

Scientists' perspectives concerning the effects of university patenting on the conduct of academic research in the life sciences

Lee Davis, Maria Theresa Larsen* and Peter Lotz

Copenhagen Business School, Department of Innovation and Organizational Economics, Kilevej 14A, 2000 Frederiksberg, Denmark

* Corresponding author: Tel.: +45 3815 2543; Fax: +45 3815 2540; Email: mtl@cbs.dk

Abstract

This paper explores scientists' perspectives on the possible "unintended effects" of university patenting on the definition of academic research agendas and on the norms of open science. Based on a survey of life science researchers in Denmark, we found that a substantial proportion of scientists were skeptical about the impact of university patenting. The most skeptical respondents were scientists oriented towards basic research (particularly the less productive ones), recipients of research council grants, scientists with close relations to industry, and full professors. Highly productive scientists were less concerned. Our results have implications for understanding the ultimate success or failure of academic patenting policies, including how increased university patenting may be affecting how scientists conduct academic research.

Keywords: Universities – Academic patenting – Scientists' perspectives – Life sciences

JEL codes: I23 – L30 – O31 – O34

1 INTRODUCTION

Recent years have witnessed a surge in the patenting and commercialization of academic research, bolstered by a range of policy initiatives and legislative changes. The most notable of these is the American Bayh-Dole Patent and Trademark Amendments Act of 1980, which granted universities the right to patent and license discoveries resulting from federally funded research. A number of European countries have taken or are presently considering similar measures (Geuna and Nesta, 2006; Verspagen, 2006).

As academic scientists have thus come under increasing pressure to apply for patents, a lively debate has emerged in the academic literature about its possible implications. But while numerous studies have examined the effects of patenting on the transfer of academic science to industry (e.g. Di Gregorio and Shane, 2003; Etzkowitz and Leydesdorff, 2000; Etzkowitz et al., 2000; Meyer, 2006; O’Shea et al., 2005; Shane, 2004), less is known about its long-term, unintended consequences.

We label these consequences “unintended” because the purpose of the Bayh-Dole Act and similar measures has been to enhance the commercial exploitation of academic research. Arguably, these measures reflect an implicit assumption by policy-makers that scientists’ research activities *per se*, and into the future, will not be affected. In other words, scientists are expected to continue to generate a stream of original (and potentially exploitable) research results. This assumption has been challenged, raising concerns that university patenting may have unintended negative effects on the progress of science itself (Azoulay et al., 2007; Mowery et al., 2001). It is this that forms the focus of our study.

But how can these effects be investigated? We decided that the best approach would be to tap directly into the source of scientific discoveries and inventions, namely the scientists themselves, as individual scientists’ views on patenting determines their willingness to disclose inventions and engage in patenting activities, and therefore ultimately also determines the success or failure of academic patenting policies. As far as we are aware, no one has yet asked the scientists themselves what they perceive to be the effects of university patenting, or investigated how these perceptions might be affecting how scientists define and carry out their research.

In this paper, we investigate two possible unintended effects. Drawing on an original survey of university researchers within the life sciences in Denmark, we first asked respondents to assess how they believed that the patenting of scholarly research had affected the freedom to choose research subjects according to academic criteria in their field. Second, we asked how they believed patenting had affected the openness with which research results are disclosed, communicated, and shared within their field, what is more generally referred to as the “norms of open science”. 27% of our respondents believed that patenting had a negative impact on academic freedom, while 41% believed it had a negative impact on the norms of open science.

We then sought to determine what characterized the scientists who were more negative, and more positive, in these regards. We found that scientists oriented towards basic research, and recipients of research council grants, were highly concerned that university patenting would negatively affect both the ability to define research agendas according to academic criteria, and the openness with which research results is communicated within their field. The less productive basic researchers were especially concerned about the effects on academic freedom. Scientists who had previously worked in industry, and full professors, were skeptical as well, particularly as regards the effects on academic freedom. Older researchers were concerned about the effects on the norms of open science. Highly productive researchers, by contrast, were less concerned about either effect.

The paper is organized as follows. In Section 2, we explore the two possible unintended consequences of university patenting on the conduct of academic research that form the focus of our analysis. In Section 3, based on the theoretical and empirical literature on the nature and effects of university patenting, we build an analytical framework to explain what might characterize the scientists who are more (or less) skeptical. This forms the basis for our hypotheses. Section 4 presents our research design, and Section 5 our results. Section 6 discusses some of the implications of our analysis, followed by the conclusion.

2 THE IMPACT OF UNIVERSITY PATENTING ON ACADEMIC RESEARCH

University researchers are motivated by a different set of values than their counterparts in business (Dasgupta and David, 1994; Merton, 1973; Siegel et al. 2003). Industrial scientists operate within a community of “proprietary science,” and are therefore concerned chiefly with the appropriation of rents from the knowledge and inventions they bring forth. Their research agendas are determined according to their companies’ larger missions and goals. Academic scientists, by contrast, have traditionally defined their own research priorities, and operated within a community of “open science,” governed by the Mertonian norms of universalism, disinterestedness, originality, skepticism, and communalism, the belief that knowledge and discoveries generated through publicly funded research should be placed in the public domain.

How might university patenting influence how scientists define and carry out their academic research? The freedom to choose research subjects according to academic criteria has long been at the heart of university research. Traditionally, scientists have been motivated to engage in research by a combination of intrinsic rewards (satisfying their curiosity to solve intriguing puzzles) and external rewards (“winning the game” by being the first to publish their results, leading to both peer recognition and, possibly, financial gains) (Stephan and Levin, 1992; Stephan et al., 2007).

A key concern is that increased pressures to patent might adversely affect the efficiency of this incentive structure (Dasgupta and David, 1994; Merton, 1973), skewing research priorities towards commercially

viable, marketable research at the expense of fundamental research, effectively curbing scientists' freedom to pursue their curiosity-driven academic agendas (e.g. Florida and Cohen, 1999; Henderson et al., 1998; Lee, 1996). Academic patenting might thereby contribute to a less efficient division of labor between public and private science, shifting academic scholars away from the activities in which they are most efficient – that is, supplying a collective good (Feller, 1990; Metcalfe, 1998; Nelson 1959, 2001) – and causing universities to “behave more like firms” (Verspagen, 2006, pg. 8).

Thus the first possible effect of patenting concerns who chooses the research agenda. The traditional university research model enables the individual professor to choose research questions based on his/her judgment as to whether the research will have scientific merit. The freedom to choose research subjects may come under pressure if universities are encouraged or even forced to produce patentable research results, which may mean that non-patentable research activities are discouraged.

The second possible effect of academic patenting concerns how it has affected how scientists disclose, share and publish their research. Traditionally, in exchange for adding to the stock of public knowledge, academic researchers have been rewarded with peer esteem, promotions, research grants and scientific prizes, based on the magnitude of their achievements. Because other scientists can test these published results, disclosure also creates social value. Peer review ensures the cumulative quality and reliability of scientific results, and that scientists do not wastefully repeat previous work. But university patenting might, for example, lead scientists to restrict communication with colleagues due to confidentiality clauses required by business partners (Blumenthal et al., 1996), limit or delay publication of findings (e.g. Calderini and Franzoni, 2004; Lee, 2000; Thursby and Thursby, 2002), engage in increased secrecy with regard to research methodology and results (Blumenthal et al., 1986), and withhold data (Campbell et al., 2000).

Closely related to these concerns is the anti-commons hypothesis, which argues that patenting may hinder the flow and diffusion of scientific knowledge (e.g. David, 2003; Heller and Eisenberg, 1998). Increased use of IPRs “privatizes” the scientific commons and limits scientific progress (Argyres and Liebeskind, 1998; Heller and Eisenberg, 1998). Specifically, IPR may inhibit the free flow and diffusion of scientific knowledge and the ability of researchers to build cumulatively on each other's discoveries (David, 2003; Etkowitz, 1998; Krinsky, 2003). Thus, university patenting may obstruct rather than promote continued scientific advance, particularly when combined with restrictive licensing terms (e.g. Mazzoleni and Nelson, 1998; Mowery et al., 2001).

In the next section, we discuss the importance of examining scientists' perspectives on these possible effects of patenting for understanding how the conduct of academic research may be affected.

3 ANALYTICAL FRAMEWORK

3.1. Possible determinants of scientists' attitudes towards university patenting

In choosing to analyze scientists' perspectives, we recognize that attitudes are subjective measures, not objective facts. But numerous studies have examined different aspects of scientists' perceptions of academic patenting, university-industry collaboration and technology transfer. Scientists' attitudes toward patenting and their motivation to disclose inventions to their universities (so that the inventions may, if desired, be commercialized) have been found key to the success or failure of academic patenting policies (e.g. Baldini et al., 2005; Bercovitz and Feldman, 2008; Blumenthal et al., 1996, 1997; Campbell et al., 2000; Gulbrandsen and Smeby, 2005; Lee, 1996, 2000; Louis et al., 1989; Moutinho et al., 2005; Owen-Smith and Powell, 2001; Renault, 2006; Siegel et al. 2003; Van Dierdonck et al., 1990).

Several authors have called attention to the importance of the individual researcher for the commercialization of academic research. The success of patenting and licensing policies is ultimately a matter of personal choice (Lee, 2000), dependent on scientists' willingness to disclose and patent their inventions (Renault, 2006). This willingness, in turn, is based on their perceptions of the effects of academic patenting and of the costs and benefits that patenting activities entail for individual researchers (e.g. Bercovitz and Feldman, 2008; Moutinho et al., 2005; Owen-Smith and Powell, 2001; Thursby et al., 2001). As Levinthal and March (1993) have argued, organizations and the individuals within them learn by drawing on personal experience or inferences from information about experience gained by others (see also Simon 1955, 1979).

A wide range of factors are thus likely to influence individual perspectives. For this study, we sought to identify what key experiences in the scientists' professional lives might best help us to understand their attitudes towards the "unintended" effects of university patenting on the conduct of academic research. We investigate three sets of factors that might be important. The first concerns the nature of the scientists' research. Scientists can choose to specialize mainly in basic research, in applied research, or in some combination of the two. To the degree that they see university patenting as compatible with the kind of research they do, they will arguably be more positive about its impact, both on the definition of their own research agendas, and the norms of open science. To the degree that they see patenting as somehow detracting from their research, they will probably be more negative.

The second factor concerns publication activity. Publishing and patenting represent the two major ways by which scientists can report their research results. Arguably, if they see patenting activities as somehow contributing to or enhancing publication productivity, they are more likely to be positive about the impact of university patenting. But if they regard patenting more as a burden, taking precious time away from publishing in refereed journals, they are likely to be more negative.

The third factor concerns the scientists' relations to industry. Some scientists keep their research activities mainly within the academic community. Others are more involved with business, where patents have long been central to R&D choices and marketing. Logically, scientists who have worked closely with companies are likely to be more aware of the constraints that patenting can put not only on the freedom to define academic research agendas, but also on the ability to share and communicate research results.

3.2. The relationship between patenting and basic research

First, we believe that scientists who are highly oriented towards basic research are more likely to be skeptical about the effects of university patenting than scientists who focus more on applied research. For one thing, it may be more difficult to patent the results of basic research. To be patented, an invention must be novel, non-obvious, and industrially useful. This third requirement may exclude much basic research from patentability. If scientists perceive that increased pressures to patent are somehow forcing them to change their research agendas so as to produce more patentable research, they might well be apprehensive about the possible effects of patenting on their academic freedom.

In addition, basic researchers will probably tend to subscribe more to the Mertonian norms of universalism and disinterestedness than applied researchers, and thus see patenting as placing limits on the openness which is vital for basic research. The growing privatization of the scientific commons (Nelson, 2004) might be particularly disquieting when patented inventions are embryonic, typically requiring extensive development and refinement before commercialization is possible (Mazzoleni and Nelson, 1998), something which is often the case for university inventions (Jensen and Thursby, 2001). Basic research can potentially provide key building blocks for future research, inspiring other scientists to pursue related puzzles, sometimes advancing in unexpected directions. If other scientists do not have full public access to the fruits of basic research, work on these new areas of inquiry may be delayed, or even lost. Applied research is by definition more incremental, as well as ripe for commercial exploitation, without the same potential to open up promising new lines of research.

This leads us to pose our first hypothesis:

***Hypothesis 1:** Scientists who are predominantly oriented towards basic research are more likely to be negative towards the effects of university patenting on the conduct of academic research.*

3.3. The relationship between patenting and publishing

No studies, to our knowledge, have explored how scientists' publication productivity might be related to their attitudes towards university patenting. The work that comes closest is the growing body of literature

that explores whether or not there is a link between researchers' proclivity to apply for patents and to publish articles in refereed journals. The same research program may generate results that are both publishable and patentable (e.g. Agrawal and Henderson, 2002, Azoulay et al., 2007; Fabrizio and DiMinin, 2005; Murray and Stern, 2007). As a result, both activities might well arise together naturally, as the scientist moves along a particular research trajectory (Azoulay et al., 2007). According to Murray and Stern (2007), for example, most of the key milestones in biotechnology research have been disclosed as patent-paper pairs, including the techniques of recombinant DNA and the discovery of the HIV retrovirus. A highly productive scientist might thus be more likely to also generate patentable results and might therefore be more positive towards patenting.

Alternatively, and also supporting a positive relationship, it may be argued that highly productive scientists might not feel threatened by pressures to patent, since such scientists enjoy more freedom than lower-ranking peers. They may feel themselves to be somewhat immune to potential requests for patenting.

In other words, highly productive scientists may either already take patenting as a natural part of their research, or they may be "high-flyers" beyond the reach of patenting demands. In both cases, the result probably is a less apprehensive attitude to university patenting.

This leads us to pose our second hypothesis:

***Hypothesis 2:** Scientists who have published extensively in refereed journals are more likely to be positive towards the effects of university patenting on the conduct of academic research*

3.4. The relationship between patenting and relations with industry

Third, close relations with industry – like research collaborations, the receipt of an industry grant, or previous work experience with a company – might play a role in the scientist's attitude to patenting. Little has been written about the possible relationship between the scientist's participation in university-business research collaborations, and his or her attitudes towards university patenting. But it seems reasonable to expect that experience with industry would make scientists more aware of how the prospect of patentability influences corporate research agendas.

Scientists with such relations would accumulate first-hand experiences about the effects of patenting on scientific research. In the context of this paper, scientists would thus become acutely aware of what might happen to university research if academics were put under more pressure to patent. Perhaps they witnessed heavy handed top-down research management control with research agendas. Perhaps they experienced restrictions regarding which of the joint research results researchers could openly discuss at scientific conferences. Perhaps they experienced publication delays. While such restrictions are necessary for commercial research, university scientists might well oppose the extension of the same logic to academic

research. Assuming that our respondents have deliberately chosen to be university researchers, we therefore expect the respondents to be more negative towards university patenting the more they know about the functioning of industrial research

This discussion leads to our final hypothesis:

***Hypothesis 3:** Scientists who have been involved in relationships with industry are more likely to be negative towards the effects of university patenting on the conduct of academic research.*

4 DATA AND METHOD

4.1 Data

This paper draws on data collected via an online questionnaire sent to academic researchers in Denmark, working within the life sciences. Following the U.S. National Science Foundation, the “life sciences” were defined as consisting of the biological sciences, medical sciences, agricultural biology, and environmental biology.

The survey was developed by two of the authors and carried out by UNI-C, an institution under the Danish Ministry of Education that provides a broad range of services for the educational and research community. All relevant Danish university departments, hospital departments and non-profit research institutions were identified. In October 2005, a letter was sent to the heads of these departments and institutions, asking them to participate in the survey and to identify relevant potential respondents from their institutions. In November 2005, information packets were sent to the heads of the participating departments and institutions, who were asked to distribute them to a total of 1,744 potential respondents. All respondents were guaranteed anonymity, both to us and to the heads of their departments and institutions. The survey was completed by the end of January 2006 and yielded 581 responses, for a response rate of 33%. 43% of the respondents were employed by a university, 41% by a hospital, and 16% by a non-profit research institute.

Because of significant variation in scientists’ perspectives toward academic patenting in these three types of academic organizations, we restrict our analysis in this paper to university scientists. To increase the chances that their responses are based on at least a minimum amount of research experience, we included only respondents who were aged 30 or above. This yielded 239 observations.

4.2 Dependent variables

We employ two dependent variables. Questionnaire respondents were asked to indicate what they believe to have been the impact of university patenting on academic freedom and the norms of open science. More

precisely, respondents were asked to “evaluate what you believe has been the impact of patenting activities by academic researchers on your field as regards (1) the freedom to choose research subjects according to academic criteria and (2) the norms of open science.” Respondents were requested to indicate their perception of the impact of patenting using a Likert scale ranging from 1 to 7 (1 indicating a very negative effect, 4 indicating no effect, and 7 indicating a very positive effect). To simplify the representation of the results and to isolate very negative and very positive effects, we re-grouped responses into one of three categories: a negative effect (responses of 1 and 2), a neutral effect (responses of 3, 4 and 5), and a positive effect (responses of 6 and 7). Other re-groupings of the categories, as well as the original seven-point Likert scale, were tested and yielded results very similar to the ones presented below.

As can be seen in Table 1, the majority of the respondents believed that patenting had little or no effect. 27% (of 172 respondents) felt that patenting had a negative impact on academic freedom, and 41% (of 161 respondents) felt it had a negative impact on the norms of open science within their research fields.¹

(Insert Table 1 about here)

To understand the reasons for these attitudes, we turn to other information gleaned from our survey.

4.3 Independent variables

To test our first hypothesis regarding the relationship between scientists’ (basic) research orientation and their attitudes towards the effects of university patenting, we use a dummy variable to isolate *basic researchers*, equal to one when the self-reported share of articles published in the last ten years in journals specializing in basic research is 50% or higher. We recognize that the self-reported basis for this variable entails certain limitations on its reliability, particularly in view of the blurred nature of the distinction between basic and applied research in the life sciences. We therefore not only asked respondents to indicate the distribution of their publications across basic and applied research journals, but also to enter a percentage for journals with a mixed basic-applied perspective. Only about 12 percent of the respondents indicated that more than 50% of their research publications appeared in journals with a mixed research orientation. Moreover, the number of missing values on this question is very low (about 3 percent). The distinction between basic and applied research thus seems to be valid for the surveyed group.

¹ 67 and 78 respondents chose not to answer the questions regarding the impact of academic patenting on academic freedom and the norms of open science, respectively. 153 respondents answered both questions.

To test our second hypothesis, we had to identify respondents who have published extensively in scientific journals. Publications are measured as the self-reported number of articles in refereed journals in the last ten years. To identify scientists with *high publication productivity*, we use a dummy variable equal to one when a scientist's number of publications lies in the upper quartile of the number of publications for university respondents.² In addition, we include an interaction effect for publishing productivity and research orientation, to examine the importance of combinations of the two variables.

We include three variables to test our third hypothesis. First, we test for the possible effect of *collaborating with industry* in the form of joint research projects, using a dummy variable equal to one when a scientist has engaged in at least one instance of cooperative research during the past ten years.³ Second, we use a dummy variable to identify and control for scientists who have received one or more *industry research grants* of minimum EUR 13,500 (DKK 100,000) within the past ten years. Third, we examine the effects on scientists' perspectives of having prior *industry work experience*, using a dummy variable equal to one when a scientist has been employed in industry for at least one full year within the past ten years.

4.4 Control variables

We control for a number of additional factors that may influence scientists' perspectives on patenting. Because attitudes towards patenting might be influenced by previous experience with patenting, we include a dummy variable which identifies scientists who are *patent inventors*, that is, who have been listed as inventor on at least one patent application in the past ten years.

We also incorporate a dummy variable that singles out researchers who have received one or more research grants of minimum EUR 13,500 (DKK 100,000) within the past ten years from Danish research councils. *Research council grants* are particularly interesting because they represent a reasonable approximation of "no strings attached"-funding as they typically require recipients to communicate their results openly according to the norms of open science. We have used this as a control rather than an independent variable, to eliminate the possibility of the scientist's predisposition for investigator-driven and no-strings-attached research.

² For scientists within this upper quartile of publication counts, differences in publication counts had no significant impact on the dependent variables examined in the study, suggesting that this is an appropriate threshold for identifying highly productive scientists.

³ We also incorporated similar dummies to indicate other forms of interaction with industry, hereunder contract research for, and consulting to, companies. These variables were not significant predictors of scientists' perspectives and therefore left out of the final model.

Finally, we use a dummy variable to identify scientists who are *full professors*, to control for the possible impact of holding a more independent senior position. We also control for the respondent's *age*, given that attitudes towards patents might change with age.⁴

4.5 Method and results

Because of the ordinal nature of the dependent variables, we use an ordered probit regression model.⁵ Regressions were run on each of the two dependent variables in three steps: first using only the control variables, then including the independent variables, and finally incorporating the interaction effect between two of the independent variables (*basic researcher* and *high productivity*). Summary statistics for all variables are reported in Table 2, along with the results of simple correlations. Regression results are reported in Table 3.

(Insert Table 2 about here)

(Insert Table 3 about here)

5 FINDINGS

5.1 The models compared

This section reports our main findings on the effects of university patenting on each of the two key dimensions of academic research. But first, let us briefly note the differences between the results of the two

⁴ Older researchers might be more wary about the growing pressures to patent, not only because it means changing ingrained habits, which might be more difficult for older scientists, but also since it goes against heartfelt traditional academic values. More generally, it should be noted that the reported results models do not include a set of other controls that turned out to be insignificant. Scientists' perspectives on university patenting may differ across research fields. Researchers specializing in medical science, for example, might be more positive towards patenting than researchers specializing in environmental biology, simply because research results from medical science are more readily applicable commercially. We controlled for this by including dummy variables for the *biological sciences*, *medical sciences*, and *environmental biology*. *Agricultural biology* constituted the reference group in the analysis. We also controlled for the location of the research units. As the greater Copenhagen hosts the largest Danish pharmaceutical companies, it might be easier for scientists to work with industry. Finally, we controlled for differences between individual research units by including dummies for departments with more than 10 respondents to the survey.

⁵ We also ran approximate likelihood-ratio tests of equality of coefficients across response categories on all models as well as Brant tests on each independent and control variable, to ensure that none of the models or variables violated the proportional odds assumption.

models. The summary statistics indicate that scientists in general were more concerned about the impact of patenting on the norms of open science than on the freedom to choose research subjects. But the model on the impact of patenting on academic freedom has greater explanatory power. This difference in explanatory power remains consistent under other specifications of the models, and with different re-groupings of the responses that form the basis for our dependent variables. It indicates that uneasiness regarding the norms of open science is not only more widespread than uneasiness regarding academic freedom, but also less correlated with the variables included in our analysis. We will return to this issue in Section 6.

5.2 The perceived impact of patenting on academic freedom

The results of our first set of regressions indicate, as expected, that scientists oriented toward basic research were *more* likely to be skeptical about the implications of university patenting for the freedom to choose research subjects according to academic criteria, while highly published researchers were *less* likely to be skeptical. Surprisingly, however, in our third model, which includes the interaction effect between these two independent variables, we found an interesting pattern. Highly productive researchers, whether they specialized in basic or applied research, were essentially neutral. Less productive applied researchers were also neutral. But the less productive basic researchers stood out – as highly skeptical. The same result appears in a simple cross-tabulation of the key variables, reported in Table 4.

(Insert Table 4 about here)

Only one of the three independent variables concerning relations to industry, namely industry work experience, was a significant predictor of scientists' attitudes. Here, we find that scientists who had prior experience working full-time in industry were likely to be more skeptical. Additional findings from this set of regressions reveal that both recipients of Danish research council grants, and full professors, were more likely to be skeptical.

5.3 The perceived impact of patenting on the norms of open science

In our second set of regressions we found, again, that basic researchers tended to be more skeptical (though this effect was less clear than the above-mentioned effect for academic freedom), while highly productive researchers were less skeptical. The interaction effect between the first two independent variables in this set of regressions was not significant.

Two of the three indicators of interaction with industry were significantly and negatively associated with this dependent variable. Both the award of an industry research grant and prior industry work experience,

increased the likelihood that the scientist would be skeptical towards the broader implications of academic patenting on the norms of open science. Older researchers were also more likely to be skeptical.

6 DISCUSSION

All in all, the most important finding of our analysis concerns the degree of skepticism associated with research orientation and publication productivity (Hypotheses 1 and 2). Broadly speaking, both hypotheses were confirmed. Basic researchers were significantly more skeptical, and highly productive scientists were significantly less skeptical, about the impact of university patenting on both academic freedom, and the norms of open science.

However, important nuances emerged from the findings. Being a basic researcher was a more significant predictor of scientists' perspectives on the impact of university patenting on academic than in the model concerning the norms of open science. Moreover, the less productive basic researchers were far more likely to be skeptical regarding the effects of patenting on academic freedom than their more productive and applied research oriented peers.

Focusing on Hypothesis 2, we see that top scientists, basic or applied, care little about possible threats from patenting. This suggests that for highly published scientists, publishing and patenting function more as complements than substitutes. If scientists can craft their research agendas to generate both publishable and patentable results, they can *ceteris paribus* generate a greater quantity of measurable results from the same research effort. Logically, then, such scientists would not see this "choice" as problematic for their academic freedom, but self-reinforcing. Likewise, taking patenting as an integral part of their research, they accept the ensuing constraints in communication with peers. Alternatively, in fields where patenting is not possible, highly productive scientists – presumably by virtue of their academic performance – are somehow immune to the implications of university patenting on their freedom to define research agendas. In other words, their performance may provide them with a certain degree of independence and insulation from external interference in their work.

When we focus our attention on average and below-average performers instead of the high performers, differences in perspectives emerge between basic and applied researchers. While applied researchers seem not to worry about the unintended effects of patenting, basic researchers clearly feel threatened by the growing focus on patenting. Such scientists may well feel under pressure (by their peers or their deans) to refocus their research into areas more compatible with patenting. The results might also indicate that certain types of academic research in the life sciences are more compatible with university patenting than other types of research.

As regards the norms of open science, our results are in line with findings by Thursby and Thursby (2002) that faculty who specialize in basic research may choose not to disclose inventions because they are unwilling to spend the time on the more applied R&D that is required to interest businesses in licensing the invention. Faculty members strongly oriented toward basic research may thus be less willing to engage in patenting, not only because of the need this implies to engage in more market-oriented research, but also because of a reluctance to spend the time and costs involved in filing for patents, and in dealing with technology transfer offices and potential licensees.

Several studies have touched on related themes. Breschi et al. (2007), for example, found that not only was there a positive relationship between patenting and publishing (see Section 3.3), but that this was also true for researchers who published in basic science oriented journals. However, according to Azoulay et al. (2006), there are indications that scientists may be refocusing the content of their research *after* patenting in ways that make their output more commercially relevant. To these scholars, this suggests that the academic incentive system, in practice, may be evolving in ways that deviate from the traditional scientific norms of openness. Our results seem to support both studies: first, that the long-term effects of university patenting may not be so worrying after all for top-tier research, and second, that, when seen in a broader perspective, university patenting may well have the effect of shifting the focus of overall scholarly endeavour towards research agendas that lend themselves more easily to patenting.

We also examined the relationship between our respondents' relations to industry and their views on patenting (Hypothesis 3). As expected, respondents with previous work experience were highly skeptical, especially regarding the definition of academic research agendas. Presumably, they saw how corporate research worked, and those experiences led them to change jobs. Scientists who had engaged in research collaboration with industry seemed not to be affected. Having received one or more industry grants was however a significant predictor of more skeptical perspective on patenting – though interestingly enough, only as regards the effect of patenting on the norms of open science, not on academic freedom.

Our findings seem to indicate that scientists who have worked with or for industry – and thereby gained first-hand knowledge of the requirements and problems associated with industrial patenting – have found that they prefer the academic way of research, with its greater emphasis on research freedom. These scientists may be said to be predisposed to academic research. Conversely, this finding may represent a difference in the level of knowledge about the way commercial research works. Scientists who have never worked for industry may have a hard time imagining what is required, and thus have no reason to be skeptical.

Our results may also be influenced by the fact that our respondents worked in the life sciences. Empirical studies have underlined how critically important patents are for the pharmaceutical industry, as compared to other sectors (e.g. Cohen et al., 2002; Levin et al., 1987; Mowery et al., 2001). Those university scientists

who collaborated with pharmaceutical firms would thus have had substantial opportunity to observe first-hand how a company's R&D priorities can be skewed towards patentable projects.

We found no effect on either dependent variable from experience with collaboration in joint research projects with industry. This may reflect a selection bias problem, since the collaboration in most instances was not randomly imposed on the scientists, but was the result of a deliberate choice. In a sense, this result seems contrary to the findings of empirical studies that university-business cooperations can provide important benefits to both parties (Fabrizio and DiMinin, 2005). For example, scientists and engineers report that interaction with industry has positively influenced their research, contributing new perspectives and important feedback (Mansfield, 1995). In our opinion, however, it is precisely because of these potential benefits that university scientists (and probably many corporate scientists as well) might find it vital to keep the two types of research separate. University patenting might be seen as skewing academic research agendas too far in the direction of corporate research priorities, ultimately to the detriment of both parties (and society more generally).

The effect for recipients of industry grants is negative, but only significant with regard to the norms of open science. This makes sense to the degree that if industry grants are given on the basis of investigator-driven applications, they do not restrict the free choice of research subject. But grant recipients might well be wary of the restrictions that may be associated with industry grants about how the resulting research is to be exploited. Industry may have granted funds conditional on first-hand insight into the results, or even tougher conditions. Perhaps grant recipients feel that they are restricted by provisions limiting their ability to share and communicate their research results with other scientists, and to present their results openly at scientific conferences.

Our analysis shows that the factors included in our three hypotheses can only partially explain the attitudes of individual researchers. Beyond our explanatory variables, we have controlled for inventor experience, whether the scientist has been the recipient of a research council grant, and the scientist's professional position and age. We found absolutely no effect on the dependent variables from inventor experience. This is not surprising, since patenting by the respondents in this survey probably was mainly carried out as a voluntary activity. Most of the patents would have been taken out before the passage of the Danish version of the Bayh-Dole Act. But it is reassuring nonetheless, as it implies that respondents – whether inventors or not – share similar attitudes towards patenting.

Research council grant receivers were rather skeptical towards the effect of patenting on academic freedom, which is not surprising, since Danish research council grants are allocated to investigator-defined research projects. This variable was not, however, significantly related to perspectives on the implications of patenting for the openness of science.

It is also intriguing that full professors were skeptical as regards the effects of university patents on academic freedom, while older researchers were skeptical as regards the effects on the norms of open science. This seems to suggest that since full professors have more influence in defining their research agendas than their lower-ranked colleagues (who may well be part of the professor's research team), they feel they have the most to lose. Similarly, older researchers, more grounded in the traditional mores of academic research, may experience the loss of openness more acutely. Alternatively, they may simply find it harder to adjust to the growing emphasis on patenting in academia than younger generations of researchers.

Finally, even these controls may not exhaust the full range of factors that can explain scientists' perspectives towards patenting. For example, the importance of local norms and behaviour in the scientist's departments and current academic peer groups has been emphasized by, among others, Bercovitz and Feldman (2008) and Owen-Smith and Powell (2001). If other scientists in the department feel either open or pressured to engage in commercial activities, the individual researcher might feel more open or pressured to do so as well. On a related note, Azoulay et al.'s (2007) analysis of the effects of institutional affiliation and scientists' social networks showed that the presence of co-authors who had patented in the past increased the likelihood of a patent application, and that scientists employed at universities with large patent portfolios were themselves more likely to patent. Our survey data do not permit us to test for this directly. But when we controlled for research unit (i.e. department), we found no systematic differences in scientists' attitudes to the effects of university patenting across institutions. This implies that peer groups either have limited influence on our respondents' perspective toward patenting, or that their peer groups lie within or across department boundaries.

It should also be noted that scientists' perspectives might also be influenced by more "personal" factors such as their own or family members' economic interests in patenting, or scientists' character traits, values or ideology. Some researchers might simply be biased against intellectual property rights *per se*, perhaps believing that they block innovation more than they stimulate it.

By definition, such factors explain the residual variation in the dependent variables, and could profitably form the focus of future research. What is particularly interesting about what we have uncovered here is that the two dependent variables vary greatly in this respect. While our respondents were more negative about the effects of university patenting on the norms of open science than on the definition of academic research agendas, the explanatory power of our model is stronger for the latter than for the former. This suggests that important reasons for scientists' skepticism regarding the norms of open science must be sought outside our theoretical framework. One possible reason for this is that while scientists can directly see how patenting affects day-to-day research activities (such as the setting of research agendas), it is more difficult to conceive of broader effects on the cumulative progress of science.

Several limitations to our work should be noted. First and foremost, the analysis draws solely on our survey data. It has not been possible to compare the respondents' replies to data from other sources, for example comparing self-reported information on publications to factual information derived from their publication records, because of the anonymity of the respondents. In addition, the low sample size and the limited explanatory power of our models should be acknowledged, along with the general limitations associated with trying to identify causal relationships between individuals' performance and experience on the one hand, and their perceptions and attitudes on the other. Our analysis does not provide any information about the underlying causality in the significant relationships identified. For example, are highly published scientists less skeptical towards patenting because of their high level of scientific performance, or are they high performers because they are also open to and possibly involved in patenting activities? Similarly, it is impossible to determine precisely the extent to which scientists' perspectives on patenting reflect the actual implications of increased university patenting, or the extent to which these perspectives influence scientists' disclosure and patenting behavior.

7 CONCLUSION

This paper sheds new light on how university patenting might affect the "inner workings" of academic research in the life sciences by asking the scientists directly about their perspectives on patenting. A substantial portion of our respondents were skeptical about the impact of university patenting on both the definition of academic research agendas, and the norms of open science.

Our findings provide indication of a distinction between researchers who subscribe to a traditional, "Mertonian" approach to research on the one hand, and researchers who take a more applied, commercially oriented approach to university research on the other. Researchers belonging to these two worlds have received the introduction of increased university patenting very differently. While applied researchers apparently care very little about the changes, at least some of the basic researchers fear that patenting might interfere with their freedom to choose research subjects. In particular, basic researchers and scientists who have industry work experience find increased patenting worrying in this regard. But when it comes to the norms of open science, an issue closely related to the anti-commons debate, it is more difficult to tease out who is negative. This suggests that the widespread concern for the norms of open science is shared among all kinds of researchers, not just a particular sub-group with special research conditions or interests.

Our analysis should be seen as a first step in evaluating the potential effects of university patenting on how scientists conduct research. Beyond the interpretations advanced above, our results may well reflect the existence of a vaguer kind of uneasiness about recent trends in university research more generally. For example, there has been a growing trend among university administrators to measure staff productivity in terms of concrete performance criteria, which can include both the number of publications in refereed

journals, and the number of patents. If the same research can lead to both, why should a scientist not choose this? Moreover, if scientists can list on their CVs not only the number of articles they have published in refereed journals, but also the number of patent applications they have been listed on, this enhances their ability to “signal” their value to the outside world (both to their academic peers and, possibly, to the corporate realm). To the extent that patent applications increasingly count as criteria for awarding professorships, this trend might well be strengthened.

We have demonstrated that high-performing scientists seem unaffected by increased university patenting. But if the kinds of basic research that might otherwise be pursued by the less published scientists are diminished, what would be lost? Is there no longer room for the academic pursuit of scholarly research whose results are not immediately patentable or publishable? Does it matter? Again, the answers must be left to future scholarship.

ACKNOWLEDGEMENTS

This project is part of a three-year research program financed by the Danish Social Sciences Research Council, *Competence, Organisation and Management in Biotech Industries (COMBI)*, directed by Finn Valentin, at the Research Centre on Biotech Business, Copenhagen Business School, whose support we gratefully acknowledge. We would also like to thank Peter Abell, Keld Laursen Toke Reichstein, Sidney Winter, Margaret Kyle, Bart Verspagen, Maryann Feldman, Ben Martin, Markus Perkmann, and Peter Murmann for useful comments and questions.

REFERENCES

- Agrawal, A. & Henderson, R. (2002). Putting Patents in Context: Exploring Knowledge Transfer from MIT. *Management Science* 48(1): 44-60.
- Argyres, N.S. & Liebeskind, J.P. (1998). Privatizing the intellectual commons: Universities and the commercialization of biotechnology. *Journal of Economic Behavior and Organization* 35: 427-454.
- Azoulay, P., Ding, W. & Stuart, T. (2006). The Impact of Academic Patenting on the Rate, Quality, and Direction of (Public) Research. NBER Working Paper No. 11917.
- Azoulay, P., Ding, W. & Stuart, T. (2007). "The determinants of faculty patenting behavior: demographics or opportunities?" *Journal of Economic Behavior and Organization* 63: 599-623.
- Baldini, N., Grimaldi, R. & Sobrero, M. (2005). Motivations and Incentives for Patenting Within Universities: A Survey of Italian Inventors. Available at SSRN: <http://ssrn.com/abstract=718481>.
- Bercovitz, J. & Feldman, M. (2008). Academic Entrepreneurs: Organizational Change at the Individual Level. *Organization Science* 19(1): 69-89.
- Blumenthal, D., Gluck, M., Louis, K. S., Soto, M. & Wise, D. (1986). Industrial support of university research in biotechnology. *Science* 231: 242-246.
- Blumenthal, D., Campbell, E.G., Causino, N. & Louis, K.S. (1996). Participation of Life-Science Faculty in Research Relationships with Industry. *The New England Journal of Medicine* 335(23): 1734-1739.
- Blumenthal, D., Campbell, E.G., Anderson, M.S., Causino, N. & Louis, K.S. (1997). Withholding research results in academic life science: evidence from a national survey of faculty. *Journal of the American Medical Association* 277: 1224-1228.
- Breschi, S., Lissoni, F. & Montobbio, F. (2007). The scientific productivity of academic inventors: New evidence from Italian data. *Economics of Innovation and New Technology* 16 (2):101-118.
- Calderini, M. & Franzoni, C. (2004). Is academic patenting detrimental to high quality research? An empirical analysis of the relationship between scientific careers and patent application. CESPRI Working Paper No. 162.
- Campbell, E.G., Weissman, J.S., Causino, N. & Blumenthal, D. (2000). Data withholding in academic medicine: characteristics of faculty denied access to research results and biomaterials. *Research Policy* 29: 303-312.
- Cohen, W.M., Nelson, R.R. & Walsh, J.P. (2002). Links and Impacts: The Influence of Public Research on Industrial R&D. *Management Science* 48(1): 1-23.
- Dasgupta, P. & David, P. (1994). Toward a new economics of science. *Research Policy* 23: 487-521.
- David, P. (2003). "Can 'Open Science' be Protected from the Evolving Regime of IPR Protections?" Stanford University Working Papers in Economics #03-011.
- Di Gregorio, D. & Shane, S. (2003). Why do some universities generate more start-ups than others? *Research Policy* 32: 209-227.
- Etzkowitz, H. (1998). The norms of entrepreneurial science: cognitive effects of the new university–industry linkages. *Research Policy* 27: 823–
- Etzkowitz, H. & Leydesdorff, L. (2000). The dynamics of innovation: from National Systems and "Mode 2" to a Triple Helix of university-industry-government relations. *Research Policy* 29: 109-123.
- Etzkowitz, H., Webster, A., Gebhardt, C., & Terra, B.R.C. (2000). The future of the university and the university of the future: evolution of ivory tower to entrepreneurial paradigm. *Research Policy* 29: 313-330.
- Fabrizio, K. and DiMinin, A. (2005). Commercializing the Laboratory: Faculty Patenting and the Open Science Environment. Goizueta Business School Paper Series GBS-OM-2005-004.
- Feller, I. (1990). Universities as engines of R&D-based economic growth: They think they can. *Research Policy* 19: 335-348.
- Florida, R. & Cohen, W.M. (1999). Engine or infrastructure? The university's role in economic development. In: Branscomb, L.M., Kodama, F. and Florida, R. (Eds.). *Industrializing Knowledge: University-Industry Linkages in Japan and the United States*. Cambridge and London: MIT Press.

- Geuna, A. & Nesta, L.J.J. (2006). University patenting and its effects on academic research: The emerging European evidence. *Research Policy* 35: 790-807.
- Gulbrandsen, M. & Smeby, J.C. (2005). Industry funding and university professors' research performance. *Research Policy* 34: 932-950.
- Heller, M. & Eisenberg, R. (1998). Can patents deter innovation? The anticommons in biomedical research. *Science* 280: 698-701.
- Henderson, R., Jaffe, A.B. & Trajtenberg, M. (1998). Universities as a Source of Commercial Technology: A Detailed Analysis of University Patenting, 1956–1998. *The Review of Economics & Statistics* 80: 119-127.
- Jensen, R. & Thursby, M. (2001). Proofs and prototypes for sale: the licensing of university inventions. *The American Economic Review* 91(1): 240-259.
- Krimsky, S. (2003). *Science in the private interest*. Oxford: Rowan and Littlefield.
- Lee, Y.S. (1996). Technology transfer' and the research university: a search for the boundaries of university-industry collaboration. *Research Policy* 26: 843-863.
- Lee, Y.S. (2000). The Sustainability of University-Industry Research Collaboration: An Empirical Assessment. *Journal of Technology Transfer* 25(2): 111-133.
- Levin, R.C., Klevorick, A., Nelson, R.R. & Winter S. (1987). Appropriating the Returns from Industrial Research and Development. *Brookings Papers on Economic Activity* 1987(No): 783-831.
- Levinthal, D.A. & March, J.G. (1993). The Myopia of Learning. *Strategic Management Journal* 14(Special Issue): 95-112.
- Louis, K. S., Blumenthal, D., Gluck, M. E. & Stoto, M.A. (1989). Entrepreneurs in Academe: An Exploration of Behaviors Among Life Scientists. *Administrative Science Quarterly* 34: 110-131.
- Mansfield, E. (1995). Academic Research Underlying Industrial Innovations: Sources, Characteristics, and Financing. *The Review of Economics and Statistics* 77(1): 55-65.
- Mazzoleni, R. & Nelson, R.R. (1998). The Benefits and Costs of Strong Patent Protection: A Contribution to the Current Debate. *Research Policy* 27: 273-284.
- Merton, R. (1973). *Sociology of Science*. Chicago: University of Chicago Press.
- Metcalfe, J.S. (1998). *Evolutionary Economics and Creative Destruction*. London and New York: Routledge.
- Meyer, M. (2006). Academic Inventiveness and Entrepreneurship: On the Importance of Start-up Companies in Commercializing Academic Patents. *The Journal of Technology Transfer* 31(4): 501-510.
- Moutinho, P., Fontes, M. & Godinho, M. (2007). Do individual factors matter? A survey of scientists' patenting in Portuguese public research organisations. *Scientometrics* 70(2): 355-377.
- Mowery, D.C., Nelson, R.R., Sampat, B.N. & Ziedonis, A.A. (2001). The growth of patenting and licensing by U.S. universities: an assessment of the effects of the Bayh-Dole Act of 1980. *Research Policy* 30: 99-119.
- Murray, F. & Stern, S. (2007). Do formal intellectual property rights hinder the free flow of scientific knowledge? An empirical test of the anti-commons hypothesis, *Journal of Economic Behavior & Organization* 63: 648-687.
- Nelson, R.R. (1959). The Simple Economics of Basic Scientific Research. *Journal of Political Economy* 67: 297-306.
- Nelson, R.R. (2001). Observations on the Post-Bayh-Dole Rise of Patenting at American Universities. *The Journal of Technology Transfer* 26(1-2): 13-19.
- Nelson, R.R. & Winter, S.G. (1982). *An Evolutionary Theory of Economic Change*. Cambridge, MA: Harvard University Press.
- O'Shea, R.P., Allen, T.J., Chevalier, A. & Roche, F. (2005). Entrepreneurial Orientation, Technology Transfer and Spinoff Performance of U.S. Universities. *Research Policy* 34(7): 994-1009.
- Owen-Smith, J. & Powell, W.W. (2001). To patent or not: faculty decisions and institutional success at technology transfer. *Journal of Technology Transfer* 26(1-2): 99-114.

- Renault, C.S. (2006). Academic Capitalism and University Incentives for Faculty Entrepreneurship. *Journal of Technology Transfer* 31(2): 227-239.
- Shane, S.A. (2004). Encouraging university entrepreneurship? The effect of the Bayh-Dole Act on university patenting in the United States. *Journal of Business Venturing* 19(1): 127-151.
- Siegel, D.S., Waldman, D., and Link, A. (2003). Assessing the impact of organizational practices on the relative productivity of university technology transfer offices: an exploratory study. *Research Policy* 32(1): 27-48.
- Simon, H.A. (1955). A Behavioral Model of Rational Choice. *The Quarterly Journal of Economics* 69(1): 99-118.
- Simon, H.A. (1979). Rational decision making in business organizations. *American Economic Review* 69: 493-513.
- Stephan, P.E., Gurnu, S., Sumell, A.J. & Black, G. (2007). Who's Patenting in the University? Evidence from the Survey of Doctorate Recipients. *Economics of innovation and New Technology* 16(2): 71-99.
- Stephan, P.E. & Levin, S.G. (1992). *Striking the Mother Lode in Science: The Importance of Age, Place, and Time*. New York: Oxford University Press.
- Thursby, J.G., Jensen, R. & Thursby, M.C. (2001). Objectives, characteristics and outcomes of university licensing: a survey of major U.S. universities. *Journal of Technology Transfer* 26(1-2): 59-72.
- Thursby, J.G. & Thursby, M.C. (2002). Who is selling the ivory tower? Sources of growth in university licensing. *Management Science* 48(1): 90-104.
- Van Dierdonck, R., Debackere, K. & Engelen, B. (1990). University-industry relationships: How does the Belgian academic community feel about it? *Research Policy* 19: 551-566.
- Verspagen, B. (2006). University research, intellectual property rights and European innovation systems. ECIS Working Paper no. 06.05.

Table 1: Scientists' perceptions of the impact of academic patenting (row %)

	Negative	Neutral	Positive	Total (N)
Impact on academic freedom	27	58	15	100 (172)
Impact on norms of open science	41	49	10	100 (161)

Table 2. Summary statistics and simple correlations

	Dependent variables		Independent variables					Control variables			
	1	2	3	4	5	6	7	8	9	10	11
No. of observations	172	161	239	239	239	239	239	239	239	239	239
Mean	1.87	1.69	0.59	0.27	0.45	0.23	0.11	0.16	0.69	0.16	46.67
Standard deviation	0.64	0.64	0.49	0.46	0.50	0.42	0.31	0.37	0.46	0.37	11.15
Minimum value	1	1	0	0	0	0	0	0	0	0	30
Maximum value	3	3	1	1	1	1	1	1	1	1	72
1 Academic freedom	+ 1.00										
2 Norms of open science	+ 0.60 ***	+ 1.00									
3 Basic researcher	- 0.21 ***	- 0.13 †	+ 1.00								
4 High productivity	+ 0.18 *	+ 0.17 *	+ 0.09	+ 1.00							
5 Collaboration with industry	- 0.07	- 0.06	+ 0.00	+ 0.14 *	+ 1.00						
6 Industry grants	- 0.03	- 0.12	- 0.10	+ 0.07	+ 0.31 ***	+ 1.00					
7 Industry work experience	- 0.24 **	- 0.12	- 0.15 *	- 0.12 †	- 0.02	- 0.06	+ 1.00				
8 Patent inventor	- 0.11	- 0.03	+ 0.06	+ 0.11 †	+ 0.24 ***	+ 0.14 *	+ 0.17 **	+ 1.00			
9 Research council grants	- 0.16 *	+ 0.08	+ 0.20 **	+ 0.26 ***	+ 0.09	+ 0.12 †	- 0.09	+ 0.12 †	+ 1.00		
10 Full professor	- 0.09	- 0.01	+ 0.03	+ 0.36 ***	+ 0.09	+ 0.16 *	- 0.01	+ 0.23 ***	+ 0.20 **	+ 1.00	
11 Age	+ 0.00	- 0.09	+ 0.13 *	+ 0.29 ***	- 0.02	+ 0.05	- 0.16 *	+ 0.10	+ 0.16 *	+ 0.40 ***	+ 1.00

* Spearman rank correlation coefficient; Significance levels: † $p \leq 0.10$, * $p \leq 0.05$, ** $p \leq 0.01$, *** $p \leq 0.001$.

Table 3. Ordered probit regression, explaining individual scientists' perceptions of the impact of university patenting on (a) academic freedom and (b) the norms of open science, with robust standard errors

	(a) Perceived impact on academic freedom			(b) Perceived impact on the norms of open science		
	(1) Controls only	(2) All variables	(3) With interaction	(1) Controls only	(2) All variables	(3) With interaction
Basic researcher (BR)		- 0.75 *** (0.21)	- 0.92 *** (0.25)		- 0.56 ** (0.20)	- 0.56 * (0.23)
High productivity (HP)		+ 0.81 *** (0.20)	+ 0.28 (0.30)		+ 0.64 ** (0.22)	+ 0.63 † (0.34)
Interaction BR*HP			+ 0.76 * (0.39)			+ 0.02 (0.41)
Collaboration with industry		- 0.24 (.20)	- 0.23 (0.20)		- 0.22 (0.20)	- 0.22 (0.20)
Industry grants		- 0.13 (0.21)	- 0.13 (0.21)		- 0.47 * (0.24)	- 0.47 * (0.24)
Industry work experience		- 1.15 ** (0.37)	- 1.19 ** (0.37)		- 0.64 † (0.33)	- 0.64 † (0.33)
Patent inventor	- 0.26 (0.19)	- 0.05 (0.20)	- 0.04 (0.20)	- 0.09 (0.22)	+ 0.12 (.24)	+ 0.12 (0.25)
Research council grants	- 0.43 † (0.22)	- 0.52 * (0.24)	- 0.57 * (0.24)	+ 0.29 (0.22)	+ 0.31 (0.22)	+ 0.31 (0.22)
Full professor	- 0.25 (0.24)	- 0.50 † (0.25)	- 0.55 * (0.26)	+ 0.10 (0.26)	+ 0.02 (0.27)	+ 0.02 (0.27)
Age	+ 0.01 (0.01)	+ 0.01 (0.01)	+ 0.01 (0.01)	- 0.01 (0.01)	- 0.02 * (0.01)	- 0.02 * (0.01)
Intercept 1	- 0.51 (0.45)	- 1.43 (0.47)	- 1.49 (0.47)	- 0.67 (0.46)	- 1.47 (0.49)	
Intercept 2	+ 1.20 (0.46)	+ 0.51 (0.47)	+ 0.47 (0.47)	+ 0.86 (0.46)	+ 0.18 (0.49)	
No. of observations	172	172	172	161	161	161
Log pseudolikelihood	- 159.51	- 141.94	- 140.57	- 150.33	- 140.15	- 140.15
Wald chi-square	(4 d.f.) 7.67	(9 d.f.) 38.92 ***	(10 d.f.) 39.28 ***	(4 d.f.) 3.32	(9 d.f.) 22.21 **	(10 d.f.) 22.23 *
Pseudo R2	0.02	0.13	0.14	0.01	0.08	0.08
Maximum likelihood (Cox-Snell) R2	0.04	0.22	0.23	0.02	0.14	0.14
Mean VIF (and maximum VIF)	1.22 (1.37)	1.23 (1.44)	1.79 (4.06)	1.19 (1.33)	1.23 (1.43)	1.73 (3.80)

* Significance levels: † $p \leq 0.10$, * $p \leq 0.05$, ** $p \leq 0.01$, *** $p \leq 0.001$. All regression results are reported with robust standard errors to account for possible heterogeneity in the models. Running the models with robust standard errors resulted only in minor changes to the p-values for the coefficients, suggesting that the models do not suffer from any important heteroscedasticity issues.

Table 4: Mean response on a scale from 1 (negative) to 3 (positive) to the question regarding the impact of patenting on academic freedom (in parentheses: standard deviation, frequency)

	Basic researcher	Not basic researcher	Total
Highly productive	2.03 (0.58, 33)	2.17 (0.58, 12)	2.07 (0.58, 45)
Less productive	1.66 (0.60, 77)	2.02 (0.65, 50)	1.80 (0.64, 127)
Total	1.77 (0.62, 110)	2.05 (0.64, 62)	1.87 (0.64, 172)