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Negative effects of university patenting: Myths and grounded evidence

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This paper reviews the literature on the concerns stemming from university patenting and licensing activities. Scholars investigated threats to scientific progress due to increasing disclosure restrictions; changes in the nature of the research (declining patents' and publications' quality, skewing research agendas toward commercial priorities, and crowding-out between patents and publications); diverting energies from teaching activity and reducing its quality. A small section explores problems lamented by industry. Each of these issues is presented and discussed, based on 82 papers published from 1980 to 2006. Some suggestions for further research conclude the essay.

Introduction

The Bayh-Dole Act of 1980 permitted U.S. institutions to patent federally-funded research results. The rapid spread of university patenting was encouraged by the attraction of having a blockbuster, such as Lycos' Internet search engine – Carnegie Mellon University has earned $25 million when the company went public (FLORIDA, 1999) – and the recombinant DNA gene-splicing patent, for which Stanford University earned $143 million [ODZA, 1996]. The Economist characterised the Bayh-Dole Act as

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"possibly the most inspired piece of legislation to be enacted in America over the past half-century", and suggested that it "helped to reverse America's precipitous slide into industrial irrelevance" [THE ECONOMIST, 2002 : 3].

Recently, Europeans started looking at the U.S. academia with a strong sense that whatever had been going on there was something to emulate. As a result, some countries, including Denmark, Germany, Austria, and Norway, reformed their laws to grant Intellectual Property Rights (IPRs) on public inventions to the employers [OECD, 2003], and others are considering similar reforms.

In the meanwhile, the limited empirical evidence concerning the Bayh-Dole suggested that the boost in the university entrepreneurial activities started before the passage of the Act, and was driven by contemporaneous shifts in IP laws [KORTUM & LERNER, 1999; MOWERY & AL., 2001; MOWERY & ZIEDONIS, 2002]. In addition, MOWERY & SAMPAT [2005] claim that much of the patenting activity that appears to have grown in the wake of the Act is a longstanding characteristic of the U.S. university system, that stems from its internationally unique scale and structure.

Despite the enthusiastic support by policymakers, management scholars raised concerns as early as in the late 1980s. However, most of the literature remained anecdotic or speculative until recently. This essay reviews more than eighty papers on potential negative effects from university patenting and licensing activities, and tries to illustrate or to contrast some widely-held beliefs with existing empirical evidence.

The importance of this issue stems from the relevance of the academia within the current innovation system. The positive contributions of public research to industrial innovation have been widely acknowledge in the past [MANSFIELD, 1991; ROSENBERG & NELSON, 1994]. As we are moving toward an era in which knowledge is both an important input and an important output of the production process, the traditional knowledge-generating institutions, like universities and research laboratories, are increasingly seen as key players within each national innovation system [ETZKOWITZ, 2002]. Therefore, any changes potentially altering the traditional ways in which the academia serves its teaching and research duties, can have profound consequences for the innovation system as a whole.

The rest of the paper is organised as follows. First, I report the methods for data gathering. In reviewing the relevant literature, I group papers according to their topics. While the researches can be categorised according to the level of analysis (the scientist, the laboratory, the university) or the nature of the data (self-reported opinions on Likert scales versus objective variables like patent counts) as well, I believe that my choice can facilitate the reader to have a complete overview of the current beliefs about each potential problem. Three main concerns can be identified in relation to university patenting activities: threats to scientific progress due to increasing disclosure restrictions; changes in the characteristics of the researches performed (declining patents' and publications' quality, skewing research agendas toward commercial priorities, and crowding-out between patents and publications); threats to teaching activities. A small section focuses on problems lamented by industry. A synopsis of the issues presented in this review is reported below, along with the papers discussing them (Table 1). This essay concludes with some suggestions for further research.

Table 1. Synopsis

Topic	Papers (chronologically listed)
Threats to scientific progress:	
• disclosure restrictions	COHEN & AL., 1994; RAHM, 1994; BLUMENTHAL & AL., 1996; LEE, 2000
• restrictions on data sharing	BLUMENTHAL & AL., 1997; CAMPBELL & AL., 2000; LOUIS & AL., 2001
• tragedy of anticommons	HELLER & EISENBERG, 1998; MAURER, 2006
• restrictions on research tools	WALSH & AL., 2003; NELSON, 2004; SAMPAT, 2006
Changes in the research:	
• decline of patents' quality	HENDERSON & AL., 1995; 1998; MOWERY & AL., 2001; 2002; MOWERY & ZIEDONIS, 2002; SAMPAT & AL., 2003; ROSELL & AGRAWAL, 2006
• substitution between basic and applied research	THURSBY & THURSBY, 2002; RANGA & AL., 2003; VAN LOOY & AL., 2004; AZOULAY & AL., 2006; SAMPAT, 2006; VAN LOOY & AL., 2006
• substitution between patents and publications	LOUIS & AL., 1989; AGRAWAL & HENDERSON, 2002; CARAYOL & MATT, 2004; LACH & SCHANKERMAN, 2003; AZOULAY & AL., 2005; GULBRANDSEN & SMEBY, 2005; MURRAY & STERN, 2005; POWERS & MCDOUGALL, 2005; STEPHAN & AL., 2005; AZOULAY & AL., 2006; MEYER, 2006A; 2006B; RENAULT, 2006
• decline of publications' quality	AGRAWAL & HENDERSON, 2002; LACH & SCHANKERMAN, 2003; MURRAY & STERN, 2005; MEYER, 2006A; 2006B
Threats to teaching activity:	
• decline of teaching time	STEPHAN, 2001; GEUNA & NESTA, 2006
• conflicts of interests	KENNEY, 1987; GLUCK & AL., 1987; MARSHALL, 2000; SLAUGHTER & AL., 2002
• decline of students' publications	GLUCK & AL., 1987; BLUMENTHAL & AL., 1996; BEHRENS & GRAY, 2001; LIN & BOZEMAN, 2006
• decline of informal learning	CAMPBELL & BLUMENTHAL, 1999
Threats to industry:	
• restrictions on university-industry communications	COHEN & AL., 1998; SCHMOCH, 1999; THURSBY AND THURSBY, 2000; COHEN & AL., 2002A; 2002B; THURSBY AND THURSBY, 2003; 2004; FONTANA & AL., 2006
• delays to industry innovation	COHEN & AL., 1994; BLUMENTHAL & AL., 1996; SIEGEL & AL., 2003; HERTZFELD & AL., 2006
• loss of proprietary information	BLUMENTHAL & AL., 1986; COHEN & AL., 1994; BLUMENTHAL & AL., 1996
• obstacle to new research fields	STEPHAN, 2001
• unreasonable cost increase (welfare reduction)	COHEN & AL., 1994; COLYVAS & AL., 2002; SIEGEL & AL., 2003; HERTZFELD & AL., 2006; LOWE, 2006

Methods

I gathered data using a three-stage strategy. First, I queried three subscription databases: ABI/INFORM, EBSCO, and EconLit, all of which are available through most universities, using as key-words “university”, “patent”, “license”, “Bayh-Dole”, “triple helix”, “secrecy”, “open science”, “academic entrepreneurship”, “anticommons”, “Mode 2”, and combinations thereof. I derived such list of key-words from my personal knowledge of the topic (stemming from eight years of research in the area of university patents), and I benefited from the suggestions by two anonymous reviewers. Given that the Bayh-Dole Act dates back to 1980, the timeframe utilised dated from 1980 to 2006. Secondly, from these results and from my previous knowledge of the topic, I drafted a list of scientific journals with impact factor (the last one available – relating to year 2005 – is provided in parentheses), in order to include those on which it was most likely to find papers pertaining to this review: *IEEE Transactions on Engineering Management* (0.864), *Industrial and Corporate Change* (1.169), *International Journal of Industrial Organisation* (0.620), *Issues in Science and Technology* (0.315), *Management Science* (1.669), *Minerva* (0.326), *R&D Management* (0.506), *Research Evaluation* (0.474), *Research Policy* (1.835), *Science Technology and Human Values* (1.439), *Scientometrics* (1.738), *Technovation* (0.497). Due to their relevance, I added three more journals – *Journal of Association of the University Technology Managers*, *Journal of Technology Transfer*, *Science and Public Policy* – and a well-known working papers database, that managed by the U.S. National Bureau of Economic Research (http://www.nber.org). The inclusion of working papers provides access to the most recent studies, yet it involves some risks since not all of them may stand up to peer review. I think that the Bureau’s database offers a good compromise, since several working papers have been subsequently published in peer-reviewed journals – almost verbatim. Also, it is by far the most important source of working papers that are cited in the works collected during the first stage.

I read the abstracts in each issue on the previous list in order to find pertinent papers, limitedly to those published from 1995 to 2006. The shorter period of observation compared to that of the first stage reflects a compromise between the need to focus on most recent and most prolific (in terms of publications) years, and the necessity to include most significant papers. Year 1995 coincides with the publication of the seminal working paper by HENDERSON & AL. [1995], which suggests that the university patents’ quality decreases as their quantity increases. This one is the first work specifically focused on measuring the effects of the Bayh-Dole Act, besides those on patent counts. Thirdly, I supplemented the review by some interesting studies (i.e. reporting innovative results and/or methodologies) that were cited in those collected during the first two stages.

Several papers focus on the broad topic of the entrepreneurial university and related issues. However, the present review will be almost limited to those contributions specifically analysing problems from university patenting and licensing activities. Therefore, a number of studies focusing on universities' patenting and licensing performances and their determinants, on a comparison between university patenting in the U.S. (and U.K.) versus continental Europe, on generic university-industry relations, on university spin-offs and incubators, will not presented due to methodological choice. In so doing, I preferred to give a quite exhaustive overview of a particular research area, rather than covering more diverse themes with a lower level of detail.

For a more general review of the patenting university, see BALDINI [2006]; for a specific focus on recent findings in the European context, see GEUNA & NESTA [2006]. For an analysis of university-industry knowledge transfer, see AGRAWAL [2001].

Threats to scientific progress

The priority-based system, which long directed the actions of researchers in the academia, encourages maximal knowledge diffusion [MERTON, 1973]. The disclosure of new ideas permits scientific progress, since it ensures higher quality to the extent to which methods and results are subjected to professional review and criticism, it reduces wasteful duplication of research efforts, and it increases the likelihood that research will contribute to further work [DASGUPTA & DAVID, 1994].

The role and the relevance of the open science model in shaping university activities is well documented. BALDINI & AL. [2007] surveyed the Italian faculty and specifically asked about the relation between the open science model and university patents. Faculty inventors rate the "open science mentality of the university" as the most important obstacle (on a twelve-item scale) suffered during their patenting activity. However, it is the least important reason (on a six-item scale) adduced by the non-patenting peers to justify their non-patenting behaviour.

Most of the papers on disclosure restrictions stemming from patenting activity are U.S.-based surveys in different settings (e.g. COHEN & AL., 1994; LEE, 2000; RAHM, 1994), in which over half of the respondents report to have been asked by firms that certain research findings be delayed or kept from publication. Some scholars focus on the life scientists, for which basic and applied research are proximate [STOKES, 1997], and restriction issues are more likely to occur. For example, BLUMENTHAL & AL. [1996] utilise survey data from 210 life-science companies (including most of those listed in the Fortune 500) and find that 82% of companies require academic researchers to keep information confidential to allow for filing a patent application, and 56% say that often or sometimes results are kept confidential even longer. Likewise, 88% of the firms report that students and fellows engaged in research relationships with them are required to keep some of the information emerged confidential.

A closely related problem is the disruption of the information-sharing tenet of university scientists. University research has been characterised by invisible colleges, small cooperative networks of information sharing with a high relevance of informal linkages [DASGUPTA & DAVID, 1994], that traditionally overcome boundaries of public research [ETZKOWITZ, 2003]. CAMPBELL & AL. [2000], based on a survey of a stratified, random sample of 2,366 faculty members in 117 U.S. medical schools (response rate 62.2%), estimate that 12.5% of all medical school researchers have data withheld from them between 1993 and 1995. The problem has proven to be more severe for star scientists [BLUMENTHAL & AL., 1997; LOUIS & AL., 2001; CAMPBELL & AL., 2000]. Indeed, withholding research data can provide a competitive edge [ROSENBERG, 1996].

To measure the restrictions posed by patenting activity on subsequent data sharing, MURRAY & STERN [2005] take 169 patent-paper pairs and a control group of publications for which no patent is granted. Publications are those appearing between 1997 and 1999 in *Nature Biotechnology*, where almost half of the published researches also led to a patent. Using a differences-in-differences estimator that accounts for fixed differences in citation rate across articles and relative to the trend in the control group, the authors show that citations received decline by between 9 and 17% after the patent grant. While the results should be interpret cautiously – citations are quite imperfect measures of data sharing – a dampening effect seems to have an empirical basis, although its modest size points against most catastrophic warnings.

A third variant of the problem discussed in this section is the so-called "tragedy of the anticommons". HELLER & EISENBERG [1998] introduced this concept to indicate that resources with fragmented ownership are often underexploited. MAURER [2006] recently provides an empirical example, by detailing how approximately one hundred academic database providers became deadlocked in trying to respond to a $2.3 million offer from industry to support a worldwide depository for human mutations data.

Finally, among disclosure restrictions, those on upstream research tools – i.e. when a university licenses exclusively or narrowly an invention that is potentially of wide use – are most dangerous for future scientific investigation [NELSON, 2004]. However, drawing on qualitative data gleaned from seventy interviews with U.S. attorneys, business managers, and scientists from twenty-five firms and six universities, WALSH & AL. [2003] show that almost none of the actors involved report promising projects being stopped because of access to IPRs on research tools. Moreover, industrial and university researchers seem to be able to develop working solutions that allow their researches to proceed. Changes in the institutional environment, particularly new pressures from powerful actors such as the U.S. National Institute of Health, also appear to reduce the threat of breakdown.

SAMPAT [2006] takes another perspective, that leads to more challenging results. Since several scholars (e.g. TRAJTENBERG & AL., 1997) propose that patents on basic scientific knowledge generate a higher level and share of non-patent references[1] than those based on (embryonic) technologies, he counts the non-patent references in all university patents granted between 1976 and 1996, and in a 1% random control sample. He finds that both the number and share of references to non-patent citations in the university sample are surging with reference to the control, suggesting that since Bayh-Dole universities are increasingly patenting science rather than technological outputs of their research.

Changing the characteristics of the researches performed

Under this heading, I group four potential threats: the skewing problem (substitution effect between basic and applied research), the crowding-out hypothesis (substitution effect between patents and publications), reduction of the publications' quality, decline of the patents' quality as patenting activities increase.

Chronologically, the latter problem is the first one to be deeply scrutinised. HENDERSON & AL. [1995, 1998] utilise a comprehensive database consisting of all patents assigned to universities or related institutions from 1965 until mid-1992, a 1% random sample of all U.S. patents granted over the same time period, and the complete set of all patents (granted after 1974) that cite either of these groups. Patent citation counts show that, during the 1980s, university patents decrease in importance (i.e. the number of citations received, proxying for the relevance of the university inventions to successive patented inventions) and generality (the degree of concentration of citing patents across technological classes, measuring the relevance of the university inventions to successive patented inventions in a broad spectrum of technological areas), so that by the late 1980s the authors cannot find any significant differences between the university and the control sample. Such decline is due to both an increase in the fraction of university patents receiving no citations, and to incumbent universities producing patents of lower quality. Mowery and colleagues [MOWERY & AL., 2001; MOWERY & ZIEDONIS, 2002] pick up the same quality measures and focus on patenting activity at the Columbia University, the University of California, and Stanford University. They find that the decline in the quality of university patenting is mainly due to entrant institutions in patenting, which nonetheless are catching up with incumbent ones. These findings are confirmed in a subsequent paper [MOWERY & AL., 2002] regressing patent citations on filing years and patent classes. Data refer to patents applied for by Carnegie institutions between 1981 and 1992 that are issued before 1994,

[1] Only novel invention are patentable. Novelty is tested against the relevant prior art, i.e. patents and publications containing related knowledge. The relevant prior art is included in the patent document and is referred to as references or citations.

and are analysed using a negative binomial specification. The thesis of the decreasing patent quality seems to be definitively overcome by SAMPAT & AL. [2003], who repeat the work by HENDERSON & AL. [1995, 1998] allowing for a longer period of observation for the citation counts, and find no change in the patent quality. The differences in the results is due to an increasing time needed by university patents to get cited.

A recent working paper by ROSELL & AGRAWAL [2006], however, challenges the agreement on this view. Although measures and econometric models do not allow for comparability with previous studies, results show a decrease in university patents' generality and originality (the concentration of cited patents across technological classes, measuring the degree to which university inventions draw on previous patented inventions in a concentrated spectrum of technological areas). The authors employ a differences-in-differences estimator to compare university to firm patents across two time periods (1980–1983 versus 1986–1989 for the measure of generality, and versus 1990–1993 for the measure of originality), allowing for a ten-year period of observation before/after the granting date. While it is argued that the reduction in the patent measures do not necessarily lead to a welfare cut, it is worthwhile emphasising that the observed changes are at least partially driven by most experienced universities, and thus they are unlikely to be temporary.

Turning to the skewing problem, THURSBY & THURSBY [2002] analyse the 64 U.S. universities responding to the AUTM survey in each year between 1994 and 1998. Using Data Envelopment Analysis, a nonparametric linear programming approach to comparing inputs and outputs, the authors find that the increasing university licensing is not due to the production of more applied research – and thus more inventions – but rather to an increased willingness to license available inventions. The authors also argue that their evidence is consistent with National Science Foundation, whose data on the average proportion of basic research to total research expenditures show a negligible decrease when confronting 1977–1980 to 1994–1998.

Two case studies focusing on the publications at the K.U. Leuven – the largest Belgian university and one with great (compared with the European average) entrepreneurial performances – point to analogous results. RANGA & AL. [2003] classify the publications by 22 research groups between 1985 and 2000, and determine their basic or applied nature according to the CHI classification system.[2] Their count data do not support the claim that a shift towards the more applied end would appear along with intensive university-industry collaboration. VAN LOOY & AL. [2004, 2006] show that faculty who systematically engage in contract research publish more (in applied fields) than their colleagues who do not engage, but not at the expense of the publications of a more basic nature. Moreover, scientific excellence (as measured by number and nature

[2] At a first level, the publications are categorised as either technology-oriented or science-oriented. At a next level, the basic and applied orientation are distinguished, resulting in the four-type categorisation.

of publications) and entrepreneurial performance (as measured by revenues) mutually reinforce thus resulting in a compound Matthew-effect[3] [MERTON, 1968]. Conclusions are drawn on ANOVAs and count measures on publication data for 14 research divisions over a ten-year period (1991–2000).

To study the issue of substitution effect between basic and applied research, AZOULAY & AL. [2006] develop several measures of the patentability of a research, to be tested in their dataset of 3,862 PhDs in scientific disciplines that have informed commercial biotechnology. They use title words in the publications of patenters, which are taken as the benchmark against which to compare the researches of the scientists who do not have patented (yet). The authors suggest that patenters may be shifting their research focus to questions of commercial interest. Results are consistent across different models, including Poisson (with robust standard errors) and fractional logit, with and without a correction that accounts for the dynamics of self-selection into patenting.

There is a growing literature concerning the relation between patenting and publication quantity and quality. While the majority of the studies suggest that patents and publications are not substitutes – and some propose that they are complements – this issue is still open, despite being the one including the larger number of papers. Major findings are presented in details in Tables 2a (reporting the relation between patents and publication quantity) and 2b (reporting the relation between patents and publication quality).

LOUIS & AL. [1989] first investigate this topic. Data are taken from a survey of 778 academic life scientist belonging to forty U.S. research universities and are analysed using an ordinary least square regression. The number of publications has significant positive effect on patenting activity, after controlling for research funds, industry funding, equity holding, and the fraction of the patenting faculty. Responses to the 1995 U.S. Survey of Doctorate Recipients point in the same direction. STEPHAN & AL. [2005] report a zero-inflated negative binomial model in which the number of publications has a strong and highly significant effect on the number of patent applications made, after controlling, among others, for gender, U.S. citizenship, tenure, involvement in R&D activity, and availability of federal support. Additional positive results are found by RENAULT [2006], using interview data on 98 professors at 12 universities in south-eastern U.S.

[3] Matthew-effect is used to refer to the fact that scientists with prior successes are able to attract greater resources (money, students, etc…) and be more fully informed about novel opportunities for progress on particular topics or phenomena (e.g., through co-authorships or participation at scientific meetings). Therefore, past success positively affects the probability of future success.

Table 2a. Patents and publications: complements or substitutes? Use of publication counts

Paper	University/ies	Observations	Method ([a])	Dep. var. ([b])	Indep. Var. ([b])	Effect ([c])
LOUIS & AL., 1989	40 U.S. universities of the 50 with most federal funds	778 life scientists (1985 survey)	OLS	dummy lifetime pat.	3-years pub. lifetime avg.	+
AGRAWAL & HENDERSON, 2002	MIT (dep. of Mechanical Engineering and Electrical Engineering & Computer Science)	213 professors (1983–97)	GLS, fixed effects	pat. (t)	pub. (t)	0
				”	pub. (t-1)	0
				”	pub. (t-2)	0
				”	pub. (t-3)	0
CARAYOL & MATT, 2004	Louis Pasteur University (Strasbourg)	83 labs (1993–2000)	OLS	pub. (t)/ faculty	pat. (t)/ faculty	+
LACH & SCHANKERMAN, 2003	102 U.S. universities responding to the AUTM survey for the years 1991–99	74 public univ. (1991–99)	OLS, 1-year lag Newey-West std. err.	disclosures (t)	pub. (t)/ faculty	0
		28 private univ. (1991–99)	OLS, 1-year lag Newey-West std. err.	disclosures (t)	pub. (t)/ faculty	+
AZOULAY & AL., 2005	U.S. doctor-granting universities (PhDs with informed commercial biotechnology)	3,884 scientists (1967–99)	logit, conditional fixed effects	dummy pat. (t)	pub. (t-1)	+
				”	pub. (t-2)	0
				”	pub. (t-3)	0
				”	cum. pub. (t-2)	0
			clustered logit	dummy pat. regime	pub. (t-1)	+
				”	pub. (t-2)	0
				”	pub. (t-3)	0
GULBRANDSEN & SMEBY, 2005	all (N=4) Norwegian universities	1,937 professors (2001 survey)	logistic	dummy lifetime pat.	1998-2000 pub.	0
STEPHAN & AL., 2005	U.S. doctor-granting universities (survey of Doctorate Recipients)	10,962 scientists (1995 survey)	zero-inflated negative binomial	1990-4 pat.	1990-4 pub.	+
			GMM neg. binomial	1990-4 pat.	1990-4 pub.	+

Table 2a. (cont.)

Paper	University/ies	Observations	Method ([a])	Dep. var. ([b])	Indep. Var. ([b])	Effect ([c])
AZOULAY & AL., 2006	U.S. doctor-granting universities (PhDs with informed commercial biotechnology)	3,862 scientists (1968-99)	clustered Poisson	pub. (t)	dummy pat. (t-1)	+
			”	”	dummy first pat.	+
			”	”	cum. pat. (t-1)	+
			Poisson, fixed effects	”	dummy pat. (t-1)	+
			”	”	dummy first pat.	+
			”	”	cum. pat. (t-1)	0
			Poisson, IPTCW	”	dummy pat. (t-1)	+
			”	”	dummy first pat.	+
			”	”	cum. pat. (t-1)	+
			clustered logit	dummy pat. (t)	pub. (t-1)	+
			”	”	cum. pub. (t-2)	0
			clustered logit	dummy pat. regime	pub. (t-1)	+
			”	”	cum. pub. (t-2)	0
RENAULT, 2006	12 U.S. Doctoral/Research Extensive univ., departments related to biotech and IT	97 professors (2003 survey)	logistic, GEE	dummy lifetime pat.	cum. pub.	+

[a] Clustered: robust standard errors, clustered on individuals. IPTCW: inverse probability and censoring weights. GEE: generalised estimating equations.

[b] 3-years pub. lifetime avg.: publications during an average three-year over the individual's lifetime; (t): count in year t; cum.: lifetime stock; cum. (t-2): stock up to year t-2; / faculty: count averaged per faculty member; dummy first pat.: dummy = 1 since the individual's first patent; dummy lifetime pat.: dummy = 1 if the individual has ever patented; dummy pat. (t): dummy = 1 if the individual has patents in year t; dummy pat. regime: dummy = 1 if the individual has patents in year t (observations discharged after first patent).

[c] Effect of the independent variable on the dependent one: + (positive, and significant at least at the 5%-level), 0 (non significant).

Table 2b. Patents and publications: complements or substitutes? Use of publication quality

Paper	University/ies	Observations	Method (a)	Dep. var. (b)	Indep. Var. (b)	Effect (c)
AGRAWAL & HENDERSON, 2002	MIT (dep. of Mechanical Engineering and Electrical Engineering & Computer Science)	213 professors (1983-97)	GLS, fixed effects	cum. cit. (t)	cum. pat. (t)	+
LACH & SCHANKERMAN, 2003	U.S. universities responding to AUTM survey	74 public univ. (1991-99)	OLS, 1-year lag Newey-West std. err.	disclosures (t)	cit. (t)/ faculty	+
					cit. (t)/ pub.	+
		28 private univ. (1991-99)	OLS, 1-year lag Newey-West std. err.	disclosures (t)	cit. (t)/ faculty	0
					cit. (t)/ pub.	-
AZOULAY & AL., 2006	U.S. doctor-granting universities (PhDs with informed commercial biotechnology)	3,862 scientists (1968-99)	clustered Poisson, with IPTCW	average JIF (t)	dummy first pat.	+ (p<10%)
			clustered Poisson	”	dummy first pat.	+

[a] Clustered std. err.: robust standard errors, clustered on individuals. IPTCW: inverse probability and censoring weights.
[b] (t): count in year t; cum. cit. (t): citation stock up to year t; average JIF (t): average of the JIF of the articles published by the individual in year (t); / faculty: count averaged per faculty member; / pub.: count averaged per publication; dummy first pat.: dummy = 1 since the individual's first patent.
[c] Effect of the independent variable on the dependent one: + (positive, and significant at least at the 5%-level or less), – (negative, and significant), 0 (non significant).

AZOULAY & AL. [2005] introduce a longer time dimension in the analyses: their dataset spans the careers of almost 4,000 academic life scientists. Using a combination of discrete-time hazard rate models and fixed effects logistic models, they argue that university patenting reflects both the influence of demographic factors (with mid-career academics being much more likely to patent), variation in scientific opportunities (patenting is often accompanied by a flurry of publication activity in the year preceding the application), and other environmental factors (the magnitude of the flurry of publications decreases with the presence of a patenting co-author and with the intensity of patenting activity in the scientist's university). Thus, the crowd-out hypothesis between patents and publications is unlikely to hold true. Additional research (AZOULAY & AL., 2006) accounts for the dynamics of self-selection into patenting by the means of inverse probability of treatment and censoring weights, and shows that patenting has a positive effect on publication counts, but no effect on their quality.

AGRAWAL & HENDERSON [2002] develop a case study on the Departments of Mechanical and Electrical Engineering at MIT during the period 1983–1997. They investigate patent and publication data using fixed effect panel regressions. On one hand, they find no effects for patents on publications, nor for publications on patents. On the other hand, when citations are used in lieu of counts, the stock of patents is positively related to the stock of paper citations, even after controlling for the stock of papers, and for the years the professor has been active. While adopting a different level of analysis, it is worth remembering here the study of patent-publications pairs by MURRAY & STERN [2005], in which a negative effect of patents on citations emerges.

GULBRANDSEN & SMEBY [2005] use publications to predict the probabilities that faculty members report patents, and find non-significant impact. The logistic regression is based on a 2001 questionnaire among all (N=1,937) faculty members at Norwegian universities. Nonetheless, the results may depend on the authors' strong assumption that the patterns are relatively stable: publications are measured on a three-year window, while commercial outputs are not limited to a specified period of time.

MEYER [2006A, 2006B] examines researchers in nanoscience and nanotechnology for United Kingdom, Germany, Belgium, and compares frequency data for publications and patents. Scientists are grouped into five quintiles according to the respective performances. While inventor-authors apparently outperform their non-inventing peers in terms of both publication and citation frequencies, they are not at the very top of the most prolific and highly cited authors. This would suggest that researchers pay a price – although small – by combining publication with patenting activity. When turning to co-authorship counts, inventors-authors are over-represented in the better performance classes and under-represented in the lower ones [MEYER, 2006A]. The results nonetheless should be taken very cautiously, since they are based on descriptive statistics only.

Whereas the preceding analyses – with the exception of MURRAY & STERN [2005] – focus on the researcher-level, CARAYOL & MATT [2004] choose the laboratory-level and investigate the research activity of eighty-three labs belonging to Louis Pasteur University (France), over the period 1993–2000. Using an ordinary least square regression, they find that patents have positive effect on publication performances, after controlling for size, scientific/technological specialisation, and professional status.

Finally, LACH & SCHANKERMAN [2003] and POWERS & MCDOUGALL [2005] use university-level data. In the first case, the authors examine a panel of 102 U.S. universities for the years 1991–1999. They use several ordinary least square regressions with Newey-West standard errors and show that publications per faculty have positive effect on invention disclosures for private universities but not for public ones, after controlling for the number of citations per publication. The latter, in turn, has positive effect on invention disclosures for public universities, and negative effect for private ones. In the second case, POWERS & MCDOUGALL [2005] collect paper and start-up information for 120 U.S. universities between May 1996 and June 2000. Two cross-sectional negative binomial regressions show that the log of paper citations has positive effect on both on the number of start-ups formed and on the number of start-ups that went public, after controlling, among others, for size, patent importance, TTO's age, and university endowments.

Threats to teaching activity

The topic of the impact upon teaching activity of increased patenting has been severely neglected. Furthermore, most conclusions are anecdotic or speculative. To make this section more informative, I have therefore included some papers examining the more general argument of the effects on students from tighter university-industry relations.

It has been suggested that the student-teacher relationship can suffer in four common ways. First, some authors (e.g. STEPHAN, 2001; GEUNA & NESTA, 2006) propose that teaching is the activity likely to suffer the highest time and commitment reduction from the engagement in patenting. Given that the actual reward system of university professors does not place a heavy weighting on teaching, the faculty will move efforts from teaching to patenting. This problem is likely to worsen if patents are included in the criteria for career advancement, as it is already happening in some countries, and as it is recommended by some policy reviews [OECD, 2003].

Secondly, KENNEY [1987] warns that a professor could very easily direct a student into topic areas that are useful for his/her firm, thereby using the student as a low-paid employee, or could transfer the unpublished results of a student's work or ideas to his/her company. As reported in the thirty-seven semi-structured interviews by SLAUGHTER & AL. [2002], the professors themselves are aware of these potential conflicts of interests, and some figure out ways to handle the conflicts between the sponsors' pressure to patenting and the students' need to publishing. In 1985, GLUCK & AL. [1987] collected survey data from 700 life science graduate students and post-doctoral fellows at six research intensive U.S. universities. Many among respondents receiving training grants or scholarships from industry report that firms limited their choice of research topics, required them to perform some work in return for the support, or to work for the supporting company after completing their training. For better or worse, there is a lot of money surrounding inventions, specially biomedical ones, and MARSHALL [2000] argued that this has changed the relationship of trust that many students presume between them and their faculty advisors.

Thirdly, students with direct support from industry report significantly fewer publications on average than do those with no industry support or those whose faculty advisors receive funds from industry [GLUCK & AL., 1987]. The previously cited survey of 210 life-science companies by BLUMENTHAL & AL. [1996] points to the same results: over half firms sponsoring graduate students or postdoctoral fellows require them to keep emerging proprietary information confidential.

These findings are questioned by BEHRENS & GRAY [2001], and their own survey (dating back to 1988–1989) of a stratified sample of 482 graduate students from largest research universities participating to the NSF's Industry-University Cooperative Research Centres Program. The most striking differences are not between industry- and government-supported projects but between sponsored projects and projects with no external sponsor. Students performing research with no external sponsor are involved in such research for shorter time (compared to government-sponsored research), perceive their project to be shorter term in its goals, and produce fewer publications. The sample is limited to two engineering departments of Industry-University Cooperative Research Centres, chemical and electrical, and this choice might explain the differences with the results from Gluck et al., which focus on life sciences at six research intensive universities.

LIN & BOZEMAN [2006] analyse 443 curricula of personnel affiliated with NSF- and DOE-sponsored university research centres and obtain mixed results. They use ordinary least square models controlling for age, gender, academic rank, number of collaborators, and ability to obtain research grants. Industry experience has a negative and significant effect on total career publications, but it turns out to be positive and significant when an interaction term between age and industry experience, which in turn is negative, enters in the model. The authors also find that faculty with prior work experience in the private sector support more Ph.D. and Master students throughout their careers than their colleagues with no industry experience. The result holds when the period of observation is limited to the five years preceding the survey (1996–2000). Given that the university's mission includes training students in state-of-the-art techniques, ensuring that graduates meet industry's needs, creating job placements and increasing the career opportunities for graduate students, this paper suggests that more variables should be used when trying to assess the net effect of university patenting activity.

Fourthly, in addition to classes, students learn through their work in laboratories and through informal discussions with other faculty, staff, and students. Anecdotal evidence suggests that joint university-industry research and commercialisation may limit learning from these less formal interactions as well [CAMPBELL & BLUMENTHAL, 1999].

Threats to industry

Among possible negative effects from university patenting activity, some relate to industry. While this issue is even less explored than threats to teaching, in the long run several problems which I reviewed in the preceding sections will concern industry R&D, too. The limitations on knowledge diffusion posed by patenting activity intervene on the most important media through which universities contribute to technical advance. In fact, as shown by the Carnegie Mellon Survey [COHEN & AL., 1998, 2002A, 2002B] and others [SCHMOCH, 1999], the dominant channels of communication between university research and industrial R&D are publications, informal channels, public meetings, and conferences. Additionally, a survey of 112 business units that had licensed-in technologies from U.S. universities between 1993 and 1997 [THURSBY & THURSBY, 2000, 2003, 2004) shows that personal contacts with faculty are the most important source for identifying the technology, while journal publications and presentations at professional meetings are as important as patent searches, and more important than TTOs' marketing efforts. Furthermore, the KNOW survey carried out in seven EU countries during year 2000, shows that the fact that SMEs screen information from scientific and business journals is a strong predictor of the likelihood to cooperate with universities [FONTANA & AL., 2006].

Industry partners of University-Industry Research Centres surveyed by COHEN & AL. [1994] are concerned with university wrangling over IPRs, and particularly with the time delays this may cause. Also, they are concerned that even though they fund research up front, they are forced into unfavourable negotiations over IP when something valuable emerges. 54% of the respondents to the survey of life-science companies by BLUMENTHAL & AL. [1996] mention that the most common obstacles to university-industry relations are university bureaucracies that make it too complicated to conclude an agreement, and 34% of companies report having disputes with their academic partners over IP. While based on very limited numbers, both works by SIEGEL & AL. [2003] – on five major public and private research universities in Arizona and North Carolina – and by HERTZFELD & AL. [2006] – on research joint ventures disclosed to the Department of Justice and the Federal Trade Commission between 1995 and 1998 – report the same problems.

Moreover, companies are concerned that university will share some vital information with their competitors, because each academic institution normally cooperates with several firms [COHEN & AL., 1994]. 58% of the biotechnology companies responding the 1984 survey by BLUMENTHAL & AL. [1986] rate a loss of proprietary information as the main perceived risk in collaborating with university, and 30% of the respondents to the subsequent 1994 survey [BLUMENTHAL & AL., 1996] report that conflicts of interests have effectively developed when the academic institution became involved with another company.

STEPHAN [2001] shows that technology transfer can also lead to the process of industry eating the seed corn for a new field. She analyses the case of bioinformatics and shows that universities were slow to start new programs in this area, because when the need was identified in industry, the first response of industry was to go to academia and hire away the star faculty, and in so doing ate the seed corn required to train additional individuals in the field.

Finally, eleven case studies by COLYVAS & AL. [2002] suggest that IPRs seem unimportant for non embryonic inventions, and indeed may hinder their transfer, by increasing the inventions' costs to allow the universities to collect revenues. A theoretical model by LOWE [2006], indeed, shows that royalties lead to sub-efficient results when the invention is licensed to a university spin-off, and that pure fixed fee contracts (e.g. the university merely takes a portion of equity in the inventor's firm) should be preferred.

Conclusions

As emerged from this review, it is difficult to arrive at simple policy prescriptions. Among the reasons, the fact that the effect of incentives for the commercialisation of university research depends on individual characteristics. Indeed, a theoretical model by JENSEN & THURSBY [2004] shows that, if faculty view both basic and applied research as goods, then it is not obvious whether policy changes that create incentives for the commercialisation of university research result in a substitution of applied for basic research. The effect depends on how such changes influence individual researchers' marginal rates of substitution between basic and applied research, and between either type of research and income. As well, the effect of policy changes that create incentives for the commercialisation of university research on the quality of education depends on how it influences the teaching load and the amount of patentable knowledge used in education. Moreover, additional models by THURSBY & AL. [2005] show that licensing yields a higher ratio of applied to basic effort throughout the life cycle, but this diversion does not mean that basic research is compromised. In fact, leisure is the activity most compromised, and in most of the models basic effort rises with the introduction of licensing. The implications of licensing for research output and for the stock of knowledge depend, not only on the effect on applied and basic effort, but also on whether applied effort contributes to the stock of knowledge. When applied effort adds nothing to the stock of knowledge, licensing reduces research output, but if applied effort leads to publishable output as well as licenses, then research output and the stock of knowledge are higher with licensing than without. When tenure is added to the model, licensing has a positive effect on research output except when the incentives to license are very high.

Nonetheless, we have learned much from this review. There are two related areas of intervention: one is the definition of what is patentable by whom, and another is the incentive system for professors and universities to engage in patenting activities.

If we give credit to the finding that patents and publications are complements, we cannot advocate the elimination of the Bayh-Dole Act, and of similar legislations around the world. Instead, appropriate incentives should be promoted in order to foster a balanced position between the old missions of research and education and the new entrepreneurial task. At the same time, limiting the existence of broad patents and the establishment of IPRs on inventions that are far way from practical application should be considered as a solution to one of the most urgent threats to an efficient and effective advance of the frontier of science. In particular, an issue that has no clear solution yet is that of the research exemption, in particular after that U.S. Federal Circuit – in its decision on Madey vs. Duke, 2002 – squarely held that basic research in universities is not exempt from infringement liability. NELSON [2004], elaborating on the proposal put forth by Rochelle Dreyfuss, suggests that non-profit labs should be granted research exemption if access to what is patented is not available on reasonable terms, and if the university agrees not to patent anything that comes out of the research, or to patent it allowing for non-exclusive royalty-free licensing.

While some suggestions about the appropriate tax rate on income-generating activities have been proposed to reach the social optimum (e.g. BEATH & AL., 2003), several of the preceding theoretical propositions need to be tested empirically in real settings. In particular, the effect of university patenting activities on students' learning and education, and on the knowledge spillovers to industry, both need additional investigations. The scientific and technical human capital model proposed by LIN & BOZEMAN [2006] is quite interesting, as it suggests that potential dampening effects on research stemming from commercial activity should be compared with the positive effects on the university ability to place students. University patenting might alter the apprentice scientists' intrinsic preferences for science versus technology, produce lower quality trainees (whose experience is mainly on the applied side of the research continuum), or facilitate their job searches in the private sector. Therefore, patenters may encourage their students to select private-sector careers above academic posts. Conversely, if patenters enlist the help of trainees in the research streams that lead to patents, and if these projects are different from the research topics chosen by non-patenters, apprentices training under patenters may be less appealing to academic departments.

At the same time, IPRs may have positive results as well, as they may enhance incentives for research by industry. If IPRs lead to more effective commercialisation, and if university inventions are embryonic, private sector organisations are likely to increase their research activity. This issue has not been investigated, yet.

AZOULAY & AL. [2005] register a flurry of publications in the year before the patenting date, using U.S. figures: it may be worthwhile to make a comparison with European data, where no grace period[4] is available. A preliminary test involves the data by AZOULAY & AL. [2005] and requires minimal work: a comparison between publication activity for inventors of U.S. patents only and for authors whose patents are extended abroad. In the latter case, in fact, the inventors are likely not to take advantage of the grace period, given that publications are included in the prejudicial disclosures by foreigner patent authorities. Results from such analyses may suggest if the grace period is worth to be taken as an international rule, as it helps to mitigate the disclosure restrictions/delays caused by patenting activity.

Some studies (e.g. LACH & SCHANKERMAN, 2003) investigate the impact of the royalties shared by the university with the inventors on university licensing income. The effect of royalties on publication quality and quantity (and on patent quality) remains an open empirical question. The relation between royalties and output variables should be investigated in depth, in order to discern if it is continuous or there is some sort of threshold effect, as implications would be very different in the two cases. Also, the field would very much benefit from more detailed studies that explore the impact of the variance in licensing agreement terms on publications, since there are different licensing contracts (royalties, sponsored research, equity, etc…), which have different effects on inventors' commercial behaviour.

It has been suggested that the development and the enforcement of strict ethical codes of conducts is a requisite that should precede the university's engagement in patenting and licensing activities [GEUNA & NESTA, 2006]. In Europe there is an urgent need for the development of codes of conduct that would help researchers to manage conflicting pressures. To my best knowledge, there are no studies analysing the diffusion, the content, and the effectiveness of such ethical codes. This topic is worth to be further investigated.

Among potential negative effects, there are the financial costs of university patenting. With the exception of TRUNE & GOSLIN [1998], who suggest that universities are not making money in their technology transfer programs, based on estimates from

[4] An invention cannot be patented if it was known or previously used. Thus, in most patent systems, including the European one, publication prevents the possibility to patent. On the contrary, according to the U.S. patent system, there is a grace period of one year after the first publication within which the inventor can file a patent on the invention.

the 1995 AUTM licensing survey, this topic remains anecdotic, and deserves further attention.

Finally, replication has great value in social science research, but little application (for a review, see PARK, 2004). Many studies reported in this essay focus on a limited context, i.e. one research area (mainly the biotechnology) or one country (for the most part the U.S.). In future research, it might also prove worthwhile to extend some of the preceding analyses to different countries and different disciplines, and it would be interesting to disentangle the differential negative effects from patenting among different types of universities – in different geographic areas or economic contexts, or among those who have different structural characteristics.

In particular, the existing focus on the life sciences, where the entrepreneurial activity is higher, might have led to overrate some potential negative effects. Also, no cross-country surveys exist, except for the OECD's patenting and licensing one, which anyway declares some sample and response biases that might seriously limit cross-country comparisons. Finally, surveys are cross-sectional: a concern is to conduct investigations that more clearly monitor trends over time.

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