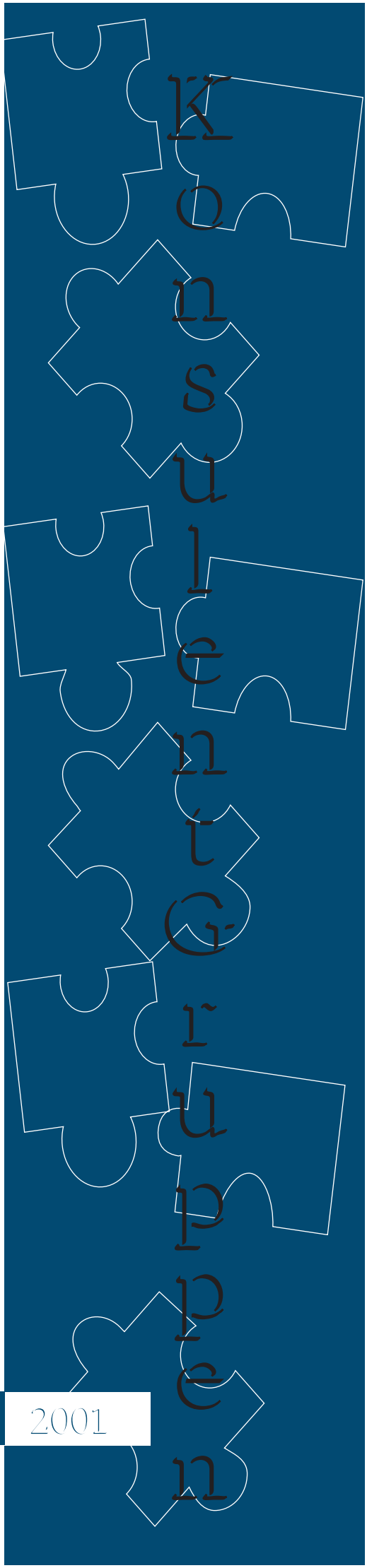
Ministry of Trade
and Industry

Economic Consequences of Legal Expense Insurance for Patents



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Summary

Small and medium-sized enterprises (SMEs) perform less research, development and patenting than large firms. It is an international phenomenon. Surveys conducted among smaller firms indicate the high costs of patent litigation as a contributory cause. The smaller firms state that they do not have the means to defend a patent, because patent litigation is very resource-intensive.[1] Studies suggest that high litigation costs are a problem particularly for smaller firms because they are subject to liquidity constraints.[2] If SMEs can foresee that they will have difficulties financing the defence of a possible patent, it reduces their incentive to perform research and development (R&D).

The lack of patenting as well as R&D by the smaller firms means less R&D overall, which is bad for the economy because it reduces productivity and growth.[3]

This report looks at the economic consequences of publicly subsidised insurance for legal expenses involving patents, which could increase the patenting and hence R&D.

Chapter 1 describes the international experiences with insurance for legal expenses. The US has a relatively well-functioning and profitable programme. The same is true for the UK, whereas in the rest of Europe there have only been limited and partially unsuccessful attempts to put such programmes into place.

The market for legal expense insurance is thus relatively underdeveloped in Europe. There can hence be a need for a temporary public subsidy on the basis of the so-called pump priming principle, where the public sector intervenes with support for a period of time until sufficient volume has been built up on the part of subscribers as well as the necessary competencies on the part of the insurance providers. The entire market, or parts of it, can subsequently function under normal business-related conditions.

[1] Small high-technology firms in America say that problems with enforcing patents are one of the reasons that they do not take out patents, cf. the survey conducted by the U.S. Small Business Administration, 1999 (www.sba.gov/advo/research). The survey performed by Kingston (2000) of SMEs in the UK, France and Denmark found that a vast majority emphasise high litigation costs as a "very large " or "significant" barrier to investment in research and development.

[2] Hall (1992) shows for example based on American figures that low R&D investments are due to liquidity constraints. Harhoff (1998) finds with German figures that this is particularly the case for small firms. Similar results are found in Hao and Jaffe (1993), Himmelberg and Petersen (1994) and Kathuria and Mueller (1995).

[3] In economic terms, the patent system contains both benefits and drawbacks. Economic literature generally shows that the benefits outweigh the drawbacks, cf. Thomson and Rushing (1996,1999), Maskus and Penubarti (1995), Gould and Gruber (1996) and Park and Ginarte (1997).

Successful legal expense insurance for patents would to a large extent be dependent upon international co-operation. Patents held by Danes in Denmark are only a small portion of the total patent portfolio held by Danes. If the programme is to have a reasonable volume, then international co-operation is required. A programme at EU level would mean mutual recognition (along the lines of the existing EPO system) and, for example, the exchange of the information needed to ensure the correct calculation of a premium. An EU arrangement would mean that Danish firms would be able to insure their *entire* European patent portfolio. It would thus have a marked effect on the R&D conducted by Danish firms.

Chapter 1 reviews the benefits and drawbacks of the different building blocks that can enter into legal expense insurance for patents, for example: a specialised "screening" institution, an electronic patent exchange, a venture structure, general or selective public subsidies, deductibles, voluntary or obligatory programme, etc. No one specific structure is recommended.

Chapter 2 shows using an arithmetic example what the consequences of one version of a legal expense insurance programme for patents are with respect to the private economic value of patent protection in Denmark. Insurance which is publicly subsidised, and which reduces the legal expenses of patent holders to a deductible of just under EUR 7,000 (DKK 50,000). The arithmetic example combines a patent valuation model[4] and patent renewal data for 46,000 Danish patent applications from the years 1967-95 and their "life" during the period of 1984-99. In Denmark, patents have a maximum validity of 20 years from the application date. Each year, the patent holder must pay a renewal fee, which increases with the age of the patent, in order to maintain the patent for another year. Most patents are dropped before the 20-year mark.

The central concept in the computations of chapter 2 is that if a patent holder decides to renew an approved patent for another year, then the patent has a private economic value[5], which exceeds the renewal fee *and* the expected expenses of any possible litigation.

The value of a patent depends upon it *not* being infringed upon. The patent authorities grant patent rights, however it is up to the patent holders themselves to enforce these rights. A patent is infringed upon if the potential infringing parties do not believe the threat of the patent holder to drag them into court. Such a threat is not credible if the patent has a commercial value to the patent holder, which cannot justify the renewal fee *and* possible legal expenses. Hence, patents that have a too low value will be dropped.

[4] The model was developed with inspiration found in Lanjouw (1998).

[5] Value must be understood here in a very broad sense. It involves both the commercial returns which the patent holder receives in the here and now as well as his expectations for future returns. Moreover, a patent can have a strategic value which is not necessarily closely associated with the tangible returns from the patented invention, but rather is a derived value because it e.g. "blocks out" competitors.

In chapter 2, we show the estimated numerical results of the following causality chain: lower litigation costs mean that more patents will be applied for, and that patents will be renewed for longer periods of time. Lower litigation costs thus increase the value of the total portfolio of patents. The patent system accordingly provides a greater implicit subsidy to R&D because it becomes more attractive to take out patents and hence to perform R&D when publicly subsidised legal expense insurance is available to assist with the enforcement.

The arithmetic example in this chapter shows that if the patent holder's litigation expenses are reduced to a deductible of slightly less than EUR 7,000, then such insurance would increase the value of the European (including Denmark) patent portfolio held by Danes by 10 percent, or EUR 26 million.[6] And when patents become easier to enforce and hence worth more, it again implies that Danish firms have a greater incentive to perform R&D.

Chapter 3 estimate the economic consequences in Denmark of a specific formulation of a European legal expense insurance programme for patents, in which Danish patent holders can insure their entire portfolio of patents taken out in Europe.

Such a legal expense insurance programme increases the value of patents. It benefits the economy via two channels. Firstly, there is the direct channel. An increase in the value of the patent system corresponds to a greater implicit subsidy to R&D efforts of the firms taking out the patents, and those efforts thus increase. Secondly, there is the indirect channel. The increased R&D efforts mean more patents, which increase the spread of knowledge in the economy. An important objective of the patent system is precisely to build up and maintain a large database of knowledge. There thus are requirements for documentation and publication in connection with the taking out of patents. It is this spreading of knowledge, which explains that the economic returns for society as a whole can be greater than the private economic returns. There hence exists an economic argument for providing public support to private R&D via, for example, a legal expense insurance programme.

The result of more R&D in the businesses and the spread of knowledge is still more inventions. This can involve inventions, which make production processes easier and less expensive. Or it could involve inventions, which increase the quality of the goods produced. Both types lead to higher productivity. When productivity rises, the welfare of the population rises. This occurs because we can produce and consume the same quantity of goods even though we have more free time. Alternatively, we can produce and consume more and better goods even though we spend the same amount of time at work.

[6] This is probably a conservative estimate because we have no direct information on the value of the most valuable patents which at no point in time are dropped, but rather are held until they expire 20 years after the date of their application. Their value could hence be undervalued.

An arithmetic example from the equilibrium model of the Ministry of Trade and Industry, MobiDK, shows that public welfare will rise by EUR 100-340 million in Denmark as a consequence of a legal expense insurance programme for patents. The range is a question of whether any positive effects from the spreading of knowledge are included or not. Correlated with the magnitude of the economy, this corresponds to a range of EUR 6-21 billion at EU level. This would involve the effect of a European legal expense insurance programme on the value of the total European patent portfolios held by Europeans.

A certain level of public involvement will probably be required during a start-up phase if it is to attain sufficient volume and critical mass, cf. chapter 1. The computed economic effects at societal level place a ceiling on how profitable it would be for a society to have the public sector supporting a legal expense insurance programme. If, for example, a requirement is posed of a rate of return of 15%, then in Denmark a maximum of EUR 260 million can be injected on the overall into the programme, and a maximum of EUR 18 billion at EU level.

Chapter 1 The design of a legal expense insurance

1.1 Introduction

Cross-country analyses show that SMEs do not patent their inventions to the same extent as large firms, cf. EPO (1994). This is confirmed by surveys among SMEs, indicating that the fear of high litigation costs is holding them back from patenting their inventions, cf. Cordes, Hertzfeld, Vonortas and Washington (1999) and Kingston (2000). Hence, there is much to suggest that a potential market exists for a legal expense insurance programme for patent holders.

Some of the European experiences with legal expense insurance show that the traditional insurance companies do not possess the requisite competencies to assess the risk of litigation for every individual patent holder. Examples of well-functioning insurance-programmes in the US and the UK set out three possible set-ups for increasing the level of information and hence improving the possibilities for a correct risk assessment:

- A traditional insurance arrangement, with a specialised 'front office' that has the expertise to assess every individual patent case.

- An electronic patent exchange, where experts evaluate every single patent before they are offered on an electronic patent exchange to interested insurers.

- A venture set-up, where the patenting firms are supported and advised by a consulting enterprise in exchange for ownership in the patenting firm.

All three programmes gather a number of competencies that assess the patent portfolios of the firms and their potential risks of patent infringements.

It has turned out to be difficult to build up a private insurance market that offers legal expense insurance for patents on a commercial basis. This is probably due to it requiring a great deal of information to compute the risks and premiums for patents in many countries with different patent systems and different legal systems. Temporary governmental involvement could direct towards gathering and conveying such information.

Some patents have a very large amount of associated uncertainty concerning the risk of litigation, etc. For these patents the premium would thus be very high, and a more permanent type of public sector involvement would be a possibility for ensuring that these patents are given the opportunity to be covered by insurance. A public programme should be a complement to the private insurance schemes here. Such a programme could, for example, be constructed using inspiration taken from the export credit programmes, which most countries offer to exporting firms.

The programme would be strengthened if it were to be established under EU or international auspices. A national programme – for example purely Danish – would presumably only encompass the patents of Danes in Denmark for two reasons:

- When there is an element of public subsidy in the programme, it would then only be offered to Danish patent holders.

- A Danish insurance institution would have special knowledge of the Danish legal and patent system, but would have somewhat greater difficulty in calculating a correct premium for legal expense insurance on, for example, a biotechnology patent taken out in Portugal.

Patents of Danish innovations taken out in Denmark only comprise a small portion of the total patent portfolio held by Danes. As such, a purely Danish programme would not attract sufficient volume. Moreover, patent insurance at EU level would mean that the requisite information on the patent and legal systems of the countries would flow more easily. This can ease the application procedures so that all firms within the EU could insure their European patent portfolio. Further, an EU programme could be the first step towards a global programme, for example under the leadership of WIPO, which functions as a representative body for the national patent authorities around the world. Such a set-up could help ensure that the individual countries do not use the insurance programme as a national support scheme.

1.2 Patenting and firm size

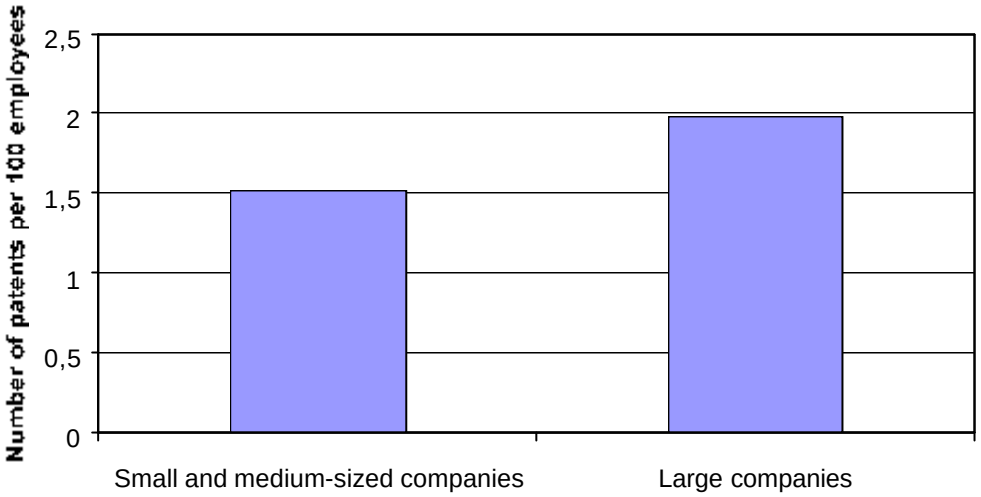
In the last 20 years, the number of patents granted has increased sharply. This is the case both globally and in Europe. Among other things, this relates to the fact that firms are using patents as strategic means of competition, cf. the Danish Patent and Trademark Office (2000). European firms, however, take out fewer patents per employed than Japanese and American firms.

Analyses from the European Patent Organisation[7] (EPO) show that the low patent activity among European firms is due to the large financial and administrative costs of taking out patents, as well as doubts as to whether the firm can overcome the financial burden which follows from possible litigation involving patent infringement. Corresponding studies[8] suggest that this is a problem for SMEs.

In addition to that, a study[9] of Danish data for the period of 1990 to 1995 shows that large firms patent 30 percent more inventions per employee than small and medium-sized firms, cf. fig. 1.1.

[7] EPO (1994)-(1999) and EPO (1994a & b)
[8] Kingston (2000), The Danish Institute for Studies in Research and Research Policy (2000), EPO (1994)-(1999) and EPO (1994a & b)
[9] The Danish Institute for Studies in Research and Research Policy (2000)

Figure 1.1 Patents and firm size, 1990-95



Note: SMEs: 1-500 employees. Large firms: Over 500 employees.
Source: The Danish Institute for Studies in Research and Research Policy and own calculations.

The large difference between the patenting rates of SMEs on the one hand and the large firms on the other hand could possibly be due to different strategies. Large firms use patents as a strategic competitive parameter to a greater extent than small firms, cf. the Danish Patent and Trademark Office (2000). However studies by Himmelberg and Petersen (1994), Hubbard (1996) and Hall (1992) all show that the capital constraints of SMEs also play a significant role. This counts both with respect to the financial and administrative costs that are connected with patent applications, as well as to the potential costs of litigation which are involved in having to enforce their intellectual property rights. This is confirmed by a number of American studies, which find that the risk of being infringed upon is significantly greater for small firms. This phenomenon is also well known among Danish firms, cf. box 1.1.

Box 1.1 A Danish case

Tommy Larsen A/S performs product development and marketing of artware and gift items in co-operation with Danish design firms. The firm was founded in the early 90ies, and is well established in the Danish market, exporting to approx. 50 countries, among which the US is clearly the largest market.

Tommy Larsen's worst experience with the patent system comes from the US, where he entered into an agreement with an American business partner in order to enter the market more easily. The partner was, however, aware that Tommy Larsen A/S was in no position to beat the large expenses which are connected with American patent litigation, and thus infringed upon Tommy Larsen's patent for a CD holder. Tommy Larsen went into the lawsuit with a budget of EUR 50,000. The case lasted for 4 years, and the expenses mounted up to EUR 500,000, of which the largest part went to lawyers in the US. After the first 3 years, Tommy Larsen won the case, however the opposing party appealed the case. An appeal in the US requires that the infringing party places a certain amount on deposit, which in this instance amounted to close to EUR 400,000. The infringing party also lost the appeal, but in the meantime he had shut down the firm and was not able to pay compensation. "So if I had heard of legal expense insurance, it definitely would have been of great assistance" says Tommy Larsen. At the same time, the litigation led to a significant drop in Tommy Larsen's turnover in the US. Other American firms did not dare to buy from a firm in the middle of a lawsuit. Today, Tommy Larsen has to begin all over again in the US with marketing, contacts with salespeople, etc.

Wiser from the experience, Tommy Larsen has chosen not to pursue competitors, who copy his inventions. In order to keep the plagiaristic firms out of the market; he has introduced a slightly cheaper copycat product. For example, Tommy Larsen has already started production of his latest invention in a number of different quality categories. "But patent insurance definitely sounds like a good supplement," concludes Tommy Larsen.

Source: Interview with Tommy Larsen A/S.

Other studies investigate the connection between the market value of a firm and the decision to conduct a patent law case. Bhagat, Brickly and Coles (1994) and Lerner (1995a) find that knowledge-based firms that become involved in a patent law case experience a significant fall in their market value. The studies show that when knowledge of a patent law case becomes public, it leads to an immediate fall in the market value of the firm, and that the fall is most significant for smaller firms. Patent law cases are hence perceived to be very expense-laden for firms, and small firms are impacted relatively harder than large firms. Because investors do not believe that SMEs can successfully handle the costs of the litigation.

1.3 Legal expense insurance and the liquidity problems of SMEs

The expenses of conducting a patent law case, implicitly influences the decisions of firms to invest in R&D, and thus the innovation intensity of the surrounding society.

Academic studies[10] find empirical evidence that small firms with limited financial strength avoid taking out patents in areas of research in which there are many pre-existing patents. Moreover, the studies show that small and new firms avoid taking out patents in classes of patents, which are dominated by large firms. By doing so, the small firms avoid conflicts with large firms with significant financial resources at their disposal. Liquidity constraints among SMEs hence contribute to hindering the access of smaller firms to new research results, which in turn can lead to less innovation in the surrounding society. Correspondingly, questionnaire-based analyses from IfO[11] and the EU Commission[12] show that a legal expense insurance programme or other similar programmes could contribute to increasing the SMEs faith in the patent system. This is supplemented by the example in box 1.2, which illustrates how American insurance programmes have contributed to equalising the financial difference between large firms and SMEs.

Box 1.2 Two American cases

The entrepreneur Herbert King from King Safety Products in St. Louis, MO, had a good idea, namely to isolate connectors used in electrical wiring with silicone, thus waterproofing them. He recently observed a significant decline in the sales of the waterproof connectors. This was due to a competitive firm having copied his concept. ”It is extremely irritating when a competitor copies one’s product, which one has pumped tons of elbow grease and research funds into … We thus chose to pursue a lawsuit … However if it had not been for our legal expense insurance, we literally would have been run over by legal expenses …” states Herbert King to The Wall Street Journal.

Software designer Rod Walz from Walz Postal Solutions in California has had a corresponding experience: ”I have benefited greatly from my legal expense insurance a number of times,” says Rod Walz to the L.A. Times. He has seen his patents infringed upon eight times. However, in none of the cases has he needed to drag the infringing party into court, primarily because ”… I could prove that I had deep pockets due to my

Sources: Wall Street Journal, Monday, 25 November 1996 and L.A. Times, Wednesday, 7 July 1999.

Other studies[13] show that there is a large probability of patent litigation in those industries that are marked by many new technological advances. According to Lerner (1995b) and Koen (1991), approx. 1 out of 100 patents will lead to a lawsuit. However, in areas of research involving new technologies, the number of patent-related lawsuits is markedly higher. For instance, within the biotechnology industry the number of patent lawsuits is up to 6 per 100 patents. The increased uncertainty in new areas of research thus means a markedly higher risk of patent lawsuits.

An insurance programme would be particularly relevant for firms operating in industries in which technological developments occur very rapidly. Small firms

[10] Lerner (1995b) and Cohen, Nelson and Walsh (1996)
[11] Institut for Opinionsanalyse A/S
[12] Enforcing small firms' patent rights, forthcoming report from the EU Commission, DG Enterprise.
[13] Koen (1991) and Lerner (1995a)

with capital constraints could be in a better position to conduct lawsuits against possible infringing parties, which could give these small firms a higher level of credibility and thus improve their access to acquiring capital, cf. the Danish Patent and Trademark Office (2000). A legal expense insurance programme would presumably minimise the total number of patent lawsuits in the long run since solely the threat posed by a firm having the backing to pursue a lawsuit will lead to fewer infringements[14]. Viewed on the overall, this can contribute to equalising some of the inequalities between small and large firms. So SMEs would achieve the financial strength which places them in a position to challenge large firms on a more equal basis.

1.4 The course of the insurance for a patent holder

As we saw in section 1.2, SMEs take out very few patents in relation to larger firms. Among other things, this is due to a patent lawsuit being an extreme burden to a firm's liquidity, and that these types of lawsuits demand a great deal of resources: they run for a long time; in front of many different courts; and require paid statements from expensive experts. Moreover, the patent lawsuits also impose great administrative demands on the firms. Even in those cases where the patent holder wins the patent lawsuit, the case costs awarded seldom match the actual costs of the case and the commercial losses of the patent holder, cf. analysis of the Danish Patent and Trademark Office of the enforcement of patent rights. The course of a patent lawsuit varies from country to country, however on the overall the mechanisms of patent insurance are the same. Box 1.3 describes a contemplated course of events as it could appear. First, a patent holder decides to subscribe the legal expense insurance. One day he believes that there has been an infringement. Hence, he contacts the insurance company, which considers the case and evaluates if it is covered by the insurance contract – regardless of whether the case is won or lost.

[14] This general problem is, however, more pronounced in the US, where legal costs are significantly higher than in Europe.

Box 1.3 The course of a case for an insurance customer

1) The firm takes out a patent on an invention and chooses to insure its patent.

2) The patent holder observes that a competing firm is infringing upon his patent rights.

3) The insured party contacts the patent insurance company, who contacts the infringing party and tells them that one of the insurance company's clients believes that his patent rights are being infringed upon.

4) The infringing party responds to the insurance company's contact.

5) The response of the infringing party is passed along to the patent holder and his advisors, who then decide upon the further course of the case.

6) If the parties do not enter into an amicable settlement, the insurance company sends the patent holder an overview over the impending course of the case, which will include an assessment of the probability of the firm winning the case (the reasons for doing this include preventing lawsuits against the insurance company)

7) The insurance company then evaluates whether the conditions of the insurance have been met and then submits the case for authorisation to its guarantors, who are responsible for paying out the legal expenses.

8) When requested, the insurance company then repays the costs of the case for expert statements, lawyers, etc. The insurance company pays the costs of the case on an on-going basis until the case is finished – either by a settlement or a judgment. When the case has ended, expenses incurred and possible case costs awarded are reconciled. Case costs awarded accrue to the insurance company for coverage or partial coverage of the expenses of the lawsuit.

Source: Intellectual Property Insurance Services Corporation

As an alternative to the more traditional insurance programme, a number of venture capital firms have entered the market for advising and financing primarily newly started SMEs, cf. section 1.5. Venture capital financing can equalise a portion of the financial inequalities between small start-ups and larger, established firms. The venture capital financing itself can be divided up into three phases: 1) The firm's establishment as the consequence of a good idea. 2) The venture capitalist screens and evaluates the firm and its products – is it an investment with potential? 3) A contingency plan of how the venture capitalist will add capital and knowledge to the firm in the best manner. Should it be 'long-term' equity capital or should it be a combination of equity capital and loans? Should the investor become actively involved in its daily operations, or should he just place his competencies at the disposal of the firm in individual matters as a type of 'free', external consultant? The points mentioned are primarily focused upon the daily operations of the firm. But how would the arrangement function if the firm's invention were to be infringed upon? There are two overall possibilities here – primarily determined on the basis of the investor's competencies. If the investor has no expertise in infringements of

intellectual property rights, then the investment functions as a 'normal' capital injection, which contributes to equalising the generally asymmetric financial differences. If the investor has expertise in intellectual property rights, it would on the other hand be natural for him to give advice and guidance during the entire process.

In many ways, the arguments for an insurance programme bring to mind the arguments for promoting venture capital. Both arrangements seek to solve the liquidity problems of smaller firms. Venture capital investments increase the access of newly started firms to capital, which in addition to a number of other advantages can make the procedure of taking out a patent and any possible subsequent lawsuit more 'financially feasible'. Whereas, the insurance programme aims to help small innovative firms in situations where their patents have been contested.

1.5 Survey of international experiences

Experiences with legal assistance for patent litigation are relatively limited. In the US, a number of insurance companies offer legal expense insurance to patent holders. All the companies require that the patent be taken out in the US. In Europe, it has only been possible to find information on an open, well-established market in the UK, where both domestic and foreign firms can insure themselves. At a national level, there have been a number of public and private initiatives for domestic insurance programmes, for example in France and Sweden.

Only the British and American insurance schemes have turned out to be profitable. In other words, they are the only arrangements, which have managed to perform a correct risk assessment of the legal expenses, which their clients have incurred. This is probably due to differences in the legal systems of the countries or different designs of the insurance. There is, however, much that indicates that other insurance programmes to a large extent have had difficulties in setting a price on the insurance premium, which reflects the true risk of patent lawsuits.

USA

The American schemes operate under three different models. All three models increase the level of information surrounding every single patent. Hence, improving the risk assessment in connection with the computation of premiums: i) a traditional insurance arrangement, with a specialised 'front office' that possesses the expertise to assess each individual patent case. ii) an electronic patent exchange, where experts evaluate every single patent before they are offered on the electronic patent exchange along with a prospectus for insurance companies interested in making a bid. iii) a venture capital set-up, where the firms with patents are supported and advised by a consulting firm in return for part ownership of the firm.

Traditional insurance arrangement

One of the most established players in the American market is Intellectual Property Insurance Service Corporation[15] (IPISC). In addition to legal expense insurance for patent claims cases, the corporation also operates in the areas of trademark and copyright insurance. Equivalent insurance can be subscribed to from Litigation Risk Management (LRM). Both companies operate as filtering front offices for insurance companies – IPISC for Hartford, XL Insurance Company and Evaston Insurance Company, which mutually reinsure each other, whereas LRM works solely for Lloyds[16]. Both IPISC and LRM function as screening offices, where each individual firm's risk of an intellectual property rights lawsuit is calculated and an assessment made of how large the insurance premium ought to be before the application is passed along to the insurance companies they work together with.

The patent holder and his lawyer decide the amount of the insurance based upon their own assessments. It is possible with both companies to choose between 5 different arrangements, each with its own ceiling for the amount of the insurance: EUR 100,000, EUR 250,000, EUR 500,000, EUR 750,000 and EUR 1,000,000. If the costs of the case exceed the amount of the insurance, the firm must pay the remaining part. The insurance company computes the premium on the basis of both the amount of the insurance and the probability of a lawsuit.

When the insured party believes he has been infringed upon, an independent lawyer must assess whether the case is covered by the insurance and estimate the expenses of the case, including also the probability of winning it. The insured party then selects the lawyer who will conduct the case. The choice is made from a number of lawyers who have bid on the case, where the insurance company has approved all the lawyers.

When the patent holder loses the case, the costs of the case are paid in full or up to the ceiling set out in the policy. If the patent holder wins the case, then the portion of the actual case costs which exceeds the compensation awarded, is paid by the firm. If the case ends with an out-of-court settlement or the patent is declared invalid, then there is no compensation unless a special agreement has been entered into with the insurance company.

Patent exchange

A variant of the traditional insurance scheme is the establishment of a so-called patent exchange. At The Patent and License Exchange[17] an authorised market place has recently been created in conjunction with Priceline[18] for the insuring of patents, trademarks and know-how. Information is communicated here on the patent portfolios of the individual firms, and lawsuit costs and risks are

[15] See also http://www.infringeins.com
[16] See http://www.lrm.com or equivalent arrangements at: http://www.anco.com, http://www.pgfm.com and http://www.iprm.com
[17] See http://www.pl-x.com
[18] See http://www.priceline.com

calculated for each individual industry and technology group, which increases the transparency of the market and makes it more liquid.

Before a firm's patent portfolio is listed on the patent exchange, the portfolio is evaluated. Similarly, a credit check is run on all prospective insurance providers. This is to ensure that only reliable and creditworthy firms can make bids and offers on the patent exchange.

All transactions take place on-line and are registered digitally. Both the buyers and the sellers on the patent exchange must be reinsured, and this preferably occurs through Swiss Re. The patent holder registers his patent in an electronic catalogue in which his patent portfolio is described, for example the potential and physical applications, or competitive advantages which make a product better or less expensive.

A facility is available on the homepage of the patent exchange for assisting the individual patent owner in rating the value of his portfolio of patents. An index figure is tabulated for the risk and price categories of the patents, and this is weighted together with accounting information from the patent holder, market data for the technology group concerned (for example the intensity of competition) and information from patents which have already been rated.

The venture capital set-up

As an alternative to the current insurance arrangement, there is also an arrangement based upon venture capital in which the patent holder and the venture capital firm enter into a long-term partnership. The firms pay the venture firm for legal and technical consulting support on patents in exchange for a percentage of future royalties or shares in the firm. By doing so, the patent holder is prepared or insured against any possible future patent lawsuits.

Among those venture capital firms, which give advice concerning intangible assets and patents, Refac[19] is one of the leading players in the American market. Refac is focused on patent and trademark cases, and places a large emphasis on consulting in connection with the formulation of long-term strategy programmes that can promote the trademarks of its clients and protect their intangible assets. Via its consulting support, Refac seeks to ease the transformation process from unutilised technologies and immaterial assets to commercial and profit-bearing licensing agreements and products for the firms.

EU

The Danish Patent and Trademark Office has long been an advocate of legal expense insurance, and has also brought the discussion up in the EU Commission. The Commission's latest expert report on intellectual property rights[20] addresses the possibilities of legal expense insurance and recommends

[19] See http://www.refac.com/

[20] Strategic Dimensions of Intellectual Property Rights in the context of Science and Technology Policy (2000), compiled by the independent ETAN expert group, appointed by the EU Commission's DG XII, Science, Research and Development Directorate.

that further work on this is continued. The Danish Patent and Trademark Office hosts the EU Commission's working group which is charged with the task of producing a proposal on how an insurance programme can be put together. In the following, we will look in more detail at some of the European experiences in the area.

The British experiences

A number of firms offering insurance exist in the British market[21]. Since the reinsurance is conducted through Lloyds, the arrangements are very similar. In the following, we have chosen to treat all the arrangements together (equivalent arrangements are offered in both Australia[22] and New Zealand[23]). In most instances, the scheme covers legal assistance for the protection of trademarks, licenses, pictures, figures and copyrights as well as patents. Lloyds sets an upper bound to the amount of the insurance at EUR 775,000, however in special cases the ceiling can be raised to EUR 1,500,000. The insurance premium varies from case to case depending upon the assessment by the insurance company of the probability that the patent holder's patent rights will be infringed upon – the annual premium typically lies at around 20% of the amount of the insurance, however with a minimum of EUR 5000.

The French experiences

An insurance programme was established in France in 1986, which until recently had existed based upon an interplay between the private and public sectors. *Brevetassur*, as the scheme was called, operated exclusively under French auspices and never managed to encompass a sufficiently large number of firms – only around 100 firms, all of which lay in the absolute highest risk group, subscribed to policies. The arrangement thus never managed to take off before it crashed. Instead, Canadian insurance providers have now moved into the French market, for example Brees[24] and Binks[25], which work together with Creechurch International. Both agents offer insurance primarily to SMEs with a turnover of under EUR 100 million. Just like the American arrangements, the insurance covers both the instance where others infringe upon a holder's patent and the instance where the insured party is alleged to have infringed upon a patent. The insurance covers the case in both the court of first instance as well as appeals. A certain limit is set on the coverage (EUR 1 million and up), all depending upon the insurance premium. For a higher premium, the possibility exists to expand the coverage to the US and/or other countries.

The Swedish experiences

The Swedish Inventors' Association (known by its Swedish acronym, SUF) created an insurance scheme in 1986. Originally, the insurance provider was

[21] Abbey Legal Protection, Crawley Warren, FirstCity, Homestead, Litigation Protection Limited, Willis Corroon and Octavian.
[22] http://www.enpat.com
[23] http://bkrinsurance.co.nz
[24] http://www.breese.fr
[25] http://www.binks.ca

Försäkringsaktiebolaget Skandia. This co-operation ceased after a few years due to poor profitability, after which the insurance was then placed with a British insurance company and subsequently with l'Union des Assurances de Paris (UAP) in 1988. The arrangement was only available to members of the Inventors' Association. In the beginning the insurance only covered infringements in Sweden, however it was later expanded to also include the EU and the US.

The scheme operated with a so-called patent board. The governing concept behind the board was that it should be independent. The board determined whether the case it was reviewing was covered by the insurance or not. The board was composed of one representative from SUF (an inventor), one representative from UAP (a lawyer), a technical adviser and a patent expert (a law professor with many years of experience in patent cases before Stockholm City Court). The board assessed for each reported infringement whether the case was covered by the insurance, cf. NUTEK (1997:4).

During the period from 1988 to 1996, there were 228 subscribers to the insurance, of which 56 believed that their patent rights had been infringed upon and moved to bring a lawsuit. The insurance board of the insurance scheme evaluated these, where it was deemed that 22 cases were entitled to support for their cases. The primary reasons for the rejection of support for a case were: incomplete information on the inventions which the cases involved, penetration outside the patent area and that the patent holder had believed there was infringement by a competitor who was using a different technical solution. All three explanations require subtle judgements and a vast amount of expertise in the area.

Due to lacking profitability, UAP shut down the availability of the insurance in 1996. UAP attributes the lack of profitability to the insurance arrangement primarily having attracted the most risk-laden patents and that the risks of the patents were not assessed correctly[26]. In order to be able to offer sustainable legal expense insurance without excessively high insurance premiums, UAP is of the opinion that the base of subscribers to the insurance must be more representative. Nor does UAP feel that they have sufficient knowledge in the area of patent cases to perform a precise risk assessment, which could set the correct insurance premium.

In co-operation with Lloyds of London, the Swedish insurance agent AssuransSelector AB has begun to offer legal expense insurance in Sweden. The arrangement corresponds to the British arrangements, and Lloyds also reinsure them. Danish insurance brokers are offering an equivalent arrangement from dahlberg assurance brokers ltd. Similar measures are being seen to an increasing extent across most of Europe. In Germany, among others, ARB[27], Gerling Global Re[28] and Allianz[29] are on their way into the market.

[26] See NUTEK (1997:4)
[27] Allgemeine Bedingungen für die Rechtsschutzversicherung

1.6 A composite overview of foreign legal expense insurance

A short summary of both the American and European insurance arrangements[30], cf. table 1.1, shows that an upper ceiling exists in all cases for the amount of the insurance. Meaning that there is no clear policy in the European schemes with respect to deductibles, whereas the American scheme operates with a deductible of 20% of the amount of the insurance.

In general, the insurance companies differentiate the premiums based upon technology groups; countries; and the size of the firm. For example, the intensity of the competition within the technology group, the significance of the firm to the market and an assessment of how the legal systems of the individual countries treat patent litigation and the level of costs of the cases from country to country. Since the costs of a lawsuit are generally relatively large in the US, the insurance premium is correspondingly higher if the insured party wishes to be insured in the US. While the American insurance companies only operate in the US, the British insurance can be subscribed to such that it covers the EU, Canada and the US.

[28] http://www.gerling.de
[29] http://www.allianz.de
[30] It can be difficult to compare the American and European experiences directly. This is due to differences between European and American patent-issuing practices, patent legislation and legal traditions. For example, there are different requirements for the inventive step, just as the American level of legal expenses and compensation amounts are higher than in Europe.

Table 1.1 Overview of the different insurance arrangements

	USA	Sweden	UK	France and Canada
Providers	IPISC, LMR, IPRM, ANCO, PGFM	SUF (terminated)	Abbey Legal Protection, Crawley Warren, FirstCity, Homestead, Litigation Protection Limited, Willis Corroon and Octavian, Enpat, BKRinsurance	Breese and Binks
Amount of insurance	EUR 100,000 - EUR 3,000,000	EUR 235,000	EUR 160,000 - EUR 1,600,000[c)]	EUR 150,000 - EUR 1,500,000
Deductible	20%	None	None	20%
Annual insurance premium	EUR 1000 – EUR 10,000	EUR 150	EUR 7,500 - EUR 75,000 [a)]	EUR 1,000 - EUR 10,000 [a)]
Who can subscribe the patent?	Patent holders in the US	Swedish firms that are members of the Inventors' Association (the arrangement has now been shut down)	Patent holder in the EU	Patent holder in France/ Canada
Where does the insurance apply?	US	World-wide	World-wide	Entire world
Whose legal expenses does the insurance reimburse?	Both plaintiff and respondent.	Plaintiff only.	Plaintiff only.	Both plaintiff and respondent.

[a)] The premium is assessed individually according to the technology, industry and country: UK, EU or worldwide excluding or including the US.
Note: All amounts are converted from the country's currency at the point in time they were quoted at the current exchange rates (to the average year-2000-EUR-exchangerate).

1.7 Building blocks for legal expense insurance for patents

Prior experiences indicate that there is an interest in establishing patent insurance both by insurance companies and by patenting firms. A small private market already exists for legal expense insurance for patent holders in a number of countries. It has, however, turned out to be difficult to maintain such arrangements because there is a need for insurance coverage in a number of countries, and the insurance providers have difficulty assessing the risk of patent lawsuits. If the establishment of a public support programme is desired that could promote the creation of legal expense insurance for patent holders and thereby increase the level of innovation among SMEs. There are, however, a number of questions of both political and commercial nature, which must be clarified:

- Which model should the construction of the arrangement be based upon?
- What role should the state play?
- How should the insurance premium be calculated?
- Should the legal expenses be covered completely, or should there be a deductible?
- Should the arrangement be voluntary or obligatory?
- Should the arrangement function at national, EU or global level?

Different insurance models

International experiences indicate that the traditional insurance companies do not possess the requisite competencies to assess the litigation risk of every single patent, which also introduces errors into the calculation of the insurance premium, cf. section 1.5. Examples from the US and the UK set out three possible routes to solving this information problem concerning the calculation of the premium:

i) A traditional insurance arrangement, with a specialised 'front office', having the expertise to evaluate every individual patent.

ii) An electronic patent exchange, where experts assess every single patent before they are offered to interested insurance providers along with a neutral prospectus surveying the potential risks of the patent.

iii) A venture capital set-up, where the patenting firms are supported and advised by a consulting firm in exchange for partial ownership of the patent-holding firm.

The concept with the first two arrangements, i) and ii), is almost identical in that they are both constructed around a competence unit or a screening office which has the ability to issue competent assessments of the risk of litigation for the patent portfolio of each individual firm. Both arrangements thus increase the transparency of the market and reduce the problems of the insurance companies in correctly determining the risks of the patents. The patent information is used by the insurance company, which takes care of the actuarial calculations of insurance premiums, etc. The difference between the arrangements is that the specialised front office, under point i), works exclusively for one insurance company, whereas the patent exchange offers the patent information on the Internet so that all interested insurance companies can bid on insuring the offered portfolios of patents.

Another problem, which the screening office can alleviate, is the risk of misuse of the insurance for unjustified attacks on competitors. With inspiration taken from the Swedish arrangement, the screening office could evaluate whether each individual patent dispute falls under the insurance arrangement, thus helping to prevent such misuse.

An alternative to the screening office is the venture capital set-up, arrangement iii), in which a venture capitalist with experience in intellectual property rights provides consulting support in exchange for a share in the future profits of the firm.

What the three arrangements have in common is that they all assemble a number of competencies, which assess the patent portfolios of the firms and their potential risks for infringement. At present, these competencies are located in many different places. The national patent and trademark offices evaluate new patent applications daily and look closely at their inventive steps; the

insurance companies know how the optimum premium is calculated; the patent lawyers are familiar with the course of a case concerning possible patent lawsuits; and the patent consultants have a number of general competencies with respect to the monitoring of the market, the application procedure, limitations with respect to future industrial applications, etc. In the American screening offices, these competencies are assembled, cf. section 1.5. In connection with a European arrangement, the institutional set-up of the office should be considered – should it be private or public, cf. the question concerning what role the state should play.

The role of the state in a future legal expense insurance programme

It can be necessary to have state involvement for a shorter or longer period of time in order to get an insurance arrangement up and running. A public programme that complements the private arrangements is *one* possibility for ensuring that a number of firms take out patents because they have the opportunity to insure themselves. Such an arrangement can be designed using inspiration taken from the export credit programmes, which most countries offer, to their exporting firms.[31]

It is of course important that any possible patent insurance programme does not compete with private providers, but instead supplements the private insurance arrangements. In other words, the public intervention should primarily be applied where the risk is too large for the private providers.

Industry-specific conditions as well as extraordinary risks related to the technology, the industry, competitive circumstances and the particular country can lead to the commercial insurance companies not offering insurance within specific areas. A public programme can - just like the export credits – be designed so that the public sector offers insurance or reinsurance directly to private insurance providers where it is not possible to construct a private insurance market. Such an arrangement shifts a part of the risk from the patent holder and the insurance provider to the public sector. Hence, making it possible for the parties involved to negotiate their way to an insurance contract where the state complements the commercial insurance providers as the state is more ”patient” with respect to balancing losses and gains over a longer period of years. Experiences from the Danish State Export Credit Agency show that it is nearly impossible in some areas to build up a self-sustaining commercial market, and there can be a need here for purely public sector insurance.

In the long run, however, it is important that the boundary between insurance offered by the private sector and public sector shifts. The public sector can pull out when the necessary competencies have been built up in the private insurance sector and the market for legal expense insurance has attained sufficient volume, for example within specific technologies or countries/legal systems. The public sector should only cover areas for which no market exists for private insurance providers. This will ensure that more inventions which can

[31] Cf. Danish Business Policy, 1998, chapter 6.

make a positive contribution to the overall level of innovation and welfare, and which are not commercialised today, will be able to be brought to life in the future.

Calculation of the insurance premium
Just like with the export credit insurance, the calculation of the insurance premium can be performed by the commercial companies, which the state enters into agreements with. In order to avoid state subsidy, an international consensus must however be entered into concerning the setting of the premiums.

In the commercial market, technology groups; countries; and the size of the firm (i.e. the competitive intensity) differentiate the premium. As well as the significance of the firm to the market and an assessment of how the legal systems of the individual countries treat patent litigation and the level of expenses from country to country. In addition to these considerations, a more general assessment follows of the certainty of the validity of the patent – and it is particularly difficult to evaluate the inventive step here within areas of new technology.

State reinsurance will shift a part of the risk from the commercial insurance providers over to the public sector, and make it less uncertain for the insurance providers to insure risk-filled patents. Lloyds, IPISC, Refac and the patent exchange all work with very standardised models for assessing the risk of each individual patent case. In those cases where the public sector provides reinsurance or offers its own insurance via the commercial insurance companies, the commercial companies still bear a part of the risk, which ensures the credibility of the premium calculations of the insurance providers.

Deductible
The American arrangements work with a deductible of 20%. The extent to which there should be a deductible or not, and if so how much it should be, is a purely actuarial computation. A certain deductible should however be considered since it can contribute to revealing the insurance subscriber’s own assessment of the risk, plus at the same time it can reduce the risk of the insurance being misused by the patent holders, for example by bothering their competitors with unfounded patent litigation.

A voluntary or obligatory arrangement?
There will always be a tendency for patent holders with a particularly high risk of patent disputes to insure themselves before patent holders who do not believe that their inventions will become involved in upcoming patent litigation do so. An obligatory arrangement would thus expand the number of insurance subscribers (primarily in the low-risk group), which – in all probability – would minimise the legal expenses of the insurance companies per insurance subscriber and hence improve the possibility of generally lower insurance premiums.

An obligatory arrangement may, however, cause problems. Firstly, it is far from all patented inventions that are commercialised, and an obligatory arrangement would thus minimise the number of patents. Secondly, there are a number of patent holders who would not subscribe to the insurance under normal conditions because they estimate the risk of patent litigation to be small. In such cases an obligatory assessment would be regarded as redistribution from patents with a low risk of lawsuits to high-risk patents.

Should the arrangement be national, European or international?

A public programme would be strengthened if it were to be established under EU or international auspices. By doing so, one ensures that the individual countries do not use the insurance arrangement as a national subsidy arrangement. Moreover, insuring the patents of Danish firms abroad poses enormous demands for knowledge of the legal system of each individual country. By assembling the knowledge of all the EU countries concerning their respective legal systems, one would be able to attain considerable efficiency gains with respect to the calculation of the premiums. This is particularly important in connection with the increasing internationalisation, where the patent portfolios of the firms to an increasing extent are being placed abroad. Just as for the export credit arrangements, one could moreover set out supranational guidelines for premium calculations, the payment of insurance sums, etc.

Chapter 2 The value of patent protection

2.1 Introduction

Chapter 1 showed that SMEs are not taking out enough patents. Expensive patent litigation could be a significant underlying cause for the low level of patent activity among SMEs.

Patent legal expense insurance can contribute to alleviating this problem.

This chapter computes the effects to the private economic value of patent protection in Denmark caused by patent legal expense insurance. Estimates are then given of the effect on the value of European patents held by Danes.

The private economic value corresponds to the value of receiving a monopoly for the Danish market for a specific invention. The calculations build upon patent renewal data and legal expenses for the 1967-95 patent application years during the period from 1984 to 99.

The conclusion of this chapter is that an example of publicly subsidised EU legal expense insurance, which for example reduces the case costs of a patent lawsuit to a deductible of EUR 7,000 (DKK 50,000), would increase the value of the patent portfolio held by Danes in Europe by 10 percent. This corresponds to an increase in the implicit subsidy rate of the patent system to the R&D costs of Danish firms of 10 percent – corresponding to a rise from 12 to 14 percent.

The ultimate economic consequences of this example of legal expense insurance will be computed in chapter 3.

The central concept behind the calculations in this chapter is that the value of a patent is reflected by when the patent is dropped. If a patent holder decides to renew an approved patent for yet another year[32], then the patent has a private economic value to the patent holder[33] which exceeds the renewal fee *and* the expenses of a possible lawsuit. Conversely, if the patent holder decides to drop the patent, then its value is too small to justify a renewal fee and the lawsuit expenses. We can thus use the comprehensive database of the Danish Patent and Trademark Office in order to identify the value of patents which are dropped.

[32] The Danish Patent and Trademark Office collects a renewal fee for each of the 20 years of a patent, and it increases with age.

[33] Value must be understood here in a very broad sense. It involves both the commercial returns which the patent holder receives in the here and now as well as his expectations for future returns. Moreover, a patent can have a strategic value which is not necessarily closely associated with the tangible returns from the invention. A patent can thus have a value because it e.g. "blocks out" competitors.

Lawsuit expenses are included in the calculations because the value of a patent depends upon it *not* being infringed upon. The patent authorities grant a patent, however it is up to the patent holders themselves to enforce their patents. And a patent will be infringed upon if the infringing parties do not take seriously the threat of the patent holder dragging them into court. And the infringing parties will not take that threat seriously if the patent has a commercial value to the patent holder that does *not exceed* the total of the renewal fee and the possible costs of a lawsuit.

Very few patent lawsuits occur copared to the number of patents. For example, there are only a couple of patent lawsuits in Denmark per year, cf. The Danish Patent and Trademark Office (1999). The calculations in this chapter likewise assume that very few lawsuits occur. They will only occur in those instances where, firstly, the commercial returns to the infringing party of the infringing behaviour exceed the costs of a possible lawsuit and, secondly, where an out-of-court settlement is not entered into.

This chapter describes and performs calculation for the following situation: lower legal expenses, for example via publicly subsidised legal expense insurance means that more patents are taken out, and that on the average patents are renewed for a longer period of time. A larger total stock of patents increases the value of the patent system. And the patent system is an implicit subsidy to the R&D of firms, cf. Lanjouw (1998).

2.2 The theoretical patent valuation model

The calculations in this chapter build upon a patent valuation model described in Lanjouw (1998). The model is used to place a value on the stock of patents in Denmark and compute the consequences of changing the costs of lawsuits.

The definition of a patent's commercial value is not limited in any manner in the following. The private economic value of a patent can reflect all those considerations which patent holders make in connection with applying and renewing their patents. A patent can have a value to the patent holder for many reasons. Beyond the value of having a monopoly on the sale of the patented invention, there could also for example be a more indirect value associated with the patent. The patent could for example prevent competitors from moving into specific markets. This chapter does not concern itself with *why* a specific patent has a commercial value to a patent holder.

The central concept of the model is solely that *when* a patent holder drops a patent, then its value has become so low that it can no longer justify the payment of the renewal fee and possible expenses of a lawsuit.

The expenses of a lawsuit enter into the valuation due to the following reasoning: The patent authorities grant patent rights but do not secure patent protection. Solely the patent holder can protect the patent rights – ultimately via

a lawsuit. The value of the patent – or in other words the value of the patent protection – thus comes to depend upon whether the threat of the patent holder to bring a lawsuit is credible. If the competitors do not believe that the patent holder will defend the patent in court, then there is nothing to stop them from infringing the patent. The patent thus has no value to the patent holder.[34]

The content of the patent is, as a part of the approval procedure, made fully available to the public. Moreover, the potential infringing parties of a patent holder's rights will typically be close competitors who have good knowledge of the patent holder's customers and market. The calculations in this chapter hence assume that the potential infringing parties are acquainted with the commercial value of a patent.[35]

The model utilises the information which is associated with each patent granted, and which thus is found in the database of the Danish Patent and Trademark Office: when it was applied for, and when it possibly was dropped. Information on the points in time when it was applied for, granted and, particularly, dropped can be used to reveal the value which the patent holder has attributed to the patent. The model is therefore using the knowledge we have of patent holders's historical behaviour. The calculations of effects of changes to the patent system thus build upon an assumption that the behaviour of new patent holders on the average can be described on the basis of historical experience.

Return in a specific age class

The return from a patent is defined in the model as the commercial value of the patent during a single year. The returns from patents with a specific age will typically be distributed such that there are many patents with low values and few with very high values. This picture is captured in the model by an exponential distribution, which has precisely that characteristic that there is a large probability for low values and a small probability for very high values.

The model does *not* attempt to explain the return from one specific 11-year old patent, for instance. The model describes an - as realistic as possible - *distribution* of returns from *all* 11-year old patents, i.e. the model describes one specific age class of patents.

Learning process

As time goes by, the patent holder becomes better and better at exploiting the commercial possibilities of the patent because he learns more and more about the technical potential of the invention and about the commercial market for the different applications of the invention. The patent holder thus goes through a

[34] The value of the patent is not identical with the value of the invention. Even though a patent may have no value because a patent holder is not in a position to enforce his *exclusive* rights, it does not mean that the invention has no commercial value.

[35] That patent disputes are marked by a very high level of information is reflected, firstly, by the very small number of patent lawsuits and, secondly, by the 50-50 probability that the patent holder will win the case, cf. The Danish Patent and Trademark Office (1999), information on patent lawsuits, and Priest & Klein (1994).

learning process, which means that the returns from a patent can rise over time.[36] However, the model also takes into account that this learning process is most important during the early years of a patent's lifetime. The estimate of the patent valuation model will tell us when this learning process is over – but more about this in section 2.4.

Some patents typically have a long introductory development, approval and/or marketing period, during which they give a very low return. The learning process of the model allows the possibility for patents to give such low returns for a certain period after the application. If the patent is renewed regardless of these low returns in the early years, then it is due, in reality as well as in the model, to the patent holder having sufficiently positive expectations for the returns in the future. The return during the very first year after the application is set equal to zero by definition.

Gradually, as the patent becomes older, the possibility for learning anything new about the uses of the tangible invention is exhausted. In the model, it is formulated such that the variance in the contribution of the learning process to the returns becomes smaller during the course of the lifetime of the patent. In other words, it is more probable that the patent holder in the model as well as in reality can find new applications for a 3-year old patent than for a 15-year old patent. The argument is, firstly, that the patent holder will always exploit the most lucrative opportunities of the patent first. Secondly, that head start which the patent originally gave the patent holder will be eroded over time, as new products and processes gradually come onto the market.

Depreciation

The learning process is designed such that patents which are not dropped will receive a higher and higher return for each year. There are, however, other things in the model which gradually pull the value of a patent downwards[37] as it becomes older:

- Trademark protection can become more important than patent protection over time as money is invested in marketing. The development of a market in the direction of monopolistic competition, where profiling occurs in the form of the construction of an image or a trademark can make a patent originally based on technology less valuable.
- Gradually, as time passes, more and more competitive inventions appear which conquer market shares from the patent.

These effects are captured in the model by, and simplified to, two types of depreciation schedules. The first one is a traditional linear depreciation rate where an asset is diminished by a fixed percentage each year. In addition,

[36] Negative surprises do not occur.

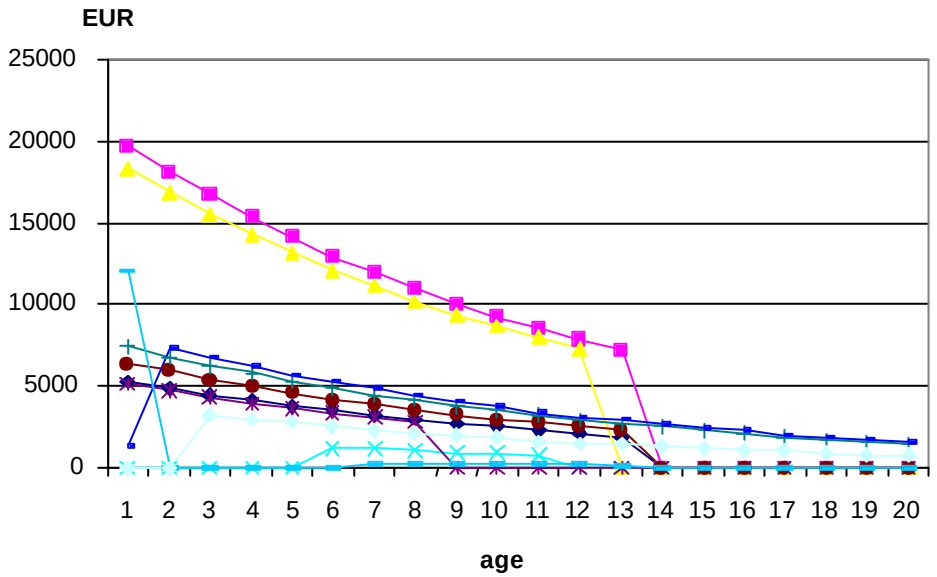
[37] Figures for the actual drop frequencies and thus the estimation of the model parameters will determine which effect is the strongest – i.e. whether the return on a patent in general will come to rise or fall over time.

patents have an acute risk of obsolescence (a depreciation rate of 100 percent), after which the patent has zero value and is dropped no matter what. Acute obsolescence can arise if a product or process suddenly enters the market which makes the old invention superfluous. It could for example be a new type of medicine providing fewer side effects and a greater effectiveness.

The model assumes that a patent at a minimum will give a return corresponding to the last year's return after depreciation. However, the patent holder can in addition perhaps also learn something absolutely new about how he can exploit his patent commercially – as mentioned above. In such cases the return will increase and exceed the depreciated level from the last period.

Fig. 2.1. shows some return sequences over the life spell of different patents generated by the estimated patent valuation model (more on this later). The patent holder can experience a positive economic shock in the return from the patent because he has learned something new about the potential applications of the invention. It can suddenly elevate the return from the patent up to a higher level. The following year, the return is still at a higher level, but depreciated by the traditional linear depreciation rate. Finally, acute obsolescence can also occur, after which the return drop to zero, regardless of the return during the prior period.

Figure 2.1 Selected return sequences for different patents over their maximum 20-year lifetime



Note: Examples of different returns profiles among the 1,000 simulated patents. The learning process means that randomly selected patents elevate themselves up above zero in the early years. In the long run, the effect of the depreciation rate dominates. Patents, which suddenly drop to zero from a relatively high level are examples of sudden obsolescence.
Source: Calculations with a point of departure in the estimated patent valuation model.

Renew or not?
The decision on whether to renew a patent or not for yet another year depends upon whether the present and future returns from the patent can counterbalance the renewal fee *and* the probability of losing a lawsuit and having to pay the expenses of the case**.**

The higher the returns now and in the future from the patent, the greater the probability that the patent will be renewed. The returns are again determined by different factors – as described above:

- The more *certain* the patent holder is of the patent's *returns* the more probable that the patent will be dropped. It is because it is less probable that the patent holder will learn anything new and positive concerning the returns from the patent at a point in time in the future.
- The *faster* the patent holder becomes more *certain* of the returns from a patent, the less the probability of a particularly large positive return in the future, and the greater the probability that the patent will be dropped.
- The longer the period of time a patent generates a *zero return* during its early years, the more probable that the patent will be dropped.
- The smaller the *depreciation rate* and the smaller the probability of *sudden obsolescence*, the greater the probability that the patent will be renewed.
- The higher the total *legal expenses* in connection with a (potential) lawsuit, and the smaller the probability that the patent holder will *win* the case, the smaller the probability that the patent will be renewed.
- The larger the *renewal fee*, the greater the probability that the patents will be dropped.

The total patent valuation model
We have now fully described the patent valuation model which illustrates the probability of a patent being dropped in the different age classes, and how much it is worth.

The model contains six unknown variables:

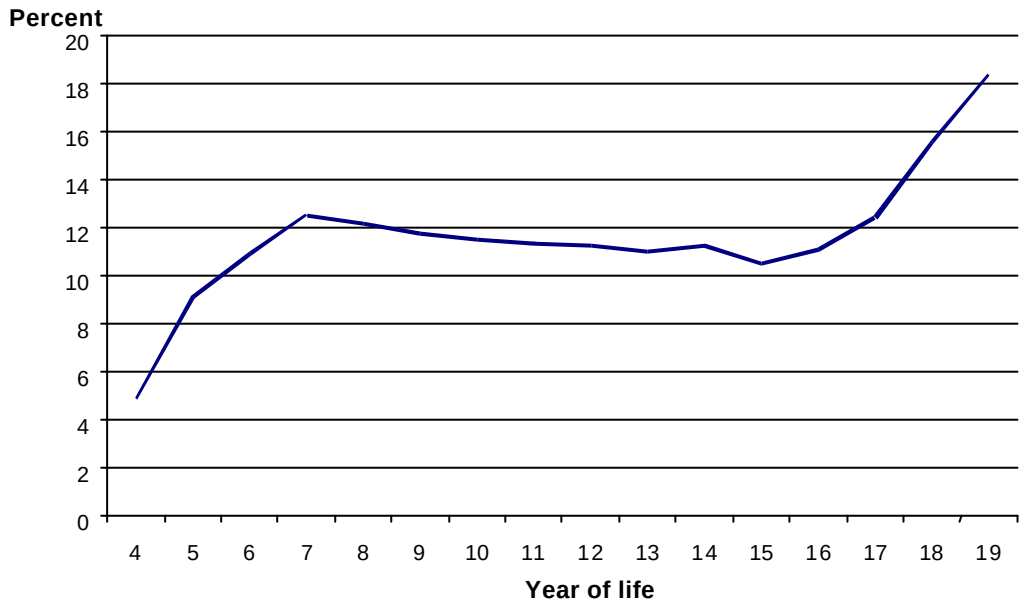
- The initial variance of the returns on a patent.
- The rate at which the patent holder becomes more certain of the returns from the patent.
- "Time-to-market": The probability that the returns will remain at zero for a certain number of years at the beginning of the patent's lifetime as a consequence of the phasing in of development, approval (for example by the public health authorities) or marketing.
- The traditional linear depreciation rate.
- The probability of acute obsolescence.
- The probability that the patent holder wins a lawsuit.

We need to know the magnitude of all these characteristics of patents in Denmark in order to be able to calculate the value of the total stock of patents and how it will react to a reduction in the magnitude of the legal expenses.

2.3 Data

In order to estimate the six unknown variables of the patent valuation model, we must use data for the drop frequencies of actual patents, cf. fig. 2.2. The frequencies are calculated on the basis of the "life story" of 46,000 patents issued in Denmark. Between the 4th and 7th year of life the portion of the patents which is dropped rises from 5 to 12 percent. That portion subsequently remains relatively constant at 12 percent until the 17th year of life, after which that portion again rises out to the final 19th year of life, where 18 percent of the granted patents which were renewed for their 17th year are not renewed for their last year.

Figure 2.2 Weighted drop frequencies for Danish patents.



Note: A drop frequency for, for example, the 13th year of life of 11 percent should be interpreted in the following manner: 11 percent of those patents which paid the 12th renewal fee did not pay the 13th renewal fee. Or in other words: 11 percent of those patents that were able to hold their 12th birthday did not make it to their 13th birthday. The information builds upon extracts from the patent database of the Danish Patent and Trademark Office and covers the "life stories" during 1984-1999 of patents with application year 1967-1995. I.e. we have 16 observations on the drop frequencies for the 13th year of life namely for the 16 application cohorts 1971-1986. The weighted drop frequencies of the figure are a weighted average of the drop frequencies calculated in the following manner over the entire data set: [Number of 12th birthdays minus number of 13th birthdays]/Number of 12th birthdays.
Source: Information from the Danish Patent and Trademark Office and own calculations.

The information covers patents taken out in Denmark whether directly through the Danish Patent and Trademark Office or indirectly via the co-operation with the European Patent Organisation, the EPO.[38] The data set for each patent consists of the points in time it was applied for, granted and possibly dropped. The information covers the "life stories" of the 1967-1995 application cohorts and events happening to them during the period from 1984 to 2000. In addition, we have used the renewal fees for the entire period converted to 1999 prices.

Finally, we have used information on the magnitude of the expenses in connection with patent lawsuits and the size of the case costs awarded. The minimum legal expenses for both parties for a single court were set to nearly EUR 15,000 (DKK 100,000). The amount corresponds to the sum of a party's own legal expenses and the opposing party's case costs, since the patent holder will be ordered to pay the case costs of the opposing party if he loses the case. The size of the amount builds in part upon the lowest case costs awarded, ascertained by a review conducted by the Danish Patent and Trademark Office (1999) of all patent lawsuits during 1970-98, and in part from information provided by lawyers in the field. In addition, the model's case costs depend upon the returns from a patent as a firm will typically use more money to defend a valuable patent.

All in all, this does, however, involve relatively low expenses in relation to a typical patent lawsuit. Plus there is the fact that the case costs awarded do not match the actual expenses of the lawsuit, cf. the Danish Patent and Trademark Office (1999). It is, however, not a problem for the model because it is solely attempting to explain the behaviour of the patent holder with a marginal patent, for which it is "touch and go" as to whether it will be dropped. If a patent does not have a particularly large commercial value, then the patent holder would only be calculating with using the minimum amount in a potential lawsuit.

2.4 Estimation and results

The identification or the estimation of the magnitude of the six unknown parameters from section 2.2 is done by choosing precisely that combination of values which causes the patent valuation model to compute drop frequencies that correspond as much as possible to the actual drop frequencies shown in fig. 2.2. In doing so we attain values for the six parameters, which (under the assumption that the reasoning of the model is correct) are - as much as possible - in agreement with data on the renewal of patents in Denmark, cf. table 2.1. The estimates give us a fully described patent valuation model which include a number of characteristics of patents taken out in Denmark.

[38] In 1990, Denmark became a member of the European co-operative effort on patents, the EPO. This brought about a large rise in the number of patents taken out on Denmark.

Table 2.1 The patent valuation model's estimated parameter values for Danish patent data from the application cohorts 1967-95 during the period of 1984-1999.

The six estimated parameters	
1. Probability of winning	0.92
2. Rate of certainty	0.58
3. Depreciation rate	0.08
4. Probability of acute obsolescence	0.05
5. Initial period with zero return	0.66
6. Variance of return[1]	5,500

1) The variance of returns is measured in EUR.

Note: The patent valuation model was estimated using Gauss. The variables 1.-3. were constrained to be between 0 and 1. Variables 5. and 6. were constrained to being positive, and variable 4. was constrained to being smaller than the empirical drop frequency. A grid search was subsequently performed in which the solution became that combination of values for the variables which minimised the sum of the squared error terms. I.e. the difference between the empirical and the model-generated drop frequencies were minimised.

Source: Own calculations with the patent model and data from the Danish Patent and Trademark Office.

The estimated probability of winning (line No. 1 in table 2.1) is high in relation to reality in the Danish courtrooms. A review of the latest many years of patent lawsuits, cf. the Danish Patent and Trademark Office (1999), shows a probability of winning of around 50 percent.[39] The difference can be explained by the relatively restrictive assumptions in the model, which requires that everyone knows everything about the returns from a patent, after which a patent holder's threat to intend to defend a patent in court is 100 percent credible. If we relax this assumption then infringements on patents would occur *even though* they are worth so much that the patent holder would be able to go to court. By far the most infringements, however, are resolved by out-of-court settlements. The estimated probability of winning of the model will thus be a weighted average of infringements which were settled out-of-court and infringements which were brought before the court.

The rate at which the patent holder becomes more and more certain that the returns from a patent (line No. 2 in table 2.1) are of the same magnitude as the estimates of Lanjouw (1998) for German patents. The rate corresponds roughly to what Lanjouw found for German textile, computer and machine patents, but is, however, slightly higher than for German pharmaceutical patents. In tangible

[39] The 50 percent is also known as the Priest-Klein Rule, cf. Priest and Klein (1984) : "If that portion of disputes that land in the court (the alternative is a settlement) goes to 0, then the plaintiff's probability of winning goes to 50 percent." The argument is: Uncertainty and lack of information creates lawsuits. Lawsuits only occur when *both* parties erroneously believe that they have the greatest probability of winning. Patent conflicts are marked by extremely professional and highly qualified consultants, who have for all intents and purposes full information. They thus rarely land in the courts, and only in those few instances where the cases are very, very difficult to call. The result is a fifty-fifty probability of winning in the courtroom.

terms, the magnitude of this parameter means that the patent holder does not learn anything more about his Danish patent after approx. six years[40].

The normal linear depreciation rate on 8 percent (line No. 3 in table 2.1) is slightly higher that the corresponding German depreciation rates of 6 percent for pharmaceutical and machine patents, 5 percent for computer patents and 4 percent for textile patents. The acute obsolescence probability of 5 percent (line No. 4 in table 2.1) is on the other hand slightly lower than the German obsolescence probabilities of 12 percent for machine patents, 8 percent for textile and pharmaceutical patents and 7 percent for computer patents.

The value of the "time-to-market" development delay (line No. 5 in table 2.1) reflects the fact that around half of the Danish patents give a zero return during the first years of their life. The greater the value, the greater the probability that the returns on a patent will remain at zero for a certain period. The delay is on a level with German pharmaceutical and textile patents and somewhat higher than German computer and machine patents. Typically, patents on products will have a much longer initial period with zero return than patents which are taken out on production processes. Pharmaceutical products in particular endure a long road to the market. The larger Danish delay in relation to that which applies for German patents could thus be due to both there being relatively more product patents and that there are relatively many pharmaceutical patents in the Danish stock of patents.

The greater the estimate of the variance of the returns in EUR (line No. 6 in table 2.1) the greater the probability that a specific patent will be very valuable in absolute figures of euros. The value is slightly less than half as large as the corresponding figures for German patents. It can still appear surprisingly high, since the value of having a monopoly in the German market must be somewhat more than twice as high as the value of having a monopoly in the Danish market. It pulls in the opposite direction, however, if a person from a third country seeks a patent in a number of European countries at the same time via the EPO system, because Denmark is typically not included[41] when it involves patents that are not particularly valuable. Germany will on the other hand nearly always be included. There are no significant differences in the magnitude of the fixed costs of taking out a patent in Denmark and Germany respectively. There will thus be a large group of patents with a relatively small value for which the large German market will justify an application but not the small Danish market.

2.5 Distribution of patent values

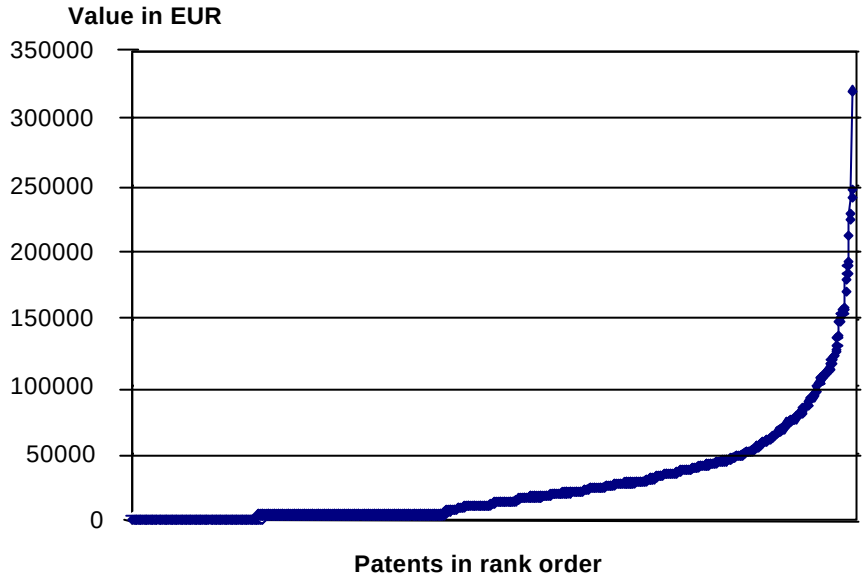
The six estimated parameters mean that we have now determined our complete patent valuation model. We have now identified an approximate "picture" of the Danish patent system, i.e. how Danish patents are dropped over time, and how much they are worth. The model can for example be used for analysing

[40] Lanjouw (1998) and Pakes (1986) find corresponding results for German patents.
[41] Cf. European Patent Office (1999).

consequences (simulations). We can change the "reality" in terms of the value of one of the six original unknown variables or for example the magnitude of the legal expenses, and then have the model give an estimate of how the values of patents will change in Denmark.

The calculations of the model show that there is a large spread in the value of patents. This is due to many patents being dropped before they expire. And when this happens, they reveal that they have a relatively low value. Fig. 2.3 shows the value distribution for 1,000 randomly selected stylised patents ordered by their value, i.e. the value of the least valuable patent is plotted first, then the value of the next-to-least valuable patent, etc. The value plotted last is the value of the most valuable patent among the 1,000. A very large part of these patents thus have a very low value, whereas a small group of patents has very high values.

Figure 2.3 The distribution of the value of 1,000 randomly selected stylised patents.



Note: The figure describes the patent value of the 1,000 patents which are rank-ordered by their value. The first point on the graph represents the value of the least valuable patent, and the last point on the graph represents the value of the most valuable patent.
Source: Calculations based upon the patent model.

The average present value of a patent over its entire lifetime is calculated to be approx. EUR 20,000, cf. table 2.2. This value is negatively influenced by the many patents which in reality are never utilised commercially and dropped quite early. In table 2.2 the principal results are shown of the simulation of the distribution of the patent values. The table should be interpreted in the following way: if 1,000 patents are rank-ordered by their value as in figure 2.3 then patent no. 750 (the 75th percentile in the distribution)[42] is worth EUR 29,000 in today money etc.

[42] I.e. 25 percent of the patents are worth more then EUR 29,000 and 75 percent of the patents

Table 2.2 Value distribution for patents in Denmark

Percentile	Value in EUR
50	8,000
75	29,000
90	56,000
95	83,000
99	134,000
99.9	228,000
Average	20,000

Source: Figure 2.3 and calculations with the patent model.

Table 2.2 probably represents a conservative estimate of the distribution of values of patents taken out in Denmark. Particularly the very valuable patents which are maintained until they expire, and for which we thus at no point in time have any direct valuation information, could be much more valuable than what our results have shown here. [43] Their value has to be inferred from patents which are dropped.

2.6 The international dimension of patents

An important feature of the patent systems are that the national patent authorities of the individual countries allow the opportunity for both the country's own citizens and firms as well as foreign citizens and firms to obtain patents and therewith the exclusive rights for exploiting an invention. This is secured through the bilateral principle on national treatment in the international conventions. In step with the increasing internationalisation, a steadily increasing number of patents are being placed outside their patent owner's home countries cf. table 2.3. Denmark became a member of the EPO in 1990. Whereas Danish firms submitted just as many applications for patents in Denmark, namely 1300, in 1990 and 1997, Danish firms today submit twice as many patent applications in the EPO countries as in 1990 and three times as many patents in the rest of the world. Correspondingly, a continually increasing number of foreign firms are applying for patents in Denmark.

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are worth less then EUR 29,000.

[43] It must be emphasised that the model represents an approximate picture of reality. The distribution of values is particularly sensitive with respect to the presumed distribution of the model – in this case the exponential distribution. A total of 30 percent of the total aggregate value of the patents arises from around the 5 percent of the patents which are renewed all the way out until they expire. As opposed to those patents which are dropped, and thus which reveal that at that point in time that they have a commercial value which is less than the "cut-off" level, there is no direct information from the patent data concerning an upper limit for the value of those patents which are maintained until they expire. The value of these patents is set indirectly via the presumed shape of the distribution and the fact that positive expectations of future returns increase the probability of renewal during the younger ages. See also Harhoff, Scherer & Vopel (1999).

Table 2.3 Patent applications in Denmark and by Danes

	1990		1997	
	number	percent	number	percent
Patent applications in Denmark	**36,000**	**100**	**84,300**	**100**
- by Danes	1,300	4	1,300	2
- by EPO country residents[1]	18,800	53	37,700	45
- by the rest of the world	15,900	44	45,300	54
Patent applications by Danes	**11,500**	**100**	**63,000**	**100**
- in Denmark	1,300	11	1,300	2
- in EPO countries[1]	5,400	47	11,500	18
- in the rest of the world	4,900	42	50,200	80

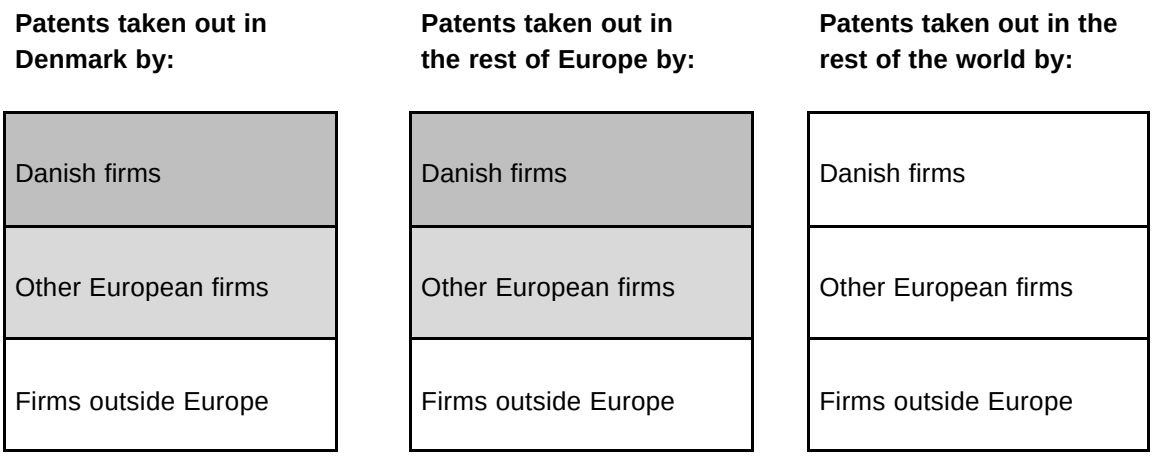
1) The EPO countries do not include Cyprus, Liechtenstein and Monaco, which are not itemised by country.

Note: As a consequence of rounding-off, the percentages do not sum up to 100 percent.

Source: OECD Basic Science and Technology Statistics 1999 Edition.

The figure below shows a grouping of all the patents in the entire world. The patent valuation model was estimated on the basis of data for patents taken out in Denmark, i.e. the model describes the three groups of patents, as are shown in the first column of fig. 2.4.

Figure 2.4 Systematic grouping of patents



A firm which is contemplating taking out a patent on an invention in, for example, Denmark will typically also wish to receive a patent on the invention in the other markets where the firm conducts business.[44] A firm's decision to research and develop new inventions which can be patented will thus depend upon the firm's assessment of the possibility for taking out and enforcing patents in *all* those countries in which the firm sells its goods. The more

[44] See also Eaton and Kortum (1995).

countries the patent insurance covers, the greater the effect on the national level of R&D.

In the following calculations, we are analyzing a European insurance arrangement covering the patents of European firms taken out in other European countries. It is an insurance model that has been proposed in connection with the discussion in the working group on the subject under the EU Commission. Centralised European co-ordination of the insurance arrangement would for example be able to establish channels that secure the efficient collection of information for premium calculation on the patent and legal systems on each individual country. It would make it less expensive to perform a premium calculation, which presumably would also be more correct in an actuarial sense, i.e. to a greater extent reflect the true risk for the patent of becoming involved in a lawsuit.

Such a joint European insurance arrangement would cover the four grey-coloured fields in figure 2.4. Danish firms would then be able to insure themselves against infringements of their patents in the rest of Europe as well as in Denmark. Firms from other European countries will correspondingly be insured in all of Europe, including Denmark. Such an arrangement can be viewed as a natural extension of the European co-operation on patents under the auspices of the EPO.

In terms of analysis we are cut off from directly being able to calculate the economic consequences of such an arrangement for all of Europe. Firstly, our patent valuation model only describes patents taken out in Denmark (the first column in the figure).[45] Secondly, we do not have access to a general equilibrium model for the *entire* EU, but are rather performing the calculations solely with MobiDK – a general equilibrium model which describes the Danish economy.

2.7 Patent protection as an implicit subsidy to R&D

The total value of the patent system can be perceived as an implicit subsidy which increases the incentive for R&D. The value of a year's worth of patents in relation to the R&D efforts during the same year is called the implicit subsidy rate. Legal expense insurance increases that value of a patent because the insurance makes it easier to enforce the patent. A greater value in taking out patents increases the incentives for R&D. When the insurance programme is introduced, it will increase the incentives of firms to perform R&D and hence to take out patents in the future. It is this effect that our calculations cover.[46] A European legal expense insurance programme for patents thus increases the

[45] We have data for the European (excl. Denmark) patents of Danes from the EPO database (second column, uppermost dark grey field). Direct modelling of the value of the patents of Danes in other countries would, however, require complete knowledge of both the fee structures as well as the legal systems (including the costs of lawsuits) for these countries.

[46] Firms with existing patents that get covered by a new insurance will experience it as a "wind fall gain". They can realise the extra profit by selling the patent.

implicit subsidy to the R&D efforts of the business community. Changes to the patent system can be compared with other policy instruments that aim at increasing the R&D efforts of the business community. [47]

The implication of interpreting the patent system as an implicit subsidy is that the Danish patent system gives a subsidy to R&D in, for example, Sweden or the US when a Swedish or American manufacturer takes out a patent in Denmark. Correspondingly, the part of the Danish R&D efforts which is directed towards taking out patents abroad is in reality receiving an indirect subsidy from the patent systems of these countries.

The total expenses of the Danish business community for R&D in 1997 is approx. EUR 2 billion, cf. table 2.4. The businesses themselves were responsible for EUR 1 3/4 billion of the R&D activity, whereas EUR 1/4 billion were for R&D expenses outside the firms. The manufacturing sector accounted for approx. 2/3 of the total R&D. Within the manufacturing sector, R&D is carried out particularly in the pharmaceutical industry and in connection with the production of machines, electronic equipment and instruments. The service sector carried out a good 1/3 of all R&D.

Table 2.4 R&D expenses of the business community in Denmark, 1997

	R&D expenses	
	---------- EUR billion ----------	
R&D expenses in own firm	**1,790**	
The manufacturing sector	1,130	
the pharmaceutical industry's share		360
machines and instruments' share		530
The service sector	650	
trade and repairs' share		160
services in connection with computers' share		170
Other (primary trade, construction, energy supply)	20	
R&D expenses outside own firm	**280**	
Total	**2,060**	

Source: OECD (1999), Basic Science and Technology and The Danish Institute for Studies in Research and Research Policy (1997).

We now calculate the implicit subsidy rate from all the European patent systems to the R&D of Danish firms. The computed value of patents taken out in Denmark (table 2.2 and first column in figure 2.4) is converted to an estimated

[47] Lanjouw (1998) argues for regarding patents as an implicit subsidy to R&D. She also discusses those problems which can arise when the patent system is compared to other types of instruments for promoting R&D. Firstly, the implicit subsidy portion is an average. If the returns on R&D investments are diminishing, then the subsidy portion to new (marginal) projects will be lower. Secondly, patent protection distinguishes itself from direct subsidies for R&D by increasing the variance on the returns, because the subsidy is only ever effectuated ("paid out") if the R&D investment becomes a success in the sense that the invention leads to a patent. Thirdly, not all patentable inventions are a result of an R&D investment. Fourthly, not all R&D projects have the objective of ending in a patent.

value for the patents of Danish firms in Denmark *and* in the rest of Europe (the two dark grey boxes in figure 2.4). The calculations are made for 1997.

Under the assumption that the average value of the Danish patents of Danish firms and the value of the Danish patents owned by foreign firms are the same, then the value of the Danish patents of Danish firms is 1,339 patents x EUR 20,000 = EUR 27 million. Cf. tables 2.2 and 2.5.

Table 2.5 Patent applications by Danes, 1997

	Number of patents	Total value, millions of euros
Patents by Danes in Denmark	1,339	27
Patents by Danes in rest of Europe	11,459	229
Total patents by Danes in Europe	**12,798**	**256**
Patents by Danes, rest of the world	50,192	1,004

Source: OECD (1997) and own calculations based upon the patent model.

A conservative estimate of the average value of the patents of Danish firms in Europe (incl. Denmark) would be 12,798 patents * EUR 20,000 = EUR 256 million. In other words, we are using the average value of a patent taken out in Denmark in the valuation of the European patents of Danes. It is a conservative estimate because the Danish market is four times smaller than the average market in Europe – measured in terms of GNP. The average value of a patent taken out in Denmark will thus presumably be somewhat less than the actual average value of a patent taken out by a Dane in Europe.

The total estimated value of the European patent portfolio of Danish firms in 1997 was a good EUR 250 million.

The effect on the average patent value of a European legal expense insurance programme which reduces the legal expenses to a deductible of nearly EUR 7,000 is found by using the estimated patent valuation model. The minimum costs of a lawsuit in the model are reduced from nearly EUR 15,000 to a little less then EUR 7,000, and the patent valuation model is then used to simulate a new value distribution. The average patent value is increased as a result from EUR 20,000 to EUR 22,000, i.e. by 10%. The lower legal costs increase the lifetime of the model's patents. The total return from the patents over their lifetimes thus becomes larger.

The higher average patent value increases the total value of the European patent portfolio held by Danes by EUR 26 million to a good EUR 280 million, cf. table 2.6.

Table 2.6 Increase in value as a consequence of patent insurance in Europe, 1997

	Value today	Value with insurance	Increase
	-------- million EUR --------		percent
Patents of Danes in Denmark	27	29	10
Patents of Danes in rest of Europe	229	252	10
Total patents of Danes in Europe	**256**	**282**	**10**
Patents of Danes, rest of the world	1,004	1,104	10

Note: All patents are valued at the average value of patents taken out in Denmark.
Source: OECD (1997) and own calculations based upon the patent model.

This corresponds to an increase in the implicit subsidy by the European patent system to the R&D of Danish firms from (256/2,060)=12 percent to (282/2,060)=14 percent, i.e. a 10 percent increase, cf. tables 2.4 and 2.6. Chapter 3 will perform further computations based upon this change in the implicit subsidy rate.

In comparison, Lanjouw (1998) finds implicit subsidy rates from German patent data of 12 percent for computers and machines, 15 percent for pharmaceutical products and 75 percent for textiles. The last-mentioned relatively unrealistically high subsidy rate is due to there being very few recorded R&D expenses in the textile industry.

Chapter 3 Economic consequences

3.1 Introduction

Patent insurance means that more patents will be taken out, and that the patents will on average be renewed for a longer period of time. The total value of the patent system will thus rise, cf. chapter 2. More patents are beneficial to the economy for two reasons. Firstly, the firms taking out patents increase their R&D. And secondly, more patents mean increased knowledge spillovers into the economy. More R&D and knowledge spillovers lead to a higher level of productivity. In chapter 3 we show that productivity is increased as a consequence of the introduction of a patent insurance programme. When productivity rises, the welfare of the population rises. Calculations with the Ministry of Trade and Industry's general equilibrium model, MobiDK, show that the minimum gain in welfare for Denmark is of an order of magnitude of EUR 100-340 million (DKK 0.7-2.5 billion) as a consequence of a patent insurance programme as outlined in chapter 2. If these effects are magnified to EU economy level, then a rough estimate indicates that we would attain welfare effects of EUR 6-21 billion (DKK 45-156 billion).

This chapter is organised in the following manner: the overall interrelationship between the patent system and, ultimately, society welfare is discussed in section 3.2. Studies show that the patent system promotes R&D and makes for increased growth and general welfare. We discuss the main results of the theoretical and empirical studies of the interrelationship between the patent system and growth.

In sections 3.3-3.6 the individual elements of the process from the organisation of the patent system to the total welfare of the surrounding society are explained. In section 3.3 we take a critical look at the first element of this process, namely the interrelationship between taking out patents and R&D. The patent system can be thought of as an implicit subsidy to R&D, cf. the discussion in chapter 2. This subsidy promotes – in the same manner as other R&D subsidies – R&D activities of the business community.

R&D affects productivity by two channels: a direct channel and an indirect channel. The direct result of more R&D in the business community is more inventions. This can either involve inventions which make production processes easier and less expensive or it can involve inventions which increase the quality of the goods produced. Both types lead to higher productivity. In section 3.4 we review a number of studies that have attempted to empirically demonstrate the theoretical relationship between R&D efforts and productivity.

An indirect result of more R&D is knowledge spillovers. An important objective of the patent system is to construct a publicly accessible database of new knowledge. The databases of the patent authorities are a unique collection of

knowledge because there are requirements for documentation and publication when taking out patents. A rise in the number of patents increases knowledge spillovers which are an important source of economic growth, cf. the discussion in section 3.5. International studies indicate that the beneficial effects on productivity as a consequence of knowledge spillovers are at least as large as the direct effects on businesses which conduct R&D.

The last element in the process from patents to society welfare is the interrelationship between productivity and welfare. When productivity rises, society becomes wealthier and consumers experience increased welfare. In section 3.6 we build on the computation of the effects of a legal expense insurance programme for patents as described in chapter 2. We find that a reduction in the enforcement costs of firms through an insurance brings about an increase in the total welfare in Denmark, cf. the above.

In section 3.7 the results are applied to European level by simple enumeration.

3.2 Welfare-promoting characteristics of the patent system

A firm can obtain exclusive rights to produce, sell, import or use a product or a process by taking out a patent. In order to obtain a patent, the firm's invention must be new and distinguish itself to a significant degree from previously known technology. The patent system has two completely fundamental functions:

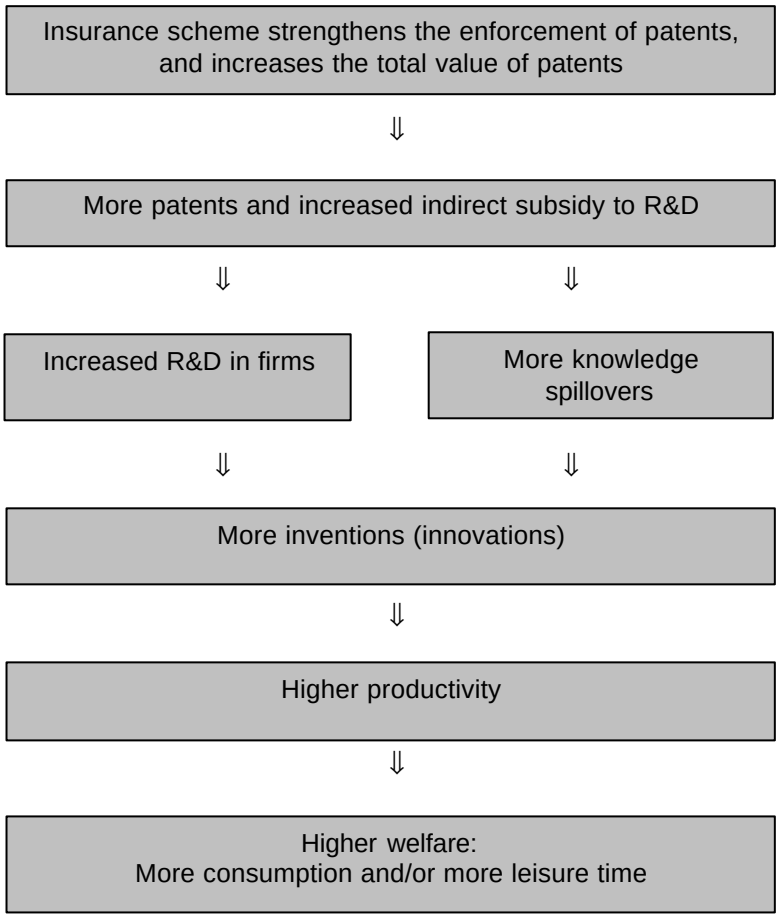
- **Incentive for R&D:** Taking out patents gives firms exclusive rights to exploit an invention commercially during a limited period of time. It increases the firms' incentives to perform R&D.
- **Knowledge database:** Via the requirement that all patents must be made public, the patent system is building up an information bank. This ensures that new knowledge will be diffused.

In economic terms, the patent system thus contains both benefits and drawbacks. The advantages are that the patent system gives an incentive to conduct R&D and spread knowledge. The drawback is the lack of competition that results from the patent holder's (time-limited) exclusive rights. Economic literature predominately indicates that the economic benefits outweigh the drawbacks, i.e. that a stronger patent protection system results in a higher rate of growth. The empirical studies of the significance of the organisation of the patent system to R&D, inventions (innovations) and growth also point in the same direction as the theoretical studies. Countries with well-developed patent systems also tend to have the highest level of welfare and have over time had the highest rates of growth.[48],[49]

[48] Thompson and Rushing (1999) in a cross-country study examine the interrelationship between the degree of patent protection and economic growth in 55 countries during the period of 1975-1990. They conclude that patent protection has a positive and significant effect on growth. Gould and Gruben (1996) find corresponding results in a similar cross-country study. See also Thompson and Rushing (1996), Park and Ginarte (1997) as well as Maskus and Penubarti (1995).

Improvements in the opportunities of firms to enforce their patents, for example through a patent insurance scheme, mean that more patents will be taken out, and that these patents on average are kept for a longer time period. This benefits the economy through two channels, cf. fig. 3.1. *Firstly*, firms will increase their R&D when it becomes easier to enforce a patent. This gives rise to new inventions and higher productivity. *Secondly*, relatively more inventions will be patented.

Figure 3.1 Interrelationship between legal expense insurance for patents and economic welfare



The publishing of patents is an important characteristic of the patent system. Knowledge spillovers are increased when more inventions are patented. This also allows others to build on already existing inventions. Such diffusion of knowledge gives rise to derived productivity gains.

[49] In the fields information and communication technology, where the rates of innovation are high, whether it is possible to patent software is continues however to be discussed. Opponents of software patents support the so-called ”Open Source” strategy.

Higher productivity ultimately means higher income and increased welfare. Either because the business community can produce more with the same inputs of capital, labour, energy and materials, or because the same level of production can be attained with smaller quantities of the production factors. Society can thus choose to either have a higher level of consumption and/or consume the same amount as before, but with a smaller work effort and hence more leisure.

In the following, we will describe the interrelationship between the patent system and R&D with the Danish economy as a case. The analysis extends the work of chapter 2, where we calculated the value of Danish patents.

3.3 Effect of the patent system on R&D

A number of studies analyse the interrelationship between patents and R&D. Most of the studies look at how R&D investments create patents as a result.[50] These studies use patent counts as a measure of the results of the R&D effort. However in this analysis we will look at the reverse chain of causation: what implications does the organisation of the patent system have on the number of patents taken out and R&D efforts in the business community? The theoretical literature indicates that the possibility of obtaining patents can increase the total R&D efforts, direct the R&D activities and make the investments of firms in R&D more far-sighted, cf. among others, O'Donoghue and Zweimüller (1998).[51]

It is very difficult to calculate how much the organisation of the patent system means to private R&D activity. In chapter 2 we argue, however, that the patent system can be thought of as an indirect subsidy to R&D, and we calculate the value of this implicit subsidy. One manner whereby we can obtain a rough impression of the effects of the patent system on R&D efforts is to draw on experiences with the effects of other types of public subsidies on R&D.

A more recent Danish study carried out by the Centre for Economic and Business Research (CEBR) looks at the effects of public support for R&D on private R&D. In this study, public support for R&D was channelled through the Danish Authorised Technological Service Institutes, cf. Jensen, Sløk and Sørensen (2000) as well as Sørensen and Marcusson (2000). They find an elasticity between private R&D expenses and public innovation support of 0.10. An elasticity of 0.10 corresponds to an increase in public innovation support of 1 percent leading to an increase in R&D expenses of 0.10 percent. Converted to the real level of public innovation support and R&D efforts, this result implies that an increase of one Danish kroner (or euro) in public innovation support increases private R&D expenses by one to one and a half kroner. Other

[50] See, among others, Grenzmann and Greif (1996) and Nielsen (1999).
[51] The contribution of O'Donoghue and Zweimüller lies within the endogenous growth literature, where the significance of intellectual property law to growth has been examined within a purely theoretical framework.

international studies find effects of a similar order of magnitude, cf. the discussion in Sørensen and Marcusson (2000) and Griliches (1998).[52]

3.4 The direct effect of R&D on productivity

When private R&D efforts rise, the number of inventions (innovations) rises. These inventions can be directed towards either increasing the quality of the firm's production (product innovation), or the inventions can serve the purpose of improving the production processes within the firm (process innovation).[53] This means that we can produce and consume the same quantity of goods even though we have more leisure. Alternatively, we can produce and consume more and better goods, even though we spend the same amount of time at work.

The link between R&D efforts, inventions (innovation) and productivity has been the subject of numerous analyses in economic literature. Jensen, Sløk and Sørensen (2000) show that a rise of one Danish kroner in public support for innovation will in part increase the private R&D expenses by 1-1.50 kroner (cf. the above) and in part increase production in the manufacturing sector by between 2 and 2.50 kroner. An increase in the R&D efforts will have completely worked its way into productivity after approx. 12 years.[54] A patent insurance as described in chapter 2 section 7 involves an implicit subsidy to R&D of (at a minimum) EUR 26 million or nearly DKK 200 million. This corresponds to nearly half of the grants of the Danish Ministry of Trade and Industry for R&D.

If we make the simplifying assumption that this indirect subsidy works in somewhat the same manner as other types of public support for innovation, then production in the business community will rise by an amount in the range of EUR 50-70 million (DKK 370-520 million).

It must be emphasised that this estimate is uncertain. On the one hand, it is difficult to speak about the effects of relatively large changes in the public subsidies on the basis of analyses of marginal changes in such subsidies. This would argue for the estimate involved being a liberal estimate. On the other hand, the calculation can be said to be a conservative estimate in that it does

[52] Griliches (1998) has gathered the results from a large number of previous studies in an overview article. A new OECD study by Guellec and van Pottelsberghe (2000) looks at the effect of different types of public support for R&D. The study finds a long-term elasticity between (direct) public grants and private R&D activities of 0.08. Translated, this result means that 1 Danish kroner (or EUR) in direct grants from the public sector brings about R&D expenses in the private sector of an additional 0.70 kroner (or EUR).

[53] Product innovation involves the value of the production increasing even though the same quantity of inputs is being used. Process innovation ultimately results in lower production costs for firms. Both product innovation and process innovation lead to higher productivity because the surrounding society can attain a relatively higher level of production in relation to the inputs of production factors.

[54] This result is confirmed by international studies which indicate that the productivity of firms increases by between 0.2 and 1.0 percent in the long run when the R&D efforts of firms are increased by 1 percent, cf., among others, Griliches (1998).

not take derived effects on other businesses into account. The indirect effects are brought into the picture in sections 3.5 and 3.6.

3.5 Indirect productivity gains through knowledge spillovers

A built-in benefit of the patent system is that patenting increases knowledge spillovers since a patented invention must be published. This gives other firms the possibility to build further on the patent with derived productivity gains as a result. The knowledge communicated through a patent description will often be able to be reworked into completely other applications and/or in other industries. A patented invention will thus increase productivity in other industries.

The OECD has performed an international comparison of the patent systems.[55] It concludes, among other things, that for a number of countries the patent documentation is an essential source for technology transfers and a manner by which to accelerate its R&D efforts.

In more recent (endogenous) growth theory, knowledge spillovers are viewed as a completely central source for maintaining a high rate of growth. The interrelationships between the spread of knowledge, productivity and growth are difficult to demonstrate empirically. A large number of empirical studies do, however, point in the same direction and show that the effect of knowledge spillovers can be at least of the same order of magnitude as the effect of a firm's own R&D described in section 3.5. The effects of the diffusion of knowledge on total production (measured by the output elasticity with respect to R&D outside the firms) is calculated in different analyses to be between half and twice as large as the elasticity between output and R&D performed within the firms, cf. Griliches (1998). These results accord with Cohen (2000) and Thompson and Rushing (1999), which indicate that the transfer of knowledge between competing firms knowledge spillovers to other industries is one of the most important sources of productivity growth.

Due to the diffusion of knowledge, the economic returns of R&D are significantly higher at macro level than at micro level. Without public subsidies the R&D activity is thus too low. The assessment has been made that the optimal extent of investment in R&D is more than two to four times as large as the actual scope of investment performed by private investors, cf. Jones and Williams (1998).

3.6 A welfare analysis of the productivity gains from increased R&D

In sections 3.2-3.5 we described how a strengthening of the patent system through a legal expense insurance programme makes it more attractive to patent inventions. It has the *direct effect* that firms perform more R&D. Hence more inventions are made. More patented inventions also have the *indirect effect* that knowledge becomes accessible to others who can build upon the

[55] Cf. OECD (1997).

patented inventions and find new applications for them. This can involve inventions which either make production processes easier and less expensive, or inventions which increase the quality of the goods produced. Both situations lead to higher productivity.

When productivity rises, the welfare of the population rises. This occurs because we can, for example, produce and consume the same quantity of goods even though we have more leisure time. Alternatively, we can produce and consume more and better goods even though we spend the same amount of time at work.

In the following, we will attempt to quantify the total economic consequences of a patent insurance scheme which reduces the patent enforcement expenses of firms. We have chosen to divide the effects up into direct effects as a consequence of more R&D in the firms taking out patents and indirect effects as a consequence of the diffusion of knowledge. The calculations are performed for the case of the Danish economy because we are using a general equilibrium model that describes Danish conditions. The model is described in more detail in box 3.1.

In chapter 2 we outlined a simple variant of a legal expense insurance programme for patent holders which would mean an increase in the value of a year's worth of patents by Danes in Denmark and in the rest of Europe of approx. EUR 26 million (nearly DKK 200 million), i.e. approx. 10 percent. Of the total R&D efforts, approx. 2/3 were performed in the manufacturing sector, whereas the service businesses accounted for a good 1/3, cf. table 2.4. By far the most part of the patents can be traced back to the manufacturing sector. It is thus assumed in the calculations that the *direct* effects on productivity as a consequence of increased R&D efforts primarily affect the manufacturing sector.

The *indirect* effects on productivity as a consequence of the diffusion of knowledge and technology spillovers from firms taking out patents have an effect on the rest of the business community. In accordance with the most careful estimates of Griliches (1998), the effects of the diffusion of knowledge are set so as to be of the same size as the direct effects on productivity as a consequence of more R&D.

It is assumed in the calculations that higher productivity manifests itself in the same quantity being able to be produced with a lower labour input and a lower capital mechanism. Alternatively, we can obtain increased production with the same labour and capital input.[56]

[56] In other words, technical progress which economises on labour and capital. Higher productivity can in principle manifest itself in reductions in all four factors of production: capital, labour, energy and materials. The analysis of the welfare effects of higher productivity build upon calculations by the general equilibrium model of the Danish Ministry of Trade and Industry, MobiDK, described in Christensen and Hoffmann (2000).

Box 3.1 The general equilibrium model of the Danish Ministry of Trade and Industry, MobiDK

The effects of higher productivity are analysed in a dynamic version of the general equilibrium model (CGE model) of the Danish Ministry of Trade and Industry, MobiDK. The MobiDK model contains a detailed description of the Danish economy and is described in Harrison, et al (1997). The model describes Denmark as a small open economy, facing constant prices in world markets. All firms are assumed to be profit-maximising, and they have the same fundamental cost structure. Firms produce using inputs of capital, labour, materials and energy.

Consumer behaviour is described in the model by assuming that the utility (or welfare) of the consumers is dependent upon both their consumption as well as their leisure time. When the consumers can work less (for example because they have become more productive), they gain more leisure and hence the total welfare rises.

The fundamental data for the model comes from the input/output tables of the national accounts for 1992 aggregated into 19 sectors. The principle of a general equilibrium model is that the economy is in equilibrium in the initial year. When the economy is subjected to a shock, for example higher productivity as a consequence of more R&D, the economy will move during the course of a certain period of time to a new equilibrium position.

The dynamic version of the MobiDK model operates with exogenous growth, i.e. the growth is not explained in the model; a constant annual growth rate is simply assumed. The agents in the model (firms and households) have rational expectations, and there is no uncertainty, see for instance Hoffmann, et al (2000). The model is solved for the period of 1999 to 2050 in intervals of one year. The calculations show that during the last model period the economy is very close to a new steady-state with the same constant growth rate as in the initial equilibrium. The result of the model simulations are obtained by comparing the economy in the new equilibrium with the economy of the original equilibrium.

Results

The calculations show that in the long run higher productivity gives rise to higher welfare for consumers, cf. table 3.1. This occurs in part because the value of the total production rises because the quality of the products increases as a consequence of new inventions (innovations). And partly because labour and capital are released from those firms which have become more efficient due to R&D and new knowledge. Labour and capital released due to productivity gains can over time be channelled into other production leading to a higher aggregate production. This gives rise to a higher level of total consumption and thus increased welfare.

When we can obtain the same production with a smaller input of labour, we obtain more leisure time. Alternatively formulated, consumers choose to convert a part of their higher income into more leisure time. More leisure time gives increased welfare. Viewed on the overall, the arithmetic example shows that the annual gain in welfare is nearly EUR 100 million (approx. DKK 690 million) if we only include the direct effects of productivity in those firms which perform more

R&D, cf. table 3.1. If we include a (moderate) estimate of the effects on the productivity of the other businesses through more diffusion of knowledge then we obtain an annual gain in welfare of a magnitude of EUR 340 million (approx. DKK 2.5 billion).

Table 3.1 Economic effects on legal expense insurance for patents

	Direct R&D effects[1]	Direct and indirect effects[2]
Annual gain in welfare in EUR millions	100	340
Present value[3] of the welfare gain in EUR millions	2,300	8,400

1) I.e. the diffusion of knowledge is set to zero.
2) The indirect effects through the diffusion of knowledge are assumed to be of the same magnitude as the direct effects.
3) The welfare gains are discounted at a discount rate of 5 percent.
Source: Our calculations with the MobiDK model.

It must be emphasised that the calculations are encumbered with uncertainty. The primary sources of uncertainty are the estimates of the effect of innovation policy on R&D and productivity which form the basis for the calculations of the model.

3.7 Putting it into perspective – welfare gains for Europe

The analyses in chapter 2 offer an estimate of the value of patents applied for in a given year in Denmark and the value of the patents of Danish firms in Denmark and in the rest of Europe. The increase in the patent value (indirect subsidy) if a patent insurance scheme was to be introduced is also calculated. An arithmetic example presented in chapter 2 shows that the value of a single year's worth of the European patents of Danish firms could rise by as much as approx. EUR 26 million (nearly DKK 200 million), i.e. 10 percent, if we introduce a patent insurance scheme. The insurance arrangement could lead to a permanent increase in total economic welfare of EUR 100-340 million (DKK 690-2,500 million).

Naturally there are differences between the EU countries with respect to industrial structure, R&D activity, the inclination to take out patents and legal systems. However, with a jumping-off point in the results for the Danish economy an initial estimate can be given of the effect of an insurance scheme under European auspices. A rough estimate[57] indicates that the economic gains of a European insurance programme for the patents of all European firms in Europe could create welfare gains of a magnitude of EUR 6-21 billion (DKK 43-156 billion).

[57] Calculated based upon the fact that the Danish economy comprises around 1½ percent of the total economy of the EU.

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