ACADEMIC PATENTING: A SYSTEMATIC REVIEW OF THE LITERATURE

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ABSTRACT

The profound economic and social changes that have occurred in the global context has caused a paradigm shift and a change in the mission of Public Research Organisations (PRO). These organizations have increasingly contributed to the processes of wealth creation and local and national competitiveness, by promoting research activities whose results can be readily transformed in technological advances and innovations. On the basis of this behaviour is, beside other aspects, the implementation of initiatives directed towards the protection and commercialisation of research results. The main objective of this paper is to present a bibliographical revision based on selected scientific articles that have investigated and discussed various aspects concerning the protection and commercialisation of Intellectual Property (IP) generated in PRO, through the utilization of patents. It considers the most relevant research problems addressed and analyses contributions, limitations, application contexts, discussions, and directions proposed for future research.

Keywords: Public research organizations, universities, patents, technology transfer.

INTRODUCTION

The protection and exploitation of research results generated in PRO is not a totally new phenomenon (Crespi et al, 2011; Mowery et al, 2001; Etzkowitz, 1998; Etzkowitz, 1996). However, only recently the initiatives undertaken in this area began to raise articulated policies, aware of the potential value of intellectual assets. Gradually, the IP was becoming an increasingly valued commodity and sold even before it can give rise to new products and processes. As a result, PRO have come to adopt a more strategic and systematic perspective of protection and exploitation of research results (Lissoni, 2013; Perkmann et al., 2013).

This evolution leads naturally to changes in the process of production and dissemination of knowledge, and numerous questions arise due to the growing commercial involvement of these institutions.

A first intense debate is generated about the knowledge production process and its impacts. Are protection and exploitation of IP indeed important activities for PRO, especially for universities? Does this commercial function affect the efficiency of the research or reorient the studies for certain areas, potentially more profitable? More particularly, to what extent do the patenting requirements affect or delay scientific publications?
Other questions refer to the management of these processes in the organizations. How should IP activities be managed? Who should belong the property of the invention? Does this new research dynamic generate any conflicts of interest?

Finally, we can ask what kind of factors can explain or potentiate patenting and licensing processes. Does this increasing academic patenting activity result from government regulations? What is the importance of the technology transfer offices? Does not the individual researcher represent a key agent in the whole process?

These are some of the questions addressed in this paper, in the next sections.

ACADEMIC PATENTING: EVIDENCES FROM USA AND EUROPE

Unquestionably, the most extensive empirical evidence on the increased protection and commercialization of IP in PRO, and particularly in universities, comes from the US.

According to OECD (2014), patenting carried out by North American universities have begun to grow faster than the average of other countries, since the year of 2000. As can be seen in Figure 1, American universities owned approximately 500 patents/year in the early 80s, about 3800 patents/year in 2000 and have increased considerably in recent years (with a value of nearly 4800 patents in 2012).

![Fig. 1 - Patents assigned to American universities, 1982-2012](uspto.png)

Source: USPTO (2014)

Despite the scarcity of statistics for international comparisons, the evidence in some OECD countries shows that the patenting performance of American universities is not a unique case. In Europe, the share of PRO’ filings (including universities) in total patent applications at the EPO has jumped from about 0.5 per cent in 1981 to nearly 4 per cent in the early 2000s (Zeebroeck et al, 2008). Anyway, it must be kept in mind that these figures are lower-bound measures, as many university invented patents are assigned to non academic institutions (generally corporations), as shown by Meyer et al (2005), and more recently by Azagra Caro...
(2010), Lissoni et al. (2010), Kenney e Patton (2011) and Lissoni (2012). The main conclusion is that European universities do not contribute less than American ones for patenting activities. Indeed, in Europe, a significant number of patents originated in universities are under ownership of companies, government agencies and non-profit entities, or under the registration of the inventors themselves. Besides that, the authors add that European universities would be less likely to require the ownership of patents given the so-called "professor’s privilege" in the case of Italy, for example, as well as the role of funding agencies, as in the case of countries like France, where such agencies impose control over the intellectual property rights of research funded by them.

**SHOULD UNIVERSITIES PATENT THEIR RESEARCH? THE COSTS AND BENEFITS**

The issue of the appropriation of the knowledge generated by the public sector through patenting is a source of a heated debate (Fontes, 2001; Liebeskind, 2001; Owen-Smith and Powell, 2001 Pavitt, 1997).

The authors that support IP protection by PRO justify their position based on the positive effects on the process of dissemination of knowledge, as well as on the economic value of patented inventions, resulting in social benefits. In this sense, the objective of establishing an IP policy in PRO is to achieve a balance between the needs of the inventors, those who will develop the invention, the research organization, the funding entities and the society in general.

We could say that it is difficult to improve the form of dissemination of knowledge through simple scientific publication; but as Moschini (2001) assumes, many findings produced by research financed with public funds can not be used in technological developments because without an exclusive license, many companies are not willing to invest in the transformation of the invention into a new product. Therefore, we can assume that the management of IP in PRO contributes to a better performance of technology markets by increasing information about the commercial potential of the knowledge produced.

Also, if the research results were published without adequate protection, any company can benefit from resources that are public without providing any return to the research organization (Fujino and Stal, 2004).

At the same time, we recognise the presence of a set of voices that warn about the increasing fragility of the system of "open science" (Dasgupta and David, 1994), which do not support the protection and commercialization of IP from PRO.

Throughout time, some scholars have shown concern regarding research collaborations between university and industry. In the early 2000s, a group of authors suggests that these interactions might originate undesired effects, focused on restrictions and distortions in the free flow of information and materials between the scientific community (Couto, 2001; Liebeskind, 2001). This claim is based on the fact that individuals or research teams in universities restrict the type, amount and destination of the disclosed information when establishing partnerships with industry, namely when the licensing of patents on an exclusive basis is at stake.
Although any interpretation should be made with due caution, the shifting behaviour of academic researchers is also emphasized by several authors. Louis et al. (2001) reveal that, when those are engaged in entrepreneurial activities, it is more likely that they refuse requests from close colleagues, at research level, than other academic members who do not engage in entrepreneurial activities. Stephan et al. (2002) also emphasize that scientists themselves depart from the traditional system of "peer review" and the benefits of quality and consensus associated with it.

As argued Argyres and Liebeskind (1998), "the institutional mechanisms of the university are designed to develop and protect the 'intellectual commons', not to exploit them. The author’s conclusion is unequivocal: enticed by private economic interests, the university may lose its identity and function as a social institution.

In addition, some authors call attention to the possibility of university researchers deviate from their academic roles because of excessive accumulation of activities aimed at the business world. A study by Rapper and Webster (1997) concludes that an increasing emphasis on patenting by universities may distort or diminish other relevant activities, especially in times of budgetary constraints, in which universities are highly oriented towards searching additional funding sources. In the same way, Liebeskind (2001) acknowledges that academic researchers with financial agendas outside the university might “influence their research in a way to serve those interests”.

Interestingly, another analyses seem, however, to contradict this change in behaviour on the researchers. Zucker e Darby (1996) reveal that important biotech scientists reached excellent research performance after becoming involved in patenting and licensing activities. Likewise, Louis et al. (2001) warn that researchers with an entrepreneurial profile have a higher academic productivity than other researchers who do not engage in entrepreneurial activities. Breschi et al. (2008) also noted a positive effect of patenting in academic scientific productivity, since the academic inventors are more productive when participating in patent activities. These results are extremely close to the ones obtained by Fabrizio e DiMinin (2005) and Azoulay et al. (2009) for the USA case. Siegel et al. (2003) further add that the researchers involved in the commercialization of IP reinvest their "earnings" in laboratory equipment and in attracting doctoral and postdoc researchers, allowing to conduct additional research.

The protection and commercialization of IP by PRO also raises a number of issues related to the traditional reward system assigned to the researcher (Stephan et al, 2002; Goldfarb e Henrekson, 2002). The commercialisation of knowledge can create income earning opportunities for the researcher and his institution (particularly, revenue from approved licenses). This type of financial compensation and material conflicts with the conventional rules of basic science, whose researcher reward system mainly focuses on prestige from public acknowledgement of the research results. It’s important to highlight that it is the public nature on its own that facilitates the creation and expansion of the researcher’s reputation; and on other hand, the reward system centred on public acknowledgement encourages the production and sharing of knowledge (Stephan et al., 2002). Conversely, trade rules impose restrictions, albeit temporary, to the accessibility and the use of scientific and technological assets in question, in contrast to certain financial compensation.

Therefore, the admission of commercial procedures in the academic institutional context has promoted the emergence of conflicts of interest, as a result of the attempted reconciliation of
“open science” system, and its forms of co-operation and information sharing with the knowledge privatization practices.

This new knowledge production and dissemination system then generates a major challenge to the scientific and technological policy authorities, who are expected to have an adjusted choice of the appropriability mechanism, depending on the state of actual knowledge (in the case of being in an embryonic and cumulative state or in a more advanced on, close to a “final product”).

LEGAL, ORGANIZATIONAL AND INDIVIDUAL DETERMINANTS OF ACADEMIC PATENTING

Although the evidence in most OECD countries shows that patenting and licensing activities have rapidly grown in PRO, this evolution varies significantly from one organization to another (OECD, 2014).

In some research organizations, a good performance at the basic research level is accompanied by a similar performance in the trade field, which results in raising revenue, establishment of close and productive relationships with industry and obtaining extensive portfolios of technology assets. Contrariwise, other organizations that even have solid basic research programs, struggle with major constraints in their IP marketing efforts.

Legal and Institutional Determinants

At an institutional level, we can argue that those differences are derived from different contexts that imprint particular characteristics to the knowledge dissemination procedures between public entities and private companies.

Therefore, it is important to stress the importance of legislation on IP, particularly about patents, existing in each country. In this context, several laws and support programs for the protection and commercialization of public research results have been adopted, especially since the early 80s. Obviously the nature of these measures, their intensity and the number of years that have passed since they are in effect, vary across countries, which could influence the number of patents registered by the PRO in different countries (Cesaroni e Piccaluga, 2005).

In the US, the publication of legislation on IP began in the 70s, and was highlighted by the adoption of the Bayh Dole Act in the 1980. The Bayh Dole Act changed the technology transfer incentives provided to the PROs, namely to the universities, since it allowed them to have the ownership of patents arising from R&D with public financing. According to senators Bayh and Dole, which sponsored that law, the Bayh Dole Act would allow universities to patent their inventions, thus raising the technology transfer and the commercial exploration of the public research results. Without patenting, many inventions developed in an academic environment would remain on the university shelves because “what is available for everyone is nobody’s interest” (Mazzoleni e Sampat, 2002).
Also in Europe, despite the existence of strong cultural and social constraints, many laws and measures to support the protection and commercialization of public research results were adopted. With few exceptions, European universities only began to develop mechanisms and protection strategies in the late 80s and early 90s. In part this can be attributed to the fact that some European governments chose to focus marketing activities in central entities (such as the British Technology Group, in the UK), or adopting more decentralized mechanisms, but under central or regional government control (such as the network of research results transfer offices located in PRO, and coordinated by a national agency of technology transfer, in Spain). As a result, the PRO in Europe have a shorter experience of autonomy and control over the protection and commercialization of IP.

Organizational Determinants

The existence of specific factors, particularly in terms of policies, mechanisms, incentives and infrastructures to support the protection and commercialization of IP within the organizations, can also influence the use of patents by PRO.

In fact, for an effective protection and commercialization of research results, PRO should develop a strategy to establish IP rights, not forgetting the important role of technology transfer offices (TTO) (OECD, 2014).

Debackere e Veugelers (2005) conclude that some of the critical factors in the pursuit of a successful technology transfer activity are the existence of clear regulations on property rights issues and the existence of decentralized management that provides enough freedom for the researchers and their groups, to be involved in activities of knowledge transfer.

Taking into account the process of dissemination of knowledge between public and private organizations, these structural features must be complemented with a key role played by TTO. These offices should seek to establish a link between "clients" (companies) and "suppliers" (researchers from PRO) of technology, which operate in different organizational environments and are driven by very different motivations (Hidalgo et al., 2014). Thus, TTO contribute for the reduction of organizational and cultural barriers between academia and industry, facilitating communication and promoting partnerships between scientists and companies. Several existing studies seek to show that the activity of these offices is much more productive than the traditional situation in which the inventor was the income beneficiary and the university was excluded (Markman et al., 2005; Powers e McDougall, 2005). This is very important, taking into account the inability and lack of resources of individual scientists to promote the commercialization of their inventions.

The IP management in PRO should also include the creation of a system of incentives to researchers, in order to stimulate their contribution to patent applications (Debackere e Veugelers, 2005). According to Siegel et al. (2003), this is one of the most critical factors that influence the performance of the PRO’s technology transfer activity. More specifically, the propensity of researchers to disclose their inventions (thus enhancing the "supply" of technologies available for commercial exploitation) is strongly related with the promotion of policies by the PRO and the revenue distribution plan from licensing. Similarly, incentive policies for employees of TTO as well as the skills and backgrounds of those employees may also influence the kind of exploitation that occurs.
**Individual Determinants**

We can argue that the performance of PRO in relation to patents, as a form of appropriation and exploitation of research results, may depend not only on institutional and organizational factors – like the quality and orientation of the research, IP policies and the existence of support infrastructures to the patent activities and its subsequent exploitation – but also individual factors – such as the attitudes and behaviours of the researchers regarding patenting processes and commercial exploitation of knowledge (Baldini, 2011; Penin, 2010; Bercovitz e Feldman, 2008; Baldini e al, 2007; Siegel et al., 2003; Stephan et al., 2002; Thursby e Thursby, 2002; Owen-Smith e Powell, 2001).

In fact, the individual researcher seems to represent a fundamental role in all this process of protection and commercial exploitation of the research results; not only because the decision of disclosure belongs to him, but also because his involvement and cooperation might be important for the later development of the invention (Thursby et al., 2001).

A study on the increase in licensing activities at US universities suggests that this phenomenon reflects an increase in the number of disclosures by researchers. The study explains that this fact seems to be related to an increased propensity of researchers to disclose inventions, rather than with other kind of factors such as the reorientation of research towards areas of greater interest for industry (Thursby e Thursby, 2002).

However, it is important to notice that the disclosures reported to the respective institution (and specifically, to the TTO - if there is one) represent only a part of academic research with commercial potential. A study by Thursby et al. (2001), on academic licensing activities in American universities, concludes that less than half of the inventions with commercial potential were revealed to TTO. In some cases, it might be related with the fact that the researcher do not have much commercial potential awareness on their ideas; nevertheless, many times, researchers decide not to disclose their inventions to TTO’s since the application of a patent may lead to a delay in publication, or even its real replacement. Indeed, some researchers argue that the delay in publication of research results can hinder the rapid dissemination of scientific knowledge, delaying the scientific and technologic progress (Geuna e Nesta, 2006). The findings obtained by Penin (2010) suggest that academic patenting might hamper seriously the spread of scientific knowledge, affecting not only the rate of diffusion, but also the content of the publications. In opposition, other studies show that publications and patents are positively related (Czanitzki et al, 2009; Stephan et al, 2007; Carayol, 2007; Agrawal e Henderson, 2002). In particular, Stephan et al. (2007) argue that academic researchers “can have their cake and eat it too”, proceeding to the publication of research results, and simultaneously, keeping other elements of the research in private. The study carried out by these authors concludes that the number of patent applications in a certain period is positive and significantly related to the number of published papers during that period.

We can also consider that the decision of researchers regarding their involvement in protection and exploitation of IP can be influenced by their own perceptions of personal and professional benefits of patents. Owen-Smith e Powell (2001), highlight, in this context, several opinions according to different research fields. Cohen et al. (2002) equally admit that in some specific sectors (like pharmaceutical industry and biotechnology) academic patenting eases the technology transfer from universities to industry.
Alongside, there are researchers who do not proceed to the disclosure of their findings once they lead basic research projects and do not want to divert their academic functions for applied research activities, naturally more oriented to the needs of the business world (A zoulay et al., 2009; Thursby e Thursby, 2002). These statement is coherent with the one by Geuna e Nesta (2006), that identify that one of the possible negative impacts on science, resulting from the growing patenting by universities, is the deviation of resources (researcher’s time and equipment) from the long term fundamental research. The same authors also assume that patenting activities negatively affect the academic productivity, with regard to the quality of teaching (as the most experienced faculty members focus on patenting, instead of focusing on teaching activities).

Other empirical studies support the idea that patents can limit activities for teams developing research in the same field or even generate conflicts of interest between the researcher and his peers (or to the institution itself). In fields of high patenting propensity, such as biotechnology and life sciences, some authors warn against the risks induced by “patent thickets” (Shapiro, 2001), with the occurrence of a “tragedy of the anticommons” (Heller e Eisenberg, 1998) or by a “privatization of the commons” (Nelson, 2004). All these expressions suggest that the proliferation of patents in specific research fields can increase the cost of access to knowledge, which in turn would reduce research in these fields. When comparing the rate of citation of scientific articles, before and after a patent is granted, Murray e Stern (2007) found a statistically significant evidence of an "anti-commons" effect due to academic patenting. However, more recent studies in the field of biomedical sciences do not consider that patents prevent access to upstream research, but have other impediments, such as confidentiality or the control over the materials needed to do research (Cohen e Walsh, 2008).

In order to understand what incentives university researchers have to be engaged in patenting processes, Baldini et al. (2006) carried out a study with 208 university professors, inventors of university patents in Italy, and concluded that they engage in patenting processes to, first, increase their prestige and reputation; second, to stimulate further research; third, to have more funding for the research; and fourthly, to increase the knowledge exchange with the private sector. The search for personal gain does not seem to be an important incentive for researchers.

A study conducted by two German authors also demonstrated that researchers engage in patenting activities not for reasons of personal gain, but to signal its achievements and gain reputation among the academic communities close to industry (Goktepe-Hulten and Mahagaonkar, 2010).

Finally, some researchers decide to proceed (or not) with the necessary activities for patenting based on “philosophical” reasons, related to their view regarding the appropriate role of scientists in the academic context (Thursby e Thursby, 2002, Owen-Smith e Powell, 2001). According to Verspagen (2006, p. 616), an open science system involves an "atmosphere of openness and sharing of knowledge, data and research results. It is this open nature of the scientific process that is responsible for much of their success. [...]Patents can transform an open culture into another, more closed". The results shown by Penin (2010) suggest however that academic patenting does not seem to interfere too much with the culture of open science (except for the issue of delay in scientific publications). In the same context, a study conducted by Moutinho et al (2007) also admit that a large majority of respondents believe that their patenting activity is very well recognised by their peers.
Additionally, the behaviours and attitudes of the researchers regarding their involvement in IP protection and exploitation activities can be conditioned by a number of factors related not only with questions of a more personal nature (in terms of their own awareness and perspectives on personal and professional advantages of patents), but also with their perceptions regarding the pursuit of such activities in the context of their work and the organization to which they belong.

Actually, it seems crucial to consider that the vision of researchers on IP policies set at the institutional level as well as their own perceptions of the existence of support infrastructures may have important impacts on their attitudes regarding patents. Owen-Smith e Powell (2001) argue that researchers with similar perspectives regarding the benefits of patents may act differently depending on the perception of difficulties in pursuing patenting and licensing activities.

Concerning the existence of difficulties during the patenting process, Baldini et al. (2006) tried to collect the perceptions of the researchers, concluding that: 1) the "open science" mentality in the PRO; 2) the difficulties in assessing the commercial potential of technologies; 3) the lack of interest in the industry towards academic research and the excessive rigidity and bureaucracy of university administrators; 4) the lack of support during the patenting activity; and 5) the lack of funds to finance patenting costs were the barriers most frequently mentioned by the researchers. When asked about the measures that should be taken by universities to stimulate patenting activities, those that were pointed out by a larger number of researchers were: 1) the increase of information and promotion of research results; 2) the creation of a TTO; 3) the adoption, by universities, of an internal regulation on patenting; and 4) institutionalization of formal agreements between industry and academia. The authors also conclude that it is very important that universities could create an encouraging environment of patenting: the more positive the assessment of the behaviour of university in support of patenting, the lower the perception of problems or difficulties would be.

Similarly, Derrick (2015) points out that it is natural that academic researchers only proceed to the disclosure of their inventions if they believe that the TTO can support them throughout the patent application process, ensuring successfully the necessary activities to its licensing.

**CONCLUSION**

The establishment of IP rights resulting from research financed by public funds is a complex phenomenon, with no clear solutions that would ensure that the public interest is protected by the dissemination of knowledge as fast as possible, and simultaneously promote economic development in general.

It will therefore be necessary to promote a deeper understanding of the trade-offs that involve greater protection and commercial exploitation of IP by PRO.

On the one hand, it will be important to analyse some factors such as the scientific and technological field in question, the technology development stage and potential, etc. On the other hand, a growing caution is required regarding the possible side effects relating to situations of confidentiality acceptance, delaying publication deadlines, licensing processes on an exclusive basis that may misrepresent the objectives that led to the assignment of IP rights to the PRO.
This analysis should also include the understanding of causes and consequences of shifting behaviour of researchers, taking into account the impact on production (quantity and quality) of basic research, on the culture of "open science" and on teaching activities.

Anyway, despite the current debates, protection and commercial exploitation of research results financed by public funds is an increasingly recognized phenomenon. As we note, these changes have been accompanied by significant institutional and legal changes (in particular the adoption of various laws and support programs by many countries, especially since the early 80s) and organizational changes (in particular the establishment of IP management structures at the PRO, such as the creation of technology transfer offices).

The truth is that the contribution of individuals for innovation and a deep understanding of the characteristics that affect innovative behaviour at an individual level are often omitted from most analyses. In this sense, we recognise the importance of further study on the factors that may influence the attitudes and behaviours of the researchers regarding their involvement in patenting processes and respective commercial exploitation of knowledge. We specifically identified, at this level, the importance of variables such as the perceptions of the personal and professional benefits and costs of patents, the personal view of the proper role of scientists in academic context and their perceptions of the institutional and organizational structure.

REFERENCES


