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Ready to Leave the Ivory Tower? – Academic Scientists' Appeal to Work in the Private Sector

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Abstract

In this study we investigate the factors that shape the attitudes of scientists toward starting their own business or working in a private sector firm. The analysis is based on data collected from scientists working in the German Max Planck Society, a research institution devoted to basic science. We find that the scientists' evaluations of the attractiveness of working in a private sector firm or of starting their own business differ considerably according to their academic discipline and the perceived commercial potential of their research. The ability to take risks, prior work experience in private firms, and personal experience with industry cooperation lead to a positive attitude towards switching to private sector employment or entrepreneurship. Strong willingness to freely distribute research findings are related to a low appeal of private sector work.

Keywords: Knowledge transfer, science, entrepreneurship, innovation, commercialization

JEL-Classification: O31, O33, L26, L32

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"... one of the strongest motives that lead men to art and science is escape from everyday life with its painful crudity and hopeless dreariness, from the fetters of one's own ever-shifting desires. A finely tempered nature longs to escape from personal life into the world of objective perception and thought." (Albert Einstein)[1]

1. Introduction[2]

Scientists have often been considered, in the notion of Albert Einstein, as people who try to escape the "real world" by hiding in the ivory tower of science. However, in the last few decades basic science has become increasingly regarded as important for innovative progress in modern economies and so acceptance of this view has become less widespread among policy makers. Numerous empirical examples have shown that interaction of researchers performing basic science with firms of innovative industries such as biotechnology, nanotechnology or advanced materials can be very fruitful for economic development (Landes, 1998). It has been shown that firms' innovative and economic performance is positively related to their link to the academic sector (Zucker et al., 2002). Firms may draw considerable benefits– in terms of generating innovative ideas and increasing R&D output– from cooperation with academic partners as well as from employment of skilled personnel possessing academic work experience (Herrara et al. 2009; Agrawal, 2006).

As awareness increases that basic science bears the potential to create technological and economic opportunities, policy as well as scholarly debate increasingly focuses on career switches of basic scientists to the private sector and processes of academic entrepreneurship (Dietz and Bozeman, 2005). Prior research has shown that the importance of inputs from basic science – and thus the demand for academic personnel – varies considerably between

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1 A. Einstein, 'Autobiographical notes', in: A. Einstein: Philosopher-Scientist. 1949. Everton(Ill.), ed. P.A. Shilpp.

2 We are indebted to Nicola Breugst, Ljubica Nedelkoska, and Alexandra Schroeter for helpful comments on earlier versions of this paper.

industries and different academic disciplines (Marsili, 1999; Salter and Martin, 2001). It should, therefore, not be surprising that scientists in disciplines such as chemistry, engineering, and law switch to jobs in the private sector more frequently than scientists in humanities (Martinelli, 2001). Empirical analyses of scientists' job migration into the private sector mainly adopted the firm perspective and focused on the impact of scientific skills in already existing firms (Subramaniam and Youndt, 2005; Vinding, 2006) or the importance of scientific expertise and human capital for academic entrepreneurship (see e.g. Shane, 2004; Etzkowitz, 2002; Shrader and Siegel, 2007). What has been more or less entirely neglected in these studies is scientists' incentives to work in the private sector. One of the rare exceptions is a study by Stern (2004) which shows that the majority of scientists who were offered jobs with higher wages in the private sector declined and remained in their publicly financed "ivory tower". This result raises a question about the determinants of scientists' motivation to stay in the ivory tower or to leave for employment in private firms. Why should scientists consider private sector employment or entrepreneurship as an attractive career opportunity? This question is quite important not only for our understanding of the transfer of academic knowledge into the commercial sector but also for policy measures trying to promote this type of knowledge transfer. A comprehensive picture of job mobility between science and industry requires an understanding of scientists' incentives and motivation to work in the private sector.

This paper aims to shed more light on the determinants driving scientists' appeal to work in private sector firms or to start their own venture. We analyze the extent to which scientists' attractiveness to switch to the business sector is determined by the commercial potential of their research, their research environment, and their experience in commercialization of scientific results, while controlling for personal and socio-demographic characteristics. Thus, we contribute to the understanding of scientists' perspective of knowledge transfer and the potential of scientists' willingness to work in the private sector.

Examining the potential for job migration may also help us to understand why knowledge transfer by job migration is rather common and, while relevant in some disciplines, is of much lesser importance in others. This will allow policy and transfer institutions to target that group of individuals which is relatively open towards job migration into the private sector.

The empirical analysis of our study is based on a sample of scientists working at research institutes of the German Max Planck Society (MPS). The mission of researchers of the MPS is to perform excellent basic research in the various fields of life science, natural science, mathematics, technology, and computer science as well as in the social sciences. As the entire budget is publicly funded, there is no pressure on scientists to perform contract research or cooperate on projects with private firms. Therefore, scientists' interest in continuing their professional career in the private sector is not influenced by formal settings, which qualifies MPS scientists as a suitable sample to investigate scientists' individual incentives to work in the private sector.

Our results suggest that scientists who work in fields with commercial orientation see a relatively high appeal to start their own firm or to work in the business sector. Commercialization experience through patenting does not influence the attractiveness to work outside academia. However, experience in research cooperation with private firms is positively related to scientists' assessment on the attractiveness of working in a private sector firm. Personal characteristics such as nationality, possession of a tenured work contract, and a positive attitude towards risk are found to have significant influence on the attractiveness of work outside academia as well. Moreover, in comparison of determinants of entrepreneurial attractiveness and early entrepreneurial activity (nascent entrepreneurship) we find some considerable differences. While a scientist's assessment of entrepreneurial attractiveness is highly influenced by the respective field of research, the effect of the research field on nascent entrepreneurship is rather weak. Moreover, commercial research output

of a scientist in form of patents only contributes to the prediction of nascent entrepreneurship but is not significantly related to entrepreneurial attractiveness.

The remainder of the paper is structured as follows. Section 2 develops hypotheses predicting that attractiveness to scientists' of working in the private sector and of starting their own company is influenced by the nature of their research and their experience in the commercialization of scientific results. Section 3 describes the framework of the Max Planck Society as scientists from this research organization are chosen as our unit of analysis. In Section 4 we provide information about sample characteristics and the measurement of variables. The results of our analysis are presented in section 5. Finally, section 6 discusses the results and concludes.

2. Commercial research and its influence on scientists' appeal to leave academia

2.1 Linking science to industry via job flow: Literature overview

Connecting basic science and the private sector has become a focal point of economic and research policy debate since the 1990's. It is widely acknowledged that high-quality basic research leads to positive economic benefits by creating technological opportunities through invention and by providing new methodological skills and novel research results to businesses in the private sector (Pavitt, 2000; Mansfield, 1998, 1995). With increasing recognition of basic science as an important source for industrial innovation, academic literature increasingly focuses on the manner in which important scientific insights should be efficiently transferred to the private sector in order to stimulate firms' innovative productivity. In this context, several studies examine different knowledge transfer channels and concluded that the most important transfer mechanisms comprehend personal interaction of academic scientists with employees of private firms (see e.g. Agrawal and Henderson, 2002; Cohen et al. 2002; Pavitt, 1998). These results relate to the notion that scientific knowledge often comprises

tacit knowledge embedded in researchers which can be most efficiently conveyed by scientists' personal involvement in industrial innovation (Pavitt, 1998; Rosenberg, 1990). Following this line of reasoning, scholars and policy makers have devoted increasing attention to mobility of researchers from the public science to the private sector as important mechanisms of knowledge transfer. Thereby, job flows of scientists to the private sector are regarded via two distinct paths, namely, academic entrepreneurship and scientists' decisions to switch to existing private sector firms.

Previous studies of scientists switching to private sector employment particularly focus on the firms' perspective. Firms are shown to benefit from employing scientists in at least two ways. First, private firms' innovation processes may rely on the specific knowledge of scientists, particularly when innovations are radical rather than incremental (Koch and Strotmann, 2008). If the development of innovative new products builds upon prior academic inventions, the probability of firms successfully transforming the academic inventions in marketable products when employing the academic inventor(s) may even increase (Agrawal, 2006). Second, even without exploiting the specific knowledge use of scientific inventors, firms may benefit considerably from the general abilities of academic scientists. Almeida et al. (2003) argue that hiring researchers represents an opportunity for firms to obtain state-of-the-art knowledge and trained personnel. Accordingly, Herrara et al. (2009) and Vinding (2006) show that firms' R&D productivity increases with the share of former academic scientists.

Literature on scientists' incentives to move to the private sector is scarce and has hardly accounted for the nature of their research and their ties to industry. Studies analyzing the mobility of scientists mainly focus on the completion of a doctoral degree as a natural career point for switching to the private sector in Europe (see e.g. Mangematin, 2000; Laafia and Simpson, 2001). While American Ph.D. students tend to stay in academia, only roughly one out of ten German doctoral

students becomes a professor in later career stages (Schomburg and Teichler, 2006). The few studies examining determinants of scientists' choices for switching career tracks focus on institutional settings as determinants for job migration. Bozeman and Gaughan (2007), for example, detect that scientists who have an industry-sponsored research contract are more likely to accept positions in the private sector afterwards. Gaughan and Robin (2004) compare the influence of science policies in the U.S. and France but do not find evidence that different science policy systems influence scientists' likelihood to switch to the private sector. The latter studies, while providing useful insights, do not focus on the individual scientists as the unit of analysis. Therefore, our understanding of scientists' motivation to switch from public science to private sector employment is still rather limited.

Prior literature on academic entrepreneurship highlighted that start-up companies founded by academic scientists are often based on scientific inventions (Wright et al. 2007). From a policy perspective, such innovative start-ups have frequently been described as important drivers of economic growth in the spirit of Schumpeter (Wennekers and Thurik, 1999) as they establish new markets or market niches. Many innovative start-ups which manage to survive the crucial first years have the ability to grow rapidly and make a significant economic impact (Zucker et al. 2007). However, entry into innovative industries is relatively risky as innovative start-ups are more likely to fail (Audretsch, 1995; Fritsch, Brixy and Falck, 2006). Therefore academic entrepreneurship is a rather risky career option for scientists. Studies dealing with the question of which scientists become entrepreneurs often highlight the importance of scientific expertise and management skills (Phan and Siegel, 2006; Toole and Czarnitzki, 2009). Additionally, social ties to the private sector have been shown to increase the likelihood of scientists becoming entrepreneurs (Stuart and Ding, 2006). However, as most studies of spin-off formation explicitly focus on start-ups in specific industries such as biotechnology or pharmaceuticals (Shane, 2004), a comprehensive picture of the appeal to scientists to

start a company across research fields is still missing. Furthermore, it is not yet sufficiently well understood which factors motivate scientists to see entrepreneurship as an attractive career opportunity.

2.2 Hypotheses on the relation of scientists' nature of research and the appeal of working in private ventures

Firms' interest in interacting with academic scientists is strongly determined by the innovativeness of their product program and innovation dynamics in their markets. Academic scientists' knowledge and skills are especially important for firms operating in fields where industrial innovation is closely related to novel results in basic science (Pavitt 1998). Such industries are biotechnology and the chemical industries, which have high demand for academic knowledge in the fields of bio-chemical science (Narin et al. 1997); the electronics industry, which relies on academic knowledge in physics (Godin, 1996); and the petroleum industry that closely cooperates with earth scientists (Klevorick et al., 1995). As such industries are relatively closely related to basic science, it is unsurprising that university-industry research cooperation is most prevalent in such fields (Hall et al. 2003).

In this line of reasoning, job migration of academic scientists is found to be most frequent in those areas of research which promise to have commercial potential. Scientists working in fields such as engineering, information technology or biotechnology tend find it easier to obtain a job in the private sector (Martinelli, 2001). While this finding might well be related to the development cycles of technological fields and their respective industries, it seems reasonable to assume that scientists who perceive that their research has commercial potential are also more inclined to regard practical application of their research as an attractive opportunity. Scientists who work on research topics with high potential for commercial application tend to be aware that their research has practical relevance. Therefore, they may regard it as an attractive idea to transform their ideas into marketable products. Moreover, scientists might be more inclined to enter private sector employment if they expect that the content of their work and their routines would not

drastically change. Hence, we hypothesize that attractiveness to scientists to work in the private sector is related to their perception of the commercial potential of their own or of related research. The larger the perceived potential of their research for commercial application, the higher the appeal of working in the private sector (H1a). We also predict that this perception is positively related to scientists' entrepreneurial propensity. Following Gittelman (1999), starting a firm can be regarded an attractive option for scientists whose research is closely related to industrial needs. This argument relates to findings by other studies reporting that scientists who become entrepreneurs often base their firm on scientific inventions (see e.g. Shane and Khurana, 2003; Buenstorf, 2009. Therefore, similar to our argumentation regarding the appeal to scientists of private sector work, we predict that the attractiveness of starting their own firm is positively related to the perception that their research has commercial potential (H1b).

H1a: Scientists' perception that their own or related research has commercial potential is positively related to attractiveness to scientists of working in the private sector.

H1b: Scientists' perception that their own or related research has commercial potential is positively related to attractiveness to scientists of starting their own company.

Apart from the potential influence of the commercial orientation of their research, scientists' appeal of working outside academia may also be shaped by the respective attitudes of their colleagues. If scientists' institutional peers see working in the private sector as relatively attractive, scientists may be likely to adopt a similar attitude. This may be the case for two reasons. First, the appeal to their peers of working in the private sector represents an indicator for the commercial orientation of research performed in the respective institute. As research at institutes commonly follows a specific research agenda, the distribution of science orientation towards business needs and academic entrepreneurship is highly skewed (Shane, 2004). Pronounced levels of entrepreneurial activity and commercialization efforts by scientists have been found in only a rather small share of

research institutions and schools (Charles and Conway, 2001; Wright et al., 2007). These results indicate that scientists' attitude toward entrepreneurial activity is at least partly dependent on the entrepreneurial orientation of their research institutes.

A second reason why peers' attitudes may relate to an individual's assessment of the attractiveness of working in the private sector is that linkages of colleagues to private sector firms may serve as social ties that facilitate the building-up of personal relations to these firms (Granovetter, 1995). Examining labor mobility of business school graduates, Dobrev (2005) provides evidence of individuals directing their careers toward companies in which fellow alumni already worked. Thus, attitudes about labor market choices may well be adopted from peers. In the context of commercialization activities of scientists, several studies have detected that the commercialization behavior of scientists' peers influence their own commercialization behavior. According to Stuart and Ding (2006), scientists are more likely to become entrepreneurs if peers at their institute are involved in commercial science. Similarly, Bercovitz and Feldman (2008) show that organizational influence stimulates the entrepreneurial activity of scientists as scientists tend to learn to adopt the behavior of peers.

Though not mutually exclusive, we assume that both aforementioned potential influences lead to a positive relationship between institutional peers' appeal toward working in the private sector with the respective attitude of an individual scientist. We predict such a positive relationship in hypothesis H2a. Assuming that such a relationship also holds in the context of venture creation, hypothesis H2b predicts that scientists' appeal of entrepreneurial activity is positively related to the respective attitude of institutional peers.

H2a: The attractiveness of working in the private sector of scientific peers is positively related to individual scientists' attractiveness of working in the private sector.

H2b: The attractiveness of becoming entrepreneurs of scientific peers is positively related to individual scientists' attractiveness of becoming entrepreneurs.

2.3 Hypotheses on the relationship between scientists' experience in commercializing research and their appeal to work in private ventures

Successful commercialization of scientific research results may stimulate scientists' appeal to work in the private sector. When scientists commercialize research results, they need to link their findings to industrial needs (Perkman and Walsh, 2007). Being aware of such potential, scientists with commercial research output may be more inclined toward private sector employment than their counterparts which have no such experience in commercialization, as they are aware of parallels between public science and private sector demands.

One channel to commercialize research findings is patenting. Toole and Czarnitzki (2009) as well as Azoulay et al. (2006) highlight that patenting productivity often serves as an indicator of scientist's commercial research orientation. Applying the aforementioned argument, we assume that scientists with patenting experience value private sector work as more attractive than scientists without patents (H3a). Furthermore, patents have been shown to be a robust predictor of scientists' entrepreneurial activity (Azoulay et al., 2006; Stuart and Ding, 2006). This may indicate that patents tend to be a natural antecedent of entrepreneurial activity as patents relate to innovative – and legally protected – ideas which potentially represent business opportunities. Accordingly, we hypothesize that patenting activity is positively related to scientists' attraction to starting their own company (H3b).

H3a: Patenting is positively related to scientists' attraction to work in the private sector.

H3b: Patenting is positively related to scientists' attraction to start their own company.

Another way for academic scientists to foster the commercial application of their research results is through joint research projects with private firms. Scientists with experience in such cooperation are aware of the potential benefits and problems when trying to transform research results into marketable products or when providing research-

related advice. Moreover, cooperative research with private firms may stimulate scientists' orientation of further research towards the demands of these firms (Segarra–Blasco and Arauzo–Carod, 2008). Research collaboration with firms can particularly increase scientists' awareness of the usefulness of their individual skills and knowledge in the private sector (Thune, 2007) and may thereby stimulate their job mobility. We therefore predict that experience in research cooperation with private firms is positively related to scientists' attractiveness of working in the private sector (H4a).

Experience in research cooperation with private firms may also have a positive effect on scientists' appeal to start their own company. Agarwal et al. (2004) describe the ability to evaluate the commercial potential of research results as market–pioneering knowhow. Combined with technological knowhow it is the key capability necessary to seize market opportunities. Similarly, Colombo and Grilli (2005) identify that the combination of scientific–technical and industry–specific knowledge is essential for founders in new technology–based firms. Thus, we hypothesize that experience in research cooperation with private firms is positively related to scientists' attractiveness in starting their own company (H4b).

H4a: Experience in research cooperation with private firms is positively related to scientists' attractiveness to work in the private sector.

H4b: Experience in research cooperation with private firms is positively related to scientists' attractiveness to start their own company.

3. Max Planck Society Scientists: Framework of the study

3.1 The Max Planck Society

The Max Planck Society (MPS) is a German research association which was initially founded in the year 1911 as the Kaiser Wilhelm Society. In 1948 the association adopted its current name. The Society consists of 79 research institutes and three additional research facilities in Germany that perform basic research in the natural sciences, life sciences, social sciences, and the humanities. Approximately 10,200

scientists are employed by Max Planck Plank Institutes, including professors, post-doctoral fellows, doctoral students, and guest scientists (as of 31.12.2008). Researchers are supplemented by roughly 3000 non-scientific employees responsible for administration and research assistance (Max Planck Society, 2009). Around 82 percent of MPS's expenditure is met by public funding from the Federal Government and the German States. The remaining 18 percent stems from donations, member contributions, and from funded projects. In 2008, the total budget of the MPS accounted for 1.4 billion euro.

MPS institutes focus on basic research. They are meant to take up new and innovative research areas that German universities are not in a position to accommodate or deal with adequately. Thus, research at Max Planck Institutes complements the work of universities and other research facilities in relevant fields. The outcome of research conducted at MPS institutes is quite distinguished, as is documented by 32 Nobel Prizes awarded to the MPS researchers since the society's foundation

There are a number of spin-off companies founded by MPS researchers. The success of some of these companies reveals that basic research can have commercial applications with high market potential. In order to support the transfer and commercialization of technology, the MPS maintains a distinct technology transfer office, Max Planck Innovation, which is responsible for all 80 institutes. This transfer office is responsible for the provision of professional services and assistance for technology-based spin-off companies from the MPS. Such services include the assessment of the commercial potential of a technology and assistance in the creation of a business plan as well as assistance in searching for potential financiers (venture capital companies, banks and business angels). However, the MPS invests no capital in the spin-offs. According to its records, the MPS transfer office has coached 86 spin-off companies since 1990, when it began its professional support of spin-offs. Max Planck Innovation lists 69 spin-off companies currently in existence which operate in high-tech industries

such as biotechnology, biochemistry and physical engineering. Altogether, these companies presently employ circa 2,260 people.

3.2 Data generation: The Max Planck Scientist Survey

Our data is based on a survey conducted in MPS institutes between mid-October and mid-December of 2007. Before performing the survey, we contacted the executive directors of each institute to obtain permission to interview the scientists. The majority of directors (67 out of 80) permitted us to conduct the interviews and provided us with the necessary contact information of scientists if it was not publicly available. The basic population for the survey consisted of 7,808 scientists working in 67 institutes. We finished with 2,604 interviews, denoting a response rate of 33.35 percent.

The survey was conducted by TNS Emnid GmbH, a professional opinion research institute. Trained interviewers from TNS Emnid GmbH contacted every scientist in the sample by phone. Participation in the survey was voluntary; scientists could refuse to respond to any specific question or to skip the entire survey. Scientists who could not be contacted after three calls were dropped from the study. The survey questions were particularly designed to analyze whether or not scientists perceive entrepreneurship and research cooperation with firms as attractive and whether scientists actively engage in commercialization of scientific research results. The feasibility and reliability of the survey questions were tested and improved during a pilot study, conducted in August and September 2007. The questions on the survey cover entrepreneurial attractiveness and business ownership experience as well as experience in commercialization activities such as patenting or consulting. Additionally, the survey contains questions regarding scientists' individual attitudes toward commercialization activities as well as questions on research experience, industrial experience, education, socio-demographic and idiosyncratic characteristics, and risk-taking behavior.

4. Data and estimation approach

4.1 Dependent variables: Entrepreneurial attractiveness and attractiveness of work in the private sector

The question *"To what degree is working in the business sector an attractive idea to you? Would you say… not attractive at all; not attractive; neutral; attractive; highly attractive?"* tried to assess scientist's attractiveness of working in the private sector. Therefore, our dependent variable is of ordinal character and can assume five different values from 1 to 5, such that higher values represent increasing attractiveness. Thus, a value of 1 represents that work in the private sector is regarded not attractive at all while a value of 5 denotes the highest level of attractiveness. In analogy, entrepreneurial attractiveness was raised by asking scientists: "*To what degree is starting your own business attractive to you? Would you say…not attractive at all; not attractive; neutral; attractive; highly attractive?"* Again, this variable was coded with values from 1 to 5 with higher values denoting higher attractiveness.

In order to compare our models of entrepreneurial attractiveness with models predicting new business formation, we relate our analysis to a prior study by Krabel and Mueller (2009) analyzing nascent entrepreneurship within the same sample. Nascent entrepreneurship is a concept introduced by the American Panel Study of Entrepreneurial Dynamics (Reynolds et al., 2004). Accordingly, scientists were classified as nascent entrepreneurs if they were engaged in any activity associated with starting a business on the day of the interview. These activities may include applying for public or private financing, seeking venture capital, writing a business plan, looking for office space, or forming a founding team. Therefore, the dependent variable was dichotomous, indicating whether the scientist is involved in start-up activities (coded as 1) or not (coded as 0) (see Krabel and Mueller, 2009, for details).

4.2 Covariates

According to our hypotheses as outlined in section 2 we include the following information about the nature of a scientist's research, institutional effects and commercialization experience into the model.

- *Nature of research:* Three variables measure the nature of research, comprising scientists' own assessment of the commercial potential of their research as well as a classification of their research field. The survey included the following statements on commercialization activities within scientists' research community: "*Commercialization activities are common in my field of research*" and *"My research group focuses on basic research, which is not suitable for commercialization.*" We again provided the aforementioned 5-point Likert-type scale, ranging from '*strongly disagree*' to '*strongly agree*.' These two measures identify scientists' personal perception of the commercial potential of their own or of related research and are used to test our hypotheses H1a and H1b. In order to disentangle scientists' perceptions from research field effects, we also include three binary variables indicating if scientists belong to the Life Science Section, the Natural Science Section or to the Humanities. Variables take a value of 1 if scientists belong to the respective research section and are otherwise coded with a value of 0.
- *Institutional influence:* Two variables capture the potential influence of peers on the attractiveness of working in the private sector and of entrepreneurship. One of these variables captures the mean entrepreneurial attractiveness stated by colleagues working at the same institute. We excluded the respective scientists' own assessment from this computation to ensure that the variable measures only the assessment in the working environment and not the respondent's own evaluation. In the same manner, we computed the mean attractiveness of working in the business sector at each institute, again excluding scientists' own evaluation.

- *Commercialization experience: Two* binary variables indicate whether or not a scientist has experience in research cooperation with private firms and whether or not scientists have ever applied for a patent (yes = 1; no= 0). These two variables allow us to investigate our predictions that commercialization of scientific results relate to scientists' attractiveness of jobs outside academia.
- A number of further variables were included that potentially influence the attractiveness of working in the private sector and of staring one's own firm. Our control variables include information on scientific position, perception of open science, and work history as well as personal and demographic variables.
- *Doctoral degree:* In order to control for differences between Ph.D. students and senior researchers with doctorate degrees, we include a binary variable assuming a value of 1 when a scientist has already obtained a doctorate and a value of 0 to indicate that a scientist has not yet completed a doctoral degree.
- *Director position:* Potential effects resulting from director positions are captured by including a variable indicating whether or not a scientist holds a director position (1 = yes, 0 = no). Directors of Max Planck Institutes are prestigious scientists in later career stages who can hardly advance in academia from their current position. This control variable captures influences of both status and research productivity. The inclusion of this variable also allows a comparison to studies reporting that star scientists are more likely to become entrepreneurs (see e.g. ; Lowe and Gonzalez-Brambila 2007, Buenstorf, 2009).
- *Perception of open science:* In order to examine if and to what degree scientists' attitudes towards science as a public good to be freely available to anyone plays a role in the attractiveness of working in the private sector or of working a firm, we include a measure of this open science attitude in our analysis. This measure is based on the degree to which scientists agreed to the following

statement: "*Your research results should be freely accessible to any other researchers and businesses.*" Scientists were asked to agree or disagree with these statements, based on a five-point Likert-type scale, ranging from '*strongly disagree*' to '*strongly agree'*. We coded the variables with a value of 1 when scientists strongly disagreed with the statement while a value of 5 indicates strong agreement. This control variable for scientists' attitudes towards free diffusion of scientific knowledge is included as scientists who intend to pursue an academic career may place particular importance on widespread research results.

- *Work experience in the private sector:* Two further control variables capture prior work experience in the private sector as business owners or as employees in private firms. *Previous business ownership experience* should predict further entrepreneurial activity (Shane 2004; Stuart and Ding 2006). Our variable indicating such experience is a binary variable with the values 1 (= yes) and 0 (= no) which includes the possibility that the respondent is currently engaged in their own firm. *Work experience in the private sector* prior to occupation at Max Planck may be conducive for subsequent entrepreneurship because it may indicate ties and contacts to actors such as other business owners, suppliers, customers, and financiers (Shane and Stuart, 2002). To control for such effects, a variable is included denoting the number of years worked in the private sector.
- *Personal and socio-demographic characteristics:* Our empirical models also account for gender, age, nationality and individual risk attitude. The measure of risk aversion is adopted from the Socio-Economic Panel in Germany (Wagner et al., 2007; Dohmen et al., 2005). Respondents were told that they have hypothetically won 100 000 Euro in a lottery and are faced with the chance of a risky but lucrative investment. They could either invest nothing, 20 percent, 40 percent, 60 percent, 80 percent or their entire lottery winnings. According to the answers given, our risk variable takes six integer values from 0 to 5. A value of 0 denotes that the respondent would

not invest anything and a value of 5 denotes that the scientist would invest the entire winnings. Two further binary variables indicate scientists' genders (female = 1, male = 0) and scientists' nationalities (1=german, 0=foreign). Scientists' ages are taken into account by two variables denoting age in years and the squared value of age in years. Finally, we include a binary control variable regarding whether scientists have a tenured work contract (1 = tenured, 0 = not tenured). Tenured work contracts may also be an important factor shaping scientists' attraction to jobs outside academia as scientists in the Max Planck Society only have a tenured work contract when they have accomplished an outstanding research record. Thus, tenured scientists may have selected themselves (or were selected) to pursue an academic career.

4.3 Sample characteristics

As interviewed scientists were allowed to skip any specific question, the following analysis is restricted to 2,331 scientists who answered all questions pertaining to our variables of interest. The following sample characteristics are subsequently reduced to these scientists. Among these scientists, 1127 are doctoral students and 1204 postdoctoral researchers, including 58 directors.

We find that entrepreneurial attractiveness in our sample is generally rather low (Figure 1). The mean value of attractiveness does not exceed the arithmetic mean value of three for scientists with and without a Ph.D. Researchers with doctorates assess entrepreneurship as being less attractive than do Ph.D. students. Attractiveness of working in the private sector (Figure 2) is considerably higher than entrepreneurial attractiveness. Again, working in the private sector is more attractive to scientists in early career stages without a Ph.D. as compared to postdoctoral researchers.

The mean values of entrepreneurial attractiveness and of working in the private sector are always higher among Ph.D. students than among

Table 1: Descriptive statistics

Attractiveness of work in business sector

	Ph.D. students			Postdoctoral researchers			t-test
	Mean	Standard deviation	Number of cases	Mean	Standard deviation	Number of cases	
Total sample	3.485	1.103	1,127	2.862	1.108	1,201	***
Life Science Section	3.557	1.042	535	2.958	1.150	505	***
Chemistry, Physics & Technology Section	3.521	1.135	505	2.868	1.071	592	***
Humanities Section	2.839	1.077	87	2.356	0.975	104	***

Share of scientists with high attractiveness of working in the business sector

	Ph.D. students		Postdoctoral researchers		t-test
Total sample	601 (1127)	53.33%	340 (1201)	28.31%	***
Life Science Section	303 (535)	56.64%	165 (505)	32.67%	***
Chemistry, Physics & Technology Section	276 (505)	54.65%	163 (592)	27.53%	***
Humanities Section	22 (87)	25.29%	12 (104)	11.54%	**

Entrepreneurial attractiveness: Distribution

	Ph.D. students			Postdoctoral researchers			t-test
	Mean	S.D.	N	Mean	S.D.	N	
Total sample	2.804	1.187	1125	2.652	1.193	1199	***
Life Science Section	2.925	1.198	535	2.804	1.221	506	*
Chemistry, Physics & Technology Section	2.744	1.178	504	2.594	1.175	589	**
Humanities Section	2.507	1.067	86	2.24	1.029	104	n.s.

Share of Scientists with High Entrepreneurial Attractiveness

	Ph.D. students		Postdoctoral researchers		t-test
Total Sample	336 (1125)	29.87%	318 (1199)	26.52%	*
Life Science Section	178 (535)	33.27%	156 (506)	30.83%	n.s.
Chemistry, Physics & Technology Section	144 (504)	28.57%	150 (589)	25.47%	n.s.
Humanities Section	14 (86)	16.28%	12 (104)	11.54%	n.s.

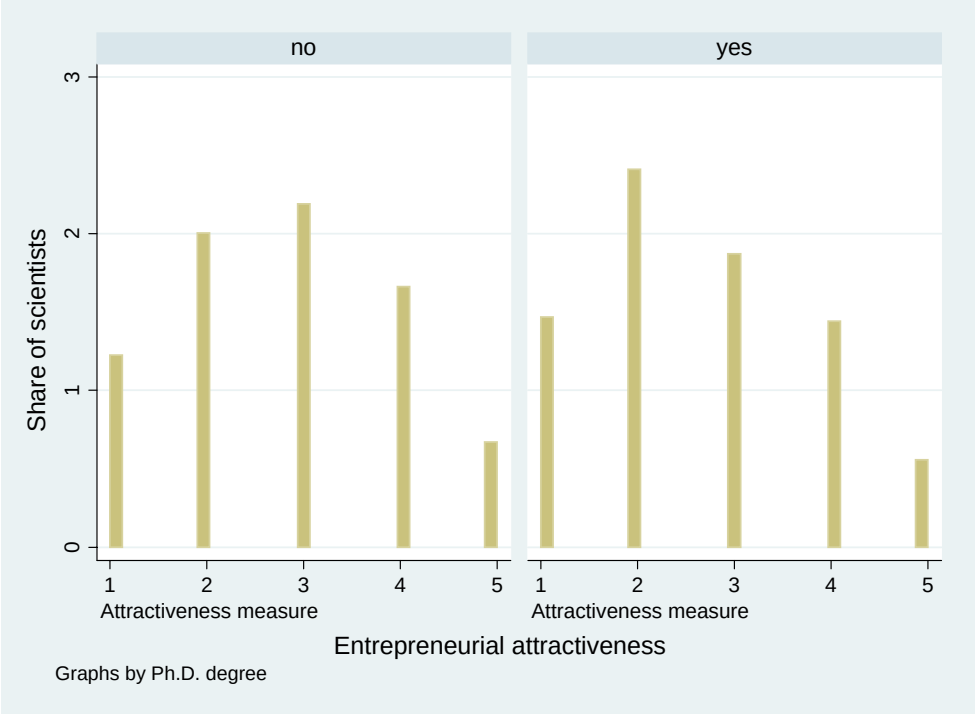

Figure 1: Distribution of entrepreneurial attractiveness by doctorate

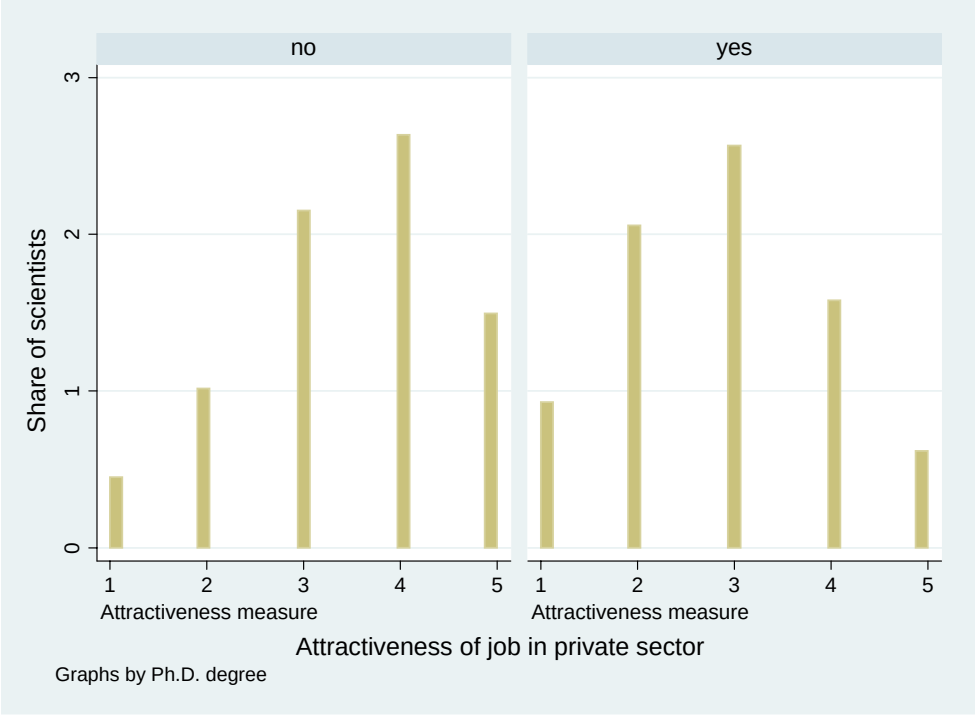

Figure 2: Distribution of job attractiveness in private sector by doctorate

Table 2: Correlation Matrix

Correlations of individual perceptions and commercialization experience

	C1	C2	C3	C4	C5	C6	C7	C8	C9
Attractiveness to work in business sector (C1)	1								
Entrepreneurial attractiveness (C2)	0.3302*	1							
Nascent entrepreneur (C3)	0.0646*	0.1822*	1						
Commercialization is common in field of research (C4)	0.1357*	0.2037*	0.1113*	1					
Research not suit able for com-mercialization (C5)	-0.1144*	-0.2121*	-0.0683*	-0.4231*	1				
Science should be freely available to anyone (C6)	-0.1377*	-0.1255*	-0.0978*	-0.1576*	0.2318*	1			
Patent applied or filed (C7)	-0.0763*	0.0701*	0.1508*	0.1737*	-0.1905*	-0.1019*	1		
Experience in R&D cooperations with industry" (C8)	0.0103	0.0753*	0.0997*	0.2065*	-0.2210*	-0.1153*	0.3051*	1	
Doctorate (C9)	-0.2724*	-0.0645*	-0.0034	-0.0039	-0.0332	0.0841*	0.1962*	0.1644*	1

Notes: Pairwise correlations are reported. The asterisk * reports significance at the 1 percent level.

postdoctoral researchers (Table 1). Comparison among these two groups with the help of t-tests shows that differences are statistically significant in the total sample as well as in most of the disciplinary subsamples. It is noteworthy that more than half of the Ph.D. students in life sciences as well as in physics, chemistry and technical sciences reported work in the business sector as either '*attractive*' or '*highly attractive*.' Comparing the share of Ph.D. students and postdoctoral researchers with high attractiveness of working in the private sector it

clearly stands out that jobs in the private sector are more attractive for PhD students. This relates to the aforementioned findings that the completion of the doctorate represents a natural point in academic careers for switching to a profession in the private sector. A similar pattern can be detected regarding entrepreneurial attractiveness. It can be seen that in all research sections the share of Ph.D. students who reported high entrepreneurial attractiveness is always higher than the respective share of scientists holding a doctorate degree.

The measures of entrepreneurial attractiveness and attractiveness of working in the private sector show a significant positive correlation coefficient of 0.3302 (Table 2). It is rather noteworthy that the correlation coefficient between our measure of entrepreneurial attractiveness and the variable indicating nascent entrepreneurship is quite low (0.1822). Such a low correlation suggests that the two variables of entrepreneurial attractiveness and nascent entrepreneurship reflect different measures which therefore should be explored separately. Relatively high negative correlation (-0.4231) can be found between the indicators of fundamental research focus ('*research not suitable for commercialization*') and the commonness of commercialization in a scientists' research field ('*commercialization is common in field of research*'). Unsurprisingly, scientists working in basic research place a stronger weight on the statement that 'science should be freely available to anyone.' Other correlations between individual perceptions on nature of research (C4-C6) are weak or insignificant.

4.4 Model specification

We separately analyze the determinants of scientists' attraction to work in the private sector and their attraction to entrepreneurial activities. Since the two attractiveness measures used as dependent variables are of ordinal character (5 point scales), we apply an ordered probit model. As our empirical analysis includes the effects of attractiveness of work in the private sector as well as entrepreneurial attractiveness among peers, the number of cases is reduced to 2,328 scientists (attractiveness of work in the private sector) and 2,324 scientists

(entrepreneurial attractiveness) due to missing values on the assessment of institutional peers that did not allow us to compute the variable for peer effects in seven (entrepreneurial attractiveness) and in three (attractiveness to work in the private sector) institutes, respectively.

The analysis is performed on the entire sample and on Ph.D. students and then on senior researchers, separately. This allows us to disentangle determinants of attractiveness values in different career stages. Such a distinction may be important for two reasons. First, senior researchers have already made the primary decision to stay in academia after completing their doctorate. They may, therefore, have higher barriers to and different incentives for considering a job in the private sector. Second, doctoral students may face pressure to search for job opportunities outside academia after finishing their dissertation, as positions in science are scarce. Thus, the distinction between researchers without a Ph.D. and senior scientists may be very helpful for analyzing the attractiveness of entrepreneurship or of working in a private firm.

In order to assess to what extent determinants of entrepreneurial attractiveness are similar to determinants of entrepreneurial action, we provide additional estimations analyzing scientists' likelihood of becoming nascent entrepreneurs. We thereby build upon results of a prior study by Krabel and Mueller (2009) on nascent entrepreneurship using the same dataset. As in this study, we apply rare event logistic estimations to analyze scientists' likelihood of becoming nascent entrepreneurs. The models include the same set of explanatory variables so that we are able to compare the results for entrepreneurial attractiveness and nascent entrepreneurship. Thus, our results in conjunction with the examination of Krabel and Mueller (2009) provide a comprehensive picture of entrepreneurial attractiveness to scientists and their choices to start up companies.

5. Results: Determinants of the attractiveness of jobs outside academia

5.1 Attractiveness of working in the business sector

The results of the ordered probit models suggest that scientists' perception of commercialization as common in their field of research is positively related to their assessment of the attractiveness of work in the private sector (Table 3) while a focus of the research group on basic research is negatively related to this attractiveness. These relationships are both statistically significant at the five percent level in the entire sample (columns 5 and 6) and significant at the one percent level in the subsample of senior researchers (columns 3 and 4) who have already completed their doctorate. This evidence supports hypothesis H1a which predicted a positive relationship between scientists' perceptions that their research has commercial potential and their attraction to work in the private sector. Scientists' attitude towards open science ("*science should be freely available to anyone"*) is negatively related to attractiveness values, which indicates that research orientation and the general attitude towards commercialization affects scientists' appeal of working outside academia. Again, these effects are mainly driven by the senior researchers and are not statistically significant in the subsample of Ph.D. students (column 1 and 2). Scientists in the humanities se working in the private sector as significantly less attractive than their peers in life sciences and natural sciences.

The mean assessment of the attractiveness of work in the private sector by institutional peers is significantly positively related to the individual assessment supporting our hypothesis H2a. However, this result is driven by the subgroup of Ph.D. students while no significant relationship can be found among senior researchers. With regards to commercialization experience, we find that holding a patent has no significant effect on a scientists' assessment of attractiveness of work in the private sector so that hypothesis H3a, which predicted a

Table 3: Results of ordered probit estimates of business sector work attractiveness

	PhD students		Senior researchers		Entire sample	
	(1)	(2)	(3)	(4)	(5)	(6)
Doctoral degree	-	-	-	-	-0.328***	-0.328***
					(0.074)	(0.074)
Life science	-0.073	-	-0.025	-	-0.027	
	(0.08)		(0.069)		(0.047)	
Chemistry, Physics and Technology	-	0.073	-	0.025		0.027
		(0.08)		(0.069)		(0.047)
Humanities	-0.360**	-0.287*	-0.348**	-0.323**	-0.358***	-0.331***
	(0.161)	(0.162)	(0.135)	(0.143)	(0.094)	(0.096)
Research context						
Commercialization is common in field of research (5-point rating scale, 1-5)	0.021	0.021	0.108***	0.108***	0.064***	0.064***
	(0.036)	(0.036)	(0.032)	(0.032)	(0.024)	(0.024)
My research is not suitable for commercialization (5-point rating scale, 1-5)	-0.030	-0.030	-0.074***	-0.074***	-0.043**	-0.043**
	(0.033)	(0.033)	(0.027)	(0.027)	(0.021)	(0.021)
Science should be freely available to anyone (5-point rating scale, 1-5)	-0.061	-0.061	-0.100**	-0.100**	-0.082*	-0.082*
	(0.038)	(0.038)	(0.041)	(0.041)	(0.033)	(0.033)
Mean attractiveness of working in industry at institute	0.518***	0.518***	0.042	0.042	0.242***	0.242***
	(0.166)	(0.166)	(0.111)	(0.111)	(0.090)	(0.090)
Work experience						
Years of work in industry	0.035**	0.035**	0.037**	0.037**	0.033***	0.033***
	(0.014)	(0.014)	(0.017)	(0.017)	(0.010)	(0.010)
Commercialization experience						
Patent filed or applied for	-0.109	-0.109	-0.040	-0.040	-0.064	-0.064
	(0.138)	(0.138)	(0.103)	(0.103)	(0.082)	(0.082)
Cooperation with industry	0.193**	0.193**	0.154*	0.154*	0.165***	0.165***
	(0.089)	(0.089)	(0.085)	(0.085)	(0.048)	(0.048)
Personal characteristics						
Risk attitude	0.024	0.024	0.046*	0.046*	0.035*	0.035*
	(0.026)	(0.026)	(0.024)	(0.024)	(0.018)	(0.018)
Gender (1=female)	0.035	0.035	0.043	0.043	0.023	0.023
	(0.063)	(0.063)	(0.082)	(0.082)	(0.051)	(0.051)
Age (years)	0.083**	0.083*	-0.079**	-0.079**	-0.02	-0.02
	(0.036)	(0.036)	(0.036)	(0.036)	(0.023)	(0.023)
Age^2 (years squared)	-0.001**	-0.001**	0.001	0.001	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)
German citizenship	0.129**	0.129**	-0.014	-0.014	0.055	0.055
	(0.065)	(0.065)	(0.076)	(0.076)	(0.044)	(0.044)
Director position	-	-	-0.695***	-0.695***	-0.575***	-0.575***
			(0.182)	(0.182)	(0.183)	(0.183)
Tenured working contract	-0.533**	-0.533**	-0.312***	-0.312***	-0.425***	-0.425***
	(0.212)	(0.212)	(0.093)	(0.093)	(0.100)	(0.100)
Number of observations	1127	1127	1201	1201	2328	2328
McFadden's R2	0.0400	0.0400	0.0708	0.0708	0.0735	0.0735
Log likelihood (full model)	-1583.32	-1583.32	-1664.27	-1664.27	-3273.99	-3273.99
Wald Chi2	X2(16)	X2(16)	X2(16)	X2(16)	X2(17)	X2(17)
	169.10***	169.10***	319.84***	319.84***	657.84***	657.84***

Robust standard errors, which are adjusted for institutes, are reported in parentheses. The asterisks *, ** and *** report significance at the 10, 5 and 1 percent level, respectively.

positive relationship between patenting and scientists' appeal to work in the private sector, is clearly rejected. Prior experience in R&D cooperation has a positive effect in the entire sample as well as within both subgroups. Thereby, our evidence is in support of hypothesis H4a, which stated that cooperation experience with private industry has a positive relationship to scientists' attraction to work in the private sector.

As is already apparent from our descriptive statistics, working in the business sector is more attractive to doctoral students. The effect of the binary variable indicating a doctoral degree is significant at the one percent level. Age has a positive influence on Ph.D. students' attraction to work in the private sector while age is negatively related to senior researchers' appeal to work in the private sector. This corresponds to results of a study by Mangematin (2000), which finds that the completion of a doctoral thesis is a natural point in time for a change of career tracks. Directors as well as scientists with tenured working contracts find it significantly less attractive to work in the business sector. While gender is not significantly related to the attractiveness of working in the private sector, German doctoral students are found to perceive work in the private sector significantly more appealing than non-German Ph.D. students. This result may well be explained by a self-selection process: Foreign doctoral students decide to move to Germany and work for the Max Planck Society with the aim of pushing their academic career by starting in a 'science powerhouse.' Therefore, these students are less likely than their German counterparts to consider work in the private sector to be attractive. Older Ph.D. students assess working in the private sector as being relatively attractive while this attractiveness decreases with the age of senior scientists. The willingness to take risks has a slightly positive and statistically significant effect on scientists' assessment of the attractiveness of work in the private sector.

5.2 Entrepreneurial attractiveness

According to our results, scientists' assessment of entrepreneurial attractiveness is relatively high when working in research fields where commercialization is common (Table 4). In contrast, the perception of a strong focus on basic research of the scientists' research group has a significantly negative effect on the appeal of working in the private sector. The negative relation of scientists' research focus is statistically significant in each of the subsamples while, among doctoral students, the perception of commercialization as common is only positively related to the attractiveness of work in the private sector. This evidence supports hypothesis H1b, which stated that scientists' perception of commercial potential of their own or related research is positively associated with their assessment of entrepreneurial attractiveness. Scientists in the life sciences value starting their own firm as significantly more attractive than their peers in natural sciences and in the humanities.

Quite surprisingly, there is no significant relationship between the mean attractiveness level of entrepreneurial activities at the institutional level and scientists' individual assessment of the attractiveness of starting a firm. Therefore, our results suggest a rejection of hypothesis H2b, which predicted a positive relationship between mean institutional and scientists' individual assessments of entrepreneurial attractiveness. We also do not see any significant positive relationship between a scientist's patenting experience and their proclivity to start a business. Thus, hypothesis H3b, which predicted that patenting is positively related to entrepreneurial attractiveness, must be rejected. Research cooperation with industry has a positive effect on the assessed attractiveness of starting one's own firm only in the entire sample, supporting hypothesis H4b. Several of the control variables show a statistically significant relationship with entrepreneurial attractiveness. While risk-proclivity has the expected positive effect on entrepreneurial

Table 4: Results of ordered probit regressions of entrepreneurial attractiveness

	PhD students		Senior researchers		Entire sample	
	(1)	(2)	(3)	(4)	(5)	(6)
Doctoral degree	-	-	-	-	-0.135**	-0.135**
					(0.064)	(0.064)
Life Science	0.306***	-	0.116	-	0.209***	-
	(0.074)		(0.075)		(0.045)	
Chemistry, Physics and Technology	-	-0.306***	-	-0.116	-	-0.209***
		(0.074)		(0.075)		(0.045)
Humanities	-0.052	-0.357***	-0.079	-0.195*	-0.046	-0.255***
	(0.119)	(0.131)	(0.093)	(0.116)	(0.065)	(0.080)
Research context						
Commercialization is common in field of research (5-point rating scale, 1-5)	0.093**	0.093**	0.047	0.047	0.065**	0.065**
	(0.041)	(0.041)	(0.042)	(0.042)	(0.029)	(0.029)
Research in my group is too basic to not suitable for commercialization (5-point rating	-0.092***	-0.092***	-0.152***	-0.152***	-0.121***	-0.121***
	(0.031)**	(0.031)**	(0.037)**	(0.037)**	(0.023)**	(0.023)**
Science should be freely available to anyone (5-point rating scale, 1-5)	-0.061*	-0.061*	-0.121***	-0.121***	-0.094***	-0.094***
	(0.036)	(0.036)	(0.032)	(0.032)	(0.027)	(0.027)
Mean attractiveness of working in industry at institute	-0.03	-0.03	0.068	0.068	0.036	0.036
	(0.142)	(0.142)	(0.124)	(0.124)	(0.093)	(0.093)
Work experience						
Years of work in industry	0.025**	0.025**	0.012	0.012	0.018*	0.018*
	(0.011)	(0.011)	(0.015)	(0.015)	(0.01)	(0.01)
Prior business ownership	0.731***	0.731***	0.664***	0.664***	0.682***	0.682***
	(0.196)	(0.196)	(0.123)	(0.123)	(0.108)	(0.108)
Commercialization experience						
Patent filed or applied for	0.048	0.048	0.130	0.130	0.107	0.107
	(0.199)	(0.199)	(0.109)	(0.109)	(0.1)	(0.1)
Cooperation with industry	0.100	0.100	0.088	0.088	0.094**	0.094**
	(0.062)	(0.062)	(0.064)	(0.064)	(0.046)	(0.046)
Personal characteristics						
Risk attitude	0.102***	0.102***	0.071***	0.071***	0.086***	0.086***
	(0.020)	(0.020)	(0.021)	(0.021)	(0.014)	(0.014)
Gender (1=female)	-0.393***	-0.393***	-0.324***	-0.324***	-0.371***	-0.371***
	(0.081)	(0.081)	(0.073)	(0.073)	(0.051)	(0.051)
Age (years)	0.042	0.042	-0.067***	-0.067***	-0.028	-0.028
	(0.044)	(0.044)	(0.025)	(0.025)	(0.02)	(0.02)
Age^2 (years squared)	-0.001	-0.001	0.001**	0.001**	0.000	0.000
	(0.001)	(0.001)	(0.000)	(0.000)	(0.001)	(0.001)
German citizenship	-0.437***	-0.437***	-0.298***	-0.298***	-0.363***	-0.363***
	(0.087)	(0.087)	(0.062)	(0.062)	(0.058)	(0.058)
Director position	-	-	0.174	0.174	0.189	0.189
			(0.166)	(0.166)	(0.163)	(0.163)
Tenured working contract	-0.227*	-0.227*	-0.217*	-0.217*	-0.233***	-0.233***
	(0.135)	(0.135)	(0.106)	(0.106)	(0.090)	(0.090)
Number of observations	1125	1125	1199	1199	2324	2324
McFadden's R2	0.0635	0.0635	0.0677	0.0677	0.0642	0.0642
Log likelihood (full model)	-1620.75	-1620.75	-1706.92	-1706.92	-3339.68	-3339.68
Wald Chi2	X2(17)	X2(17)	X2(17)	X2(17)	X2(18)	X2(18)
	590.21***	590.21***	368.56***	368.56***	508.67***	508.67***

Robust standard errors, which are adjusted for institutes, are reported in parantheses. The asterisks *, ** and *** report significance at the 10, 5 and 1 percent level, respectively.

Table 5: Rare event logistic estimations on likelihood to be a nascent entrepreneur

	PhDs (37 nascents)	Senior researchers (36 nascents)		Entire sample (73 nascents)	
	(1)	(2)	(3)	(4)	(5)
Doctoral degree	-	-	-	-0.494	-0.494
				(0.359)	(0.359)
Life Science	0.273	0.040	-	0.064	-
	(0.504)	(0.406)		(0.323)	
Chemistry, Physics and Technology	-	-	-0.398	-	-0.064
			(0.406)		(0.323)
Humanities	-	1.288*	1.248	0.048	-0.016
		(0.712)	(0.772)	(0.539)	(0.645)
Research context					
Commercialization is common in field of research (5-point rating scale, 1-5)	0.356*	0.198	0.198	0.279*	0.279*
	(0.191)	(0.196)	(0.196)	(0.156)	(0.156)
My research is not suitable for commercialization (5-point rating scale, 1-5)	0.083	0.078	0.078	0.042	0.042
	(0.176)	(0.268)	(0.268)	(0.155)	(0.155)
Science should be freely available to anyone (5-point rating scale, 1-5)	-0.173	-0.506**	-0.506**	-0.349***	-0.349***
	(0.177)	(0.204)	(0.204)	(0.128)	(0.128)
Mean attractiveness of working in industry at institute	-0.938	1.044	1.044	0.056	0.056
	(1.037)	(0.994)	(0.994)	(0.044)	(0.044)
Work experience					
Years of work in industry	0.040	0.090	0.090	0.056	0.056
	(0.061)	(0.062)	(0.062)	(0.044)	(0.044)
Prior business ownership	1.454***	1.276***	1.276***	1.348***	1.348***
	(0.505)	(0.416))	(0.416))	(0.295)	(0.295)
Commercialization experience					
Patent filed or applied for	1.349***	1.242***	1.242***	1.298***	1.298***
	(0.393)	(0.462)	(0.462)	(0.299)	(0.299)
Cooperation with industry	0.662	0.759	0.759	0.702**	0.702**
	(0.408)	(0.475)	(0.475)	(0.289)	(0.289)
Personal characteristics					
Risk attitude	-0.051	0.150	0.150	0.068	0.068
	(0.124)	(0.100)	(0.100)	(0.078)	(0.078)
Gender (1=female)	-0.299	0.268	0.268	-0.039	-0.039
	(0.347)	(0.463)	(0.463)	(0.255)	(0.255)
Age (years)	-0.201	-0.142	-0.142	-0.112	-0.112
	(0.140)	(0.165)	(0.165)	(0.114)	(0.114)
Age^2 (years squared)	0.002	0.001	0.001	0.001	0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
German citizenship	-1.362***	-0.554	-0.554	-0.935***	-0.935***
	(0.429)	(0.386)	(0.386)	(0.344)	(0.344)
Director position	-	1.858*	1.858*	1.603**	1.603**
		(1.016)	(1.016)	(0.789)	(0.789)
Tenured working contract	-0.422	-0.594	-0.594	-0.449	-0.449
	(0.602)	(0.824)	(0.824)	(0.475)	(0.475)
Constant	2.733	-3.129	-3.129	-0.259	-0.259
	(4.148)	(5.344)	(5.344)	(3.638)	(3.638)
Number of observations	1124	1197	1197	2321	2321
Pseudo R2	0.1455	0.2673	0.2673	0.2673	0.1829
Wald Chi2	X2(15) 207.17***	X2(17) 156.85***	X2(17) 156.85***	X2(17) 156.85***	X2(17) 236.07***

Robust standard errors, which are adjusted for institutes, are reported in parantheses. The asterisks *, ** and *** report significance at the 10, 5 and 1 percent level, respectively.

attractiveness, we find that females and scientists with German nationality find starting their own firm significantly less appealing than their male and foreign-born counterparts. Scientists with tenured working contracts place the attractiveness of entrepreneurship at a relatively low level.

The determinants of scientists' propensities to take entrepreneurial action and become nascent entrepreneurs (table 5) differ considerably from the factors that affect their assessment of entrepreneurial attractiveness. Note that among doctoral students in the humanities, no nascent entrepreneur is found, so we disregard this variable in the analysis. While the nature of scientists' research and its perceived commercial potential has a robust positive and significant relation to entrepreneurial attractiveness, nascent entrepreneurship seems to be largely independent of the respective research field. Furthermore, patent activity is shown to be a strong predictor of nascent entrepreneurship but is not related to entrepreneurial attractiveness. Also, individual risk attitude and gender, which have an effect on entrepreneurial attractiveness, do not explain nascent entrepreneurship.

6. Discussion and Conclusions

The purpose of this study was to identify factors that shape scientists' appeal toward work outside academia. Results indicate that working in the business sector is regarded as attractive or highly attractive by about 40 percent of the scientists in our sample. Among Ph.D. students this share exceeds 50 percent, while less than 30 percent of postdoctoral researchers find it attractive to work in the business sector. Differences between doctoral students' appeal to work in the private sector are significantly different and robust. Thereby, our results correspond to the findings by Mangematin (2000) and Laafia and Simpson (2001) that a relatively high share of European Ph.D. students intend to pursue a career in the private sector after receiving their doctorate. Doctoral students are also more likely to adopt the attitude of

colleagues. The mean attractiveness, as valued by institutional peers, is positively related to the individual appeal of doctoral students toward work in the business sector while not being significantly related to the assessment of the senior scientists in their department. This indicates that young scientists' interest in career continuation outside academia can be influenced by the view of peers.

Regarding scientists' appeal towards entrepreneurial activity we do not find any such significant institutional effect. Moreover, entrepreneurial attractiveness is only slightly higher among Ph.D. students as compared to postdoctoral researchers. Among doctoral students, 29.8 percent value entrepreneurial activity as 'attractive' or 'highly attractive,' while 26.4 of postdoctoral scientists report such high values. However, while denoting only slight differences between postdoctoral researchers and doctoral students, the numbers reveal a remarkably high share, given that most researchers of our sample work in basic science and do not face any pressure to make research results applicable to industry.

There is considerable variation in the attractiveness of work in the business sector or of starting one's own firm between the research disciplines. Scholars in natural sciences and in life sciences find it significantly more attractive to work in private sector firms than do researchers in the humanities. More than 40 percent of scientists in life sciences and natural sciences assess working in the business sector as attractive or highly attractive, while this is the case for less than 20 percent of scientists in the humanities. We interpret this evidence as an indication that scientists in the humanities mainly intend to pursue academic careers as they are aware of the relatively low chance of switching to the private sector. For scholars working in the humanities, starting their own firm appears to be considerably less attractive than working in the private sector. Thus, the potential for spin-off activity among scientists is mainly given in natural and life sciences.

Apart from their affiliation to a certain research section, scientists' own assessment on the nature of their research and its

commercial potential has a strong influence on scientists' appeal to both work in the business sector and to start their own firm. Scientists' assessment of commercialization as being common in their field of research is positively related to their appeal to work outside academia. Moreover, the opinion that the research conducted has no commercial potential and that scientific research should be made accessible to anyone interested impedes scientists' attraction toward work in the business sector or toward starting their own firm. These results indicate that scientists' research focus and discipline influence their attraction to private sector jobs. Moreover, scientists who value see distribution of scientific results as rather important tend to find work in the private sector as less attractive. This result opens a new research window as the question arises as to whether open access to science is important in scientific careers while being less important to scientists who intend to connect themselves to private firms.

Our analyses also provide evidence that patenting activity does not influence scientists' appeal to work in the private sector while experience in research cooperation with private firms does. Prior work experience in industry also seems to act as a stimulus for scientists to switch to business sector employment. Interestingly, the share of scientists with private sector work experience is highest among the humanities section. 23.03 percent of the scientists in this section have work experience in the private sector, compared to 18.23 percent in the chemistry, physics and technology section and 17.40 percent of life science researchers. Given the relatively high share of scientists with private sector work experience, the low share of scientists in the humanities who report high levels of attractiveness toward work in the private sector is quite surprising.

With regards to personal characteristics of scientists, our results suggest that tenured working contracts impede the proclivity for job migration. In line with prior research in entrepreneurship, the willingness to take risks is found to have a positive influence on the attraction to start one's own business (Shane et al., 2003; Forlani and Mullins,

2000), while female scientists are less likely to find it appealing to start a firm (Stephan and El-Ganainy, 2007; Murray and Graham, 2007). The longer a scientist has stayed in academia, the less attractive he or she regards private sector employment.

Interestingly, we find some considerable differences between the determinants of entrepreneurial attractiveness and the factor driving nascent entrepreneurship. While patenting of research results is a robust indicator of nascent entrepreneurship, it is not related to entrepreneurial attractiveness. Two explanations for this result seem plausible. First, scientists interested in starting a company may only patent after deciding to found a business while patenting activity per se is not motivated by start-up intentions. Second, the results might be driven by the sample choice as Max Planck Innovation, the technology transfer office of the Max Planck Society, focuses particularly on supporting start-ups based on scientific inventions. These are usually patented in order to secure the intellectual property rights of promising inventions.

We also found that the characteristics of the research field, particularly scientists' assessments that commercialization activities are relatively common in their field of research, have a strong effect on scientists' assessment of entrepreneurial attractiveness while being barely related to nascent entrepreneurship. This result suggests that there is hidden potential for further entrepreneurial activity in areas where commercialization activities are frequently pursued**.**

We conclude that scientists' appeals toward work in the private sector – either as a dependent employee or as an entrepreneur – differ considerably according to the commercial potential of their research and their commitment to the norms of open science. Moreover, prior work experience in industry and cooperative research projects with private firms lead to higher evaluation of attractiveness of working in the private sector. Hence, our results suggest that job mobility between public science and private sector work can be stimulated by policy measures that promote commercial research orientation and science-

industry interaction. Moreover, despite focusing on a sample of researchers in the field of basic science who have no pressure to interact with industry, we detect a relatively high share of scientists assessing work in the private sector as attractive. The surprisingly weak relationship between scientists' assessment of entrepreneurial attractiveness and nascent entrepreneurship should be subject to further research.

Since the data underlying our analysis is just a snapshot taken at a certain point in time, we are unable to analyze the degree to which scientists' higher appeal toward work in the private sector increases the likelihood of future employment in the private sector in later career stages. Moreover, our analysis is based on a sample of scientists whose research is devoted to basic science and research excellence. In order to provide a more complete picture on scientific job flow and scientists' incentives to work in the private sector, we encourage further similar studies in other research settings. Such additional studies could provide important support for the design of policies aiming to support knowledge transfer.

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