University Patenting and its Effects on Academic Research: The Emerging European Evidence

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Abstract

This paper surveys the existing fragmentary data on the growth of university-owned patents and university-invented patents in Europe. We find evidence that university patenting is growing, but this phenomenon remains heterogeneous across countries and disciplines. We find no evidence that university licensing is profitable for most universities, although some do succeed in attracting substantial additional revenues. This might be due to the fact that patents and publications tend to go hand in hand. In a dynamic setting however, we fear that the increase in university patenting exacerbate differences across universities in terms of financial resources and research outcome.

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

JEL: O3, I28, H4

1. Introduction

This paper reviews the literature on university patenting 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 patenting by universities for two main reasons. First, non-university Public Research Organisations (PROs), such as research institutes - e.g. CNRS in France, CSIC in Spain, etc. - are increasingly being subsumed by the university structure.[1] 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).

It is widely acknowledged that more and more production activities rely on scientific and technical knowledge and that increasingly firms are drawing on the scientific and technical expertise of universities. The ethos and incentive structure of universities 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 universities 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 universities (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 universities while universities are being pushed to increase their 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 universities become increasingly involved in TT activities, questions naturally arise regarding the original mission of public research. To what extent are such

[1] This is more so in France, Italy and Spain than in Germany. For 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%). Mixed structures are research units that are co-held by the CNRS and other

TT activities growing in universities? 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?

It is extremely difficult to assess the impact on academic research of an increased institutional involvement with IPR. A major source of that difficulty is the fact that institutional ownership and licensing of discoveries, inventions and creative works are just a part of a set of new TT tools that have been deployed by European universities during the past 10 to 20 years. All TT activities could affect the way in which academic research is carried out: universities' IPR programmes are only one element of the multiple, and potentially interacting factors that may influence the behaviour of academic researchers. The conceptualisation of university TT activities has altered in a way that has given greater prominence to IPR. Whereas formerly it tended to be seen as an aspect of the management of universities' research agreements with firms, the current view is that the central task of TT agents is to 'assess and protect IP and make it available to industry'. Consequently, in addressing the broader issues raised by the increased TT activity in European universities, this paper necessarily will focus on the possible consequences for academic research of increased patenting.

This paper is organised as follows. Section 2 presents 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 3 addresses the evident bias in the recent European policy documents on the subject, which have focused almost exclusively upon the supposed benefits of greater university involvement in the commercialisation of research results, but have yet to assess the actual effects. We review the currently available evidence on the changes taking place in public research in Europe as a result of increased patenting and increased institutionalisation of patent-ownership. Given the paucity of the available empirical evidence regarding the likely efficacy of the policy of promoting greater European university involvement in patenting and exploitation of IPR, Section 4

organisations, most of which are universities (CNRS, 2001).

discusses possible analytical approaches to identifying short-term and long-term consequences. Section 5 discusses the key issues for future empirical assessments; it aims at providing a grounding for future evidence-based policies affecting this vital institutional component of the European Research Area (ERA).

2. University patenting in European countries

In the past decade, universities have witnessed substantial changes in terms of research objectives and funding sources. First, universities gradually were obliged to diversify the sources of their finance. Government structural funds substantially declined (by different degrees in different countries, for example, the decline was much more significant in the UK than in France) and have been partially replaced by competitive funds (Geuna, 2001).[2] 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 have been incentives to 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 in funds from non-profit organisations and by tighter relationships between university and industry. Overall, university researchers and university research centres are now clearly being encouraged to embark upon collaborations with private companies (Geuna, 2001).

Second, changes in financial resources have entailed corresponding changes in the legal status of researchers. Researchers receive incentives 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 Schaeffer, 2003). It should be noted that such legal changes have produced 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

[2] Government structural funds are those financial resources allocated to universities through public budgetary channels, while competitive funds are financial resources allocated to universities through direct competitive contracts by government and other organisations (e.g. firms, charities, the European Commission)

discoveries, even though the patent legally belongs to the institution in which the discovery was developed.

2.1 University-owned patents

Unfortunately, there are very little reliable historical data on patenting and licensing by PROs for OECD countries other than the US and Canada.[3] The OECD (OECD, 2003) has recently made an attempt to systematically collect data on the patenting activity of PROs; however, as pointed out in the Executive Summary of the report, the results of the OECD survey should be viewed as an experiment and should be read with extreme caution as a large number of the responses are partial or incomplete and allow weak comparability across countries.

In the UK a report by the University Companies Association (UNICO) has been produced (UNICO and NUBS, 2002) on the first annual survey of university commercialisation activity. A response rate of 80% (or 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 from this at all); 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 lags behind both the US and Canada in terms of income from licensing, number of licences executed and, in particular, number of patents issued.

Some information about three other European countries is presented in Cesaroni and Piccaluga's (2002) study. They constructed a database of comparable data for France, Italy and Spain on patents granted to public research centres and universities from the European Patent Office (EPO) and the US Patent Office (USPTO) during the period

[3] The Association of University Technology Managers (AUTM) conducted a survey of US and Canadian universities in 1995, which collected information going back to 1991. For Canada see also the *Survey of Intellectual Property Commercialisation in the Higher Education Sector*, Statistics Canada (1999).

1982-2002. The number of patents granted to universities and public research centres in these were respectively 911, 723 and 127. CNRS, CNR and CSIC are the public organisations holding the highest number of patents. It is interesting to note that in France and Italy only about 10% of patents granted to public organisations are owned by universities, while in Spain universities own nearly 50% of the patents granted to PROs. 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 which are with firms).

2.2 University-invented patents

In the eighties and nineties, the European data on IPR available at TTO (university-owned patents such as those included in the Cesaroni and Piccaluga's database or the OECD survey) tend to be downward biased due to the tendency for researchers/professors to let 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 assignees. University-invented patents, defined as those patents that have a member of university faculty among the inventors whether or not the university is the patent assignee , should be included in the analysis. In recent years, there have been a few studies that have combined data on university-invented patents in Belgium, Finland, France, Germany and Italy. The studies by Balconi et al. (2003), Meyer (2003) 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.

{TABLE 1 APPROXIMATELY HERE}

Table 1 summarises the available evidence for five European countries. Balconi et al. (2003) identified that out of 1,475 university-invented patents in Italy in the period 1978 to 1999 only 40 EPO patents had university assignees[4] whereas Italian university inventor patents account for 3.8% of EPO patents by Italian inventors. Meyer (2003) 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 increased continuously from less than 200 in the early 1970s to around 1,800 in 2000 (Schmoch, 2000). 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.[5] Similarly, no aggregate data are available for France, but Azagra-Caro and Llerena (2003) point out that although French universities are legally entitled to own patents on faculty research results, in practice the 'university invented, but not university owned' patent has been and remains the most common form of 'academic' patent. These authors offer statistical evidence relating to the University Louis Pasteur (ULP) in Strasbourg, which, in 1993 to2000 had 463 patents (from the French patent office, the EPO and other patent offices) of which only 62 were owned by the university.

University-invented patents can be analysed looking at the distribution across science or technology areas. 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). Whether a corresponding degree of concentration in this area exists for university patents in Europe is less than clear-cut, but the available evidence is not at odds with this assumption. On the one hand, the results of the OECD PRO IP survey (OECD, 2003) seem to point to less dominance by the bio-medical area, but, on the other, Cesaroni and Piccaluga's data point to a clear preponderance of patenting in the broadly defined area of Chemistry and Human Necessities (which includes biotechnology). The data on university-invented patents in Belgium, France, Finland, Germany and Italy show that the technological areas where patenting is most frequent are those relating to biotechnology and pharmaceuticals (see Table 1 for the three technology/sciences areas of highest university patenting activity). The case of Italy is striking in that about 28% of Italian EPO patents in biotechnology

[4] 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.
[5] Informal discussion confirms this result, though less strikingly, for two other Belgian universities.

include at least one academic inventor (Balconi et al., 2004). Nevertheless, it remains true that the strongest technological sectors in each country tend also to be those where university patents are heavily concentrated, for instance, telecommunications in Finland account for 12% of university-invented patents while pharmaceuticals and biotechnology account for about 9% each (Meyer, 2003).

Three preliminary conclusions can be drawn from the analysis of European academic patenting. First, the broadly defined research area of biotechnology and pharmaceuticals tends to be an area of extremely high university patenting activity across countries. Second, historical developments in Italy and Germany seem to support the view that university patenting is not a new phenomenon. Taken together, these two findings suggest that the rapid rise of academic patenting in the closing quarter of the twentieth century was driven more by the growing technological opportunities in the bio-medical sciences (and maybe also in ICT) and the feasibility of pursuing those opportunities in university laboratories, than by policy changes affecting the universities' rights to own patents arising from publicly funded research.[6]

The foregoing conclusions would make the European experience entirely consistent with the US account, as it has been described recently by Mowery et al. (2001), Nelson (2001) and Mowery and Ziedonis (2002). But other interpretations are possible. For instance, studies that will be discussed in the next section –i.e., Gulbrandsen and Smeby (2002) on Norway, and Ranga (2003) on Belgium - find some evidence of industrial funding of universities being positively associated with university patenting activity, although the direction of causation between the two correlated variables remains unclear.

Third, and surely least controversial among the conclusions that can be drawn, is that the data from the PRO IP survey conducted by the OECD on institutionally owned patents, while interesting and indicative, are not sufficient to inform policy-making in this area. National data on university-invented patents, such as the one used in the

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

studies developed for all the countries mentioned, should be gathered from the same patent offices to ensure comparability.

3. Policy advocacy and reality: surveying the evidence about the effects of IPR in the university

This section contrasts the vision presented by much of the recent policy literature setting out the case for European university TT based upon IPR ownership with the evidence that is available on the subject. Its main focus is on the changes in public research provoked by the diffusion of academic patenting, the assignment of patent rights to higher education institutions and university patent licensing activities. As there is still a rather surprising dearth of systematic research devoted to examining the impacts of these trends at the European level, we also discuss the findings of a few studies that have viewed them from a somewhat broader perspective. These studies consider the changes taking place in the public research sector due to increased interaction between universities and firms via research contracts, university spin-offs and patent licensing.

3.1 Policy literature on university IPR - is it one-sided?

The consensus in recent policy documents on IPR and university TT activity in European countries,[7] much of it having been consciously influenced by perceptions of the experience of the United States during the 1980s and 1990s, is unambiguous in pointing to the following positive consequences of academic patenting for the universities themselves:

- Increased financial resources (as a result of increased licensing and royalties) available for discretionary use, possibly to foster a new area of research or to develop new teaching opportunities;
- Increased contract research funding for further developments of the IPR into a final product;
- Creation of spin-off companies that are partially owned by the university;
- Faster commercial exploitation of new inventions, a benefit for both society at large and the IPR-owning institutions.

[7] See, among others, OECD (2003) and NAO (2002).

These ‘benefits’ are presented without any supporting statistical empirical evidence and can only be regarded as a mixture of suppositions and expectations. This is a not uncommon basis for the initiation of a comparatively new policy whose workings remain to be revealed. However, it is remarkable that in most cases these putative advantages have been enumerated in an unqualified manner, with no spelling out of the possible costs or risks involved. To say the least, this conveys a rather one-sidedly favourable picture; it is policy advocacy freed not only from the requirement of evidence-based policy, but also from comprehensive analytical assessment of the plausible range of consequences.

An illustration of the lack of attention to ‘balance’ in the policy literature featuring the presumed benefits of university IPR exploitation is seen clearly 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.[8] The survey instrument actually included probing questions about a number of possible drawbacks from greater university involvement in research commercialisation, including difficulties arising from differences in culture and incentives between the public and private sectors, conflicts between the need to publish versus the confidentiality required for patenting, and other possible inconsistencies with the educational mission of universities. However, the discussion in the report of the interviewees’ responses to such questions is relegated to a few paragraphs in the appendix, where such statistical information as is provided is incomplete. In contrast, the report’s main text is devoted exclusively to describing the benefits from, and the means of improving commercialisation of university-generated IP.

But, even at the quite straightforward level of evaluating the conditions under which the promised benefits for universities would materialise, the policy literature seems committed to hoping for the best and avoids the pessimism in thinking about the probable. Consider the simple point that the first of the positive outcomes listed above – an enlarged stream of funds available to the university – would materialise only if the

[8] 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.

costs of running the TT operation are more than counterbalanced by gross earnings from patent (or copyright) licences, or equity in IPR-based start-ups. Yet, in the case of UK universities, and for US institutions for which even more abundant statistical evidence exists, most university TTOs do not generate positive net incomes (Nelsen, 1998; Charles and Conway, 2001). The results of the recent OECD PRO IP survey (OECD, 2003) show that very few such organisations earn appreciable amounts of money, and the majority receive little or no income from their IPR holdings: in the sample of OECD member countries surveyed, between 10% and 60% of reporting organisations that had an active TTO derived no gross income whatsoever from IP.

In a similarly optimistic vein, the policy literature generally glosses over the realities of university-owned research spin-offs. It is true that some institutions have scored notable financial successes with start-up firms based upon university owned patents. For example Oxford University's technology transfer company, ISIS Innovation, established 22 firms with a combined market capitalisation of over £2 billion in the period 1998 to 2001. Since the 1950s, Oxford can count about 60 spin-offs, including some major achievements, such as PowerJect and Oxford Molecular. Similar success stories can be found in other European countries, such as the universities of Grenoble, Helsinki and Gothenburg all of which have achieved even more spin-offs than Oxford (Lawton Smith, 2004).[9] The recent policy literature does not directly address the fact that returns from equity investments in young companies founded upon IPR are notoriously skewed. Consequently, investing in the development of one or two start-up firms, based upon patents that happen to have been generated by the university's researchers, is a very risky proposition indeed; and while it may be possible to spread the risks by following a 'portfolio' strategy — such as that typical of venture capital firms — the typical success rate ('hit rate') is quite low.[10]

[9] It is worth remembering that usually the spin-offs are not wholly owned by the university and the amount of royalty income the university actually obtains from licensing is far from proportional to their market capitalisation.

[10] Current data on the survival of these types of firms in a normal situation of limited availability of venture capital for further development are not available. In the late 1990s the availability of venture capital was inflated due to the stock exchange bubble, but it was observed in the US that this had the effect of encouraging the entry of less discriminating 'portfolio investors' among venture capital firms,

3.2 Evidence about the effects of IPR on the university

In the past decade American universities have been much more active than their European counterparts in enforcing and exploiting IPRs on the research carried out by their faculties. 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 the annual figure was approaching 3,300 patents. This rapid growth has attracted the attention not only of scientists and practitioners, but also of the wider public via discussion in the national press of university patenting issues. A large number of academic, policy and practitioner works has examined the impact on academic research and the legal aspects connected with the ownership of IPRs by universities in the USA[11] whereas, very little systematic research has been carried out at the European level.

There are 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 single university, for which little supporting statistical evidence is provided. Two studies, however, one by Gulbrandsen and Smeby (2002) on Norway and one by Ranga (2003) on the Katholik Universiteit van Leuven (KUL) in Belgium, examine the question in a more systematic quantitative fashion. The survey of university faculty members in Norway[12] produced evidence on the impact of increased TT activities within their 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 in terms of autonomy and independence of research (the share reporting such problems drops to 12% of researchers who had secured industrial funding). Finally, confirming the results of Canadian and US studies (Godin, 1998; Blumenthal et al., 1996), this survey produced evidence that faculty who received industrial funding publish more journal articles than

with the result that average 'hit rates' were pushed downwards from 1 in 10 to 1 in 20 start-ups reaching the IPO (initial public offering) stage.

[11] 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).

[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.

both other researchers with other types of external funds (such as Research Council, charities the EU) and other researchers with no external funding. However, when the results of the analysis across scientific fields are examined (unfortunately only briefly reported in the article) it can be seen that higher publication output of researchers with industrial funding is statistically significant across scientific fields only when compared with the performance of researchers with no external funding. The positive difference is not significant in all scientific fields when compared with researchers with other external funds. These results seems to point to the fact that in certain fields (the authors do not report which) what matters is external funding in general rather than specific industrial funding. Ranga's (2003) study confirms the relationship between high publication output and industrial funding. She presents a time series analysis showing that the total number of publications by research groups at KUL was positively correlated with receipt of contract funding.

Both the study on the Norwegian universities and the KUL study found a positive statistical association between industrial funding of university research and university patenting activity. This correlation might well reflect the presence of talented academic researchers whose work would attract external research support whether or not they generated patents for their respective institutions. Nonetheless, as the supporting firms would most likely be interested in securing exclusive licences to commercialise any patentable research results, this would encourage the university (or its researchers) to seek such patents. Alternatively, the latent variable might be cutbacks in public support for research, which led some universities to make greater efforts to seek both industrial funding and licensing income from patents. These two hypotheses are not mutually exclusive.

Both suggested interpretations, however, can be distinguished from the more conventional view that the opportunity to benefit from university-owned IPR should have had the effect of re-directing the attention of researchers towards applied, technological problems that also were likely to be of greater interest to industry, and hence more likely to attract private R&D support. The results reported in the study by Gulbrandsen and Smeby (2002) of lower involvement in basic research by faculty with industrial funding are consistent with this interpretation. On the other hand, Ranga's (2003) findings do not seem to fit with this interpretation. She provides some statistical evidence that at KUL there was no significant shift towards applied research publications during the period 1985-2000, when the university was receiving increasing research funding from industry and had an increasing number of patents.[13]

Unfortunately, none of the surveys conducted by TTO associations (either in the US/Canada or in Europe) address the issue of the impact upon academic research of increased patenting and increased institutionalisation of patenting.[14] 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

[13] It should be noted that these results are affected by the way in which publications are classified as basic or applied. Ranga makes use of the Computer Horizons Inc. (CHI) classification, which links scientific journals to specific types of research and development, but reclassifies classes 1 and 2 as applied research and classes 3 and 4 as basic research. This seems to be a peculiar classification given the fact that usually only class 4 is considered basic research while class 3 is judged to be applied research or clinical investigation (see, for example, Narin and Rozek, 1988; Brusoni and Geuna, 2003). A different reclassification could have resulted in different conclusions (a simple look at the time series graph seems to indicate a lower growth rate for basic research –class 4 – compared to the other classes from the early nineties).

survey was probably carried out in the late 1990s (the report does not provide this information). 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, p. 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 the 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 alone, it is clear that a large majority of respondents (about 65%, adding together those with and without past patenting experience) had experienced some degree of delay.

{FIGURE 1 APPROXIMATELY HERE}

Though we applaud the effort to collect new and much needed data on the possible effect of increased reliance on IPR in PROs, the way in which the data were collected and analysed in this survey rendered the conclusions of the report very unreliable. Of the 1,500 questionnaires administered, 154 respondents were from PROs, either

[14] See, for example, the content of the AUTM Licensing Survey - FY 2000 (2002) and the UNICO and

individuals or institutions that had used or were planning to use the patent system. Though not stated explicitly in the report, it would seem that the statistical analysis was carried out on a sub-sample of the respondents in order to achieve a 50:50 ratio of institutional to individual responses. The report does not specify who were the 'institutional' respondents, which makes the interpretation of results problematic. Quite different answers would be expected, for example, 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 respondents, which further complicates interpreting the message in the results. Finally, the fact that the questions were asking about something that *had* 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 groups (in terms of institutional recognition) tended to patent more, but add the caveat that much more detailed data are needed to produce 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

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NUBS University Commercialisation Activities Survey - FY 2001 (2002).

consequences of increasing university patenting and increased institutionalisation of patenting.

4.1 Possible negative impacts of university patenting

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.

While there does seem to be some justification for institutional ownership of a patent, this type of management of university IP may in itself reinforce or vitiate the effects stemming directly from the growth of university IPR ownership.[15] The institutionalisation of IPR is likely both to modify the current researcher incentive structure and modify the faculty selection effect: universities may favour the hiring of researchers willing to work close to the boundary of technological applications. This is an effect additional to the effects of inducing a change in the behaviour of existing university researchers who are likely to work more or less strenuously depending on the distribution of motives and dispositions that led them to academic careers in scientific or technological research.

We have identified five main possible negative impacts of increased university involvement in and increased institutionalisation of IPR. These are:

- Substitution effect between publishing and patenting. Particularly important is the possibility of different impacts 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 a substitution effect, because they have

[15] For example, the results of the TTO/OECD survey provide some empirical evidence that IP activity does already ‘have a positive influence on the recruitment and careers of researchers and a stronger influence on [their] earnings’ (OECD 2003, p. 31).

already accumulated intellectual capital while for young researchers, publishing activity has a greater effect than patenting on the formation of intellectual capital.[16] Hence, young researchers who are active in patenting from the start of their careers, may prove to be less productive in the long-term.

- Threat to teaching quality. Teaching is not associated with a heavy weighting in the assessment of the performance of university professors; thus teaching 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.[17]

- Negative impact on 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.

- 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 varies greatly across scientific fields. 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.

[16] 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.

[17] See Stephan (2001) for a broader description of implications for education of university-industry technology transfer.

- Threat to future scientific investigation from IPR on previous research. In theory, patent law provides a research and experimental use exception from patent infringement 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.[18] Moreover in Madey v. Duke University (June 2003), the US Court of Appeals for the Federal Circuit, the highest patent court, stated that research institutions are neither automatically entitled to, nor automatically ineligible for, the experimental use defence. To establish whether the exemption applies, one must also consider the specific objectives for which the patented inventions are being used.[19]

To bring new insights to the debate, we focus in the following on whether the choices made by researchers to patent or to publish, given their teaching commitment, will modify the basic or applied nature of their research. This short-run analysis is then distinguished from the study of the long-term impacts of changes in institutional policies concerned with IPR.

4.2 The researcher incentives structure

This section is concerned with how researchers decide whether to patent or publish and, ultimately, how they allocate their time between basic and applied research. This is likely to depend on the researcher incentive structure. 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). This is consistent with the second contribution (Jensen and Thursby, 2002), which proposes a general analytical

[18] See for example the case of Ariad Pharmaceuticals, which owns the exclusive licence to a key biological trigger, the NF-κB messenger protein (Brickley, 2002).

[19] This case has alerted the academic community, parts of which had tended to assume that when carrying out pure research with no direct commercial goal, it need not worry about IPRs of other researchers. The court has now ruled that the experimental use defence is strictly confined to actions performed "for amusement, to satisfy idle curiosity, or for strictly philosophical inquiry". Importantly, the burden of proving the exemption now falls on non-profit organisations rather than on the patent assignee, which previously had to prove patent infringement.

model representing the researcher's decision to allocate her/his time between basic and applied research. We present these complementary views in the next two subsections.

Researchers' perceptions of university patenting

In thinking about the faculty researcher's decision to patent (or not), one should go beyond the highly stylised economic constructs that suppose all individuals to be alike and to be equally susceptible to pecuniary incentives. Let us suppose that the individuals forming each cohort of researchers are heterogeneous in their tastes and motives, and that for each of them only a minor subset (and perhaps only a single one) among the following array of motivations is predominant: 1) curiosity – for some researchers gain most pleasure from the discovery process itself; 2) reputation - peer recognition from and prestige within the group of their fellow researchers; indeed, for some, the lure is fame in the wider world and perhaps enduring eponymy (in the association of a phenomenon or its explanation with their name; 3) career advancement - researchers aspire to professional security and advancement to positions of influence within their organisations and their profession; 4) augmented research resources to permit the building of a more effective, appropriately equipped scientific team under their direction; 5) personal financial gain. How does the above set of preferences enter into the researcher's utility function?

Drawing on qualitative data gleaned from 68 interviews, Owen-Smith and Powell (2001) explain widely disparate rates of knowledge disclosure through patents by suggesting 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 2), 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 2 presents the expected benefits from patent outcomes by faculty researchers.

{TABLE 2 APPROXIMATELY HERE}

The cost structure of patenting by university researchers 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 cost of patenting ; (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, p. 113).

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.[20]

General modelling of the researcher's allocation of time resources between applied and basic research

To address the problem of the distribution of university faculty effort between research and education, i.e. teaching, Jensen and Thursby (2002) analyse the allocation by a representative faculty 'agent' of her time among three types of tasks: basic research,

[20] Lach and Shakerrman (2003) recently developed a model of induced applied research and patenting in response to the share of royalties offered to the faculty inventor. The authors estimate their model using

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 representative member of the faculty 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 typical faculty decision, given 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 fractions of time dedicated to basic and applied research respectively ($e + a + b = 1$).[21] 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 f of the royalties goes to the faculty inventor, while the fraction $(1-f)$ goes to the university. From the university or university administration point of view, the objective is to increase the university's prestige and income. The researcher's problem is thus to choose the amount of time spent on both applied and basic research, in order to maximise his/her current utility (subject to time constraints and given wages w and teaching load e). The administration's utility function is itself a function of the time spent by the researcher on research and education, and he/she chooses the researcher's wage w and teaching load e so as to maximise his/her current utility. Given this simple representation, 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.

US data. Although their work indirectly concerns the issue of publication by university researchers, it does not explicitly deal with the publication v. patent trade-off.

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

2. 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.
3. Policies that encourage university patenting are likely to have a negative effect on the quality of teaching, because the administration may choose to increase its revenues more through patenting than through teaching, thus allowing researchers to spend time in applied research.
4. The rise in applied research might not lead to less basic research, thus there is no process of substitution, or crowding-out, between patenting and publishing activities. Note that by supposing a uniform time constraint and identical productivity, patenting must increase as a response to incentives while the publication rate remains unchanged. Holding the effort level in teaching fixed with the wage offer, it is necessarily the quality of teaching which deteriorates.

The last conclusion is consistent with the results of the work of Stephan et al. (2003),[22] addressing 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 patents for publications:[23] 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.

There are two aspects where this stylised representation remains highly questionable. First, 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'. Instead, suppose that *w* were to become conditional also on past patenting, this incentive scheme would be consistent with, though not rigorously

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

equivalent to, those that condition professional careers on researchers' patenting activity. The latter amounts to saying Jensen and Thursby's model may not reflect entirely the incentive structure of university researchers: *ceteris paribus*, researchers may be more interested in patenting than publishing simply because wages are also linked to patenting (i.e. the marginal rate of substitution of research of applied for basic research would become increasing in a and decreasing in b).

Second, the Jensen-Thursby model assumes that writing a patent rather than a publishable scientific paper is simply a matter of time allocation at the margin. In fact, it is worth questioning the nature of the activity involved in codification. When asked recently for their opinions 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 at all.* (Interview with a university researcher in Barcelona, June 2002).

This quote contrasts sharply with the report by the European Commission on the causes of publication failure (EC, 2002). This report latter notes that 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. Instead, the citation suggests there are substantial 'set-up' costs involved in university patenting. Policies that try to enforce university patenting should allow for the costs inherent in learning to write patent applications.

Both the contributions of Owen-Smith and Powell (2001) and Jensen and Thursby (2002) stress that the researchers' decision to publish or patent is seen as relevant for analysis of the short-term consequences of increased patenting. The review reveals that in the short run, there is no substitution effect between publishing and patenting. To maintain this balance, however, researchers are likely to lower the quality of their teaching contribution. Increasing university patenting does not seem to withdraw the attention of university researchers from their secular mission of producing publicly available knowledge. But, as will be shown in the next section, analysis of the long-term consequences warns against the danger of an uneven development - favouring successful universities and locking others into the second tier of research activities.

4.3 Long-term consequences

In the short-term approach discussed above, 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. In the long-term framework, on the other hand, we investigate the potential and cumulative consequences that the decline in structural funds is likely to yield. Indeed policies that encourage university patenting have 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 of the bio-pharmaceuticals industry. The increase in university patenting is also seen as providing an additional source of funding in the form of royalties.

Diverging paths in a world of skew-distributed outcomes

Empirical information about university licences for Europe being almost non-existent, we have little detail 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) observed an exponential growth in licensing revenues since the mid-eighties (see Table 3). 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.

The above is fairly consistent with the fact that useful inventions are inherently rare. From Table 3, 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 stress 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 geographic 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 3 APPROXIMATELY 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.

Is the Win-it-All/Lose-it-All scenario likely to occur?

The representation of the value of licences following a skew-distribution therefore 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. 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?

The previously mentioned paper by Stephan et al. (2003) brings additional insights. One key result is 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. A related study has addressed the issue of institutional learning. In this case, universities may or may not accumulate patenting expertise, thus closing 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) entrant universities are catching up with incumbent universities in terms of quality of patents. 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.

It should be noted 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.

5. Key issues for future empirical assessments

Chapter 6 of the OECD ST&I Outlook 2002, devoted to patenting and licensing in PROS, concludes: "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, 2002; p. 198). Our research confirms and further reinforces this conclusion. Currently, the data available on university patenting for the European countries are unreliable and are not useful for assessing the potential impact on 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 merely 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 acquisition by firms.

Most 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; more research is needed to assess the efficiency of university patenting in technology transfer rather than assuming it.

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. Later development in Europe than the US was probably due to the later development of research in the bio-medical area in the European countries.

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. Studies such as the one analysed in this paper must be further refined to include an analysis of the type of research outcome in terns of basicness.

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.

This paper has highlighted that the substitution of 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 and 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.

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 (Gamala, 2000; Strauss, 2002). 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 the conflict of interests.

Finally, 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, 2002; p. 198). The data from the OECD IP survey, though interesting, do not provide enough evidence to support this assertion. These conflicting statements are indicative of the current debate in which people and organisations tend to claim to develop evidence-based policy, where most of the time the evidence is not presented and exists only in the statements made. 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.

6. Conclusions

Little is known about the impact upon European public sector research of increased academic patenting and increased institutional ownership of intellectual property rights. This paper has surveyed the existing fragmentary data on the growth of university-owned patents and university-invented patents. We found evidence that university patenting is growing in Europe, but this phenomenon is heterogeneous across countries and disciplines. Moreover, we found no evidence that university licensing is profitable for most universities, although a small number of them do succeed in attracting substantial additional revenues. This might be due to the fact that patent and publication tend to overlap. To many, this is a positive outcome, as publications and patents are not substitutes. The negative side, which we fear, is that with the increase in university patenting, a growing number of universities will witness scarcer resources. In a dynamic setting, these mechanisms may reinforce and result in differences across universities being exacerbated in terms of financial resources and, ultimately, in terms of research output.

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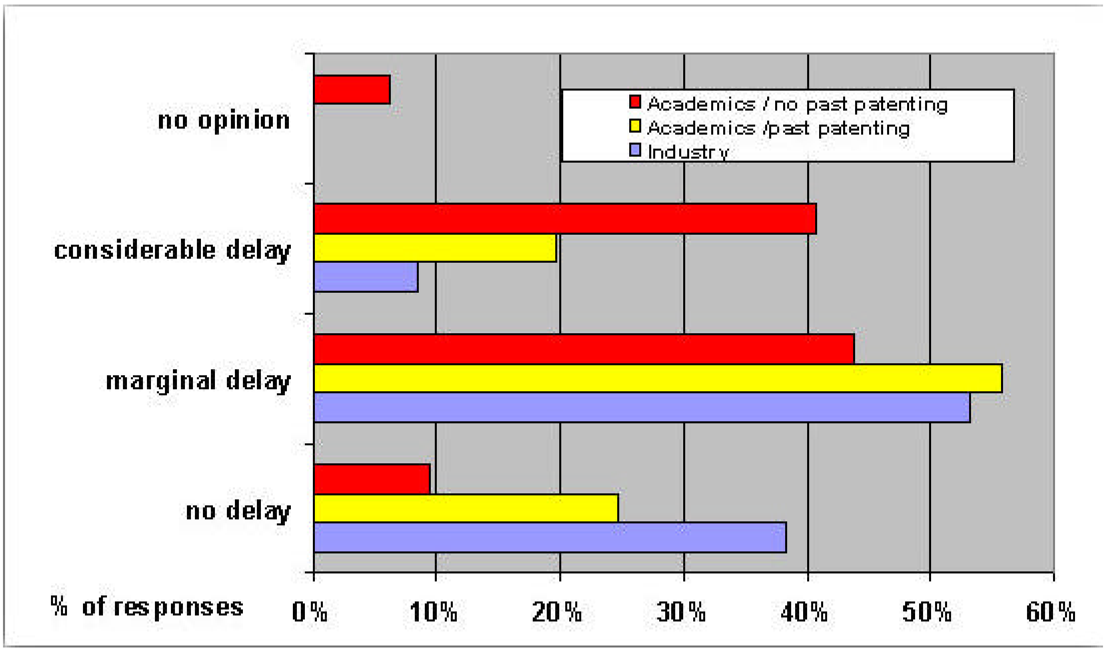
Figure 1: Delay in scientific publication due to the patenting of the invention



Source: European Commission. (2002

Table 1: University-owned and university-invented patents				
	No University owned patents	No University invented patents	Time Period	3 Technology/Science areas of highest university activity*
Italy	40 - EPO	1,475 - EPO	1978-1999	Biotechnology Drugs Organic Chemistry
Finland	36 - USPTO	530 - USPTO	1986-2000	Telecommunications Instruments Pharmaceuticals/Biotechnology
Germany		200 (1970) – 1800 (2000) German patents	1970-2000	Environmental Technology Biotechnology Medical Engineering /Organic Chemistry/Control Technology
Belgium	153 - EPO	For 50% of the universities between 35% and 78% of the EPO patents were invented but not owned	1985-1999	Biotechnology
France	62 – Various patents University of Strasbourg	463 – Various patents	1993-2000	Genetics Biology Physics

*: In the case of Germany we present the highest positive specialisation (of German patent office patents of German professors compares to the average technological distribution of EPO). Has to be noted that in absolute terms environmental technology is much less important than the other technological fields

Sources: Azagra-Caro and Llerena (2003); Balconi et al. 2003, 2004; Meyer (2003); OECD (2002); Saragossi and van Pottelsberghe de la Potterie (2003); Schmoch (2000)

EPO data refers to patent applications. USPTO data refers to granted patents.

The sources use different technological/scientific classifications.

Table 2: 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 3: 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).