

**Study on evaluating the knowledge economy
what are patents actually worth?**

The value of patents for today's economy and society

Tender n° MARKT/2004/09/E, Lot 2

FINAL REPORT

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Authors and acknowledgements

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Associated to this Report is a Technical Report that constitutes an integral part of the output produced for this Tender. The Technical Report is composed of ten studies conducted by the following people: Katrin Cremers, Gustavo Crespi, Thorsten Doherr, Alfonso Gambardella, Aldo Geuna, Walter Garcia Fontes, Paola Giuri, Raul Gonzalez, Dietmar Harhoff, Norbert Janz, Ulrich Kaiser, Georg Licht, Myriam Mariani, Lionel Nesta, Attila Varga, and Bart Verspagen.

EXECUTIVE SUMMARY

This Report summarizes the results of detailed technical studies about the value of patents in Europe. From the results of these studies it highlights some policy implications.

The analysis focussed on four major areas that are particularly important for understanding the impact of patents on today's knowledge economy and societies at large, viz.:

- Monetary value of patents
- Economic and social impact on patents, and particularly
 - Share of patents used for commercial and industrial purposes
 - Patent licensing
 - Creation of new firms from patents, and implications for employment
- Relationships between patents, R&D, and innovation
- Inter-industry differences.

Monetary Value of Patents

The value of patents is highly skewed. Few patents account for a large share of their total value.

Moreover, the value of patent is different from the value of the patented invention. It is the latter net of the value of the invention if the inventor had no patent on it. This nails down the specific value of having a patent rather than the value of the invention *per se*. Some authors have called it the “patent premium”.

Finally, the value of patents has to be understood as the value of an asset. It is then the sum of the annual discounted profits obtained from the invention when patented net of the same discounted stream if there was no patent on it.

A measure of the value of a patent is then the minimum price at which the patent holder would be willing to sell the patent at the moment in which it is granted, as it corresponds to the discounted stream of profit that the patent owner would obtain. In this Report we employed data from a large survey of European inventors, PatVal-EU, which asked almost 10,000 inventors in eight countries (Denmark, France, Germany, Hungary, Italy, Netherlands, Spain, UK) questions about the patent price above, along with other information.

By using these data we estimated that the patent premium in our eight countries is quite high, about 3 million euros on average. However, we also find a quite skewed distribution, which confirms that few patents account for the bulk of the overall economic value of patents. Our estimated median is 300 thousand euros.

We also found that the patent premium is roughly 1% of the GDP in 1994-1996 and has increased during the 1990s, both in absolute terms and as a percentage of GDP. In 2000-2002 the value of patents is 1.16% of GDP¹. Thus, the value of patents has increased faster than GDP.

This share is slightly smaller than the share of annual R&D investments on GDP (1.9% in 2000-2002 in our eight countries). However, many R&D-based innovations are not patented (and some patents may not be based on R&D). Moreover, these values are not the values of the patented invention, but of holding a patent about them (the patent premium).

Germany exhibits the highest aggregate value of patents among our EU-8. As a share of GDP, it increased from 1.4% in 1994-1996 to 2.1% in 2000-2002.

It is important to note that this is one of the very first attempts to measure the monetary value of patents and to estimate the total value of patenting by country. This is an area where evaluation and measurement are at a very crude stage compared to other areas where economic indicators are widely available (eg. exports and imports or R&D investments). We did the best that could be done to estimate the value of patents with the data collected in the PatVal-EU survey. New data collections are thus crucial for setting up systematic indicators of the value of patents in additional years and countries.

Share of Patent Used

We estimated that about one third of the European patents are not used for any industrial or commercial purpose. This is not a trivial share, and it calls for actions in order to increase the rate of utilization of patents.

About half of the unused patents are “blocking” patents, i.e. they are meant to block rivals from using a given technology even if the technology is not used by the patent holder. However, half of the unused patents are “sleeping” patents, i.e. they are simply left unexploited by the patent holder. The sleeping patents are natural targets for enhancing the rate of utilization of patents.

Small firms (less than 100 employees) use 80% of their patents, whereas large firms (more than 250 employees) use slightly less than 60% of their patents (medium firms, 100-250 employees, use about 75% of their patents). Large firms are more likely to hold blocking patents, which explains in part their lower utilization rate. However, they also have a good share of sleeping patents, which typically arise as by-product inventions in non-core technologies from their large R&D budgets. Since large firms hold almost three-fourth of all the patents, in absolute terms their sleeping patents make up a

¹ Because of the time lag between date of application and granting of the patents, 2002 is the last available year with complete EPO data about number of patent applications (source: EPOLine and Eurostat data, June 2006).

significant reservoirs of technologies that can be potentially exploited possibly by other parties.

Patent Licensing

The most effective way of enhancing the utilization of patents is by encouraging patent licensing and markets for technology more generally. For example, reducing patenting costs to small firms, which are more likely to use their patents, may only lower their patenting threshold, with the consequence that they will patent less valuable, but then also less usable, inventions.

We estimated a sizable market for European patents. Moreover, this market has grown in the 1990s. However, we also estimated that the market for European patents could be 50% larger. This is because our PatVal-EU revealed that quite a few patent owners are willing to sell their technologies but were unable to do so.

In a detailed technical study we found that the willing-to-but-not-licensed patents are not less valuable than the actually licensed patents. This rules out that they are minor patents that were not licensed because they were less important or less usable. The main alternative hypothesis is that transaction costs in technology trade have impeded the technology transfer, a hypothesis consistent with other studies on the matter.

We also found that small firms license a much larger share of their patents than large firms. Yet, because the latter own many more patents in absolute terms the large companies can bring several technologies to these markets. In sum, both large and small firms can be active technology suppliers.

The UK and Germany have markedly different shares of licensed patents, with the UK showing a high share and Germany a low one. Italy and France look more similar to Germany, while Denmark and the Netherlands are more similar to the UK. Spain is becoming more similar to the UK.

Hungary exhibits a large share of licensed patents. Given the costs of downstream innovation development, this suggests that becoming technology suppliers in well defined niches within technology markets can a sensible strategy for New Member State countries, as the success of Israel or Ireland has shown.

Patents to Create New Firms

Quite often new technology-based companies are created around a patent. This is because the patent provides them with the necessary protection that they cannot enjoy because of alternative means for appropriating the rents from innovation, like downstream assets, or control of final markets.

About 5% of patents in our eight countries are used to form new companies. Interestingly, Germany and the UK are again at opposite extremes, with the UK showing a higher share of new companies built around patents. Denmark looks more

similar to the UK, while France is more similar to Germany. Hungary and Spain also exhibit a high rate of new company formation from patents, which reinforces our earlier view that these countries may exploit new strategies in continental technology markets.

The value of new firms from patents as a share of GDP is higher than the share of the employment that they create on total employment. This is a consequence of the well known phenomenon that technology-based industries produce higher economic values than direct increases in employment. The indirect effects on employment are possibly larger.

Relationships between Patents, R&D and Innovation

Since the 1990s the number of patent applications have increased faster than R&D. This has been true of the US, and among the European countries the trend has been particularly pronounced for Germany. The question is whether this reflects a genuine increase in the productivity of R&D, or a higher propensity to patent for reasons other than increases in the productivity of the innovation process.

We conducted a systematic study of German companies and found no clear evidence that the propensity to patent was not produced by an increase in the productivity of R&D. In turn, this is consistent with the evidence provided by other studies, which suggest that the productivity of R&D might have increased for reasons like the advances in some basic disciplines, e.g. life sciences or engineering sciences, or better tools for conducting or managing research (ICT, software, etc.).

Our study covered mostly medium-sized R&D performers, and not the largest R&D-performing companies. Evidence from other studies suggests that the largest R&D-performers might have increased their propensity to patent even beyond any increase in R&D productivity. However, as noted earlier, large firms seem to have increased both their strategic patenting behaviour and their innovations potentially available to other parties.

Inter-industry Differences

The chemical-based industries (organic chemistry, pharmaceuticals, etc.) produce patents with higher average and median values compared to the electronics and ICT industries. However, the latter show a relatively higher total value of patenting. This suggests that they have many patents of relatively lower value, while the chemical-based industries have fewer patents of higher value. We also found that both chemical-based and electronic-based industries have a high share of unused patents. This confirms that more prolific producers of patents use a diminishing share of them, and therefore they are also valid sources of new uses to be exploited via licenses, alliances and the like.

The highest shares of patents licensed, and of patents giving rise to new firms, are typically in industries populated by smaller companies and technology specialists, like

biotechnology or medical technology. Moreover, the total value of patents licensed has increased considerably in these industries in the 1990s, suggesting that the markets for technology in these sectors are growing at a significant pace.

Policy Implications

The high average and median value of patents suggest that policy actions in this area can have important economic and social implications for Europe. Among other things, this Report suggests that a relevant area to be targeted is the utilization rate of patents. While it is virtually impossible to reduce this rate to zero, we found that there are opportunities for reducing it.

The main tool for enhancing the use of patents is by encouraging patent licensing. To do so, an important policy target should be the reduction of the transaction costs of technology trade, which we have shown to provide serious impediments to patent licensing. This can take various forms, like the creation of standard contracts for technology trade that reduce contractual ambiguities; the formation of intermediating companies that facilitate the match of buyers and suppliers; actions to define standard prices for technologies according to their characteristics, as well as public information about technology prices.

We also showed that large firms are repositories of unused technologies. The search for ways of diffusing the utilization of unused large firm patents can be another effective means for enhancing technology trade. In addition, this Report confirmed that small firms are vehicles of “open innovation” systems. They are more likely to license and to form new companies. This strengthens the view that strategies to encourage smaller technology specialists can provide valid stimuli for innovation and competitiveness.

Two final policy issues from this Report are the following.

First, we confirmed the conventional wisdom that there are different trends in Europe in terms of utilization of patents, effectiveness of technology markets to enhance their use, and the formation of new technology-based companies. The UK model is closer to these patterns than the German model. France and Italy are closer to the latter, while Denmark and the Netherlands are more similar to the former. Spain is approaching the UK model. In this respect, an ideal combination of the two models is to encourage the use of large firm German technologies along with small firm UK technology specialists. Clearly, things are not black or white, and large firm UK technologies, as well as smaller technology makers in Continental Europe can play a role too.

Second, we uncovered a potentially interesting role for the New Member States. Hungary too shows high rates of technology licensing and formation of new companies from patented technologies. This was not unexpected. Less advanced economies find it relatively easier to concoct new technologies and ideas in areas in which they have some specialization and expertise, than making costly investments in large scale downstream assets to develop them. Technology markets can then become a means by which these countries sell their technologies without having to incur these costly

investments. In turn, if these markets exist and function, companies in these countries are motivated to invest in the initial ideas as they know that they can profit from selling them, and they do not need to make the full downstream investments, which can discourage them to carry out the initial investment in the innovation.

1. INTRODUCTION

The past two decades have witnessed a significant upsurge in patent activities all over the world. The US patent applications have increased from about 100 thousands per year during the 1970s to about 350 thousands in 2003 (Kortum and Lerner, 1999; www.uspto.gov). Similarly, annual EPO patent applications have increased up to 160 thousands in 2003 from less than half of that figure a decade or so earlier (www.epo.org).

The increasing relevance of this phenomenon calls for a better understanding of it. In this Report we focus on some issues that are particularly relevant for policy in this area, specifically:

- 1) **MONETARY VALUE OF PATENTS** – how much is a patent worth on average? What is the aggregate value of patents? What is the value of patents as a share of GDP? Have these values increased in recent years?
- 2) **ECONOMIC AND SOCIAL IMPACT OF PATENTS IN THE EU**, particularly:
 - 2a) *Share of patents used*. Many patents are not used for industrial or commercial purposes. This raises the policy question about the means for increasing the rate of utilization of patents, with implied increase in their economic impact and social value.
 - 2b) *Patent licensing*. This is a corollary of the previous point. We will argue that an important way of increasing the use of patents is to encourage patent licensing and markets for technology. This is because for many patents the best user of the technology is not its producer, and many patents are not used because the technology producer does not have the same incentives to use them as some other agent.
 - 2c) *Creation of new firms and employment*. The formation of new firms, and technological entrepreneurship more generally, have been a major new vehicle for innovation, industrial competitiveness, exploration of technological opportunities and markets. Yet, many of these new firms cannot rely on physical or other assets to protect their innovations. As a result, without legal protection, they may be discouraged to invest in producing them because they cannot retrieve enough rents from these investments. We will assess the extent to which patents encourage the formation of new firms. Since these firms are potentially important for employment, we will also assess the implications for the latter.
- 3) **RELATIONSHIPS BETWEEN PATENTS, R&D AND INNOVATION**. R&D affects innovation, as it is an input to it. To the extent that patents reflect the production of innovation, R&D should be correlated with them as well. Yet, in recent years,

patents have increased faster than R&D in many advanced economies. This raises two hypotheses:

- a) the productivity of R&D has increased, i.e. the increase in patents reflects a genuine increase in innovation;
- b) the propensity to patent has increased with no genuine increase in innovation.

Understanding the extent to which the first or second hypotheses is more relevant is important for policy. The latter case would call for some greater control of the use of patents because the higher propensity to patent may reflect a relative higher cost in terms of *ex-post* diffusion of the innovations compared to the *ex-ante* incentives that patents typically provide to the innovators. This Report will summarize the results of a detailed econometric study that assessed the relative importance of the first vis-à-vis the second hypothesis in Europe in recent years.

- 4) **DIFFERENT ROLE OF PATENTS IN DIFFERENT INDUSTRIES.** We will discuss in which industries patents exhibit a greater average value and why. Relatedly, we will discuss inter-industry differences in the use of patents, licensing, and formation of new firms. This discussion will enable us to single out the industries in which patent policies may be more effective for innovation and competitiveness.

The following four sections deal with the four points above. Section 5 concludes by providing policy recommendations based on the analyses of the previous sections.

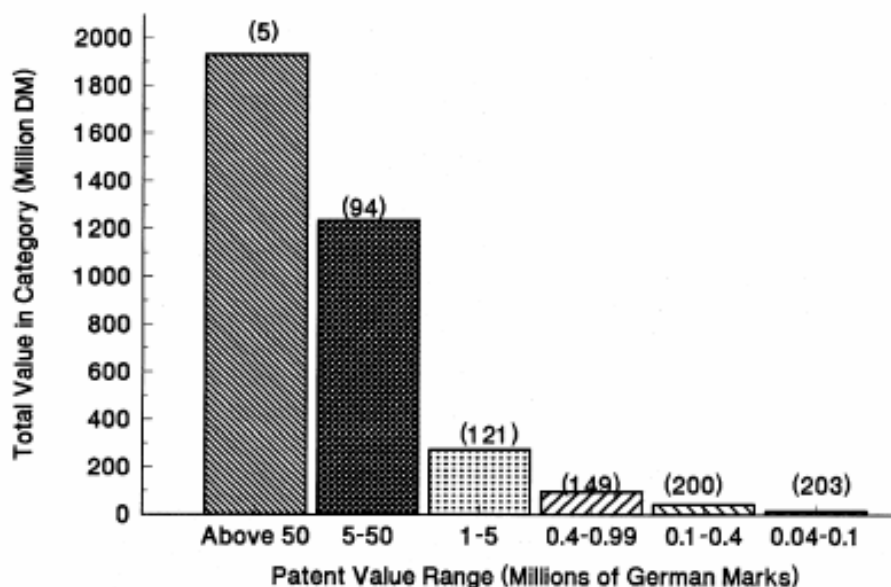
2. MONETARY VALUE OF PATENTS

As with any economic magnitude, we need to understand how much patents are worth both individually and at the aggregate level.

However, before presenting some data on the matter, it is important to know some basic facts about the value of patents.

First, the **value of patents is very skewed**, that is few patents are worth large amounts of money, while most patents have no or very small monetary values. This was shown for example by Scherer and Harhoff (2000) who used information drawn from a questionnaire survey on 772 patent applications filed with the German Patent Office in 1977. As Figure 1 below shows, they find that 54% of the total value of these patents is concentrated in the 5 patents worth 50 million Deutsche Marks or more.

Figure 1. Distribution of Patent Values for 772 German Patent Applications filed in 1977, from Scherer and Harhoff (2000)



Second, the **value of a patent has to be thought of as the value of an asset**. In this respect, the value of a patent is the discounted sum of the yearly profits that the patent holder expects to earn because of the patent. This could be the annual profits from selling the products or the price of the license if the patent right is licensed out. The price of the license is correlated with the present value of the discounted stream of profits that the patent holder would earn without the license.

Most importantly, **the value of a patent is not the value of the patented invention, but of the patented invention net of the value of the invention if there was no patent on it**. Simply put, the worth of the patent depends on the difference between having the patent or not. Thus, for example, the value of the patent is the difference between the present value of profits on the invention when the inventor holds a patent right, and it is therefore likely to be a monopolist for that invention, and a competitive situation in which, with no patent, others could produce and commercialize products based on that invention. Similarly, the value of a patent is the different the price of a license if the inventor holds a patent or not.

Arora et al. (2003) call this the “patent premium”. The patent premium could be high. For example, competition may drive profits to zero, and therefore the value of the patent could be close to the full value of the invention. [See Box 1.]

Against this background, we estimated the value of patents by employing a unique and comprehensive dataset drawn from a large scale survey (PatVal-EU) of European patents with priority date 1993-1997 granted at the EPO in eight countries: Denmark, France, Germany, Hungary, Italy, Netherlands, Spain, and UK. [See Box 2.] These countries cover almost 90% of the EU-25 patents. Hence, the inferences made from

them are close to what we would expect from the entire population of EU patented inventions.

The PatVal-EU sample was drawn from a population of 50,236 patents with priority date in 1993-1997 (we refer to it as “the PatVal-EU population”).

Consistently with the view of patents as assets, PatVal-EU followed Harhoff, Scherer and Vopel (2003) and **asked the inventors the following question:**

“What is your best guess of the minimum price at which the owner of the patent would sell the patent right to an independent party on the day in which the patent was granted?”

Box 1: Value of Patents (“Patent Premium”)

The value of a patent is not the value of the patented invention.

It is the value of the invention when the inventor holds a patent net of the value of the invention when she has no patent on it. Thus for example, if the patent provides a monopoly on a new product, the value of the patent is the difference between selling the product under monopoly as opposed to selling it under competitive conditions. Arora et al. (2003) call this value the “patent premium”.

Moreover, the value of patent is the value of an asset. It is the difference between the discounted stream of profits since the grant of the patent when the inventor holds a patent and the equivalent discount stream of profits without the patent.

This is a measure of the present value of patents as assets because the price at which the patent owner is willing to sell the patent at the moment of grant reflects the present value of the discounted stream of profits obtained when holding the patent as opposed to not holding the patent.

We offered a menu of ten interval responses: less than €30K; 30-100K; 100-300K; 300K-1M; 1-3M; 3-10M; 10-30M; 30-100M; 100-300M; more than 300M.

We used this information to make predictions about the value of the 1993-1997 patents of the PatVal-EU population in our eight countries.

Moreover, as we shall see below, we developed some predictions for all patents granted at the EPO in 1994-2002 in the eight countries. The Appendix describes the methodology that we employed to make these inferences.

It is important to note that this is one of the very first attempts to measure the monetary value of patents and to estimate the total value of patenting by country. This is an area where evaluation and measurement are at a very crude stage compared to other areas

where economic indicators are widely available (eg. exports and imports or R&D investments). We did the best that could be done to estimate the value of patents with the data collected in the PatVal-EU survey. New data collections are thus crucial for setting up systematic indicators of the value of patents in additional years and countries.

Figure 2 reports the average and median value of the 1993-1997 patents of the PatVal-EU population in our eight countries. Several features of Figure 2 are worth noting:

- 1) The average value of patents is much higher than the median. This reflects a **very skewed distribution**. PatVal-EU produced a distribution of patent values similar to Scherer and Harhoff (2000).

Box 2: The PatVal-EU Survey

The PatVal-EU survey collected data on 9,962 patents (out of nearly 28,882 questionnaire submissions), including their value and a broad set of characteristics describing the context of the invention.

The sample was drawn from a population of 50,236 patents granted at the EPO. All patents in the PatVal-population have priority date 1993-1997, are granted by the European Patent Office, and they are such that the address of the first inventor listed in the patent is in Denmark, France, Germany, Hungary, Italy, the Netherlands, Spain or the UK.

The survey data are obtained from questionnaire responses produced by the first inventor or, if the first inventor was not available, by any other inventor on the patent whose address is in one of our six countries. Details of the survey for France, Germany, Italy, Netherlands, Spain and the UK are provided in Giuri, Mariani et al. (2006). For the specific research leading to this Report we added the survey for Denmark and Hungary following the same approach and methodology of the other six countries (see the Annex of the Technical Report of this Tender).

- 2) The **average patent value for our EU-8 countries is about 3 million euros**. This is a high value. However, as in Scherer and Harhoff, this average is produced by few very valuable patents. We computed the average value of patents in the Scherer and Harhoff sample, and obtained a figure of about 4 million Deutsche Marks, which is about 2 million euros. Since Scherer and Harhoff patents were applied for in 1977, it is reasonable that 1995-1997 patents are about 50% more valuable, given that the 1980s were a period of high inflation, and most importantly given the notable increase in the demand for patents since the 1980s. In brief, our estimates and those by Scherer and Harhoff are surprisingly close, which reinforces our confidence in them.

- 3) The **median value of patents is about 300 thousand euros**. When dealing with skewed distributions, the median provides a better estimate of the “typical” observation in the distribution.
- 4) Both **average and median values are quite similar across our eight countries**. In Section 5 we shall see that differences across industries in the average and median values of patents are more pronounced.

Figure 2. Average and median patent value by country, 1993-1997

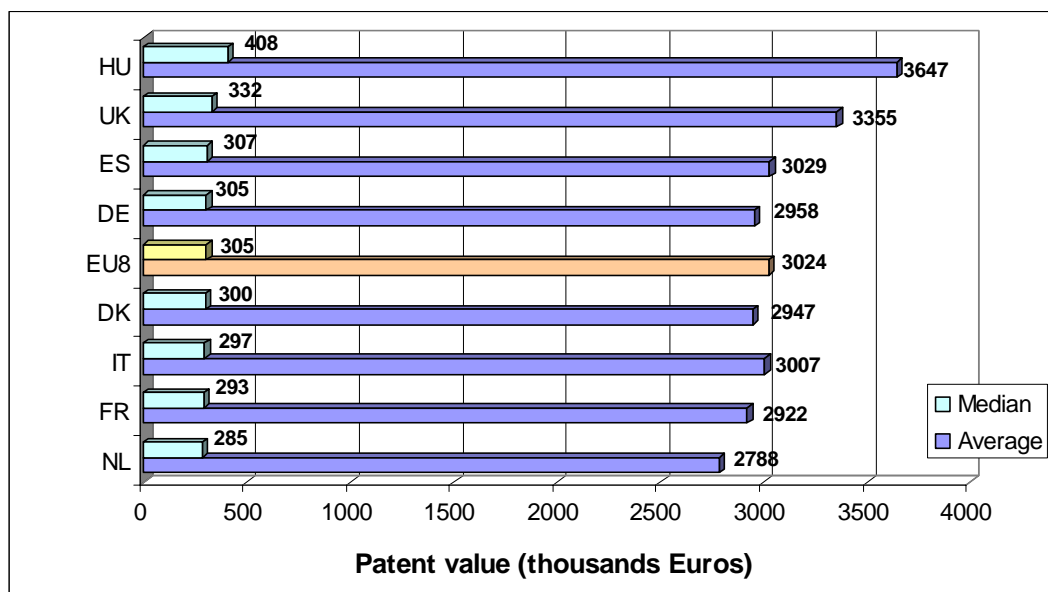


Figure 3 reports the aggregate value of patents as a percentage of the country GDP. Moreover, we made inferences on the aggregate value of patents, and its share of GDP, for all EPO patents granted in 1994-1996, 1997-1999 and 2000-2002. The Appendix discusses how we estimated the later shares. [See Box 3.]

Figure 3 shows that:

- 1) The **aggregate value of patents is around 1% of GDP for the EU-8**. This share is slightly smaller than the share of annual R&D investments on GDP (1.9% in 2000-2002 in our eight countries). However, many R&D-based innovations are not patented (and some patents may not be based on R&D). Moreover, as noted, the values that we are computing are not the values of the patented invention, but of holding a patent about them (the patent premium). As a result, our data in Figure 3 show that *the patent premium is high*. To put things in perspective, *1% of GDP is roughly the size of the software industry in these countries*.

- 2) **Germany exhibits the highest aggregate value of patents** among our EU-8. As a share of GDP, it increased from 1.4% in 1994-1996 to 2.1% in 2000-2002. Consistently, the share of R&D on GDP in Germany increased from 2.2% in 1994-1996 to 2.5% in 2000-2002.
- 3) **The aggregate value of patents has increased considerably in 2000-2002.** Moreover, since Figure 3 reports shares of GDP, the increase in these shares suggests that the value of patents has increased faster than GDP. Only in the UK the value of patents has decreased compared to GDP. Germany exhibits the highest increase in the share of GDP among the eight countries, which is intriguing given that Germany had the highest share of GDP in the initial period 1994-1996. Only Denmark and the Netherlands have kept the pace of Germany in terms of increase in the share of the value of patents on GDP.

Box 3: Inferences for 1994-1996, 1997-1999 & 2000-2002

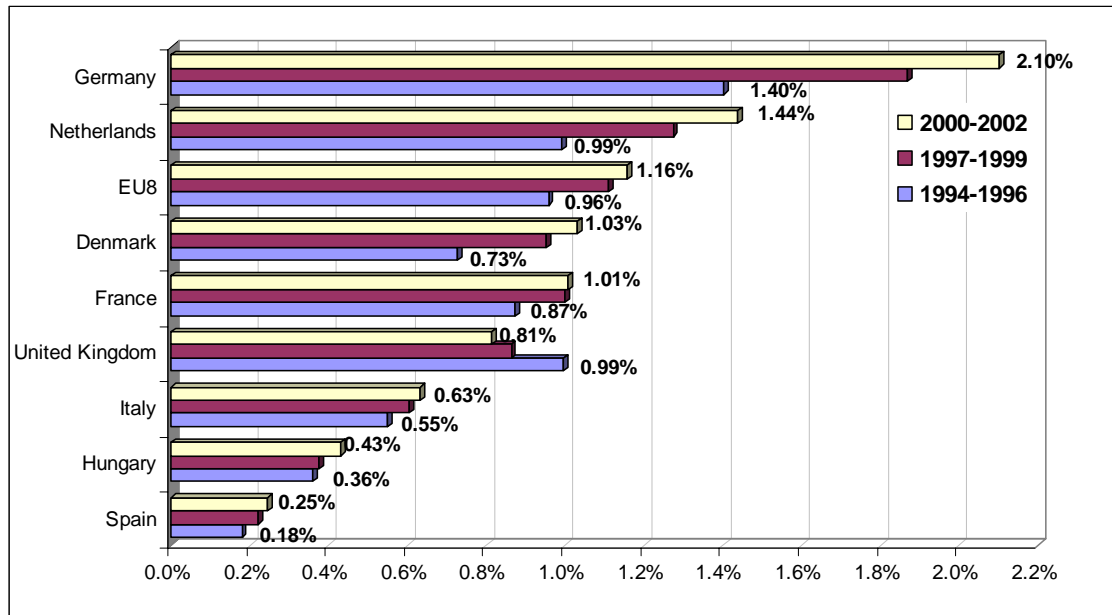
To infer the patent values for 1994-1996, 1997-1999 & 2000-2002 we employed the 1993-1997 average values by country and 30 industry classes obtained from the IPC 6-digit technological classes of the 1993-1997 patents of the PatVal-EU population. This conversion is based on the classification jointly elaborated by the German Fraunhofer Institute of Systems and Innovation Research (ISI), the French patent office (INPI) and the Observatoire des Science and des Techniques (OST) (Hinze et al., 1997).

Because of the time lag between date of application and granting of the patents, 2002 is the last available year with complete EPO data about number of patent applications (source: EPOLine and Eurostat data, June 2006).

The 1993-1997 country-industry values are multiplied by the number of all EPO country-industry patents in 1994-2002 to obtain an estimate of the total country-industry value. This is then summed up by industry to obtain the aggregate value by country, and by country to obtain the whole aggregate value for EU-8. The shares are then obtained by dividing by the appropriate GDP.

Thus, our predictions for 1997-1999 and 2000-2002 are based only on changes in the industry composition of patents within each country and not on changes in the average values. While this is an obvious limitation, it is however the best we could do to extrapolate information about the aggregate values of patents in future years, given that our key source of information, the PatVal-EU population, covered patents with priority date in 1993-1997. Even if we wanted to, it would have been hard to extend the PatVal-EU survey for later patents. First, later patents do not have complete data on forward citations, which is a key proxy for making inferences on patent values, as shown in the Appendix. Second, in the case of earlier patents the interviewed inventor may have more information about the patent value, while for recent inventions their estimates about the value might be subject to a greater error.

Figure 3. Value of patents / GDP by country



Finally, Figures 4 and 5 report the total value of all EPO patents in 1994-1996 and 2000-2002 for our eight countries. Figure 5 reports in parenthesis the growth rate between the two periods. Given that Germany, Denmark and the Netherlands start from high absolute values of patents, Figure 5 confirms that these are the countries in which the increase in the aggregate value of patents has been most pronounced.

Figure 4. Total value of patents by country, 1994-1996

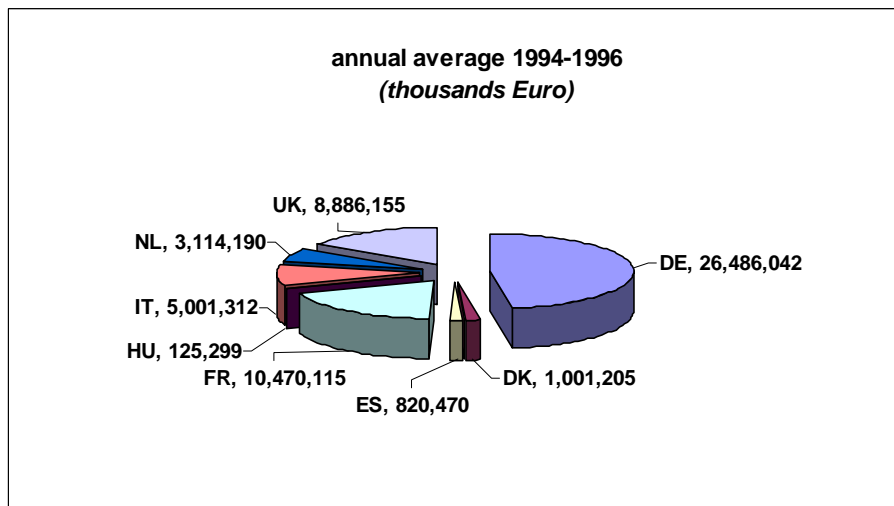
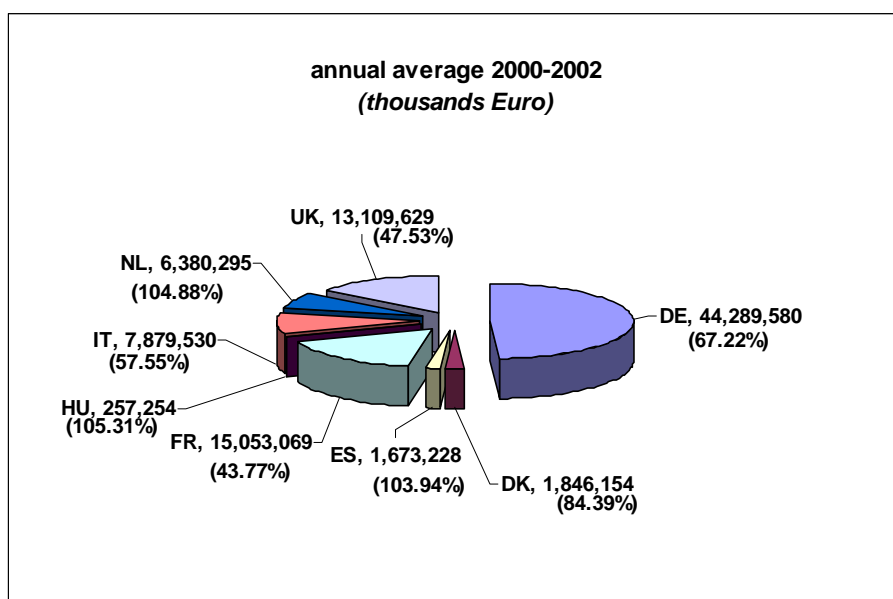


Figure 5. Total value of patents by country, 2000-2002



Note: growth rates between 1994-1996 and 2000-2002 in parenthesis

3. ECONOMIC AND SOCIAL IMPACT OF PATENTS IN THE EU

3.1 Use vs. Non-Use of Patents

An important question about patents is the extent to which they are actually used for economic purposes. Before this research, there was only limited information on the matter.

A survey of the Japanese Patent Office (JPO) found that 64% of their patents were not used (Motohashi, 2004; see also Nagaoka, 2003, and JPO, 2004). Since patents are reservoirs of potential innovations, an increase in the rate of their utilization has social benefits. The JPO survey also found that the share of unused patents is higher in larger firms (more than 70%) than in small-medium firms (about 55%).

According to another survey of European, North American and Japanese firms (BTG, 1998) the share of unused patents covers more than 35 % of the patent portfolios of the surveyed firms. Furthermore, nearly two-thirds of such organizations have some unutilized patents, and one in eight has at least 1,000 patents in excess.

In this research we employed the PatVal-EU questionnaire to address this issue. Specifically, **PatVal-EU asked our inventors whether:**

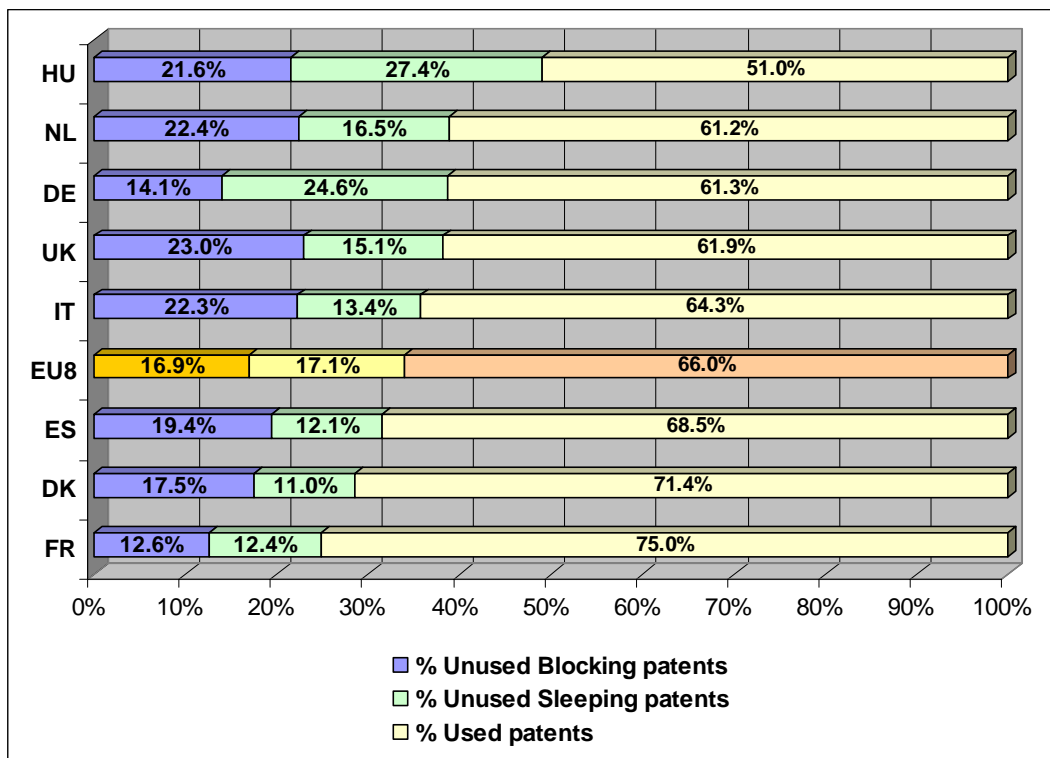
- i) *the patent was used* internally by the patent owner for industrial or commercial purposes;
- ii) *if not, whether it was licensed* to third parties.

A negative answer to both question indicated that the patent was unused. Figure 6 reports our estimates of the shares of patents used in the 1993-1993 PatVal-EU population of European patents. The Appendix describes the methodology that we employed to obtain these shares from the PatVal-EU sample responses.

PatVal-EU also enabled us to distinguish between “blocking” and “sleeping” patents. The former are patents that are neither used internally nor licensed, but that are meant to block some rivals from using the technology. The latter are instead unused patents that are simply left unexploited, but that are not deemed strategic in any respect by the patent holder. [See Box 4.]

Figure 6 also distinguishes whether the unused patents were blocking or sleeping. Clearly, sleeping patents are the most amenable to potential use. Since blocking patents are meant to prevent rivals from using the technology, it is less likely that the owner is willing to use them if encouraged to do so, or at least the incentives to use them have to be more substantial. By contrast, since sleeping patents are simply “forgotten”, they may be used by the owner or other parties if given a simple and not costly option to do so. Blocking patents are of course a quite sensitive issue, as the borderline between them and anticompetitive behaviour can be blurred. It is therefore important to understand how large is the share of blocking patents.

Figure 6. Share of unused patents by country, 1993-1997



According to Figure 6, in 1993-1997 34% of our EU-8 patents were neither used internally nor licensed. This is a sizable figure, even though smaller than the JPO prediction for Japan, and similar to the BTG research. Yet, it is not unfair to say that such high rates of underutilization of patents call for actions to increase the use of patents and therefore raise their economic impact and social value. We also find that for the EU-8 sleeping and blocking patents were roughly equal, around 17% each.

Across countries, Hungarian patents are the least likely to be used among our EU-8. A potential reason is that in relatively less advanced country patents are less valuable, and hence less useful. Yet, Figure 2 in the previous Section showed that both the average and median value of the Hungarian patents is not lower than other countries. We do not think that Hungarian inventors have inflated the values of their inventions. We rather believe that in a country like Hungary the costs of applying and maintaining patents may be higher than elsewhere because of the lack of experience in patenting, and of legal offices and structures for managing the patent process (e.g. compare with the patenting experience of countries like Germany, the UK, or the Netherlands). As a result, Hungarians may patent only valuable inventions, which is consistent with what we observe in Figure 2.

Box 4: Blocking vs Sleeping Patents, PatVal-EU definition

The PatVal-EU survey asked the interviewees to provide an answer on a 1-5 scale (1 = not at all; 5 = yes, sure) on whether the patent was used to block rivals.

In Figure 6 we defined blocking patents as patents that were not used (neither internally nor licensed) and that reported an answer 4 or 5 to the question whether the patent was used to block rivals.

Sleeping patents are patents that were not used and that gave answers 1-3 to the question about blocking rivals.

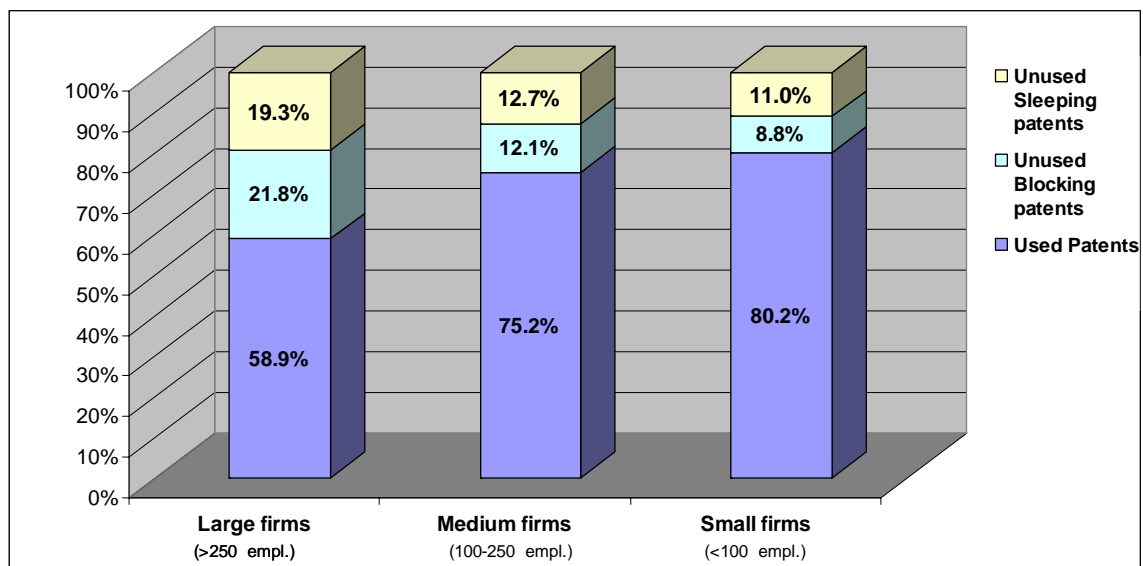
Thus, we are more inclined to think that the high rate of underutilization of Hungarian patents mirrors the fact that the resources for developing inventions are often much more sizable and costly than those that are required for concocting the initial idea or prototype. As a result, in a relatively less advanced country, even when inventions are produced, the lack of resources or innovation development capabilities more generally, stifle the utilization of patents. Figure 6 also shows that the share of underutilization of patents in Hungary is determined largely by the sleeping, and not blocking, patents. Thus, underuse is not strategic in Hungary, but most likely it is produced by the relative inability to raise resources for innovation development, which induces the inventors to shelve their patents.

Among the large countries, Figure 6 shows that Germany, the UK and the Netherlands exhibit a relatively lower use of patents than France. Interestingly, in Germany the underuse of patents is explained to a greater extent by sleeping patents, while in the UK and the Netherlands there is a greater share of blocking patents.

Since the use of patents is an important aspect of their social and economic impact we also conducted a systematic econometric study of the determinants of patent use. (See Study A2.2 of the Technical Report of this Tender.) This study finds that the most important factor in affecting the use of patents is firm size, viz. other things being equal, large firms have a far higher share of unused patents than small-medium firms.

This is also shown in Figure 7 where we report the share of use vs. non-use of patents (including blocking and sleeping) in the PatVal-EU sample. We employ the standard EU definition of small-medium enterprises, viz. large firms have more than 250 employees, whereas medium firms have 100-250 employees and small firms have fewer than 100 employees.¹ As the Figure shows small firms use about 80% of their patents, medium firms use about 75%, while large firms use only 59%. Moreover, the large firms have a high share of blocking patents compared to their sleeping patents. The latter however also cover a rather high share of the unused patents of large firms.

Figure 7. Share of unused patents by firm size



¹ Unfortunately, we do not have information on the number of employees for the entire population of PatVal-EU patent applicants in 1993-1997. As a result, we cannot make inferences for the population as we did in the previous figures. However, the PatVal-EU sample is a good predictor of the population shares because it is a stratified sample with only a minor oversampling towards important patents. See Giuri, Mariani et al. (2006) for details. Also, in the PatVal-EU sample we grouped firms by their ultimate parent. Thus, we are genuinely distinguishing between firms of different size, with no potential confusion produced by the presence of subsidiaries.

There are two main reasons why smaller firms are more likely to use their patents. First, firms with larger R&D budgets produce by-product and non-core innovations that are patented but not used. Second, larger firms have lower marginal costs of patenting because of internal legal or even IP or licensing departments. Thus, they also patent innovations that they do not use. By contrast, small firms face greater costs of patenting. Hence, if they patent, it is because they plan to use the innovation and enjoy returns from it.

This also suggests that the reason why larger firms have a lower utilization rate of patents is in good part physiological to the nature of these firms. To be sure, part of the reason why they do not use patents is because they have a greater propensity to patent for strategic reasons. However, the by-product reason noted above is also relevant, and it is a source of potential benefits for society. More generally, in spite of their high share of blocking patents, large firms still exhibit a sizable share of sleeping patents. This suggests that the reservoirs of inventions, and particularly of by-product inventions, that they produce are potentially usable. We shall see in the next section that this is one of the main sources of potential patent licenses.

Our econometric study found other determinants of the use of patents. Most notably patents are more likely to be used if:

- the **users** are an important source of knowledge of the patented invention – this confirms the importance of users for producing inventions that are more likely to be utilized and to produce economic returns
- the patents are **less science-based** – as implied by the natural distance between more scientific research and applications
- the patents are more **valuable** – as implied by the higher opportunity cost of leaving them unexploited
- the applicant operates in a more **competitive environment**, as defined by the number of different applicants in the same IPC-4 digit patent class.

However, our study also shows that while these factors can affect the rate of use of patents, the **most important effect is by far the firm size effect** that we discussed earlier, viz. unused patents are mostly large firm patents. This is therefore where one should direct policies for enhancing the use of patents. We shall summarize some of these policies in the final section. As a related point, we found that blocking patents are not more valuable than sleeping patents. This is important for policy as it suggests that sleeping patents are not necessarily left unused simply because they are less valuable. [See Box 5.]

Box 5: Factors Affecting the Use of Patents

FIRM SIZE: This is by far the most important factor. Large firms are repositories of unused patents. (See Figure 7.) This is partly physiological as large firms produce by-product inventions from their large R&D budgets, and have lower costs of patenting because of experience, resources, administrative structures dedicated to patenting. Though they have a higher share of blocking patents, large firms also exhibit a sizable share of sleeping patents, which reinforces the view that their patents could be used, if anything by others.

OTHER(MINOR) FACTORS: users as source of knowledge; applied (less scientific) technologies; patent value; competition.

3.2 Licensing and Technology Markets

Patent licensing and technology markets can be important means for increasing the rate of utilization of patents. Other strategies are unlikely to achieve this goal. For example, because small firms use a higher share of their patents, one may think of reducing the patenting costs of small firms, or of other policies for increasing their rate of patenting, which would amount to a reduction in their patenting costs. Yet, this would only encourage the small firms to patent less valuable patents, which are less likely to be used. As noted earlier, small firms use more patents because they patent only valuable inventions, given that they face a higher cost of patenting. Thus, lowering their patent costs may only lower their patenting threshold, with implied patenting of less valuable inventions, which are in turn less likely to be used.

In principle, if the small firms had the same costs of patenting of the large firms they may end up having the same utilization rates. The point is that to enhance utilization, one has to intervene directly on it, and not on the cost of patenting. Lowering the transaction costs of patent licensing can then be an effective policy target in this context. It is probably more effective than enhancing the internal exploitation of patents by the applicant organization because if a patent is valuable the applicant is likely to exploit it. By contrast, we know that transaction costs in technology trade are high, as shown by Razgaitis (2004) who reports survey evidence about the fact that the willingness to conclude a licensing can encounter several impediments, like inability to find the right buyer, lack of standard contracts for technology exchange which raises the costs of contracting or the risks of opportunism by the parties. In turn, this suggests that there is room for increasing the use of patents by reducing such transaction costs. Moreover, because the large firms have lower utilization rates, policy actions to enhance the use of their patents are likely to be most effective compared to the small firm patents, as they already exhibit a higher rate of utilization.

To summarize, a higher rate of utilization of patents by the smaller firms is a natural feature of the patent system because they face higher costs of patenting, and therefore

they patent more valuable inventions which are more likely to be used. However, this does not mean that we can increase the utilization of patents by making it easier for the smaller firms to patent. Policy has to target the use of patents by agents other than the owners of these patents. Since the assignees will most likely use their valuable patents, it is harder to increase the rate at which they exploit their own patents. By contrast, lower transaction costs may help find other users uncovering potential gains from trade. This set of remarks is reinforced by our earlier observation that a good deal of unused patents are dormant patents rather than strategic ones, which is also true of the large firms. As a result, these patents are likely to be sold if the assignee is given the option to, at relatively low transaction costs. [See Box 6.]

To discuss the extent of patent licensing in Europe, we employed our PatVal-EU survey. **PatVal-EU asked the inventors to indicate whether:**

- a) they were *willing to license* the patent to an independent third party if they were asked to;
- b) if so, whether they *actually licensed* the patent

Box 6: Unused Patents, Technology Markets, and Transaction Costs

The high rate of unused patents calls for strategies for increasing their use.

Patent licensing and technology market can be important means for achieving this goal, and therefore increase the economic and social impact of patents.

Other strategies are unlikely to be as effective. For example, reducing the patent costs, or encouraging patents by small firms, which have higher utilization rates, would only encourage them to patent less valuable inventions, which are less likely to be used.

In turn, since technology trade is hindered by serious transaction costs, an effective intervention to encourage patent licensing, and to increase the use of patents, is to remove such transaction costs.

Standard contracts for technology trade, better means for matching technology demand and supply, venture capitalists and the growth of intermediaries in technology trade would be typical means for achieving this goal.

Moreover, since large firms are important repositories of unused technologies, a related important means for enhancing the use of patents is to encourage the trade of large firms unused patents, as also argued by Rivette and Kline (2000).

By the same methodology employed in the previous sections, and discussed in the Appendix, we used the shares in the PatVal-EU population of 1993-1997 patents to extrapolate the shares of

- i) *licensed* patents

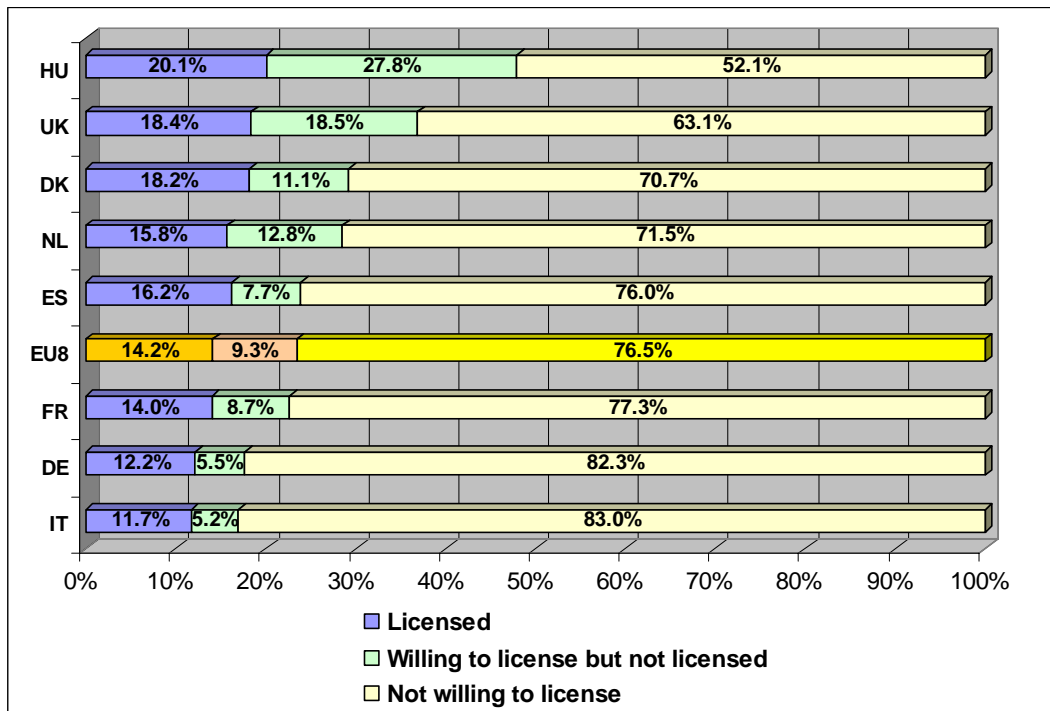
ii) *willing-but-not-licensed* patents

iii) *not-willing-to-be-licensed* patents

Figure 8 reports these shares. We estimated that for the EU-8 23.5 % of patents are willing to be licensed but only 14.2% are actually licensed. This suggests that there is a notable potential for expanding technology licensing in Europe, and most likely for enhancing in this way the use of patents. If the willing-to-be-licensed patents were all licensed, the EU-8 market for patents would increase by more than 50%.

Figure 8 also shows that both licensing and willingness to license are least pronounced in Germany and Italy, followed by France and Spain. Spain however has a relatively high share of actual licensing, close to the Netherlands, Denmark, and the UK, which also have rather high shares of willingness to license. In particular, the UK has the highest share of actual licenses and willingness to license after Hungary.

Figure 8. Share of licensed patents by country, 1993-1997



All in all these results suggest that there is a UK and a German model that appear to be at somewhat opposite extremes. In the former there is a rather active market for patent, which in turn suggests that institutions for technology trade exist, and the transaction costs in technology trade are relatively low. By contrast, in the German model patent licensing is less common, with implied lower effort to create institutions supporting these markets. Italy and France seem to be closer to the German model, while Denmark

and the Netherlands appear to be more similar to the UK model. Spain seems to be moving towards the UK model.

Even though the Hungarian licensing figures are based on a small sample, they are consistent with our earlier discussion that in relatively less advanced countries inventors may lack the costly assets and resources to develop innovations. As a result, they are more willing to license their patents. To be sure, as we shall also discuss in our concluding section, this is suggestive of the fact that markets for technology may become particularly important for enhancing innovation capabilities in less advanced countries. Once they have the ability to develop initial ideas or technology, it may not be profitable to make costly investments in downstream assets. They may have to build from scratch, and the country may not have comparative advantages in this activity. It may be rather more efficient to become active suppliers in the world or continental technology market. Israel and Ireland have been forerunners of this strategy, which may provide a good benchmark for some of the New Member States. [See Box 7.]

Box 7: Technology Markets in Europe

Germany and the UK represent two different models of patent licensing, which is relatively low in the former and high in the latter.

Italy and France are closer to the German model, while Denmark and the Netherlands are closer to the UK model. Spain seem to be moving towards the UK model.

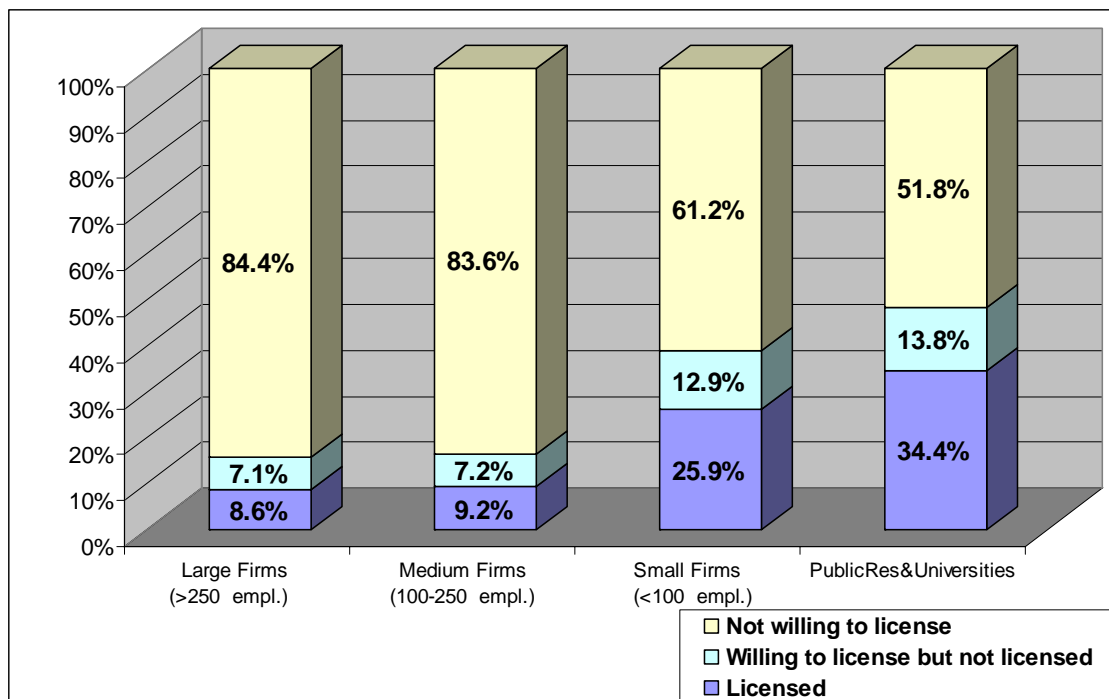
The high shares of licensing in Hungary suggests that becoming active suppliers in technology markets can be an interesting strategy for some New Member States. They lack resources and experience for costly downstream innovation development investments, and they may not have comparative advantages in these activities. Active technology markets may help them gain rents from patented inventions in specific technological areas in which they are specialized. Israel or Ireland are good benchmarks.

As far as applicant types are concerned, licensed and willing-to-be-licensed patents reflect what we observed in patent use, viz. large firms license and are willing to license a smaller share of their patents. We could not extrapolate these shares for the entire population of PatVal-EU patents because we do not have information on the applicant types for the entire set of 1993-1997 EPO patent applications. However, Figure 9 reports the shares of licensed, willing-to-license, and unwilling-to-license patents by type of applicant for the PatVal-EU sample. As the Figure shows, small firms are willing to license 38.8% of their patents against 16.4% and 15.7% by the medium and large firms. Moreover, the small firms actually license 25.9% of their patents with respect to 9.2% and 8.6 by the other two types. As expected, Figure 9 also shows that

public research organizations exhibit the largest shares of willingness to license and actual licenses.

The reasons why smaller firms have a higher propensity to license is quite natural. The ability to further develop innovations depends on whether the applicant has adequate downstream assets, and in this respect large scale downstream assets can often provide important advantages in terms of static and dynamic economies of scale, or economies of scope. While this has the obvious implication that larger firms have greater incentives to use their patented inventions internally, it also raises the important issue that smaller firms, and particularly start-ups and spin-offs, can be important vehicles for innovation and competitiveness. In this respect, as noted earlier, patents encourage the founding of these firms, and their investment in innovation. Since they typically lack other assets to protect their innovations, particularly downstream assets, legal mechanisms for appropriating inventions, like patents, can be crucial for obtaining returns from their innovations. They can be the only means to ensure such returns. As a result, patent may encourage these firms to be founded, invest in innovation, and sell them to other parties that may be more suited to develop them on a large scale. This “division of innovative labour” based on comparative advantages in different stages of the innovation cycle can be quite beneficial from a social point of view. The PatVal-EU shares in Figure 9 are consistent with these remarks.

Figure 9. Share of licensed patents by type of organisation



To provide a more thorough assessment of the determinants of the willingness to license, and the actual licenses, of the patent applicants, in this research we also performed a detailed econometric study based on the PatVal-EU data. (See Study A2.1 of the Technical Report of this Tender.) **The results of this study can be summarized as follows:**

- They **confirm that firm size is the most important determinant of licensing**. A patent owned by a large firm has a much lower probability of being licensed.
- The **probability of licensing increases** when
 - *patents provide more protection* – better protected patents are more likely to produce rents for the licensor because they prevent imitation or opportunistic behaviour of the buyer who may use the knowledge without paying a price for it
 - *the underlying knowledge is more codified* – in this case patents identify more clearly the object of the transaction, which reduces contractual ambiguities and related transaction costs in technology trade
 - *the patent is of greater economic value* – as less valuable patents have more limited demand.

However the impact of these factors is smaller than firm size.

- **All the factors above significantly affect the willingness to license, but only a few of them affect the probability that the licensing event occurs**. As a result, the determinants of the actual probability of licensing are more subtle.
- Most interestingly, the study finds that **the willing-but-not-licensed patents are not less valuable than the patents that are actually licensed**. This rules out that the willing-but-not-licensed patents are just marginal and less important inventions, and this is why they are not licensed. The most serious alternative explanation is that they are not licensed because these patents face **transaction costs in technology trade** (e.g. inability to find buyers, contractual ambiguities).
- **Large firms are less likely to license even when they are willing to do so**. The probability that a large firm offers a patent for licensing is about 20% lower than a small firm, while the conditional probability of an actual license given that the firm is willing to license it is about 14% lower.

These findings suggest a number of **relevant issues** that can form the basis for some policy implications aimed at enhancing technology markets, and therefore a greater use of patents:

- First, we find that **there are transaction costs in markets for technologies** that prevent a licensing agreement from being concluded. Policy should remove the obstacles that prevent the rise of supporting institutions and intermediaries in the

markets for technology, or should support their formation when they have difficulties emerging. Moreover, especially at their outset, markets are not very good at providing the economic agents with the right incentives to coordinate in order to create such institutions (e.g. proposing legal standards for technology contracts). Policy can sustain or accelerate this coordination.

- Second, **markets for technology expands when there is technological entrepreneurship**, when the environment is germane to the formation of smaller technology-based firms, and more generally when there are smaller technology specialists that find it profitable to sell the technology rather than investing in the downstream assets to become a fully-fledged final producer. Policies that favour the formation of technological entrepreneurship, or that sustain technology-based small firms, may have the additional advantage of raising the economic use of patents.
- Third, **not only are the large firms less willing to license their technologies, but they are also less likely to license when they choose to put their technologies in the market**. From a policy perspective, these impediments are less straight forward to remove compared to the previous ones. The large firms are repositories of under-utilized technologies. Their willingness to license may increase if licensing becomes a profitable opportunity. Policy cannot do much to increase the actual licensing rate of large firms without important changes in the way they deal or organize their licensing business. Our finding suggests that just putting the technologies of large firms into the market is not enough. It has to be accompanied by a more systematic assessment of licensing as a business, and a careful definition of the strategies and the organizational models that can make it into a profitable economic activity.

To conclude our analysis of licensing and technology markets in Europe, it is worth **assessing the actual and potential size of the market for patents in Europe in monetary values**.

The *actual market* is the one based on the actual licensing, while the *potential market* includes the patents that are not licensed but that the applicant is willing to license.

Details of the methodology by which we calculated the monetary values of licensing for all EPO patents in 1994-1996, 1997-1998, and 2000-2002 are given in the Appendix. [See Box 8.]

Box 8: Estimating Value of Licenses, 94-96, 97-99, 00-02

To infer the monetary values of licenses we first computed the probability that any given patents in the PatVal-EU population of 1993-1997 patents for our EU-8 is licensed or there is willingness to license, as described in the Appendix. For each country-technological class patent, we then multiplied the estimated value computed in Section 2 by its estimated probability of licensing or willingness to license. (For the PatVal-EU patents we employed the dummy equal to 1 if the patent was actually licensed or there was willingness to license, and zero otherwise – that is we exploited the actual information that we had on those patents.)

For all EPO patents in 1994-1996, 1997-1999 and 2000-2002 we used the share of licenses or willingness to license in each country-technological class to predict the number of licenses or willing-to-license patents in that class, and multiplied them by the average patent values for each country-technological class. This means that our predictions of the values of the actual and potential market for patents for the later years depend only on changes in the composition of patents according to country-technological classes, and not on changes of the patent values or the share of licensing in each country-technology cell. However, for the reasons discussed in Box 3, this was the best way to obtain these predictions.

Table 1 reports our **estimate of the size of the market for patents in Europe** in 1994-1996, 1997-1999, and 2000-2002. Our estimate of this market for the EU-8 countries is 9.4 billion euros in 1994-1996, 12.7 in 1997-1999, and 15.6 in 2000-2002, which correspond to 0.16%, 0.19%, and 0.20% of GDP, and a total growth between the third and the first period of 65%. By any standard this suggests that the market is sizable and growing. Moreover, the potential market has grown from 14.8 to 24.4 billions. As noted earlier, the potential market suggests that there are notable untapped opportunities for enhancing the market for patents in Europe, and correspondingly for using this means in order to increase the rate of utilization of patents.

Table 1. Value of the Actual and Potential European Market for Patents

	1994-1996	1997-1999	2000-2002	1994-1996	1997-1999	2000-2002
	Value of Market for Patents annual average, thousands Euros			Value of Market for Patents share of GDP		
DE	4,011,921	5,648,377	6,888,072	0.21%	0.29%	0.33%
DK	235,761	358,418	451,658	0.17%	0.23%	0.25%
ES	161,137	231,844	336,455	0.04%	0.04%	0.05%
FR	1,794,026	2,270,936	2,619,226	0.15%	0.17%	0.18%
HU	26,225	30,768	50,388	0.08%	0.07%	0.08%
IT	724,385	960,290	1,171,929	0.08%	0.09%	0.09%
NL	577,446	854,525	1,178,859	0.18%	0.24%	0.27%
UK	1,898,447	2,398,219	2,887,333	0.21%	0.19%	0.18%
EU8	9,429,348	12,753,377	15,583,921	0.16%	0.19%	0.20%
	Value of Potential Market for Patents annual average, thousands Euros			Value of Potential Market for Patents share of GDP		
DE	5,674,704	7,974,081	9,754,762	0.30%	0.41%	0.46%
DK	355,690	541,717	687,091	0.26%	0.35%	0.38%
ES	239,702	339,797	501,670	0.05%	0.06%	0.07%
FR	2,800,123	3,542,511	4,098,987	0.23%	0.27%	0.27%
HU	62,571	77,572	134,307	0.18%	0.18%	0.22%
IT	1,031,054	1,369,557	1,668,952	0.11%	0.13%	0.13%
NL	995,162	1,479,591	2,038,278	0.32%	0.41%	0.46%
UK	3,620,035	4,561,443	5,491,941	0.40%	0.36%	0.34%
EU8	14,779,041	19,886,269	24,375,989	0.25%	0.30%	0.31%

3.3 Patents to create new companies, and implications for employment

A recent survey of *The Economist* (October 2005) dedicated to the “market for ideas” noted that many start-ups adopt business models that use patents as core assets. Quite often a patent, or possibly a group of patents, is the key element around which a start-up organizes its entire business.

Moreover, when intellectual property rights are strong and well enforced, new companies are more likely to start-up because they can specialize in developing the technology and selling it to other firms, without incurring the much higher costs and risks of investing in the large scale assets for production and commercialisation.

Understanding the entrepreneurial process spurred by patenting activities is crucial for European competitiveness, since the rate of formation of new technology-based firms is much higher in the US than Europe (European Commission 2001, 2002). Moreover, entrepreneurship has a crucial role as generator of jobs, and as a major driver for innovation, competition and economic growth.

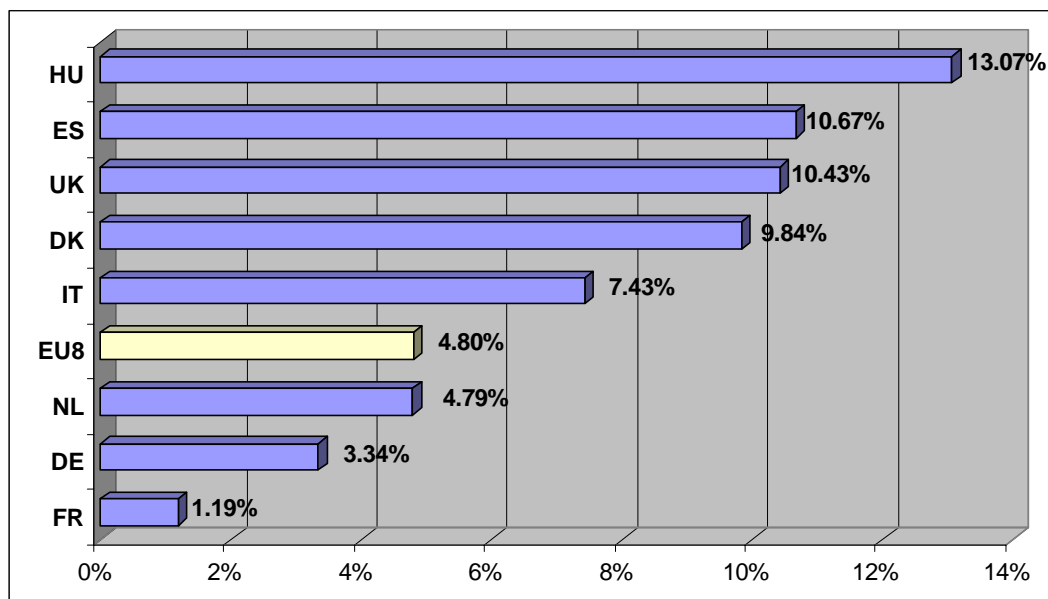
We employed the PatVal-EU survey to assess the extent to which patents encourage the formation of new firms. PatVal-EU asked the inventors whether the patent was

employed to start a new venture. We estimated the probability that any given patent was used to create a new firm in the PatVal-EU population of 1993-1997 patents. (See the Appendix for methodological details.)

Figure 10 reports that on average 4.8% of the patents have been used for starting a new venture. Although the share of new firms is not huge, it produces important economic and social benefits because this also contributes to increase the rate of economic use of patents.

Differences across countries are marked. The share of new firms is only 1.2% in France and 3.3 % in Germany. It is instead larger than the average in all the other countries, which is symptomatic of a more favourable environment to the formation of new firms. Moreover, smaller countries spawn a large share of spin-offs: about 13% in Hungary, 10.7% in Spain, and 9.8% in Denmark. The UK is the most prolific large country with 10.4% of patents that generate new technology-based firms. These differences suggest that the creation of new firms require suitable institutions that are present in certain countries, and less so in others.

Figure 10. Share of new firms by country, 1993-1997



For a more comprehensive assessment of the process of formation of patent-based new firms, we carried out an econometric study on what determines the use of patents to form new firms. (See Study B1.1 of the Technical Report of this Tender.)

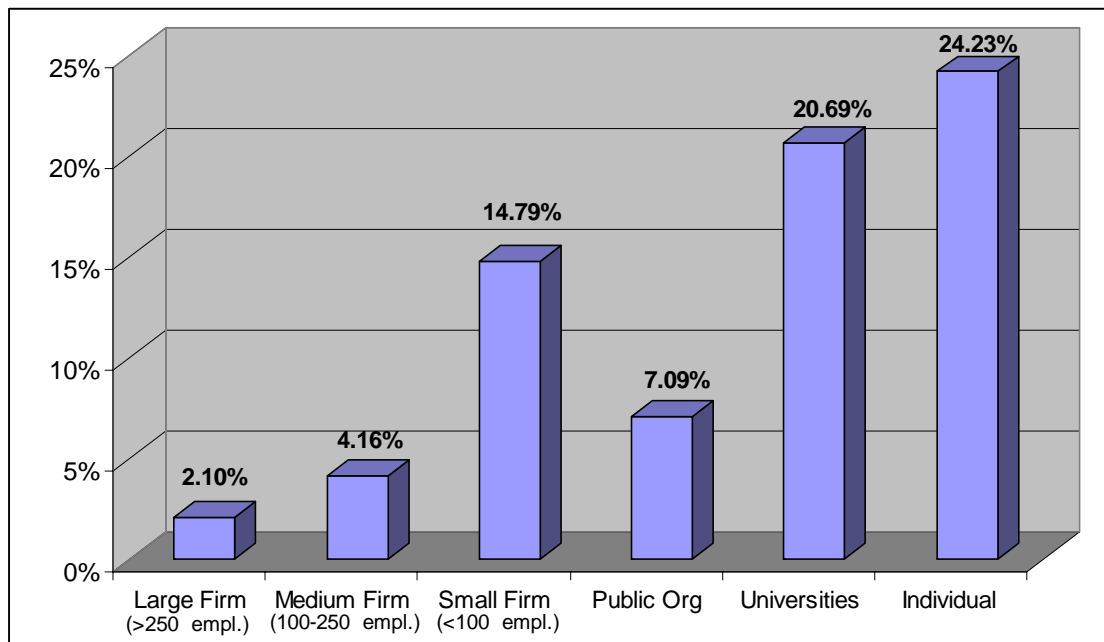
The most important findings of this study are the following:

- **Small firms and individual inventors are the largest contributors to entrepreneurial activities based on patents.**

- **The share of spin-offs spawned by large firms is the lowest.** Large firms still contribute significantly to entrepreneurship in absolute term because of their large number of patents in the population – viz. one-third of the total number of new companies. Typically large firms contribute to new venture through the patenting of non-core technologies.

The role of large firms can also be observed in Figure 11, which reports the shares of the creation of patent-based new firms by type of applicant. Only 2.1% of the patents of large firms are the base for a spin-off company. The creation of new ventures by medium firms is only slightly larger (4.2%), while the share of new patent-based ventures from small firms is much larger, 14.8%. This corresponds to about 28% of the total number of new ventures.

Figure 11. Share of new firms by type of organisation



Individual applicants exhibit the largest share of patents giving rise to new firms, 24.2%. If we sum the new ventures by SMEs and individuals we obtain a higher number of patent-based new ventures in our sample (189) than in the case of large firms (111). Clearly, some of the individual inventors might have been employed by a larger company in the past. However, what matters for our analysis is the applicant of the patent, and we find that only 2.1% of the patents whose applicant is a large firm are used to found a new company, while this percentage is higher when the patent applicant is an SME or an individual. In short, the system of smaller firms is relatively more active than large firms in using patents to form new companies.

As expected, we also find that the share of new ventures from public research organisations is notable, with a predominant role of Universities (20.7% of patent-based new firms) with respect to other public research institutions.

Other relevant findings of our econometric study are the following:

- **Patent-based entrepreneurship is more likely when patent protection is broad.** This is consistent with the view that patent protection may be relatively more important for smaller companies, which have no other means to protect their inventions. With patents, these companies are encouraged to form new technology-based firms.
- **Geographical proximity *per se* does not foster entrepreneurial activities.** By contrast, interactions with external agents may produce positive spillovers. For example we found that interactions with research labs, with unaffiliated partners funding the inventions, or the affiliation to a non-domestic European company positively affect the formation of new ventures. The latter can be thought of as spillovers potentially created by multinational companies.
- **Germany, France, Italy, and the Netherlands (viz. largely Continental Europe) are far less likely to spawn new firms from patents than the UK or Denmark.**

Our results finally suggest that the growth of small technology-based firms can have reinforcing effects because they are more likely to spawn new firms. However, because large firms have many patents, the number of new firms from their patents can ultimately be sizable. Thus, both large and small firms, even though for potentially different reasons, can give rise to a good number of technology-based ventures from their patents. [See Box 9.]

Box 9: Determinants of Patent-Based New Firms

FIRM SIZE: Small firms and individual inventors have the highest probability of spawning new firms from a patent. Large firms have the lowest probability. However, because they own the largest share of patents in the population, their absolute contribution to the creation of new ventures is sizable, i.e. almost one third of the total number of new companies.

COUNTRY: The UK and the smaller countries generate a larger share of new firms than countries in Continental Europe (Germany, France, Italy and the Netherlands).

OTHER FACTORS: Broad patent protection, interactions with research labs, external investors, multinational companies.

To finally assess the magnitude of the economic impact of new firms, we estimated the total value of the patents generating the new firms and the contribution of new firms to

total employment. The methodology for these assessments is described in detail in the Appendix. [See Box 10].

Box 10: Estimating Value and Employment of New Firms, 94-96, 97-99, 00-02

To infer the number of patent-based new firms in 1994-1996, 1997-1999 and 2000-2002 and the monetary values of these patents we first computed the probability that any given patents in the PatVal-EU population of 1993-1997 EPO patents for our EU-8 is employed to start a new venture, as described in the Appendix. For each country-technological class we multiplied the value computed in Section 2 by its estimated probability of starting a new venture. (For the PatVal-EU patents we employed instead the dummy equal to 1 if the patent was actually employed to start a new venture, and zero otherwise)

For all EPO patents in 1994-1996, 1997-1999 and 2000-2002 we used the share of new firms in each country-technological class to predict the number of new firms, and multiplied them by the average patent values for each country-technological class. Our predictions are then subject to the same caveats discussed in Box 3, viz. number and values of new firms depend only on changes in the composition of patents according to country-technological classes, and not on changes of the patent values or the share of new firms in each country-technology cell.

To infer the contribution of new firms to total employment we used the average number of employees of new firms in each country reported in Bartelsman et al. (2003). We multiplied the number of new firms by their average size for the country to obtain the total number of employees generated by new firms in that country. Not all new firms survive in the long run. Bartelsman et al. report that 67% of the new firms in the manufacturing sector survive after 4 years. To reflect the long-run contribution to employment we discounted by this percentage the total employment by new firms.

Table 2 reports the total monetary value of the patents generating new firms in all EPO patents in 1994-1996, 1997-1999 and 2000-2002 by country. While this is the value of the patent, we are probably not far from the value of the new firms created from the patent. This is because the patent plays a crucial role in their creation. Without the patent the firm would probably not be created. Thus, the answer to the PatVal-EU question about the price at which the patent owner is willing to sell it is very much a question about the price at which she would sell the company. Since the latter may also have some few other assets, these values are probably just slight underestimates of the value of the companies. For the EU-8 we obtained an aggregate value of about 3.2 billion Euros in 1994-1996, 4.4 billion Euros in 1997-1999 and 5.4 billion Euros in 2000-2002. The value as a share of GDP is on average 0.6% in the first two periods and 0.7% in 2000-2002.

Germany has the largest total value of patents by new firms in absolute terms, although as noted earlier the share of new firms from patents is quite small. This mainly depends on the large number of patents in Germany. It is also possible that in countries where it

is harder to create these companies only more valuable companies are formed from patents. Denmark and the UK exhibit the largest share of the total value of new firms on GDP (respectively 0.13% and 0.10% in 2000-2002).

Table 3 shows the estimated number of new firms from patents in the three periods, our prediction of the total employment of these new firms in the same periods, and the contribution to total employment in the manufacturing sector.

The annual average number of new firms grows from 864 in 1994-1996 to 1465 in 2000-2002. In absolute terms, Germany, UK and Italy are the largest generators of new firms, and relatedly of new jobs. On average patent-based new firms created 8,625 jobs in 1994-1996, 11,853 in 1997-1999 and 14,452 in 2000-2002. In 2000-2002 the jobs generated by patent-based new firms represented 0.04% of total employment in the manufacturing sector. The largest contribution to employment is in Denmark and the UK (0.14% and 0.09%).

Broadly speaking, the employment figures are not impressive. In all our countries these figures correspond roughly to the total employment of a relatively small large firm. Also, the shares on employment are smaller than the shares of new firm patent values on GDP in the previous table. All this confirms the well known fact that in high-tech and innovation business the contributions to economic value are typically more prominent than the contributions to employment. In fact, the value created by these companies may have indirect effects on employment, which are unable to estimate here. However, in terms of direct effects patents have a relatively higher impact on value than employment

Table 2. Value of New Firms by country

	Total value of new firms <i>annual average, thousands Euro</i>			Total value of new firms <i>share of GDP</i>		
	1994-1996	1997-1999	2000-2002	1994-1996	1997-1999	2000-2002
DE	1,159,095	1,651,001	1,989,340	0.06%	0.08%	0.09%
DK	108,995	185,197	238,389	0.08%	0.12%	0.13%
ES	107,383	160,424	224,826	0.02%	0.03%	0.03%
FR	170,975	214,811	241,027	0.01%	0.02%	0.02%
HU	15,124	20,420	34,367	0.04%	0.05%	0.06%
IT	445,972	608,583	743,530	0.05%	0.06%	0.06%
NL	188,647	270,179	354,940	0.06%	0.07%	0.08%
UK	1,025,329	1,312,103	1,572,846	0.11%	0.10%	0.10%
EU8	3,221,519	4,422,719	5,399,265	0.06%	0.07%	0.07%

Table 3. New Firms and Employment

	Number of new firms <i>annual average</i>			Number of employees in new firms - <i>annual average</i>			Share of total employment*
	1994-1996	1997-1999	2000-2002	1994-1996	1997-1999	2000-2002	2000-2002
DE	298	430	518	2,563	3,695	4,455	0.04%
DK	32	51	65	481	769	989	0.14%
ES	29	45	62	215	329	454	0.01%
FR	43	54	61	666	836	938	0.02%
HU	4	5	9	27	38	66	0.01%
IT	130	176	217	952	1,296	1,592	0.02%
NL	55	79	105	382	548	729	0.05%
UK	273	356	428	3,339	4,341	5,229	0.09%
EU8	864	1,195	1,465	8,625	11,853	14,452	0.04%

* Discounted by 67% to account for long-term survival of new firms, see Box 10.

4. THE RELATIONSHIPS BETWEEN PATENTS, R&D, AND INNOVATION

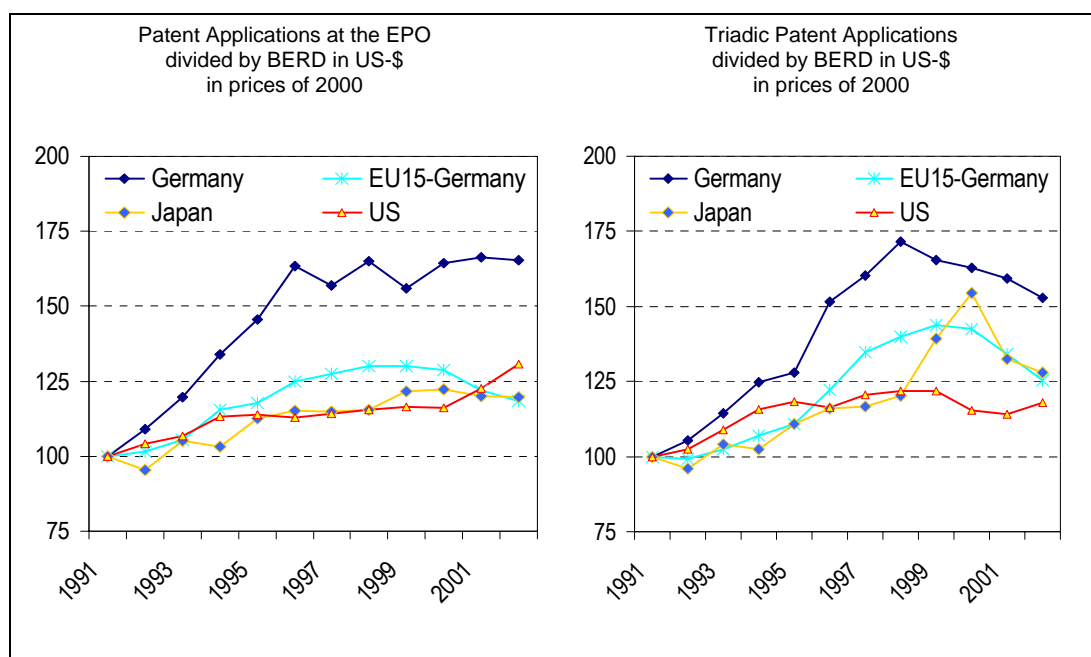
The classical rationale for patenting is that they increase the *ex-ante* incentives of the innovators to produce the innovation. This is because they provide a legal means for appropriating the returns to the investments that are necessary to create the technology. The problem with innovation is that it exhibits the classical characteristics of knowledge-based products, that is once they are revealed they can be reproduced at low cost. Hence, without a legal appropriation the rents of the innovator could diminish substantially because others can use or replicate the innovation. The well known trade-off of patents for society is that in order to guarantee the *ex-ante* incentives to innovate, it has to limit its *ex-post* diffusion by enabling the patent holder to exclude any other party to use the invention, unless allowed for by the patent holder herself.

We believe that today this classical rationale for patents has become less important, at least relatively to the many other issues that are begin raised about patents, like patent licensing or the other points discussed earlier. Yet, it is still worth understanding these processes because in recent years the issue has become wider and more complex. As discussed, there have been increasing strategic reasons for patenting, viz. companies applying for blocking patents that they do not use. Moreover, there is a practical reason for dealing with this point. In the past decade or so, the number of patent applications has increased faster than R&D spending, with an implied increase in the patent to R&D ratio, as shown by Figure 12.

This may reflect two factors:

- a) a *higher productivity of R&D*, as the increase in patents reflect a genuine increase in innovation with no increase in R&D spending;
- b) a *higher propensity to patent*, which mirrors a greater incentive to protect innovations, possibly for strategic reasons like blocking rivals

Figure 12. Trends in Patent Applications to R&D ratio (1991=100)



Source: OECD MSTI 2005-2

Clearly, the latter hypothesis would reduce the *ex-post* social value of patents and the underlying innovations because there is an increase in the social costs of patents in the form of stronger *ex-ante* incentives to monopolize innovations.

The economic literature has already addressed the problem of whether patents induce R&D or not. In general, the evidence is that they do, even though the extent to which patents encourage R&D may not be crucial. This is also why we argue that the roles of patents are probably changing, and they are becoming increasingly important for other reasons, like the creation of technology markets, as we discussed in the previous section.

For example, one of the most detailed studies on this matter is Arora et al. (2003). They look at the patent vs. R&D relation using US survey data and find that the patent premium is positively correlated with the patents-to-R&D ratio. By contrast, Bessen and Hunt (2004) observe that the increase in software patents exceeds the increase in software R&D. They explain this by a strong increase in the propensity to patent due to more effective patents on software which in turn has a negative impact on software R&D. However, this result and its interpretation have been challenged by Hahn and Wallsten (2003) on methodological ground and on their use of the data. Hahn and Wallsten argue that the Bessen-Hunt result of an increasing propensity to patent is neither robust to slight changes in the data nor in the method. Hall (2004) shows that the increase in US patents occurs across most fields of technology but is unevenly distributed across industries. She shows that the value of patents depends on firm characteristics. The value of patents is larger for market entrants especially because

patents signal valuable assets. She also argues that patent premium has increased after 1984. The most recent approach is developed by Lanjouw and Schankerman (2004) who estimated a patent production function with quality weighted patents in order to disentangle reasons for the decline in research productivity. They used a composite quality index. In their results they found that adjustment for patent quality explains a substantial part of the variation in research productivity at the sector level. In addition, based on German survey data Blind *et al.* (2004) claim that a rising propensity to patent is observed only in large firms only. SMEs did not change their propensity to patent in the past decade.

In this research we performed a detailed econometric study to assess the relationships between patents and R&D, and to disentangle the potentially different reasons for the increase in the propensity to patent. (See Study A1.4 of the Technical Report of this Tender.) We employed micro-data for German companies. The use of German data was justified by two main reasons. First, as shown by Figure 12, Germany is the country where the increase in the patent to R&D ratio has been most pronounced, which makes it a natural test-bed for our analysis. Second, the micro-level data that were needed for this analysis were available only for German companies. Thus, a broader analysis involving more countries could have affected our results, and our ability to disentangle the effects we were interested in.

Here we **summarize the key findings of our empirical model**. The interested reader is encouraged to check our full study referenced above:

- ***We did not find convincing evidence that the change in the patent-R&D link is produced by an increasing propensity to patent inventions.*** The results are more in line with the hypothesis that the propensity to patent is constant or it has even decreased slightly. In turn, this suggests that the higher number of patents per R&D investment reflects a genuine increase in the productivity of innovation, due for example to the rise of new general-purpose technologies like information and communication technologies, or new scientific bases like the life sciences, or new approaches to the management of R&D, as also argued for instance by Kortum and Lerner (1999).
- ***We also find that the technological change in invention and innovation processes is R&D saving and spillover-using.*** The latter result implies an increasing focus of firms on knowledge produced outside their own domain either from the public sector or more importantly from other private firms including knowledge generated abroad. More recently, the term “open innovation” has been coined for this development.
- ***We did not find evidence in favour of the alternative explanation that “informal innovation”, i.e. the use of knowledge not produced by R&D, has become more important.*** Specifically, we did not find an additional empirical

contribution of non-R&D innovation expenditure (available from innovation surveys) in explaining the increase in the number of patents.

A limitation of these conclusions is that our sample mainly consists of medium-sized, R&D-performing firms. For econometric reasons we have not included the largest R&D spenders which are also large patent applicants in terms of the number of patent applications. A recent survey which looks at the changing propensity to patent in Germany found that the change in the propensity to patent due to change in patent strategies is most pronounced in the largest firms. Our finding of only a small change in the patenting behaviour of firms might then be valid for the majority of patent applicants in Germany, but it might not be valid for the significant share of patent applications that comes from the biggest firms.

Moreover, the results discussed in the previous two sections also point to a larger share of blocking patents by the large firms. However, they also show that the large firms are repositories of sleeping patents. Thus, our general conclusion is that we cannot rule out that large firms have produced an increased share of patents that reflect strategic reasons rather than innovation. Yet, we should not underestimate that the very same large firms produce a growing number of patents that may be licensed to others, as discussed in the previous section. [See Box 11.]

Box 11: Relationships between Patents, R&D, and Innovation

In recent years the number of patent applications has grown faster than R&D. This is true of the US, and in Europe the trend looks particularly pronounced in Germany.

We do not find significant evidence that this trend is produced by an increase in the propensity to patent inventions without a genuine increase in innovation and the productivity of R&D.

Potential sources of increase in R&D productivity are new basic technologies (life sciences, engineering sciences) and new tools for conducting or managing research (e.g. ICT, software).

The propensity to patent might have increased in the largest firms, with implied increase in strategic patenting. However, large firms also remain important reservoirs of unused technologies that can be potentially used by others via licensing or else (e.g. strategic alliances).

5. PATENTS IN SPECIFIC INDUSTRIES

In this section we focus on inter-industry differences in the various aspects of patents discussed in the previous sections. We distinguish between the 30 technological classes

that we presented earlier, and that are obtained from converting IPC 6-digit patent classes into industrial sectors. Further details on this classification were presented in Box 3.

Figure 13 shows the average and median values of patents by our 30 sectors (ranked by the median), and Table 4 reports their total values in our three periods (ranked by the 2000-2002 total values). A comparison of the two classifications reveals the following:

- **Technologies based on the chemical paradigm** (e.g. various chemical industries, materials & metallurgy, pharmaceuticals) **tend to rank high in terms of average and median values of patents**. In particular, they rank **higher than electronics and ICT-based sectors** like Telecommunications or Information Technology. This reflects the well known fact that patents are more valuable in the chemical-based industries (e.g. Levin et al., 1987). In turn, this has various explanations. An important one is that in these industries technologies tend to be codified and easier to patent. In addition, this means that patents provide a better protection because the object of the protection can be identified with fewer ambiguities.
- However, **in terms of total value**, while chemical-based technologies like organic chemistry and pharmaceuticals still rank high, **ICT-sectors** (particularly Telecom and Information Technology) now **also rank high**. This means that the latter produce many patents of relatively lower value, while the former produce fewer patents of higher value. Moreover, according to Table 4, over time the total value of ICT patents has grown much faster, reflecting the growth in the number of patents in these industries

Figure 14 ranks our 30 sectors in terms of their share of unused patents. Interestingly, organic chemistry ranks first in this classification as well. This suggests that in this industry there are many unused valuable patents. At the same time, some key electronics and ICT industries now rank high as well. For example, semiconductors is the fourth sector in terms of share of unused patents. As noted for instance by Hall and Ziedonis (2001), this industry features a great deal of blocking patents and more generally it is an industry in which the leading producers tend to define their fields of actions by protecting their intellectual property.

Note also that the industries with the highest total values of patents also rank high in terms of share of unused patents. This is suggestive of our earlier remark that companies or industries producing a large number of innovations also produce by-product innovations that may not be used immediately.

Figure 13. Average and Median Monetary Value of Patents by Sectors

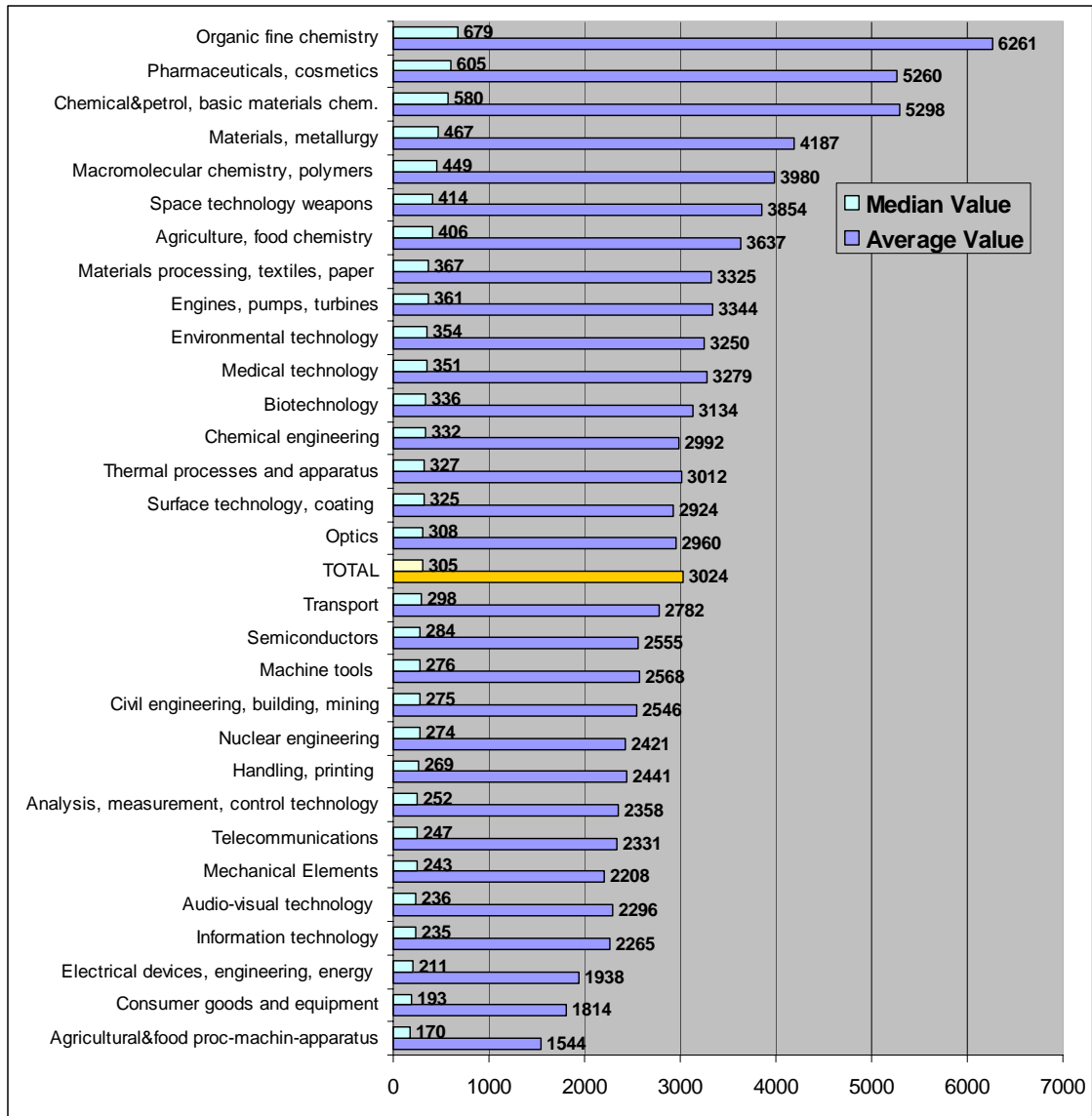


Table 4. Total Monetary Value of Patents by Sectors (in million euros)

	1994-1996	1997-1999	2000-2002
Organic fine chemistry	6,957	7,644	8,687
Pharmaceuticals, cosmetics	3,038	4,438	6,432
Telecommunications	2,273	4,143	6,050
Transport	3,175	4,871	5,922
Analysis, measurement, control technology	2,901	4,187	5,230
Electrical devices, engineering, energy	2,476	3,468	3,870
Handling, printing	2,778	3,419	3,724
Medical technology	2,277	3,219	3,723
Information technology	1,067	1,952	3,634
Engines, pumps, turbines	1,602	2,448	3,583
Materials processing, textiles, paper	2,673	3,138	3,485
Civil engineering, building, mining	2,332	3,146	3,422
Macromolecular chemistry, polymers	2,715	3,066	3,357
Chemical&petrol, basic materials chem.	2,914	3,201	3,238
Consumer goods and equipment	1,835	2,427	2,798
Mechanical Elements	1,818	2,439	2,776
Biotechnology	1,186	1,909	2,483
Chemical engineering	1,744	2,107	2,470
Materials, metallurgy	1,741	2,203	2,230
Machine tools	1,396	1,899	2,095
Optics	1,204	1,507	2,048
Audio-visual technology	824	1,253	1,751
Semiconductors	596	1,055	1,410
Thermal processes and apparatus	1,029	1,316	1,376
Environmental technology	884	1,050	1,137
Surface technology, coating	773	1,060	1,134
Agriculture, food chemistry	640	809	914
Agricultural&food proc-machin-apparatus	439	622	722
Space technology weapons	420	490	549
Nuclear engineering	196	198	238
TOTAL	55,905	74,684	90,489

Figure 14. Share of Unused Patents by Sector

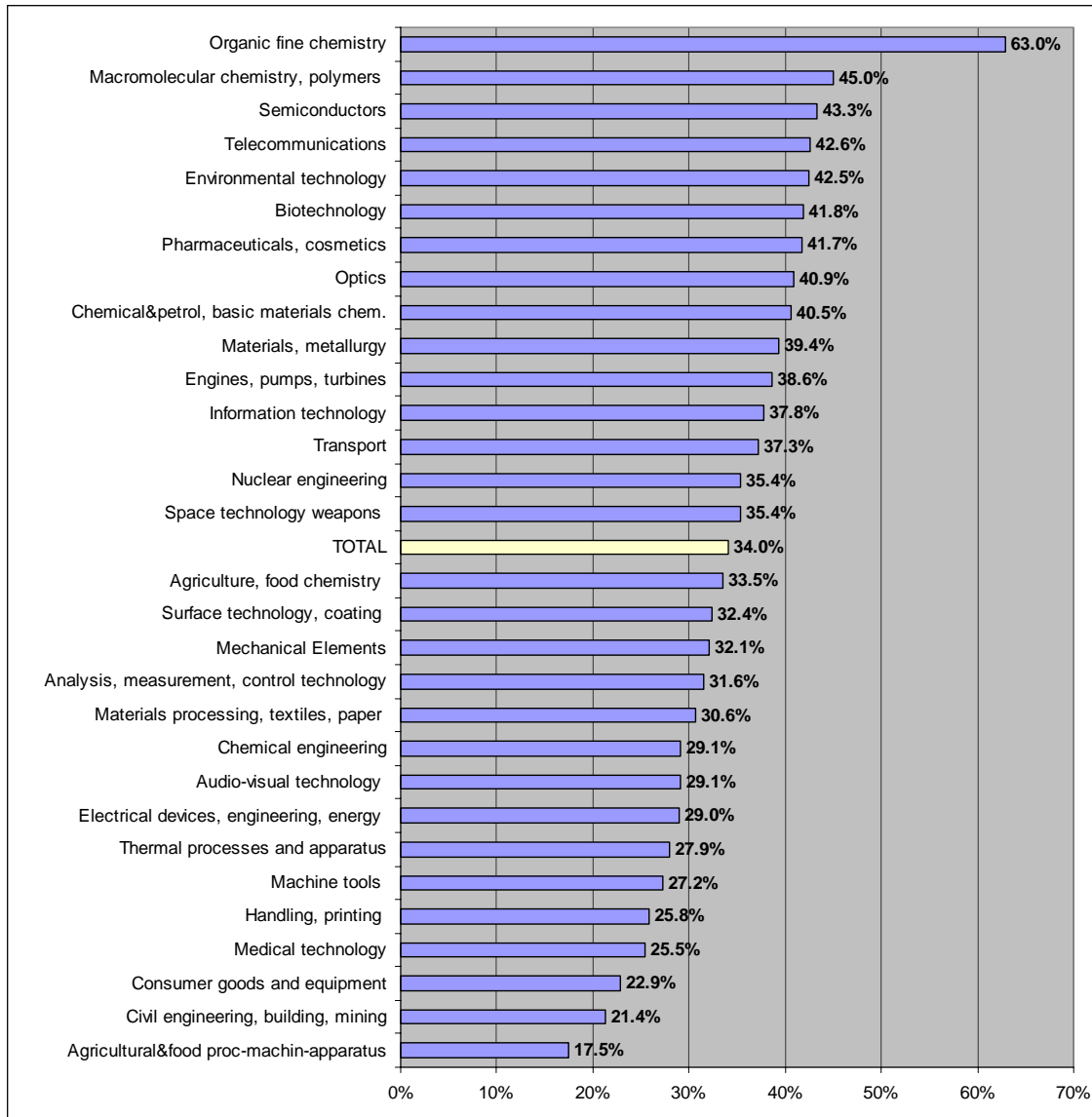


Figure 15. Share of Licensed Patents by Sector

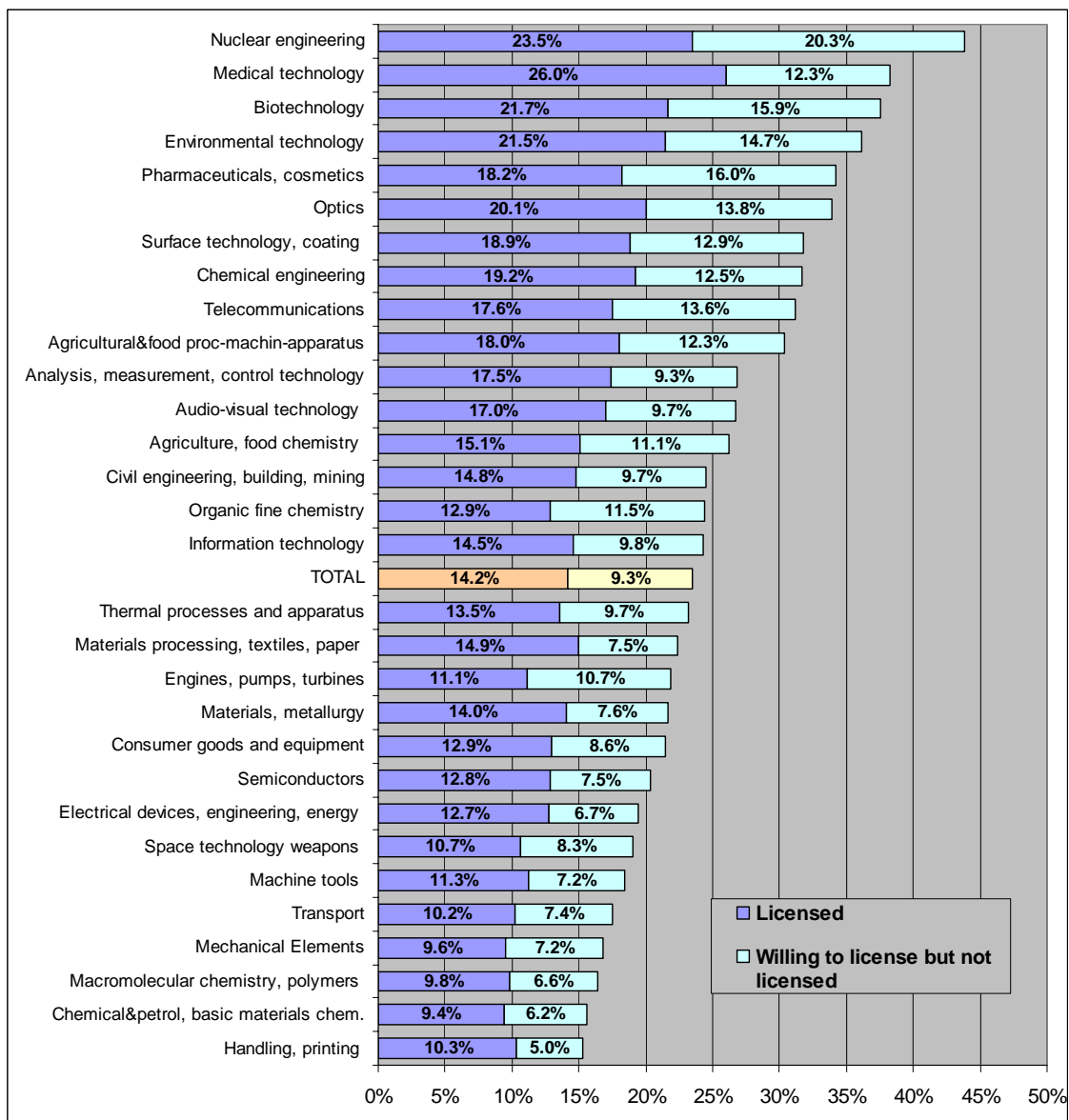


Table 5. Value of the Market for Patents by Sector (in million euros)

	1994-1996	1997-1999	2000-2002
Pharmaceuticals, cosmetics	601	1,009	1,269
Organic fine chemistry	987	1,154	1,266
Telecommunications	464	984	1,206
Medical technology	706	1,090	1,151
Analysis, measurement, control technology	576	900	1,030
Transport	405	694	757
Information technology	195	468	689
Civil engineering, building, mining	440	647	641
Materials processing, textiles, paper	482	598	620
Biotechnology	290	556	579
Electrical devices, engineering, energy	371	560	576
Chemical engineering	393	510	556
Consumer goods and equipment	309	446	472
Engines, pumps, turbines	213	378	466
Handling, printing	348	463	464
Optics	274	364	460
Audio-visual technology	171	300	374
Macromolecular chemistry, polymers	290	342	362
Chemical&petrol, basic materials chem.	313	345	343
Materials, metallurgy	271	357	339
Mechanical Elements	205	289	310
Machine tools	202	294	304
Environmental technology	215	283	277
Thermal processes and apparatus	173	232	233
Surface technology, coating	153	218	222
Semiconductors	79	160	185
Agricultural&food proc-machin-apparatus	95	147	156
Agriculture, food chemistry	105	137	150
Space technology weapons	56	72	73
Nuclear engineering	46	49	52
TOTAL	9,429	14,046	15,584

Figure 16. Share of Patents Leading to New Firms by Sector

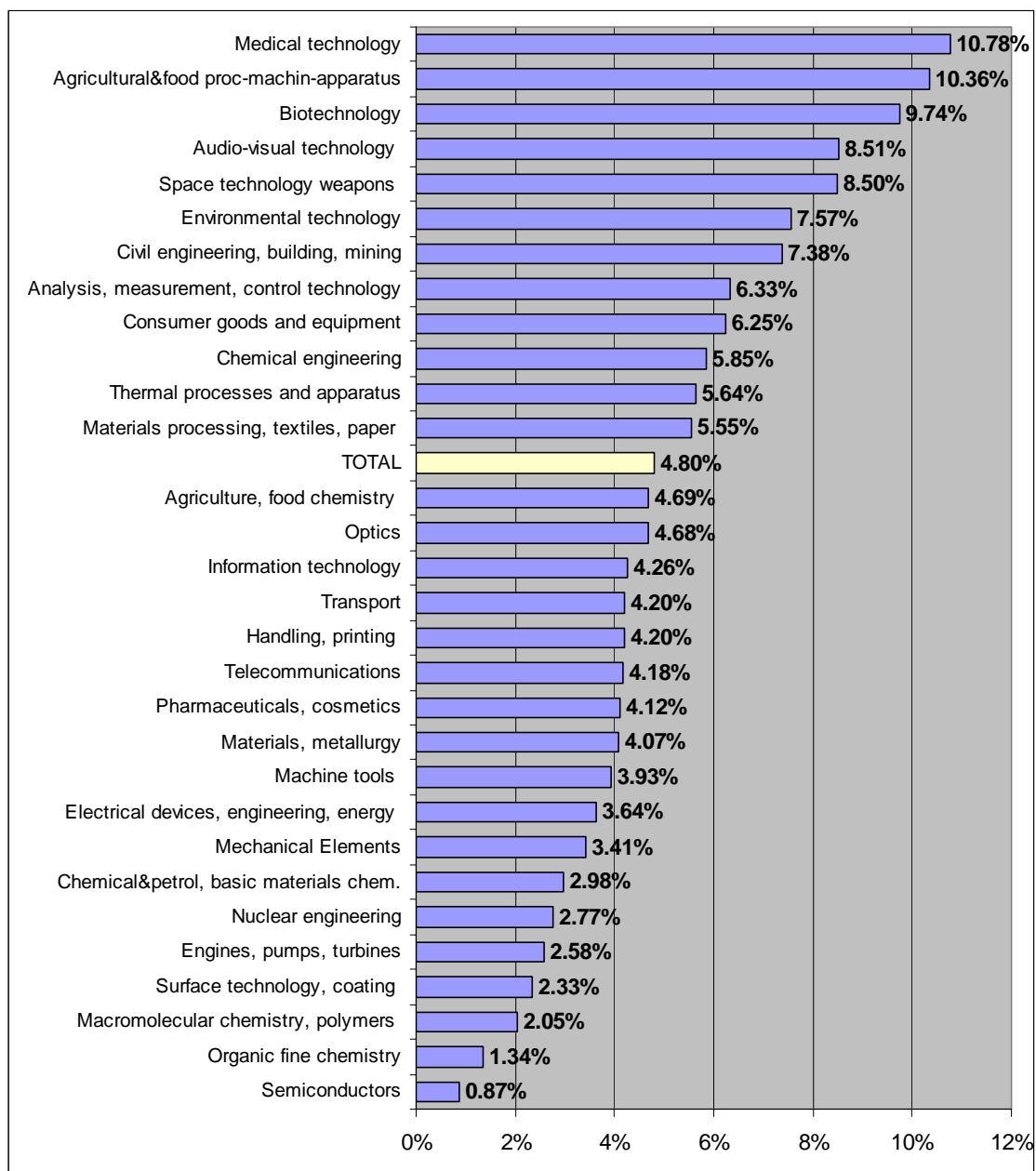


Figure 15 reports instead the share of licensed and willing-to-license patents. Typically the willingness to license is proportional to actual licenses, and therefore we can simply discuss the general attitude towards licensing of these industries. Interestingly, the leading industries in terms of licensing shares are different from the ones that we have seen so far. They are typically industries populated by small technology specialist firms, like environmental technologies, biotech, medical technologies, optics, along with some classical licensing industries like pharmaceuticals.

Table 5 then estimates the size of the markets for technology by industry. Pharmaceutical and Organic chemistry feature again as the leading industries, which is largely produced by the fact that they have a large number of patents, and on average they are quite valuable. However, note that in this case Telecommunications and Information Technology figure back at the top of the list. Moreover, they both exhibit a significant growth in the total value of their licenses.

Finally, Figure 16 presents the shares of patents leading to new firms by sectors. Again, sectors typically populated by small technology specialists rank high in this list. In particular, these figures highlight the importance of patents to form new companies in medical technology.

6. CONCLUSIONS AND POLICY IMPLICATIONS

This Report showed that the value of patenting, i.e. the difference between having a patent or not, can be quite high, and in this respect it can significantly encourage innovation. This is certainly so for the large firms, but it is even more so for small-medium technology specialists, spin-offs or start-ups who have no other means of appropriating rents from their innovations than a legal right.

Specifically, we found that on average a patent in our EU-8 countries is worth about 3 million euros. In fact, since the distribution of patent values is very skewed only very few patents are worth this much or even more. However, we also found that the median patent is worth 300 thousand euros, which means that the typical patent can be quite valuable too.

Such high values make patents a natural target for policy. In particular, we found that there is room for increasing the economic utilization of patents, as almost one third of them are not used. In this respect, we found two policy targets for enhancing the rate of utilization of patents:

- a) the large firms, which have sizable shares of unused patents. Some of them are not used, but play a strategic role, as they are employed to block the use of technology by rivals. Yet, they also produce several technologies as by-product

of their large R&D activities. These “sleeping” patents amount to a significant reservoirs of unused technologies that could be exploited by the patent holder or by other parties.

- b) the small technology-based firms, which have a higher shares of licensed patents than the large firms. More generally, the so-called “open innovation systems” (Chesbrough, 2003) can seriously help the diffusion and the widespread use of patented technologies.

We also argued that to enhance the rate of utilization of patents the most effective strategy is to encourage the growth of technology markets. Other means, like reducing the patenting costs of small firms, may only induce them to patent less valuable, and hence less usable technologies, thereby aggravating rather than solving the problem.

To encourage technology markets a first important policy target should be the reduction of transaction costs in technology trade. Our analysis showed that they produce serious impediments to patent licensing. Tools for achieving this goal range from the creation of standard contracts for technology trade that reduce contractual ambiguities; to the formation of intermediating companies that facilitate the match of buyers and suppliers; to actions that define standard prices for technologies according to their characteristics, as well as public information about technology prices.

Actions to favour the licensing and diffusion of large firm patents are also important, but they are also less obvious. The paradox here is that these firms have many unused technologies, and they would even like to license some of them. Yet, our technical studies found that either they do not make enough efforts to do so, or even when they do others are not so easy about buying technologies from a company that is seen as a threatening potential rival in the same field. The large reservoirs of technologies of these firms however calls for serious thoughts about how to make them available more widely, as other studies like Rivette and Kline (2000) have noted.

Our analysis also confirmed the conventional wisdom that there are different trends in Europe in terms of utilization of patents, effectiveness of technology markets to enhance their use, and the formation of new technology-based companies. The UK model is closer to the “open innovation” model than Germany. France and Italy are closer to the latter, while Denmark and the Netherlands are more similar to the former. Spain is approaching the UK model. In this respect, an ideal combination of the two models is to encourage the use of large firm German technologies along with the diffusion of technologies from small firm UK technology specialists. Clearly, things are not black or white, and large firm UK technologies, as well as smaller technology makers in Continental Europe can play a role too.

A final important remark is that we uncovered a potentially interesting role for the New Member States. Hungary shows high rates of technology licensing and formation of new companies from patented technologies. This was not unexpected. Less advanced

economies find it relatively easier to concoct new technologies and ideas in areas in which they have some specialization and expertise, than making costly investments in large scale downstream assets to develop them. Technology markets can then become a means by which these countries sell their technologies without having to incur these costly investments. In turn, if these markets exist and function, companies in these countries are motivated to invest in the initial ideas as they know that they can profit from selling them. They do not need to make the full downstream investments, which can discourage them to carry out the initial investment in the innovation. Israel and Ireland are good examples.

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Appendix. Methodology

This Appendix describes the steps that we performed to estimate the value of patents, the share of unused patents, the share and value of licensed patents and the share and value of patents generating new firms for the population of EPO patents on 1994-2002.

Value of patents

Step 1

We run an interval regression (ordered probit with known thresholds) to estimate the value of patents in the PatVal-EU sample (8,215 observations).

The dependent variable is the value intervals from 0-30K euros to more than 300 million euros, as reported in the text.

We employed the following variables as regressors:

- 4 indirect indicators that are well known to be correlated with the value of the patents: forward citations; backward citations; number of claims in the patent; number of patents filed with different patent authorities referring to the same invention
- Dummies for the type of applicant: firm, university, other government organization, individual
- Country dummies: Denmark, Germany, France, Hungary, Italy, Netherlands, Spain, and the UK
- 30 technological class dummies
- Dummies for 1993-1998 application years.

The rationale for these (and not other) regressors is that they are also available for the entire population of patents from which the PatVal-EU sample was drawn, as noted in Step 2 below.

All four indicators turned out to have a positive and statistically significant impact, which reinforced our confidence in their predictive ability.

Step 2

We estimated the values of the dependent variable for each patent in the PatVal-EU population of 50,236 patents granted at the EPO with priority date in 1993-1997 from which the PatVal-sample sample was drawn. This was done by using the estimated parameters and the value of all the covariates for the entire population.

Step 3

We computed the average of the estimated value of patents for each country-technology cell (8x30 cells) in the PatVal-EU population of 1993-1997 patents.

We computed the total value of EPO patents granted in 1994-2002 by multiplying the country-technology value by the number of patents in each country-technology cell in each year.

Since for recent patents the information on whether the patent has been granted is not available for all the patents, we estimated the number of patents granted in each year by applying the share of 1994-1996 EPO patents granted in all eight countries to all EPO patent applications in 1994-2002.

Remarks

- Also noted in Box 3 in the text, our predictions for 1997-1999 and 2000-2002 are based only on changes in the industry composition of patents within each country and not on changes in the average values.
- Inventors may inflate their responses about the value of their patents. To obtain conservative estimates, in Step 2 we applied the constant for German patents (i.e. the German dummy) to compute the value of all the patents in the population. The

rationale is that the German inventors have a better idea of the value of their patents because of the German Employees Inventor Compensation Act. The Act establishes that the employers can claim the patent rights from an inventor by providing him with a fair compensation (see Harhoff and Hoisl, 2005, for details). This means that the German inventors have something concrete to hang their PatVal-EU answers. As a matter of fact, in our Step 1 regression the German dummy was the lowest among all the country dummies.

Unused patents

Step 1

We run a heckman probit regression to estimate the probability that the patent is not used, and if so that the patent is “blocking” or “sleeping”. The dependent variable of the selection equation is the dummy for unused patent, while the dependent variable for the conditional equation is the dummy for whether the unused patent is blocking or sleeping. The regressors include all variables used in the previous estimation of the patent value. As exclusion restriction, we included the 30 technological classes only in the selection equation. In the conditional equation we used instead 5 macro-technological classes, which grouped the 30 technological classes in larger sets. Details of the rationale for this are reported in the Study A2.2 of the Technical Report of this Tender.

Step 2

By the same procedure employed in the previous case, we retrieved the probabilities that any given patent in the 1993-1997 PatVal-EU population in 1993-1997 is unused, and that it is “blocking” or “sleeping”.

Licensed patents

Step 1

We run a heckman probit regression to estimate the probability that there is willingness to license a patent, and if so that the patent has actually been licensed. The dependent variable of the selection equation is the dummy for willingness to license a patent, while the dependent variable for the conditional equation is the dummy for whether the patent is actually licensed or not. The regressors include all variables used in the previous estimation of the patent value. We use the same exclusion restriction as in the heckman estimation of unused patents.

Step 2

We retrieved the probabilities that any given patent in the PatVal-EU population in 1993-1997 is licensed or it is willing-but-not-licensed.

Step 3

To compute the total value of licensed and willing-but-not-licensed patents, we multiplied the estimated value of each patent in the population by respectively its estimated probability of licensing and its estimated probability of being a willing-but-not-licensed patent.

Step 4

We computed the average value of licensed and willing-but-not-licensed patents for each country-technological cell, and used them to compute the total value of actual and potentially licensed EPO patents granted in 1994-2002 in the 8 countries and 30 technological classes.

Patents generating new firms

Step 1

We run a probit regression to estimate the probability that a patent is employed to start a new venture. The regressors are all the variables in the patent value estimation.

Step 2

We retrieved the probabilities that any given patent in the PatVal-EU population in 1993-1997 is employed to start a new venture.

Step 3

We computed for each 8x30 country-technology cell the expected share of new firms and applied it to the corresponding EPO patents cells in 1994-2002.

Step 4

To compute the total value of patents generating new firms, we multiplied the estimated value of each patent in the population by its estimated probability of being used to start a new firm. We then computed the average value of patents generating a new firm for each country-technology cell (8x30 cells), and applied them to compute the total value of patents generating new firms granted at the EPO in 1994-2002 in the 8 countries and 30 technological classes.