

Inventing and patenting activities of scientists: in the expectation of money or reputation?

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Abstract We propose that scientists use patents/invention disclosures as signals to gain reputation than financial benefits. Based on a newly created dataset on the commercial activities among 2,500 scientists affiliated with 67 institutes of the German Max Planck Society, we explore the relation between the expectations of scientists concerning the outcomes of commercial activities and the likelihood of their patenting and disclosure behaviors. We find that expectation of gaining financial benefits are not related with the patenting activities of scientists without industrial cooperation. Instead, their expectation to gain/increase reputation through commercial activities is correlated with their patenting and disclosures activities. This may in turn also increase the possibility to gain academic promotion, financial benefits through industrial collaboration etc., rather than the immediate personal financial gains.

Keywords Academic commercialization · Patents · Rewards · Reputation · Signaling

JEL Classification B31 · O31 · O34

1 Introduction

Scientists carry out the tasks of education, research and commercial activities (the third task) at universities. Despite their importance, the roles, motivations and perceptions of university inventors have been relatively neglected topics of study. As Link and Siegel (2007) have argued, since the initiation of the Bayh–Dole Act, scholars who assess university technology transfer have examined institutions that have emerged to facilitate entrepreneurial

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commercialization, such as university technology transfer offices (TTOs), industry-university cooperative research centers, research/science parks, and incubators and different patent legislations. Most studies on university-industry relations have focused on a few selected elite universities in the United States, in specific science-based sectors. In these studies, the focus of interest is primarily the importance of institutions (patent legislation, policy mechanisms) and organizations (TTOs, university administration) in the patenting and other entrepreneurial activities of scientists (see recent reviews by Siegel and Phan 2005; Phan and Siegel 2006; Siegel et al. 2007; Rothermael et al. 2007). Some studies initiated the importance of individuals, but rather limited themselves only to entrepreneurial traits, experience, scientific background and demographic factors such as age in order to analyze commercialization motives of scientists. In particular there have been a few studies that paid attention to the roles of individual inventors in the university-industry technology transfer and explore why academic scientists patent (Gulbrandsen 2005; Meyer 2005; Azoulay et al. 2007; Allen et al. 2007; Baldini et al. 2007; Bercovitz and Feldman 2008; Goktepe 2008).

The primary missions of scientists employed at universities and PROs (public research organizations) have been the creation and dissemination of knowledge and education of students. After the 1990s, scientists are also expected to carry out a third mission, namely commercial activities like patenting and company formation. Patenting is a mechanism to ‘privatize’ information by excluding others to the intellectual property to gain monopoly rights over the commercial use of the inventions, and it is essentially an economic phenomenon. According to Thursby and Thursby (2007), the common rationale behind university patenting and licensing is that they provide financial incentives for universities, faculty, and firms to engage in the commercialization of university research findings.¹ It is almost believed that any invention would barely come out of a human’s brain if that human did not have the possibility to earn all or part of the stream of economic rents that results from the industrial exploitation of his or her invention, a preliminary condition for that being that he or she ought to own a propriety right (usually a patent) over that invention (Schmookler 1966).

Although commercial activities are seen as potential revenue sources for universities, it is not clear if scientists will also pursue commercial activities as potential revenue sources or it is bolted on to their traditional roles and expectations of being engaged in science. Expected monetary benefits due to patenting and licensing activities are more relevant for firms and TTOs. However benefits that patents provide to firms might not be the same as for the individual scientists. Academic scientists may have different concerns and expectations when they are involved in patenting activities compared to firms and university-TTOs. For instance, based on their research on the patenting and licensing activities in the US, Thursby and Thursby (2007, p. 633) found licensing income is the most important objective for the TTO and the central administration, and firms. For faculty funds for sponsored research are the most important objective. Thursby and Thursby (2007, p. 625) suggested “patents are not necessary to provide incentives for university scientists and engineers to invent and disclose; the norms of science and the reward structure for science provide incentives for invention and public disclosure. Likewise, Rosenberg (1974) had already argued that inventive activity—along with technological change and the production of scientific and technical knowledge—as something that was independent of economic needs and motivations.

Accordingly a deeper understanding of scientists’ expectations will provide better policy insights on the initiation of entrepreneurial activities at the universities and PROs. We therefore specifically focus on the relationship between the likelihood of scientists’

¹ This has been a common argument for the initiation of the Bayh-Dole Act as well.

patenting and inventing activities and the rewards they are expecting from commercial activities which are measured in terms of financial benefits and scientific reputation. In line with these arguments, it is of particular interest to understand what matters for scientists to disclose their inventions to authorities and patent. Is it correlated to the expectations for gaining reputation or financial rewards?

In order to address this question we use a unique database developed on the commercialization activities of over 2,500 scientists at 67 different institutes of Max Planck Society for Advancement of Sciences (hereafter referred as MPG). Using discrete choice models on patenting and invention disclosure to the MPG, we analyzed if expectation of financial benefits and reputation influence the inventing and patenting activities of scientists. We distinguish between industry-collaborating and non-collaborating scientists to focus on specific motivations of non-collaborators' innovation activities. We control for different socio-demographic as well as institutional factors and scientific fields in our analysis. We find that for non-collaborating academic inventors, invention disclosure and patenting activities are not automatically related to their financial expectations from the commercial activities. Instead, the expectation of reputation that drives patenting and invention disclosure activities of scientists. This confirms the assertions made by Long (2002) that patenting is basically an information transfer mechanism and patentees use patents not always for the expected financial benefits by excluding others but for the non-monetary benefits that accrue due to the information conveyed. Individuals may resort to actions that signal their knowledge, skills and resources by conveying the right information to the relevant group.

It can be interpreted that scientists who are working under the conditions of generous research funds, like MPG, but with a strong desire as well as stipulation of doing cutting-edge research will still be motivated by traditional academic values, like increasing recognition and reputation by showing the novelty of their research. Yet, we can not conclude scientists who are facing more scarce/limited resources for research maybe forced to engage in commercial activities or patenting in order to gain more money. Patenting activities could, to a certain extent, be independent from private economic incentives. Therefore rather than a total transition to an entrepreneurial identity or mission, scientists are still keeping their traditional expectations from science as focus. There may be other reasons that academic scientists are not willing or in need to abandon the norms of science even when they are involved in commercialization activities.

The structure of the paper is organized as follows, the following section deals with the question of why scientists patent and disclose their inventions and takes the view of patents as reputation signals that scientists use. In the third section, perceptions and motivations of scientists are shed light upon and propositions are put forward after which in the fourth section the new dataset is introduced along with the variables of interest and methodology. The fifth section puts forward the estimation results and analysis and sixth concludes.

2 Theoretical background

In order to develop the principal arguments of this paper, we revisit some studies on norms and rewards in science² and the basic arguments behind patents. From a legal perspective,

² The concept of rewards (benefits) from science should not be misinterpreted as the sole reason of scientists is to obtain social status and financial gains. There is considerable evidence that scientists have a desire for inventing. Scientists at universities are intrinsically motivated to do research. Much of the incentive to

a patent confers legal rights concerning the exploitation of an invention which allows the owner the best opportunity to profit from the invention by preventing others from copying it. With a patent, an inventor has the right to exclude others from commercial use of the intellectual property rights conferred by the patent. This allows the inventor to appropriate economic returns from her inventive activity (Arrow 1962). The prospect of gaining profits from this special form of protection serves to promote research activity and to give an incentive for new investment. An inventor does not need a patent in order to exploit an invention; but without a patent the inventor would not be able to prevent others from copying the invention. Inventors are often not in a position to produce or market their invention from their own resources. Patents, being a form of commercial property, provide a basis for owners to negotiate with potential investors or other business partners while preserving their intellectual property rights.

Academic inventors are also supposed to disclose the details of the invention/innovation. While making the research results publicly available allows others to build on the invention, as such it also compels others to recognize and respect to the scientific results shown in the invention. Although there have been concerns that increase in university patenting has challenged the open nature of university research and shifted academic research towards more commercialization, a number of scholars have investigated the relationship between patenting and open dissemination of research results by scientists in the forms of publications (Agrawal and Henderson 2002; Jensen and Murray 2005; Van Looy et al. 2006). These studies have also found that publication and patenting are complementary and not competing activities of university researchers. Most of these studies have found a positive relationship between scientific publication and patenting activities. Jensen and Murray (2005) stated that most university research generates dual outcomes which can be utilized as paper-patent pairs. Scientific publications will follow as in most cases a research project can generate outputs that simultaneously contribute to public knowledge and to commercialization. Academic inventor manages to show his research value both as a scientific discovery and a potential commercial product.

University research is typically conducted in the context of the norms of science (Merton 1973). As such, there exists a 'natural' incentive within universities both to invent and to disclose rather than there being a tension between the two incentives (Eisenberg 1987).³ Scientific knowledge principles should be 'assigned to the community' rather than the scientist, and the scientist's claim to intellectual property from their work should be limited to 'recognition and esteem'. As implied by communalism, the reward for discovery and research should be recognition. Stephan (1996) argues that the priority reward system confers a form of property right that differs from the patent system in providing for incentives to invent and disclose. The priority reward is exclusionary in that the first to discover a principle receives the recognition and then captures the reputation for the discovery, and, as such, it requires no separate disclosure requirement. This winner-takes-all property provides an incentive to invent and, at the same time, it promotes the incentive to disclose. A scientist will disclose a discovery as soon as there is sufficient evidence of

Footnote 2 continued

invent comes from the joy of solving research questions (Levin and Stephan 1991; Stephan 1996). But their behavior is inevitably influenced by social rewards. In particular, the possibility that someone else gets credit and due to himself is as unacceptable to a scientist as to anyone else (Ben-David and Sullivan 1975).

³ In the context of industrial research and development, there is a natural tension between the incentives for patenting and invention disclosure. If firm could not exclude others from commercial use; it would have an incentive to keep secret the inventions.

validity in order to gain recognition and reputation in a timely fashion among their peers. As firms and TTOs are expecting monetary benefits on account of patenting and licensing activities it is also interesting to investigate if financial rewards are relevant for the invention disclosure and patenting activities of individual academic scientists.

In the light of the brief overview as a point of departure we tip our hand with two basic assumptions: (1) scientists have an interest in recognition and prestige; (2) scientists have an interest in achieving economic gains⁴ (Stephan and Levin 1992).

2.1 Norms and rewards of science

2.1.1 *Recognition and prestige:*

Merton (1957) stated that the institution of science has developed “a reward system designed to give recognition and esteem to those who has best fulfilled their roles, to those who have made genuinely original contributions to the common stock of knowledge”. The reward system operates to encourage creative scientists to be highly productive and to produce a higher correlation between the quantity and quality of their output (Cole and Cole 1967). Therefore scientists are motivated by rewards of recognition and prestige among peers, and they have a strong interest in winning the game. By the nature of their work scientists constantly ask research questions and aim to show their research results among their peers to achieve reputation and recognition (Merton 1957).

Merton (1957) also noted the apparent contradiction between the norms of communality which require scientists to publish their research results and consider them as the property of mankind, and their sensitivity and desire for superiority in discoveries. He argued the proper recognition of discovery is a necessary condition for the maintenance of communality, since without recognition scientists could not defend their intellectual property. These statements created a theoretically meaningful basis for further empirical research of the correlation between rewards and the patenting activities of scientists.

Patenting can enhance the prestige and increase the scientific productivity of the scientists by reaffirming the novelty and usefulness of their research (Owen-Smith and Powell 2001, 2003). More recent empirical findings also show patenting as a matter of doing something professionally satisfying and rewarding (Gulbrandsen 2005; Baldini et al. 2007; Goktepe 2008). As we discuss below, due to ongoing changes in the role of scientific institutes and scientists, some scientists may use patents to signal the quality and novelty of their research. Although there is no explicit evidence that patents are used as a criterion to evaluate the academic merits of the scientists (e.g. in academic promotion), some scientists may consider patenting in order to increase their visibility and reputation.

On the other hand, the extent to which scientists and their research milieus are ready for rewarding commercial activities as an academic merit will influence the decision of scientists to patent or not. Scientists who are concerned or surrounded by cohorts with more traditional academic values like open (public) nature of science might be less motivated to patent. Similarly, in order not to risk their career development scientists, e.g. junior scientists, who are more anxious or unsure about how peers, leaders and potential future employees will assess/react to their commercial/patenting activities, will be less likely to patent.

⁴ Financial rewards are measured in two ways; (1) gains from commercial activities and (2) getting access to external funds, industrial research grants.

2.1.2 Source of personal income

Etzkowitz (1998) and Slaughter and Leslie (1997) underlined financial rewards, monetary compensation and profit motive in their analyses of the new entrepreneurial scientist. Universities that provide greater rewards for scientists' involvement in patenting (e.g. in the forms of equity shares, royalty distribution) are found to motivate scientists to commercialize (patent) more. Greater rewards are measured by the amount of royalty income received by the inventor. Owen-Smith and Powell (2001) argued that scientists' decisions to disclose are shaped by their perceptions of the benefits of patenting, licensing and start-up company formation. The incentives to be involved in technology transfer are magnified or minimized by the perceived costs and gains of interacting with industry and TTOs. Siegel et al. (2003) concluded that organizational factors, in particular scientists' reward systems and technology transfer office compensation, influence the productivity of the technology transfer activities and thus the motivations of scientists to disclose their inventions.

Bercovitz and Feldman (2008) assumed that faculty members would be responsive to financial incentives and that there would be a direct relationship between licensing royalty distribution rates and the amount of technology transfer across universities. Thursby et al. (2001) and Lach and Schankerman (2003) provided empirical evidence that milestone payments and share of license revenues from their inventions are positively related to the motivations of inventors to patent. Markman et al. (2004) investigated the relationship between entrepreneurial activities and payments to scientists, departments and TTO staff. They argued that scientists and their departments will be unlikely to disclose or participate in technology transfer activities unless they are given proper incentives to do so. They expect licensing revenues from technology transfer activities can motivate scientists and their departments towards entrepreneurial activities given the scarcity of resources on research.

However, there are counter arguments why financial rewards may not influence commercialization activities. In addition to Mertonian norms⁵ (see Merton 1973); there is considerable evidence that scientists have a desire for doing research and inventing. The puzzle-solving nature of research is described by the historian of science, Robert Hull (1988 in Stephan and Levin 2005). Puzzle-solving involves a fascination for the research process itself (Stephan and Levin 2005). Scientists at universities are intrinsically motivated to do research. Much of the incentive to invent comes from the joy of solving research questions (Levin and Stephan 1991; Stephan 1996). Thus they are intrinsically motivated to conduct research, quite apart from the ability to earn financial rents from their effort (Hellmann 2007).

“A scientist, by choice of vocation, would heretofore have been assumed to have put aside all thoughts of business-like activity to live a monk-like existence as a searcher for truths about nature” (Etzkowitz 1998). Etzkowitz continues—“attired in a white lab coat to protect their street clothing from chemical spills, the uniform of the scientist also signified a certain purity of motives, an abstraction from material concerns and a bemused tendency toward absentmindedness in daily life”. Further, “they were believed to find rewards for their discoveries not in pecuniary advantage but in recognition from their scientific peers through citation in the literature, election to a national academy and the ultimate accolade of the Nobel Prize”.

⁵ Merton suggested four norms of science: universalism, communism (or communalism), disinterestedness, and organized skepticism.

In a recent study Jeon and Menicucci (2008) discussed the allocation of talent (brain drain) between the science and private sectors when agents value money and fame. They assumed not only monetary rewards matter in agents decisions but fame, which is defined as peer recognition, matters as well. Recent empirical studies have also confirmed that the innate curiosity of scientists make them research that can be publishable. Gulbrandsen (2005), Goktepe (2008) investigated the motives of inventors to patent. They asked whether monetary rewards or non-monetary rewards were important motivations for patenting. Consistently these studies although limited in scope found that personal satisfaction and doing something professionally enjoyable were important reasons for scientists to be involved in commercialization. They found that social and personal rewards (i.e. the fact that the innovation might increase the performance of the organization where the inventor works), personal satisfaction to show that something is technically possible, and gaining prestige and reputation) were considered by the inventors to be more important than other types of compensation like monetary rewards and career advancement.

2.2 Patents as quality signals

Anton and Yao (2004) find that many of the patents do not actually reveal complete information on the invention process, therefore leading to ‘little patents-big secrets’. So, with this finding it seems plausible that monetary benefits to patents can be still assured, without a danger to the knowledge underlying the invention process. But do all individuals patent just because they want money by excluding others? While we know about the monetary gains from patents, an equally intriguing gain is reputation. Since we are interested in individuals, reputation seems to be another interest that would drive them to act on different things.

Recognition is allotted to scientists to the extent they fulfilled their academic tasks (Blume and Sinclair 1973). Reputation can be achieved and shown by scientific publications, honorific awards, positions at top-ranked institutes, and citations. Scientists (researchers) have to publish in order not only to show the findings of their research but also the quality, novelty and uniqueness of their findings. Publishing internationally peer-reviewed scientific articles in top journals, being cited, participating in or even prestigious being invited in top international conferences, teaching skills and receiving grants are always considered as academic merits and improve the chances of academic promotion and reputation. Due to the intensification of university-industry relations economic development through technology transfer has become a “third academic mission” on a par with universities’ traditional missions of teaching and research. We therefore wonder in addition to the abovementioned tools, if scientists’ expectation of gaining reputation (visibility/recognition) is correlated with their patenting and disclosure behaviors.

Competition for reputation among scientists, universities, public research organizations creates both rising demand for and supply of researchers (Ben-David and Sullivan 1975). Higher education departments of German states and university presidents in the US were particularly inclined to accept scientific reputation as criterion for appointing professors and evaluating institutions. Reputable scientists and lobbies (e.g. Gesellschaft deutscher Natur und Ärzte)⁶ persuade governments to establish new chairs and recognize new fields. Reputation is believed to be a relatively objective, almost measurable yardstick (Ben-David 1972 in Ben-David and Sullivan 1975).

⁶ http://www.gdnae.de/be89d0ed8a4810173299eb1891120558/de/start/ueber_die_gdnae/index.html.

Quantity and quality of scientific publications, citations, conference presentations etc. have been and are still guarantees of recognition from the scientific community and employers. Although patents are not peer reviewed, the patenting process is exhaustive and extensive concerning the novelty, usefulness, non-obviousness and technical utility. In particular, for the fulfillment of Third Mission activities, scientists are expected to interact with the surrounding society and be more active in commercial activities in addition to their usual tasks. Patenting activities have thus become considered as tools for rewards to gain reputation/recognition, and financial benefits. In order to be reputable, in the first place, information has to be conveyed about the person in context. In this view, a scientist can be thought of conveying ‘his type’ (highly productive–low productive) to specifically two or more groups of people. One major group would be the compatriots in the research field concerned while another can be the employer. To the first group, scientists have three ways to convey information about their type—either publish, or patent, or do both. To the second group in addition to these two ways, one specific channel would be to report their findings officially—meaning—disclose their invention to the employer on an official basis.⁷

While the rewards for academic researchers are still largely based on publications, they also receive some (limited) commercial returns to patenting and other forms of commercial science (Edwards et al. 2006). Even when financially unsuccessful, commercial science provides additional scientific resources. For example, Murray and Graham (2007) show that participation in commercial science brings with it distinctive forms of status and resources and that patents have become an integral part of faculty strategies for the dissemination of ideas and for signaling interest in commercial activities. Patents can be used as a tool to trade with industry for access to funding, equipment, materials and other opportunities from industry (Stephan and Levin 1992; Owen-Smith and Powell 2001). Scientists can use patents as a signal to show the industrial relevance and applicability of their research results in order to attract more industrial support. In this case, the research results would be likely to be patented together with the industrial financier of the project.

Based on the arguments posed until now, we frame the following hypotheses for empirical analysis. Since we do not make a case for only reputation or only money drives patenting, we test several possibilities in terms of methodology. To empirically test these specific hypotheses, we also account for several individual and external (institution specific) factors that may influence patenting and invention disclosure decision of scientists.

- *H1: Expected reputation affects scientists’ patenting and invention disclosure activities.*
- *H2: Expected monetary benefits affect scientists’ patenting and invention disclosure activities.*

3 Research context

In this section we first give brief information about public research organization, i.e. Max Planck Society, as the background for our research context. We then present the rules and regulations concerning industrial co-operation and patenting activities of scientists who are

⁷ Invention disclosure to the employer is a job requirement. Different from the former university patent legislation (university teachers’ privilege (Sect. 42 ArbNErfG—Law on Employees’ Inventions), [organizational] ownership of intellectual property rights (IPR) regime has been valid since the 1970s.

affiliated with different institutes at Max Planck Society (MPG hereafter).⁸ MPG was founded in the late 1940s in Germany. The Max Planck Institutes are engaged in numerous disciplines which are highly regarded as national and international centers of excellence, and their scientists publish more than 12,000 scientific articles, books, conference reports and other publications each year. The research results (discoveries, inventions, patents) of MPG scientists have also industrial applications. For example, the so-called FLASH-technology in magnetic resonance imaging and the novel cancer treatment Sutent[®] are both based on the research work of scientists from the Max Planck Society.⁹

Rules concerning the ownership of intellectual property (IP) at MPG have been always different from the former university patent legislation (a.k.a. university teachers' privilege—Law on Employees' Inventions). Quite similar to the US Bayh–Dole Act, organizational ownership of intellectual property rights (IPR) regime has been valid since the 1970s. In 2002, this regime has become a model of organizing IPR for university inventions as well. Since 1971 MPG has also a well-established tradition of technology transfer through a dedicated technology transfer office (Max Planck Innovation, MPG–TTO) to promote technology transfer, and provide guidance e.g. patenting, licensing and venture creation (Buenstorf 2006). Its primary aim is the transfer of patented and non-patented technologies developed by Max Planck Institutes to industry and to negotiate and close license agreements.¹⁰

The survey was conducted in the last part of 2007 at 67 institutes (out of 80 institutes) specialized in different scientific disciplines and located different cities in Germany. The MPG is funded to large extent by both the federal and state governments. Although the aim is to conduct basic research in the interest of general public in natural sciences, life sciences, social sciences and the humanities; the institutes takes up new and innovative ideas that the German universities are not in a position to conduct adequately. By providing equipments, facilities the research at the MPG complements the work done at the universities. Currently the MPG has 4,300 scientists and substantial amount of graduate students, post-docs and guests scientists. 51% come from abroad. In 2006, the budget was around 1,379.1 million euros. 82% is from federal and state governments, while 13% is from projects supported by government, federal states and the EU. Donations, evaluation royalties etc. amount to 5%. The MPG has not only a strong scientific base, but a well-established tradition of technology transfer, as well as has been a seedbed for technological developments.

3.1 Industrial co-operations

Industry often is interested to collaborate on a particular research area with a Max Planck Institute or to further develop a licensed invention in collaboration with the Max Planck Institute. The respective cooperation agreements usually provide for grants that allow the institute to carry out the developmental work. However it should be ensured that the subject of the collaboration is sufficiently narrowed down so that it does not comprise the whole research area of the department involved; that the freedom of the institute to publish is guaranteed (taking into account the interest of the collaboration partner); that inventions made by scientists of the MPG within the scope of the collaboration are owned by the MPG, and not by the industry partner (usually, the industrial partner is granted an option

⁸ http://www.max-planck-innovation.de/en/inventors_founders/inventors_faq/#08.

⁹ http://www.max-planck-innovation.de/en/industry/services_industry/.

¹⁰ Source: Max Planck Innovation Website. <http://www.max-planck-innovation.de/en/>.

for a license with fair terms), and that license fees are not waived in exchange for contributions in kind or research grants. Although MPG provides support for the closing of a consultancy agreement, the formal responsibility lies with institute and the finance department of the MPG. In contrast to license agreements, which are closed by Max Planck Innovation (MPG–TTO), cooperation agreements are concluded between the industrial partner and the institute itself. Since 1979 Max Planck Innovation (MPG–TTO) have closed more than 1,500 contracts with companies of all sizes and from all sectors, from start-ups to global corporations. About half of the profits originate in the US, the other half in Germany, Europe and Japan.

3.2 Invention disclosures and patenting¹¹

According to Max Planck Society (MPG) employment contracts and also to the Employees' Inventions Act, all occupational findings or ideas that may have inventive character must be reported to the institute's management. Inventions made by MPG staff members usually emerge within the scope of their research activities or are based on the institute's experience or work. These inventions are thus called "employee inventions". In accordance with the German Employees' Inventions Act, the employer, i.e. the Max Planck Society, is entitled to such inventions—in so far as the Max Planck Society claims them under the stipulations of the act. The claim will be examined and lodged within 4 months after the filing of the invention disclosure form. Once the Max Planck Innovation (MPG–TTO), has filed a patent application, priority is ensured under patent law and there is usually no obstacle to scientific publication.

Scientists of the MPG are obliged to publish the results of their research as soon as possible, but they should try to protect their invention by filing for patent applications prior to publication. Due to the fact that such publications such as conference posters, abstracts, proceedings, handouts or masters and PhD theses etc., are damaging to novelty. They endanger later IP protection in relation to the inventive step. Therefore, scientists should contact Max Planck Innovation (MPG–TTO), prior to the publication of any research results that seem—or whose further development seems—to be commercially viable.

After receiving the invention disclosure form, MPG–TTO examine whether the invention is likely to lead to a successful patent application and MPG–TTO evaluate the commercial potential. To this end, they conduct patent searches and market research. If the evaluation is positive—and after clearance with the inventor(s) and the Max Planck Institute, who meet the costs of the application—MPG–TTO instruct an independent patent attorney experienced in the relevant field to draw up the patent application. They aim to burden the inventor(s) as little as possible with this process. In general, the rough draft of a planned publication is a sufficient basis for a patent application. Subsequently, inventor(s) will receive an outline of the application for review and will be asked to answer any unresolved questions sometimes with a patent attorney.

¹¹ As we expect complementarities between patenting and publishing activities, i.e. most patentable research is also publishable we do not go into the details on the publication activities of the scientists. As the MPG-survey was conducted anonymously, we don't have the names—other type of personal information about the identity of the scientists—which could have been used to identify their publication rate. But as the previous literature confirmed most patentable research is also publishable and MPG scientists are expected to publish we are expecting these scientists are also quite active in publishing.

Furthermore, the inventor must, to the best of his ability, support the Max Planck Society in its efforts to apply for and commercialize his invention. As a rule, scientists' complementary know-how is necessary to enable a future licensee to realize the economic potential of a product based on the invention. According to the current MPG regulations inventors generally stand to receive up to 30% of the gross license income that MPG-TTO receives from the commercialization of the IP or know-how the scientists created. This compensation exceeds the minimum rates of indemnification for employee inventions provided for by guidelines currently in force in private industry and in the public sector, and is intended to motivate scientists to participate actively in technology transfer.

4 Data characteristics, variables of interest and methodology

This paper is based on a large-scale survey of over 2,500 scientists in Germany aimed at obtaining information about the commercialization activities.¹² The scientists pooled for this research are from the independent German non-profit research organization—the Max Planck Society for the Advancement of Science (MPG hereafter). The survey was conducted by a professional consultancy company TNS-EMNID from October 2007 till December 2007. It was a telephone-based survey and names of the participants were kept confidential and are not to be revealed. Previous studies on technology transfer, academic entrepreneurship and available interview guides and questionnaires were consulted before constructing the survey. To check for possible interpretation errors and mistakes, pilot surveys were conducted with randomly contacted scientists from other public research organizations in Germany. The survey has four parts in which, the first part is about invention, patenting and research cooperation activities. Second part focuses on entrepreneurial activities. The third part is about the perceptions of scientists on commercial activities in general. The final part deals with individual and professional demographic information (age, gender, academic title and education, citizenship).

We chose inventions disclosed to MPG-innovation (TTO) and patents applied for as our measure of a scientist's involvement in commercialization activity. Disclosure is a process by which scientists inform the TTO that they have developed an invention that they believe has the potential for commercial applications. It is then the responsibility of the TTO and the institute where the researcher is employed to either pursue IP protection or decline the disclosure. While employment contracts at MPG mandate disclosure to the TTO, in practice the process may turn into a voluntary activity where scientists take the initiative to inform the TTO of their inventions. Under these conditions, the micro-motives and social factors identified earlier become salient influences on the scientist's disclosure and patenting activities.

4.1 Empirical strategy

In order to construct the variables we first concentrate on the variable of interest—patenting and invention disclosure. We use three groups of scientists to measure the relationship between likelihood of scientists' patenting activities and their expectations concerning the outcomes of commercial activities. Scientists who have only applied for a patent; scientists who have only disclosed inventions to the MPG and do not have a patent

¹² Survey tool can be made available upon request.

and scientists who have both disclosed inventions to the MPG and also have applied for a patent.

We further investigate if there is any difference regarding reputation and financial rewards between the scientists who patented and who had only disclosed their inventions to their employees. Inventing and patenting are two separable phenomena. It is accepted that not every invention can be patentable, even if scientists may have the expectations to patent. Investigating and comparing what are the perceptions of scientists who patented and who made invention disclosures to their employees would shed some light on the current debate on the role and ownership of IP at universities and (PROs).

As mentioned before, we concentrate on the expectations of scientists who do not have any form collaboration with industry (joint projects, direct consultancy etc.). It is important to make this distinction due to some reasons. The choice to collaborate with academia may be an initiative driven by firm's objectives. Blind et al. (2006) showed that German firms collaborate with academia for several strategic reasons. Mainly firm's expect the patents generated from collaboration to leverage their own knowledge as well as their positions in negotiations with partners, suppliers and the financial sector. Therefore, the scientific outcomes from a collaborative effort may result in patents mainly due to the firm's interests, rather than of the scientists. Moreover concentrating on non-collaborating scientists gives us a chance to isolate the sample to those who have never been involved actively in commercial activities and would be an ideal sample to test our hypotheses: what would drive those scientists to patent who were never before involved in commercialization activities?

Since our interest was also to control the demographic nature of the respondents, we have used age, gender (female or not), foreign-born scientist variables. We further utilize data on their industry experience, MPG experience, the position (whether a director, a group leader, a post doctoral fellow), and which field of science do they belong. In order to clearly track the patenting and invention disclosure behavior one has to also account for the personal opinions of the scientists with respect to the nature and mode of commercialization. Scientists were therefore asked if they want their research to be open (free from exclusion) and if they think a technology transfer office (TTO) is indeed needed to take their research to industry or commercialize it in any other fashion. We utilize this information in order to account for the personal opinion of scientists about commercialization in general that may affect their actual commercialization behavior.

The group of studies that focuses on individuals is inspired partly by psychology and behavioral sciences. These studies have focused on the socio-demographic characteristics of inventors. Macdonald 1984, 1986, Sirilli 1987, Amesse et al. 1991, Klofsten and Jones-Evans 2000, investigated the characteristics, background and socio-demographic features of inventors. Stephan and Levin (2005) investigated whether personal characteristics, age (life-cycle), citizenship status, gender and receipt of federal funding were related to patenting behaviors. They found little evidence of age effects, yet they found that tenured scientists are more likely to patent than non-tenured ones (Levin and Stephan 1991; Stephan 1996). Women patent less than men, although the effect is smaller since the number of women employed in science and engineering fields relative to men is low. The socio-demographic findings of these different studies are fairly consistent (see also Azoulay et al. 2007). Inventors were most often men; the average age being between 45 and 48. They were highly educated and had technical and commercial knowledge and had experience above the average.

In addition to the individual (socio-demographic) factors, we also account for the perceptions of scientists on the nature of their research (and scientific field), on the use of knowledge (whether research should be open) and commercialization is not found to be proper. Thursby et al. (2001) argued that scientists who specialize in basic research may not disclose because they are unwilling to spend time on the applied R&D required to interest business in licensing invention. Thursby et al. (2001) also stated scientists may not disclose because they believe that commercial activity is not appropriate for an academic scientists. Having this kind of perception or believing in the Mertonian norms of ‘disinterestedness’—scientists would perceive that their research results should be freely accessible to any other scientists and businesses. Such scientists are also expected to be less interested in patenting or other commercial activities.

Additionally the role of organizational factors, like the need for technology transfer office (TTO) to help scientists in their commercial activities may also influence the likelihood of their patenting activities. Owen-Smith and Powell (2001, 2003) found that scientists’ incentives to be involved in technology transfer are magnified or minimized by the perceived costs of interacting with industry, TTOs, or dealing with patenting, licensing and company formation individually. Faculty decisions towards commercialization are shaped by the institutional and organizational environments which are supportive or oppositional for university-industry technology transfer. We therefore control for scientists’ perception on the role of technology transfer offices.

The set up for the econometric model therefore is of a multinomial discrete choice model; specifically we use the multinomial logit estimation method. Measuring perceptions is a tricky issue. Since our main propositions are on reputation and money there are many ways that we could measure it. The scientists were asked whether they expect commercialization (patenting, starting up a new venture, industrial collaboration, consulting services etc.) to increase their reputation basing on a 5 point scale. In the same vein, the question on whether they expect commercialization to make money was asked. Using these two measures we constructed variables—high money, high reputation if the respondents strongly agree with the prospects of getting money, or getting reputation.

The underlying model can be formulated as follows:

Patenting/disclosure Activity = f (expected rewards; age, gender, citizenship, career experience, research milieu)

5 Estimation results and analysis

This section puts forward some statistics indicating on the nature of data, the variables considered and the estimation results from the multinomial logit model. In order to test if the multinomial specification is suitable we conducted Wald tests for combining alternatives in multinomial specification. After conducting Wald tests, we performed the Small–Hsiao test for independence of irrelevant alternatives assumption. Tables 1 and 2 (in Appendix) report the test statistics. As can be observed, the Wald tests support the choice of multinomial logit method, while for two categories in the non-cooperator sample the IIA assumption is not satisfied. However, for the cooperators sample this problem does not seem to occur. This dissimilarity is mainly attributed to the method deficiencies in Small–Hsiao tests mentioned by Long and Freese (2006) who cite a Monte-Carlo study by Cheng and Long (2007) concluding that Small–Hsiao tests are not sufficient to test for IIA

assumption especially when sample sizes are small. Therefore, we depend on the Wald test and also on the fact that our categories are mutually exclusively coded in order to formulate a multinomial logit specification to test our hypotheses.

After the necessary data requirements for the paper (cooperators, non-cooperators etc.) we had almost 1,100 usable responses. Out of this sample, 110 scientists reported only patenting, 99 reported only disclosure and 187 reported both patenting and disclosure. Tables 3 and 4 (in Appendix) provides the descriptive statistics on the variables we consider. It can be clearly seen that most of the scientists take both paths of patenting and invention disclosure, but only few of them do it for money. It's also interesting to see that scientists who consider their research to be freely available for everyone also patent and disclose inventions to MPG. The mean ages for every mechanism is around 40 while less than a quarter of scientists patenting, disclosing or doing both, is female. Almost half of the foreign-born scientists patent and the number is almost the same for disclosure, but lesser for both.

Directors show a very high patenting and disclosing behavior, if not for each of them individually. There is almost an equal share of scientists patenting in the broad fields of biology and medicine compared to chemistry, physics and other technical subjects. Post-docs and group leaders seem to show very high patenting and disclosure behavior. This may be because they need to show performance mainly after Ph.D. and therefore they might be more active in inventing and patenting. Given this scenario, we tested a multinomial logit model where all the three categories (only patent, only disclose, both patent and disclose) are considered. We provide the estimation results for both cooperators and non-cooperators sample. Table 5 provides the estimation results based on the non-cooperators sample and Table 6 (in Appendix) provides estimation results on the cooperators sample.

5.1 Non-cooperators sample

Based on our estimation results in Table 5 (in Appendix), we can observe that the scientists who expect high reputation from commercialization activities are more likely to perform both patenting as well as invention disclosure. This confirms our first hypothesis that scientists who expect high reputation are more likely to use both mechanisms. It can be interpreted as the scientists who would expect to have high reputation would signal it through patenting and disclosing their invention to reach the relevant audience who receive the signal. Secondly, we can see the effect is so strong that if scientists want reputation they do not necessarily take any one of the paths, but are very highly likely to take both.

Is money driving the patenting and invention disclosure behavior then? The answer seems to be no. As can be seen in Table 5 (in Appendix) monetary expectations do not affect the patenting and invention disclosure activities of scientists. In the light of these results, our hypothesis that expectation of monetary gains affects patenting activity stands to be rejected. It is indeed reputation that drives these two and scientists may view achieving reputation more important than money. Academic interests might be of more value to the scientists than monetary interests and this might be driven by the inner philosophy of science and interest in basic research in order to solve the puzzle, answer the questions that are left unanswered and other motivations.

This leads to the result on the perception of scientists on research as being 'open'. Even though descriptive statistics show that there are a number of scientists who patent and disclose while having the view of open research, the estimation findings confirm

their opinion. Scientists who consider research to be open are less likely to take any of the three paths to commercialization. Scientists who consider costs of commercialization to be high are less likely to disclose their inventions but are more likely to patent and disclose. If a scientist considers costs as high, she would not be willing to approach the MPG to disclose the invention in the first place whereas if the research has high potential (may be through reputation), it might be possible that the scientist is willing to both patent and disclose.

Another interesting result is on the position variable. As a sequential process—the group leaders and directors are more likely to only disclose or take both paths. This might be possible due to the experience that each of these persons have by understanding the rules, regulations and institutional culture of the MPG (i.e. existence of organizational ownership of patents and an active TTO since 1970s). If the scientists respond that TTOs are indeed needed for commercialization then that positively affects the likelihood to only patent or take up both the paths. It is as well as due to the fact that the personal responsibilities towards disclosing inventions may grow over time. This is confirmed by the MPG experience variable, that scientists having higher number of years with the MPG are more likely to disclose their inventions to the MPG.

On the demographic aspects it can be observed that older scientists are more likely to patent and rather than only disclose their inventions or do both. Female scientists are less likely to choose both paths and gender does not have an effect on any one of these paths exclusively. The subject-area effects of scientists are taken into account too.

5.2 Cooperators sample

Table 6 (in Appendix) presents the results on the non-cooperators sample. As can be observed the non-cooperators are not affected by reputational expectations when patenting or disclosing their inventions. In fact, a striking result shows up on the monetary expectations variable. Scientists who expect monetary rewards to be high in commercialization are less likely to disclose or patent and disclose. A simple explanation can be found in the fact that they are cooperators with the firms. As mentioned before, firstly, the choice to collaborate with academia may be an initiative driven by firm's objectives. Blind et al. (2006) showed that German firms collaborate with academia for several strategic reasons. Mainly firm's expect the patents generated from collaboration to leverage their own positions in negotiations with partners, suppliers and the financial sector. Therefore, the scientific outcomes from a collaborative effort take shape of patents mainly because of the firm's interests, rather than of the scientists. Scientists in cooperation agreements would very well know this fact and therefore, if they are driven by monetary interests, they might not choose the patenting path and look for other paths such as start-up activities or new product development that can be commercialized directly from the labs.

The results on open research seem to be also valid for cooperators, in that, the scientists who prefer their research to be openly available to others are less likely to patent or disclose. The need for TTOs affects the patenting activities positively. As with the cooperators, the group leaders are more likely to patent and disclose while the directors are more likely to only disclose and do both. Years of experience in Max Planck affects the likelihood of disclosures and choosing both paths positively. Age has a positive effect on patenting and female scientists are less likely to patent and disclose. Industry experience affects disclosure likelihood positively.

6 Discussion and concluding remarks

Understanding of scientists' patenting activities is still a recent phenomenon. Although the patenting activities of scientists (universities and public research organizations) have been seen as sources for innovation and economic development, concerns have also been raised that scientists are moving towards applied research and away from fundamental research in order to patent with the expectations of financial benefits. Many therefore argued that patenting may challenge the culture and norms of open science. However, despite the ongoing debates on the detrimental influences of patenting on scientific production and norms of science, why researchers patent has not until recently received the same amount of attention. Only recently some studies started to examine the incentives and motivations behind scientists' invention disclosure and patenting behaviors. This paper aims to open this discussion and interest further.

In this paper we investigate to what extent financial benefits or reputation and recognition expected to result due to commercial activities influence the inventing and patenting activities of scientists. These assumptions have been debated concerning the context of industrial knowledge creation, protection, research and development (Schmookler 1966; Rosenberg 1974; Eisenberg 1989; Merges and Nelson 1990, 1994; Long 2002; Cohen 2005; Thursby and Thursby 2007). We discussed this tension (money or fame) specifically within the context of academic knowledge creation and from the perceptions of scientists and their decisions to make inventions disclosures and patenting. Instead of making a case for or against one factor, we investigated both aspects. By doing so, we move beyond the traditional argumentation of financial incentives matter for inventing activities while norms of science loses its ground due to increasing commercial activities. We found despite scientists' involvement in inventing and patenting activities, such activities are related to their traditional academic concerns i.e. gaining reputation and visibility than financial expectations. This paper thus also contributed to the debate on the role of IPR and commercial activities at the universities and public research organizations.

We used a newly created survey data on 2,500 scientists from 67 different institutes of the Max Planck Society in Germany conducted in 2007–2008. To observe the effects of individual factors (expectations and commercial activities), our identification strategy involved studying two different samples of non-cooperating and cooperating scientists respectively, in relation to industry collaboration. This identification strategy gives a straightforward test for assessing the effects of motivations by isolating the sample that entirely concentrates on laboratory activities for academic purpose, and hence how they drive patenting activities.

Empirically, we show that non-cooperating scientists who have more expectations to gain scientific reputation and visibility will more likely to patent. On the other hand scientists' commercialization activities do not necessarily respond to monetary expectations. Scientists' inventing activities are rather related to their expectations of recognition and reputation while financial benefits are less important. Specifically, the scientists who expect high reputation from commercialization activities are more likely to perform both patenting as well as invention disclosure. This confirms our first hypothesis that scientists who expect high reputation are more likely to use both mechanisms. It can be interpreted as the scientists who would expect to have high reputation would signal it through patenting and disclosing their invention to reach the relevant audience who receive the signal.

The scientists involved in industrial cooperation however, seem to be not driven by reputational expectations and their patenting and disclosure activities might be more or less affected by the firm in context and its motives. The scientists may rather choose some other path of earning monetary gains than choose patenting because they expect patenting to benefit the firms.

Invention disclosure and patenting activities could to a certain extent be independent from private economic incentives. It can be clearly seen that most of the scientists take both paths of patenting and invention disclosure, but only few of them do it in the expectation of gaining financial benefits. It's also interesting to see that scientists who consider their research to be freely available for everyone patent and disclose inventions to a lesser extent. Both of these can be viewed as information transfer mechanisms, not necessarily for monetary gains but for the non-monetary benefits—such as reputation—and prestige that the academic researchers foresee to be accrued. These findings are also important because it means that the despite patenting activities and traditional academic values seemed intact. Even when there are less or no financial expectations, commercial science provides additional scientific resources and participation in commercial science brings some kind of status and resources and that patents have become an integral part of faculty strategies for the dissemination of ideas and for signaling interest in commercial activities (see Murray and Graham 2007). However this does not mean that the design of intellectual property rights, other forms of incentives (e.g. accepting patenting activities as an academic merit, qualification for promotion or providing research funds to patenting scientists), in academic organizations would not have effects on economic growth and productivity. Controlling for a variety of other determinants, including age, gender, citizenship, scientific discipline, industrial and academic experience, scientists with high reputation expectation from commercial activities will more likely to patent. We acknowledge that, these factors (reputation and financial rewards) are not mutually exclusive meaning that under certain conditions (in the long term) reputation and visibility of scientists may bring financial rewards maybe in the forms of research funds, if not personal gains.

Even though scientists do no longer have a monk-like existence searching for truths about nature, scientist's involvement in entrepreneurial activity is not a transition from their academic roles to another. By doing so, we indicate that, for these individuals, the decision to participate in commercial activity is akin to managing multiple identities (Pratt and Foreman 2000 in George et al. 2005) in order to signal that they have multiple skills and knowledge (both academic and industrial); and they are able to better respond to a variety of situations. Scientists are establishing a unique set of experiences and values that are closely linked to their roles and academic career. We assume scientists can not or will not easily suspend these sets of values even if they consider being involved in commercialization activity. Therefore albeit scientists are encouraged to get involved in commercialization activities (e.g. Third Mission), the financial prospects of commercial activities is balanced against the cost of giving up norms and thus expected rewards associated with their identity as scientists. Moreover, despite rules and regulations scientists often possess high levels of discretion when contemplating their involvement with commercial activity. More generally, although a wider range of commercialization of academic research has becoming a component of scientists activities, expectations from such activities are bolted on to the traditional streams of research and what scientists generally value as a reward. Given this scenario, we suggest that these individuals are likely to embrace valued aspects of their existing role identity even as they enter the realm of commercialization. Especially in

the context of Max Planck Society and in Germany, as scientists remain as academic and having an academic focus is typically more respected than scientists having a commercial focus.

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Appendix

See Tables 1, 2, 3, 4, 5 and 6.

Table 1 Specification tests: Wald tests for combining alternatives in the multinomial specification

Alternatives tested	χ^2	df	$P > \chi^2$
<i>Non-cooperators</i>			
1-2	7.214	15	0.951
1-3	44.048	15	0.000
1-0	24.443	15	0.058
2-3	61.473	15	0.000
2-0	28.901	15	0.017
3-0	16,167.954	15	0.000
<i>Cooperators</i>			
1-2	61.611	15	0.000
1-3	95.007	15	0.000
1-0	38,438.235	15	0.000
2-3	24.894	15	0.051
2-0	40.584	15	0.000
3-0	109.824	15	0.000

Ho: All coefficients except intercepts associated with a given pair of alternatives are 0 (i.e., alternatives can be combined)
 Categories 0, 1, 2 and 3 denote no-commercialization, only patenting, only invention-disclosure, patenting plus disclosure respectively

Table 2 Specification tests: small Hsiao-Tests for independence of irrelevant alternatives assumption (IIA)

Omitted variable	ln L(full)	ln L(omit)	χ^2	df	$P > \chi^2$	Evidence
<i>Non-cooperators</i>						
1	-182.943	-133.349	99.188	32	0.000	Against H0
2	-159.450	-138.222	42.457	32	0.102	For Ho
3	-174.547	-134.674	79.745	32	0.000	Against H0
<i>Cooperators</i>						
1	-216.996	-199.398	35.197	32	0.319	For H0
2	-191.277	-174.655	33.244	32	0.406	For H0
3	-160.783	-142.865	35.836	32	0.293	For H0

Ho: Odds(Outcome-J vs. Outcome-K) are independent of other alternatives

Categories 0, 1, 2 and 3 denote no-commercialization, only patenting, only invention-disclosure, patenting plus disclosure respectively

Table 3 Descriptive statistics on scientist patenting and invention disclosures

Variable	Only patent (110)	Only invention disclosure (99)	Patent and disclosure (187)
High financial benefits (3-4 on a 5 point scale)	28	24	37
High reputation (3-4 on a 5 point scale)	52	45	85
Open research	66	69	106
Commercialization costs are high	78	69	153
TTOs are needed	94	75	148
Age (mean)	41	40	44
Female	27	28	22
Foreign-born	42	40	49
Post-Doc	38	22	32
Group leader	26	24	78
Director	5	8	26
MPG experience(mean years)	8.3	8.9	12.2
Industry experience(mean years)	1.1	1.2	0.7
Biology & Medicine	50	46	105
Chemistry/Physics and other technical subjects	58	49	80

The opinion based questions report numbers that respond to “highly agree and strongly agree” in the 5 point scale. All others are particular numbers that pertain to the column category. Source: Own calculation based on MPG Survey

Table 4 Partial Correlations of MNL categories of patenting and invention activity with variables in the estimation

Variable	Overall sample		Non-cooperators		Cooperators	
	Corr.	Sig.	Corr.	Sig.	Corr.	Sig.
Reputation	0.0735	0.001	0.076	0.004	0.0516	0.180
Monetary incentives	-0.0946	0.000	-0.0211	0.428	-0.1773	0.000
Open research	-0.1293	0.000	-0.0828	0.002	-0.1225	0.001
High costs of commercialization	0.0271	0.215	0.0255	0.340	0.0215	0.577
Need for TTOs	0.0333	0.127	0.0617	0.021	0.0158	0.682
Post-doc	0.0398	0.069	0.0308	0.248	0.0525	0.173
Group leader	0.2168	0.000	0.1914	0.000	0.1911	0.000
Director	0.2019	0.000	0.1886	0.000	0.1816	0.000
MPG experience	0.1098	0.000	0.0434	0.104	0.1301	0.001
Foreigner	0.01	0.648	0.0354	0.185	0.0051	0.895
Age (log)	0.0152	0.488	-0.0001	0.997	0.0175	0.650
Female	-0.0626	0.004	-0.0306	0.251	-0.067	0.082
Industry experience	0.0596	0.006	0.0166	0.534	0.0856	0.026

Table 5 Multinomial logit estimates of reputation and financial benefits on inventing and patenting Activities of scientists: sample 1: non-cooperators

MNL categories	Only patenting	Only disclosure	Patenting and disclosure
<i>Explanatory variables</i>			
Reputation	0.0934 (0.19)	0.0254 (0.18)	0.499*** (0.19)
Monetary expectations	-0.214 (0.18)	-0.134 (0.21)	-0.161 (0.21)
Open research	-0.153 (0.18)	-0.177 (0.21)	-0.536*** (0.18)
High costs of commercialization	-0.108 (0.18)	-0.245 (0.22)	0.545 (0.39)
Need for TTOs	0.423* (0.23)	0.0376 (0.24)	0.576** (0.29)
Post doctoral fellow	0.446 (0.35)	0.296 (0.53)	0.277 (0.53)
Group leader	0.793 (0.64)	1.944*** (0.65)	2.232*** (0.62)
Director	1.402 (0.85)	3.104*** (0.89)	3.246*** (1.11)
Years in Max Planck	-0.0478 (0.040)	-0.0224 (0.040)	0.0503 (0.035)
Foreign-born scientists	0.516 (0.37)	0.502 (0.42)	0.312 (0.37)
Age (log)	2.428*** (0.90)	-0.129 (1.37)	-0.00615 (1.63)
Female	0.0461 (0.40)	0.0972 (0.43)	-0.940* (0.50)
Years work in industry	0.102 (0.25)	0.365 (0.30)	0.183 (0.32)
Biology & Medicine	0.725 (0.82)	0.477 (0.91)	19.14*** (5.77)
Chemistry/Physics/Technical subjects	0.558 (0.83)	0.653 (0.86)	18.19*** (5.79)
Constant	-13.70*** (3.07)	-3.135 (4.89)	-25.88 (0)
Observations	1,418	1,418	1,418
Pseudo R^2	0.17		

Robust standard errors in parentheses; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Reputation and Monetary incentive variables are mean centered. Odds-ratios reported

Table 6 Multinomial logit estimates of reputation and financial benefits on inventing and patenting Activities of scientists: sample 2: cooperators

MNL categories	Only patenting	Only disclosure	Patenting and disclosure
<i>Explanatory variables</i>			
Reputation expectation	0.0614 (0.14)	0.101 (0.15)	0.196 (0.12)
Monetary expectation	-0.244 (0.16)	-0.349** (0.17)	-0.535*** (0.12)
Open research	-0.418*** (0.14)	-0.169 (0.14)	-0.333*** (0.11)
High costs of commercialization	-0.166 (0.18)	-0.260 (0.22)	0.178 (0.19)
Need for TTOs	0.316* (0.19)	0.288 (0.18)	-0.0153 (0.13)
Post doctoral fellow	0.339 (0.38)	0.186 (0.40)	0.425 (0.32)
Group leader	0.188 (0.40)	0.207 (0.41)	1.440*** (0.31)
Director	0.361 (0.82)	1.224* (0.66)	2.252*** (0.56)
Years in Max Planck	-0.00893 (0.028)	0.0470* (0.026)	0.0531*** (0.020)
Foreign-born scientists	-0.123 (0.34)	-0.00732 (0.34)	0.0901 (0.27)
Age (log)	3.045*** (0.96)	1.044 (1.07)	0.413 (0.74)
Female	-0.0677 (0.38)	0.209 (0.36)	-0.761** (0.35)
Years work in industry	0.235 (0.21)	0.594*** (0.19)	0.252 (0.17)
Biology & Medicine	18.35*** (3.35)	0.324 (0.85)	1.363* (0.75)

Table 6 continued

MNL categories	Only patenting	Only disclosure	Patenting and disclosure
Chemistry/Physics/Technical subjects	18.62*** (3.32)	0.111 (0.85)	0.996 (0.76)
Constant	−30.88 (0)	−6.558 (4.00)	−4.615 (2.87)
Observations	689	689	689
Pseudo R ²	0.15		

Robust standard errors in parentheses; *** p < 0.01, ** p < 0.05, * p < 0.1. Reputation and Monetary incentive variables are mean centered. Odds-ratios reported

References

- Agrawal, A., & Henderson, R. (2002). Putting patents in context: Exploring Knowledge transfer from MIT. *Management Science*, 48, 44–60. doi:[10.1287/mnsc.48.1.44.14279](https://doi.org/10.1287/mnsc.48.1.44.14279).
- Allen, S. D., Link, A. N., & Rosenbaum, D. T. (2007). Entrepreneurship and human capital: Evidence of patenting activity from the academic sector. *Entrepreneurship: Theory and Practice*, 31, 937–951. doi:[10.1111/j.1540-6520.2007.00207.x](https://doi.org/10.1111/j.1540-6520.2007.00207.x).
- Amesse, F., Desranleau, C., Etemad, H., Fortier, Y., & Seguin-Dulude, L. (1991). The individual inventor and the role of entrepreneurship: A survey of the canadian evidence. *Research Policy*, 20, 13–27. doi:[10.1016/0048-7333\(91\)90081-Z](https://doi.org/10.1016/0048-7333(91)90081-Z).
- Anton, J. J., & Yao, D. Y. (2004). Little patents and big secrets: Managing intellectual property. *RAND Journal of Economics. The RAND Corporation*, 35, 1–22. doi:[10.2307/1593727](https://doi.org/10.2307/1593727).
- Arrow, K. J. (1962). The economic implications of learning by doing. *The Review of Economic Studies*, 29, 155–173. doi:[10.2307/2295952](https://doi.org/10.2307/2295952).
- Azoulay, P., Ding, W., & Stuart, T. (2007). The determinants of faculty patenting behavior: Demographics or opportunities? *Journal of Economic Behavior & Organization*, 63, 599–623. doi:[10.1016/j.jebo.2006.05.015](https://doi.org/10.1016/j.jebo.2006.05.015).
- Baldini, N., Grimaldi, R., & Sobrero, M. (2007). To patent or not to patent? A survey of Italian inventors on motivations, incentives, and obstacles to university patenting. *Scientometrics*, 70, 333–354. doi:[10.1007/s1192-007-0206-5](https://doi.org/10.1007/s1192-007-0206-5).
- Ben-David, J. (1972). *American higher education* (p. 137). New York: McGraw-Hill.
- Ben-David, J., & Sullivan, T. A. (1975). Sociology of science. *Annual Review of Sociology*, 1, 203–222. doi:[10.1146/annurev.so.01.080175.001223](https://doi.org/10.1146/annurev.so.01.080175.001223).
- Bercovitz, J., & Feldman, M. (2008). Academic entrepreneurs: Organizational change at the individual level. *Organization Science*, 19, 69–89. doi:[10.1287/orsc.1070.0295](https://doi.org/10.1287/orsc.1070.0295).
- Blind, K., Edler, J., Frietsch, R., & Schmoch, U. (2006). Motives to patent: Empirical evidence from Germany. *Research Policy*, 35, 655–672. doi:[10.1016/j.respol.2006.03.002](https://doi.org/10.1016/j.respol.2006.03.002).
- Blume, S. S., & Sinclair, R. (1973). Chemists in British universities: A study of the reward system in science. *American Sociological Review*, 38, 126–138. doi:[10.2307/2094336](https://doi.org/10.2307/2094336).
- Buenstorf, G. (2006). Is academic entrepreneurship good or bad for science? Empirical evidence from the Max Planck society. Discussion paper No.2006-17, Max Planck Institute of Economics.
- Cheng, S., & Long, J. S. (2007). Testing for IIA in the multinomial logit model. *Sociological Methods & Research*, 35, 583–600. doi:[10.1177/0049124106292361](https://doi.org/10.1177/0049124106292361).
- Cohen, W. (2005). Patents and appropriation: Concerns and evidence. *The Journal of Technology Transfer*, 30, 57–71. doi:[10.1007/s10961-004-4358-7](https://doi.org/10.1007/s10961-004-4358-7).
- Cole, S., & Cole, J. R. (1967). Scientific output and recognition: A study in the operation of the reward system in science. *American Sociological Review*, 32, 377–390. doi:[10.2307/2091085](https://doi.org/10.2307/2091085).
- Edwards, M. G., Murray, F., & Yu, R. (2006). Gold in the ivory tower: Equity rewards of out-licensing. *Nature Biotechnology*, 24(5), 509–515. doi:[10.1038/nbt0506-509](https://doi.org/10.1038/nbt0506-509).
- Eisenberg, R. (1987). Proprietary rights and the norms of science in biotechnology research. *The Yale Law Journal*, 97, 177–231. doi:[10.2307/796481](https://doi.org/10.2307/796481).
- Eisenberg, R. (1989). Patents and the progress of science—Exclusive rights and experimental use. *The University of Chicago Law Review. University of Chicago. Law School*, 56, 1017–1086. doi:[10.2307/1599761](https://doi.org/10.2307/1599761).

- Etzkowitz, H. (1998). The norms of entrepreneurial science: Cognitive effects of the new university-industry linkages. *Research Policy*, 27, 823–833. doi:[10.1016/S0048-7333\(98\)00093-6](https://doi.org/10.1016/S0048-7333(98)00093-6).
- George, G., Jain, S., & Maltarich, M. A. (2005). Academics or entrepreneurs? Entrepreneurial identity and invention disclosure behavior of university scientists. SSRN eLibrary.
- Goktepe, D. (2008). *Inside the ivory tower: Inventors and patents at Lund university*, PhD thesis.
- Gulbrandsen, M. (2005). But Peter's in it for the money—the liminality of entrepreneurial scientists. *VEST Journal for Science and Technology Studies*, 18(1–2), 49–75.
- Hellmann, T. (2007). The role of patents for bridging the science to market gap. *Journal of Economic Behavior & Organization*, 63, 624–647. doi:[10.1016/j.jebo.2006.05.013](https://doi.org/10.1016/j.jebo.2006.05.013).
- Jensen, K., & Murray, F. (2005). The intellectual property landscape of the human genome. *Science*, 310(10), 239–240. doi:[10.1126/science.1120014](https://doi.org/10.1126/science.1120014).
- Jeon, D. S., & Menicucci, D. (2008). Money, fame and the allocation of talent: Brain drain and the institution of science. *Journal of Economic Behavior & Organization*, 66, 558–581. doi:[10.1016/j.jebo.2006.06.012](https://doi.org/10.1016/j.jebo.2006.06.012).
- Klofsten, M., & Jones-Evans, D. (2000). Comparing academic entrepreneurship in Europe: The case of Sweden and Ireland. *Small Business Economics*, 14, 299–309. doi:[10.1023/A:1008184601282](https://doi.org/10.1023/A:1008184601282).
- Lach, S., & Schankerman, M. (2003). Incentives and invention in universities. *CEPR discussion papers* 3916.
- Levin, S., & Stephan, P. (1991). Research productivity over the life cycle: Evidence for academic scientists. *The American Economic Review*, 81, 114–132.
- Link, A., & Siegel, D. S. (2007). *Innovation, entrepreneurship, and technical change*. Oxford: Oxford University Press.
- Long, C. (2002). Patent signals. *The University of Chicago Law Review*, 69, 625–679.
- Long, J. S., & Freese, J. (2006). *Regression models for categorical dependent variables using STATA* (2nd ed.). College Station: Stata Press.
- Macdonald, S. (1984). The patent system and the individual inventor. *The inventor*, 24, 25–29.
- Macdonald, S. (1986). The distinctive research of the individual inventor. *Research Policy*, 15, 199–210. doi:[10.1016/0048-7333\(86\)90015-6](https://doi.org/10.1016/0048-7333(86)90015-6).
- Markman, G. D., Gianiodis, P. T., Phan, P. H., & Balkin, D. B. (2004). Entrepreneurship from the ivory tower: Do incentive systems matter? *The Journal of Technology Transfer*, 29, 353–364. doi:[10.1023/B:JOTT.0000034127.01889.86](https://doi.org/10.1023/B:JOTT.0000034127.01889.86).
- Merges, R., & Nelson, R. R. (1990). On the complex economics of patent scope. *Columbia Law Review*, 90, 839–916.
- Merges, R., & Nelson, R. R. (1994). On limiting or encouraging rivalry in technical progress: The effect of patent scope decisions. *Journal of Economic Behavior and Organization*, 25, 1–24.
- Merton, R. C. (1957). Priorities in scientific discovery: A chapter in the sociology of science. *American Sociological Review*, 22, 635–659. doi:[10.2307/2089193](https://doi.org/10.2307/2089193).
- Merton, R. C. (1973). The normative structure of science'. In R. C. Merton (Ed.), *The sociology of science*. Chicago: University of Chicago Press.
- Meyer, M. (2005). Independent inventors and public support measures: Insights from 33 case studies in finland. *World Patent Information*, 27, 113–123.
- Murray, F., & Graham, L. (2007). Buying science & selling science: Gender stratification in commercial science. *Industrial and Corporate Change*, 16, 657–689. doi:[10.1093/icc/dtm021](https://doi.org/10.1093/icc/dtm021).
- Owen-Smith, J., & Powell, W. (2001). Careers and contradictions: Faculty responses to the transformation of knowledge and its uses in the life sciences research. *Sociology of Work*, 10, 109–140. doi:[10.1016/S0277-2833\(01\)80023-6](https://doi.org/10.1016/S0277-2833(01)80023-6).
- Owen-Smith, J., & Powell, W. (2003). The expanding role of university patenting in the life sciences: Assessing the importance of experience and connectivity. *Research Policy*, 32, 1695–1711. doi:[10.1016/S0048-7333\(03\)00045-3](https://doi.org/10.1016/S0048-7333(03)00045-3).
- Phan, P., & Siegel, D. S. (2006). The effectiveness of university technology transfer: Lessons learned, managerial and policy implications, and the road forward. *Foundations and Trends in Entrepreneurship*, 2, 77–144. doi:[10.1561/0300000006](https://doi.org/10.1561/0300000006).
- Pratt, M. G., & Foreman, P. O. (2000). Classifying managerial responses to multiple organizational identities. *Academy of Management Review*, 25, 18–42. doi:[10.2307/259261](https://doi.org/10.2307/259261).
- Rosenberg, N. (1974). Science, invention and economic growth. *The Economic Journal*, 84, 90–108. doi:[10.2307/2230485](https://doi.org/10.2307/2230485).
- Rothermael, F. T., Agung, S. D., & Jian, L. (2007). University entrepreneurship: A taxonomy of the literature. *Industrial and Corporate Change*, 16, 691–792. doi:[10.1093/icc/dtm023](https://doi.org/10.1093/icc/dtm023).
- Schmookler, J. (1966). *Invention and economic growth*. Cambridge, MA; London: Harvard University Press.

- Siegel, D. S., & Phan, P. (2005). Analyzing the effectiveness of university technology transfer: Implications for entrepreneurship education. In G. Libecap (Ed.), *Advances in the study of entrepreneurship, innovation, and economic growth* (Vol. 16, pp. 1–38). Amsterdam: Elsevier Science/JAI Press.
- Siegel, D. S., Waldman, D., & Link, A. (2003). Assessing the impact of organizational practices on the relative productivity of university technology transfer offices: An exploratory study. *Research Policy*, 32, 27–48. doi:[10.1016/S0048-7333\(01\)00196-2](https://doi.org/10.1016/S0048-7333(01)00196-2).
- Siegel, D. S., Veugelers, R., & Wright, M. (2007). Technology transfer offices and commercialization of university intellectual property: Performance and policy implications. *Oxford Review of Economic Policy*, 23(4), 640–660. doi:[10.1093/oxrep/grm036](https://doi.org/10.1093/oxrep/grm036).
- Sirilli, G. (1987). Patents and inventors: An empirical study. *Research Policy*, 16, 157–174. doi:[10.1016/0048-7333\(87\)90029-1](https://doi.org/10.1016/0048-7333(87)90029-1).
- Slaughter, S., & Leslie, L. L. (1997). *Academic capitalism: Politics, policies, and the entrepreneurial university*. Baltimore: Johns Hopkins University Press.
- Stephan, P. (1996). The economics of science. *Journal of Economic Literature*, 34, 1199–1235.
- Stephan, P., & Levin, S. (1992). *Striking the mother lode in science: The importance of age, place, and time*. New York: Oxford University Press.
- Stephan, P. E., & Levin, S. G. (2005). Leaving careers in IT: Gender difference in retention. *The Journal of Technology Transfer*, 30, 383–396. doi:[10.1007/s10961-005-2583-3](https://doi.org/10.1007/s10961-005-2583-3).
- Thursby, J. G., & Thursby, M. C. (2007). University licensing. *Oxford Review of Economic Policy*, 23, 620–639. doi:[10.1093/oxrep/grm031](https://doi.org/10.1093/oxrep/grm031).
- Thursby, J. G., Jensen, R., & Thursby, M. C. (2001). Objectives, Characteristics and Outcomes of University Licensing: A Survey of Major U.S. Universities. *The Journal of Technology Transfer*, 26, 59–72. doi:[10.1023/A:1007884111883](https://doi.org/10.1023/A:1007884111883).
- Van Looy, B., Callaert, J., & Debackere, K. (2006). Publication and patent behavior of academic researchers: Conflicting, reinforcing or merely co-existing? *Research Policy*, 35, 596–608. doi:[10.1016/j.respol.2006.02.003](https://doi.org/10.1016/j.respol.2006.02.003).