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Abstract

The paper explores the possible consequences for academic research of increased patenting in European universities. It underlines that most of the policy literature refers to the advantages of university patenting without balancing them against the costs or the risks involved in the activities. We provide a brief description of university patenting activity in Europe examining both university-owned patents and university-invented patents. The review of the literature reveals that unlike the United States, little is known in Europe about the changes taking place in public research as a result of increased patenting and increased institutionalisation of patents. We discuss possible analytical approaches to identify both short-term and long-term effects. Concluding remarks addressing the key issues for future empirical assessments are presented in the last section.

Key words: University patenting, university-industry relationships, technology transfer, European universities.

JEL: O3, I28, H4

1. Introduction

It is widely acknowledged that production activities rely more and more on scientific and technical knowledge and that increasingly firms are drawing on the scientific and technical expertise of Public Research Organisations (PROs). The ethos and incentive structure of PROs have stressed the role of training (graduate and undergraduate) and scientific publication as the means of delivering scientific and technological knowledge to the public. In the open science model, access to scientific and technological knowledge produced in PROs is free of additional costs; these institutions are financed by government because they produce outputs that are characterised by positive externalities beneficial to society as a whole. However, firms may not necessarily have the capacity to assimilate and exploit the knowledge produced by PROs (Cohen and Levinthal, 1989) and they may well fail to actually benefit from this public research. Firms may need to develop upstream research activities to be able to benefit from the available information and knowledge produced by PROs, while PROs are being pushed to increase their effort in technology transfer (TT) activities.

There are various forms of TT activities, ranging from development of new technical artefacts (e.g. databases, software, patents) to research conducted in collaborations between public and private organisations (e.g. via research contracts, university spin-offs). But, as PROs become increasingly involved in TT activities, questions naturally arise regarding the original mission of public research. To what extent are such TT activities growing in PROs? Is the discovery of fundamental knowledge affected by the rise in TT activities? Do upstream research and TT activities substitute for or complement one another? How should researchers be rewarded for devoting part of their time to TT activities?

This paper deals with the patenting activities of universities in Europe. It looks at the impact of changes in Intellectual Property Right (IPR) systems on the research activities of universities. The paper focuses on university patenting for two main reasons. First, non-university PROs (such as research institutes, e.g. CNRS in France, CSIC in Spain, etc.) are increasingly being subsumed by the university structure.[1] For

[1] This is more so in France, Italy and Spain than in Germany.

example, in 2000, 743 of the 1,170 research units in the French CNRS were 'mixed' structures co-held by universities, while in 1992 this was 100 out of 1,297 (8%).[2] Second, most of the available literature focuses almost entirely on university research (we were able to find only three articles dealing with changes in non-university public research organisations). Thus, a focus on university patenting only, makes the inquiry in this paper more consistent and allows better characterisation of the issues being examined.

It is extremely difficult to assess the impact on academic research of an increased reliance on IPR by universities because IPRs are just one of a set of new TT activities developed over the last 10 to 20 years in European universities. However, opinion about TT activities has shifted from their being seen as mainly engaged in managing research agreements with firms, to the current view in which the primary task of TT is to 'assess and protect IP and make it available to industry'. All TT activities could affect the way in which academic research is carried out: IPR is only one of multiple factors that influence the behaviour of academic researchers. This paper, while devoting particular attention to the impact of increased involvement in patenting by universities, addresses the broader issue of increased TT activity in PROs.

The paper focuses on the possible consequences for academic research of increased patenting in European universities. We acknowledge that IPR could have positive impacts for the university exploiting them. The literature identifies the following:

- Increased financial resources (as a result of increased licensing and royalties) that could be allocated on a discretionary basis perhaps to foster a new area of research or to develop new teaching opportunities - both of which are usually difficult to finance from traditional funding.
- Increased contract research funding for further developments into a final product of the IPR.
- Creation of spin-off companies that are partially owned by the university.
- Faster exploitation of new inventions.

[2] Mixed structures are research units that are co-held by the CNRS and other organisations, most of which are universities. Rapport d'activité du CNRS (2001).

It is important to notice that most of the policy literature refers to these advantages without balancing them against the costs or the risks involved in the activities.[3] The advantages are presented with no supporting statistical empirical evidence and, therefore, can only be considered to be assumptions. For example, the first of the positive impacts listed above will only occur if the costs of running the TT operation are counterbalanced by income. In the case of US and UK universities, for which statistical evidence exists, most Technology Transfer Office (TTO) in universities do not yield a positive net income (Nelsen, 1998; Charles and Conway, 2001). The results of the recent OECD survey on patenting by PROs show that very few organisations earn large sums of money while the majority make little or nothing out of IPRs - between 10% and 60% of reporting organisations in the countries surveyed reaped no income from IP though they had a TTO. Investing money in the development of a spin-off company is a very risky activity with a very low success rate: current data on the survival of these types of firms in a normal situation of scarce availability of venture capital for further development (in the late nineties the availability of venture capital was upwards biased due to the stock exchange bubble) are not available. An example of the bias of the policy literature in favour of the benefits can be clearly seen in the UK National Audit Office report ‘Delivering the Commercialisation of Public Science’ (NAO, 2002). This report is based on a survey of 155 university researchers.[4] Although the survey considers possible conflicts of interest, such as differences in culture and incentives between the public and private sectors and conflicts between the need to publish versus the confidentiality required for patenting, discussion of the interviewees’ responses to these questions is relegated to a few paragraphs in the appendix and provides incomplete information. The main text of the report is devoted exclusively to analyse the benefits from and the means to improve commercialisation.

This paper is organised as follows. In section two we give a brief description of current activities in IP of PROs in European countries. We focus on both university-owned patents and university-invented patents (patents with at least one inventor working at a university). Section three provides a review of the literature on the

[3] See, among others, OECD (2002a) and NAO (2002).

changes taking place in public research in Europe as a result of increased patenting and increased institutionalisation of patents (in recent years in a large number of European countries ownership of patents has been transferred to universities). Given the scarce literature available (especially on the impact in Europe), in section four we discuss possible analytical approaches to identify both short-term and long-term effects. Concluding remarks addressing the key issues for future empirical assessments are presented in the last section.

2. University patenting in European countries

In the past decade, universities have witnessed substantial changes in terms of research objectives and sources of funds. First, universities were gradually required to diversify the sources of their financial resources. Government structural funds substantially declined (at different levels in different countries, for example, the decline was much more significant in the UK than in France) and have been partially substituted by competitive funds (Geuna, 2001). Government structural funds are those financial resources allocated to universities through public budgetary channels. Structural funds have been the cornerstone of European university research since the Second World War. However, the budget constraints of the eighties and early nineties and the changes in the rationale for the public support of science incentivised governments to allocate funds through new, more competitive channels in the form of problem-oriented or industry-oriented public programmes. The general decline in public structural funds has been partially compensated for by the increase of funds from non-profit organisations and by tighter relationships between university and industry. Overall, university researchers and university research centres are now clearly encouraged to embark on collaborations with private companies (Geuna, 2001).

Second, changes in financial resources have entailed corresponding changes in the legal status of researchers. Researchers are incentivised to complement their research activities with technology transfer activities. For example, in France researchers now have the right to spend a proportion of their time in industry (Llerena, Matt and

[4] The researchers were sampled from a population of researchers funded by the Biotechnology and Biological Sciences Research Council, the Medical Research Council and the Natural Environment Research Council.

Schaeffer, 2003). It should be noted that such legal changes have yielded changes in the incentive or reward structures within universities. In a number of EU countries, researchers may now receive a portion of the royalties derived from their patented discoveries, even though the patent legally belongs to the institution in which the discovery was developed.

Changes in the university IPR system should be seen as a central device for the enhancement of TT activities and financial resources. It is not clear what might be the implications of these changes for the future of academic research. A thorough survey of the literature points to the fact that not only is there little empirical evidence on the changes in academic research at the European level but also that there are very few reliable data on the phenomenon of university patenting *per se.*

If we exclude the US and Canada, where the annual survey of the Association of University Technology Managers (AUTM)[5] was carried out for the first time in 1995, there is very little reliable historical data on patenting and licensing by PROs for the other OECD countries.

In the UK a report on the first annual survey of university commercialisation activity by the University Companies Association (UNICO) has been produced (UNICO and NUBS, 2002). A response rate of 80% (63% if we exclude nil responses) accounting for about 85% of research spending in UK universities in 2001, provides a good picture of the current situation in the UK. The 77 universities that responded account for 1,402 invention disclosures, 743 patent applications and 276 patents granted. The majority (56%) of the responding institutions had not had any patents granted. 60% of respondents earned less than £50,000 from licences (while 40% received no income at all from licences); for 68% of institutions expenditure on IP management was less than £50,000 but only 14% had no expenditure for this item. Comparing these results with those of the latest AUTM survey (AUTM 2002), it can be seen that the UK is behind both US and Canada in terms of income from licensing, number of licences executed and, in particular, number of patents issued.

[5] For Canada see also the *Survey of Intellectual Property Commercialisation in the Higher Education Sector, 1999* by Statistics Canada.

The OECD (OECD, 2002a) has recently made an attempt to systematically collect data on the patenting activity of PROs; however, as pointed out in the conclusion to the first chapter of the OECD report, the results of the OECD survey should be read with extreme caution as most of the responses are partial or incomplete.

Cesaroni and Piccaluga (2002) constructed a database of comparable data for France, Italy and Spain on PRO institutionally granted patents from the European Patent Office (EPO) and the US Patent Office (USPTO) during the period 1982-2002. PROs in these three countries were granted respectively 911, 723 and 127 patents. CNRS, CNR and CSIC are the three PROs with the highest number of patents. It is interesting to note that in France and Italy only about 10% of the granted patents are owned by universities, while in Spain universities own nearly 50%. Finally, the study highlights the high level of co-patenting activity with between 20% and 30% of the patents having more than one assignee (more than 50% of such patents are with firms).

In Belgium, Finland, France, Germany and Italy, the data on IPR available at TTO (patents owned by universities such as those included in the database of Cesaroni and Piccaluga or the OECD survey) for the eighties and nineties are downward biased due to the habit of researchers/professors to leave ownership of the patent be assigned to the firm that financed the research project but to be included in the list of inventors or to apply individually as patent assignee. We define university invented patents as patents with a member of a university faculty among the inventors, whether or not the university is the assignee of the patent. The studies by Balconi et al. (2002), Meyer (2002) and Saragossi and van Pottelsberghe de la Potterie (2003) provide clear empirical evidence that the number of university invented patents is much higher than the number of patents owned by universities. Balconi et al. (2002) identified that out of 1,300 university inventor patents in Italy in the period 1979-1999 only 90 EPO patents had university assignees[6] whereas Italian university inventor patents account for 3.8% of EPO patents by Italian inventors. Meyer (2002) reports that Finnish universities own 36 USPTO patents, but that there were 530 Finnish university inventor patents in the period 1986-2000. Similarly, in Germany university assignee patents are relatively rare, but university invented patents have continuously increased

[6] The authors point out that this is a lower bound estimate because their search on university inventor patents was based only on university faculty active in 2000.

from less than 200 in the early 1970s to around 1,800 in 2000 (OECD, 2002b). There are no aggregate data for Belgium, but Saragossi and van Pottelsberghe de la Potterie's (2003) study points out that the number of university invented EPO patents for Université Libre de Bruxelles (ULB) is more than double the number of university owned patents for the whole period 1985-1999.[7] Similarly, no aggregate data are available for France; however, Azagra-Caro and Llerena (2003) stress that in France though legally the university has the right to own the patent, in practice the most common form of university patents was and still is the university invented one. They offer statistical evidence relating to the University Louis Pasteur in Strasbourg. In the period 1993-2000, the university had 463 patents (French patent office, EPO and world patents) of which only 62 were owned by the university.

In the US 41% of academic USPTO patents in 1998 were in three areas of biomedicine indicating a strong focus on developments in the life sciences and biotechnology fields. In terms of revenues, about half of total royalties were related to life sciences (including biotechnology) (NSF, 2002). The situation is less clear-cut in Europe. On the one hand, the results of the OECD PRO IP survey seem to point to less dominance by the bio-medical area, but, on the other, Cesaroni and Piccaluga's data point to clear dominance of the broadly defined area of Chemistry and Human Necessities (which includes biotechnology). The data on university inventor patents in Belgium, France, Finland and Italy show that the technological areas with the highest frequency are those relating to biotechnology and pharmaceuticals (Azagra-Caro and Llerena, 2003; Meyer, 2002; Saragossi and van Pottelsberghe de la Potterie, 2003): the case of Italy is striking in that about 30% of Italian EPO patents in biotechnology include at least one academic inventor (Balconi et al. 2002). However the strongest technological sectors in each country (for instance, information and communication technology in Finland) tend also to have a very high frequency in university patents.

Three preliminary conclusions can be drawn from the analysis of European university patents. First, the scientific field with the highest activity across countries is biomedicine. Second, historical developments in Italy and Germany seem to confirm the view that university patenting is not a new phenomenon and its development (as

[7] Informal discussion confirms this result, though in a less striking way, for two other Belgian universities.

pointed out by Mowery et al. (2001) Nelson (2001) and Mowery and Ziedonis (2002) for the US) is due more to the growing technological opportunities in the bio-medical (and maybe ICT) area than to policy regulation.[8] It is interesting to note that two studies, one by Gulbrandsen and Smeby (2002) on Norway and one by Ranga (2003) on Belgium, have found some evidence of industrial funding being linked to university patenting (the direction of causation is not clear). This result could provoke speculation that the increase in university patenting has been indirectly affected by policy actions that have forced university research to become more reliant on industrial funding. Third, although interesting, the data from the PRO IP survey conducted by the OECD on institutionally owned patents are not sufficient; national data on university invented patents, such as the used in the studies developed for all the above countries, should be gathered from the same patent offices to ensure comparability.

3. Changes in public research a survey of current evidence

This section focuses on the changes in public research provoked by the diffusion of IPR. As very few studies have examined this issue at the European level, we will also discuss a few studies that have examined the changes in public research from the broader perspective of increased interaction between universities and firms via, among others, research contracts, university spin-offs and patents.

In the last 10 years American universities have been much more active than their European counterparts in enforcing and exploiting IPRs on the research carried out by their researchers. Between the late 1980s and the end of the 1990s the number of USPTO patents granted to US academic institutions more than tripled and by 2002 numbered nearly 3,300. This rapid growth was paralleled by the development of specialised management/administrative organisations (including a complementary number of patent lawyers) within universities devoted to the economic exploitation of academic research, by the creation in the science curricula of specialist training in patent law and, as the result of a some major public mishaps, by the development of a code of conduct designed to cope with potential conflicts of interests. Two major implications of this radical organisational innovation: the impact on academic

[8] See also the study on patenting output from the Chalmers University of Technology in Sweden by Wallmark (1997).

research and the legal aspects connected with the ownership of property rights, have attracted the attention not only of scientists and practitioners but also of the wider public via the discussion of these issues in the national press. [9]

Analysing the impact of university IPR on academic research in Europe requires that two separate aspects be taken into account. First, we need to consider the impact of an increase in university IPR: does increased involvement in IPR by university researchers affect their research activity? Second, the move by universities towards institutional patenting – i.e. the institutionalisation of patenting being one of the activities of university researchers — could result in the creation of a new incentive structure that would affect the behaviour of academic staff.

These two aspects are equally important. The OECD ST&I Outlook 2002 report (OECD, 2002b) discusses in some detail the advantages of institutional ownership over individual ownership of IPR in PROs; here we want to put forward two more reasons that would justify an institutional approach. First, such an approach allows the potential sharing of benefits with the TTO, the inventor, the department/faculty of the inventor and the rest of the university, recognising that although it is possible to identify only *one* inventor, many factors (people and infrastructure) have contributed to the realisation of the invention. However, it should be noted, that there is very little evidence of any active redistribution of the profits across departments.[10] Second, given the high costs of patent applications, in the case of contract research with industry, there is, as we have already said, a tendency to assign ownership rights to the firm in exchange for direct compensation that precludes the possibility of future claims for rewards based on the invention. While there does seem to be some justification for institutional ownership of a patent, this type of management of university IP may also induce an exacerbation of the effects connected with a rise in university IPR. For example, the results of the TTO/OECD survey provide some empirical evidence that IP activity does already 'have a positive influence on the

9 A large number of academic, policy and practitioner works which examine the US context have recently been published. See, among others, Blumenthal et al. (1997), Campbell et al. (2000), Cohen (2001), Nelson (2001), Thursby et al. (2001), Campbell et al. (2002) and Jensen and Thursby (2002).

10 Given the constraints on funding for university teaching and research, particularly in the case of European universities where independent sources of funds such as endowments or alumni are usually negligible, income from IPR, if it materialised, could become a potentially very important source of

recruitment and careers of researchers and a stronger influence on earnings' (OECD 2002a, p. 27). If this is the case, the institutionalisation of IPR could greatly influence the behaviour of researchers. Let us assume that the reasons for research activity are: 1) curiosity - researchers gain pleasure from the discovery process; 2) reputation - researchers want to become famous; they want to contribute to posterity; 3) career - researchers aspire to achieving tenured chairs, they want to make progress in their careers; 4) research money for the creation and development of a research team and 5) personal money - researchers are only human and generally therefore have the desire to make more money. An institutional IPR will directly affect the third and fourth of these aims and probably also the second. Researchers will therefore likely react very quickly to the new incentive structure and divert part of the time and effort previously devoted to publishing, teaching and administration, to the new activity of patenting.[11]

There have been some recent studies that have analysed the impact on European academic research of increased reliance on industrial funding. The majority are case studies of a university with little supporting statistical evidence. Two studies, one by Gulbrandsen and Smeby (2002) on Norway and one by Ranga (2003) on the Katholik Universiteit van Leuven (KUL) in Belgium examine the issue based on statistical data. The survey of university faculty in Norway[12] produced evidence on the impact of increased TT activity by universities. First, faculty with funding from industry perform significantly less basic research than researchers with no external funds or other types of external funds; however, researchers with industrial funding carry out less experimental development than researchers with no external funds. Second, about 20% of respondents reported that contract research is problematic with regard to autonomy and independence of research (the share of researchers with industrial funding drops to 12%). Finally, confirming the results of Canadian and US studies, this survey produced evidence that faculty with industrial funding publish more than other researchers. The analysis across fields (unfortunately only briefly reported in the survey) confirms this result for researchers with no external funding, but the

money, not tied to a specific activity, that the university could use to develop new (or currently under-funded) research or teaching areas.

[11] Section 4 discusses in greater detail the motivations behind the researcher's decision to patent.

[12] The survey, carried out in 2001, included all faculty member with the position of assistant professor or higher in Norway's four universities. The survey had a response rate of 60%. Similar 'university census' surveys were carried out in 1982 and 1992.

difference is not significant in all fields of learning for researchers with other external funds.

The preliminary study by Ranga (2003) provides some tentative evidence that there was no shift towards applied research publication in KUL during the period 1985-2000 though the university received increased funds from industry in that period. Also, Ranga presents some preliminary evidence to show that, in the case of KUL, the total number of publications by research groups has a positive correlation with contract funding.

Unfortunately, none of the surveys conducted by TTO associations (either in US/Canada, or in Europe) addresses the issue of the impact upon academic research of increased patenting and increased institutionalisation of patenting.[13] We were able to identify only two studies that directly addressed the issue of the impact of increased university patenting on academic research in Europe: by Webster and Packer (1997) and the European Commission (2002).

Webster and Packer's (1997) study examines the results of a questionnaire involving UK universities and a set of semi-structured interviews with TTO managers, patent agents, patent examiners and industrialists in the UK in 1993. In addition to a set of questions on patenting and licensing by UK universities the survey addressed the issue of disclosure and dissemination of research results. Although they do not report statistical results, the authors claim that 'it is apparent from our survey that academic dissemination can be compromised'. On the basis of both the survey results and the interviews, they point out that a number of respondents have become much more strategic in their choice of what information to disclose in their publications to avoid the possibility of a future patent application being compromised.

The European Commission (2002) report summarises the results of a survey of public and private researchers designed to investigate the issue of publication delay. The survey was probably carried out in the late 1990s (the report does not provide this information).

[13] See, for example, the content of the AUTM Licensing Survey - FY 2000 (2002) and the UNICO and NUBS University Commercialisation Activities Survey - FY 2001 (2002).

The report identifies the policy concerns that: ‘a public research policy that supports both rapid dissemination to foster scientific progress and patenting to support exploitation of the results of publicly funded research has to establish framework conditions that help researchers to avoid conflicts of interest, e.g. ensures rapid publication while giving protection to the results’ (European Commission, 2002: 10). The survey was carried out to assess the current situation in order to be better able to establish framework conditions.

The report identifies three main results:

- A small fraction of researchers cited considerable delay in publication of research results; the less experienced users of the patent system experience the highest delay.
- Public research sector researchers strongly favour the introduction of a grace period.
- Public research sector researchers support the idea of filing a provisional patent application as an alternative to a grace period.

Figure 1 presents the responses to the question about whether a delay in scientific publication had occurred (could occur) on results that had been (could be) the subject of a patent application. Though the report claims that only a small fraction of researchers experienced a considerable delay, when we focus on academic researchers it is clear that a large majority of respondents had experienced some degree of delay.

{FIGURE 1 ABOUT HERE}

Though we praise the intention to collect new and much needed data on the possible effect of increased reliance on IPR in PROs, they way in which the data were collected and analysed in this survey rendered the conclusions of the report very unreliable. Out of the 1,500 questionnaires administered, 154 respondents were from PROs, either individuals or institutions that have used or were planning to use the patent system. Though not explicitly stated in the report, it would seem that the statistical analysis was carried out on a sub-sample of the respondents in order to achieve 50:50 ratio institutional to individual responses. The report does not specify who were the institutional respondents, which makes the interpretation of results problematic. For example, quite different answers would be expected from a member of the central university administration and a member of the technology transfer office. Furthermore, the statistics come from a mix of institutional and individual responses, which limits the possibility of their interpretation even more. Finally, the fact that the questions were asking about something that *has* happened and something that *could* happen mixes factual responses with opinion based ones.

Indirect evidence about the relation between academic research and university patenting is offered in the study by Azagra-Caro and Llerena (2003). They develop a model to explain the characteristics of the laboratories at the University Louis Pasteur that affect their patenting output. They found some empirical evidence to support the view that the laboratories of more prestigious (in terms of institutional recognition) institutions tend to patent more. However, they conclude that much more detailed data are needed to come to robust conclusions.

The scant evidence on the impact of increased IPR in universities and the lack of comparable data across European countries and over time, prevent any firm conclusions being drawn about the impact of increased IPR on the characteristics of public research. Therefore, in the next section we will examine how the impact of increased patenting in universities can be assessed analytically.

4. Analytical approaches

The above sections have reviewed the small available literature on recent changes in university patenting in European countries and their potential implications. This section focuses on the development of analytical approaches to assess the possible consequences of increasing university patenting and increased institutionalisation of patenting. Five main possible negative impacts can be identified. They are:

- Negative impact upon the culture of open science, in the form of increased secrecy (reduced willingness to share data with colleagues), delays in publication, increased costs of accessing research material or tools, etc.

- Substitution effect between publishing and patenting. Particularly important is the possible different impact depending on the age of researchers. A hypothesis worth testing is that older researchers may have the ability to publish and patent at the same time, without substitution effect, because they have already accumulated intellectual capital while for young researchers, publishing activity has a greater effect than patenting on the formation of intellectual capital.[14] Hence, young researchers that are active in patenting from the start of their careers, may prove to be less productive in the long-term.

- Diverting research resources (researchers' time and equipment) from the exploration of fundamental long-term research questions that tend not to be suited to the development of IPRs. This impact is strongly affected by the scientific field. In some cases such as transfer sciences (Blume 1990) or 'Pasteur's Quadrant' sciences (Stokes, 1997 e.g. biotechnology or ICTs), the distinction between fundamental/basic research and applied research does not hold. However, for other sciences, such as physics, in which the distinction between basic and applied research is more pronounced, the diversion of resources can have major consequences.

- Threat to future scientific investigation from IPR on previous research. In theory, patent law provides a research and experimental use exception that allows university researchers to use patented inventions for their research without being obliged to pay licence fees. However, this exception can be weak if the firm that obtains the exclusive right to exploit a patent decides that the research exception is not applicable to university projects financed by industry.[15]

- Threat to teaching quality. Teaching is not associated with a heavy weighting in the assessment of the performance of university professors, thus teaching

[14] It is interesting to note that recent attempts to increase publication output have resulted in shorter and less inclusive (less scholarly) types of articles. This phenomenon is affecting the relationship between publications and intellectual capital formation in a negative way.
[15] See for example the case of Ariad Pharmaceuticals that owns the exclusive licence to a key biological trigger, the NF-κB messenger protein (Brickley, 2002).

has a low impact on their careers. If patent output is to be used in the academic evaluation process (as is already happening in a few countries and as is being promoted by some policy reviews), this will create incentives for researchers to reduce their time/commitment to some of their activities - and, given the current weighting scheme, teaching will be the activity likely to suffer the highest time reduction.[16]

To bring new insights to the debate, we introduce some in depth analyses on the choices made by researchers to patent or to publish. These contributions help to formalise the behaviour of faculty researchers and allow a distinction to be made between short and long-term impacts. In the short-term approach, structural funds and IPR are considered as exogenous, i.e. given to researchers, and thus the ability of researchers and, to a larger extent, the capacity of universities to patent are examined and related to publication rate. We analyse firstly the likely effects of EU fragmentation and the introduction of a grace period on researchers' decisions to patent or publish. Secondly, we investigate the potential and cumulative consequences that the decline in structural funds is likely to yield, bearing in mind that only few patents become economically valuable.

4.1 The researchers' decision to patent or to publish

This section is concerned with how researchers decide to patent or publish and, ultimately, how they allocate their time between basic and applied research. There are only a few published contributions in this area. The first contribution is empirical and is based on two university case studies (Owen-Smith and Powell, 2001). Owen-Smith and Powell suggest that the faculty researcher's decision to patent (or not) follows a cost-benefit analysis. This is consistent with Jensen and Thursby's (2002) static model. We present these complementary views in the next two subsections because they provide a detailed description and/or representation of the mechanisms that condition faculty researchers to patent.

Researchers' Perceptions of University Patenting

[16] See Stephan (2001) for a broader description of the educational implications of university-industry technology transfer.

Drawing on qualitative data gleaned from 68 interviews, Owen-Smith and Powell (2001) develop an explanation for widely disparate rates of knowledge disclosure by means of patents and explore the reasons why researchers would be willing or not to patent. Not surprisingly, the qualitative results suggest that the researcher's decisions are based on: (i) their perceptions of the personal and professional benefits of patenting; (ii) their perceptions about the time and resource costs of interacting with TTOs; (iii) their immediate environment, i.e. general view of technology transfer.

A key finding was that the decision to disclose patentable knowledge follows a cost-benefit analysis. If the cost exceeds the expected benefits, the researcher will rationally reject patenting. As to what are perceived as benefits, the results differ greatly between the physical and the life sciences (see table 1), but researchers from both fields agree that pecuniary incentives are undoubtedly major driving forces. Researchers decide to patent because they perceive positive personal (obviously pecuniary, but also curiosity) and professional (prestige, validation of basic research, freedom of public research) outcomes from establishing intellectual property protection. Table 1 presents the expected benefits from patent outcomes by faculty researchers.

{Table 1 ABOUT HERE}

The cost structure of university patenting is somewhat less clear. The qualitative results in Owen-Smith and Powell's study suggest that the cost structure is: (i) a negative function of past patenting by the researcher - past experience with the legal aspects of knowledge appropriation should reduce future patenting efforts; (ii) a negative function of the level of expertise in the university technology transfer offices; (iii) a negative function of the quality of interactions with the university technology transfer offices. An additional result that comes out of their research is that the cost-benefit analysis conducted by researchers is influenced by the faculty to which they belong. The widespread awareness of success and patent benefits, the supportive peer environment and the ascription of academic status to commercial success are all factors that contribute to an institutional environment in which both basic and applied research are likely to be undertaken simultaneously (Owen-Smith and Powell, 2001: 113).

On the whole, the decision of researchers to patent or not is likely to be based on a cost-benefit analysis. In a recent paper, Jensen and Thursby (2002) investigated the effect of changes in patent policy on academic research by developing a formal representation of the faculty researcher's decision to patent or publish that is consistent with the empirical assessment made by Owen-Smith and Powell. Because, to our knowledge, this is the only attempt to model such an issue, it is worth presenting its construction in detail.

General Modelling of the Researchers' Allocation of Time Resources between Applied and Basic Research

To address the problem of university research and education, i.e. teaching, Jensen and Thursby (2002) analyse the allocation by faculty of time to three types of tasks: basic research, leading to publication k, applied research, leading to patent application p, and quality of teaching q. What is analysed is not the aggregate level of output for the university but the equilibrium at which both the university, as an administrative entity, and the researchers, maximise their respective utility. Because researchers may at any time exit to a next best alternative outside the university, the model is explicitly a principal-agent problem.

The model starts from the faculty decision on wages w and teaching load e for each researcher. Given this information, researchers decide to allocate their time share between two types of research: basic or applied. Let b and a be the fraction of time dedicated to basic and applied research respectively ($e + a + b = 1$). Current basic research and teaching load will determine the researcher's wage for the next period, while changes in the number of licences provide an additional income. Licences are a simple, linear function of the stock of patentable knowledge $L = L(p)$. The researchers' set of preferences is of two types: pecuniary, i.e. income Y_r, and non-pecuniary, i.e. research effort (curiosity, pleasure in doing research) and prestige. It is assumed that a fraction ϕ of the royalties goes to the faculty inventor, while the fraction (1-ϕ) goes to the university. From the university, or university administration, point of view, the objective is to increase the university's prestige and income. Thus, the researchers and administration utility functions are respectively $U_r(a;b;Y_r;k;p)$ and $U_A(Y_A;k;p)$, *with* $Y_r = w + \phi \cdot L(p)$ and $Y_A = E(q) + (1-\phi)\cdot L(p) - w$.

The researcher's problem is thus to choose the amount of effort, i.e. the time spent (*a* and *b*) on both applied and basic research, so as to maximise his/her current utility U_r subject to time constraints and given wages *w* and teaching load *e*, while the administration's utility function is itself a function of the researcher's time spent by the researcher on research and education.[17] The administration problem is to choose the researcher's wage *w* and *q* so as to maximise his/her current utility U_A. Given this simple representation, and assuming that the optimal solution is decreasing in *a* and increasing in *b*, the model yields the following results.

1. Whether the researcher specialises in basic or applied research, or spends time on both, depends on the marginal rate of substitution of applied for basic research (mrs_{ab}). If mrs_{ab} is superior to unity, the researcher specialises in applied research ($a = 1 - e$, $b = 0$); if inferior to unity, she specialises in basic research ($b = 1 - e$, $a = 0$). If mrs_{ab} is equal to unity, the researcher splits her time between *a* and *b*. Whether policy changes have the effect of increasing university patenting depends on how these changes affect the rate of substitution of applied for basic research.

2. Regarding the quality of teaching *q*, the outcome of the model remains ambiguous, but as the authors state, policies that encourage university patenting are likely to have a negative effect on the quality of teaching. The reason for this is that an increase in the stock of patentable knowledge increases the quality of teaching only if such knowledge is used in education. But the administration may establish a lower *q* to allow the researcher to spend less time on educating, i.e. more time in either *a* or *b*. In other words, it is likely that a decrease in time spent on education will not be offset by an increase in the quality of the knowledge used in education.

[17] This model does not include the possibility of buying-out the teaching load.

3. Interestingly enough, the model shows that changes in the share of licence ϕ have no effect on the optimal wages *w* and the quality of teaching *q*.

The above model has been developed in order to investigate the effect of changes in patenting policies in universities on its two secular missions: education and research. The results are ambiguous for teaching, and they do not provide sufficient insights into whether such changes (in patent policies) will affect the balance between applied and basic research. However, there are a number of other important findings. First, the rise in applied research might not lead to less basic research. The wage policy and the quality of teaching will actually determine the final decision of the researchers about how their time is split between basic and applied research. Second, the quality of teaching is quite likely to suffer from an increase in applied research if research outputs systematically become codified in patents. Should this happen, little room would be left for dissemination of knowledge through education. In summary, what can be inferred from the foregoing is that:

1. If the costs of patenting outweigh the benefits, the researcher will decide not to patent (Owen Smith and Powell, 2001).
2. If the marginal increase in the utility function from an additional patent is lower than the marginal increase in the utility function from an additional publication, then the researcher is likely to opt for publication, depending on her/his wage *w* and teaching load *q* (Jensen and Thursby, 2002).

Unfortunately, the model does not make the wage *w* conditional on past patenting. The inventor's incentive to patent is thus only conditional on expectations of future revenues, i.e. licence fees linked to the patent. But it is widely acknowledged that the economic value of patents shows wide variation. Most patents have a little economic value, but few become the rare 'golden egg'. Suppose that *w* were to become conditional on past patenting, this incentive scheme would be consistent with, though not rigorously equivalent to, those that condition professional careers on researchers' patenting activity. The latter amounts to assuming that *ceteris paribus,* researchers may be more interested in patenting than publishing, so that the marginal rate of substitution of research of applied for basic research mrs_{ab} becomes increasing in *a* and decreasing in *b*.

4.2 Key Issues Revisited

The model provides a useful framework within which to discuss the issues that have gained momentum in Europe. On this basis, we first investigate the effect of the fragmentation of the European patent systems on university patenting. We find that if this fragmentation is a hurdle for both public and private researchers, faculty researchers are likely to systematically opt for publication to avoid the additional costs induced by this fragmentation. The introduction of 'grace periods' is then discussed so as to deduce its possible consequences. Finally, we study the impact of scarcer structural funds in a world of skew-distributed outcomes.

The Fragmentation of European Patent Systems

What does the model say in the case of a fragmented system, such as is the case in Europe? The above model helps us to formalise the choices of the researchers with respect to patenting or publishing. Assuming (i) substitution between publishing and patenting; (ii) that basic and applied research induce non-redeployability of the research result from *a* to *b* and *vice versa* ($a \cap b = \emptyset$), the choice of the researcher between patenting and publishing is proportional to the time *a* and *b* that she chooses. Building on the previous model, it is quite likely that the fragmented patent system leads to larger costs for actually applying for a patent. The productivity of the time *a* spent on applied research is likely to decrease substantially, as, in turn, would the number of licences *L(p)*. A simple numerical exercise shows that following a linear assumption, a duplication (or a multiplication by *x*) of the time spent in applying for patents equates with a division by two (or by *x*) of the number of applications. In other words, the marginal rate of substitution between basic and applied research, leading unequivocally to publication and patenting respectively, will become inferior to unity, leading the researcher to systematically specialise in basic research.

Based on the model, the multiplicity of patent systems in Europe will make it difficult for any Europe-wide policy in favour of university patenting to be implemented. The EPO itself stresses the need for a Community Patent to be agreed, which would be equivalent to introducing unitary patent protection for the whole territory of the

European Union (European Commission, n.d.). First, in the absence of any legal authority at European level, the establishment of legal certainty is the main requirement if a Community Patent is to be effective. The arrangements for settling legal disputes involving Community and European patents have yet to be discussed, and may prove problematic. Secondly, inventors and firms have highlighted the particular need for reasonable translation requirements, which, in turn, is likely to increase the cost of patent applications.

All of these aspects represent a cost for all types of researchers. If firms are required to appropriate the potential benefits associated with invention, most of the cost will be sunk costs in the sense that private companies will have to bear them. Faculty researchers however, may systematically opt for publications, preferring not to incur the costs associated with the multiplicities of the patent systems that must be dealt with. This in part explains the lower patenting activity of European universities compared to their American counterparts. Because the costs greatly outweigh the benefits a researcher may expect to enjoy from patenting, a researcher will rationally opt for basic research. This conclusion positively echoes the more qualitative analysis carried out by Owen-Smith and Powell (2001).

Introduction of a Grace Period

Much has been written about a grace period, not least because such a mechanism would possibly reconcile researchers' behaviour vis-à-vis their main objective of knowledge dissemination. The grace period is a legal device to allow the patenting activity of university researchers to potentially become compatible with the publishing standards of Open Science. In order to correctly understand both the scope and the goal of the grace period, it is necessary to briefly outline the current patent law in several countries.

Countries in Europe created their own legal context on the basis of the Paris Convention (1883) for the Protection of Industrial Property. The core principle of the convention is the first-to-file system: that is, the person that receives Intellectual Protection is the first to file an application, regardless of whether s/he is the original inventor. For an invention to be patentable, it must be considered new insofar as it does not form part of the state-of-the-art (article 54 of the Paris Convention). Subject to certain exceptions, public disclosure constitutes a prejudicial antecedent that annihilates its novelty, thus preventing subsequent patent application. There are, however, some non-prejudicial types of disclosure that, for a given period of time, do not compromise the future patent application: "(i) an evident abuse in relation to the applicant or his legal predecessor; (ii) the fact that the applicant or his legal predecessor has displayed the invention at an official or officially recognised, international exhibition …" (art. 55).

Unless otherwise stated, publications constitute a prejudicial form of disclosure for any patentable knowledge. This means that each is incompatible and is excludable and, in the terms of the model above, means that patents are the sole function of the time spent on applied research *a* and publications are the function of only the time spent on basic research *b*. Knowledge that could be either published or patented presents an immediate dilemma for the researcher, for publication whether in scientific journals, at conferences or during seminars is *de facto* prejudicial to the subsequent filing of patent applications. Thus, in cases where knowledge can be codified in either publications or patents, a tension is likely to arise.[18] A solution would be to include scientific publication in the non-prejudicial disclosures, thereby allowing researchers to divulge their scientific theories without prejudicial delay - at least for a certain period of time. The grace period is understood as "a specific period of time preceding the filing of a patent application during which disclosure by any means … for which the patent application is filed by the inventor or his/her successor in title do not constitute prior art in respect of the patent application at hand" (Strauss, 2002). It is significant that public disclosure does not constitute a priority date in that no immunity is provided against parallel development during that period, although public disclosure constitutes prior art for any third party willing to patent.

Recently, the idea of a grace period has gained momentum as it aims to reconcile the growing awareness of the economic value of scientific knowledge with the secular, primary and Mertonian value of Open Science. Thus, in 1998, the EPO sought the

[18] Another condition is still necessary for the tension to arise. As Monotti (2002) notes, "An inventor may perceive the patent route as less scholarly and therefore prejudicial for promotion. … He may be unwilling to expend the necessary time in developing the invention and prefer to pursue other fundamental research questions. … He may be a purist whose only research motivation is to advance knowledge through open discussion." (p. 476).

opinions of two experts on the introduction of a grace period in European Patent Law. The view of M. Galama, one of the experts consulted, was that such a mechanism would introduce a higher level of uncertainty in the protection of inventions because early publication could be exploited by a third party, thereby reducing or even negating the potential benefits of the inventions. Should faculty researchers want to benefit economically from their research, they must invoke the rules of intellectual property protection already in place. Professor Strauss, the other expert, took a different view. He argued that such a legal period of grace is already provided for in 38 countries, including the USA, Japan, Australia, and three candidate countries for accession to the European Union. For these countries the grace period does not seem to have created any major uncertainties, which is probably linked to the fact that this legal tool is not frequently used (see Nelson, 2001). This is consistent with the fact that faculty researchers in the countries in question are increasingly being asked to patent their discoveries.

The perceived effects of the introduction of a grace period were explored further in a European Commission report on the implications for basic genetic engineering research of failure to publish patentable inventions (EC, 2002). A total of 1,500 questionnaires was sent to public and private researchers, only 240 of which were completed. The results reflect the divergence of opinion: faculty researchers are strongly in favour of the grace period, while industry researchers are strongly against it. The industry argument is that the grace period does not include any priority date, that is, protection, for the published invention. The priority date remains the date of patent application. Therefore, industry researchers would be more likely to use the provisional patent application. A provisional patent application allows the applicant to obtain a filing date without fulfilling the formal requirements involved in a completed patent application, while conferring on the applicant a regular filing date. This filing date offers intellectual protection, provided that a patent is subsequently granted to the applicant. In the meantime, the researcher is free to disclose her/his invention without prejudice to its patentability.

Typically, the objective of the grace period would be to reconcile the time spent on applied research *a* with the time spent on basic research *b*. Clearly, this would only apply if the research in question could result in both a patent and a scientific publication. This is tantamount to assuming that time spent on applied research a is not clearly distinguishable from time spent on basic research b, i.e. $a \cap b \neq \emptyset$. Only certain scientific fields would fall into this category, for instance, biotechnology.[19] It is also now necessary to distinguish between the type of research being undertaken - basic or applied,[20] - with the time spent in actually codifying the produced knowledge. Suppose, for example, that the time spent on basic research consists of time spent performing the research b_r and time spent on codification for publication b_c, so that $b = b_r + b_c$. Suppose, also, that the time spent on applied research consists of time spent doing applied research a_r and time spent on codification into a patent application a_c, so that $a = a_r + a_c$. Leaving aside the possible overlap between b_r and a_r, it is worth questioning the nature of the activity involved in codification. According to the European Commission report on the causes of publication failure (EC 2002), the level of scientific expertise and codification experience required for patent applications is far less than that required for scientific publication. Thus, learning both how and when to patent should be a minor cost for scientists. Many faculty researchers contest this view. When asked for their opinions recently on policies supporting university patenting in Europe, practitioners indicated that writing a publication is quite different from writing a patent application. One interviewee noted that:

> *This whole desire to make a university researcher apply for patents does not make sense. We are trained to do research. We are trained to explain what we do in our research, so that experiments can be done elsewhere, on the basis of what is written, and if possible without direct interactions. Thus the whole exercise in publication is to narrow down the range of phenomena for which the experiment holds, and to foster its duplication in any other place in the world. Instead, we are asked to write patent applications, but the exercise is absolutely opposite. University researchers must think of the whole range of possible applications so as to be able to claim for as many situations as possible. University researchers are not trained for that*

[19] The story of the biotechnology firm, Cetus, offers ample examples of the tensions between publishing and patenting that can arise. Cetus was created in 1971, and turned to biotechnology at the end of that decade. The successful development of the Polymerase Chain Reaction (PCR) gave rise to a patent application in 1985 and later publications, though both proved problematic within the firm (see Rabinow, 1996).

at all. (Interview with University Researcher in Barcelona, June 2002).

The above may be brief, but contains very important information about the activity of public, i.e. university, researchers. The grace period is likely to have little effect on university researchers due to the traditional incentive system in universities and natural disposition of researchers to publish their results. Policies that try to enforce university patenting must allow for the costs inherent in learning to write patent applications.

Diverging paths in a world of skew-distributed outcomes.

Policies that encourage university patenting have also been reinforced by the considerable decrease in structural funding for universities. With the erosion of public funding, universities are being forced to find alternative financial resources. These financial resources include, among others, competitive grants allocated through publicly funded programmes and support obtained through collaborations with large firms - typical in the pharmaceuticals industry. The increase in university patenting is also seen as providing an additional source of funding in the form of royalties.

Empirical figures on university licences for Europe being almost non-existent, we have little information about university licensing and its revenue. In the case of three US universities (University of California, Stanford University and Columbia University), Mowery, Nelson, Sampat and Ziedonis (2001) have observed an exponential growth in licensing revenues since the mid-eighties (see table 2). Although this suggests that licences do ensure a substantial share of extra-structural funding, it appears that these particular universities are in the minority. In fact, in most universities' budgets the operating costs of their TTOs significantly outweigh the revenues from licences. We would agree with Nelson (2001) when he states that it is a myth that universities can expect a lot of money to result from their patenting and licensing activities.

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[20] This is equivalent to assuming that such a distinction holds.

The above is fairly consistent with the fact that useful inventions are inherently rare. From table 2, we can see that the largest share of revenues is captured by the top five inventions. As noted by Sherer and Harhoff (2001), the value of invention and innovation follows a highly skewed distribution: “most innovations yield modest returns, and the size distribution has a long thin tail encompassing a relatively few innovations with particularly high returns” (p. 559). This raises the question of geographic dispersion or concentration of the most valuable inventions. We would maintain that the fact that valuable inventions are rare does not preclude their being geographically concentrated. The published empirical results on spillovers repeatedly stresses the fact that knowledge is a public good that primarily benefits the immediate locale. It follows that most valuable inventions trigger additional valuable inventions at the local level. Assuming a similar geographical concentration of licences, it is likely that the vast majority of universities will, following Nelson (2001), maintain non-profitable TTOs, and only a few will enjoy any financial benefits.

{Table 2 ABOUT HERE}

Most inventions are not sufficiently profitable to generate enough revenue to counteract the decrease in structural funds. Science policies must recognise that the world of science is a skew-distributed world and that structure is inherent –i.e. it is the result of dispersed probabilistic outcomes far more than the variance in effort or competencies of the universities. In the face of little or no evidence, we see no reason why the well-recognised Matthew effect in science discovery should not be equally relevant to economically valuable inventions. For policy makers, the problem is the financial resources of universities. The reduction in structural funds produces great financial difficulties for most universities while benefiting only a few. In turn, because the value of inventions is difficult or impossible to forecast, policy makers should promote diversity of research both in basic and applied research, bearing in mind that first, most seeds do not bear fruit and second, that no method exists to discriminate between fertile and infertile seeds.

Representation of the value of licences following a skew-distribution suggests that only a few universities are likely to win, while the majority will eventually get poorer through the expensive daily conduct of their technology transfer and patenting offices.

This is consistent with the model developed by Jensen and Thursby, which is based on the assumption that researchers do not benefit from their patenting experience.[21] Therefore, initial differences across researchers persist. It follows that ill-considered institutional arrangements may prove very costly in terms of basic research, applied research, patents and technology transfer.

Is the Win-it-All/Lose-it-All Scenario Likely to Occur?

The representation of the value of licences following a skew-distribution suggests that only a few universities are likely to win it all, while the majority of universities will eventually become poorer through the expensive daily running of their technology transfer and patenting offices.[22]

To create a more dynamic model, let us now introduce a learning curve of the simplest form. Bayesian learning in patenting implies that the ultimate value of a patent is a positive function of past experience. This implies that the researcher can expect a much higher return on investment in applied research. What is the effect, in the long run, of the basic or applied nature of research activities chosen by the researcher? To answer this would need the development of another model. However, a recent paper by Paula Stephan and colleagues (Stephan et al. 2003)[23] has addressed the issue of crowding out of publications by patents at the level of researchers. Using a sample of 10,962 individual doctoral scientists, the authors found evidence that the effect of an additional publication on patents is positive and significant. This suggests that there is no substitution effect of patent for publications. Besides, this effect is more pronounced for scientific disciplines such as life sciences, physical sciences and, to a lesser extent, engineering. No such effect is detectable for computer sciences. Besides, the number of patents is a function of the experience of the researcher. One very interesting result is that tenured faculty patent significantly less than non-tenured faculty, which indicates that patenting activity is an increasing function of the

[21] This assumption is crucial because it leads researchers to favour “publishing” over “patenting”. Consequently, the mrs_{ab} is decreasing in a and increasing in b.

[22] This is also consistent with the model developed by Jensen and Thursby which is based on the assumption that researchers do not benefit from their past patenting experience. This assumption is crucial because it leads researchers to favour “publishing” over “patenting”. Consequently, the mrs_{ab} is decreasing in a and increasing in b.

[23] We are grateful to the authors who have given us access to the first draft of unpublished work.

seniority of the position. Clearly, the incentive structure for both types of faculty is different.

There is thus evidence that publications and patents are complements rather than substitutes. Also, there is evidence that researchers do *learn* how to patent, the results of this learning being likely to result in more patent applications in the later phases of their careers. An analogue study has been done at the level of institutional learning. In this case, universities may or may not accumulate patenting expertise, thus closing up the gap, or not, with initially higher patenting universities. The question of learning to patent and accumulated institutional experience was investigated in the context of US universities after the Bayh-Dole Act of 1981 (Mowery, Nelson, Sampat and Ziedonis, 2001). Their findings can be summarised as follows: (i) the authors find little evidence of a decline in the quality of university patenting for incumbent universities for the period under investigation; (ii) the quality of patents for entrant universities is catching up with incumbent universities. This corroborates the idea of the presence of institutional learning in patent codification and applications. However, the sources of this institutional learning are hard to locate. The authors test for the presence of (a) a mere learning-by-doing effect, which is similar to introducing Bayesian learning at the institutional level; (b) relationships with research corporations; (c) allocation of administrative talent to technology transfer activities. The lack of significant relationships with improvements in patenting suggests that the locus of institutional learning is more diffused.

The effect of both personal and institutional learning to patent on university research suggests that the patenting activity might go hand-in-hand with publication. It should be noted, however, that the linkage of patenting with both reputation and additional funding in the form of licences, is equally likely to increase inter-university differences in terms of financial resources. If more successful universities are able to gather a larger financial base, they may also choose to reinvest licence revenues in basic research. In turn, the fact that publication and patents are complementary, means that the Matthew effect in patenting is likely to overlap with the Matthew effect in publication, making way for an even clearer win-it-all/lose-it-all scenario.

The discussion on the analytical models presented above clearly stresses that the abstract representation of the decisions of researchers to publish or patent is seen as relevant for analysis of the short-term consequences of increased patenting. The analytical approach of Jensen and Thursby does not identify a process of substitution, or crowding-out, between patenting and publishing activities. This is consistent with the results of the work of Stephan et al. (2003), which suggests that the most productive researchers in terms of publishing are also those with the most patents, although the scope of complementarity is likely to differ significantly across scientific fields. Furthermore, the analytical approach of Jensen and Thursby does carry the caveat that an increase in applied research is likely to have negative consequences for the quality of education dispensed by faculties. Human capital takes a long time to acquire and implies a large share of sunk costs. The problem with increasing dependence on licences to finance a department is that it increases the dependence of universities on the immediate utility of research output. Assuming that this equates in some cases to short-term research, the danger of making structural funds scarcer overtime is that this may lead to a decrease in the quality of education, and thus to a loss in human capital.

The analytical model discussed above also demonstrates that in Europe, policies aimed at increasing university patenting are likely to become very costly because researchers will spend a large proportion of their time dealing with the legal and organisational niceties instead of doing research. First, policies aiming at increasing university patenting should encompass a simplified legal system that would allow researchers to benefit from intellectual property rights on a larger geographical scale. This would significantly reduce the cost structure of university patenting, although, of course, the same benefits would also apply to firms. Second, macro policies in favour of university patenting are likely to have little impact if they are not accompanied by corresponding investment in development of technology transfer expertise at the level of universities. Empirical evidence from Europe points to a dramatic lack of expertise in TTOs at the local level. Third, the grace period is likely to impact on the activities of researchers in only those areas where basic research cannot be clearly differentiated from applied research, because the logic of a grace period relies explicitly on the fact that the same (group of) results become simultaneously publishable and patentable. Typically, the grace period is more directly related to disciplines like biotechnology and/or information technology, while making little difference in disciplines such as the physical sciences.

5. Conclusions: key issues for future empirical assessments

"To understand whether concerns about the scientific and economic impacts of strategic IP behaviour are valid, governments, researchers and other stakeholders need more information on the quantity and quality of IP actually under management at PROs" (OECD, 2002b; p. 198), Chapter 6 of the OECD ST&I Outlook 2002, devoted to patenting and licensing in PROS, concludes. Our research confirms and further reinforces this conclusion. Currently, the data on university patenting available for the European countries are unreliable and are not useful for assessing the potential impact upon open research of an increased strategic IP behaviour or PROs.

Most of the current debate is based on a one-off observation or ideology, for example policy and practitioner documents (mainly those of TO managers) quite often state that considerable innovation potential goes unused because PROs do not take out patents on their discoveries. The causality between not taking patents and less innovation has not been proved: it is only assumed. Statements like: "a lot of great inventions could have emerged if only they had not been hidden in university closets" (in Agres, 2002) misrepresent the process of knowledge transfer from the university and the process of knowledge acquisitions by firms. Indeed, if this view were fact it would mean that firms would be unable to read and understand the published results of scientific research developed by researchers in universities and other public and private research organisations; it makes the implicit assumption that firms do not have any scientific and technological knowledge, which is clearly not the case.

The view that universities are ivory towers that produce academic output disconnected from technology is rhetoric that is not supported by evidence. In fact, the few studies available on university patenting in Europe show convincingly that university invented patents were and are an important phenomenon: researchers did and do produce research relevant to technological development as proven by the fact that they were and are included in the inventor lists of industrial owned patents. As is the case in the US (Mowery et al. 2001, Mowery and Sampat, 2001), university patenting in Europe is not a new phenomenon and did not require specific policy incentives to be developed. In the two countries for which historical data on university invented patents are available (Germany and Italy) and in the other countries for which some information is available (Belgium, Finland and the UK), it seems that the increase in university patenting has been due more to the opportunities in the bio-medical field than to any new policy action. The developments probably occurred later in Europe than the US due to the later development of research in the bio-medical area in the European countries.

Given the first conclusion of Chapter 6 of the OECD ST&I Outlook 2002 quoted above, it is puzzling that, on the same page, the report *tentatively* concludes that: “for many OECD countries, fears that PRO IP activities will distort the public scientific endeavour are premature” (OECD, 2002b; p. 198). The data from the OECD IP survey, though interesting, do not provide enough evidence to support this assertion. These conflicting statements are symptomatic of the current debate in which people and organisations, though aware of the lack of empirical evidence to support any serious conclusions, claim to have evidence to support their assumptions. Given current policy activity across European countries in support of more active use of IP in PROs, there is an urgent need for more reliable and more useful data (on a time series basis) to be collected, not only on IP activity but also on the inputs and outputs of the other activities carried out by researchers and research organisations. Only a broad analysis including the various activities carried out by university researchers in research, TT, teaching and administration can provide the correct framework to shed some light on these issues.

Some literature argues that increased university IPR has not tilted the balance between applied and basic research. For example, referring to the results of studies by Zucker and Darby (1996) and Louis et al. (2001) that provide evidence that entrepreneurial scientists (researchers with a track record of technology transfer activity) have high scientific productivity, Poyago-Theotoky et al. (2002) maintain that TT activity does not divert from basic research. Given the difficulty of defining basic and applied research in the ‘transfer sciences’ (Blume, 1990) or ‘Pasteur’s Quadrant’ sciences (Stokes, 1997), and especially in the areas of biotechnology where university patenting is currently most important, we do not feel comfortable with these conclusions. The major problem with them is that publications span the whole spectrum from basic to applied research, so a high publication output it is not *a priori* a good indicator of the basicness of the research. Thus the generalisation that 'interestingly, some preliminary evidence appears to contradict the conventional wisdom that university technology transfer reduces the quantity and quality of basic research performed by academics' (Poyago-Theotoky et al. 2002: p.18,) is misleading. Much more detailed research on different scientific fields and more detailed output indicators would be needed to reach such a conclusion. For example, it would be useful to classify publications using the Computer Horizons Inc. (CHI) journal classification in four major categories of research - applied technology, engineering technological science, applied research and basic research.

The empirical evidence on publishing and patenting available mostly for the US, shows that for a subset of scientists working in the bio-medical area, there has been no substitution effect between TT and publishing. That is, it provides evidence to confirm that in the bio-medical field, as in other transfer sciences, it is not possible, and not useful, to make a clear distinction between the activities and outputs of basic research and applied research; the boundaries between basic research and applied research are blurred and researchers can produce outputs that are of relevance to both science and technology without damaging their reputation in science or affecting the exploitability of their discoveries.

The preliminary evidence put forward in this paper allows us to highlight four main issues that require attention in any future empirical assessment. First, though European universities' institutional patenting is low, university invented patents seem to be relevant at least in the bio-medical area. Any policy action aiming at creating incentives for 'more efficient' technology transfer via university patenting should take into account the pre-existing phenomenon of university invented patents.

Second, there is a need for more comparable data across European countries that acknowledge the institutional specificities in different countries. A possible interpretation in the case of European countries of the conclusion of the analytical models discussed above points out that policies aiming at increasing university patenting in Europe are likely to become very costly if they do not encompass a simplified legal system that would allow researchers to benefit from intellectual property rights on a larger geographical scale. The fragmentation of the European patent law system together with the intensive and increasing cross-country research activity can produce serious problems. It lowers incentives for researchers to patent at the European level due to the high costs of translation. It also greatly complicates pan-European collaborative tasks in European Universities. Consider a collaborative project between two members of a university-CNRS 'unité' mixte' in France, a Professor and a PhD student in the UK, two professors and three PhD students in Italy, and a Dutch professor, working together with a multinational firms. One can imagine the potential conflicting and complex issues arising in the case of a highly valuable patent deriving from such a contract.

Third, in the US and Canada there has been wide ranging debate on the conflicts of interest that fostered the development of strong regulation to protect the more traditional role of the university in contributing to open knowledge (Argyres and Porter Liebeskind, 1998; Kondro, 2001). From the available evidence, research papers, green papers and opinion papers, etc., it seems that such issues do not reach the same audience in Europe as in the US. There is an urgent need for the development of codes of conduct that would help researchers to manage conflicting pressures. In Europe some discussion has focused on the introduction of a grace period. It is important to underscore that a grace period is likely to have unequal effects across scientific disciplines. In disciplines where the distinction between basic and applied sciences is clear (e.g. the physical sciences), the introduction of a grace period is likely to have very little, if not non-existent effects. In disciplines where the distinction between basic and applied sciences is more blurred (e.g. biotechnology), the introduction of a grace period is likely to have a considerable impact possibly reducing some of the conflict of interest.

Fourth, substituting short-term funds and licences for structural funds carries two types of threat. In the short run, it is likely that the net difference in the financial resources on which universities may base their activities will be negative for the vast majority. Although the scope of the net loss of financial, and thus research, resources may, in turn, not be dramatic for most, it is not clear what the consequences for basic research and teaching may turn out to be. Neither is it clear who between the students or the universities will support the financial gap. In the long run, cumulative effects are likely to exacerbate differences between universities. Universities with low revenues from royalties will be penalised in order to spur them to come up with future highly valuable inventions. Universities with high revenues from royalties will be able to enjoy above normal research budgets that will allow them to implement above normal research projects.

Finally, most of current policy action in the area of university IPR is grounded on the assumption that university patents facilitate technology transfer and, thus, increase the innovation potential of an economy. The survey of the literature carried out for this paper does not provide any conclusive evidence that patenting is an efficient device for transferring technologies and know-how. There is empirical and theoretical evidence both in support of (Poyago-Theotoky et al., 2002) and against (Nelson, 2001) the view that university patenting would accelerate commercialisation. Current policies to support university patenting may well create incentives that could change the behaviour of researchers. These policies are based upon weak empirical evidence thus more research is needed to assess the efficiency of university patenting in technology transfer rather than assuming it.

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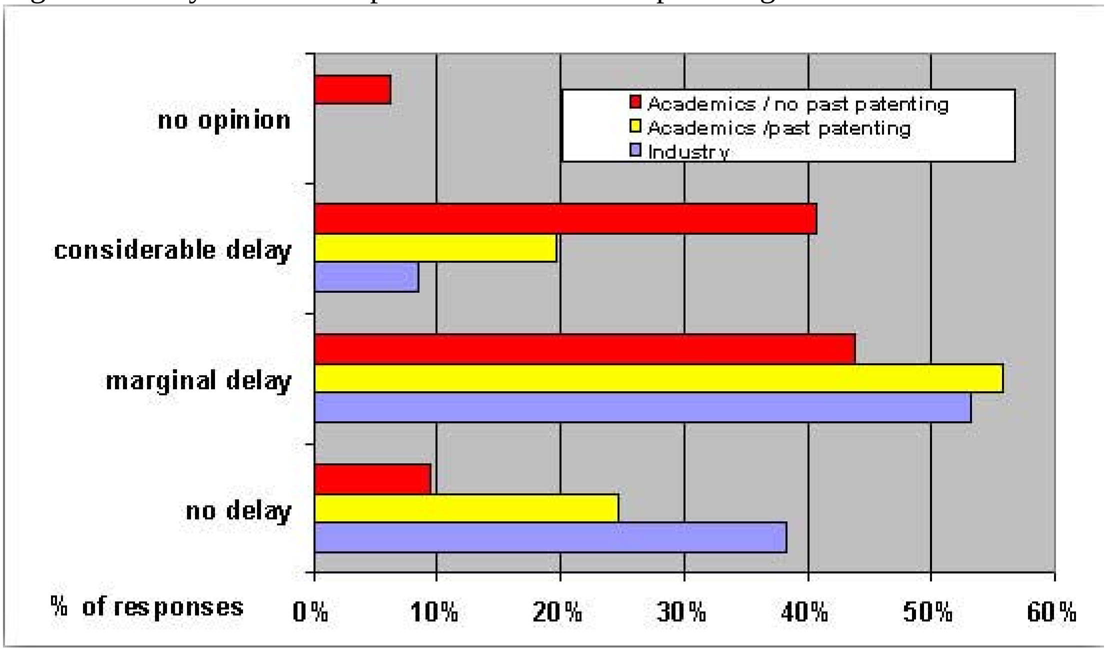
Figure 1: Delay in scientific publication due to the patenting of the invention



Source: European Commission. (2002)

Table 1: Perception of Patent Outcomes by Faculty researchers

Outcome	Physical Sciences	Life Sciences
Protection	Limits restraints on communication Enables commercialisation Limits actions of foreign competitors	Protects academic freedom from commercially held patents Enables commercialisation required for drug development Keeps findings from being ‘robbed’ Keeps faculty from being ‘skinned’ by firms Keeps faculty from missing the ‘golden egg’
Leverage	Enables requests for funds from deans, department chairs Leads to consulting and sponsored research Aids in having federal grants by getting private equipment	Helps convince firms to pay for development research
Money	Getting rich	Getting rich
Intangibles	Curiosity Validation of research Increased prestige Helps forwards ‘basic science’ thinking	Serving the public good Fighting disease Increased prestige Helps forwards ‘basic science’ thinking
Education	Helps students get jobs Reading/writing patents, negotiations as professional skills	

Source: Owen-Smith and Powell (2001).

Table 2: Licensing income-1970-1995 for three US universities

University	1970	1975	1980	1985	1990	1995
University of California						
Gross Income (1992$ $\times 10^3$)	1,140.4	1,470.7	2,113.9	3,914.3	13,240.4	58,556.0
Share of top 5 inventions	79	73	51	47	55	66
Stanford University						
Gross Income (1992$ $\times 10^3$)	180.4	842.6	1084.4	4890.9	14,757.5	35,833.1
Share of top 5 inventions		69	86	69	76	85
Columbia University						
Gross Income (1992$ $\times 10^3$)				542	6,903.5	31,790.3
Share of top 5 inventions				99	92	94

Source: Mowery, *et. al* (2001).