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Do individual factors matter? A survey of scientists' patenting in Portuguese public research organisations

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This paper addresses scientists' behaviour regarding the patenting of knowledge produced in universities and other public sector research organisations (PSROs). Recent years have witnessed a rapid growth in patenting and licensing activities by PSROs. We argue that the whole process depends to a certain extent on scientists' willingness to disclose their inventions. Given this assumption, we conduct research into individual behaviour in order to understand scientists' views concerning the patenting of their research results. Data from a questionnaire survey of Portuguese researchers from nine PSROs in life sciences and biotechnology is presented and analysed and complemented with in-depth interviews. The results reveal that overall the scientists surveyed show a low propensity to become involved in patenting and licensing activities, despite the fact that the majority had no "ethical" objections to the disclosure of their inventions and the commercial exploitation of these. Perceptions about the impacts of these activities on certain fundamental aspects of knowledge production and dissemination are however divergent. This may account for the low participation levels. Furthermore, most scientists perceived the personal benefits deriving from this type of activity to be low. Similarly, the majority also believed that there are many difficulties associated with the patenting process and that they receive limited support from their organisations, which lack the proper competences and structures to assist with patenting and licensing.

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Introduction

In recent years, there has been an increase in activities relating to the commercialisation of public sector research, particularly in the most advanced economies. The expansion of patenting activities has been one of the components of this process. Changes in both national legal frameworks and institutional regulations, leading to intellectual property rights (IPR) regimes that are more favourable to the identification and exploitation of research with commercial potential, have been introduced simultaneously with this process, which has also been accompanied by the development or reinforcement of organisational structures and practices promoting technology transfer (GEUNA & NESTA, 2004; MOWERY et al., 2001; ARGYRES & LIEBESKIND, 1998; HENDERSON et al., 1998).

However, recent research has pointed out that the whole process depends greatly on individual scientists' willingness to disclose their inventions to the research organisation (BERCOVITZ & FELDMAN, 2003; SIEGEL et al., 2002; THURSBY et al., 2001). This suggests the need for research that focuses on individual behaviour, in order to understand both: (1) the scientists' position towards the appropriation of results from their research through patents, as opposed to their dissemination exclusively through "open science" mechanisms; and (2) their motivations to conduct the activities required to patent and license their inventions.

The objective of this paper is, therefore, to investigate the factors that influence individual scientists to disclose their inventions and continue with the patenting process. This aim will be pursued by surveying researchers from Portuguese public sector research organisations (PSROs) in life sciences and biotechnology. The Portuguese case is relevant since there has been a notable increase in patenting activity at PSROs since the mid 1990s. Although patenting by Portuguese PSROs has not reached the same level as in the most advanced economies, this discussion may produce some conclusions that are relevant for other countries experiencing similar conditions.

The paper is organised as follows. Firstly, drawing on the literature on the subject, we discuss the conditions that influence the behaviour of individual scientists in relation to the appropriation and exploitation of scientific and technological knowledge. Based on that discussion, we derive our working hypotheses. Then we introduce the empirical research and present the results obtained. Concluding remarks addressing key issues are presented in the final section.

Factors influencing scientists' behaviour in relation to patenting activities

Evidence from most OECD countries shows that patenting and licensing activities have been growing rapidly at PSROs, but the situation varies significantly across countries and research organisations (OECD, 2002).

These differences are shaped by distinctive institutional, organisational and disciplinary contexts. MEYER-KRAHMER & SCHMOCH (1998) and PAVITT (1998) argue that it is the legal and financial framework that explains differences in academic patenting activities. An important stream of literature has developed around the effects of the Bayh-Dole Act and similar legislation, emphasising the importance of legal changes in accounting for recent trends (ZUCKER et al., 1998; THURSBY, 2001; THURSBY et al., 2002). Other studies suggest that, regardless of the institutional and legal environments, organisational structures play a key role in the patenting and licensing performance of public research organisations (SIEGEL et al., 2002; BERCOVITZ et al., 2001; THURSBY et al., 2001). Further to pointing out to the historical development of universities and the derived institutional arrangements, certain authors have also focused on the advances in biomedical sciences and other technology-related science areas as an important factor accounting for university patenting trends in recent years (ARGYRES & LIEBESKIND, 1998; MOWERY et al., 2004).

Recently, attention has also begun to focus on the individual determinants of academic patenting and licensing (BERCOVITZ & FELDMAN, 2003; COUTINHO et al., 2003; THURSBY & THURSBY, 2002; OWEN-SMITH & POWELL, 2001). This approach suggests that the patenting performance of PSROs is also influenced by scientists' attitudes and perceptions regarding their involvement in these activities. More specifically, it is argued that the whole process greatly depends on scientists' willingness to disclose their inventions. Individual attitudes are especially relevant in the absence of proactive technology transfer structures that ensure the systematic search for commercially viable technologies and pursue the activities required for patenting and licensing them. Under such circumstances, more substantial responsibility falls upon the scientists themselves. Following this line of reasoning, recent research has started to address the factors that influence individual decisions on patenting, focusing on three main types of factors: the impact of academic incentives and reward systems; the influence of the institutional setting, both in terms of institutional culture and in terms of the organisation of research; and the role of support structures.

The influence of the traditional academic incentive and reward system on individual patenting behaviour has been one of the most widely discussed issues (CALDERINI & FRANZONI, 2004; CARAYOL, 2004; AGRAWAL & HENDERSON, 2002; STEPHAN et al., 2002; THURSBY & THURSBY, 2002). Particular emphasis has been laid on the potential trade-off between patenting and publication. As is known, this latter activity is essential for both the advancement of scientific productivity and the establishment of reputations, which are basic incentives in the academic reward system (MERTON, 1973; STEPHAN, 1996). The potential for competition between those two research outputs is based on two arguments: patenting may lead to a publication delay (DASGUPTA & DAVID, 1994; LIEBESKIND, 2001), which seems to be particularly serious in the case of Europe, where a "grace period" is not available; patenting may direct scientists' interests to more

applied research that may be less publishable, at least in high-impact, refereed journals (BRESCHI et al., 2005; GEUNA & NESTA, 2004). This latter aspect gives rise to a wider concern: that patenting may influence scientists' agendas, directing them away from basic research, with inevitable impacts on scientific progress (DAVID, 2000; HELLER & HEISENBERG, 1998; HENDERSON et al., 1998). No definitive conclusions have been reached regarding this question. While most studies suggest that patenting and publishing are related activities and that patent and publication productivity are positively correlated at both the individual and institutional levels, the nature of this relationship and its implications for research agendas remains elusive (BRESCHI et al., 2005; CALDERINI et al., 2005; CARAYOL, 2004; STEPHAN et al., 2004; AGRAWAL & HENDERSON, 2002).

However, it was found that personal factors, such as age and career status, affect scientists' patenting behaviour by influencing their position in relation to the reward system. Thus, older and more senior scientists appear to be more likely to patent, while younger scientists still building a career are more likely to concentrate on publishing (CARAYOL, 2004; STEPHAN et al., 2004; WALLMARK, 1997). This higher propensity for patenting amongst senior scientists was also justified by their wider experience and greater capacity for attributing value to their research results.

The institutional culture, i.e., the level of acceptance and encouragement of technology transfer activities in general and of patenting in particular, have also been found to influence scientists' behaviour (OWEN-SMITH & POWELL, 2001; BALDINI et al., 2002). BERCOVITZ & FELDMAN (2003) argue that individual scientists work in a social context, which shapes their individual behaviour. They have found that social effects are at work and can influence the decision to patent, producing what they describe as "observational learning".

The impact of the research organisation on patenting behaviour has been addressed by CARAYOL (2004), who has found positive impacts resulting from laboratory size, full-time research and private funding. Indeed, industry-oriented activities (namely collaborative R&D) and industry funding have been generally identified as determinants of academic patenting (BALCONI et al., 2004; AZAGRA-CARO et al., 2003; MEYER-KRAHMER & SCHMOCH, 1998). However, this effect has also raised concerns regarding potential biases in scientists' choice of research areas, leading them to redefine their activities according to industry interests (DAVID, 2000; ARGYRES & LIEBESKIND, 1998).

The impact of supportive structures on scientists' motivation to patent has been addressed by various authors. Patenting decisions have been found to be influenced by the presence of proactive and qualified technology transfer (or licensing) offices (TTOs/TLOs) (THURSBY & THURSBY, 2002; BERCOVITZ et al., 2001; OWEN-SMITH & POWELL, 2001). One possible explanation lies in the fact that patenting activities are not part of scientists' training and therefore they have to be "educated" about the patenting process (STEPHAN et al., 2004). OWEN-SMITH & POWELL (2001) add that negative

experiences in scientists' dealings with the TTO are likely to limit their future efforts. In the European context, where the institutional involvement of the university is more recent, MEYER et al. (2005) discuss the effectiveness of introducing incentive schemes when support structures are missing or do not possess the required skills.

The research presented above has produced a wealth of results – and also some unsolved puzzles – regarding the determinants of individual patenting behaviour. However, research into the actual *attitudes* of scientists is more limited. OWEN-SMITH & POWELL (2001) explored this issue and uncovered a number of beliefs held by scientists regarding the outcomes of patents and patenting (as well as some differences between scientists from physics and life sciences). They argued that willingness to become involved in patenting activities is associated with scientists' perception of the benefits of patenting and of the costs of pursuing it through their organisation. Furthermore, they suggest that even positive attitudes towards patenting, deriving from scientists' perceptions of its benefits, can be offset by negative perceptions of the costs incurred in engaging in those activities in an environment that is not particularly supportive. This view brings the analysis closer to DASGUPTA & DAVID's (1994) arguments, according to which the incentives to which scientists react go beyond the question of their self-fulfilment (brought about by discovery) and scientific reputation.

Apart from OWEN-SMITH & POWELL's qualitative study (2001), we are not aware of any other research that adopts the approach of *directly questioning* scientists, in order to assess their views regarding involvement in patenting activities and their perceptions in relation to a number of questions that may influence such involvement. That is the main contribution of this paper.

Empirical research into scientists' characteristics and behaviour

Research methodology

Drawing on the approach of Owen-Smith and Powell, as well as on the results obtained – or ambiguities observed – in other studies of the determinants of individual patenting behaviour, we have built our own model of the individual factors that influence scientists' behaviour, which include their respective characteristics, attitudes and perceptions. According to this model, scientists' behaviour would depend on: (a) their attitude towards the appropriation and commercial exploitation of their research results – i.e. how scientists see their mission and how the private appropriation of knowledge fits into this; (b) their perceptions regarding the impact of patenting and licensing on their research activity and their careers; (c) their perceptions of the difficulties and relative costs and benefits associated with patenting and licensing activities, as well as of the level of encouragement/support provided by their organisation.

Regarding (a), it was considered pertinent to question scientists about their position concerning their involvement in activities leading to the appropriation and commercial exploitation of public research. It was assumed that scientists who had been "acculturated" into the open science regime (DASGUPTA & DAVID, 1994), and who worked in an institutional context where such a regime was fully applied, at least until recently, could have a negative or puzzled attitude towards norms and practices that "represent fundamentally different and potentially contradictory arrangements for the creation, dissemination and use of new scientific and technological knowledge" (OWEN-SMITH, 2003: 1081). On the other hand, it was acknowledged that these same scientists had already been confronted, in their own environment, with some changes (albeit timid) in these institutional arrangements, and also that they were not immune to current debates on these issues, about which they might have a personal position.

Regarding (b), the impacts of patenting on scientists' activity – both at a personal level and at a more general professional level – our objective was to elicit the actual views and experiences of the scientists in relation to some of the issues currently under discussion. Our choice was therefore to ask their opinion about these issues, using as a starting point the extensive and sometimes contradictory evidence offered by the literature.

Regarding (c), the relative costs of pursuing patenting activities, our objective was to identify the types of difficulties experienced by scientists and their perceptions of the support provided by their organisation. The option of asking scientists about their views on the behaviour of their organisation was judged to be the most suitable, considering that we are looking at a context in which changes in IPR regulations are already underway and where the organisational structures set up to support their implementation are either still being formed or in their very early beginnings (COUTINHO et al., 2003).

In accordance with the previous assumptions, a number of working hypotheses were developed concerning the behaviour of individual scientists, which postulated an association between scientists' involvement in patenting activities and their (i) individual and professional characteristics; (ii) personal views regarding their mission in the academic context; (iii) perceptions of the personal and professional benefits of patenting; and (iv) perceptions about the organisational environment (difficulties faced and organisational support).

The empirical research was aimed at individual researchers from nine Portuguese PSROs in life sciences and biotechnology, which correspond to the main organisations acting in this field in Portugal.[1] PSROs working in life sciences and biotechnology

[1] The PSROs selected were: Instituto de Tecnologia Química e Biológica (UNL), Centro de Engenharia Biológica e Química (IST), Instituto de Biologia Molecular e Celular (UB), Instituto de Patologia e Imunologia Molecular (UP), Escola Superior de Biotecnologia (UCP), Centro de Biologia Celular (UA), Centro de Neurociências (UC), Centro de Engenharia Biológica (UM), Instituto Gulbenkian de Ciência.

were chosen as the target, because these are the fields in which university patenting tends to occur more frequently (HENDERSON et al., 1998; ARGYRES & LIEBESKIND, 1998).

The research unit selected to trace the scientists was the "university research centre", rather than the university or university faculty. In Portugal this is an organisational form that brings together university faculties (sometimes from different universities), full-time research fellows (usually young researchers with temporary positions), PhD and other graduate students, whose work is centred around specific missions, lines of research or projects. The choice was based on the fact that, at least in the life sciences, these centres – which enjoy greater autonomy and flexibility than university departments – are the main locus of university research. The organisation and behaviour of these research organisations are discussed in detail in FONTES & PÁDUA (2002).

The instrument adopted for data collection was a questionnaire survey, which was administered between May and July 2003 by e-mail (since this is a privileged means of communication in the research community), sent to approximately 1100 individual researchers. Overall, 106 valid questionnaires were received, which corresponds to a response rate of approximately 10%. It should be pointed out that there may be some bias in the answers to the questionnaire, as these may have been predominantly answered by those researchers who had a greater interest in IPR and patenting issues, whether or not they had been directly involved in patenting activities. The survey was complemented with eleven interviews with scientists who had already patented (six interviews) and with staff from the technology transfer or patenting offices (five interviews), whenever these existed. Given the small number of interviews and limitations of space, we will only resort to this source of information to corroborate a few points about which there was a clear coincidence of opinions among the interviewed.

Portuguese context for academic patenting

The patenting performance is generally very low in Portugal (OECD, 2003). However, the patenting activity of Portuguese PSROs has been growing in recent years, and at a higher rate than that of business firms and independent inventors (GODINHO et al., 2003). Changes in the regulatory and institutional environment can partly contribute towards explaining this growth.

One key element in this process was the creation of a network of Industrial Property Support Offices (GAPIs) managed by the National Patent Office in 2001, as part of a wider government scheme (SIUPI), which also included financial incentives to assist patent application, as well as the development by the patent owner of prototypes or pilot systems. At the time of the survey, there were GAPIs at the associated universities of

six of the PSROs surveyed, three of them replacing or complementing the activities of a previous TTO. One further PSRO had no GAPI but relied on its university TTO.

Simultaneously, the presence of a GAPI and, more generally, a greater institutional awareness of IP issues led these universities to introduce internal IPR regulations. Under the Portuguese legal system, the patent will in principle belong to the organisation in which the discovery is developed, unless it decides not to pursue a patent, but those researchers who are patent inventors may receive a share of the royalties derived from their patented discovery.[2] Existing internal IPR regulations confirm the university property of patents, establish the duty to disclose inventions, and detail administrative procedures and the distribution of royalties. However, involvement in patenting activities is still not considered to be a relevant criterion in the rules regulating recruitment and advancement in academic and scientific careers.[3]

Patenting performance among the scientists surveyed

A previous involvement in patenting activities was referred to by only 15 out of the 106 researchers surveyed, corresponding to 14% of the sample.

In order to have an idea of the importance of patenting relative to other activities that permit the application and/or commercial exploitation of research results, the researchers were simultaneously asked about their participation in a range of industry-oriented activities. It was found that the majority had already been involved in activities such as collaborative R&D projects (71%) or contract research (29%),[4] which suggests that patenting is still a relatively unimportant activity when compared with research-based, industry-oriented activities.[5]

However, it is interesting to note that, when asked about whether they expected their current activities to give rise, in the near future, to results with the potential for further application, and about which type of activities these might generate, 27 researchers mentioned the possibility of future involvement in patenting. Taking previous experience into account, this corresponds to a relatively higher proportion (25%) when compared with those mentioning the possibility of conducting collaborative or contract

[2] The only exception to this ownership rule concerns the regulation of the "research career" (which governs the activity of researchers that are not university faculties): it determines that property is shared between the organisation and the inventor(s).

[3] A recent regulation concerning the evaluation of research units, for the purpose of base funding by the National Research Council, introduced in 2005, includes patenting as an additional (bonus) criterion. This new approach may have some impact upon scientists' future decisions.

[4] However, activities such as "consultancy", "creation of spin-off companies", "sale of products or processes originating from the PSRO" were even less frequent than patenting.

[5] This is confirmed by the literature, even for universities with higher patenting propensities (e.g. AGRAWAL & HENDERSON, 2002 for the MIT).

research (37% and 12% respectively). While bearing in mind that stated intentions should always be regarded with caution, this result suggests that patenting is in fact becoming a more important feature in the agenda of researchers.

Research findings

The hypotheses concerning the individual factors that might influence the patenting of PSROs were tested through the comparison of the characteristics and perceptions of different groups of scientists. We compared scientists who have already been involved in patenting activities (patenting scientists) with those who have never been involved (non-patenting scientists). Additionally, given the very small number of patenting scientists, we also considered the case of those scientists who expressed a willingness to patent in the future, comparing them with those who did not.[6] The main results of this analysis are presented and discussed in the next sections.

Individual characteristics and patenting activities

The association between the variable "involvement in patenting activities" and individual characteristics was tested using the Chi-square statistical test. A significant relationship was found to exist between patenting activities and age, academic qualifications, job stability and the career stage attained by respondents.[7] Interestingly, no significant relationship was found between these personal characteristics and the variable "willingness to patent in the future".

A significant relationship was found between patenting and participation in a number of industry-oriented activities. Furthermore, there is a clear relationship between patenting and the willingness to become involved in the exploitation of research results in the future.[8] In this case, we also found a significant relationship between "willingness to patent in the future" and participation in some industry-oriented activities, the major difference being the fact that the association did not hold for the case of collaborative R&D.

Table 1 presents a more detailed analysis of the results obtained from the cross tabulation of those variables that showed a significant relationship with previous involvement in patenting.

[6] We thank a referee for having drawn our attention to this latter approach.

[7] The Chi-square statistical test significances were 0.003, 0.018, 0.031 and 0.004, respectively.

[8] The Chi-square statistical test significances were 0.007 (Collaborative R&D projects); 0.001 (Contract research); 0.000 (Consultancy); 0.000 (Creation of a spin-off company); 0.004 (Other technology transfer activities); and 0.000 (willingness to become involved in the exploitation of research results in the near future).

Table 1. Relationship between "Involvement in patenting activities" and personal and professional characteristics

	Involvement in patenting activities	
	Patenting researchers *n=15* (%)	Non-patenting researchers *n=91* (%)
Age		
Less than 30	20	57.1
30 – 40	40	33
More than 40	40	9.9
Academic qualifications		
PhD	80	40,7
Master's degree	13.3	45.1
First degree	6.7	14.3
Job stability		
Permanent job	71.4	40.7
No permanent job	28.6	59.3
Industry-oriented activities performed in the past 10 years		
Collaborative R&D projects	100	65.9
Contract research	66.7	23.1
Consultancy	40	5.5
Creation of a spin-off company	33.3	3.3
Other technology transfer activities	33.3	7.7
Willingness to become involved in the exploitation of research results in the near future		
Willing to become involved	93.3	36.3

These results show that researchers who are older, hold a PhD and have a permanent job are relatively more likely to have patented than those that are younger, do not hold a PhD and do not have a permanent position. Additionally, closer observation shows that among researchers who have a permanent position, those at the top end of the career structure are more likely to have patented than those who are at the beginning of their careers, and that both sets of researchers are more likely to have patented than those without a career position (postgraduate students or post-doctoral students), whatever their qualifications. This suggests that, while formal institutional status generally favours involvement in patenting, the current reward system is likely to compel less senior researchers to favour publishing rather than patenting.

The results also show that patenting researchers are more likely to have been previously involved in industry-oriented activities, all of them having at least worked in collaborative R&D projects. The fact that those researchers who claimed to be willing to patent in the future were also more likely to have been involved in these industry-oriented activities further confirms the impact of exposure to industry on patenting behaviour.

These results are consistent with other research that has found a positive association between patenting and age, career status or industry-oriented research (CARAYOL, 2004; AGRAWAL & HENDERSON, 2002; THURSBY & THURSBY, 2001).

Researchers' view of their mission in the academic context

The vast majority of researchers (84%) had no objections regarding scientists' involvement in the exploitation of research results. Moreover, no significant differences were found between both patenting and non-patenting researchers, or between researchers that were willing to patent and those not-willing to patent, as far as their attitude towards the exploitation of research results in the academic context was concerned.[9] These results suggest that, at least among the life science researchers that were surveyed, the "third mission" of academic research has generally been assumed.

Perceptions on the personal and professional benefits of patenting

Following OWEN-SMITH & POWELL (2001), we hypothesised that the decision to patent depends on researchers' perceptions about the potential impacts of patenting. We considered three major categories of beliefs, related respectively with: (i) the role of patenting in the protection and dissemination of knowledge; (ii) its influences on the definition and pursuit of research strategies (organisation of research activities, funding, relations with industry) at a professional level; and (iii) its tangible and intangible outcomes (monetary gains, reputation, career organisation) at a personal level. These generic categories were then translated into a series of statements, about which the researchers were asked to express their level of (dis)agreement.

To design our questions, we partially followed OWEN-SMITH & POWELL's (2001: 106) "perceptions of patent outcomes", derived from scientists' accounts of why they patent. These were completed by a series of statements addressing other points that correspond to relevant issues raised in the literature (see Table 2).

Uncovering scientists' perceptions. Table 2 summarises researchers' beliefs concerning the impacts of patenting, obtained through a Likert scale (between 2 and –2).[10]

[9] The statistical tool used was the Wilcoxon Mann-Whitney test, a non-parametric test used for comparing two populations. This does not require the assumption that the differences between the two samples are normally distributed and can be applied to ordinal data. We used it to test the null hypothesis that the two samples come from identical populations, as against the alternative hypothesis that the two samples come from different populations. The significances were respectively 0.577 and 0.161.

[10] The results are presented with an aggregation of both the positive (1 & 2) and the negative (–1 & –2) scales, because this permits a clearer differentiation between positions of agreement, disagreement or neutrality towards the statements. This option was based on the fact that, with one exception ("protects inventions from "predatory" behaviour"), there is no concentration of answers at the extremes of the scale, as can be concluded from the values of the mode and the median (which refer to the full scale).

Table 2. Researchers' perceptions of patenting impacts

	Disagree (–1 & –2)	Neutral (0)	Agree (1& 2)	Median
■ Impacts on knowledge protection				
Protects inventions from "predatory" behaviour	6.5	9.7	**83.9**	1
Restricts the free circulation of information	25.0	19.6	**55.4**	1
Upholds academic freedom vis-à-vis industry	25.0	32.6	42.4	0
Limits the activity of other teams working in the same research area	19.4	40.9	39.8	0
■ Impacts on organisation of research				
Directs research to some areas that are potentially more lucrative	7.6	17.4	**75.0**	1
Supports validation of research	19.4	21.5	**59.1**	1
Produces conflicts of interest between researchers and the organisation	17.4	25.0	**57.6**	1
Enables development of new research programmes	8.7	38.0	**53.3**	1
Limits the development of basic research programmes	26.4	28.6	45.1	0
Influences academic productivity negatively	**62.4**	10.8	26.9	–1
■ Impacts on the funding of research				
Assists in obtaining industry funding	4.3	14.1	**81.5**	1
Assists in obtaining funding from internal sources	12.9	29.0	**58.1**	1
Assists in obtaining government funding	6.6	37.4	**56.0**	1
Permits economic gains through licensing	9.9	19.8	**70.3**	1
Generates return on the investment	15.1	30.1	**54.8**	1
■ Impacts on relationships with industry				
Facilitates development of collaborative R&D projects	4.3	14.1	**81.5**	1
Signals competences to industry, attracting sponsored research	4.3	15.2	**80.4**	1
Promotes consulting activities	3.3	45.7	**51.1**	1
Facilitates commercialisation	17.2	25.8	**57.0**	1
Assists in obtaining industry funding	*4.3*	*14.1*	***81.5***	*1*
■ Impacts on individual careers				
Brings status and peer recognition	9.7	23.7	**66.7**	1
Helps career progression	10.9	35.9	**53.3**	1
Enables monetary gains	13.0	46.7	40.2	0
Reduces choice in terms of research areas	35.2	27.5	37.4	0

The answers were classified on a Likert scale, where: **2=**total agreement; **1**=agreement; **0**=indifferent/neutral; **–1**=disagreement; **–2**=total disagreement.

The area where we can find greatest agreement about the impact of patents is in the relationship between research and industry. Around 80% of researchers believe that patenting facilitates collaboration, signals competences and attracts industry funding. However, researchers appear to be less sure about the potential of patenting for

affording protection in dealings with industry. A vast majority strongly believe that patenting can protect their inventions from the predatory behaviour of industry, but there is much less consensus regarding its impact on upholding academic freedom vis-à-vis industry (1/4 of respondents believe that it does not do this).

Patenting is also believed to have a positive influence in attracting funding from the PSRO and from the government, although there is not such a high consensus in this case. Additionally, patents are believed by about 70% of researchers to be a source of economic gains through licensing, but there is less consensus regarding their potential to generate a return on the investment. As far as the potential for individual monetary gains from patenting is concerned, there is, roughly speaking, a balance between those who believe it does provide such gains and those who do not.

There is also some divergence regarding the impact of patenting on the "open science" regime: while more than half of the researchers believe that it restricts the free circulation of information, there is a greater variety of opinions regarding its restrictive impact on the activity of other teams working in similar areas, with neutral effects being most often mentioned.

Researchers' perceptions are again not consensual about the impact of patenting on the organisation of research. They definitely believe that a focus on patenting directs research towards certain areas that are potentially more lucrative (75%), but there is great dispersion of opinions regarding its negative impact on the development of basic research programmes. Moreover, there is still a high proportion of researchers (62%) who do not believe that it influences academic productivity negatively (although about ¼ of researchers believe that it does). Patenting is moderately believed to enable the development of new research programmes (although the absence of any such impact is recognised by 38% of researchers). Additionally, more than half of the researchers believe that patenting may produce conflicts of interest within the organisation.

The impact of patenting on individual careers is again an area where there is limited consensus. About 2/3 of researchers believe it brings status and peer recognition – which may reflect recent changes in cultural attitudes at university level. But the belief in its importance for career advancement is less strong: about half of the respondents believe it to be positive and very few researchers regard it as negative, but 36% still believe it has no impact. These results are reinforced if we recall researchers' moderate beliefs in relation to other previously discussed questions, which have some bearing on career development (considering the current reward system): the impact of patenting on academic productivity and on the ability to engage in basic research.

There is also little consensus regarding the impact of patenting on researchers' freedom for choosing their research topics, with positive and negative opinions being approximately equivalent. If we compare this result with a similar one regarding the role of patents in upholding academic freedom vis-à-vis industry, we can conclude that there is a great diversity of opinions regarding this issue.

Interviews conducted with researchers who had already had patenting experience went further into the question of its impact on careers. Generally, these researchers did not see patents as having a positive impact on individual careers, given the current system of career advancement. This was regarded as a constraint, which they believed acted as a restriction on more extensive involvement. Based on this evidence, it is possible to suggest that the motivation of these scientists to patent has not been positively influenced by the current incentive and reward system.

Comparing perceptions of different groups of researchers. In order to explore this issue further, we compared the perceptions of patenting and non-patenting researchers (using the statistical Wilcoxon Mann-Whitney test). It was found that perceptions of the impacts of patenting do not vary significantly across the two groups of researchers. It was only possible to obtain statistically significant differences for two beliefs – that patents "limit the activity of other teams working in the same research area" and that they "reduce choice in terms of research areas" – which are given greater importance by patenting researchers. Since previous patenting experience did not seem to differentiate between researchers in terms of perceptions, we tested whether there were significant differences between scientists who were willing to patent in the future and those who were not. However, the results obtained were roughly the same.

The results from both our own and other research pointing to differences in patenting behaviour at different career stages led us to test whether there were significant differences in the perceptions of the impacts of patenting, according to age and job stability. Surprisingly, no significant differences were found between the groups tested. The only exception was in the belief that patenting "influences academic productivity negatively", which was found to have more importance for those researchers who had a permanent job. The fact that there were no great differences between groups of researchers at different career stages and with diverse previous experience and perspectives regarding patenting suggests that many of those issues are transversal to the research community in the biotechnology field, or at least to the sub-set that answered this questionnaire. On the other hand, it is also relevant to note that this type of issue is still a relatively new one for the Portuguese community and therefore it is probable that, with a few exceptions, professional activities and personal careers have not yet been strongly affected (either negatively or positively) by the actual performance of patenting activities.

Perceptions on the organisational environment

We will now examine the relationship between the characteristics of the organisational environment and researchers' patenting behaviour.

We investigated whether an association exists between researchers' perceptions of the organisational environment – e.g., internal capacities and infrastructures for

patenting and licensing – and their involvement in patenting activities. Specifically, we assumed that patenting can be influenced by scientists' awareness of an IPR policy in their organisation, by the perceived difficulties in pursuing patenting and licensing activities and by the support that scientists expect to receive from their organisation. When interpreting the results, it is important to bear in mind that, because the establishment of most TTOs /TLOs is very recent in Portugal, their staff are still likely to have limited experience of patenting and licensing activities. For the same reasons, researchers might not have been fully aware of the activities of these organisations or had the opportunity to resort to them. Similarly, they might not have been familiar with the new IPR regulations.

Researchers were, first of all, asked about the existence of an IPR policy in their organisation and about its clarity (Table 3). A comparison between the answers of patenting researchers and non-patenting researchers shows that there was a much more substantial proportion of non-patenting researchers who did not know whether their organisation had an IPR policy (41% as against 13%). On the other hand, the majority of patenting researchers (73%) responded affirmatively about the presence of such a policy, as compared with only 41% of non-patenting researchers. However, it is interesting to note that, in both groups, a high percentage of researchers felt the need for a clarification of their organisation's IPR policy or for the development of such a policy when it did not exist.

The next step consisted in assessing researchers' perceptions of the difficulties associated with patenting. Patenting researchers were questioned about the difficulties that they experienced in the patenting and licensing process. Similarly, non-patenting researchers were asked about the areas in which they anticipated greater difficulties, if they decided to become involved in such activities. The questionnaire presented the same list of difficulties to each group and asked the respondents to rank them on a Likert scale (from 0="low importance" to 3="crucial"). Table 4 presents the average value of each difficulty for the two groups.

Table 3. Awareness of PSRO IPR policy and opinion about its clarity

	Involvement in patenting activities	
	Patenting researchers (%)	Non-patenting researchers (%)
Awareness of IPR policy at the research organisation		
Yes, it exists.	73.3	40.7
No, it does not exist.	13.3	18.7
Do not know	13.3	40.7
Need for clarification or development of IPR policy		
Yes	60	70.3
No	26.7	4.4
Have no opinion	13.3	25.3

Table 4. Difficulties anticipated and difficulties experienced in patenting and licensing processes

	Difficulties experienced by patenting researchers		Difficulties anticipated by non-patenting researchers	
	Average value	Ranking	Average value	Ranking
Patenting activities				
Ignorance of legal frameworks and institutional regulations	1.53	*1*	2.34	*2*
Identifying the commercial and technological potential of research results	0.80	*9*	1.36	*9*
Accessing information on existing patents in the same area	0.93	*7*	1.80	*7*
Filing a patent application	1.47	*2*	2.07	*4*
Relationships with examiners from patent offices	0.87	*8*	1.93	*6*
Accessing financial resources	1.13	*6*	2.35	*1*
Licensing activities				
Identifying potential clients	1.33	*4*	1.80	*7*
Accessing complementary competences (e.g. marketing)	1.27	*5*	1.94	*5*
Negotiating licensing agreements	1.40	*3*	2.33	*3*
Establishing technological relationships with industry or other organisations	1.33	*4*	1.74	*8*

A comparison between the answers of the two groups shows that, on average, those researchers who have never been involved in patenting attribute a higher value to all difficulties than those who have patented and so have effectively experienced these difficulties. Thus, while, overall, patenting emerges as a process that is paved with difficulties, the perceptions of those difficulties appear to be greater than the actual complexity.

Despite these differences, "ignorance of legal frameworks and institutional regulations" and "filing a patent application" are considered to be major difficulties by both groups of researchers. Thus, a key problem concerns the specific knowledge associated with the formal and legal aspects of patenting, with which researchers are usually unfamiliar. Similarly, negotiating licensing agreements – an activity that combines legal skills and expertise in the marketing of technology – ranks amongst the most problematical activities for both groups.

"Accessing financial resources" is considered to be the most serious anticipated difficulty, while actually ranking sixth among the difficulties experienced, suggesting that access to funding may be overestimated as a difficulty by researchers who have had no previous involvement in patenting.

Conversely, difficulties relating to the commercialisation process, such as: "establishing technological relationships with industry or other organisations" and "identifying potential clients", which rank high among patenting researchers, may be

underestimated by the other group. Since these kinds of difficulties only become perceptible at a more advanced stage, non-patenting researchers may not even be aware of them.

Researchers were also asked about those areas in which their research organisation could assist them. It was found that, in both groups, only a minority of researchers perceive the existence of any organisational support, in terms of competences and infrastructures directed towards patenting and licensing activities.

Interviews with researchers who have already had patenting experience confirm and reinforce the above results. Even when there are organisational structures supporting technology transfer and/or patenting, most researchers perceive these as being underfunded and understaffed and refer to the lack of qualifications and competences of their staff and, particularly, to their poor marketing, technical and negotiation skills.

Patenting and licensing involve a set of skills that academic researchers rarely possess. As a consequence, without any effective structures to assist them, the more productive scientists may be particularly reluctant to spend time on tasks that they usually see as marginal to their core activity and that are not valued by the academic reward systems.

In order to test if perceptions of better support might have some impact on the willingness to patent, we asked researchers whether a number of changes in their organisation, at that level, would stimulate their involvement in patenting.[11] Using the Mann-Whitney statistical test, significant differences were found between researchers who were willing and those who were not willing to patent, in relation to such questions as the "definition of an internal IPR policy", "presence of specific support in terms of infrastructures and competences" and "an environment that was globally supportive to entrepreneurial activities".[12] These results suggest that, in Portugal as elsewhere, clear policies and incentives at the organisational level are indeed important, whilst also pointing to the need to reinforce the activity and competences of TTO/TLOs.

Conclusions

This paper addressed the individual determinants of patenting among scientists from public sector research organisations. An empirical analysis was carried out on a sample of 106 researchers, from nine of the most important Portuguese public sector research organizations (PSROs) in the fields of life sciences and biotechnology. These researchers were asked about their views on scientists' involvement in patenting and about their perceptions of the professional and personal impacts of patenting and the difficulties in performing it within their organisation.

[11] The importance of each change was classified on a Likert scale between 0 (not relevant) and 3 (very important).
[12] The significances were 0.015, 0.019 and 0.05, respectively.

It was found that few researchers (14%) had already filed a patent and that most of them showed little willingness to become involved in this type of activity. Interestingly, this behaviour occurs against a background in which most researchers have no "ethical" objections to scientists' involvement in the commercial exploitation of their research results and have already been involved in other technology transfer activities.

Researchers' perceptions about the impacts of patenting on their individual careers can partly contribute towards explaining this finding. Overall, they perceived the effect to be a moderate one, and there was some divergence about what can be described as professional aspects: i.e. the impact of patenting on the protection and dissemination of knowledge and its influence on the definition and pursuit of research strategies. The only exception concerned its impact on the relationships with industry, which was generally perceived as positive. On the other hand, most researchers perceived that there were many difficulties associated with the patenting process, particularly among those who had never been involved in patenting. Moreover, most respondents also referred to the limited support that they received from their organisation in that area.

We tested a number of hypotheses relating to the impact of individual factors on patenting, through a comparison between different groups: on the one hand, researchers who had already been involved in patenting activities and those who had not; on the other hand, researchers who expressed a willingness to patent in the future and those who did not.

Personal characteristics, such as age, job stability and career stage (which are often related), were found to be associated with previous involvement in patenting. This confirms the expectations that greater experience, reputation and institutional status favour patenting. But these results also suggest that the current incentive and reward system, with its emphasis on scientific productivity, is compelling younger scientists – who are often still seeking access to the academic career structure or are at very early stages in their careers – to direct their efforts towards more basic research and publication. Although these younger scientists seem to be relatively open-minded about patenting, they are not prepared to be actively involved. Evidence about perceptions of the personal and professional impacts of patents – although not fully conclusive – and interviews with patenting researchers would appear to confirm this view.

It was found that participation in industry-oriented activities is associated with actual and intended involvement in patenting, confirming the importance of previous experience with industry as an inducement for furthering patenting performance. This is consistent with previous findings in the literature which point out that increased direct interaction between universities and industry favour the direct commercialization of academic research results (GULBRANDSEN & SMEBY, 2005; VAN LOOY et al., 2004).

Interestingly, perceptions of the personal and professional advantages of patents are rarely associated with previous or future patenting performance. Indeed, mixed opinions regarding the impact of patenting on the organisation of research and on the protection

and dissemination of knowledge were found across different types of individuals (regardless their age and career groups, that in other research were found to behave differently with respect to patenting). Such pattern is not totally unexpected. On the one hand, it mirrors the controversies surrounding the effects of patenting both on the appropriation of publicly funded research and on the "open science" regime – particularly its effects upon the definition of research agendas and the widespread dissemination of results. On the other hand, it may reflect the relative novelty of involvement in patenting activities amongst a research community whose "acculturation" took place under the "old regime". This community is now being confronted with a changing environment, where only recently some incentive mechanisms to encourage researchers to disclose their inventions and engage in patenting activity have begun to be introduced. However, because of the transnational nature of its activities and relationships, it has already been exposed to the practices of researchers from other countries (namely the US) and to the debates associated with this. Our survey was carried out amongst Portuguese researchers in a period of change and at a time when they are faced with an eventual re-assessment of their own attitudes towards these issues. It would therefore be interesting to revisit them in the coming years in order to follow up this process.

On the contrary, some differences were found between researchers in terms of their perceptions of the organisational environment. Non-patenting researchers are less aware of IPR policies and attribute a greater importance to all the difficulties associated with patenting and licensing than those who have actually experienced them. Additionally, researchers who expressed a willingness to patent in the future consider that improvements in institutional policies and in support structures will effectively stimulate patenting. This is consistent with other research that points to the key role played by qualified organisational structures in motivating scientists for patenting (THURSBY & THURSBY, 2002; BERCOVITZ et al., 2001; OWEN-SMITH & POWELL, 2001).

Although some significant differences were found between scientists with different patenting behaviour, we are aware that, given the small number of researchers with actual patenting experience, these results cannot be considered to be fully conclusive. It can nevertheless be argued that since most researchers perceive patenting as providing weak personal benefits and as representing a complex process, these individual perceptions are relevant factors in accounting for the low level of patenting in Portuguese PSROs.

In policy terms, the above conclusions – relating to the characteristics of patenting and non-patenting scientists, the perceptions of the advantages and disadvantages of patents, as well as the difficulties associated with pursuing patenting activities – provide some indications about possible actions to be taken.

The most immediate actions should consider adapting the existing institutional regulations – namely the incentive and reward systems – and the organisational structures, in order to motivate scientists to disclose their inventions and engage in the activities required to patent them. With respect to the organisational structures, our results also suggest that TTOs/TLOs may have a critical role to play in inducing scientists who have had no previous involvement in patenting, to engage in such activity. In fact, it was noted that previous participation tends to reduce the perceived barriers to further participation. If these scientists become more familiar with the processes of patenting and licensing, namely through the demonstration effects provided by more experienced ones, participation rates may increase substantially (BERCOVITZ & FELDMAN, 2003).

It is also interesting to note that the "imprinting effect" of negative experiences (OWEN-SMITH & POWELL, 2001) does not seem to be at work in this case: most researchers who had already patented expressed the willingness to do so again, despite their perceptions of the difficulties involved and the inadequacy of the support provided. The fact that researchers are conscious of the still incipient nature of existing structures and expect these to improve, may explain their attitude. This creates a "window of tolerance" that should be used by these structures to become more effective.

The historical accounts of the emergence and evolution of entities such as the Research Corporation, founded at UC Berkeley as early as 1912, or the BTG group, founded in Britain in 1948, show how important such types of structures, that are specialised in dealing with IPR and have emerged from academic contexts, might be in encouraging patenting activities. Examples such as these confirm that experienced TLO/TTO staff is an important requirement for improving both the conditions under which researchers disclose their inventions and the opportunities arising in the subsequent process. In short, proactive measures, such as the setting up of new IP offices and the improvement of existing ones, are needed in order to remove the barriers to initial involvement as well as to sustain the efforts of more proactive scientists.

The research presented in this paper was largely exploratory. It addressed a context where rules, attitudes and practices are starting to change, but where some of those changes are subject to a number of obstacles: on the one hand, they are hindered by the uneven pace at which different elements in the process are evolving; on the other hand, they are challenged on account of their ethical implications and potential impacts on scientific progress. The research conducted for this paper observed this evolution through the views and perceptions of individual scientists, who are an important and interested party in the process, but who have rarely been asked about it. We believe that, despite the small number of researchers who answered the survey and the potential bias towards those who are more interested in IPR/patenting questions, our research has provided some useful insights. These concern the direction of the changes taking place,

the obstacles to their continued pursuit and also the areas of indefinition, controversy or potential conflict, as seen from the standpoint of a key actor. These results, as well as the methodological approach used to elicit them, may be relevant to other countries going through similar processes.

Moreover, some useful inferences might be drawn for future research in this area. Proper frameworks should be developed linking together individual factors (attitudes, characteristics, behaviour) and contextual factors (organisational, disciplinary, legal and institutional). The present study, though focusing essentially on individual factors and presenting the limitations of an exploratory work, should be seen as a contribution towards that goal. Moreover, forthcoming investigations should be cross-national so that the inter-country variation in individual and contextual factors might also be understood.

References

AGRAWAL, A., R. HENDERSON (2002), Putting Patents in Context: Exploring Knowledge Transfer from MIT, *Management Science*, 48 : 44–61.

ARGYRES, N. S., J. P. LIEBESKIND (1998), Privatizing the Intellectual Commons: Universities and the Commercialisation of Biotechnology, *Journal of Economic Behaviour and Organisation*, 35 : 427–454.

AZAGRA-CARO, J. M., N. CARAYOL, P. LLERENA (2003), *Contractual Funding and University Patents: from Analysis to a Case Study*, DRUID Summer Conference 2003, Copenhagen June 12-14 2003.

BALCONI, M. S. BRESCHI, F. LISSONI (2004), Networks of Innovators and the Role of Academia: An Exploration of Italian Patent Data, *Research Policy*, 33 : 127–145.

BALDINI, N., R. GRIMALDI, M. SOBRERO (2002), *Institutional Changes and the Commercialization of Academic Knowledge: A study of Italian universities' patenting activities between 1965 and 2002*, CRESCO Working paper n. 11, Università degli Studi di Siena, http://www.cresco.unisi.it/wpeng/wp11eng.pdf

BERCOVITZ, J., M. FELDMAN (2003), *Technology Transfer and the Academic Department: Who Participates and Why?*, DRUID Summer Conference 2003, Copenhagen June 12–14 2003.

BERCOVITZ, J., M. FELDMAN, I. FELLER, R. BURTON (2001), Organizational Structure as Determinant of Academic Patent and Licensing Behavior: An Exploratory Study of Duke, Johns Hopkins and Pennsylvania State Universities, *Journal of Technology Transfer*, 26 : 21–35.

BRESCHI S., F. LISSONI, F. MONTOBBIO (2005), Open Science and University Patenting: A Bibliometric Approach, In: VAN POTTELSBERGHE DE LA POTTERIE B., DE MEYER A.: *Economic and Management Perspectives on Intellectual Property Rights*. Palgrave: McMillan (forthcoming).

CALDERINI M., C. FRANZONI (2004), *Is Academic Patenting Detrimental to High Quality Research? An empirical analysis of the relationship between scientific careers and patent application*, CESPRI Working Paper n. 162, http:// econpapers.repec.org/ paper/cricespri/ wp162.htm

CALDERINI, M., C. FRANZONI, A. VEZZULLI (2005), *If Star Scientists do not Patent: An event history analysis of scientific eminence and the decision to patent in the academic world*, CESPRI Working Paper n. 169, http://www.cespri.unibocconi.it

CARAYOL, N. (2004), *Academic Incentives and Research Organization for Patenting at a Large French University*, BETA, Université Louis Pasteur, http://cournot2.u-strasbg.fr/EEAAS/carayol/ academic_patent.pdf

COUTINHO M., E. BALBACHEVKY, D. HOLZHACKER, D. PATRÃO, R. VÊNCIO, R. SILVA, M. LUCATELLI, L. REIS, M. MARIN (2003), Intellectual Property and Public Research in Biotechnology: the scientists opinion, *Scientometrics*, 58 : 641–656.

DASGUPTA, P., P. A. DAVID (1994), Towards a new economics of science, *Research Policy*, 23 : 487–521.

DAVID, P. (2000), The Digital Technology Boomerang. New Intellectual Property Rights Threaten Global 'Open Science', *World Bank Conference*, 27 June 2000, Paris.

FONTES, M. (2001), *Patenting Performance of Universities and Other Research Organizations in Portugal*, Working Paper, DMS 010/01, Lisboa: INETI.

FONTES, M., M. PÁDUA (2002), The Impact of Biotechnology Pervasiveness and User Heterogeneity on the Organisation of Public Sector Research, *Technology Analysis and Strategic Management*, 14 (4) : 419–441.

GERING, T., U. SCHMOCH (2003), *Management of Intellectual Assets by German Public Research Organisations*, in OECD (2003).

GEUNA, A., L. NESTA (2004), University Patenting and its Effects on Academic Research: The Emerging European Evidence, *Research Policy*, (forthcoming), http://cournot2.u-strasbg.fr/EEAAS/geuna_nesta.pdf

GODINHO, M., T. PEREIRA, V. SIMÕES, S. MENDONÇA, V. SOUSA (2003), *Estudo Sobre a Utilização da Propriedade Industrial em Portugal*, Colecção Leituras de Propriedade Industrial – Volume I, Lisboa: Instituto Nacional da Propriedade Industrial.

GULBRANDSEN, M., SMEBY, J. (2005), Industry Funding and University Professors' Research Performance, *Research Policy*, 34 : 932–950.

HELLER, M., H. EISENBERG (1998), Can Patents Deter Innovation? The Anticommons in Biomedical Research, *Science*, 280 : 698–701.

HENDERSON, R., A. B. JAFFE, M. TRAJTENBERG (1998), Universities as a Source of Commercial Technology: A detailed analysis of University Patenting, 1965–1988, *Review of Economics and Statistics*, 80 (1) : 119–127.

LIEBESKIND, J. (2001), Risky Business: Universities and Intellectual Property, *Academe 87*, Available in: http://www.aaup.org/publications/Academe/01SO/so01lie.htm

MERTON, R. K. (1973), *The Sociology of Science: Theoretical and Empirical Investigations* (Edited by N. W. Storen), University of Chicago Press.

MEYER, M. (2003), Academic Patents as an Indicator of Useful Research? A New Approach to Measure Academic Inventiveness, *Research Evaluation*, 12 : 17–27.

MEYER, M., M. DU PLESSIS, T. TUKEVA, J. T. UTECHT (2005), Inventive Output of Academic Research: A Comparison of Two Science Systems, *Scientometrics*, 63 : 145–161.

MEYER-KRAHMER, F., U. SCHMOCH (1998), Science-Based Technologies: University-industry Interactions in Four Fields, *Research Policy*, 27 : 835–851.

MOWERY, D. C., R. R. NELSON, B. N. SAMPAT, A. A. ZIEDONIS (2001), The Growth of Patenting and Licensing by US Universities: An Assessment of the Effects of the Bayh-Dole Act of 1980, *Research Policy*, 30 : 99–119.

MOWERY, D. C., R. R. NELSON, B. N. SAMPAT, A. A. ZIEDONIS (2004), *'Ivory Tower' and Industrial Innovation: University-Industry Technology Transfer Before and After the Bayh-Dole Act*, Stanford University Press.

OECD (2002) ,*OECD Science, Technology and Industry Outlook 2002*, Paris: OECD.

OECD (2003), *Turning Science into Business – Patenting and Licensing at Public Research Organizations*, Paris: OECD

OWEN-SMITH, J. (2003), From Separate Systems to a Hybrid Order: Accumulative Advantage Across Public and Private Science at Research One Universities, *Research Policy*, 32 : 1081–1104.

OWEN-SMITH, J., W. POWELL (2001), To Patent or Not: Faculty Decisions and Institutional Success at Technology Transfer, *Journal of Technology Transfer*, 26 : 99–114.

PAVITT, K. (1998), Do Patents Reflect the Useful Research Output of Universities?, *Research Evaluation*, 7 : 105–111.

SARAGOSSI, S., B. VAN POTTELSBERGHE (2003), What Patent Data Reveal about Universities: The case of Belgium, *The Journal of Technology Transfer*, 28 : 47–51.

SHANE, S. (2002), Selling University Technology: Patterns from MIT, *Management Science*, 48 : 122–137.

SIEGEL, D., D. WALDMAN, A. LINK (2002), Assessing the Impact of Organizational Practices on the Relative Productivity of University Technology Transfer Offices: An Exploratory Study, *Research Policy*, 1375 : 1–22.

STEPHAN, P., S. GURMU, A. J. SUMELL, G. BLACK (2002), Individual Patenting and Publication Activity: Having One's Cake and Eating It, *NPRNet Conference 2002*, 23 March, University of Sussex.

STEPHAN, P. E. (1996), The Economics of Science, *Journal of Economic Literature*, 34 : 1199–1235.

STEPHAN, P. E., S. GURMU, G. BLACK (2004), *Who's Patenting in the University? Evidence from the Survey of Doctorate Recipients*, Working Paper, Dep. Economics, Andrew School of Policy Studies, Georgia State University.

THURSBY, J., R. JENSEN, M. THURSBY (2001), Objectives, Characteristics and Outcomes of University Licensing: A Survey of Major U.S. Universities, *Journal of Technology Transfer*, 26, : 59–72.

THURSBY, J., M. THURSBY (2002), Who is Selling the Ivory Tower? Sources of Growth in University Licensing, *Management Science*, 48 (1) : 90–104.

VAN LOOY, B., M. RANGA, J. CALLAERT, K. DEBACKERE, E. ZIMMERMANN (2004), Combining entrepreneurial and scientific performance in academia: Towards a compounded and reciprocal Matthew Effect? *Research Policy*, 33 : 425–441.

WALLMARK, J. T. (1997), Inventions and Patents at Universities: The Case of Chalmers University of Technology, *Technovation*, 17 (3) : 127–139.

ZUCKER, L. G., M. R. DARBY, J. ARMSTRONG (1998), Geographically Localised Knowledge: Spillovers or Markets?, *Economic Inquiry*, 36 : 65–86.