The Value of European Patents

Evidence from

a Survey of European Inventors

Final Report of the PatVal EU Project

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SECTION 1. THE ECONOMIC VALUE OF PATENTS IN EUROPE

1.1 The value of European patents

The transition of the European Union towards the "knowledge-based economy" is a priority of the agenda of the Lisbon Summit (European Commission, 2003a). The investment in education, research and innovation is crucial to achieve these goals.

This report focuses on a number of ingredients that determine the innovative performance of the European countries and their potentialities for economic growth. It includes key figures concerning the research inputs (such as the characteristics of the inventors, the motivations to innovate, the characteristics of the innovation process), and the innovative performance of six European countries (i.e. the value of the innovations produced by European inventors).

The data on which the report is based are drawn from a survey of a large sample of inventors of EPO patent applications. The survey was carried out under the PatVal-EU project sponsored by the European Commission (see Section 2 for details). These data, which are not available from any other source, will be used to understand how economically valuable innovations are invented in Europe, and to derive implications for increasing the number of inventions that yield economic returns.

There is a long literature on innovation. Some contributions use data on human resources devoted to R&D and other input measures such as company R&D expenditure. Many studies employ the information drawn from the patent documents. The use of patent citations, for example, has become fairly standard in the literature (for a survey see Hall *et al.*, 2001). Citations made to previous patents are used as indicators of knowledge spillovers from the cited to the citing innovations (Jaffe *et al.*, 1993). Citations received by a patent are a proxy for the importance/value of the innovation. Several contributions also show that there is a positive relationship between patent indicators and the *ex-post* value of the innovations as given by traditional accounting evaluation (Hall *et al.*, 2005). A classical contribution is Trajtenberg (1990), who shows that there is a non-linear association between patent counts weighted by forward citations and the social value of innovations in the Computer Tomography Scanner industry. Harhoff *et al.* (1999a) claim that the number of backward citations to other patents and to the non-patent literature, and the number of citations received after the publication of a patent are positively correlated with the value of the innovation. This also holds true for patents applied for in many countries, and for patents that incur in opposition and annulment procedures (Harhoff and Reitzig, 2004). Griliches *et al.* (1987) use data on patent renewal rates and fees to estimate the private value of patent rights (see also Pakes and Schankerman, 1984; Pakes, 1986; Schankerman and Pakes, 1986). Lanjouw and Schankerman (2004) use multiple indicators to construct a composite measure of the quality of patents, and show that forward citations and claims are the most informative indicators. After controlling for the physical capital stock of the firms, another set of studies correlate the market value of the firms with the stock of R&D and patents, and find a positive and significant marginal value of the patent stock (Pakes, 1985; Hall, Jaffe and 2005, 1999; Lerner, 1994).

Another stream of the literature examines the motivations to patent and the use of the innovations. Some contributions examine the transfer of patent rights, and more generally the rise of markets for technology. However, the research on this issue is limited by the availability of detailed data on the economic use of patents and the licensing strategies of the firms. These limitations explain the focus of this part of the literature on sectors in which there is a high propensity to license, like semiconductors, chemicals and computers (Anand and Khanna, 2000; Cohen et al., 2000; Grindley and Teece, 1997; Hall and Ziedonis, 2001; Arora, Fosfuri and Gambardella, 2001; Cesaroni, 2003). As far as the motivations to patent are concerned, Cohen, Nelson and Walsh (2000) show that in the US patents are not the most important means for appropriating the returns from innovation. Secret, lead-time and investments in complementary assets are on average more important. They also claim that, apart from the mere protection of innovations that are exploited internally, licensing, cross-licensing and other strategic reasons are also important reasons to patent.

Although these patent and non-patent indicators have been used extensively in the literature, they have limitations as well (see Griliches, 1990 for patent indicators). More detailed and original data would be necessary to increase our understanding of the process and products of R&D activities. This was the aim of the PatVal-EU survey that was directed to the actors of the innovation process (i.e. the inventors) in order to open the "black box" of the innovation process and to understand the determinants of the economic value of the innovations.

This report describes the following four aspects of the European innovation system, and highlights the differences among the six European countries that were part of the survey:

1. the characteristics of the European inventors such as their education, their employment status, their mobility across different companies and institutions;
2. the features of the innovative process and the sources of knowledge that the inventors use to produce the innovations;
3. the property rights and the inventors' rewards;
4. the use and the economic value of patents.

The rest of this section summarises the methodology used in the project and the key findings of the research. Section 2 provides details about the sample of patents whose inventors have been interviewed, and describes the methodology adopted to conduct the survey. Sections 3 to 6 present the key figures on the four issues listed above. Section 7 concludes and presents some future research agenda based on the PatVal-EU data.

1.2 The Inventors and the Invention process

The primary goal of the PatVal-EU survey was to gather information on the economic value of the European patents. The PatVal-EU survey, however, produced other interesting and unique data on:

the characteristics of the inventors, like their age, educational and work background, the institutions to which they belong; *the process that led to the innovation* such as the sources of knowledge used in the research leading to the patent, the setting up of formal or informal collaborations among individual inventors and organisations; *the motivations to patent and the use of property rights*, such as the licensing behaviour of firms, the strategic reasons to patent, etc. By combining together these information we will get a better understanding of the relationship between the input and output variables of the innovation process. In turn, this will help derive policy implications for the European innovative and economic performance.

1.3 The Survey of European Inventors

The full scale PatVal-EU survey was conducted from May 2003 to January 2004, and was directed to the inventors of 27,531 patents granted at the EPO with priority date in 1993-1997 located in France, Germany, Italy, the Netherlands, Spain and the United Kingdom. The targeted number of patents for which we expected the inventors to respond was 10,000. In the end the European inventors responded to 9,216 questionnaires covering 9,017 patents.

The distribution of the surveyed patents across countries is the following: 3,346 patents are invented in Germany, 1,486 in France, 1,542 in the UK, 1,250 in Italy, 1,124 in the Netherlands, and 269 in Spain. The number of patents surveyed in each country mirrors the relative size of the country population.

Section 2 describes the questionnaire, the sampling decisions, the pilot tests, the problems we faced during the survey, and the solutions we adopted. It also illustrates the composition of the final sample.

1.4 Key Findings

This sub-section summarizes the main findings of the PatVal-EU project. Sections 3 to 6 present the detailed Tables and Figures, and discuss the results.

Inventors' characteristics

- ***Education***. Three fourths of the European inventors in the PatVal-EU dataset have a university degree. Only one fourth of them has a Ph.D. Italy has a different profile with about 56% of the inventors with tertiary education, and only 3% with a Ph.D.
- ***Employment status***. At the time when the research leading to the patent was performed around 90% of the European inventors were employed in other people's organisations. Self-employment was limited to fewer than 8% of the inventors. The business sector and in particular the large firms employed the vast majority of the inventors in all six countries.
- ***Researchers' mobility.*** The European inventors show a low mobility across jobs during their carrier. About three fourths of the inventors never moved from their job. The UK is

the country with the largest share (about 35%) of inventors who changed job at least once during their carrier.

The innovation process

- ***Inventors' collaborations.*** "Single" inventors develop only one third of the overall PatVal-EU patents. This suggests that the formation of research teams for producing innovations is frequent among European inventors.
- ***Inventors' affiliation***. "Organisational proximity" among inventors matters: 76% of the patents are invented by inventors belonging to the same organisation, and only 24% of the patents are developed by inventors affiliated to different organisations. Moreover, "organisational proximity" is particularly important for collaboration if the researchers are geographically close.
- ***Collaborations between organisations.*** About 20% of the PatVal-EU patents are developed through collaborations between the employer organisation and other partners, with variations across countries. In particular, the (large) French and German companies tend to rely less than companies in other countries on external collaborations, and they use more extensively competencies internal to the firm. Moreover, 75% of these collaborations are formalised through specific contracts. Only one fourth of the collaborations are managed on an informal basis.
- ***Sources of innovation.*** The firm's customers are the most important source of innovation, followed by the knowledge supplied by the patent literature and the scientific literature. The interaction with the firm's competitors, the participation in conferences and workshops and the contacts with the suppliers rank afterwards. Surprisingly, university and non-university research laboratories are at the bottom of the list. This is so for the EU6 as a whole, with very little variation among countries.
- ***Origins of the innovation.*** Half of the innovations are the direct or indirect output of a targeted research project. In the other 50% of the cases, the innovations arise unexpectedly from research projects undertaken for other purposes, or from activities other than the inventing activity.
- ***Intertwined patents.*** About 44% of the EU6 patents are part of a group of "intertwined patents". We defined intertwined patents to be "a group of patents that crucially depend on each other technically or in terms of their value". The wording in quotes was reported in the question so that the interviewee knew what we meant about intertwined patents.
- ***Sources of funding.*** The firm's internal funds cover the production of about 90% of the PatVal-EU innovations. Government research funds rank second with about 8% of the patents. The rest of the funding comes from unaffiliated organisations that join the research project, and from banks and other financial institutions.

Motivations to patent

- ***Inventors' rewards.*** The inventors consider monetary rewards and other rewards like career advances or benefits less important than personal and social rewards, like personal satisfaction, prestige, reputation, and the contribution to the performance of the organization.

- ***Monetary compensation.*** About 40% of the European inventors received some monetary compensation for their innovations. In 90% of these cases the compensation was transitory. There are, however, significant differences among countries. For example, as we shall discuss in Section 5, the German compensation schemes encourages the applicant organisations to compensate their inventors. As a result about 60% of the German inventors received a monetary compensation, while this was the case only for 15% of the Spanish and Dutch inventors.
- ***Reasons to patent: the firm's point of view.*** At the company level, the most important reason to patent is the commercial exploitation of the innovation, together with the possibility of preventing imitation. The possibility to block competitors that might patent similar innovations comes next. Licensing and cross licensing are considered less important. At the bottom of the list there is the need to gain reputation.

The use of patent rights and the value of the innovations

- ***The use of patents.*** Not all patents are used for commercial exploitation: about 36% of the European patents in our sample are never used for industrial or commercial purposes. Some innovations are patented for strategic reasons (i.e. blocking rivals). Others are licensed out (about 13% of the PatVal-EU patents), and yet others are not used for commercial purposes because of strategic reasons or because the owners lack the complementary downstream assets to exploit them.
- ***Start-up firms.*** Innovations can be exploited economically by starting up a new firm (about 5% of the cases) that is based on the patented innovation. This share is higher in the UK and Spain, and falls to less than 3% in Germany.
- ***The value of European patents.*** Consistently with previous findings in the literature, the economic value (measured in monetary terms) of the PatVal-EU patents is skewed: a small share of patents yields very high economic returns. The distribution of the high value patents is slightly different among countries.

SECTION 2. THE SURVEY OF EUROPEAN INVENTORS

2.1 Overview of the methodology

The PatVal-EU dataset is based on a survey directed to 27,531 patents granted at the EPO with priority date 1993-1997. At the time of the innovation, the inventors of these patents were located in the six European countries that participate in the project: France, Germany, Italy, the Netherlands, Spain, and the United Kingdom. The production of the questionnaire was highly interactive. The team members held several meeting and interacted regularly via phone and email. The questionnaire underwent three pilot tests before the full scale survey.

The next sub-sections illustrate the methodology adopted in the survey. Section 2.2 describes the content and the structure of the questionnaire. Section 2.3 discusses the criteria to select the sample of patents and inventors. Section 2.4 illustrates the methodology used to interview the inventors (mail, web, telephone), the procedures adopted for searching their addresses, and the outcomes of the three pilot tests. Section 2.5 reports the details of the full scale survey in the six countries, and section 2.6 shows the composition of the final dataset.

2.2 Questionnaire

The questionnaire, which is attached to this report as Annex I, sought to collect information about the invention process and its output that is not available from other sources. It focussed on the following topics:

1. *Information about the economic value of the patents.* E.g. information about the costs and time of the research that led to the patented innovation; the inventor's estimate of the strategic and economic value of the patent both in categorical terms (we asked the inventor to locate the patent among the top 10%, 25%, 50% or in the bottom 50% category of patents in the industry or technological field) and in monetary terms (we proposed a hypothetical situation where the applicant had to sell the patent to a potential competitor).

2. *Information about the inventors.* E.g. age, educational and professional background, affiliation.

3. *Information about the process that led to the invention.* E.g. information about the sources of knowledge that were used in the research project and the assessment about the importance of the most relevant sources of knowledge (i.e. University laboratories, scientific literature, patent literature, and technical conferences and workshop); the use of collaborations and interactions with other actors during the research leading to the patent.

4. *Information about property rights*. E.g. we asked if the patent right was licensed out and to whom, the strategic motive for patenting (for example, if the patent was licensed for commercial exploitation, for licensing/cross-licensing, or as a means for blocking rivals) and whether the patent gave rise to litigations.

The questionnaire was articulated in six sections:

- Section A: Personal Information of the inventors
- Section B: Education of the inventors
- Section C: Inventors' Employment and Mobility
- Section D: The Invention Process
- Section E: Inventors' Rewards
- Section F: The Value of the Patent.

2.3 Definition of the sample

Countries

According to the EPO EPASYS database, at the time of the survey our six countries covered 42.2% of the total EPO patents by country of first inventor, and 88% of the EPO patents with country of first inventor being one of the EU-15.

The share of questionnaires submitted to the inventors in each country was roughly proportional to the country shares in the population of patents. Patents were assigned to countries according to the location of the first inventor listed in the patent document. With this criterion, the EPO EPASYS database produced the following country shares in the population of patents: the Netherlands (6.2%), Germany (49.7%), France (19.5%), UK (15.0%), Italy (8.5%) and Spain (1.07%). We under-sampled the share of German and French patents, and over-sampled the patents invented in the other countries in order to have sufficiently large samples for all the countries. To obtain about 10,000 returned questionnaires, we set the following targets by country: Germany 3500 questionnaires, France 1750, UK 1750, Italy 1250, Netherlands 1250, Spain 500. The response rate obtained in the preliminary phases helped decide the final number of questionnaires to send to the inventors in each country in order to obtain returns close to our targets.

Period

Our population is composed of all the EPO patents with priority date between 1993 and 1997 and the address of the first inventor in one of our six countries. The choice of the time-period is justified as follows. On the one hand, if we sampled "old" patents, it would be difficult to track the inventors or to find inventors who had memory about the invention process. On the other hand, "recent" patents might not carry enough information about their value and use. For the latter patents we also lack information about the mobility of the inventors after the innovation.

Over-sampling important patents

Since the existing literature shows that the distribution of patent values and impacts is highly skewed, we over-sampled the "important" patents. We defined the latter as patents that were opposed or that received at least one citation. The over-sampling allows us to have more information on the upper tail of the distribution of the patent value. Clearly, this implies that we have to be cautious when making inferences about the population of patents from our sample. Any factor that is positively correlated with the importance of the patent will be overrepresented in our sample, while any factor that is negatively correlated with importance will be underepresented.

Table 2.1 describes the population of 1993-1997 patents that were opposed, that were not opposed with at least one citation, and patents that were not opposed and have zero citations. This will be compared with Tables 2.2 and 2.7 below, which report the equivalent shares for the patents selected for our full scale survey and those actually returned that compose our sample.

Table 2.1 Composition of the population of 1993-1997 patents, by country

Group	DE	ES	FR	IT	NL	UK	EU6
Opposed Patents	7.18%	4.18%	5.25%	5.13%	4.73%	3.91%	5.56%
Not opposed and cited	34.20%	19.04%	18.81%	25.30%	13.83%	11.51%	22.90%
Others (not opposed and not cited)	58.62%	76.78%	75.94%	69.57%	81.44%	84.58%	71.54%
Total	15595	814	14287	6205	3955	8222	49078

Note: EU6 includes the six surveyed countries.

Multiple inventors

Some inventors invented more than one EPO patent. If they had to fill out multiple questionnaires, they could decide to drop them all producing a potential bias against the more prolific inventors in our sample. To avoid this problem, we treated the multiple inventors in the following way:

i) we sent a maximum of five questionnaires per inventor (i.e. five patents) even if he/she was listed in more than five of the patents that we had selected for submission of the questionnaire. This is to avoid work overload to the respondent, and to increase the probability that he/she responded. The cases of individuals with more than 5 patents selected for submission of the questionnaire were however very few;

ii) we sent some questionnaires to the co-inventors (if there was any) of the multiple patents' inventors;

iii) we asked the multiple patents' inventors to fill out the complete questionnaire only for one patent and to skip Section A (personal information) and eventually Sections B and C (unless their answers were different) in the other patents;

iv) we paid a special attention and exerted a special effort to convince the multiple patent inventors to respond.

2.4 Survey methods and pilot tests

To conduct the survey we first searched for the addresses of the inventors and their telephone numbers. We then contacted the inventors, and sent them the questionnaires. All the countries, with the exception of the Netherlands and France, used a professional poll-company for conducting some steps of the survey. In France the survey was conducted by the Ministère de la jeunesse, de l'éducation nationale et de la recherche. The Dutch team had internal skills to conduct the survey and did not use a professional poll company.

The goals of Pilot tests 0 and 1 were to choose the methods for submitting the questionnaire (mail, telephone, web) and to check if the respondents understood the questions clearly. In Pilot test 2 we reproduced the conditions under which the full scale survey was going to be performed in order to single out potential problems. We found that different methods were more suited according to the country, the kind of expertise of the team, and the professional poll company. As we shall see below, we then used telephone, mail or web according to the different structure of the phone directories, and the different predisposition of the interviewees to answer by telephone, mail or web.

Searching for the inventors

The search of the recent address and telephone number of the inventors posed two problems. First, at the time of the survey (2002-2003) the addresses of the "mobile" inventors changed with respect to those listed in the patent application in 1993-1997. Second, the patent document does not include the telephone number of the inventors, which was necessary to check their address and to contact them for the telephone interviews.

To solve these problems we crosschecked the inventors' addresses reported in the EPO database with external directories of telephone customers in each country (i.e. the Yellow and White Pages). We also established a common set of rules to search for addresses and telephone numbers in the six countries. These were the following. We started by searching for the address and the telephone number of the first inventor listed in each patent. We obtained on average 64% "exact matches" in which the name-surname and address of the inventor listed in the patent corresponded to those found in the White Pages. In these cases we could easily approach the inventors. In the remaining cases, we had to devise ways to find the inventors. This is discussed under Pilot 1 below.[1]

Sometimes the inventor's address reported in the patent is the address of the organisation in which he/she is employed. In this case, we contacted the company and we asked to interview the inventor. However, some inventors moved to another company after the innovation, which made it harder to find them. In these cases we tried to crosscheck the inventor's name with the White Pages in order

[1] The "exact match" rate for the UK (18%) was lower than the other countries (France 65%, Germany 86%, Italy 62%, Netherlands 66%, Spain 89%). One reason is that in the UK people are asked whether they want to be listed in the phone directory. In the other countries they are listed without asking, and one has to ask not to be listed.

to reduce the under representation in our sample of the inventors who moved after the patented invention.

Pilot 0

In Pilot 0 we submitted a draft questionnaire to 8-12 inventors in each country in April-June 2002. They were selected among people whom we thought could provide good feedbacks on the process. Some of these interviews were conducted *face-to-face*, others by *telephone*. We asked about the phrasing of the questions, the length of the questionnaire, and the relevance of the subject in some specific questions. We also asked the respondents to provide general comments, whether he/she was the right person to answer our questions, and if he/she had memory about the (precise) answers.

The feedbacks from Pilot 0 were used to develop an improved version of the questionnaire and to figure out the best way to approach the inventors. We also found that in order to have a higher response rate, we needed some support from the Commission or other institutions. Through the Scientific Officer of the PatVal-EU project, the Commission agreed to provide a letter accompanying and supporting the questionnaire. The European Patent Office provided another accompanying letter. In the additional steps of our survey we noted that many people felt more comfortable in responding because of these letters, which helped reaching a higher response rate.

Pilot 1

Pilot 1 was conducted in October 2002. In each country the questionnaire was sent on average to 100 inventors in order to obtain responses for about 30 questionnaires. The goals of Pilot 1 were to assess the phrasing and the effectiveness of the second version of the questionnaire, to investigate the best method for administering the survey, to collect useful information for contacting the inventors, to evaluate the time-length of the interview, and to have an idea of the expected response rates.

The countries involved in the project used three modes to conduct the survey: a *web based survey***,** a *postal survey* and a *telephone survey***.** All the countries, with the exception of the UK, first contacted the inventors by phone in order to be sure about their identity and to inform them about the objective of the survey.[2]

In the postal survey a paper questionnaire was sent to the inventors together with the accompanying letters of the European Commission and the European Patent Office, and with a postage-paid return envelope. When the questionnaires were not returned via mail within 3-4 weeks, we used telephone follow-ups to raise the response rate.

In the case of the telephone survey, the questionnaire was sent by ordinary mail or by e-mail to make the inventors familiar with the questions and to let them gather all the information needed to complete the questionnaire. They were then contacted again and they were asked to fill out the questionnaire by telephone. If specifically requested by the inventors they could return a paper copy by regular mail or fax.

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[2] The UK team used telephone contacts, when possible, only for follow up interviews.

We created a website in which we uploaded the questionnaires in the six languages to test a web-based version of the survey. The six sections were clearly identified and separated from each another to avoid that the respondents confused the section in which they had to respond. The Dutch team, which was responsible for developing the website and programme, put particular effort in testing the web survey. It argued that because the Dutch inventors are familiar with the web, it could be employed for the full scale survey without producing any particular bias; in turn, this would reduce considerably the cost of obtaining a good response rate. The Dutch team sent a letter to the inventors selected for this mode that explained the objective of the survey and provided them with a username, a password and the website address. All the other teams gave the contacted inventors the option to respond via web. The instructions (username, password and web address) were indicated in the letter for the postal survey or the option was mentioned over the phone for the telephone survey.

The results of Pilot 1 helped refine our survey in several ways. First, they helped improve the questionnaire. Second, we realised that the best method to conduct the survey was different in different countries. Therefore, while before Pilot 1 we meant to use only one method to interview the inventors in all six countries, after Pilot 1 the differences observed across countries – mainly different structure of the phone directories; different propensity of people to answer by telephone, mail or web; different mobility of people – convinced us that we had to differentiate the survey method to obtain a higher and less biased response rate. For example, the response rate to the web survey was low in all countries, with the exception of the Netherlands and the UK. However, while the Netherlands used the web survey also in the full-scale survey, the UK found that the postal survey was the best method anyway. Germany decided to keep the option open and to offer the possibility to fill out the web survey to the inventors.

Finally, Pilot 1 prompted us to codify a common procedure to retrieve the inventors whose address in the White or Yellow Pages did not match with that in the patent document. To avoid sample biases, we wanted our sample to include both inventors who did not move after the patent (i.e. same address in the patent as in the telephone directory) and inventors who moved (i.e. not found in the telephone directory or found with a different address). To help find the mobile inventors it was decided to search for other EPO patents that they might have produced more recently (i.e. after 1997, last year of our survey) in order to obtain their “new” address. However, we also had to find other criteria to avoid picking only mobile inventors who are more productive because they have produced other EPO patents later on.

To be precise, we had to search for two types of “non-exact matches”, inventors *with* and *without* EPO patents after 1997. In the former case, if the address in the later patent matched what we found in the national phone directories, we considered it to be the new address of the inventor where to contact him for submitting the questionnaire. The problem was for the inventors who did not have other EPO patents or who had other patents but still the addresses did not match with the phone directories. The latter were few cases, and for all practical purposes we can ignore them. The inventors with no EPO patents after 1997 were the hardest to find. We were unable to devise any good general criterion to look for them. It was then decided to follow the following steps:

1. Check whether the same name-surname was in the city even though at a different address. In this case, call the person to check whether he was the inventor. If there were up to 2-3

individuals with the same name-surname, call them to find out whether one was the inventor.

2. Search for the same name-surname in the wider regional area or at the national level. Again, with one or 2-3 name-surname call the person to find out whether he was the inventor.

3. Check for the address of the second or third inventors (if there were any) in the 1993-1997 EPO patent selected for our survey, and ask about the first inventor (including his address). When the first inventor was found, the questionnaire had to be submitted to him, otherwise to the second or third inventor.

4. Check the US patent data set to find the inventor and an address that matched exactly what we had in the national directories, or surf on the web.

Each step was to be followed after the previous step was not successful. To harmonise the procedure we issued a "Guideline to search for the inventors" that was distributed to the team members in the six countries and described the steps for searching the inventors' addresses and telephone numbers.[3]

Pilot 2

The third pilot survey – Pilot 2 – was conducted in January-February 2003. The aim of Pilot 2 was to test the latest version of the questionnaire and to involve the poll-companies in the project. The interaction with the poll-companies at this stage was important: they became familiar with the questionnaire, they set up the administrative procedures for the collection of the data, and they tested the software program for retrieving the data needed during the full-scale survey. Another goal of Pilot 2 was to interview some inventors with multiple patents in order to check their reaction when they were asked to fill out more than one questionnaire. The response rate to Pilot 2 also helped decide the number of questionnaires for the full-scale survey.

This pilot was conducted in Germany, Italy and the UK. Given the low number of Spanish patents, during Pilot 2 Spain started to interact with the poll-company, and used all the patents invented in Spain for the full-scale survey. The Dutch team improved the web-version of the questionnaire, but they did not work with any poll-company. France started to set-up the full-scale survey together with the Ministère de la jeunesse, de l'éducation nationale et de la recherche, who was then in charge of administering the survey.

In Pilot 2 we conducted about 30 interviews in each country. Like in Pilot 1 we set 30 to be the target number of questionnaires to be filled out per country, and we contacted as many inventors as it took to achieve this goal (around 100 in each country). We also tried to find some of the non-mobile inventors discussed earlier to check how hard it was to find them. In general, we tried to

[3] In the UK there was an additional problem in that the phone-books only report the surname and the initials of the first names. This made the search for the right person more difficult when there was not an exact match because there are many more people with the same surname and initials. Steps 1, 2, and in part 3 were then more impractical than in the other countries as more calls had to be made to find the person. This explains why the UK had to sent out relatively more questionnaires than the other countries to reach the target number of patents, as shown by Table 2.3 (lower response rate). See also the discussion about the UK survey method in Section 2.5.

mimic the conditions under which the full-scale survey was performed. We employed the procedures described in the "Guideline" to search for the addresses of the inventors, and we used the common glossary for labelling the variables and building up the dataset.[4]

2.5 Full scale survey

The full scale survey started with the definition of the final version of the questionnaire. Each team decided the methodology to apply to the own country to maximize the response rate. We selected a stratified sample that included all the opposed or cited patents in our 1993-1997 sample period and in our six countries, and a random sample of the other patents such that the expected number of returns was close to the targeted size of our dataset, as discussed in Section 2.3. To choose the number of patents to which to submit the questionnaires, we estimated the response rates from the ones observed in Pilot 1 and 2. Table 2.2 shows the composition of the patents to which we submitted the questionnaires. It can be compared with the population of 1993-1997 patents in Table 2.1 above, and with the patents that were returned and constitute our dataset in Table 2.7 below.

Table 2.2 Composition of target patents for the full scale survey, by country

Group	DE	ES	FR	IT	NL	UK	EU6
Opposed Patents	9.98%	4.17%	12.82%	12.72%	4.73%	3.96%	8.40%
Not opposed and cited	50.79%	19.02%	46.01%	62.80%	13.83%	11.42%	35.52%
Others (not opposed and not cited)	39.23%	76.81%	41.17%	24.48%	81.44%	84.62%	56.08%
Total	10500	815	5842	2500	3955	7846	31458

Period

The full scale survey started in May 2003 with the exception of France where the survey started in September 2003.

The first round of interviews was performed by telephone, mail or web, and was followed by a large number of recalls. The last country to finish the interviews was France in April 2004.

Survey method

Although the six countries in the project chose different means to administer the survey (paper questionnaire, telephone interviews, web survey, poll-companies), all of them employed a "recall strategy" in order to encourage the inventors to reply. Moreover, all the teams managed by themselves (not through the poll company) all the interviews with the inventors with three or more patents.

The Spanish survey was conducted by telephone. Inventors were approached by asking the

[4] We did not however over-sample the important patents at this stage.

applicant of the patent to talk to them, or by calling them at home. On average, Spain spent 10 telephone calls per patent.

The Dutch team implemented the web questionnaire both in Dutch and in English. Inventors were assigned a login number and a password. Each inventor had a personal web page with the data about his/her specific patent (i.e. name of the applicant, name of the co-inventors, etc.) Each inventor received a letter with the description of the project, the recommendation letters of the European Commission and the EPO, and the title and abstract of the patent. The letter asked him/her to login to the survey web page and to fill out the survey. The login page of the website asked the respondent to indicate if he/she was the inventor of the patent. If the inventors did not fill out the questionnaire after 3-4 weeks, the Dutch team sent them a reminder letter.[5] While the letters were out, about 15 inventors contacted the team, indicating they could not fill out the questionnaire on the web because they did not have Internet access, or because of problems in the browser (old browsers and some non-IE browsers). Almost all these inventors were interviewed by telephone. Two inventors asked for a paper questionnaire and filled it out, and the information they provided was entered in the website.

The German inventors could choose whether to reply by mail or by web. To do so the paper questionnaires were sent to the inventors by a subcontractor company (Target Group, Nürnberg, Germany) together with a letter. The letter contained a link to the web questionnaire. Questionnaires addressed to multiple inventors and to inventors with addresses abroad were forwarded by the German team. The first recall took place on July 8th, 2003 through a reminder postcard sent to 7,056 inventors who did not fill out the questionnaire. The remainder to single inventors was carried out by the subcontractor company; the German team did the remainder to multiple inventors and inventors living abroad. The second recall took place on October 15th, 2003 and was directed to a random sample of 1,250 inventors drawn from all the inventors who did not answer so far. Assuming that these inventors had already thrown away the questionnaires, the German team sent them another copy of the questionnaire by mail.

The pilot tests suggested that the web survey was not well suited for the Italian inventors. Therefore Italy performed telephone interviews. The inventors were first contacted by telephone to inform them about the survey and to confirm the mailing address. They received a paper version of the questionnaire together with a one-page information about their patent(s) and with a letter about the PatVal-EU project. The Italian survey took place in three waves: the first one was managed by a poll-company between May and July 2003; the second one started in September 2003; and the last one was run between December 2003 and January 2004. The Italian team administered the final two waves. The data collection finished in January 2004. During the first wave of the survey we divided the sample in two groups: one composed of all the inventors with one or two patents; the other one composed of inventors with “multiple patents” (more than two patents). The poll-company contacted the first group, while the Italian team managed directly the second one. The Italian team

[5] For all the inventors who did not fill out the questionnaire, the team started a telephone campaign on July 3rd. Inventors who did not respond after the reminder were asked by telephone to fill in the survey on the web, or to do an interview by telephone. If the inventor chose the latter, the interviewers (students of Eindhoven University of Technology) logged in and read the questions from the screen. These cases were considered as a sub-sample of the non-response group after the reminder, and we plan to use them as a check for potential non-response analyses.

performed two rounds of telephone recalls in order to raise the response rate.

In the UK the survey was conducted by mail. 7,846 questionnaires were sent to the first inventor listed in the patents. At the end of the first round, 754 questionnaires had been completed. Then, 1,822 inventors who received the paper questionnaire were called by telephone to invite them to fill out the questionnaire. If the inventors had lost the questionnaire, the UK sent them another copy. The UK also gave the inventors the possibility to fill out a web-based questionnaire. The English team particularly insisted on patent categories 1 and 2 during the telephone reminders. The UK sent out a second round of 2,000 additional questionnaires to the inventors (for budgetary reasons the poll-company NOP could not send more than 2,000 questionnaires). In the meanwhile, 110 first inventors who were contacted in the first round asked for another copy of the questionnaire. In a third round, the UK sent 1,705 questionnaires to 1,529 inventors from SPRU directly to the third inventor listed in the patents and to inventors found from telephone reminders.

In France, the survey was conducted by the Ministère de la jeunesse, de l'éducation nationale et de la recherche in Paris. It was a mail survey with four reminders. The first questionnaire was sent to all the inventors to the addresses listed in the patent document. When the questionnaire returned to the Ministère with the mention "unknown at this address", the French team started to search for the actual address of the "not found" inventors. The search was performed by looking at more recent patents applied by the same inventors and, if this method was not successful, the French team consulted the White Pages.

The French survey had some differences with respect to the other countries. The Statistical Department of the Ministry had extensive databases and information about the applicant organisations that made it easier to contact them (e.g. directories of firms or institutions, addresses, departments). As a result, some of the questions could be directed to managers or other people inside the organisation who could answer in a more informed way than the inventors. We could not adopt the same procedure for the other teams, as they did not have similar information about the applicant organisation, as we shall also discuss in Section 6.3. Thus, in the French case, the questions about the costs of the research, the source of funding, the use and the value of the patents were asked to the patent applicant (i.e. the firm or the public research institution that submitted the patent application at the EPO). They are questions D10-D19 and all the questions of Section F (F1-F8). (See our questionnaire in Annex I.) To reduce the burden of response on the inventors, they were not asked these questions. Only the question about the monetary value of the individual patent (question F7) was asked to both the inventors and the companies. All the other questions were asked only to the inventors. The applicant companies with 1 or 2 patents received a mail questionnaire followed by 2 reminders. The applicants with more than 2 patents were first contacted by telephone, while the questionnaires were shipped only after the French team found a person in the organization who was going to fill them out.

It is also important to clarify that in the French survey the questionnaires were not just sent to the applicant organisation or the inventor, and some questions were answered by the latter while others were answered by a manager. The mails with the questionnaires were shipped independently to the inventors and the managers. The applicant organisations returned 1,002 questionnaires, and the inventors returned 1,486. Of these 587 questionnaires overlapped, that is they were about the same patents.[6]

Response rate

The number of responses by country is reported in Table 2.3, together with the number of contacted patents and response rates. The observed differences in the country response rates stem from the different methodologies adopted to contact the inventors. The extreme cases are Italy and the UK. They can be easily explained by the different survey methodologies, which – as noted – were justified by the need to match the different attitudes and characteristics of the countries and their inventors. The UK sent out 7,846 questionnaires to the inventors listed in the EPO patents without checking in advance the validity of the address. As noted earlier, this is because the procedure set forth in our “Guidelines to search for the inventors”, and discussed under Pilot 1 in Section 2.4 above, was more impractical for the UK as the phone books only report surname and initials (rather than full first name). They therefore obtained a response rate of 19.65%. In Italy the questionnaires were sent out only to inventors with a correct address. These inventors were contacted by telephone before mailing them the questionnaire. They accepted to participate in the survey, and they were called twice afterwards to remind them to fill out the papers. The higher response rate of the Netherlands can be explained by the greater effectiveness, in that country, of the web questionnaire, which reduced the inventors’ response time and cost. All other countries have a response rate around one-third, which is in line with most surveys.

In the French case Table 2.3 shows the total number of responses and the response rates of the questionnaires returned by the inventors. The response rate for the 1,002 patents returned by the applicants is 23.86%, while the response rate for the 587 questionnaires responded by both the applicants and the inventors is 13.98%.[7]

Table 2.3 Full scale survey, response rates

Group	DE	ES	FR*	IT	NL	UK	EU6
Number of contacted patents	10215	815	4199	1857	2594	7846	27531
Number of responses (patents)	3346	269	1486	1250	1124	1542	9017
Response rate (in relation to the number of contacted patents)	32.76%	33.01%	35.39%	67.31%	43.33%	19.65%	32.75%

* Number of responses by inventors.

[6] Ex-post, we regretted that the questions that were asked to the managers were not also asked to the inventors. This might have reduced the inventors’ response rates because of a slightly higher burden of response (though not higher than in the other countries). But we would have collected the inventors’ responses on these questions like for the other countries.

[7] The total number of French patents for which the questionnaire was filled out is then 1,901, that is (1,486+1,002-587).

2.6 Final dataset

In order to harmonise the data collection across countries, we prepared a glossary to code the information gathered through the questionnaire. The glossary was tested in Pilot 2 and was used to construct the final dataset.

In the end we received 9,216 questionnaires filled out by the inventors, with the following distribution: Germany 3,346; France 1,651; Italy 1,250; the Netherlands 1,157; Spain 270; the UK 1,542 (Table 2.4). Some questionnaires were filled out also by 1 or 2 co-inventors, and hence they were about the same patent. We received 2 questionnaires on the same patent from 2 different respondents for 185 innovations (155 in France, 29 in the Netherlands and 1 in Spain); and 3 questionnaires on the same patent from 3 respondents for 7 innovations (5 in France, 2 in the Netherlands). Table 2.4 shows the distribution of the surveyed patents by country. It mirrors the relative size of the country population of patents. In the French case we reported the number of questionnaires filled out by the inventors, and the corresponding number of patents.

Table 2.4 Size of the final PatVal-EU datasets

Country	N. questionnaires	%	N. patents	%
Germany	3,346	36.32%	3,346	37.11%
Spain	270	2.93%	269	2.98%
France	1,651	17.91%	1,486	16.48%
Italy	1,250	13.56%	1,250	13.86%
Netherlands	1,157	12.55%	1,124	12.47%
UK	1,542	16.73%	1,542	17.10%
Total	9,216	100%	9,017	100%

Our final dataset includes about 7% responses from inventors whose exact address only matched a later EPO patent (after 1997) and 5% inventors without a later EPO patent, whose address was found with the procedure discussed under Pilot 1 in Section 2.4 above.[8] Because the average exact matches were 64%, our full scale dataset under-represents the 36% non exact matches. Also, we have no way to figure out whether the proportions between inventors with and without later EPO patents are really 7 over 5. We can only say that we have to be careful about this potential bias in our data. However, the high rate of exact matches (64% on average, but even above 80% for Germany or Spain, and about two-thirds for France, Italy and the Netherlands – see footnote 1) suggests that in Europe the mobility of inventors is not pronounced. Hence, the extent of this potential bias may not be dramatic. It may be more serious for our UK data.

In the reminder of the report we show the country statistics based on the number of patents (and not the number of questionnaires). We therefore excluded (randomly) the double or triple answers for

[8] There are minimal differences in these two percentages across our six countries.

the same patent.[9] All the statistics are computed by excluding the missing values from the total number of observations. Annex II shows the detailed and complete summary statistics, and indicates the number of missing values for each question. In the case of France our Tables on patent characteristics use the information given by the inventors in order to ensure homogeneity with the other countries.

Table 2.5 describes the composition of the datasets by macro technological classes. The five technological macro-classes are defined according to the ISI-INIPI-OST patent classification based on the EPO IPC classes.[10] Mechanical engineering and process engineering are the most represented classes at the EU6 level. In the Netherlands the share of electrical engineering patents is higher than the European average, while in the UK the share of Instruments is above the average. Table 2.6 shows the country distribution of patents by using a more disaggregated technological classification.

Table 2.5 Macro-technological classes by country, in %

Technological Class	DE	ES	FR	IT	NL	UK	EU6
Electrical engineering	13.33%	10.45%	15.54%	16.03%	23.40%	16.73%	15.83%
Instruments	10.28%	6.72%	11.04%	8.41%	10.68%	14.92%	10.88%
Chemistry, Pharmaceuticals	19.16%	20.52%	15.55%	16.19%	20.46%	20.10%	18.51%
Process engineering	25.37%	27.24%	25.37%	26.28%	25.53%	21.66%	24.94%
Mechanical engineering	31.86%	35.07%	32.50%	33.09%	19.93%	26.59%	29.84%
Total	100%	100%	100%	100%	100%	100%	100%

Note: patents have been classified according to the ISI macro classes.

[9] The information on double or triple patents were however used to check for the consistency of information provided by different inventors. We found that there was a quite good consistency among the responses.

[10] We used the technology-oriented classification system jointly elaborated by the German Fraunhofer Institute of Systems and Innovation Research (ISI), the French Patent Office (INIPI) and the Observatoire des Science and des Techniques (OST). It distinguishes among 30 technologies and 5 higher-level technology areas based on the International Patent Classification (IPC). For the concordance between ISI-INIPI-OST technological classes and EPO IPC classes see Hinze *et al*. (1997).

Table 2.6 Technological classes by country, in %

	DE	ES	FR	IT	NL	UK	EU6
Electrical devices, electrical engineering, electrical energy	8.03%	6.71%	7.84%	6.84%	8.26%	6.27%	7.51%
Audio-visual technology	1.23%	0.37%	1.28%	1.28%	5.16%	2.66%	1.95%
Telecommunications	2.09%	2.99%	3.23%	2.80%	6.49%	3.44%	3.18%
Information technology	1.02%	0.37%	2.49%	3.04%	2.49%	3.96%	2.21%
Semiconductors	0.96%	0.00%	0.74%	2.08%	0.98%	0.39%	0.95%
Optics	1.55%	0.00%	1.41%	1.36%	2.85%	3.05%	1.87%
Analysis, measurement, control technology	6.31%	4.10%	5.38%	3.93%	4.98%	8.43%	5.96%
Medical technology	2.03%	2.61%	3.50%	2.64%	2.58%	2.85%	2.58%
Organic fine chemistry	6.72%	8.58%	5.65%	5.53%	3.83%	6.81%	6.09%
Macromolecular chemistry, polymers	6.96%	4.10%	2.49%	5.37%	6.14%	2.98%	5.14%
Pharmaceuticals, cosmetics	1.43%	2.24%	3.43%	1.36%	1.25%	2.33%	1.91%
Biotechnology	0.30%	0.00%	1.01%	0.56%	2.14%	0.91%	0.78%
Materials, metallurgy	3.62%	4.85%	4.91%	2.48%	2.40%	2.79%	3.42%
Agriculture, food chemistry	0.39%	2.24%	1.21%	1.04%	3.38%	1.75%	1.28%
Chemical and petrol industry, basic materials chemistry	3.35%	3.36%	1.75%	2.32%	3.74%	5.32%	3.33%
Chemical engineering	2.96%	2.99%	4.37%	2.08%	3.38%	3.50%	3.22%
Surface technology, coating	1.64%	2.24%	1.21%	1.52%	0.89%	1.82%	1.51%
Materials processing, textiles, paper	5.53%	3.73%	4.91%	7.85%	4.45%	4.60%	5.40%
Thermal processes and apparatus	2.15%	1.49%	2.02%	2.64%	2.94%	1.23%	2.12%
Environmental technology	2.15%	1.12%	0.87%	1.12%	1.69%	1.56%	1.61%
Machine tools	4.06%	4.48%	3.03%	6.25%	1.25%	2.08%	3.52%
Engines, pumps, turbines	3.02%	2.24%	1.95%	3.37%	1.16%	4.22%	2.84%
Mechanical Elements	5.83%	2.24%	4.17%	3.13%	2.40%	3.96%	4.33%
Handling, printing	7.92%	9.33%	5.85%	10.10%	7.38%	6.10%	7.54%
Agricultural and food processing, machinery and apparatus	1.55%	2.99%	3.23%	1.12%	5.34%	1.30%	2.24%
Transport	8.55%	6.72%	7.40%	6.09%	4.18%	5.84%	6.96%
Nuclear engineering	0.39%	0.00%	0.74%	0.48%	0.27%	0.58%	0.47%
Space technology weapons	0.57%	1.12%	1.68%	0.32%	0.09%	0.32%	0.63%
Consumer goods and equipment	3.89%	10.82%	6.80%	7.69%	4.00%	4.35%	5.19%
Civil engineering, building, mining	3.80%	5.97%	5.45%	3.61%	3.91%	4.60%	4.26%
	100%	100%	100%	100%	100%	100%	100%

Table 2.7 highlights the impact of the over-sampling criteria adopted in the sampling procedure, and shows the composition of our dataset by country. Compared to the population of patents in Table 2.1, the over-sampling procedure produced about 15% additional observations for the “important patents” at the aggregate EU6 level in our final dataset. The share of “important patents” is higher in Italy, Germany and France compared to the other three countries.

Table 2.7 Dataset composition by Country

	DE	ES	FR	IT	NL	UK	EU6
Opposed Patents	9.99%	4.48%	11.71%	10.09%	6.49%	3.63%	8.59%
Not opposed and cited	51.79%	16.04%	26.58%	48.16%	13.97%	12.52%	34.64%
Others (not opposed and not cited)	38.22%	79.48%	61.71%	41.75%	79.54%	83.85%	56.77%
Total	3346	269	1486	1250	1124	1542	9017

Figure 2.1 and Table 2.9 show the sex and age of the inventors. Figure 2.1 displays the share of female respondents and their distribution across the EU6 countries. There are only 2.82% female inventors in the EU6. The largest share is in Spain (8.21%) and the lowest is in Germany (1.64%). The extremely low share of women in inventive activity is consistent with the statistics about women’s participation in S&T reported in the *Third European Report on Science and Technology Indicators* (European Commission, 2003b). However, the proportion of female inventors is strikingly smaller than the share of women researchers in all disciplines (29%) at the EU-15 level, of women researchers in engineering disciplines (12%) and of female R&D personnel in the business sector (European Commission, 2003b). These data, in line with the European debate on this issue, suggest that women represent a broad unexploited potential for the intensification of the inventive activity in Europe.

As far as their age is concerned, Table 2.9 shows that the inventors are uniformly distributed across the age classes between 31 and 60 years with a peak in the central class. About 5% of inventors are less than 30 years old and 5.5% are older than 60 years old. Interestingly, the share of young inventors (under 40) is the highest in the Netherlands, while the share of “old” inventors is the largest in Germany (above 50).

Figure 2.1 Female inventors as % of all inventors

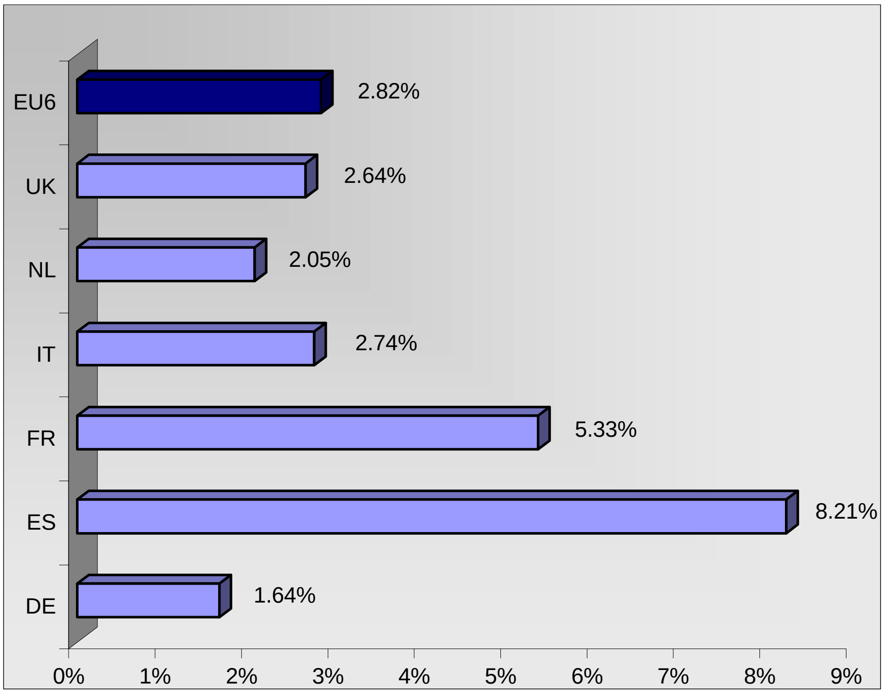


Table 2.8 Age of inventors

	DE	ES	FR	IT	NL	UK	EU6
<=30	2.72%	11.11%	6.03%	5.61%	6.49%	5.05%	4.79%
31-40	31.40%	32.94%	27.75%	30.46%	36.66%	26.66%	30.55%
41-50	27.20%	28.17%	36.44%	32.98%	33.54%	38.35%	32.31%
51-60	32.00%	21.03%	25.02%	25.26%	21.06%	24.16%	26.85%
61-70	6.29%	5.56%	4.00%	5.28%	2.08%	5.12%	5.00%
>70	0.39%	1.19%	0.76%	0.41%	0.17%	0.66%	0.50%
	100%	100%	100%	100%	100%	100%	100%

SECTION 3. EDUCATION, EMPLOYMENT, AND MOBILITY

3.1 Inventors' education

This section examines the characteristics of the inventors in the PatVal-EU survey. It deals with their education, their working status at the time in which the research leading to the patent was performed, and their mobility across different firms and institutions. There is a broad consensus among economists and policy-makers about the impact of R&D and innovation in general, and human capital in particular, on productivity and economic growth. The *Key Figures 2003-2004* issued by the European Commission recognise the role of education and training as important means to achieve the overall Lisbon objectives. The European Commission (2002) also estimates that one additional year of schooling increases the aggregate productivity by 6.2% for a typical European country (European Commission, 2002). For the time being, however, the amount of resources devoted to R&D, the quality of the education system, and the number and productivity of skilled human capital vary enormously across the EU countries. This section contributes to highlight the status of the inventors in Europe, and the differences across the six EU countries interviewed.

Figure 3.1 Share of inventors with tertiary education and Ph.D degree

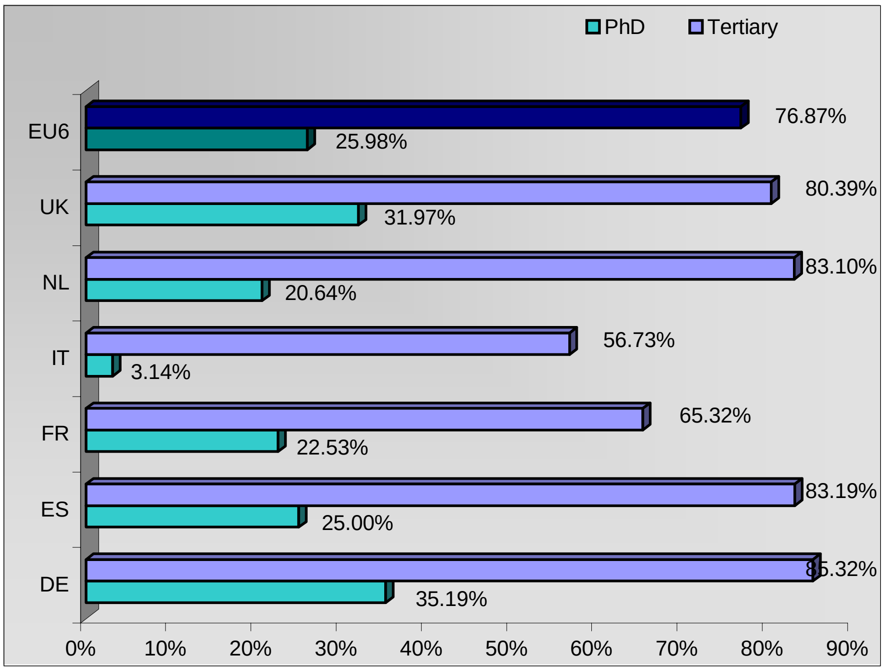


Figure 3.1 shows the level of education of the PatVal-EU inventors. The overall share of inventors with university degree is 76.87%, while the share of inventors with a Ph.D is 25.98%. There is

considerable variation across countries. Germany is leading the other 5 countries in both indicators: the share of tertiary educated inventors is 85.32% and the share of inventors with a Ph.D is 35.19%. The share of inventors with tertiary education in Spain, the Netherlands and the UK is close to Germany (83.19%, 83.10% and 80.39% respectively). It falls to 65.32% for the French inventors. The share of inventors with a Ph.D is around 20-25% in the Netherlands, Spain and France while in the UK is much closer to the German one (31.97%). Italy is lagging behind: the share of inventors with tertiary education is only 56.73% and the share of inventors with a Ph.D is 3.14%.

3.2 Patents, inventors and organizations

Figure 3.2 looks at the employment position of the inventors when the research leading to the patent was performed. The largest majority of the inventors are employed in organisations that they do not own ("dependent" inventors, 89.23% for the overall EU6). This share reaches a peak in the Netherlands (93.06%), followed by Germany (91.86%), the UK (90.48%), France (85.95%), Italy (82.74%), and Spain (81.10%). In the EU6 a small fraction of the inventors is self-employed (an average of 7.81%) with no considerable variation across countries.

Figure 3.2 Inventors' employment position when the research leading to the patent was performed

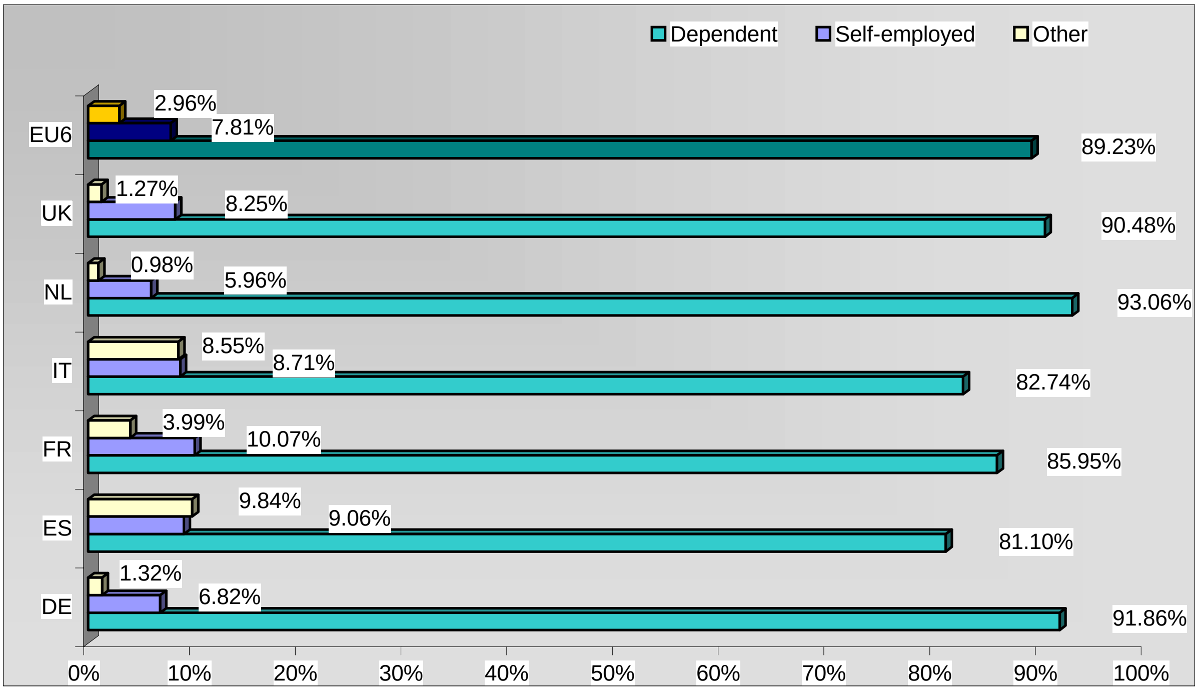
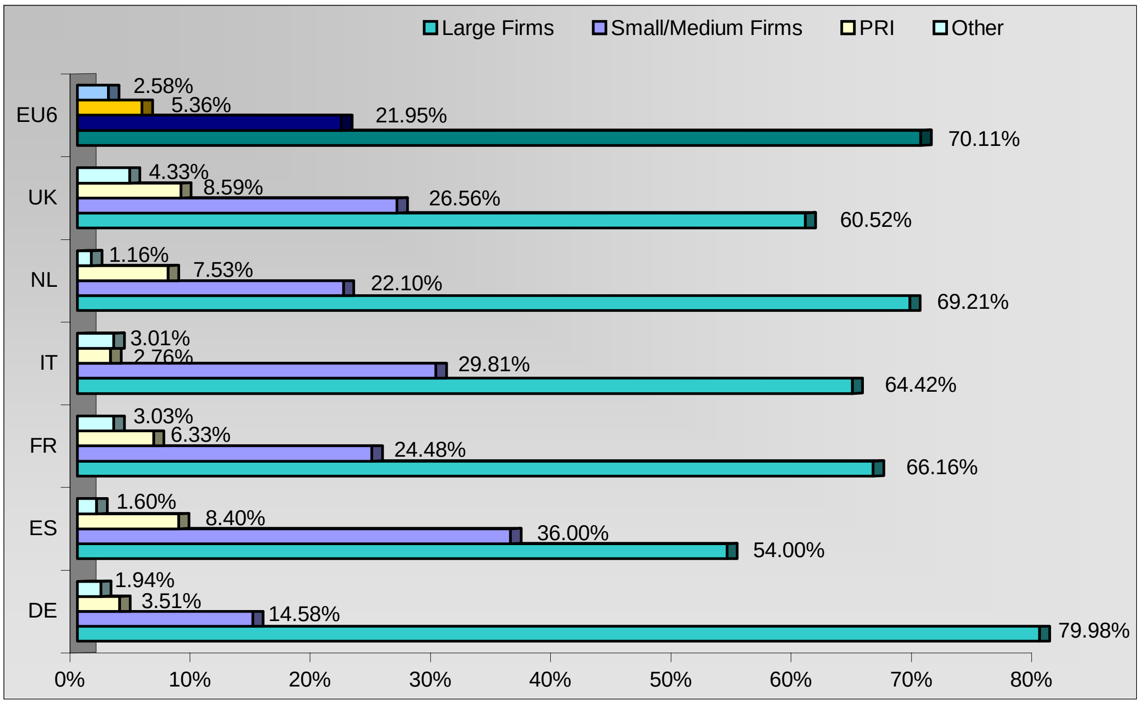


Figure 3.3 Type of organisation in which the inventors were working when the research leading to the patent was performed



Note: "PRI" indicates Public Research Institutes such as Government Research Organization, University and other Education Institutes; "Other" stands for Hospital, Foundation, Private Research Organization and Other residual categories. Large firms denote firms with more than 250 employees; small-medium firms less than 250.

Figure 3.3 shows the type of organisation in which the inventors were employed. The business sector is the largest source of innovations in all six countries: 70.11% of the total number of inventors is employed in large companies (more than 250 employees); 21.95% are in small and medium enterprises (less than 250). Only 5.36% of the inventors work in Public Research Institutes, and 2.58% are in other organisations like hospitals and foundations.

There is diversity among the six countries, however, in terms of the importance of the large *vs.* the small and medium firms in producing innovations. As expected, the largest share of inventors employed in large organisations is in Germany: 79.98% of the inventors are employed in large companies against a share of 14.58% working in small and medium enterprises. The share of inventors employed by large firms is around 69% in the Netherlands, 65% in France and Italy, and 60% in the UK. In Spain the share of inventors employed in large firms falls to 54%. In the same country, the share of inventors employed by small and medium firms is the highest among the EU6 countries (36%). Italy and the UK follow with 29.81% and 26.56% respectively. All in all these data are indicative of the relative importance of the business sector, and in particular of the large firms, in producing innovations in Europe. It also confirms the role of the small and medium enterprises in producing innovations in countries like Italy and Spain.

Finally, the UK exhibits the largest share of inventors working in public research institutions (8.59%). The lowest is in Italy (2.76%).

3.3 Inventors' mobility

Table 3.1 displays the inventors' job mobility.

Table 3.1 Number of times the inventors changed employer after the invention

	DE	ES	FR	IT	NL	UK	EU6
0	83.14%	88.80%	82.28%	75.43%	69.88%	65.28%	77.52%
1	10.98%	9.65%	11.79%	16.55%	18.23%	23.39%	14.78%
2	4.12%	1.54%	4.09%	6.41%	7.33%	7.33%	5.32%
3	1.38%	0.00%	1.23%	0.97%	1.88%	3.01%	1.58%
More than 3	0.37%	0.00%	0.61%	0.65%	2.68%	0.79%	0.80%
Total	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

Most of the inventors never changed job after the patented invention. The EU6 share of inventors who never moved is 77.52%, with differences across countries. The less mobile inventors are in Spain, Germany and France: 88.80%, 83.14% and 82.28%. Italy and the Netherlands follow with 75.43% and 69.88%. The UK is the country with the smallest share of non-mobile inventors: 65.28%. Most of the inventors who changed job, moved only once. The share of EU6 inventors who moved more than three times is 0.80%. Recent contributions point out that there is a positive correlation between the researchers' productivity and their mobility, and highlight the importance of human capital mobility as a mechanism through which knowledge spillovers take place (Klepper, 2001; Zucker, Darby and Armstrong, 1998). A goal of our research agenda based on the PatVal-EU data is to investigate the relationship between the inventors' mobility and their innovative performance.

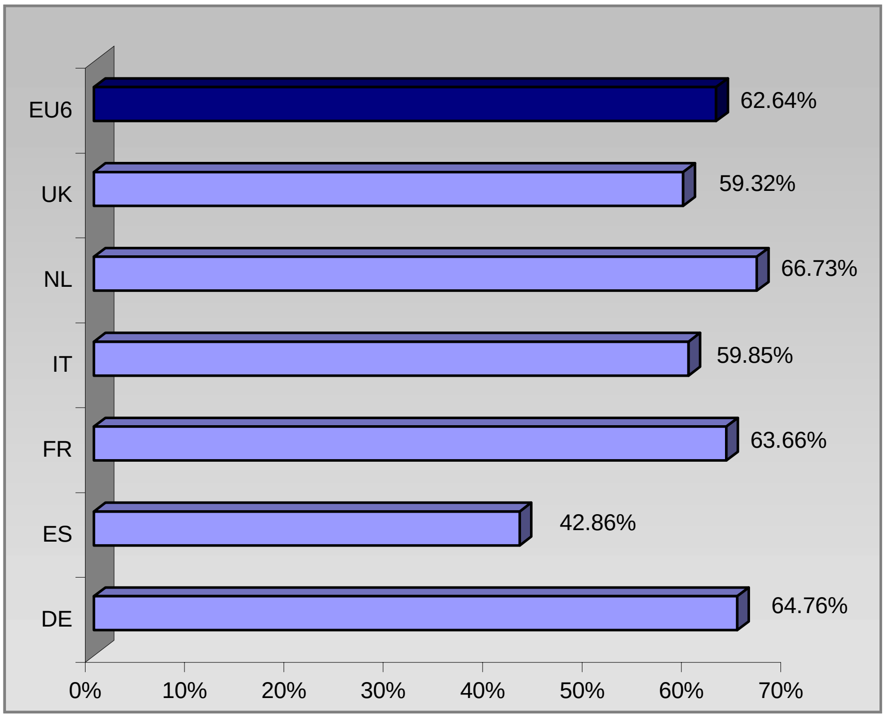
SECTION 4. THE INVENTION PROCESS

This section explores the "black box" of knowledge production. It deals with three issues: the importance of collaborations among individual inventors and among different organisations in the innovation process; the sources of knowledge to produce the innovations, and their relative importance; the origin of the innovations.

4.1 Collaboration

Figure 4.1 shows the extent of collaboration among individual inventors in the research leading to the patent. Only one third of the overall number of PatVal-EU patents is developed by "individual" inventors. The overall EU6 share of "multiple inventors" patents is 62.64%. Compared to the EU6 average, the size of the research networks is larger in the Netherlands (66.73% of "multiple inventors" patents) and in Germany (64.76%). The UK (59.32%) and Italy (59.85%) are below the EU6 Average. Spain is at the bottom of the list in terms of the propensity to establish research networks among individual inventors: the share of patents invented by "multiple inventors" is 42.86%.

Figure 4.1 Share of patents with more than one inventor



The "multiple inventors" considered in Figure 4.1 might belong either to the same organisation or to different organisations. In fact, quite often there are no multiple applicants even if the invention is conducted under some formal, let alone informal, collaboration. Figure 4.2 reveals whether one or more co-inventors involved in the development of "multiple inventors" patents are affiliated to organisations different from the primary inventor's organisation. The EU6 share of patents developed by inventors affiliated to different organisations is 23.94%. In the UK this share reaches 35.52%. It falls to 21.88%, 19.29% and 16.05% in Spain, France and Italy respectively, where the networks of inventors tend to be within the same organisation, with a limited role of external linkages compared to the other countries. The Netherlands and Germany are close to the EU6 average.

Figure 4.2 Share of patents where one or more co-inventors are affiliated to organizations other than the inventor's primary employer

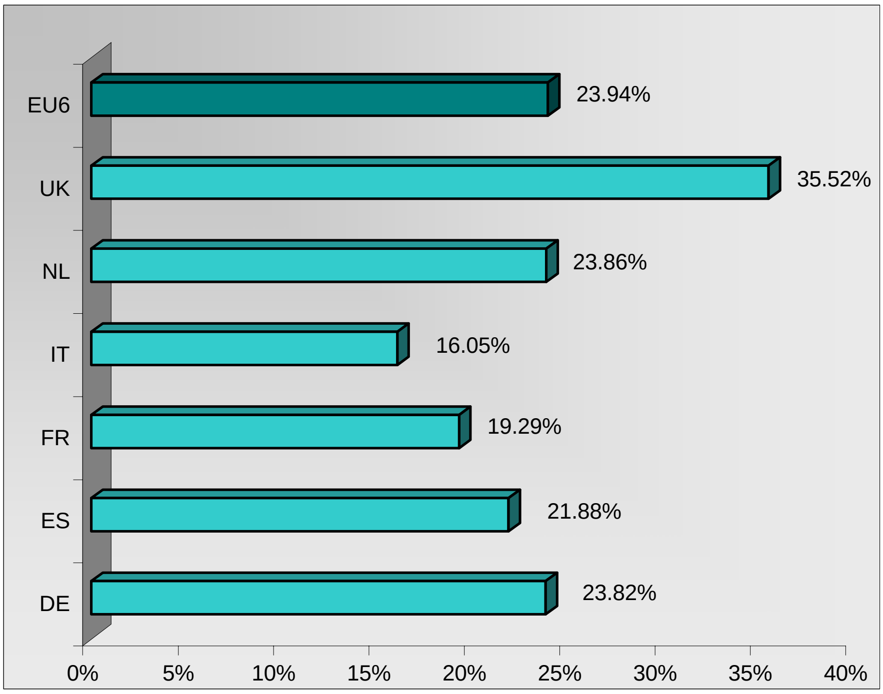
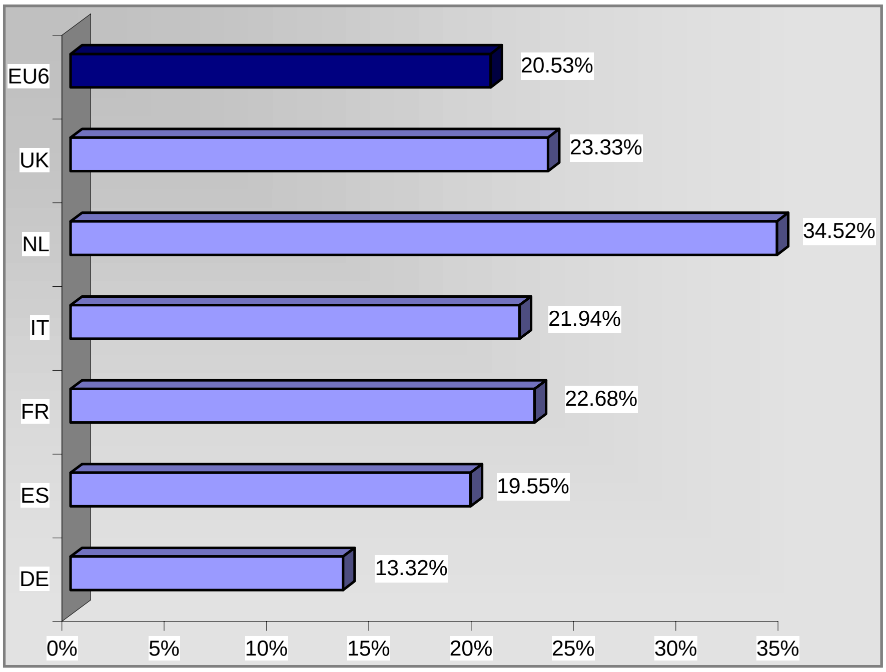


Figure 4.3 shows the share of patents invented in collaboration with other partners. Consistently with Figure 4.2, the EU6 share of patents produced by using external collaborations is 20.53%. This share is higher in the Netherlands (34.52%), while the UK, France, Italy and Spain are close to the EU6 average. Only 13.32% of German patents are invented in research projects that involve external firms and institutions. This is consistent with Figure 3.3 that shows that a high share of German inventors are employed in large companies that tend to internalise the R&D process within the firm boundaries.

Figure 4.3 Share of patents developed through a formal or informal collaboration between the employer organisation and other partners

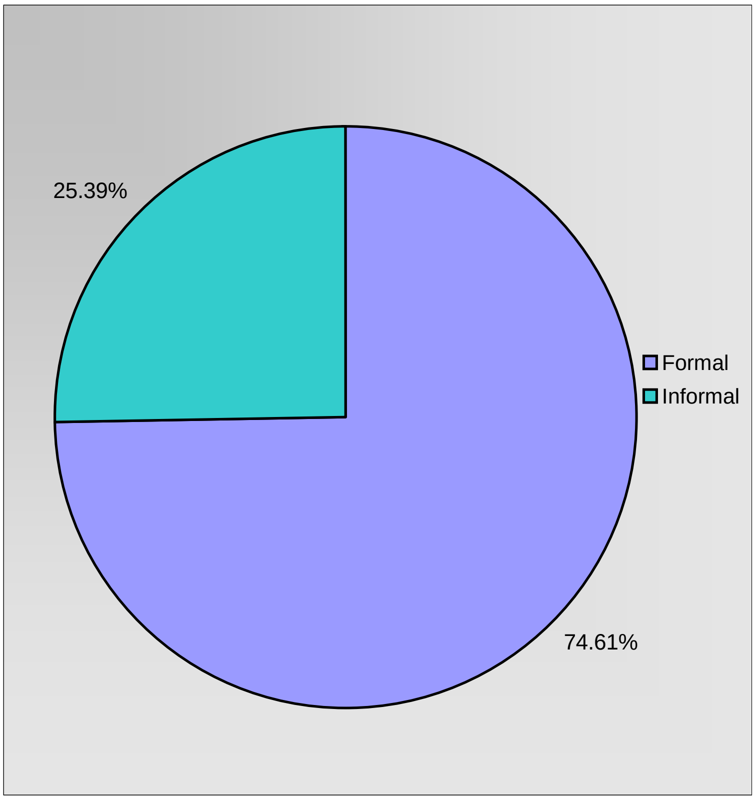


No distinction is made in Figure 4.3 between formal and informal collaborations to develop the innovations. Figure 4.4 shows the share of formal collaborations (i.e. collaborations through well defined contracts among the parties) in the PatVal-EU database. It indicates that, when different firms and institutions take part in a research project leading to a patent, the partners normally establish formal collaborations (74.61%). About one fourth of the collaborations, however, are informal. This is the part of the inter-organisation networking that the data on multiple applicants, R&D collaborations, etc. do not capture. This also suggests that there are some informal interactions among organisations that give rise to knowledge spillovers among inventors and institutions that are not mediated by any apparent market mechanism.

To explore further the role of the collaborations among inventors, Table 4.1 uses a scale from 1 to 5 to show the average importance of the interactions that the inventors set up either with people belonging to his/her own organisation, or with people belonging to other organisations. It also considers the geographical distance between the parties (i.e. less or more than one hour to reach physically the partner) to highlight the effect of geographical proximity in fostering knowledge exchange.

Table 4.1 indicates that the interaction with other members of the same organisation are on average more important than the interaction with people affiliated to other organisations, especially if they are geographically close. For the overall EU6, the importance of the interaction with people belonging to same organisation of the inventor (including affiliates) that typically takes less than one hour to be reached ranks first (3.02). This is so for all the six countries. When it takes more than one hour to reach the location of the other researcher, the inventors rank very similarly the importance of the interaction with people from the same organisation and from other organisations, both at the EU6 level (1.31 and 1.32 respectively) and in each country. Only in Spain the affiliation to the same firm seems to be important in fostering the interaction between close and distant inventors. Finally, the interaction with people from other organisations that are geographically close is the least important form of collaboration both at the overall EU6 level and in each country, which suggests that, on average, geographical proximity does not encourage interactions among unaffiliated organizations.

Figure 4.4 Share of formal collaboration agreements



Note: The above shares have been computed by considering all collaborations set up to develop the innovation. If we only consider the first collaboration listed by the inventor for each patent, the share of formal collaboration is 76.88% and the share of informal collaboration is 23.12%.

Table 4.1 Average importance of the interactions between the inventor and other people

Forms of Interactions	DE	ES	FR	IT	NL	UK	EU6
Inventors' organisation (including affiliates), and it typically took less than one hour to reach the other people's office or location	2.88 *(1.91)*	3.51 *(1.83)*	3.20 *(1.80)*	2.53 *(1.92)*	3.31 *(1.85)*	3.24 *(1.81)*	3.02 *(1.88)*
Inventors' organisation (including affiliates), and it typically took more than one hour to reach the other people's office or location	1.07 *(1.55)*	2.85 *(2.18)*	1.42 *(1.69)*	1.12 *(1.65)*	1.23 *(1.65)*	1.69 *(1.84)*	1.31 *(1.70)*
Other (unaffiliated) organisations, and it typically took less than one hour to reach the other people's office or location	0.73 *(1.33)*	0.73 *(1.50)*	1.41 *(1.71)*	0.57 *(1.19)*	0.85 *(1.45)*	0.96 *(1.44)*	0.88 *(1.45)*
Other (unaffiliated) organisations, and it typically took more than one hour to reach the other people's office or location	1.25 *(1.75)*	0.94 *(1.63)*	1.53 *(1.80)*	1.08 *(1.67)*	1.30 *(1.76)*	1.54 *(1.83)*	1.32 *(1.77)*

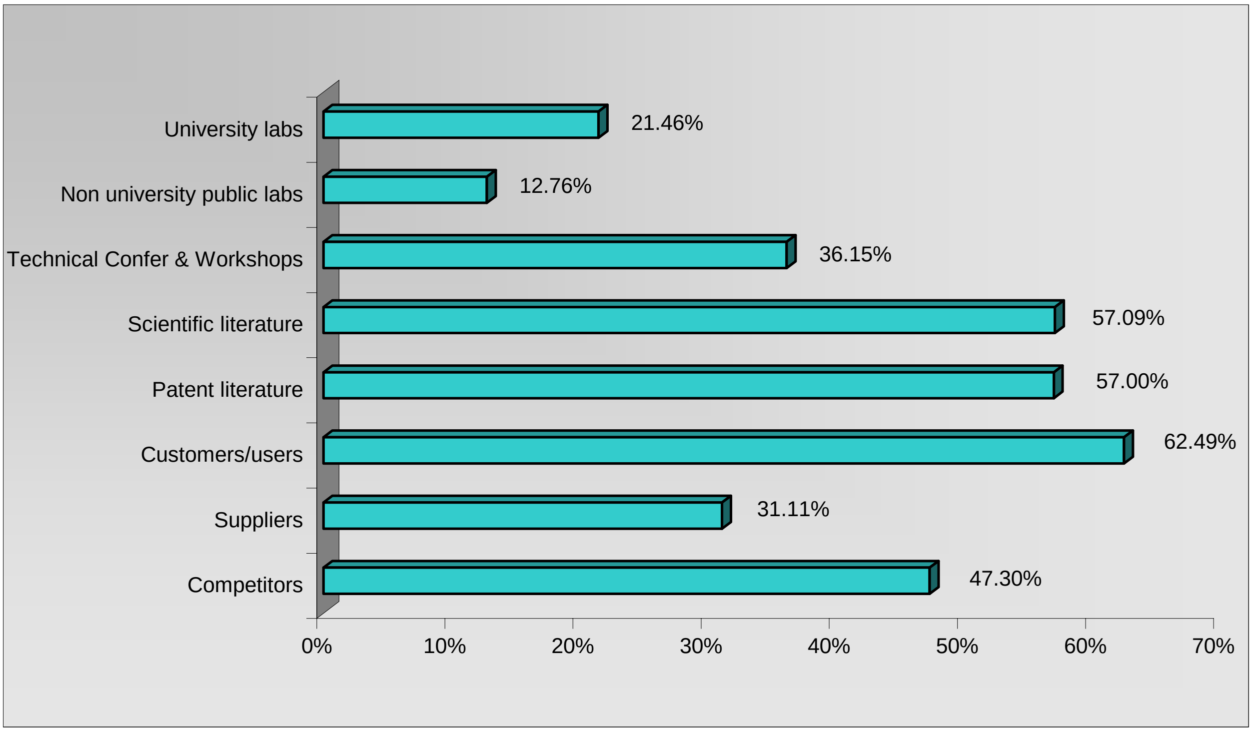
Note: Average values. Standard deviations are in parentheses.
Scale adopted: 0=no interactions; 1=not important, 5=very important.

4.2 Sources of knowledge

Figure 4.5 and Table 4.2 list the sources of knowledge for developing the innovation, and their average importance on a scale from 0 to 5. The sources of innovation taken into account are: the firm's competitors, the suppliers, the customers, other patents developed before the patent in the survey, the scientific literature, the participation in conferences and workshops, the knowledge developed in university and non-university laboratories.

Figure 4.5 shows the share of inventors who rated "important" the use of the sources of innovation listed above, i.e. the share of inventors who assigned at least 3 (on a scale from 0 to 5) to the importance of the sources of innovation. The firm's customers are the most common source of innovation with 62.49% of the inventors who rated them as important, followed by the knowledge supplied by the patent literature and the scientific literature (57% both). The interaction with the firm's competitors is an important source of innovation for 47.30% of the inventors. The participation in conferences and workshop is important in 36.15% of the cases, and the contacts with the firm's suppliers are important for 31.11% of the inventors. University and non-university research laboratories are a relatively unimportant source of innovation. Only 21.46% and 12.76% of the inventors rated the knowledge coming from university laboratories and from non-university laboratories as important.

Figure 4.5 Share of inventors who rated "important" the use of the following sources of innovation



Note: Share of inventors who assigned at least 3 to the importance of each source of knowledge on a scale 0-5 (0=not used, 5=very important).

Table 4.2 Average level of importance of sources of innovation by country

	DE	ES	FR	IT	NL	UK	EU6
University labs	1.23 *(1.59)*	0.94 *(1.63)*	1.19 *(1.60)*	0.63 *(1.37)*	1.43 *(1.75)*	1.21 *(1.69)*	1.15 *(1.62)*
Non university public labs	0.91 *(1.37)*	0.64 *(1.36)*	0.94 *(1.40)*	0.31 *(0.95)*	0.96 *(1.44)*	0.69 *(1.22)*	0.79 *(1.32)*
Technical Confer & Workshops	1.99 *(1.78)*	1.20 *(1.63)*	1.51 *(1.65)*	1.36 *(1.71)*	1.55 *(1.56)*	1.55 *(1.68)*	1.67 *(1.72)*
Scientific literature	2.71 *(1.84)*	2.37 *(2.01)*	2.35 *(1.94)*	2.50 *(1.97)*	2.4 *(1.74)*	2.54 *(1.93)*	2.55 *(1.89)*
Patent literature	2.83 *(1.86)*	2.76 *(1.83)*	2.62 *(1.93)*	2.14 *(1.94)*	2.40 *(1.74)*	2.59 *(1.95)*	2.60 *(1.90)*
Customers/users	3.25 *(1.90)*	2.50 *(1.95)*	2.40 *(2.00)*	2.64 *(2.03)*	2.81 *(1.88)*	2.8 *(2.02)*	2.88 *(1.98)*
Suppliers	1.58 *(1.71)*	1.26 *(1.53)*	1.73 *(1.81)*	1.04 *(1.57)*	1.56 *(1.64)*	1.7 *(1.83)*	1.55 *(1.73)*
Competitors	2.42 *(1.87)*	1.88 *(1.72)*	2.38 *(1.96)*	1.67 *(1.84)*	2.00 *(1.70)*	1.90 *(1.84)*	2.15 *(1.87)*

Note: Average values. Standard deviations are in parentheses.
Scale adopted: 0=not used, 5=very important.

Table 4.2 looks at the average importance of the sources of innovations listed in Figure 4.5. At the overall EU6 level, the firm's customers are ranked first (2.88), with little variation among the six European countries. The patent and scientific literature are in the second and third position (2.6 and 2.55), followed by the firm's competitors (2.15), the participation in technical conferences and workshops (1.67), and the interaction with suppliers (1.55). Finally, the knowledge coming from university and non-university research laboratories are at the bottom of the ranking with an average importance of 1.15 and 0.79.

4.3 Origins of the invention

This sub-section shows the origins of the innovations in terms of the research project that led to the patent, the fact that the innovation is part of a group of intertwined patents, and the type of funds that the inventors used to develop the innovation.

Table 4.3 lists some scenarios that describe the invention process leading to the patent. The most frequent answer is that the invention is the expected output of a research project aimed at achieving a specific goal (38.20%). This is so for all the six countries in the survey, with some variation among them. At the overall EU6 level, the second most frequent scenario is that the idea leading to the patent was directly related to the inventor's normal job which is not inventing, and it was further developed in a research project afterwards (20.17%). The remaining 40% of the inventors are distributed evenly across the other three scenarios: the invention was an expected by-product of a research project not directly related to the main target of the project (11.55%); the invention was an unexpected by-product of a research project not directly related to the main target of the project (11.57%); the idea came from pure inspiration and creativity or from the inventor's normal job which is not inventing, and was patented without further research or development efforts (13.87%).

Therefore, roughly half of the innovations are the direct or indirect expected output of a targeted research project (i.e. the invention was a targeted achievement or an expected by-product of a research project). The remaining half arises unexpectedly from research projects undertaken for other purposes or from activities other than inventing. This is so for all the six countries. Moreover, when the innovation is directly related to the inventor's normal job, which is not inventing, companies tend to develop it further in a targeted research project. This is so for Spain (23.2%), France (34.5%), Italy (25.4%), The Netherlands (16.7%), and the UK (16.4%).

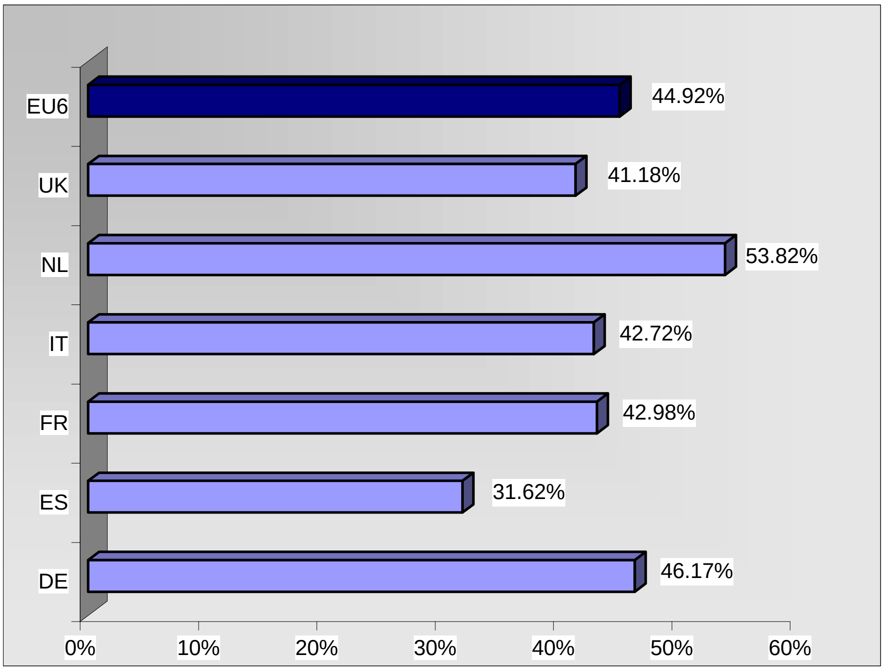
Table 4.3 Scenario that best describes the innovative process (share of inventors)

	DE	ES	FR	IT	NL	UK	EU6
The invention was the targeted achievement of a research project	29.66	57.60	44.00	37.01	40.83	45.83	38.20
The invention was an expected by-product of a research project, not directly related to the main target of the project	16.77	6.40	5.62	13.10	10.50	6.98	11.55
The invention was an unexpected by-product of a research project, not directly related to the main target of the project	16.65	3.20	3.19	5.78	16.64	11.60	11.57
The idea for the invention was directly related to the inventor's normal job (which is not inventing), and was then further developed in a (research) project	14.17	23.20	34.58	25.39	16.73	16.36	20.17
The idea for the invention came from pure inspiration/creativity or from your normal job (which is not inventing), and was not further developed in a (research or development) project (was patented without further research or development costs)	20.47	3.60	3.66	17.58	6.94	14.08	13.87
Other	2.28	6.00	8.95	1.14	8.36	5.15	4.64
Total	*100*	*100*	*100*	*100*	*100*	*100*	*100*

Figure 4.6 shows the share of patents that are part of a group of intertwined patents. As noted earlier, for "intertwined patents" we mean a group of patents that crucially depend on each other technically or in terms of their value. The EU6 share of patents that are part of a group of intertwined patents is 44.92%. There are, however, differences among countries. The Netherlands,

for example, have 53.82% of such patents, followed by Germany (46.17%), France (42.98%), Italy (42.72%), the UK (41.18%), and Spain (31.62%). A goal of our research agenda is to understand the factors that explain the production of intertwined patents. For example, the scale of the research projects carried out in large firms, the technological complexity of some innovations, or strategic reasons might induce to apply for groups of related patents.

Figure 4.6 Share of patents that are part of a group of intertwined patents



Finally, Table 4.4 lists four sources of funding for the research leading to the patent. The inventors were allowed to pick more than answer, which explains why the sums in the columns are above 100%. At the overall EU6 level 89.37% of the innovations were developed by using the firm's internal funding. There is little variability among countries. The two extremes are the Netherlands with the lowest share of company funding (77.94%) and Germany with the largest (94.03%). Government research funds come second at the EU6 level, with 8.70% of the patents. This is the second source of funding in all six countries with the exception of the Netherlands where, although the share is 11.21%, government funding is ranked third, after the funds provided by unaffiliated organisations that join the research project. In all the other countries, and for the EU6 as a whole, the unaffiliated organisations are the third most important source of funding. The banks and other financial institutions enter the picture only marginally with 1.15% of patents at the EU6 level, with no large variation among countries.

Table 4.4 Types of financing of the research leading to the patent (share of inventors in %)

	DE	ES	FR	IT	NL	UK	EU6
Internal funds of the patent applicant (including his subsidiaries)	94.03	90.84	91.73	88.00	77.94	87.33	89.37
Funds from any other unaffiliated organization joining the project	3.27	2.39	3.62	2.40	13.08	3.83	4.59
Funds from financial intermediaries of any kind (banks, other financial institutions, etc.)	0.37	1.20	1.55	2.40	1.42	1.32	1.15
Government Research Programmes or other government funds	5.41	23.11	10.24	9.52	11.21	9.77	8.70
Other	4.70	2.39	1.55	6.95	4.36	8.05	5.16

Note: Multiple responses allowed.

SECTION 5. INVENTORS' REWARDS

The rewards of the inventors from their patents differ according to the institutional system in which the inventors and their organisation operate, the type of organisation in which the inventors are employed, and the policies adopted to affect the inventors' performance. In some countries, the law regulates the assignment of the property rights between the inventor and the organization. For example, by allowing university patenting on Federally funded research, the US Bayh-Dole Act enables the universities to require that their employee disclose their inventions in order to prepare the patent application and define the distribution of rights between the university itself and the government (see, e.g. Mowery *et al.*, 2001.) In some cases there are formal rules to reward the successful inventors, like in the German compensation scheme (German Employees' Inventions Act, 1957). This is a formal rule enacted by law whereby the employers can claim the inventions developed by their employees by "reasonably" compensating the inventors. The compensation is calculated from some guidelines provided by the Act, and it is based on the expected value of the innovations.

Of course, individual organizations may have different policies to reward their inventors. In many cases there are no rewards. The most active companies in rewarding their inventors are those that place greater to attention to an efficient management of their patent portfolios, and hence that have a natural interest in motivating their inventors. In some large companies technology managers organise internal competitions to reward the most productive inventors in terms of quantity or expected value of the innovations. For example AT&T, a company known for its forceful patenting strategy, selects a few patents (2 to 5 per year) that receive the "AT&T Strategic Patent Award" for the significant contribution of these patents to the company business.[11]

Apart from monetary compensation, inventors can benefit from other personal or social rewards for their innovations. According to the importance that they assign to these rewards, firms can design different policies to influence the innovative performance of their researchers. Table 5.1 shows the average importance assigned by the surveyed inventors to six types of patent rewards. The last column summarises the EU6 values, and it shows that monetary rewards, and other rewards created by the employer like career advances or benefits, are considered less important than "personal" rewards like personal satisfaction or prestige and reputation. In particular, the latter two motivations are deemed very important by a large portion of inventors.

There are only a few cross-country differences in the ranking of these preferences. German inventors assign very high values to all types of rewards, with the exception of career advances. Similarly, the UK inventors consider all the motivations important, with the exception of the impact that the innovation might have on the performance of the organisation. Monetary rewards and other

[11] See the website http://www.att.com/attlabs/reputation/patents/index.html .

rewards coming from the employers receive low scores by the Spanish inventors, who have greater consideration for personal and social rewards.

Table 5.1 Average level of importance of rewards for the invention

Rewards	DE	ES	FR	IT	NL	UK	EU6
Monetary rewards	3.03 *(1.36)*	2.13 *(1.37)*	3.59 *(1.25)*	3.00 *(1.36)*	2.65 *(1.37)*	3.01 *(1.43)*	3.05 *(1.39)*
Career advances and opportunities for new/better jobs	2.70 *(1.32)*	2.60 *(1.42)*	3.31 *(1.30)*	3.13 *(1.33)*	2.87 *(1.29)*	3.26 *(1.32)*	2.97 *(1.34)*
Benefits in terms of working condition as a reward by the employer	3.68 *(1.22)*	3.30 *(1.37)*	2.94 *(1.23)*	3.08 *(1.28)*	3.20 *(1.20)*	3.70 *(1.15)*	3.43 *(1.26)*
Satisfaction to show that something is technically possible	4.12 *(1.07)*	4.12 *(1.16)*	4.06 *(1.07)*	3.96 *(1.13)*	4.05 *(1.02)*	3.87 *(1.20)*	4.04 *(1.10)*
Prestige/reputation	3.99 *(1.13)*	3.92 *(1.18)*	3.88 *(1.16)*	3.85 *(1.20)*	3.87 *(1.17)*	4.02 *(1.08)*	3.94 *(1.14)*
Innovations increase the performance of the organisation the inventor works for	2.95 *(1.37)*	2.17 *(1.29)*	1.91 *(1.19)*	2.75 *(1.32)*	2.19 *(1.22)*	2.37 *(1.28)*	2.57 *(1.36)*

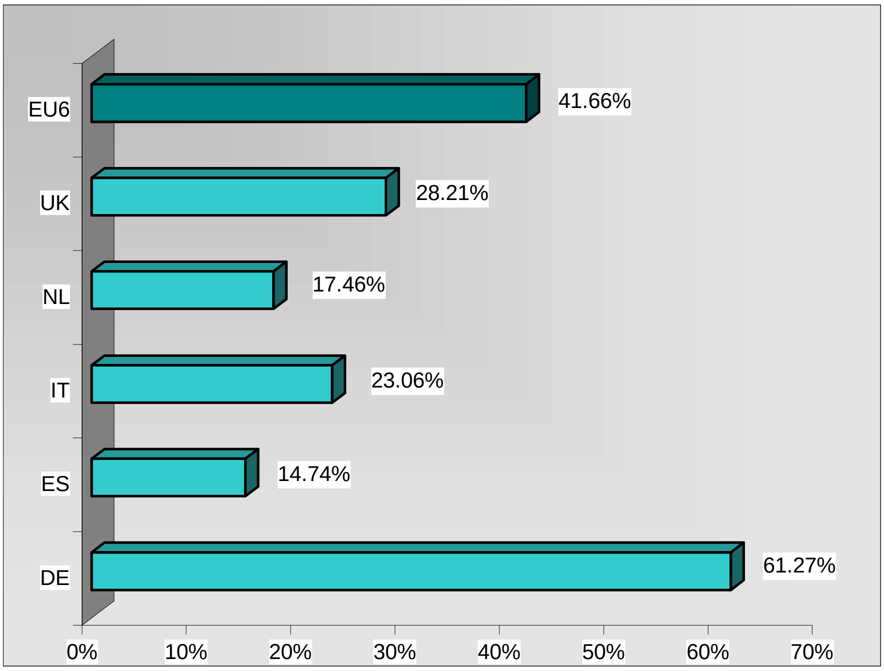
Note. Scale: 1=not important, 5=very important. Standard deviations in parentheses.

Inventors were also asked if they have actually received some monetary compensation for the surveyed patent, and if the compensation was permanent or transitory. Figure 5.1 reveals that one third of the EU6 inventors received some monetary compensation. However, the differences by country are noticeable. Because of the German's Act it is not surprising that this country exhibits the highest share of patents in which the inventor was compensated (61.27%). The effectiveness of the Act shows quite clearly as the second country is the UK with only 28.21% of the patents producing a compensation to the inventors. Italy (23.06%), the Netherlands (17.46%), and Spain (14.74%) follow. We could not include France in this analysis because of the very high number of missing observations.

The monetary compensation is transitory in most of the cases (Figure 5.2). At the EU6 level 89.02% of the inventors who received a monetary compensation for their patent had a transitory compensation, 3.81% had a permanent compensation, and 7.17% received both types of rewards. In Spain, Italy, and the Netherlands, where the share of inventors who received a monetary compensation is lower compared to the other countries, the share of permanent reward is the highest, and it ranges between 15% and 19%. In the other countries the share of permanent rewards is much lower.

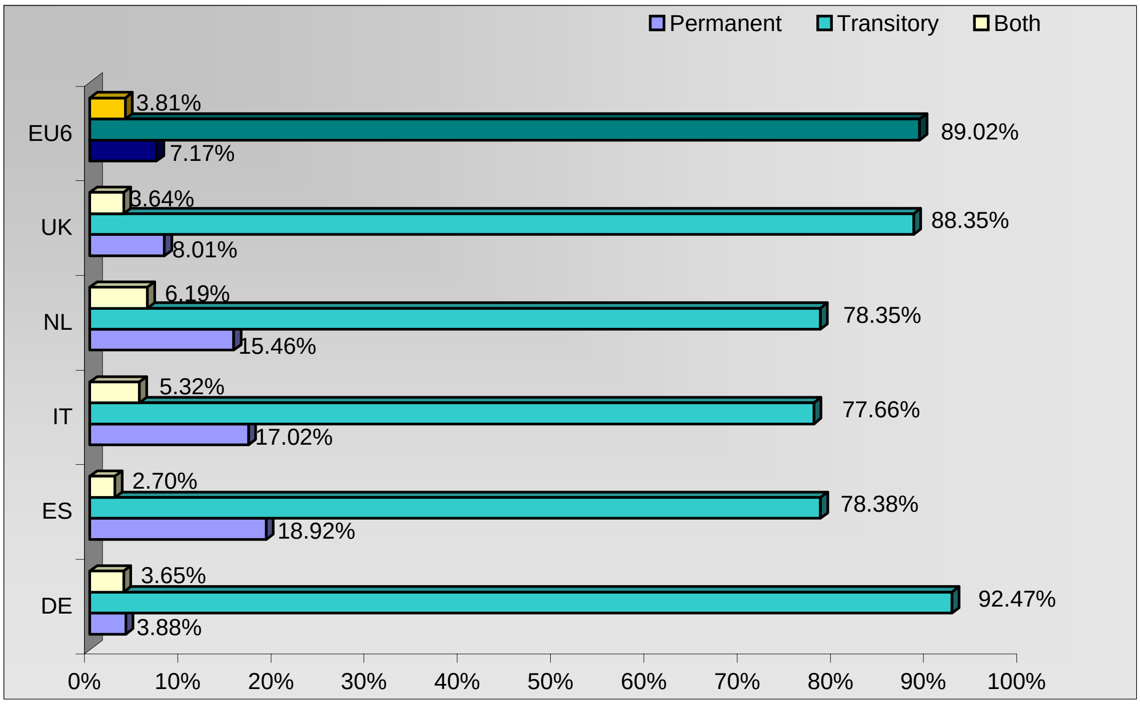
Finally, we can compare the actual share of inventors who received a monetary compensation with the importance assigned by the inventors to different forms of reward. Inventors consider social and personal rewards more important than other types of compensation. But this is probably because they are aware of the "incentive" policies operated by their organizations, which usually do not contemplate monetary compensation (with the exception of Germany). Therefore, their incentives to innovate are *de facto* different from receiving money. In general, however, the social motivations to innovate are quite strong, both when the inventors actually receive a monetary compensation and when they do not. These data also confirm that it is not common for the employers to introduce tangible monetary incentives in their innovation policies. The research on this issue is crucial for managers and policy makers because it provides information that help improve the policies for innovation.

Figure 5.1 Inventors who received a monetary compensation for their patents (%)



Note: France is not included due to the high number of missing values on this variable.

Figure 5.2 Types of monetary rewards (%)



Note: Percentage computed on the inventors who received some monetary compensation.

SECTION 6. THE VALUE OF PATENTS

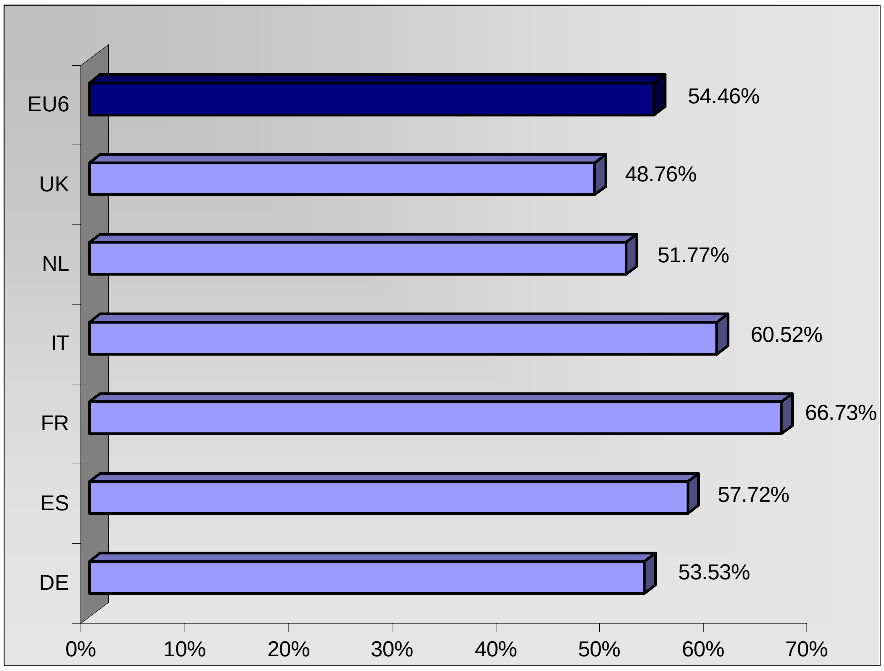
6.1 The economic use of patents

The production of a patented innovation does not imply that it will be used economically. For one reason, the path between the invention and the actual commercialisation of a new product or technology can be long and costly. Thus, many patents are never employed commercially, and in general only few inventions yield economic returns. On many occasions, the non-use of a patent does not depend on intrinsic features of the innovations, but for example the inventors may not have adequate assets to exploit them (e.g. smaller firms, individual inventors, scientific institutions). This is an important point because the ability to translate new technologies into economically valuable goods or services is crucial for the competitiveness of firms, regions, and countries. At the same time, many patents are simply left unexploited ("sleeping patents") (Palomeras, 2003), and Rivette and Kline (2000) have shown that this is most often the case in large firms. Finally, some patents are not used because they were applied only for strategic reasons, like blocking some competitor. In our survey we asked for the motivation of the applicants to patent, and as we shall see below in quite a few cases patents were sought to block rivals.

Figure 6.1 shows that the share of "internally" used patents in our sample. These are the patents that are exploited by the applicant for industrial and commercial purposes. Roughly 55% of the EU6 patents are used internally by the applicant. The country shares range between 48% and 67%. The non-internally used patents could either be unused or licensed to a third party that exploits them. Figure 6.2 shows that the EU6 share of licensed patents in our sample is 13.38%. The UK leads the other countries with 17.93% of licensed patents. Germany is at the bottom of the list with 10.76% of licensed patents, and it is followed very closely by Italy (11.38%). Spain and the Netherlands license out 15.85% and 16.07% of their patents respectively.

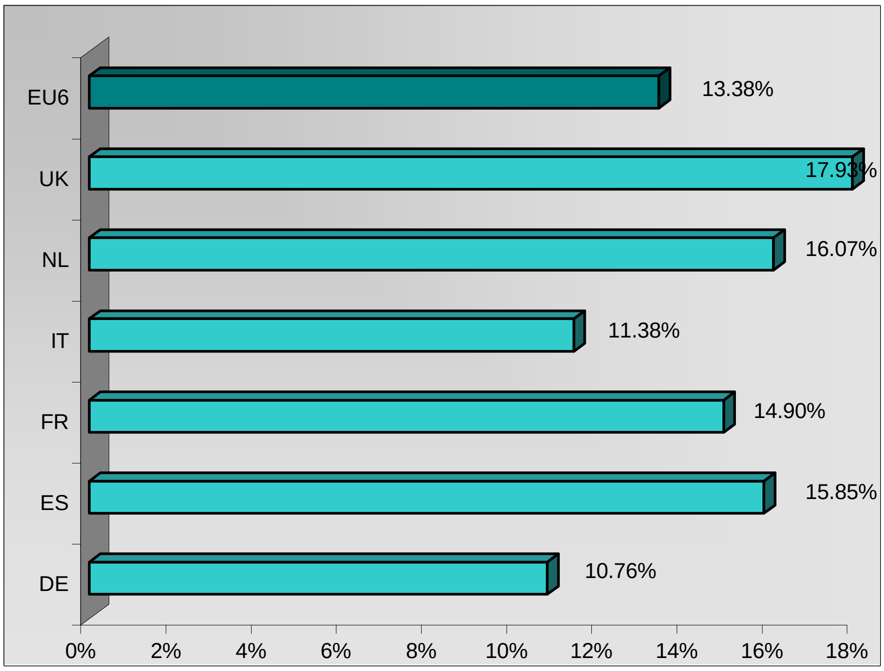
By combining the information about licensing and internal use we obtain the proportion of unused patents (Figure 6.3). It turns out that on average 36.13% of the patents in our sample are not used. Since we over-sampled important patents, the share of unused patents in the population is probably higher than in our sample, because the important patents are more likely to be used than the average patent. The share of unused patents can then be quite large. The information on the use or non-use of the patents is important for policy. Unused patents are likely to be socially undesirable because not only are they not used, but they also prevent others from using the invention. Understanding the determinants of unused patents can help design better policies for a more intensive exploitation of the innovations.

Figure 6.1 Share of patents used for commercial or industrial purposes



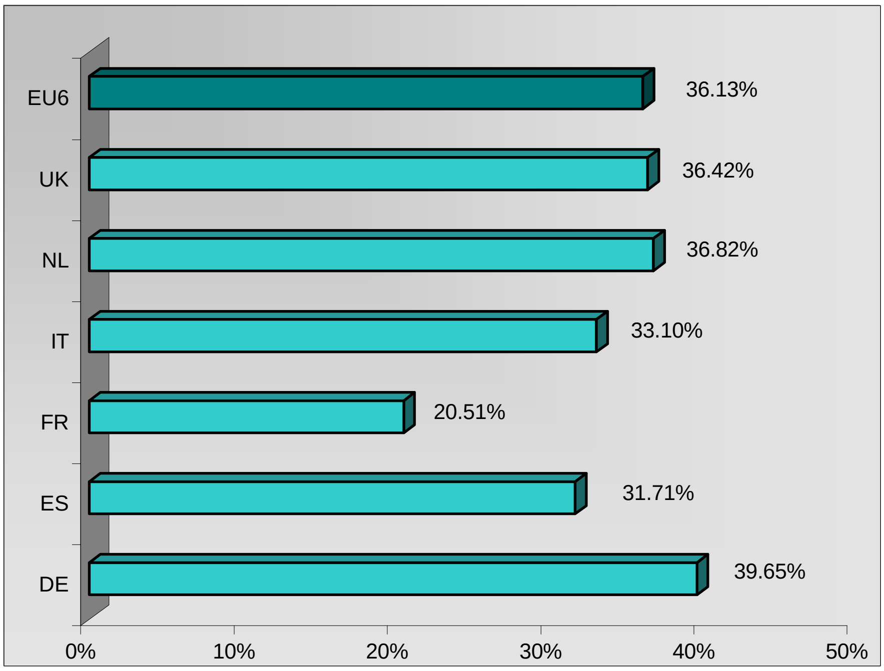
Note: France shows a high number of missing values on this variable (about 15.5% for France against 2.3% on average for the other 5 EU countries).

Figure 6.2 Share of licensed patents



Note: France shows a high number of missing values on this variable (about 30.4% for France against 4% on average for the other 5 EU countries).

Figure 6.3 Share of unused patents



Note: France shows a high number of missing values on this variable (about 35.6% for France against 4.5% on average for the other 5 EU countries).

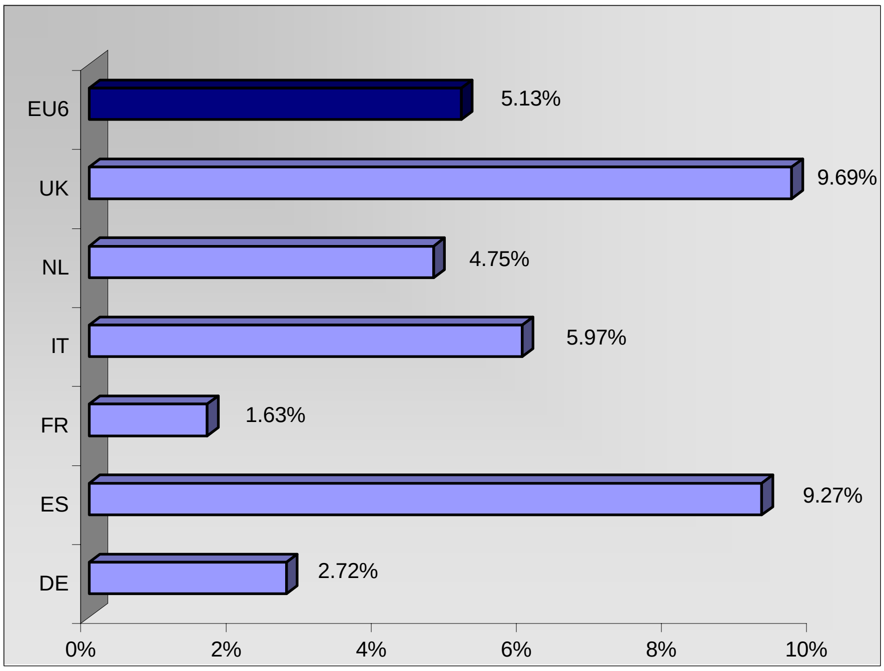
Along with the unused patents, the shares of licensed patents suggest that there is room for improving the functioning of the markets for patented technologies. The transfer of patent rights, and more generally the rise of markets for technology have become increasingly important in recent years. They raise the expected returns from patents, as the latter can be sold by the patent holder to other organisations that have the resources and the competencies to exploit them. Research on this issue can benefit from the detailed data we collected through the PatVal-EU survey. Existing empirical analyses on the commercialisation of innovations focus on the sectors in which licensing is more frequent, like semiconductors, chemical and computer. Some of them use aggregate cross-section analysis (Anand and Khanna, 2000; Cohen *et al.*, 2000) while others are grounded on studies in specific sectors (for example in the semiconductors Grindley and Teece, 1997; Hall and Ziedonis, 2001; in chemicals Arora, Fosfuri and Gambardella, 2001; Cesaroni, 2003).

A patent can also be used to create a new firm that exploits economically the patented innovation. Many start-ups in industries like biotechnology, semiconductors, instruments and chemicals used their intellectual property as a means for obtaining financing and corporate partners that are critical for the successful commercialisation of new knowledge.

Moreover, if firms do not have the resources and the capabilities needed to exploit the innovation economically, they might decide not to produce the innovation in the first place. The intellectual property rights enable them to sell the rights on the innovation to other firms that own the development and commercialisation assets. This encourages the formation of firms that operate in the upstream innovation sector, and the further development of the markets for technology. Some recent literature analyses the determinants and the extent of university spin-offs that use licensed patents. These contributions are based on studies of specific universities and research institutions (Shane, 2004; Shane and Kharuna, 2003).

Figure 6.4 reports the share of patents used to start-up a new firm. On average, 5.13% of patents gave rise to a new firm. This share is the highest in the UK (9.69%) and Spain (9.27%). It is the lowest in Germany (2.72 %) and France (1.63%). In the UK both the share of licensed patents and new firm formation is higher than the EU6 average, together with the share of tertiary educated and PhD inventors, and with a high propensity to patent by the university and other research institutions. By controlling for other factors, our future research will study these correlations. It will suggest policy implications based on the relationship between entrepreneurship, innovation and the presence of tertiary and post-graduate educated researchers. Moreover, small firms specialised in the production of new technologies can be a major factor in enhancing the employment and the economic performance of specific regions (see also Eurostat, 2002). Therefore, a patent system that allows for the formation of such firms can produce positive economic effects.

Figure 6.4 Share of patents used to start a new company



6.2 Motivations for patenting

The factors that motivate inventors to patent can be different from the factors that motivate the organisations in which they work. Inventors might want to gain tangible compensations or, more often, they want to receive social rewards or personal satisfaction. At the organisation level, patents are normally part of a strategy of protection of intellectual property rights. A study conducted in the US by Cohen, Nelson and Walsh (2000) shows that patents are not the most important mean for appropriating the returns from innovation. Secret, lead-time and investments in complementary assets are on average more important. They also point out that there are reasons for patenting that are different from the mere protection of innovation which is internally exploited for industrial purposes, like licensing, cross-licensing or other strategic reasons.

Table 6.1 shows the average importance of six motivations to patent for the organisations in which the inventors are employed. The values for the EU6 indicate that the most important reasons for patenting are the commercial exploitation and the prevention from imitation. In other words, the organisations patent mainly because they seek exclusive rights to exploit economically, and because, by patenting the "inventions around", they prevent others to imitate their valuable innovations. Another reason for patenting is to block competitors that might patent similar innovations, which suggests that patents are important for competitive reasons more than for evaluating or motivating people within the organizations. Indeed, organisations do not see reputation as being one of the most important reasons for patenting, while it ranked high as a motivation for the inventors.

At the country level prevention from imitation is the most important reason in Germany, while strategic reasons, like blocking patents, are lower than the European average. Licensing and cross-licensing are relatively more important in the UK.

Table 6.1 Average level of importance of reasons to patent

	DE	ES	FR	IT	NL	UK	EU6
Commercial exploitation	3.64 (1.56)	4.09 (1.39)	3.89 (1.47)	3.58 (1.75)	3.70 (1.65)	4.23 (1.29)	3.79 (1.56)
Licensing	2.15 (1.33)	2.68 (1.72)	1.65 (1.41)	1.52 (1.51)	1.93 (1.77)	2.45 (1.66)	2.06 (1.54)
Cross-licensing	1.85 (1.22)	1.46 (1.31)	2.09 (1.62)	1.37 (1.41)	1.66 (1.79)	1.99 (1.47)	1.78 (1.44)
Prevention from imitation	4.01 (1.40)	3.78 (1.60)	3.61 (1.64)	3.63 (1.77)	3.28 (1.80)	3.71 (1.56)	3.76 (1.60)
Blocking patents	2.45 (1.50)	3.47 (1.63)	3.32 (1.73)	3.35 (1.86)	3.39 (1.75)	3.45 (1.62)	3.00 (1.70)
Reputation	2.24 (1.34)	2.90 (1.65)	2.20 (1.55)	2.17 (1.75)	1.79 (1.67)	2.61 (1.60)	2.26 (1.56)

Note. Scale: 0=not at all important; 1=not important, 5=very important. Standard deviations in parentheses.

6.3 The economic value of patents

Patents are expected to have a positive impact on competitiveness, entrepreneurship, and employment, which offset some of the social costs of intellectual property protection. Section 6.1 has shown some data on the economic use of patents, which can be interpreted as indirect measures of their (social) value. In this section we consider a monetary measure of patent value.

Several authors estimated the value of patents by employing indirect measures. Some contributions employed information on the renewal fees paid by the patent holders (Pakes and Schankerman, 1984; Pakes, 1986; Schankerman and Pakes, 1986). The rationale for this approach is that the renewal fees are paid only if the expected returns from the patents are higher than the costs of keeping the patent rights. Other contributions found a positive correlation between the economic value of the patents and their forward citations (Trajtenberg, 1990; Hall *et al.*, 2001). Lanjouw and Schankerman (1999) constructed a composite indicator of value based on observable correlates like citations, oppositions, and family size. Only a few studies use survey-based information on the economic value of patents in specific countries (see, for German and US patents, Harhoff *et al.*, 1999a, 1999b, 2003; Scherer and Harhoff, 2000).

In the PatVal-EU survey we asked the inventors to estimate the minimum price at which the owner of the patent (whether the firm, other organisations, or the inventor himself) would have sold the patent rights on the very day in which the patent was granted. This is a measure of the present value of the patent for the applicant.

We asked the inventor to assume that the applicant had all the information available at the moment in which he responded to the questionnaire. This improves the precision of the estimate as we employ more information about the patent. There could be differences in the amount of available information about the patent value, e.g. more recent patents use less information. Yet, the answers to the questionnaires were given in 2003-2004 (see Section 2.5). This is 6-7 years after the application year of the latest patents in the survey (1997). This is a sufficient time span for a good deal of information to become available. Most likely, there is far less additional information 10-11 years after the application (for the earliest 1993 patents in PatVal-EU) compare to 6-7 years thereafter than, say, between 0 and 4 years after the application.

The Figures below report the monetary value of patents obtained through the PatVal-EU survey. Figure 6.5 shows that the distribution of patent value is skewed, with only a small share of high-valued patents. Only 16.81 % of the patents are worth more than 3 million Euros, and 7.23 % are worth more than 10 million Euros. This monetary measure allows us to discriminate between low value patents that cannot be observed by using other correlates like patent citations (for which the number of zeros is very high).[12] Also, recall that the PatVal-EU sample overweights opposed patents and patents with at least one citation. This makes our distribution more skewed to the right than the distribution of the population of patents.

[12] See for example Harhoff et al. (1999a, 2003), Scherer and Harhoff (2000).

Figure 6.5 Distribution of the patent value (Euro)

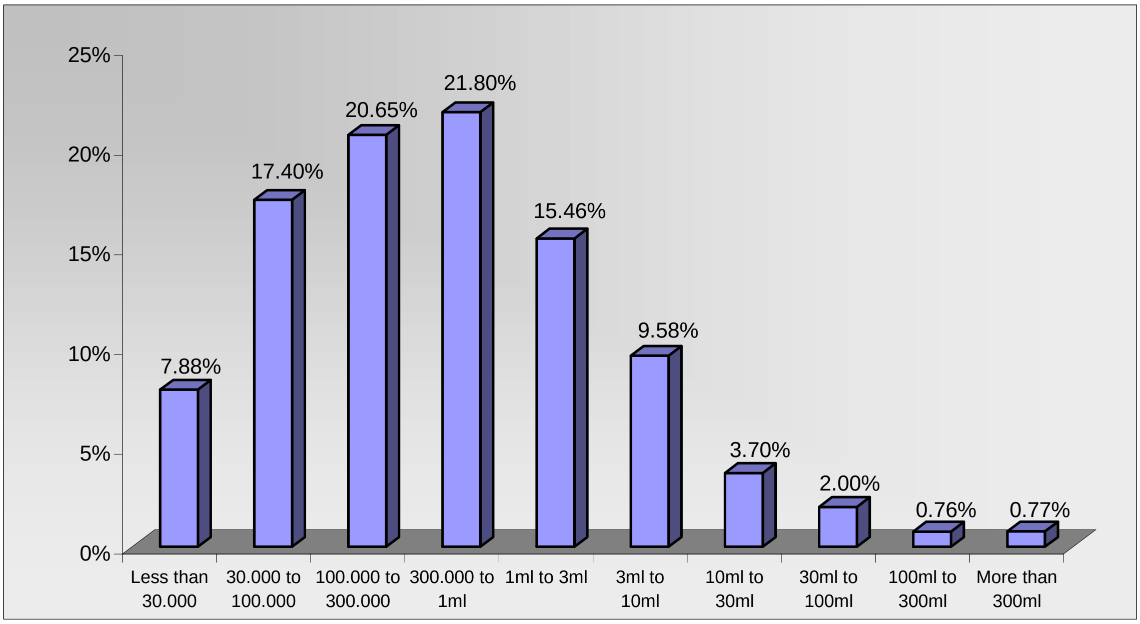
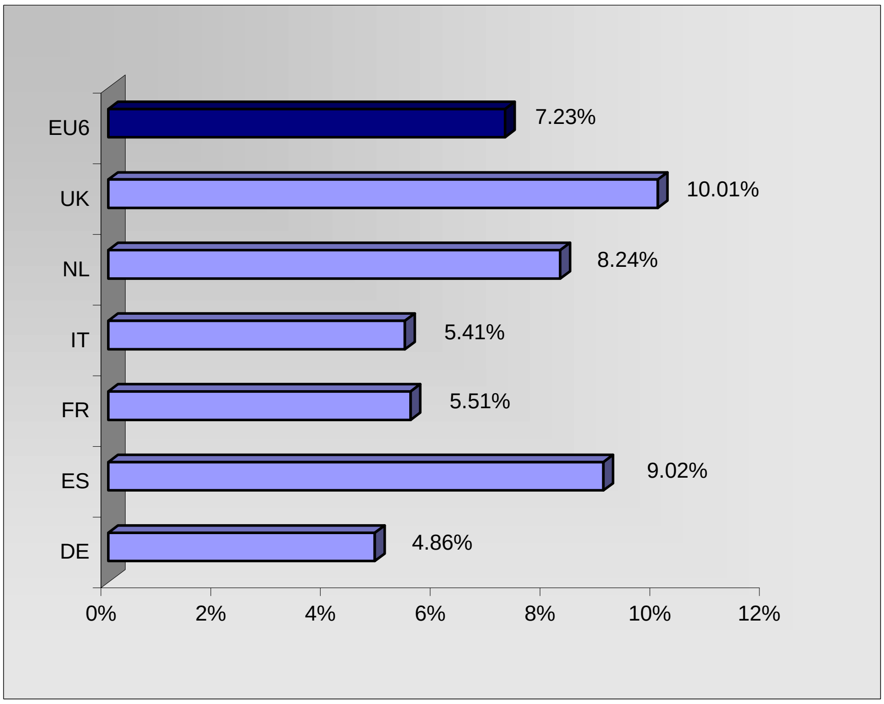


Figure 6.6 concentrates on the upper tail of the distribution. It shows the share of patents valued 10 million Euros or more over the total number patents surveyed in each country. In our sample, this share is about 10.01% in the UK, and 9.02% in Spain. In the Netherlands it is 8.24%, while in Italy and France it is around 5%. Germany is in the bottom of the list with 4.86% of high value patents.

Figure 6.6 Distribution by country of the top valued patents

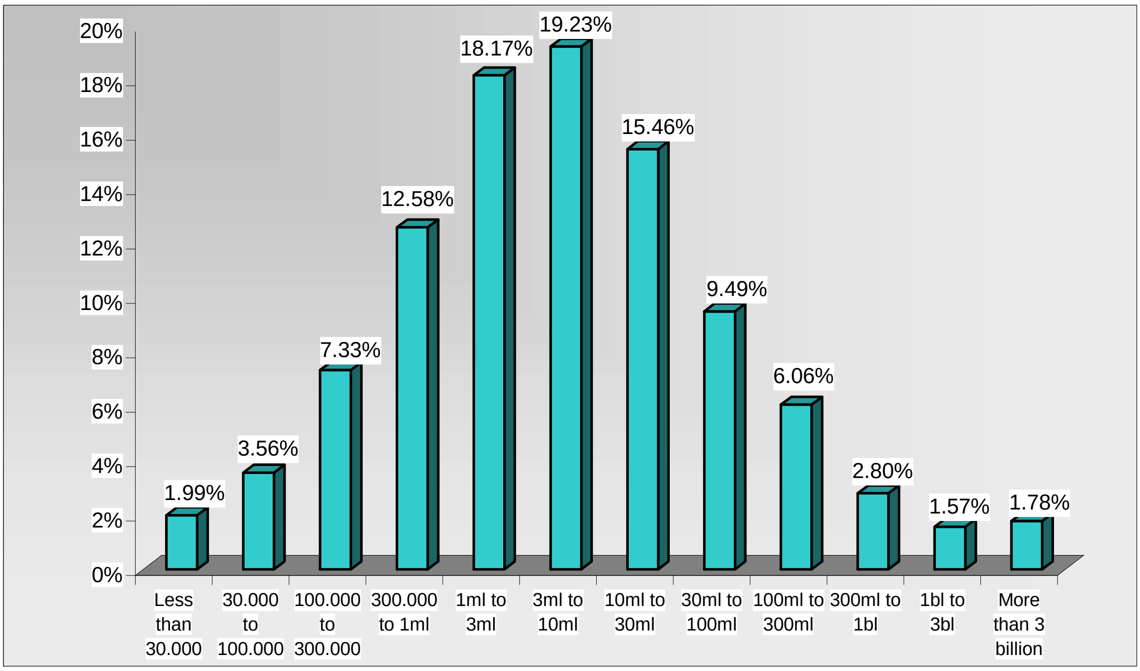


Note: Patents valued 10 million Euros or more.

Figure 6.7 shows the distribution of the value of groups of “intertwined patents”. This is less skewed than the distribution drawn for the individual patents. Of course, the average value of a group of intertwined patents is larger than the value of an individual patent. This explains why the share of high value groups of intertwined patents is higher compared to that of individual patents. These data also suggest that when an organisation invests in a research trajectory by producing several patents, it wants to exploit the patents economically either internally or through licensing and cross-licensing. It might also produce several patents to prevent from imitation or to block competitors.

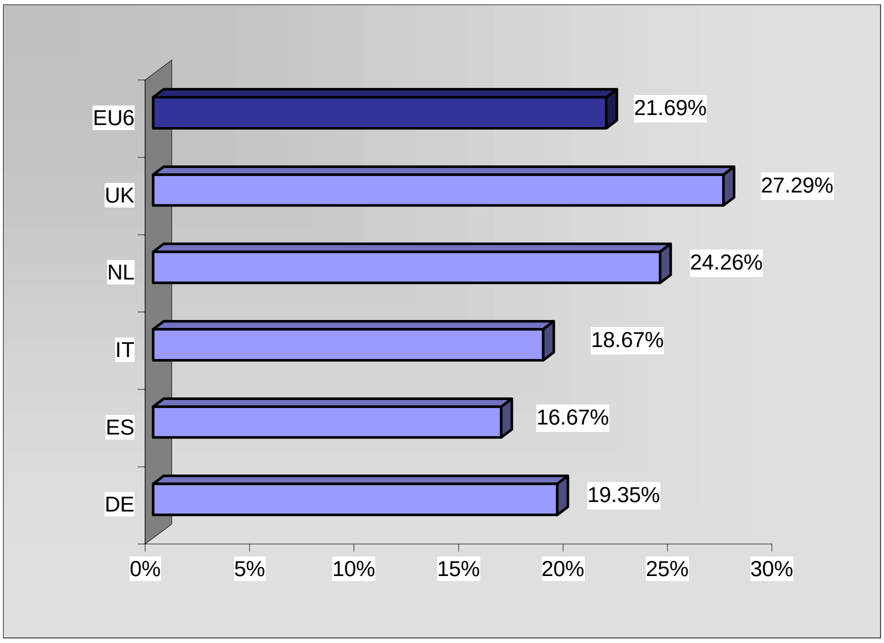
At the country level, the UK, Italy and the Netherlands have a share of valuable groups of intertwined patents higher than the EU6 share. For Spain the share of high value groups of intertwined patents is low compared to the Spanish share of valued patents, which is consistent with the low presence of large firms. It is also interesting to note that the UK also invented the largest share of licensed patents and patents that give rise to new firms. This is consistent with the result that the UK has a large share of high value individual patents. Similarly, in Spain a high number of patents were used to set up new firms, which is consistent with the relatively high share of valued individual patents compared to the relative position in terms of valued groups of intertwined patents.

Figure 6.7 Distribution of the value of groups of intertwined patents (Euro)



Note: France not included in these figures because of the very large number of missing values.

Figure 6.8 Distribution by country of the top valued groups of intertwined patents



Note: Patents valued 30 million Euros or more.
France not included because of the very large number of missing values to this question.

6.4 Inventor and manager responses about the value of patents

One concern with our measure of patent value is that the inventors may not be the most informed respondents about the value of the patents. For one reason, they may have different information. When the inventor exploits the patent himself, or he is in a self-employed firm, or in a small firm, he may be better informed to answer our question. In larger firms they may not know much about the value of the patent, and a manager would be a more suitable person to ask. Since about 70% of our patents are applied for by large firms, this may be a valid remark. Similarly, for university patents, individual scientists or researchers may know less than the managers in university licensing offices.

We have been aware of this problem since we started our survey. Yet, as noted in Section 2.5, apart from the French survey, where the Ministry had access to good information about the applicant organisations, the teams in the other countries did not have similar information. By contrast, in the case of the inventors, we had an address in the patent document from which to start locating them. Moreover, without some good idea about who to contact in the applicant organisation one could introduce other biases. The costs and length of the survey could have increased considerably if we had to find, for a number of patents and applicant organisations as large as the scale of our survey, the most suited person to respond. At the same time, it is not clear that we could find in a systematic way, for all our patents, somebody who knew about them better than the inventor. For example, the right manager might have gone after six or more years. Organisations have probably a better memory about the successful patents than the less successful or minor ones, while the inventors are likely to have good memory of all their patents. In the end, we might have increased rather than reduced biases and problems of low response rates.

In addition, the inventor is a well defined "type" of individual to look for, and definitely one who knows about the patent. By a contrast, a "knowledgeable" manager or person for our patent is a more blurred type. He could be the manager of a patent department in a large firm, or simply the boss of the inventor, or the technology licensing manager in a university, etc. This also casts doubts about the very procedure we used in the French case. We sent the questionnaire to the applicant organisations without really checking who was going to answer – i.e. a "generic" technology manager, or someone who was actually there and knew about the patent. It is not clear whether this produced better estimates than asking the inventors, who, as noted, were there when the patent was applied for and know about it. Probably, for a few patents, making an effort to search for the right person in the organisation might have been feasible. But our trade-off was that we were after a large scale survey. This was only possible at the expense of a lower cost per interview, which made it unfeasible to find the right respondent for each patent. We concluded that asking the inventor was the best option that we had to pick systematically, at the scale we chose to conduct our survey, a person who had, on average, a reasonably good knowledge about the value of the patent.

However, because we have always been aware of the problem, in our pilots, and during the full scale telephone interviews with the inventors, we monitored whether they actually knew about the value of their invention. In all the countries, our feeling, well supported by conversations with the inventors in the pilot tests, was that they had a pretty good idea of what the economic value of their patent was, and we felt that this was so for the inventors of the larger firms (or of the universities) as well. If anything, we are not sure whether they overestimated the value of their invention because of pride or else. But this may affect the average of our distribution (everyone claims that his invention is better) and not much its shape.

We also performed a more rigorous test of the potential bias in the inventors' response to the patent value question. As noted in Section 2.5, in the French questionnaire we had 587 patents with responses from both the inventor and the applicant organisation. For 233 of these patents there was no response to the value question by either the inventor, the applicant or both. This produced 354 patents with two valid answers. Figure 6.9 shows the distributions of the two value classes. Figure 6.10 shows the distribution of the difference between the classes picked by the inventor and the manager: –1 indicates that the inventor picked one class shorter than the manager, and +1 denotes the opposite. Similarly, for (–2; + 2) and so on. Given that there are ten classes, this difference ranges between (–9; 9). The two distributions in Figure 6.9 overlap to a great extent. They have the same quartiles, respectively classes 30,000-100,000, 100,000-300,000, 300,000-1ml. Figure 6.10 shows that in slightly more than two-third of the patents the inventors and managers miss each other by at most one contiguous class (difference between –1 and 1), and for almost 90% of the patents they miss each other by at most two contiguous classes (–2; 2). Note that the extremes of the observed distribution of the differences are –5 and 6. Thus French inventors and managers never pick more than 6 classes apart from one another.

Figure 6.9 Distribution of patent values, responses by French inventors and managers

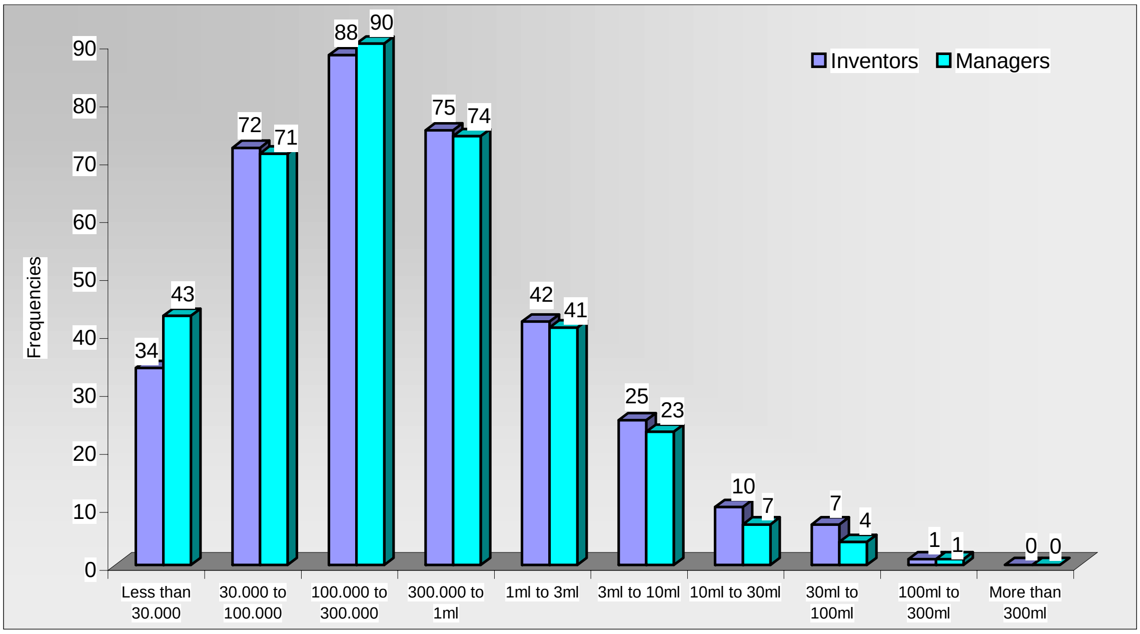
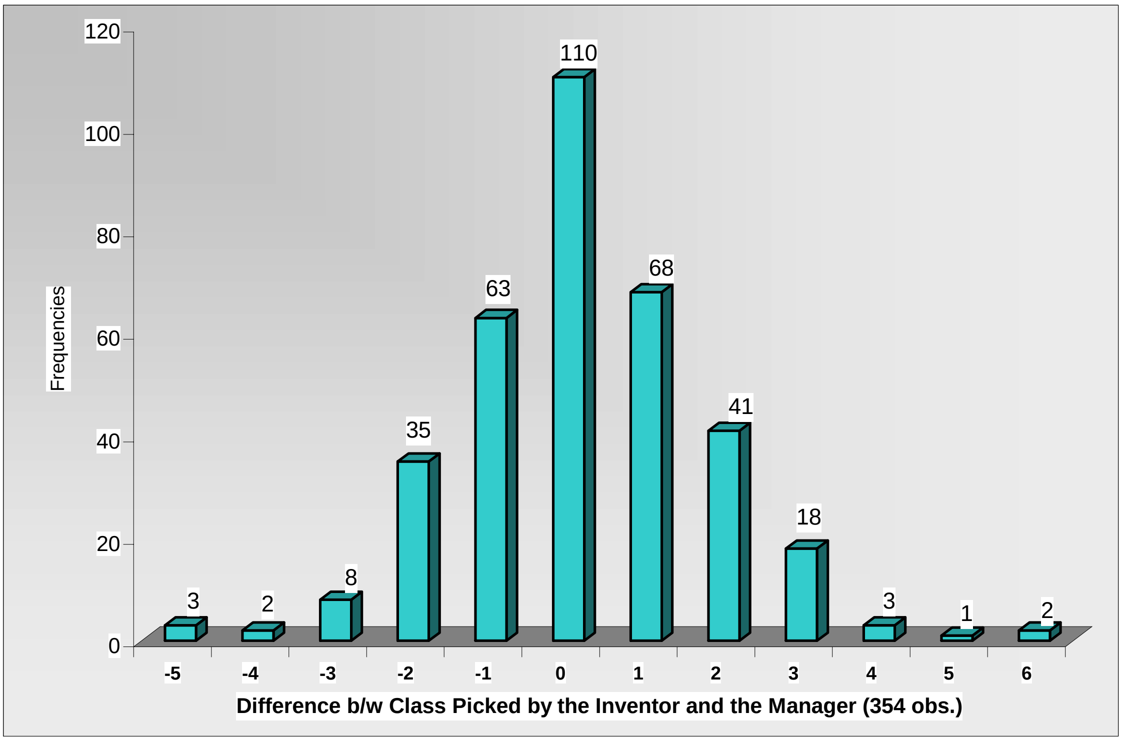


Figure 6.10 Distribution of the difference between the patent value class picked by the inventor and the manager, responses by French inventors and manager



To compare the two distributions more formally, we labelled the 10 patent value classes 1-10. The means of the two distributions are 3.49 for the inventors and 3.35 for the managers. We found that a two-tail t-test does not reject the hypothesis that the two means are different for a p-value smaller than 10%. As noted earlier, pride or other factors may induce the inventors to boost the results of their work. This suggests that they can only overestimate the value of their patents. If so, it is reasonable to employ a one tail t-test of the null hypothesis of no difference between the two means against the alternative that the mean response of the inventors is higher than that of the managers. We find that in this case the null hypothesis of equality of the means is rejected at $p < 5\%$. The inventors seem to overestimate the economic value of their patents compared to the applicant organisations. However, such an overestimation is small. We also performed other tests. In particular, we cannot reject the hypothesis of equality of the standard deviations of the two distributions, and the Kolmogorov-Smirnov and Wilcoxon rank-sum (Mann-Whitney) test do not reject the hypothesis that the two distributions are equal.

We also compared the different responses between inventors and managers in the small and large firms. As noted earlier, the inventors in the large companies may be less informed about the value of their patents because of the greater organizational distance and the more intensive specialization of tasks. As a result, the gap in response should be wider in these firms. Among our 354 French patents we distinguished between the patents applied for by the large firms (more than 250 employees), the small-medium firms (less than 250 employees), and the universities and other research organisations. We found that the inventors in the larger firms exhibit a higher average difference in the evaluation of their patents' value with respect to their managers than in the smaller firms. The inventors in academia and other non-profit research institutions behave like the small companies. The three pairs of means (inventors-managers) for large firms, small-medium firms, and research institutions are respectively: 3.58-3.39, 3.26-3.19, 3.61-3.53. Moreover, we find that the equality of mean responses between inventors and managers is rejected for the large firms (two-tail at $p < 10\%$, one tail at $p < 5\%$), while it cannot be rejected for the small firms and research institutions. In addition, one cannot reject the hypothesis that, pairwise, the three average differences in the inventor-manager responses are equal, and one cannot reject the hypothesis that, pairwise, the three standard deviations of the distributions of the differences are equal. Finally, one cannot reject the two by two hypothesis of the equality of the three distributions according to the Kolmogorv-Smirnov and the Wilcoxon rank-sum (Mann-Whitney) test. In sum, the slight overestimate of the inventor's assessment of the value of their patents compared to the managers seems to be produced by the inventors in the large firms.

CONCLUSIONS AND RESEARCH AGENDA

The investment in the production of new ideas, new knowledge, and new technologies is the engine for improving the European competitiveness in terms of economic growth and employment levels. This report presented the micro-level characteristics of the European innovation system.

The data on which the report is based are collected through a survey conducted in 2003 by interviewing the inventors of 9,432 patent applications submitted to the EPO in 1993-1997. The project that made the survey possible was funded by the European Commission, and it aimed at collecting new information on the characteristics of the European inventors, the innovation process in which they are involved, and the economic value of the innovations they produce.

Sections 3 to 6 presented the main findings of the survey. Our data confirm the small share of inventors with Ph.Ds in the European innovation system, and the limited mobility of human capital across companies and organisations. The data also show the relative importance of the business sector, and in particular of the large firms, in producing innovations. The firms with more than 250 employees account for 70% of the patents in our sample.

Many patents have multiple inventors, which suggests that inventions are a team activity. However, the vast majority of the co-inventors in the patents belong to the same organisation and are geographically close. The most common source of knowledge in the innovation process is the interaction with the customers. University and non-university research is rarely used. Furthermore, the main source of funding for innovation is provided by the firm, with a minor role of government research funds and funds from other organisations like banks and financial institutions.

About one third of European inventors received some monetary compensation for their innovations. However, the data suggest that the motivations of the individual inventors to innovate are more important than the economic reasons. The data also show that about 55% of the patents are used internally by the applicant for industrial or commercial reasons. 13% of patents are licensed to other parties. The patents that are not used economically (either for licensing or internal use) are 36%. Some of them are simply left unexploited ("sleeping patents"); others serve strategic purposes, like blocking rivals; yet others are not exploited because the firms lack the downstream capabilities to use them. This is an important issue, as the unwillingness or inability of firms to exploit the new technologies economically might hamper economic competitiveness and growth. Because we are over-sampling important patents, which are more likely to be used economically, the share of unused patents in the population could even be larger.

Finally, the survey produced information about the monetary value of the innovations. The existing literature uses indirect measures drawn from the patent documents. We confirm that the distribution of patent values is skewed, and only few patents yield large returns. PatVal-EU also enabled us to observe differences in the upper and bottom tail of the patent value distribution. This is not easily observable from other indicators. For example, citations are zero for the bottom 60% of the distribution.

Our next step in the analysis of the PatVal-EU data will be to explain the patterns presented in this report by performing rigorous scientific research. Papers will be produced on specific issues. Most likely, PatVal-EU will be used in combination with complementary data. The scientific understanding of the underlying issues will also be employed to discuss policy implications for the European intellectual property rights and more generally for improving the European innovative performance.

REFERENCES

Anand B.N., Khanna T. (2000), "The Structure of Licensing Contracts", *The Journal of Industrial Economics*, 48, 103-135.

Arora, A., Fosfuri, A., Gambardella, A. (2001), *Markets for Technology*, MIT Press, Cambridge (MA).

Cesaroni F. (2003), "Technology strategies in the knowledge economy: The licensing activity of Himont", *International Journal of Innovation Management*, 7, 1-23.

Cohen W., Nelson R., Walsh J. (2000), "Protecting their intellectual Assets: Appropriability Conditions and Why U.S. manufacturing firms patent (Not)", NBER Working paper 7552, Cambridge Mass.

European Commission (2002), *Human Capital in a global and knowledge-based economy*, European Commission, Brussels.

European Commission (2003a), *Key Figures 2003-2004. Towards a European Research Area Science, Technology and Innovation*, European Commission, Brussels.

European Commission (2003b), *Third European Report on Science & Technology Indicators. Towards a knowledge-based economy*. European Commission, Brussels.

Eurostat (2002), SMEs in Europe. Competitiveness, innovation and the knowledge-driven society, 1996-2001. European Commission, Brussels.

Griliches Z. (1990), "Patent Statistics as Economic Indicators: A Survey", *Journal of Economic Literature*, 28, 1661-1707.

Griliches Z., Pakes A., Hall B. (1987), "The Value of Patents as Indicators of Inventive Activity", in: Dasgupta, P., Stoneman, P., (Eds.), *Economic Policy and Technological Performance*, Cambridge University Press, Cambridge (MA).

Grindley P.C., Teece D.J. (1997), "Managing intellectual capital: Licensing and cross-licensing in semiconductors and electronics", *California Management Review*, 39, 8.

Hall B., Jaffe A., Trajtenberg M. (2001) The NBER Patent Citations Data File: Lessons, Insights and Methodological Tools, NBER working paper No. 8498.

Hall B., Jaffe A., Trajtenberg M. (2005), "Market Value and Patent Citations", *Rand Journal of Economics*, forthcoming.

Hall B.H., Ziedonis R.H. (2001), "The Patent Paradox Revisited: and Empirical Study of Patenting in the US semiconductor Industry 1979-1995", *The RAND Journal of Economics*, 32, 101-128.

Harhoff D., Reitzig M. (2004), "Determinants of Opposition Against EPO Patent Grants – The Case of Biotechnology and Pharmaceuticals", *International Journal of Industrial Organization*, 22, 443-480.

Harhoff, D., F. M. Scherer, K. Vopel (1999a), "Citations, Family Values, Opposition, and the Value of Patent Rights", ZEW Discussion Paper, Zentrum für Europäische Wirtschaftsforschung (ZEW), Mannheim.

Harhoff D., Narin F., Scherer F.M., Vopel K. (1999b), "Citation Frequency and the Value of Patented Innovation" *Review of Economics and Statistics*, 81, 511-515.

Harhoff D., Scherer F.M., Vopel K. (2003), “Exploring the Tail of Patented Invention Value Distribution”, *in* O. Granstrand (ed.), *Economics, Law and Intellectual Property: Seeking strategies for research and teaching in a developing field*, Kluwer Academic Publishers, Boston.

Jaffe A., Trajtenberg M., Henderson R. (1993), “Geographic Localization of Knowledge Spillovers as Evidenced by Patent Citations”, *Quarterly Journal of Economics*, 63, 577-598.

Klepper S. (2001), “Employee start-ups in high tech industries”, *Industrial and Corporate Change*, 10, 639-74.

Lanjouw J.O., Schankerman M. (2004), “Patent Quality and Research Productivity: Measuring Innovation with Multiple Indicators”, *Economic Journal*, 114, 441-465.

Lerner J. (1994), “The importance of patent scope: an empirical analysis”, *RAND Journal of Economics*, 25 (2), 319-333.

Mowery D., Nelson R., Sampat B., Ziedonis A. (2001), “The Growth of Patenting and Licensing by U.S. Universities: An Assessment of the Effects of the Bayh-Dole Act of 1980”, *Research Policy* 30, 99-119.

Pakes A. (1985), “On Patents, R&D, and the Stock Market Rate of Return”, *Journal of Political Economy*, 93, 390-409.

Pakes A. (1986), “Patents as Options: Some Estimates of the Value of Holding European Patent Stocks”, *Econometrica*, 54, 755-784.

Pakes A., Schankerman M. (1984), “The Rate of Obsolescence of Patents, Research Gestation Lags, and the Private Rate of Return to Research Resources”, in Griliches, Z. (ed.) *R&D, Patents, and Productivity*, University of Chicago Press, Chicago.

Palomeras N. (2003), Sleeping patents: any reason to wake up?, IESE Research Papers No D/506.

Rivette K.G., Kline D. (2000), “Discovering New Value in Intellectual Property”, *Harvard Business Review* 78, 54-66.

Schankerman M., Pakes A. (1986), “Estimates of the Value of Patent Rights in European Countries During the Post 1950 Period”, *Economic Journal*, 96, 1052-1076.

Scherer M., Harhoff D. (2000), “Technology Policy in a World of Skew-Distributed Outcomes”, *Research Policy* 29, 559-566.

Shane S. (2004), *Academic entrepreneurship*, Edward Elgar.

Shane S., Kharuna R. (2003), “Bringing individuals back in: the effects of career experience in new firm founding”, *Industrial and Corporate Change*, 12, 519-543.

Trajtenberg M. (1990), “A Penny for Your Quotes: Patent Citations and the Value of Inventions”, *RAND Journal of Economics*, 21, 172-187.

Hinze S., Reiss T., Schmoch U. (1997), “Statistical Analysis on the Distance Between Fields of Technology”, Innovation Systems and European Integration (ISE), Targeted Socio-Economic Research Program, 4th Framework Program of the European Commission (DGXII), Frauenhofer-Institute Systems and Innovation Research (ISI), Karlsruhe Germany.

Zucker L., Darby M., Armstrong J. (1998), “Geographically localized knowledge: Spillovers or markets?”, *Economic Inquiry*, 36, 65-86.