

An initial economic investigation of the working of the patent system reveals limitations in the adequacy of this system for enhancing innovation and diffusion of technology. Historically, the patent system evolved for various purposes, including, but not only, the economic benefit to society. In this respect, it is necessary to review recent problems with a certain sense of urgency, but it might also be useful, in a longer-term perspective, to revisit certain pillars of patent systems as they stand today.

An immediate issue is to assess how *new areas of technology and knowledge* are addressed by the patent system. Software, genetics, and business methods are the most recent, and are soon to be followed by proteins and nanotechnology. New areas are subject to controversy: should they be patent subject matter at all? How to ensure that patent protection in these areas is not mainly an instrument for rent seeking and blocking access? How to equip patent offices with the ability to grant patents of sufficient quality in these new areas (*e.g.* relevant breadth, sufficient inventive step, *etc.*)?

As the patenting tradition evolves based on experience gained in established fields, accommodating new fields is not straightforward. Patent offices faced this problem previously when chemicals and pharmaceuticals became patent subject matter. The issue actually is twofold: *i)* to analyse the economic impact of patent protection in these fields and compare it with alternatives, such as copyright or no specific legal protection at all; and *ii)* to have patent offices rapidly accumulate experience in new fields so as to avoid early-stage mistakes. Databases of prior art should be set up rapidly. In addition, criteria for granting or rejecting applications and for giving patents an appropriate breadth should be clarified as rapidly as possible after patentability of the subject matter has been decided (more rapidly than was the case for biotechnology and software).

A second issue is the *quality of patents*. Low-quality patents are those that protect inventions of limited novelty or that provide overly broad protection. Low quality patents can be costly to society. Their proliferation not only swells the number of patents and patent applications that must be reviewed by potential innovators and patent offices, but also creates uncertainty about the validity and enforcement of patents more generally. The societal benefits of such patents are likely to be low, but they can nevertheless be leveraged by their holders for rent-seeking purposes: they may be used as a threat against other companies, especially small ones, or as part of patent thickets for closing market access to potential competitors. The more important patents become to innovation and economic performance, the more necessary it is to improve the quality of granted patents, and to do so at a reasonable cost. Various means have been already set in place in different jurisdictions and could be considered by others:

- *An opposition system* seems an efficient way of ensuring the quality of patents: once a granted patent is published, third parties can oppose the decision at the patent office, where an internal court examines the case including any new evidence provided in the opposition process. The positive European experience supports this approach, which should be carefully examined by other offices.

- *A centralised court system* is necessary for ensuring higher legal certainty of enforcement and the validity of rights. The United States pioneered this with the creation of the CAFC in 1982, Japan is following step now with an IP high court, and it is key to the success of the future Community patent that Europe does the same.

- *International co-operation for promoting quality at the lowest cost*. Current negotiations at WIPO (Substantive Patent Law Treaty, SPLT) and formal co-operation among the trilateral offices go in this direction. Discussions are being conducted for setting up databases of prior art in new fields and mutual recognition of search and examination results. These are steps, in a way, towards the objective of a *global patent system* which would allow inventions to be protected worldwide. The rationale for this evolution is the increasing share of patent applications filed in different national offices at the same time (as part of the globalisation process), which generates duplication of work between national patent offices and increases costs for patentees. Limits to international harmonisation at this stage are fixed by differing patent regimes across countries concerning, among other things, subject matter, inventive step or scope of patents.

- *Encouraging patentees to self-select their applications*: The social cost of filing patents could also be reduced by discouraging both applications for minor or economically unimportant inventions and strategic patenting. Alternative means for that purpose include the following: *i) stricter examination*: low-quality applications would be deterred by a low probability being granted; *ii) reduction of fees once a patent is granted (as opposed to rejected)*: such a discount would encourage self-selection by patentees so that the number of low-quality applications would decrease; *iii) second-tier patent protection*: enhance the use of so-called petty patents or utility models systems as an alternative to standard patents for minor and less novel inventions (such a system has been working for a long time in many countries; it was recently modernised in Australia); and *iv) setting up a credible public domain alternative:* for example, encouraging firms to publicise their inventions on dedicated Internet sites at low cost when the only purpose for patenting is to avoid others patenting first (a practice referred to as defensive patenting).

Taking a longer-term perspective, certain fundamentals of the patent system could be subjected to economic scrutiny with the view to improving the incentives to innovate and diffuse technology. The uniformity of the patent system, understood as equal treatment for all inventions within the subject matter, is a prominent example of a principle which should be reviewed. Given the diversity of inventions across industries and fields of technology in terms of cost, and the existence of other means of protection or market conditions, it is not clear whether the "one size fits all" principle of the current patent system should be maintained. Should patent protection for software and drugs be awarded for the duration, given that technology and economic cycles are widely different in these two areas? What are the alternatives to this uniform approach, and what would be their costs and advantages as compared with the current system? Other directions to be investigated in the long term include the possibility of tailoring the degree of protection to the value of the invention. This is already the case for renewal fees. Considering that patentees have to pay to keep their patents in force, there is an incentive to inventors to stop renewing protection once the value falls below a certain level and let them lapse so that the invention becomes part of the public domain. Such an approach could be consistently extended to other aspects of patents which affect the degree of protection, notably breadth. This is to some extent the purpose of petty patent systems, which provide narrower and less expensive protection than standard patent systems. The current two-tiered system in Europe, with national patents of national validity only, a usually smaller novelty requirement and a lower cost than Europe-wide patents granted by the EPO corresponds in a way to this differentiated approach. Having patentees pay more for broader patents would not be straightforward to implement, but it certainly deserves investigation.

As patents play an essential role in market-centred systems of innovation, economic criteria should be used more systematically to evaluate the ability of patent systems to foster innovation and to encourage technology diffusion. Despite broad changes in patent regimes over the past two decades, no systematic economic evaluation has been carried out with a view to informing policy choices. The patent system will face new challenges in the future with the emergence of new technologies; the increasing importance of service-type innovations; the growing role of markets in the production and diffusion of knowledge; the arrival of new countries on the technological scene; increased globalisation; the convergence of various technology domains (*e.g.* biotechnology and ICT), fostered by the emergence of broad-band communication, which generates overlapping of various types of IPR (database protection, copyright and patents); and the promotion of the public domain in the Internet age. In this context, the importance of patents will not decrease but the conditions under which patent systems fulfil their role, encouraging innovation and diffusion, will evolve. Patent systems will be better prepared to confront these challenges if they have already been subjected to policy-oriented economic analysis.

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