Patents and scientific publications: an empirical analysis of the Italian system of academic professor recruitment

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Abstract

The recent increase in patenting by European and American university researchers has raised concerns among observers that increased patenting may be associated with less open publication of research results. This leads us to examine if the propensity to academic patenting would negatively affect publication of scientific research results and, therefore, result in less diffusion of knowledge resources; or, conversely, if it could increase the quantity and quality of scientific publications and therefore improve academic performances.

We propose a quantitative approach through which we aim to test whether academic researchers who both publish and patent are less productive than their peers who concentrate exclusively on scholarly publication, in order to communicate their research results. More specifically, by using the statistical model of comparison between sample means, we analyse if the average number of publications by academic inventors is lower than the average of non-academic ones. We use a panel dataset comprising Italian academic researchers who have obtained the National Scientific Qualification as full professor in the sector “02/B3 - Applied Physics”, in the session 2012. With regard to the relationship between patenting and publishing by university researchers there is not an unanimous doctrinal orientation. Additionally, there is only limited empirical evidence regarding the correlation between these two variables. Our study contributes to the existing literature by supporting the thesis according to which the open publication of university research results is not inhibited by patenting by university faculty members.

The outcomes of the application suggest that it would appear appropriate to encourage a greater use of patents by university researchers. It would seem, in fact, that – thanks to the financial support to academic research and, in general, to the incentives arising from contact with industry – the development of industrial applications is likely to produce an additional stream of results, which are relevant also in the eyes of the scientific community. These observations allow us to assert that patents could be recognized as efficient indicators of knowledge production.

Keywords – Intellectual capital, scientific productivity, academic patenting, technology transfer

Introduction

The strategic importance of intangible assets for a company's success is widely recognized. This importance has only grown in the recent years due to the increase in international economical competition and to development of what is commonly known as the *knowledge economy* (Bosworth and Webster, 2006; Edvinsson and Malone, 1997; Foray, 2006; Ghidini, 2009; Lev, 2003; Rifkin, 2001; Rullani, 2004; Stewart, 1999; Sveiby, 1997; Trequattrini, 2008; Zanda, 2009). Particularly, knowing that the competitive advantage amongst different economies is basically related to the efficacy of implementation of the innovative system has lead the economists to pay special attention to the role of science as one of the main *input*s to generate growth within an economical system (Romer, 1990).

In that context, it is widely known the crucial role of Public Research Institutions (PRI) and especially of the universities, which play into the technological transfer of knowledge by the appropriate endorsement of the scientific research (Cicchetti *et al*., 2007; Lazzeroni, 2004; Mansfield, 1991; Mansfield, 1995; Mansfield, 1998; Narin *et al*., 1997; Piccaluga, 2001). Thus, in the latest years a gradual process of transformation of universities has happened. Nowadays, they have developed new functions due to a greater open-mindedness towards the external environment and to the growing desire to satisfy research needs and to offer new educational services within their economic and social system (Bonaccorsi, 2000; Godin and Gingras, 2000). There are new activities of technological transfer towards private firms that have been implemented, as well as the more traditional activities done by the universities, such as the delivery of technical and scientific knowledge and the development of competence.

The *Triple Helix Model* (Etzkowitz and Leydesdorff, 2000) is a representation of that "entrepreneurial" function. According to this model, the development of technological innovation is a collective and localized activity (Antonelli, 1999) that requires a synergic co-operation between universities, the industrial world and institutional players. In fact, reading the actual economical scenarios through the items and variables that is possible to represent in that model, universities would assume a third mission (in addition to the traditional researching and educational activities) to participate in the national economic growth, in particular the economic growth of their home region. Thus, a new educational model has developed: the "entrepreneurial university".

To better understand the numerous structured activities implemented by the universities to deliver technological transfer, it is possible to examine the kind of knowledge and players involved (Baglieri, 2008). According to the traditional classification made by Polanyi (1958), knowledge can be considered as codified knowledge – very easy to transfer thanks to a formal language used (the code) – or as tacit knowledge, held by the producer and therefore it is more difficult to transfer and reproduce.

With regard to the actors involved, the technological transfer can be started by the university throughout its direct relationships with companies or by the individual professors. When the result of the research is tacit knowledge and the actor involved is the university, the process of adding value to it (also a commercial value) happens through the foundation of *spin-off* companies, whose share could also partially belong to the university itself; on the other hand the process of value diffusion happens through personal contacts. Basically, that is the hypothesis when the researchers change the academic institution to whom they belong in order to follow the pattern of their own results or when industrial researchers stay for long periods in laboratories where the research undertaken by the firms takes place. Meanwhile, when the technological transfer is promoted by an individual professor those consulting activities bring some benefits to the university. The increase in internship opportunities and employment for the graduate students, as well as the chance to strengthen the scientific production indicators, are only some of the advantages for an academic institution that the university can exploit.

When the results of the research mainly belong to the type of codified knowledge, the process of value adding made by the university can be patented and eventually transferred by an exclusive or non-exclusive licence. In contrast, an individual professor can diffuse knowledge mainly through publications and presentations to conventions. It is particularly useful then to analyze the individual level of professors' results. The Italian legislation about university patents allocates to the researcher, rather than to the university, the exclusive ownership of the royalties from the invention patented (D.Lgs. February 10, 2005, no. 30, art. 65). That represents a preferential treatment when compared with existing regulations in other European countries. In fact, France, Germany and Great Britain have chosen to allocate the property of the royalties to universities, to endeavor to reduce the differences between private and public academic institutions and also between the professors themselves. That effort is inspired to the Bayh-Dole Act (USA, 1980) that allocates to universities the royalties and copyrights and to collect the profits given by licenses (Henderson *et al*., 1998; Jaffe, 2000).

Presumably, the purpose of the Italian law is to incentivize the researchers to patent their inventions. All these matters suggest some main consequences. First of all**,** universities that aim for local economic growth have to implement technological transfer activities using systematic procedures. In addition, most of the transfer activities require the legal protection of a patent. Also within the range of the non-formal knowledge transfer there is the possibility to apply for some patents. For instance, even the constitution of spin-off companies (technological transfer of tacit knowledge) is often based on the transfer of a patent – codified knowledge – to protect the inventor (Cesaroni and Gambardella, 2001).

On the other hand, the results of a professor's cooperative researches could lead to patents that would be owned by both the partner enterprise and by the professors. In this case, the professors will be listed amongst the patent's inventors. That is the *inventorship* process. Because of those considerations and the growing demand by the European and American universities to register patents, we are using university patents as an index of knowledge production. In the following paragraph we will glance at the literature's view on the consequences that patents on academic research have on scientific progress. The purpose is to analyze if either the attempts to patent techniques and tools that are used in the scientific research will encourage knowledge production and diffusion; or, on the contrary, whether it would limit scientific progress, due to the rising costs of research. The third paragraph will demonstrate the reliability of university patents as a proxy for knowledge production activity, through a quantitative analysis of the Italian market. It will then illustrate the statistical methodology applied to the sample and its characteristics and resulting data.
Finally, the fourth paragraph presents the conclusions, focusing on both the study's limitations and the research evolutions that could be done.

Literature review

This section aims to investigate the effects produced by academic patenting on scientific research. The purpose is to analyze whether patents enhance the production and transfer of knowledge or represent a limitation to the scientific progress. The second hypothesis considers scientific process as a cumulative kind of process, thus, it has to be based on the free access to the stock of existing knowledge. Part of the literature supports the theory that scientific progress is a collective and cumulative enterprise (Behrens and Gray, 2001; Blumenthal *et al*., 1986; Cohen *et al*., 2002; Dasgupta and David, 1994; Geuna, 2001; Krimsky, 2003; Lee, 1998). That means the research tools– laboratory equipment, experimental procedures, measurement tools– developed by scientists are fully available for others researchers, that can easily refer to the results obtained by their colleagues' work, in order to add innovative results to the former researches. Instead patenting could restrict the access to the research's results, so to affect the effective production of knowledge. The exclusive use of research tools by those scientists that invented them and own the exclusive licenses, could slow down the scientific progress and, therefore, the total amount of discoveries.

Heller and Eisenberg (1998) suggested that since the end of 1980s patenting has moved firstly within biomedical research. They pointed out that the intellectual property of tools is fragmented in many patents held by several owners, causing a multiple overlaps and concatenations between them. This phenomenon is known as *tragedy of the anti-commons*: the researcher has to require several licenses to access to the common pool of scientific discoveries necessary to deepen his research. The negative effects would be enhanced by the diffusion of the so-called *reach-through license agreement*, that allows the owner of a patented invention to preserve the rights on downstream discoveries around basic inventions.

Murray and Stern (2007) developed an experiment to test the anti-common hypothesis. Their study is based on the concept of *dual knowledge*, in which a single discovery may contribute to both scientific research and useful commercial applications. A key implication of dual knowledge is that it may be simultaneously instantiated as a scientific research article and as a patent. Such patent-paper pair is at the heart of their empirical analysis. The authors exploit the fact that patents are granted with a substantial lag, often many years after the knowledge is initially disclosed through paper publication. The knowledge associated with a patent paper pair, therefore, diffuses within two distinct intellectual property environments – one associated with the pre-grant period and another after formal IP rights are granted. Relative to the expected citation pattern for publications with a given quality level, anti-commons theory predicts that the citation rate to a scientific publication should fall after formal IP rights associated with that publication are granted. Employing a differences-indifferences estimator for 169 patent-paper pairs (and including a control group of publications from the same journal for which no patent is granted), they find evidence for a modest anti-commons effect (the citation rate after the patent grant declines by between 9% and 17%). This decline becomes more pronounced with the number of years elapsed since the date of the patent grant, and is particularly salient for articles authored by researchers with public sector affiliations. Some other surveys arrive to the same conclusions (Sampat, 2004).

Another disadvantage associated with the protection of the scientific research results would be the inventors' attitude to replace publishing with patenting. An assumption widely accepted by the scientific community claims that the youngest researchers need to firstly enforce their intellectual capital. Thus, if starting the career protecting their scientific output, they risk to be less productive in the future time; in contrast, the older colleagues, thanks to the previously accumulated knowledge, would be able to devote themselves to patent the results of their efforts (Beraldo, 2007). That consequence, together with the slowing down of publications, would lead to a quality depletion.

Henderson et al. (1998) compared the amount of university patents between 1965 and 1988 with a random control sample equals to 1% of patents granted by the *United States Patent and Trademark Office – USPTO*. The authors also measured the *generality* and the *importance* of university patents for the control sample. The generality index measures the number of technological classes in which a given patent is cited, while the importance index takes into account the number of citations received. The results show that university patents are more important and more general than controls along the period analyzed. However comparing generality and importance of university patents with controls decreased after the introduction of the *Bayh-Dole Act*. That reduction has been due to two factors:

1) the BDA would induce patenting even smaller universities, whose research and inventions are not original; 2) there would be also a reduction in the average quality of patents of larger institutions, with a considerable increase of patents that do not get any citations.

Finally, another disadvantage of academic patenting would lie on the shift of resources allocated to basic research towards more "attractive" applied research, sacrificing activities of medium-long term. While some fields do not express a distinction between basic and applied research (biotechnology), some other fields could be affected by relevant consequences, such as the physical shift of resources. On the other hand, part of the doctrine agrees with the assumption that patents do not constitute a limitation to the production and dissemination of knowledge for several reasons, but rather an effective boost for the scientific research.

Firstly, a possible consequence of applying for a patent is that academic scientists become acquainted with researchers in companies. As these acquaintances develop into relationships, it is expected that industry contacts might become sources of ideas for new research projects (Azoulay *et al*., 2009). In fact, academic researchers report that problems they work on in academic research often come from ideas and problems encountered during industrial consulting (Mansfield, 1995). Another survey of scientists reported that 65% of researchers found out that interaction with industry has influenced their research. One respondent commented: "There is no doubt that working with industry scientists has made me a better researcher. They help me refine my experiments and sometimes have a different perspective on a problem that sparks my own ideas" (Siegel *et al*., 2003). This involvement and feedback may produce additional publications, and potentially additional patents. As Agrawal e Henderson (2002) highlighted «*most patentable research is also publishable*».

University researcher involvement in commercialization activities may also provide additional information to the researcher about the value of various research streams. Research grants and consulting have, and continue to, serve this purpose in many academic settings. Additional exposure to and interaction with commercialization and industry may supplement these other indicators (Feller, 1990). In addition, there is a natural analogy to the complementarities observed between applied and basic research in industrial firms. Rosenberg (1998), for example, documented that innovations born out of contact with commercial enterprises in the applied field of chemical engineering ushered a new era of basic discoveries in chemistry. Yet, scientific publications are indicators of explicit knowledge generated in research and development stages of innovation (Cicchetti *et al*., 2007). Therefore, part of the doctrine believes that if the patents number is positively correlated to the scientific publications, the patent would considered as a tool to promote the production of new knowledge.

With that regard, Markiewicz and Di Minin (2004) found that between these variables may exist a positive relationship due to two main reasons: 1) publications may serve as a type of advertisement, increasing the awareness and knowledgability of the relevant scientific community with regard to the patented technology. This can raise the value of the patented research because it increases the legitimacy of the technology and creates a set of researchers who know about and may be interested in utilizing the patented research; 2) patents and publications may be positively correlated without being causally linked. If "good" researchers produce more and better research output, than these researchers will have more patents and publications. Similarly, if the work of a researcher develops or improves over time, then the researcher may increase both patents and publications. Thus, the fact that higher numbers of patents and publications are both indicators of researcher quality suggests that a positive correlation would hold.

One could also imagine that patenting, and the associated possibility of licensing and industry involvement, would allow a university researcher access to additional funding (either from licensing revenue or industry funding) that he could spend on his research and lab expenses. The respondent quoted above also stated: "Also, my involvement with firms has allowed me to purchase better equipment for my lab, which means I can conduct more experiments" (Siegel *et al*., 2003). The additional funding could allow for additional equipment, researchers, and junior faculty members, all of which could contribute positively to the publications and patents produced by the lab. This "pyramid effect" of patents and publications produced under the supervision of a university researcher, whose name appears on many of the patents and publications, complicates the interpretation on a positive correlation between patenting and publishing.

Finally, patents would be a source of information because of the recognition of the citations' number as an indicator of knowledge spillovers phenomena. In fact, a patent generally quotes a certain number of previous patents and scientific publications, to whom the invention is connected. Just the citations' number received by a patent is, according to some important studies (Harhoff *et al*., 1999; Jaffe *et al*., 1993; Jaffe and Trajtenberg, 1996; Jaffe and Trajtenberg, 1999; Jaffe *et al*., 2002), a significant indicator of its commercial value. In other words, patents can be weighed on the citations' number received by future patents. Therefore, patents have an important function as a source of information about the state of the art (Grupp and Schmoch, 1999). The idea for which patents would represent a stimulus to the production of cognitive resources leads us to focus attention on some empirical studies, which – although in limited number – have tested the ability of patents to generate knowledge by analysing the existence of a *trade-off* at the individual level between patenting activity and scientific publications.

These empirical analyses have followed so far common methodologies and provided essentially similar results. Agrawal and Henderson (2002) explore the degree to which patents are representative of the magnitude, direction, and impact of the knowledge spilling out of the university by focusing on *MIT–Massachusetts Institute of Technology*, and in particular on the departments of *Mechanical Engineering (ME)* and *Electrical Engineering and Computer Science (EECS)*. Drawing on both qualitative and quantitative data, they show that patenting is a minority activity: a majority of the faculty in the sample considered never patent, and publication rates far outstrip patenting rates. Most faculty members estimate that patents account for less than 10% of the knowledge that transfers from their labs. Their results also suggest that in two important ways patenting is not representative of the patterns of knowledge generation and transfer from MIT: patent volume does not predict publication volume, and those firms that cite MIT papers are in general not the same firms as those that cite MIT patents. However, patent volume is positively correlated with paper citations, suggesting that patent counts may be reasonable measures of research impact.

Calderini and Franzoni (2004), draw on bibliometrics, biographical and patent data of a sample of 1.323 Italian public researchers in the field *Engineering Chemistry* and *Nanotechnology for New Material Sciences* along 30 years (1971-2001). They measure scientific performances in each year as: a) the number of publications in that year and b) the quality of the publications, given by the average Impact Factor of the journals where the researcher published his/her work. Results of descriptive statistics and panel data analysis showed that patenting is never detrimental to quantity and quality of publications. The study suggests that scientific performances of scientists are likely to increase in the proximity of a patent event: panel data estimates seem to indicate that patenting is likely to generate a temporary increase in the number of publications, with no decrease in expected quality. Additional publications are made in the biennium of patent priority and, above all, in the following one.

Markiewicz and Di Minim (2004) compare a sample of 150 academic inventors and an equivalent sample of academic non-inventors employed in different sectors from 1975 to 1995. The results presented in their study suggest that the open publication of university research results is not inhibited by patenting by university faculty members: the annual number of publications by a faculty member increases following application for a successful patent, controlling for field, year, and time profile of publications by matched non-inventors. A doubling in the number of patents by a researcher is associated with a 5-10% increase in annual publications. That tendency is confirmed by Breschi *et al*. (2007), who found that start to patent implies

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an increase of scientific productivity of about 15%.

Meyer (2005) examines for the field of *nanoscience* and *nanotechnology* whether researchers who both publish and patent are more productive and more highly cited than their peers who concentrate on scholarly publication in communicating their research results. His study is based on an analysis of nano-science publications and nanotechnology patents of a small set of European countries (Belgium, Germany, United Kingdom). While only a very small number of nano-scientists appear to hold patents in nanotechnology, a considerable number of nano-inventors seem to be actively publishing nano-science research. Overall, these co-active individuals appear to outperform their solely publishing, non-inventing peers in terms of publication counts and citation frequency.

Azoulay *et al*. (2009) examine the influence of faculty patenting activity on the rate, quality, and content of public research outputs in a panel dataset spanning the careers of 3.862 academic life scientists, all of whom have been employed at U.S. universities or public research institutions between 1968 and 1999. They find that academic scientists who patent are more productive than otherwise equivalent scientists that are not listed as inventors on patents, but that publication quality appears relatively similar in the two groups. So they find that patenting has a positive effect on the rate of publication of journal articles, but no effect on the quality of these publications.

An important result of Italian data (Breschi *et al*., 2005; Breschi *et al*., 2007) presents two different types of academic inventors, «occasional» and «persistent», that behave differently towards patents and publications. Occasional inventors are scientists who patented only once in the course of their career. They increase the publications normally a couple of years preceding the patent and one following year. Persistent inventors are those that patented at least twice in their career. Their publications have a positive and continuous effect from the patenting activity even three years after the first patent.

In line with the empirical studies mentioned, this paper aims to analyze the impact produced by scientific patenting on academic publishing activity.

The empirical analysis

Methodology

In this section the effectiveness of university patents as tools used to measure performance related to the production of new knowledge will be tested by verifying the existence of a correlation at individual level between patents and scientific publications, using data referring to the Italian context. The reasons underlying this analysis are different.

Firstly, an academic scientist could allocate their energies towards more economically profitable activities and, therefore, devote the majority of their time to patenting or to the development of patents whose applications have already been filed. This could reduce the effort in terms of scientific publications.

Secondly, patenting of scientific output may cause a delay in the publication to not invalidate the patent, together with the affixing of restrictions on the dissemination of scientific results. This problems is particularly felt in Europe, where the researcher wants to patent his scientific output cannot rely on the so-called *grace period*, which in the United States allows to publish research results aimed to patenting up to 12 months prior to the submission of the patent application, without this invalids the novelty requirement of the latter.

Finally, the results of the study are useful to understand if a greater propensity to patenting can change the orientation of academic research, moving it towards more specific and applied aims at the expense of general and theoretical ones. This change could cause a shift from academic basic research to applied research and, therefore, it could prevent patents from being recognized as efficient indicators of knowledge production.

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Below the statistical methodology used, the characteristics of the sample analyzed and the results observed will be exposed. The empirical study has been conducted to test the hypothesis for which the productivity of academic inventors, in terms of scientific publications number, is not divergent from the academic non-inventors one. In other words, we aim to understand if propensity to academic patenting could affect the publication of scientific research results and, therefore, lead to a lower diffusion of cognitive resources; or, conversely, if it represent a tool to improve their academic performances by increasing the quantity and quality of scientific publications. The analysis has been conducted by comparing two sample: a sample of academic inventors – academics who hold at least one patent or one patent application – and a sample of academics with similar characteristics, but they never patented any results of their scientific research. In order to test the above hypothesis we have used the statistical model of comparison between sample means, referring to the average number of publications produced by each sample. The number of scientific publications of each academic is computed with reference to a period common to the components of both samples. The result obtained has been subjected to a test of significance to estimate his reliability.

Sample characteristics and data

The empirical investigation has been conducted with reference to academic researchers that qualified as "full professor" at the National Scientific Qualification 2012. We focused on 5 areas: 1) "05/F1 – Applied Biology"; 2) "05/E2 – Molecular Biology"; 3) "02/B3 – Applied Physics"; 4) "03/B1 – Chemical Sciences and Inorganic Systems"; 5) "06/A2 – General and Clinical Pathology".

Therefore, we divided each of the 5 groups analyzed into 2 sub-groups: academic inventors, those who applied at least for one patent, and academic non-inventors, that never filed any patents about their academic scientific research. Those 10 groups are the sample considered, as follows:

1) "05/F1 – Applied Biology": 156 qualified full professors, divided into 74 inventors and 82 non-inventors;
2) "05/E2 – Molecular Biology": 78 qualified full professors, divided into 50 inventors and 28 non-inventors;
3) "02/B3 – Applied Physics": 70 qualified full professors, divided into 31 inventors and 39 non-inventors;
4) "03/B1 – Chemical Sciences and Inorganic Systems": 119 qualified full professors, divided into 43 inventors and 76 non-inventors;
5) "06/A2 – General and Clinical Pathology": 116 qualified full professors, divided into 64 inventors and 52 non-inventors;

For each of the 5 groups, both samples can be considered significant because of the following reasons:

- most of academic inventors holds a number of patents or patent applications exceeding 1;
- in the other sectors it has not been possible to identify a significant sample of academic inventors, also because of the small number of participants who have obtained a favourable judgment to qualification.

In order to compute scientific publications number we have considered the period 1997-2012, as common to all academics of both samples. Consequently, the total number of publications of each faculty member has been purified from those previous the period in question.

The data related to both samples are indicated in the following tables, that have been made for each sector (1; 2; 3; 4; 5; 6; 7; 8; 9; 10):

Table 1 – *Number of scientific publications made by academic inventors qualified as full professor in the area "05/F1 – Applied Biology". Years 1997-2012.*

Academic Inventors	*No. of Publications*	*No. of Patents*	*No. of Patent Applications*
A1	39	3	0
A2	65	5	10
A3	46	0	1
A4	79	0	1
A5	37	2	0
A6	102	2	0
A7	31	1	0
A8	72	8	0
A9	64	1	0
A10	38	1	0
A11	30	3	0
A12	43	1	0
A13	134	2	2
A14	193	3	2
A15	57	0	4
A16	28	0	1
A17	77	1	0
A18	37	1	3
A19	59	1	0
A20	66	3	1
A21	23	0	2
A22	30	2	1
A23	120	21	7
A24	45	0	1
A25	28	2	0
A26	34	3	0
A27	89	0	1
A28	82	3	1
A29	106	0	11
A30	24	1	0
A31	176	0	6
A32	93	2	0
A33	92	0	1
A34	69	0	2
A35	22	0	1
A36	29	2	0
A37	68	0	4
A38	106	1	0
A39	104	2	3
A40	147	0	3
A41	41	5	0
A42	65	0	1

A43	27	0	1
A44	42	1	1
A45	65	0	1
A46	63	2	0
A47	65	0	1
A48	45	0	1
A49	50	2	1
A50	51	1	3
A51	44	0	2
A52	25	0	1
A53	49	3	3
A54	35	1	0
A55	70	1	0
A56	78	0	8
A57	93	0	1
A58	100	0	2
A59	49	1	0
A60	55	2	0
A61	44	2	1
A62	65	1	2
A63	24	0	1
A64	57	2	2
A65	102	1	1
A66	31	0	1
A67	28	1	0
A68	69	0	1
A69	45	3	3
A70	74	1	0
A71	55	1	1
A72	171	0	4
A73	117	5	0
A74	62	0	5

Table 2 – *Number of scientific publications made by academic non-inventors qualified as full professor in the area "05/F1 – Applied Biology". Years 1997-2012.*

Academic Non-Inventors	*No. of Publications*
B1	53
B2	39
B3	98
B4	88
B5	44
B6	72
B7	33
B8	94
B9	48

B10	32
B11	25
B12	46
B13	41
B14	88
B15	25
B16	83
B17	92
B18	29
B19	45
B20	32
B21	16
B22	134
B23	18
B24	56
B25	58
B26	85
B27	49
B28	88
B29	47
B30	44
B31	78
B32	63
B33	49
B34	52
B35	107
B36	39
B37	34
B38	32
B39	34
B40	30
B41	25
B42	70
B43	38
B44	28
B45	33
B46	169
B47	70
B48	78
B49	73
B50	33
B51	35
B52	35
B53	38
B54	22

B55	68
B56	297
B57	92
B58	111
B59	52
B60	112
B61	30
B62	97
B63	116
B64	64
B65	20
B66	91
B67	47
B68	62
B69	48
B70	46
B71	27
B72	59
B73	45
B74	52
B75	19
B76	60
B77	207
B78	34
B79	118
B80	42
B81	41
B82	54

Table 3 – *Number of scientific publications made by academic inventors qualified as full professor in the area "05/E2 – Molecular Biology". Years 1997-2012.*

Academic Inventors	*No. of Publications*	*No. of Patents*	*No. of Patent Applications*
A1	39	3	0
A2	86	12	0
A3	99	0	9
A4	45	2	0
A5	57	1	1
A6	55	0	1
A7	102	2	0
A8	49	0	2
A9	133	2	3
A10	62	2	1
A11	78	0	2
A12	202	2	6
A13	34	0	1

A14	23	0	2
A15	30	2	1
A16	45	0	1
A17	34	0	3
A18	52	0	5
A19	106	1	10
A20	56	1	0
A21	36	0	1
A22	65	0	2
A23	99	0	1
A24	86	2	0
A25	144	3	1
A26	68	0	4
A27	33	1	0
A28	154	0	1
A29	38	1	0
A30	41	2	4
A31	27	0	1
A32	63	0	2
A33	38	0	1
A34	25	0	1
A35	30	3	1
A36	90	15	27
A37	31	1	0
A38	56	1	0
A39	35	0	1
A40	56	1	0
A41	106	16	7
A42	71	2	3
A43	253	1	0
A44	93	1	0
A45	14	0	1
A46	49	1	0
A47	35	1	3
A48	103	1	3
A49	116	2	3
A50	118	5	0

Table 4 – *Number of scientific publications made by academic non-inventors qualified as full professor in the area "05/E2 – Molecular Biology". Years 1997-2012.*

Academic Non-Inventors	*No. of Publications*
B1	78
B2	94
B3	26
B4	31
B5	76

B6	25
B7	53
B8	99
B9	80
B10	43
B11	48
B12	70
B13	65
B14	52
B15	88
B16	27
B17	25
B18	62
B19	52
B20	50
B21	97
B22	24
B23	62
B24	113
B25	53
B26	47
B27	34
B28	42

Table 5 – *Number of scientific publications made by academic inventors qualified as full professor in the area "02/B3 – Applied Physics". Years 1997-2012.*

Academic Inventors	*No. of Publications*	*No. of Patents*	*No. of Patent Applications*
A1	182	4	5
A2	88	3	0
A3	59	3	3
A4	60	2	0
A5	211	1	4
A6	120	0	2
A7	93	0	5
A8	107	0	3
A9	133	3	5
A10	101	7	3
A11	125	2	3
A12	328	5	0
A13	60	3	0
A14	200	1	0
A15	70	6	2
A16	72	5	1
A17	80	4	0
A18	142	2	1

A19	86	0	2
A20	20	0	1
A21	69	2	0
A22	100	4	0
A23	162	7	0
A24	146	21	0
A25	189	4	2
A26	90	0	1
A27	135	1	1
A28	166	1	4
A29	64	0	1
A30	176	0	3
A31	169	1	0

Table 6 – *Number of scientific publications made by academic non-inventors qualified as full professor in the area "02/B3 – Applied Physics".Years 1997-2012.*

Academic Non-Inventors	*No. of Publications*
B1	157
B2	80
B3	184
B4	133
B5	138
B6	67
B7	110
B8	52
B9	77
B10	20
B11	52
B12	118
B13	117
B14	69
B15	200
B16	116
B17	72
B18	63
B19	78
B20	110
B21	137
B22	142
B23	108
B24	90
B25	103
B26	233
B27	154
B28	182

B29	65
B30	105
B31	63
B32	98
B33	146
B34	250
B35	90
B36	53
B37	78
B38	72
B39	80

Table 7 – *Number of scientific publications made by academic inventors qualified as full professor in the area "03/B1 – Chemical Sciences and Inorganic Systems". Years 1997-2012.*

Academic Inventors	*No. of Publications*	*No. of Patents*	*No. of Patent Applications*
A1	120	5	5
A2	172	2	0
A3	65	3	1
A4	225	3	2
A5	140	2	3
A6	75	0	2
A7	71	1	0
A8	123	0	2
A9	261	6	6
A10	66	1	6
A11	196	0	1
A12	139	0	1
A13	149	1	4
A14	142	11	8
A15	131	1	3
A16	92	3	2
A17	200	2	10
A18	94	2	1
A19	142	3	3
A20	82	1	4
A21	64	0	11
A22	109	2	3
A23	80	0	8
A24	110	4	0
A25	228	0	1
A26	76	3	2
A27	113	5	2
A28	96	0	1
A29	130	0	3
A30	116	9	0

A31	177	3	1
A32	72	1	0
A33	58	1	1
A34	96	2	1
A35	142	0	4
A36	137	2	2
A37	65	0	2
A38	88	2	6
A39	57	0	1
A40	128	2	1
A41	108	1	2
A42	86	11	13
A43	211	2	0

Table 8 – *Number of scientific publications made by academic non-inventors qualified as full professor in the area "03/B1 – Chemical Sciences and Inorganic Systems". Years 1997-2012.*

Academic Non-Inventors	*No. of Publications*
B1	72
B2	77
B3	108
B4	158
B5	47
B6	109
B7	108
B8	277
B9	86
B10	97
B11	214
B12	71
B13	39
B14	232
B15	95
B16	55
B17	61
B18	77
B19	96
B20	163
B21	135
B22	73
B23	56
B24	85
B25	125
B26	155
B27	85
B28	150

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B29	83
B30	43
B31	97
B32	92
B33	107
B34	80
B35	66
B36	84
B37	51
B38	110
B39	86
B40	96
B41	90
B42	175
B43	85
B44	94
B45	35
B46	112
B47	89
B48	111
B49	165
B50	124
B51	142
B52	119
B53	101
B54	124
B55	77
B56	52
B57	71
B58	46
B59	91
B60	107
B61	76
B62	57
B63	129
B64	190
B65	90
B66	84
B67	82
B68	88
B69	246
B70	84
B71	93
B72	71
B73	72

B74	93
B75	222
B76	74

Table 9 – *Number of scientific publications made by academic inventors qualified as full professor in the area "06/A2 – General and Clinic Pathology". Years 1997-2012.*

Academic Inventors	*No. of Publications*	*No. of Patents*	*No. of Patent Applications*
A1	206	9	3
A2	168	0	1
A3	134	1	1
A4	86	2	10
A5	89	1	1
A6	99	0	9
A7	67	1	0
A8	97	4	2
A9	72	5	3
A10	222	0	6
A11	100	2	5
A12	87	7	0
A13	193	2	2
A14	77	1	0
A15	79	3	4
A16	63	2	0
A17	56	1	5
A18	45	0	1
A19	104	1	0
A20	34	3	0
A21	112	1	1
A22	89	0	1
A23	72	1	0
A24	107	2	4
A25	154	0	1
A26	93	1	5
A27	37	0	1
A28	151	0	2
A29	113	0	1
A30	93	1	1
A31	121	0	1
A32	51	0	2
A33	140	1	1
A34	81	1	0
A35	75	1	1
A36	84	0	1
A37	103	0	1
A38	82	2	11

A39	46	0	1
A40	102	0	2
A41	108	3	3
A42	78	0	3
A43	221	2	0
A44	66	1	0
A45	90	3	3
A46	101	4	16
A47	76	1	0
A48	130	1	2
A49	56	1	4
A50	77	3	5
A51	50	3	0
A52	59	1	0
A53	123	0	2
A54	100	0	2
A55	44	0	1
A56	100	0	4
A57	74	1	0
A58	102	1	1
A59	90	0	1
A60	77	1	4
A61	132	0	2
A62	90	0	1
A63	55	1	1
A64	67	0	2

Table 10 – *Number of scientific publications made by academic non-inventors qualified as full professor in the area "06/A2 – General and Clinic Pathology". Years 1997-2012.*

Academic Non-Inventors	*No. of Publications*
B1	142
B2	153
B3	78
B4	87
B5	20
B6	100
B7	100
B8	68
B9	20
B10	52
B11	111
B12	28
B13	74
B14	49
B15	133

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B16	163
B17	61
B18	188
B19	112
B20	80
B21	58
B22	87
B23	92
B24	104
B25	93
B26	83
B27	77
B28	63
B29	91
B30	91
B31	423
B32	62
B33	77
B34	50
B35	80
B36	55
B37	87
B38	50
B39	97
B40	134
B41	50
B42	45
B43	53
B44	147
B45	64
B46	65
B47	20
B48	112
B49	95
B50	97
B51	255
B52	48

So, we tested the following research hypothesis:

HP. *The average number of academic inventors publications does not differ from the average number of academic non-inventors' ones*. In the following tables are reported for each sector some summary statistics referring to both the samples analyzed (tables 11, 12, 13, 14, 15).

Table 11 – *Descriptive statistics of academic inventors and non-inventors for the sector "05/F1 – Applied Biology"*

Sample	Inventors	Non-Inventors
Minimum	22	16
Q1	38,25	34
Mean	65,405	61,927
Median	58	48,5
Q3	78,75	78
Maximum	193	297
Standard Deviation	37,052	43,146

Table 12 – *Descriptive statistics of academic inventors and non-inventors for the sector "05/E2 – Molecular Biology"*

Sample	Inventors	Non-Inventors
Minimum	14	24
Q1	36,5	40
Mean	71,2	57,714
Median	56	52,5
Q3	97,5	76,5
Maximum	253	113
Standard Deviation	47,076	25,361

Table 13 – *Descriptive statistics of academic inventors and non-inventors for the sector "02/B3 – Applied Physics"*

Sample	Inventors	Non-Inventors
Minimum	20	20
Q1	76	72
Mean	122,677	109,282
Median	107	103
Q3	164	137,5
Maximum	328	250
Standard Deviation	61,947	51,047

Table 14 – *Descriptive statistics of academic inventors and non-inventors for the sector "03/B1 – Chemical Sciences and Inorganic Systems"*

Sample	Inventors	Non-Inventors
Minimum	57	35
Q1	81	75,5
Mean	121,674	103,447
Median	113	90,5
Q3	142	113,75
Maximum	261	277
Standard Deviation	51,024	48,433

Table 15 – *Descriptive statistics of academic inventors and non-inventors for the sector "06/A2 – General and Clinic Pathology"*

Sample	Inventors	Non- Inventors
Minimum	34	20
Q1	72	57,25
Mean	96,094	92,769
Median	89,5	81,5
Q3	107,25	101
Maximum	222	423
Standard Deviation	41,247	63,759

Analyzing the descriptive statistics, we found out that in each sector the average number of publications of the professors that file patents is higher than their peers. Nevertheless, the two sample means do not differ significantly. They respectively differ by 4, 14, 13, 18 e 4 publications. Therefore, we used a statistically significance test to test the data relevance. Placing a level of significance α = 5%, the results lead us to accept the hypothesis for 4 of the 5 sectors analyzed (Applied Biology, Molecular Biology, Applied Physics, General and Clinical Pathology). For those 4 areas analyzed the difference between the sample means is not significant. The significance test leads us to reject the hypothesis only for one of the fields analyzed, Chemical Sciences and Inorganic Systems. In that sector the difference between the average number of publications made by the inventors and non-inventors is significant.

In the following tables are reported the tests results (tables 16, 17, 18, 19, 20).

Table 16 – *Test on the average values of publications made by inventors and non-inventors in the sector "05/F1 – Applied Biology"*

Sample	Inventors	Non-inventors
Sample size	74	82
Average no. of publications	65	61
Standard error	4,307	4,765
t-value	0,537	
Degrees of freedom	154	
p-value	0,592	

Table 17 – *Test on the average values of publications made by inventors and non-inventors in the sector "05/E2 – Molecular Biology"*

Sample	Inventors	Non-Inventors
Sample size	50	28
Average no. of publications	71	57
Standard error	6,658	4,793
t-value	1,644	
Degrees of freedom	76	
p-value	0,104	

Table 18 – *Test on the average values of publications made by inventors and non-inventors in the sector "02/B3 – Applied Physics"*

Sample	Inventors	Non-inventors
Sample size	31	39
Average no of publications	122	109
Standard error	9,020	8,174
t-value	0,992	
Degrees of freedom	68	
p-value	0,325	

Table 19 – *Test on the average values of publications made by inventors and non-inventors in the sector "03/B1 – Chemical Sciences and Inorganic Systems"*

Sample	Inventors	Non-inventors
Sample size	43	76
Average no .of publications	121	103
Standard error	7,781	5,556
t-value	1,934	
Degrees of freedom	117	
p-value	0,055	

Table 20 – *Test on the average values of publications made by inventors and non-inventors in the sector "06/A2 – General and Clinical Pathology"*

Sample	Inventors	Non-Inventors
Sample size	64	52
Average no. of pblications	96	92
Standard error	5,156	8,842
t-value	0,325	
Degrees of freedom	84	
p-value	0,746	

We can now state our main finding that the academics' attitude in patenting the results of their scientific researches does not prevent them from also publishing their outputs. Therefore, academic patenting not only is not preventing the diffusion of knowledge, but also is having a positive impact on the number of academic publications made by the researchers.

Discussion of results

The quantitative study we have proposed has considerably reinforced the theoretical strand corroborating the assumption that university patenting could positively influence academic research. The results observed, in fact, do not confirm the lower productivity of faculty member involved in relationships with industry, being the average of their scientific publications higher in number – even if to a limited extent – with respect to that of their non-inventor colleagues. Moreover, the higher number of academic inventors' scientific publications clearly emerges also from the majority of the descriptive statistics. The explanations for which academic patenting would increase incentives of researchers to produce and publish rapidly their results research may be different.

Firstly, as Azoulay *et al*. (2009) pointed out, the market for university inventions is rife with asymmetric information. Academic discoveries often require years of additional development to yield marketable products; there is likely to be a great deal of uncertainty surrounding the commercial and scientific merit of discoveries at this primitive stage; and exhaustive due diligence regarding the value of a discovery is costly. Because of these information problems, is reasonable to believe that scientists' reputations are essential in the market for university technology: an academic researcher's scientific reputation is his/her most important currency in the effort to capitalize on intellectual property in the market for university-originated technology. By acting as a signal of invention quality, the prominence of a patenting faculty in the community of science diminishes the search and screening costs that potential licensees must incur in the process of identifying promising university technology. Furthermore, university technology transfer officers are aware of the certification role of scientific eminence. Other things equal, because the discoveries of prominent scientists are more marketable in industry. TTOs are more likely to choose to file for patents on the discoveries of high-status scientists. Therefore, the ex post search, screening, and contracting problems in the market for ideas increase faculty's ex ante incentives to maintain their reputation on the scientific labor market, as doing so enhances both the odds of finding an industrial match for their inventions, and the value of their patents conditional on a match.

Secondly, the presence of the option to patent would not reduce scientists' incentives to invest in the production of public science thanks to the increased financial resources (as a result of increased licensing and royalties) that could be allocated on a discretionary basis perhaps to foster a new area of research or to develop new teaching opportunities – both of which are usually difficult to finance from traditional funding (Geuna and Nesta, 2003). Useful commercial discoveries often lead to industrial sources of funding for the laboratory of the patenting scientist. Even without access to new pools of knowledge, the ability to hire additional post-doctoral scientists or graduate students might result in higher scientific output for a scientist's lab. A related point is that many seminal scientific achievements have been made possible only by technological advances in instrumentation. In the biomedical fields and other areas of science, technological and scientific advances are therefore interdependent: new understandings are often beholden to progress in instrumentation. If patenting scientists are more likely to be in a position to negotiate access to state-of-the-art equipment in corporate laboratories (Owen-Smith and Powell, 2001), or if they are more likely to have developed the technical expertise to understand and modify research equipment, complementarities between the capital stock of their laboratory and that of their industrial partners might also increase publication output.

Finally, the idea for which the propensity to academic patenting does not seem to affect the incentive or ability of scientists to contribute public advances to the scientific literature is supported by the likely achievement of economies of scope that emerge when a scientist is involved in the development of both academic and commercial science. The possibility of within-scientist economies of scope is also consistent with evolutionary theories of technological and scientific progress in which major advances are understood to represent insightful combinations of disparate pieces of knowledge (Hull, 1988; Weitzman, 1998). Insofar as access to diverse information facilitates the development of new and fruitful lines of scientific inquiry, patenting may facilitate the creation of the professional ties that productively broaden researchers' information networks. It would seem, therefore, that ideas might simultaneously have high scientific value and important commercial potential (Stokes, 1997).

Conclusions

Access to university-based research knowledge is critical for innovation in many industries. As patenting by university researchers has grown, observers are asking if that is associated with fewer open publications and research. The economic theories are not unanimous about the relationship between patenting and publishing by university researchers. Some of the economists support the theory that universities that strengthen patents would affect negatively the academic institutions themselves. A scientific output protection would have a negative impact on "free knowledge", because of a higher level of secrecy, a slowdown in publications and more boundaries to access to scientific information about the research activities.

On the other hand, the alternative view suggests that patents are not a tool to prevent the production and diffusion of knowledge, but rather an effective boost to scientific research. Basically, the interaction with industrycould enhance research and spark new research ideas. Funding from industry sources and money from licensing revenues may help researchers to implement additional research activities, to hire researchers, and to purchase new lab equipment. It is widely recognized that «*the biggest money comes from industry in return for collaborative research*» (Etzkowitz, 1998). Furthermore, it is possible that the enterprises, even before receiving the industrial funds, will already be selecting the most proactive and dynamic researchers. Thus, the faculty members would be encouraged to publish the results of their scientific researches.

Regarding the relationship between patenting and publishing by university researchers there is a limited amount of empirical evidence: the results of the studies we have analyzed found that academic inventors are more likely to belong to the group of the most scientifically productive professors. Our research contributes to the existing literature by providing an empirical investigation of faculty patenting and publishing with a dataset containing academic researchers that qualified as "full professor" at the National Scientific Qualification 2012 in the sectors: 1) "05/F1– Applied Biology"; 2) "05/E2 – Molecular Biology"; 3) "02/B3 – Applied Physics"; 4) "03/B1 – Chemical Sciences and Inorganic Systems"; 5) "06/A2 – General and Clinical Pathology".

This paper suggests that the open publications of university research is not inhibited by patenting of faculty members. In fact, the analysis found that the average number of academic inventors' publications is higher than academic non-inventors. Thus, the results do not confirm the hypothesis of lower productivity of faculty members involved in patenting activities.The results suggest it would be appropriate to encourage a greater use of patents by university researchers. It appears that thanks to the financial support to academic research and to the incentives brought by the industry, the development of industrial applications is likely to produce an additional stream of relevant results for the scientific community. The results of the survey suggest that patents have to be recognized as a significant indicator of knowledge production.

The survey suffers some limitations that could be filled by further insights. In fact, we analyzed the publications made by the professors for 5 scientific sectors, thus further researches could take in account more sectors. Therefore, future developments of that research could take place starting from different industries to be analysed. Moreover, the analysis is exclusively quantitative and it does not refer to the qualitative academic publications' outcomes.

Nevertheless, the open-mindedness of universities towards technology transfers deserves further consideration. If that trend were to be overexploited it might bring some negative consequences. In fact, it is worth remembering that universities are mainly meant to produce knowledge available to everyone, throughout publications and mobility of researchers. That happens also thanks to a continuous transfer of information and experiences allocated in a network structure (Beraldo, 2007). If academic researches' outcomes were patented "at the beginning" it would generate a risk to "deform" one of the most important sources of knowledge production.

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