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Why Do Scientists in Public Research Institutions Cooperate with Private Firms?

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Abstract:
As public research institutions are increasingly pressured to transfer research results to industry, evaluation of their performance is not only based on their scientific output but also on their commercialization success. Although it is well known that research cooperation activities are an important channel of knowledge transfer, the knowledge about factors driving research cooperation is limited. This paper explicitly focuses on scientist perspective and investigates the relevance of academic values and perceived costs and benefits of cooperation for a scientist's decision to cooperate with private firms. Our analysis is based on two survey waves performed with scientists in the Max Planck Society in Germany which is a publicly funded research organization focusing on basic research. Our empirical results suggest that open science identity is an important determinant of scientist fundamental decision to cooperate with private firms at all. The decision to keep on cooperating with private firms is directly influenced by cost sharing incentives and by firms' confidentiality requirements. Besides these direct effects, our results suggest that perceived reputational reward, monetary benefits, and time costs associated with cooperation influence cooperation behavior indirectly through their impact on the attractiveness of cooperation. The latter is a strong and robust predictor of cooperation behavior.

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1 Introduction

In facing stiffening economic competition policymakers have called on universities and public research institutions to transfer knowledge more effectively in order to make the best societal use of academic research (Cohen et al., 2002, 1998; Buenstorf, 2009). For this reason, university administrators, deans and scientists, thereby, face the task of transforming universities and public research labs into more entrepreneurial organizations incorporating knowledge transfer to the private sector as part of the mission science has to fulfill. The success of knowledge transfer, however, depends on *scientists' willingness* to commercialize their research findings, as scientists can hardly be forced to do so. Therefore, leaders of research organizations, who want to improve the commercialization performance of their organizations, should understand the individual benefits and drawbacks associated with commercialization activities which determine the scientists' decision to commercialize their research findings.

Due to the changing role of public research institutions and the task of advancing commercial research, over the past few decades scholarly literature has increasingly focused on scientists' commercialization activities. However, this strand of literature focuses for the most part on academic entrepreneurship (see e.g. Powers and McDougall, 2005; Bercovitz and Feldman, 2008; Stuart and Ding, 2006) and academic patenting (see e.g. Azoulay et al., 2007; Henderson et al., 1998; Thursby and Thursby, 2002). While providing interesting and important insights, studies on academic entrepreneurship and university patenting do not reveal a complete picture. The founding of a new firm based on university inventions is a rare event and patent data has limited explanatory power as both firms and scientists acknowledge that patents account for a relatively small proportion of knowledge transfer to the private sector (Agrawal and Henderson, 2002; Cohen et al., 2002). In contrast, collaborative research with private firms represents the most frequently used form of knowledge transfer (Gulbrandsen and Smeby, 2005; Sellenthin, 2009). Furthermore, firms value transfer via direct interaction with academic scientists as the most important source of knowledge (Cohen et al., 2002). In view of this evidence it is surprising that cooperative research projects have not been studied to the same extent as entrepreneurship or patenting. Cooperative research projects allow the flow of tacit knowledge which is often described as being of crucial importance in the successful commercialization of science (Zucker et al., 1998; Pavitt, 1998; Fleming and Sorenson, 2004).

The present study aims to examine why *scientists* decide to cooperate with private firms in order to improve our understanding of this relevant transfer channel. Even at face value an individual scientist's decision to perform cooperative research projects with private firms is not straightforward. Scientists need to weigh up the benefits and the drawbacks of commercializing scientific results. Therefore values relating to the scientific reward system are likely to be a crucial factor in shaping scientists' decision about whether or not to cooperate with private firms at all. Apart from the question why scientists cooperate with private firms at all, it is also important to assess why scientists with cooperation experience engage in further cooperation. In the present study we propose that reputation, monetary incentives and time constraints influence the subsequent cooperation behavior of those scientists with cooperation experience.

In order to examine cooperation behavior empirically, we make use of a dataset obtained through survey interviews conducted with scientists of the Max Planck Society (MPS) in Germany. Scientists were interviewed by phone in two survey waves. An initial survey was implemented with the aim of identifying the group of scientists with cooperation experience and examining scientists' appeal of research cooperation with private firms. In a follow-up survey, those scientists with cooperation experience were interviewed again six to seven months later. The data obtained in the initial survey allows us to examine how scientists' attitude towards open science as well as the reputational reward associated with commercial research relate to scientists' cooperation experience. In order to assess the impact of cooperation attractiveness on cooperation, we also focus on the attractiveness of research cooperation as identified by individual scientists. Using the information from the follow-up survey, we are able to analyze how private benefits such as the monetary gains and reputational award associated with cooperative research with private firms and the perceived drawbacks in terms of time costs influence scientists subsequent cooperation behavior. In our empirical analysis the inclusion of attractiveness allows us to investigate both the direct and indirect (mediated by cooperation attractiveness) effects of explanatory variables on cooperation behavior.

Our results suggest that reputational rewards from commercialization and open science identity are important factors in explaining why some scientists cooperate and others do not. Both cooperation experience and subsequent cooperation behavior are highly influenced by individual attractiveness of cooperation. Among scientists who already have cooperation experience financial benefits, reputational reward and time demand associated with cooperation activities influence individual attractiveness of cooperation but do not directly influence individual decision on subsequent cooperation. Thus, time and monetary aspects have an indirect influence on cooperation behavior mediated by cooperation attractiveness. The secrecy requirements of firms have a negative direct effect on the probability of engaging in future cooperations.

The remainder of this paper is structured as follows. The theory and hypotheses are derived in section 2. Section 3 describes the framework of our study, which is based on two survey waves conducted with scientists within the Max Planck Society. In order to provide the reader with necessary background information, the institutional setting of Max Planck Society Institutes is introduced followed by a description of the research methodology. In section 4, the variables of interest are introduced and descriptive statistics as well as sample characteristics are presented. The empirical analysis and estimation results are presented in section 5. Section 6 discusses the results and section 7 concludes.

2 Theoretical framework

The Entrepreneurial University: Criteria of Evaluating Work in Science

The transition from research universities and public labs to entrepreneurial organizations has gained increasing attention among strategic management and industrial economics scholars over the past few decades. Research groups in universities are becoming "quasi-firms" who potentially commercialize their research results (Etzkowitz, 2003). Existing studies highlight that since the early 1980's policymakers reacted to economic studies and government reports which highlighted the importance of knowledge and scientific advances in industrial innovation and, consequently, in economic growth. Thus, policy assigned research organizations the role of economic actors and demanded scientists to fulfill multiple tasks. Apart from performing research and education faculty is increasingly required to transfer scientific results more effectively to the private sector (Cohen et al., 2002; Lee, 1996).

In order to support commercial research, technology transfer offices were installed in many US and European universities with the aim of providing support for scientists in filing patent applications, to assists scientists in start-up activities and to connect scientists with private actors. Observing this (external) effort to enhance scientists' commercialization activities, scholarly concern on commercial research activities and work practices within scientific institutions evolved. One of the key questions hereby is to what extent changing evaluation criteria of scientific work lead scientists to alter their work practices toward higher emphasis on bridging knowledge to the private sector.

According to organizational theory it is essential to examine the evaluation criteria of scientific work in order to assess what incentives and determinants lead scientists to commercialize their research findings. Theoretical works argue that the important features in the transformation process of organizations are changing values and conflicting internal interests leading to a reconsideration of work routines (see e.g. Greenwood and Hinings, 1996; Oliver, 1992). Existing organizational change models emphasize that the transformation of work evaluation criteria occurs at the individual level but is significantly influenced by organizational values, norms and cultures (Whelan-Berry et al., 2003; Kanter et al., 1992; Dacin et al., 2002). Therefore, the adoption of new work criteria is especially difficult in institutions with traditions and well-established norms (DiMaggio and Powell, 1983; Kraatz and Moore, 2002). In the spirit of Merton (1957) the institution of science has such traditional academic norms. For this reason the intended transformation of scientific institutions into key actors in modern economies represents a challenge to leaders and deans of research institutions as well as policymakers in providing a research climate which stimulates scientists to transfer their knowledge to the private sector.

An ongoing discussion in the literature deals with the interrelation of changing academic values and scientists' efforts to transfer research results to private partners. Critics of the concept of the *entrepreneurial university* fear that engagement with industry shifts researchers' agendas toward applied, industry-relevant topics at the expense of academic freedom, the traditional norm of open science and the focus on basic research (Florida and Cohen, 1999). Yet, collaborative research projects between academic scientists and industry employees often yield new academic insights and ideas despite the applied nature of research aims (D'Este and Perkmann, 2010). As a result, scientists may well face both benefits and drawbacks when having to decide whether it is beneficial for them to engage in collaborative work with private firms.

To cooperate or not to cooperate – a fundamental decision

Scientists' cooperation behavior with private firms is comprised of two different important stages of analysis. The first stage of analysis deals with scientists' fundamental decision as to whether or not to cooperate with firms at all. Academic researchers who have not collaborated with private partners cannot rely on past experience when having to decide whether or not to cooperate with private firms. It is difficult for these scientists to assess to what extent private benefits arise from cooperation with private firms. We, therefore, argue that the fundamental decision to cooperate with private firms relates to scientists' views on the academic values of open science and reputational reward.

The value of open science

Within the discussion of values in academic science there is the view that scientific knowledge is a public good as knowledge does not deplete when shared with others (Arrow, 1962; Scherer, 1982). Distinguishing scientific research from technological research, Dasgupta and David (1987) claim that scientists are thought to devote their efforts to the accumulation of freely available knowledge. This view of open science with free dissemination of knowledge is often shared by researchers for two reasons. Firstly, the seminal work on the sociology of science by Merton (1957) describes the norm of *communism*. According to the norm of communism scientists are incentivized to give up intellectual property rights in exchange for recognition and esteem (Merton, 1973, p.273). This incentive leads to communist activity in the sense that scientists share their work with the community for the common good. Essentially, Merton's complex set for the ethos of science included that progress in science comes by means of cooperation and collaboration between individual scientists. Scientists identify science as open and freely distribute their knowledge and findings to the entire scientific community.

Moreover, researchers are incentivized to publish the outcome of their research results as priority in discovery is the key to scientific recognition (Stephan, 1996; Stephan and Levin, 1992). When researchers communicate an advance in knowledge, they are rewarded by the scientific community for being first. Scientists striving for recognition will, therefore, publish new findings as soon as possible after their discovery. In the publication business, the time of submission or publication makes the claim of priority more convincing (Stephan and Levin, 1992). Thus, academic science developed institutions for rewarding the production and dissemination of knowledge where scientists receive recognition for being the first to demonstrate discovery to the scientific community (David, 2003; Hong and Walsh, 2009). Yet, esteem from colleagues is not limited to its own rewards. Over the course of a scientific career, recognition from colleagues potentially translates into pecuniary rewards in terms of well-paid research positions, well-funded research projects or laboratories (Stephan, 1996).

When cooperating with private firms, knowledge is often appropriated by firms. In R&D cooperation, novel results are concealed and meant to secure firms a competitive advantage. In this case, it is evident that academic scientists' incentives are in conflict to the goals of industrial firms. Hall (2002) argues that scientific research and commercial innovation can be seen as two worlds with respect to the twin goals of appropriating or diffusing knowledge. Similarly, Hong and Walsh (2009) argue that appropriation of knowledge can become an important obstacle to science-industry cooperations. While firms intend to appropriate new knowledge, scientists are incentivized to make their research results freely available to anyone. From this line of reasoning, we predict that the identity of open science represents a key obstacle for scientists in engaging in cooperation with private firms.

HYPOTHESIS 1: *If scientists believe in the concept of open science and the free availability of research results, they are less likely to cooperate with private firms at all.*

Reputational Rewards

While the open and free distribution of scientific results in the spirit of Merton (Merton, 1957, 1973) has dominated academia over decades, there is an ongoing debate that has increasingly diminished this view since the late 1980's. Currently, there is widespread belief among academics that the institution of science is facing ever more demand to become further intertwined with commercial activity (Owen-Smith and Powell, 2004; Hong and Walsh, 2009).

Science is increasingly demanded to provide innovative results with commercial potential in the private sector. Starting in the early 1990s, a stream of literature evolved addressing the changing culture of science and the emergence of a second competing point of view. This view suggests that science is under increasing pressure to provide research results relevant to industry (Cohen et al., 1998; Hong and Walsh, 2009). With the increasing relevance of scientific excellence in global economic competition and the diminishing proportion of university research being publicly supported, science must in part fulfil the tasks of commercial research towards advancements in technology. Therefore, Hackett (1990) and Owen-Smith and Powell (2003) argue that scientific success is increasingly measured in commercial success.

The commercialization of research results may lead to greater scientific reputation among researchers. Owen-Smith and Powell (2003) argue, that commercialization success and the attention of corporate partners make scientists visible in their research field. These scientists are often able to attract attention and funding, which, in turn, leads to greater reputation. Such feedback loops seem plausible, as researcher quality and commercial success are complements (Thursby et al., 2001). The latter study and Buenstorf (2009) find that higher quality faculty results in higher license income and more sponsored research. In the case of venture creation, scientist research productivity and entrepreneurial activity are complements (Lowe and Gonzalez-Brambila, 2007). Moreover, firm collaboration choices are influenced by scientists' expertise. This pattern is shown by Audretsch and Stephan (1996) who detect that firms cluster around star scientists in the biotechnology industry. Firms seemingly profit from the expertise of reputable scientists, as Zucker et al. (2002) show that the higher a scientist's research quality, the more important the scientist is for firms' commercial success. Breakthrough discoveries often involve the joint work of firms with top scientists. Thus, the increasing commercialization of science in general may shift scientists' evaluation of commercialization activities. As scientists may perceive there to be an increase in academic reputation in successfully commercializing research, we hypothesize:

HYPOTHESIS 2a: *If scientists' perceive the commercialization of research as leading to high reputational reward, they are more likely to cooperate with private firms at all.*

Scientists' motivation to engage in further cooperation

In light of the relevance of science-industry cooperation as an important knowledge transfer channel, scientists' cooperation behavior should not be restricted to the fundamental decision whether or not to cooperate with firms at all. Apart from determinants disentangling cooperators from non-cooperators it is also crucial to understand why scientists with cooperation experience decide to engage in further cooperation with private firms. While the fundamental decision to cooperate with private firms tends be driven by scientists' attitudes towards commercialization in general, the decision of scientists with cooperation experience to engage in subsequent cooperation is likely to be driven by scientists' perception of the benefits and drawbacks of cooperating with industry.

Private benefits: Recognition and monetary gains

One of the potential private benefits of cooperation relates to the aforementioned argumentation on the fundamental decision to cooperate. Scientists may expect reputational reward from cooperating with private firms. Firms choose, in general, to collaborate with *'star'* scientists as they wish to come close to the scientific frontier. Thus, as noted above, scientists may signify research quality when cooperating with private firms. We, consequently, argue that reputational reward may not only drive scientists' fundamental decision to cooperate with private firms or not, but also cooperators' decision to engage in further collaboration.

HYPOTHESIS 2b: *If scientists with cooperation experience perceive there to be high reputational rewards from cooperation of research, they are more likely to engage in subsequent cooperation with private firms.*

Monetary returns may represent a further important driver for scientists to cooperate with private firms. By surveying science and engineering faculty in the US Lee (2000) finds that a key motivation of scientists to collaborate with private partners is the access to resources which secure the funding of research. We argue that – beyond the want to secure research funding – scientists with cooperation experience may be attracted by financial benefits. If scientists with cooperation experience regard collaboration with private firms as financially lucrative, such cooperation represents a second source of income.

Furthermore, several studies find that scientists have a preference for research (Stern, 2004) and that the most interesting research is often complete before private companies begin showing interest in commercial applications (Aghion et al., 2005; Jensen and Thursby, 2001). These findings suggest that scientists may only work with industrial partners if high monetary incentives compensate scientists for less interesting work. Prior evidence of commercializing research via disclosure indicates that scientists' will not commercialize their findings unless adequate royalty payments are paid to incentivize scientists to commercialize their research (Jensen et al., 2003; Thursby et al., 2001). We expect this finding to hold in the context of research cooperation, such that high financial benefits influence subsequent cooperation behavior in the subgroup of scientists with cooperation experience. cooperation experience

HYPOTHESIS 3: *If scientists with cooperation experience perceive there to be high financial benefits in cooperation, they are more likely to engage in subsequent cooperation with private firms.*

Time costs

The allocation of time for commercializing research may represent an important drawback of scientists' engagement in commercialization activities. Stern (2004) argues that scientists have a preference for doing research rather than working on possible industrial applications. Therefore, it seems reasonable that scientists would prefer to allocate as much time as possible to academic research. Several empirical studies analyze whether commercialization activities crowd out basic research. Most existing studies analyzing the relationship of research output and commercialization efforts detect a complementary relationship. Empirical evidence, which is mostly based on U.S. data, suggests that the patenting and disclosure of inventions have a positive impact on publication output (Agrawal and Henderson, 2002;

Azoulay et al., 2006). This result is also confirmed by empirical studies based on European data (Breschi, 2007). Hence, patents and licenses may be complementary to fundamental research as conflicts between research and commercialization time are not prevalent. Moreover, time demanding tasks associated with patenting are often carried out by technology transfer offices.

When considering research cooperation activities, the allocation of time for commercialization is likely to be a more relevant obstacle compared to patenting and licensing. Cooperative research with private firms often requires scientists to allocate time to meetings with industry researchers in order to coordinate research. Thus, time demands in research cooperation are relatively high compared to other transfer channels. If scientists cooperate with private firms and experience high demands on their time, then further cooperation with private partners is unattractive and the scientist will refrain from joint work with industry. In view of that the following is hypothesized:

HYPOTHESIS 4: *If scientists with cooperation experience perceive there to be high time costs in cooperating with private firms research, they are less likely to engage in subsequent cooperation with private firms.*

3 Research Method

Framework of our study: The Max Planck Society

In order to analyze scientists' cooperation behavior, a survey of scientists within the MPS was conducted. The MPS is an independent, publicly funded research organization in Germany. Scientists from this society were chosen as the unit of analysis as MPS Institutes seek research excellence and promote academic freedom without obligation to attract external funding. Since research in the MPS is mostly basic and given the society's demand for excellent research, scientists work at the frontiers of research without regard for commercial potential. Thereby, MPS research can be described as pursuing ground-breaking new results, but not necessarily with the goal of application. Thus, scientists' incentives to commercialize research are hardly affected by external pressure.

As of January, 2010, the MPS employed more than 9,000 scientists working at 78 institutes. Each institute focuses on a special, specific, statutory task, be it to research the structure of matter, the function of our nervous system, or the birth and development of stars and galaxies. The Max Planck Institutes are classified by the Society in three different sections: the Biology and Medicine Section, the Chemistry, Physics and Technology Section and the Humanities Section.

Although the MPS consists of many different institutes, the institutional setting is consistent throughout. All institutes select and carry out their research autonomously and independently within the aforementioned scope of the MPS. Each institute administers its own budget and is free to set their research agenda. The consistent structure of MPS institutes allows us to analyze the cooperation behavior of scientists under a similar institutional setting although scientists work in differing fields of research.

Max Planck Scientist Surveys

Initial Survey: Commercialization Activities and Attitudes towards Commercialization

In order to analyze scientists' commercialization activities and attitudes towards commercialization, a survey capturing possible stimuli and barriers to the commercialization of scientific results was developed. The questionnaire contains questions with regard to scientists' knowledge transfer via engagement in research cooperation, patenting and nascent entrepreneurship. Furthermore, scientists' attitudes towards commercialization activities as well as questions on industrial work experience, education, demographics, and time in research were included. Survey questions were developed with the aim of quantitatively analyzing the commercialization activities of scientists on the individual level. Questions were improved during a pilot study conducted in August and September 2007. The pilot study was performed with randomly selected scientists at German research organizations, excluding MPS scientists. With respect to cooperation behavior the initial survey allows us to identify scientists who have any cooperation experience. Moreover, scientists assessed the attractiveness of cooperation activities with private firms.

Before interviewing scientists of the Max Planck Society, we contacted the executive directors and heads of administration of all MPS institutes and asked for permission to survey the scientists in their institute. Out of the entire Society, 67 institutes allowed us to perform our survey and provided us with the contact phone numbers of their scientists, if these were not publicly available. Our sample population for the survey consisted of 7,808 scientists working for these 67 MPS institutes. Prior to the survey interviews, we emailed scientists and informed them about our study. Interviews were conducted by phone and implemented by TNS Emnid GmbH, a professional opinion research institute. Trained interviewers from TNS Emnid GmbH contacted scientists between mid-October and mid-December 2007. The dataset includes data from 2,604 interviews, a response rate of 33.35 percent.

Follow-Up Survey: Cooperation Behavior and Attitudes towards Cooperation

In June to July, 2008, we performed an additional survey wave with those scientists, who had reported cooperation experience in the initial survey. This survey was designed to get more explicit information on scientists' cooperation behavior as we asked whether or not they had cooperated with private firms before their time at Max Planck, during their time in Max Planck, during the last 6 months, and if they had concrete plans to cooperate with private firms in the next two years. As this survey was performed six to eight months after the first interview, we are able to analyze whether scientists cooperation attractiveness – reported in the initial survey – influences scientists' subsequent cooperation behavior and their intent to cooperate with firms in the near future. Furthermore, we asked the cooperators explicitly about the benefits and drawbacks associated with cooperation.

The second step of the survey analysis was also conducted by professional interviewers of TNS Emnid GmbH. In the initial survey we asked scientists if they were willing to participate in a second survey. This wish was respected, so that only those scientists who agreed to further participation were contacted again. Out of the 813 cooperating scientists identified in the initial survey wave, 624 researchers agreed to be available for a follow-up interview. Therefrom, we were able to conduct follow-up interviews with 476 researchers, denoting a response rate of 76.28 per cent.

Sample Selection: Senior Scientists

Our empirical analysis focuses on senior scientists. We exclude PhD students from our investigation because our analysis on cooperation behavior in relation to the scientific reward system may be heavily biased when including doctorates. Though they were given the same survey as senior researchers, results may be biased when including doctoral students. These researchers usually do not decide whether or not they engage in collaboration with private firms but rather follow the decision of their supervisor. Moreover, a large share of doctoral students in Germany make career track changes to the private sector after receiving their doctorate Schomburg and Teichler (2006).

Excluding doctoral students reduces the sample of analysis. Furthermore, we excluded all scientists who did not answer any question relating to a variable of interest, such that the descriptive information capture the information of the reduced sample which is used in the econometric analysis. Due to this exclusion our sample of analysis captures 1176 senior scientists interviewed in the initial survey wave. Within the follow-up survey we capture 240 senior scientists which completed the interview and, thus, are used in the empirical analysis.

4 Measurement of Variables

Initial Survey

Dependent variables

In order to identify scientists with *cooperation experience* the surveyed scientists were asked the following question: "*Have you ever cooperated or are you currently cooperating on research with or for firms in the private sector?*" In our empirical analysis cooperation experience is a dichotomous dependent variable which takes on the value one if a scientist reports that he or she has cooperation experience and zero otherwise. Scientists' *cooperation attractiveness* is measured by the answer to the following question: "*To what degree is cooperative research with private firms an attractive idea to you?*". This dependent variable is an ordinal variable which takes on values between 1 (not attractive at all) and 5 (highly attractive).

Explanatory variables

In order to examine the determinants of scientists' fundamental decision whether or not to cooperate with firms we included in the questionnaire several statements associated with commercialization activities in general. These statements refer to reputational reward from commercialization, open science identity, and commercialization of research within a scientist's research group as well as within his or her scientific community. In this way, scientists were asked to what degree they agree or disagree with these statements, given a 5-point Likert-type scale ranging from 1 (strongly disagree) to 5 (strongly agree). In the empirical analysis these statements are used in two ways. Firstly we use ordinal variables reflecting the Likert-type scale ranging from 1 to 5. Secondly, we used the change from value 3 (neutral) to 4 (agree) as the cut-off-level and induced binary variables taking a value of 1 if scientists either *agreed* or *strongly agreed* to the statements given. Statements are presented in Table 1.

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insert Table 1 about here

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Further explanatory variables reflect scientists' socio-demographic characteristics. Different binary variables account for scientists work experience in industry, gender and German citizenship. Additionally we account for scientists' age, the length of their time at Max Planck and scientists' research field and their research position. To provid a control for research field we use several binary variables indicating whether scientists are group leaders, directors or postdoctoral researchers. Similarly, binary variables indicate whether or not scientists belong to the Life Science Section of the MPS, the Natural Science Section or Humanities.

Follow-Up Survey

Dependent Variables

In the follow-up survey we asked scientists with cooperation experience whether they had cooperated with private firms during the last six months and whether they had concrete plans to cooperate with private firms within the next two years. The dependent variable *subsequent cooperation* takes on the value one if a scientist reports that she or he has cooperated with private firms during the last six months and zero otherwise. The dependent variable *planned cooperation* takes on the value one if a scientist reports that she or he has concrete plans for cooperation in the next two years and zero otherwise. In addition, scientists were asked whether they cooperated with private firms during their time at Max Planck – not counting the last six months. As a result, we are able to distinct scientists' cooperation before their employment at Max Planck and during their time at Max Planck.

Explanatory Variables

Our explanatory variables reflect whether scientists perceive there to be benefits and drawbacks related to cooperation. We explicitly provided statements to interviewees reflecting to what degree they perceived academic reputation, income opportunity and time constraints as benefits or drawbacks of cooperation. Furthermore, we included statements capturing to what extent scientists regarded cost sharing, confindentialyity problems of research outcome and different research approaches as being associated with cooperating with private firms. Again, scientists were asked to agree or disagree to these statements given a 5-point Likert-type scale (see Table 2). Statements are designed such that our investigation may complement the initial survey analysis.

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insert Table 2 about here

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Descriptive Statistics

Descriptive statistics for senior scientists' cooperation behavior are given in Table 3. The upper half of the table reports on the proportion of scientists with cooperation experience identified in the initial screening survey. Both, the cooperation shares as well as the attractiveness levels are given for the entire sample and separately reported for each MPS section. The lower half of Table 3 refers to the 240 interviewed cooperators in the follow-up survey. The table summarizes the percentage of scientists who had cooperation experience before their MPS employment, during their engagement at MPS - not counting the last six months - and during the last half year. Again, the shares are given separately for the entire follow-up sample and separately reported for each MPS section.

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insert Table 3 about here

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Summary statistics for all variables are provided in Table 4. Information is again reported separately for the 1176 interviewed scientists in the initial screening survey and the 240 cooperators examined in the follow-up survey. Forty percent of the 1176 scientists looked at in the initial sample have cooperation experience with private firms. Comparing the individual perceptions of scientists in the initial survey, it can be seen that scientists attach much importance to the value of open science reflected by the statement on free accessibility of research results. Regarding the follow-up survey it can be observed that reputational reward and the opportunity to share research costs are considered as relatively more important cooperation benefits than income opportunity.

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insert Table 4 about here

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5 Econometric Specification

Cooperation Behavior

In a first step we analyze how scientists' views on scientific rewards as well as commercialization attitudes and their research field are related to the individual decision to cooperate or not to cooperate. To do so, we use the data of the initial survey in which scientists were asked whether they had cooperated with firms or not, irrespective of the time of cooperation. The dependent variable of the empirical analysis is a dummy variable that takes the value one if a scientist has cooperation experience and zero otherwise. This analysis is provided in Model 1a which is estimated by using a logit regression model (see Appendix A1). As our baseline model we estimate scientists' likelihood of having cooperation experience as dependent on attractiveness of cooperation and further control variables (relevance of commercialization in one's research field, PhD discipline and personal characteristics). We then include the measures of scientists' attitudes towards the free availability of scientific results and reputational rewards as further variables.

As explained in Section 2 it can be expected that the decision to engage in further cooperation is determined by other factors than just the decision to cooperate at all. In order to analyze scientists' subsequent cooperation behavior we examine scientists cooperation activities subsequent to the first interview. To do this we rely on the information provided in the follow-up survey as cooperators identified in the initial survey were asked whether they had cooperated with firms in the past six months *subsequent cooperation*.

However, we cannot exclude the possibility that results may be affected by endogeneity problems. As causation is a central issue in strategy research recent studies by (Durand and Vaara, 2009) and (Hamilton and Nickerson, 2003) point out statistical analysis can suffer from biased coefficient estimates when potential endogeneity problems are not taken into account. With respect to our empirical analysis of the fundamental decision to cooperate or not (Model Ia) concerns may be raised about reverse causality, as it could be that cooperation experience may affect the perceived attractiveness of cooperation or vice versa. Further cooperation and attractiveness of cooperation may both be influenced by an unobserved (omitted) variable causing endogeneity. Such endogeneity problems would not arise if the attractiveness of cooperation were more or less constant over time, e.g. attractiveness was already high *before* a scientist decided to cooperate. As time invariance of perceived cooperation attractiveness is a strong assumption, we acknowledge that the possibility of endogeneity cannot be completely ruled out in Model 1a. Thereby, we can only refer to *correlations* rather than causation. For the empirical analysis of *subsequent* cooperation (Model 1b), however, potential endogeneity should be a lesser problem for two reasons: Firstly, *all* scientists of the subsample of cooperators have cooperation experience, so that no bias can result from not having cooperation experience. Secondly, the attractiveness measure is taken from the screening survey which was conducted six to eight months before the follow-up survey wave was implemented – and the indicator for subsequent cooperation activities does not cover the time of the initial survey.

Moreover, endogeneity may hardly arise when analyzing to what extent explanatory variables predict *planned* cooperation behavior in the next two years. Thus, in order to provide a comprehensive and reliable analysis on scientists' cooperation behavior we test whether the personal benefits and drawbacks associated with science-industry cooperation affected scientists' intention to engage in cooperation with private firms in the near future. To do this we rely on the data obtained in the follow-up survey since questions on cooperation benefits were provided only to scientists' with cooperation experience (in the follow-up survey wave). In Model 1c we estimate to what extent private benefits, research field and demographics influence scientists' *planned* cooperation behavior.

Attractiveness of Cooperation

In order to provide a full picture of scientists' cooperation behavior, we analyze what factors shape scientists' appeal (expressed *attractiveness*) to cooperation in a second step. We thereby analyze the relationship between the perceived attractiveness of cooperation and open science identity, reputational rewards, financial benefits, and time demand of commercialization activities in general and cooperation in particular. This second step is done to investigate whether the relationship between cooperation behavior and these factors is *mediated* by the attractiveness of cooperation. It is possible, for instance, that there is no direct relationship between these variables and cooperation behavior but that they influence the attractiveness of cooperation which in turn is related to cooperation behavior. Since our dataset contains measures of cooperation as well as an indicator for the attractiveness of cooperation we are able to analyze this indirect link. Again, we analyze attractiveness indicators in both the initial and the follow-up survey results. The analysis of Model 2a is based on data obtained in the initial survey. We investigate to what extent the perception of open science and reputational benefits associated with commercialization in general relate to the attractiveness of cooperation. Using the data obtained in the follow-up survey, we are able to estimate how the private benefits and drawbacks associated with research cooperation activities with private firms relate to the perceived attractiveness of cooperation (Model 2b). Since the dependent variable is an ordinal variable, we make use of an ordered logit model (see Appendix A1).

6 Estimation Results

Cooperation Behavior

Cooperation Experience

In Table 5 the results of Model 1a – the analysis on determinants of scientists' cooperation experience – are presented. Both, coefficients and marginal effects for the baseline and the extended model are presented. In columns (5) and (6) all ordinal explanatory variables are included as binary variables which take a value 1 if the ordinal variable takes a value of 4 or 5. These results suggest that cooperation experience is significantly positively related to cooperation attractiveness. Furthermore, our measure of open science is significantly negatively related to cooperation experience which can be observed in the estimation results presented in columns (3) to (6). This evidence is in support of our hypothesis H1. The more scientists agree that their research results should be freely available, the less likely it is that these scientists have cooperation experience. With respect to reputational reward we do not find any evidence in Model 1a that reputation is directly related to scientists cooperation experience (as predicted in hypothesis H2a).

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insert Table 5 about here

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Moreover, apart from cooperation attractiveness and open science identity we find that scientists' perceived commercial potential of their research relates to their cooperation experience. The coefficients and marginal effects of the two measures reflecting the basic research focusing of a scientist's research group and the extent of commercialization in a scientist's research community are significant and respectively negatively and positively related to cooperation experience. Further, German scientists, group leaders and scientists with work experience in industry are more likely to have cooperation experience.

Subsequent cooperation

We turn now to the results of Model 1b – the estimation of a logit model based on the data of the *follow-up survey* where the dependent variable is *subsequent cooperation* denoting cooperation activity in the past six months. The results are presented in Table 6 which reports the coefficients and marginal effects for the baseline and the extended model. In columns (5) and (6) we again include all ordinal explanatory variables as binary variables which take on the value 1 if the ordinal variable takes a value of 4 or 5 in order to check the robustness of our results.

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insert Table 6 about here

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As can be seen from the Table 6 the estimated coefficient and the estimate of the average marginal effect of attractiveness of cooperation are statistically significant and positive. However, this effect does not remain significant when restricting the analysis to the binary variables (see columns (5) and (6)). With respect to the reputational benefits associated with cooperation we do not find evidence in support of H2b, which predicted a direct link between perceived reputational reward and cooperation behavior. Regarding financial benefits from cooperation our results point to a negative effect of income opportunities associated with cooperation. This effect is, however, only statistically significant if ordinal measure is used (Columns 3 and 4) but not if we include the respective dummy variable (Columns 5 and 6). Hence, hypothesis H3 is not supported by our results.

Furthermore, we find weak evidence in support of our hypothesis H4, as time costs are negatively related to probability of being engaged in subsequent cooperation activities. The effect is significant at the 10 percent level in models presented in columns (3),(4) and (6). Moreover, those scientists who agree that cooperaton helps to increase their research budget are more likely to engage in subsequent cooperation activities whereas scientists who believe that their results are not applicable for industrial purposes are less likely to cooperate. Estimated coefficients and marginal effects are significant at the 1 percent level (see Columns

(3)-(6)). In addition, directors are more likely to engage in subsequent cooperation activities.

Planned Cooperation

In order to test to what extent the private benefits associated with cooperation effect scientists' cooperation behavior we additionally examine scientists' plans to cooperate in the next two years. Similar to the previous models we provide estimates using cooperation attractiveness, the perceived relevance of commercialization in scientists' research field, PhD discipline and demographic measures as explanatory variables (columns (1) and (2)). Measures regarding benefits and drawbacks associated with cooperation are included in estimations reported in columns (3) to (6).

Results are shown in Table 7. The estimation results suggest that attractiveness of cooperation predicts planned cooperation behavior. The estimated coefficient of attractiveness of cooperation as well as the average marginal effect are statistically significant throughout all regressions. Scientists reporting in the initial survey that they find cooperation attractive or highly attractive have a 12.9 percentage points higher probability of having concrete plans for cooperation activities with private firms within the next two years than other scientists (see Column 6). In contrast, expected reputational rewards, financial benefits or time demand of cooperation activities with private firms are not significantly related to planned cooperation activities. Hence, the results do not point to a direct link between planned cooperation and perceived personal benefits and drawbacks of cooperation. The probability of having concrete plans for cooperation activities is, however, negatively affected by perceived problems due to confidentiality requirements by firms and by perceived non-applicability of scientists' own research for industrial purposes. Scientists who are of the opinion that confidentiality is a problem have a 20.7 percentage points lower probability of having concrete plans for cooperation activities (see Column 6).

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insert Table 7 about here

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To sum up, our results suggest that academic values are directly related to cooperation experience whereas there is only very weak evidence for a direct link between cooperation behavior and the individual benefits and drawbacks of cooperation. The perceived attractiveness of cooperation, however, is directly linked to cooperation experience, subsequent cooperation activities, and planned cooperation activities. The marginal effects of attractiveness of cooperation on the probability of cooperation are presented graphically in Figure 1. As pointed out by (Wiersema and Bowen, 2009) the assessment of marginal effects and their respective z-statistic values is best done graphically and we therefore plot these values against the predicted value of the outcomes, i.e. cooperation experience, subsequent cooperation, and planned cooperation. Marginal effects and z-statistics are computed for each observation using the results of logit estimations presented in Column (1) of Tables 5, 6 and 7. As can be seen from Figure 1 the marginal effects of the attractiveness of cooperation are positive for all observations (1176 for cooperation experience and 240 for subsequent and planned cooperation). Moreover, the estimates are statistically significant for all observations in the case of cooperation experience. For subsequent and planned cooperation activities z-statistic is below 1.96 in absolute value at high or low probabilities of subsequent and planned cooperation activities. Hence, the relationship between cooperation behavior and attractiveness of cooperation is positive and statistically significant. This suggests that individual motivation of scientists is important for establishing and maintaining cooperation activities with private firms.

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insert Figure 1 about here

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Attractiveness of Cooperation

Initial Survey

Although we do not find much evidence for a direct link between cooperation behavior and reputational awards, financial benefits, and time costs associated with cooperation activities, there might be an indirect link mediated by the attractiveness of cooperation. We therefore turn now to the second step of the empirical analysis of Model 2a where the dependent variable is the attractiveness of cooperation and explanatory variables are scientists' attitudes towards *commercialization* in general. By using data gathered in the initial survey, we investigate empirically whether scientists' attitudes towards commercialization affect cooperation behavior indirectly through their influence on the attractiveness of cooperation.

Table 8 reports on the estimation results of ordered logit regressions where the attitudes towards *commercialization* are the explanatory variables. In columns (1) and (2) the baseline is presented, which only includes open science identity and reputational rewards associated with commercialization activities as independent variables. Extended models are presented in columns (3) and (4) which also include commercialization relevance in scientists' research field, PhD discipline and demographic variables. Again, we use scientists perceptions as both ordinal explanatory variables – referring to 5-point-scales: see columns (1) and (3) – and as binary variables which take on the value 1 if the ordinal variable takes a value of 4 or 5 – see columns (2) and (4). The fit statistics suggest that the attitudes towards commercialization have explanatory power and that the fit is improved when controls are included.[1]

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insert Table 8 about here

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Two striking results are that scientists attitudes toward free accessibility of research results are negatively while reputational reward are positively related to scientists' cooperation attractiveness. In all four models presented the effect of both variables is statistically significant at the 1 percent level. Combining these results with the strong positive effect of attractiveness of cooperation on cooperation behavior, this result suggests that there are

[1]Statistical tests suggest that cut-points are statistically significant and therefore using the 5 point Likert-type scale of the dependent variable is appropriate. Robust standard errors are reported which correct for clustering effects at the institute level.

indirect effects of open science identity and reputational reward on cooperation behavior which supports our hypotheses H1 and H2a.

Follow-Up Survey

The second analysis of cooperation attractiveness is based on the sample of cooperators and includes scientists' attitudes towards *cooperation* as explanatory variables. We acknowledge that this analysis requires the assumption that the scientists' perceived attractiveness of cooperation has not changed considerably between the initial and the follow-up survey, since the attractiveness of cooperation was measured in the initial survey while some of the explanatory variables stem from the follow-up survey. However, only scientists with cooperation experience participated in the follow-up survey and it is not very likely that scientists who already knew the benefits and drawbacks of cooperation activities with private firms would quickly change their mind. Table 9 reports the results of Model 2b. Similar to the aforementioned analysis our baseline model captures solely the variables reflecting scientists' personal benefits of cooperation and its drawbacks, while extended models use further explanatory variables as controls.

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insert Table 9 about here

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As seen in Table 9 the estimated coefficient of reputational reward is positive and statistically significant. This result indicates that within the subsample of cooperating scientists reputational reward indirectly affect scientists' subsequent cooperation behavior. This indirect effect supports our hypothesis H2b, which states that scientists with cooperation experience are more likely to engage in further cooperation if they find cooperation is increases their scientific reputation. Moreover, with respect to financial benefits we find that the variable reflecting scientists' opportunity to gain personal income is significantly and positively related to scientists' cooperation attractiveness. Given the strong positive effect of cooperation attractiveness and cooperation behavior we find a further indirect effect – of income opportunity on cooperation behavior. Moreover, we find that time costs are an important barrier to cooperation behavior as the reduction of time for own research due to cooperation with private firms is significantly and negatively related to cooperation attractiveness in all four models presented.

7 Discussion

Our survey of scientists working at Max Planck Institutes in Germany shows that research cooperation is a frequently used channel of knowledge transfer. This result is in line with the findings of other studies (Gulbrandsen and Smeby, 2005; Sellenthin, 2009). Roughly 40 percent of the surveyed scientists reported that they had cooperation experience and most of the surveyed scientists with cooperation experience reported that they gathered cooperation experience when working at Max Planck institutes. Moreover, among the surveyed scientists with cooperation experience roughly 43 percent are engaged in subsequent cooperation activities and more than 50 percent plan to cooperate with private firms in the next two years.

Against the background of complete public funding of Max Planck Institutes and their focus on basic research, the strong involvement of Max Planck scientists in cooperation activities with private firms is striking and our results suggest that individual motivation is important for establishing and maintaining cooperation activities with private firms. In particular, our empirical analysis provides answers to two basic questions: Why do scientists cooperate with private firms at all? Why do some scientists proceed to cooperate with private firms while others abandon their cooperation activities?

Our results indicate that scientists face various trade-offs between scientific and commercial incentives. Reputational rewards are a main determinant of scientists' fundamental decision to cooperate with private firms at all, since they make cooperation more attractive and thereby increase the probability of cooperation with private firms. If, however, scientists believe in the concept of open science it is less likely that they will be engaged in research cooperation activities.

Once the fundamental cooperation decision is made and a scientist has gathered cooperation experience he or she has to decide whether or not to engage in further cooperation activities. We find that subsequent cooperation behavior and planned cooperation activities are positively related to an expected increase in income and reputational rewards from cooperation while being negatively related to expected time demand. However, expected reputational rewards, income and time demand do only *indirectly* affect subsequent cooperation behavior and planned cooperation activities via their influence on cooperation attractiveness but not directly. In other words, the effects are mediated by cooperation attractiveness. Furthermore, the probability of future engagement in cooperation activities is influenced by firms' confidentiality requirements. Scientists with cooperation experience who agree that confidentiality is a problem – because industrial partners wish or contractually enforce that results will not be published – are less likely to engage in future cooperation activities.

Implications for leaders and managers of scientific institutions

Successful technology transfer has become an important element in the evaluation of the performance of scientific institutions. For leaders of scientific institutions who aim at increasing knowledge transfer to the private sector, it is essential to account for scientists' trade-off between the expected benefits from cooperation and the cost associated with cooperation.

Our results show that both monetary and reputational rewards positively affect the attractiveness of cooperation which in turn increases the probability of cooperating with private firms. Hence, our results indicate that there are two ways for managers of scientific institutions to motivate scientists to engage in cooperation and compensate them for the cost of cooperation. First, monetary benefits that are directly related to cooperation with private firms tend to lead to more cooperation. Therefore management of scientific institutions may advertise rewards for successful cooperation activities. Second, non-monetary reputation effects that are directly related to cooperation activities are also likely to motivate scientists, e.g. honors for successful cooperation activities. One may ask, however, whether such monetary and non-monetary rewards will reduce scientist incentives to conduct basic research. Theoretical results suggest that commercial rewards may not only induce the researcher to develop more and to reduce research efforts but may also affect the choice of the research project. Banal-Estanol and Macho-Stadler (2010, p.187) show theoretically "that the introduction of commercial rewards prompts researchers to increase the search for (*ex post*) high quality ideas, which are more likely to be generated through (*ex ante*) to riskier research programs". If basic research is associated with high uncertainty this may imply that commercial incentives do not necessarily lead to a reduction in basic research.

Moreover, the management of scientific institutions has to deal with problems accruing from the confidentiality requirements of private firms. On the one hand these requirements may be in conflict with individual open science identity and may therefore reduce the attractiveness of cooperation. On the other hand many scientific institutions have strict publication requirements, i.e. research results have to be published. In such a case a scientist may fall between two stools. While private partners require confidentiality, publication rules of scientific institutions typically demand the diffusion of knowledge.

From the point of view of firms this may imply that especially those firms which accept the open science paradigm and are willing to engage in an open, non-exclusive exchange of knowledge are more likely to cooperate with scientists in public research institutions. This is confirmed by the results reported by Hong and Walsh (2009) examining university-industry collaboration. They find that collaboration with academics is more frequent in firms if customization of information is more important than exclusivity. In turn, our results suggest that firms need to be aware that the form of contract is likely to matter. While firm scientists can be forced to keep results secret, public researchers are often more likely to refrain from cooperation in case of secrecy clauses. Hence, R&D managers in private firms intending to establish cooperation activities with scientists in public research institutes have to make sure that open science norm is not undermined by the cooperation.

Thus, in sum our results suggest that publication requirements of scientific institutions, confidentiality demands of private firms and time demand of cooperation may hamper scientists' willingness to cooperate with private firms. In order to incentivize scientists to such cooperation, monetary gains or reputational rewards need to be high enough to compensate for the costs of cooperation.

Implications for future research

Our examination suggests that future analysis on scientists' cooperation behavior needs to distinguish between the fundamental decision of whether or not to cooperate with private firms and the decision of scientists with cooperation experience to engage in subsequent cooperation activities with private firms. Moreover, our results suggest that the expected benefits and cost of cooperation affect scientists' cooperation behavior *directly* or *indirectly* via their influence on cooperation attractiveness. Consequently, studies which investigate the effects of scientists' private benefits and cost of commercialization – as income, reputation or time demand – need to account for the possibility of mediated relationships. When only analyzing direct effects one may erroneously conclude that such private benefits do not or only hardly affect commercialization activities. Moreover, there is a lack of theoretical research with respect to scientist cooperation behavior. While there are numerous theoretical studies that investigate scientist patenting, licensing and entrepreneurial behavior, cooperation activities between scientists and industry have been largely overlooked in theory. We believe that our results provide several suggestions for future theoretical work, as the link between cooperation behavior and cooperation attractiveness could be further analyzed.

Finally, we acknowledge that our study has (at least) two limitations. First, the Max Planck Society represents an institutional setting similar to research universities in the US. Further studies in different academic settings would strengthen our understanding of scientists' individual motivation to commercialize research. Second, our empirical analyses are based on two survey waves which do not really allow us to investigate the development of individual cooperation behavior. Therefore, we encourage further longitudinal studies on the topics addressed.

Appendix

A1: Econometric Techniques

For the econometric analysis of Model 1a, Model 1b, and Model 1c we employ a logit model. We assume that scientist *i's* propensity to engage in cooperation activities y_i^*, which cannot be observed, is linearly related to the observable variables x_i:

$$y_i^* = x_i^{'}\beta + u_i \tag{1}$$

where u_i is an error term and β is a vector of unknown parameters of the explanatory variables. We assume that the observed cooperation dummy variable y_i – whether scientist i engages in cooperation activities or not – takes the value one if $y^* > 0$ and zero otherwise. If the cumulative distribution of u_i is logistic, the probability of cooperation is given by

$$P_i = P(y_i = 1) = F(x_i^{'}\beta) = \frac{exp(x_i^{'}\beta)}{1 + exp(x_i^{'}\beta)} \tag{2}$$

which is known as the *logit* model. Note that the estimated coefficients of the logit model must be interpreted with care as they reflect the rate of change in the *log-odds* as x_{ij} changes. The explanation of these coefficients is therefore not very intuitive compared to the marginal effects of explanatory variable on a scientist's *probability* of having cooperation activities. Such marginal effects are given by the following computation.

$$\frac{\partial P_i}{\partial x_{ij}} = \beta_j P_i \left(1 - P_i\right)$$

Hence, the marginal effect on the probability of cooperation has the same sign as the estimated coefficient β_j. However, the value of this marginal effect is not the same for all observations but depends on the values of all explanatory variables. Moreover, the significance of this marginal effect is not identical with the significance level of the estimated coefficient. Following Hoetker (2007), we therefore also present estimates of the average marginal effects. Moreover, we provide two measures of model fit: McFadden's pseudo-R^2 and the adjusted Count R^2. The former represents a percental increase in the log-likelihood function, while the latter reflects the proportion of correct predictions adjusted for the most frequent outcome (Hoetker, 2007).

The dependent variable of Model 2a and Model 2b, the attractiveness of cooperation, is an ordinal variable with five categories (5 point scale). Therefore, we make use of an ordered logit model and assume a linear relationship between the unobserved latent variable attractiveness of cooperation a_i^* and the vector of explanatory variables z_i:

$$a_i^* = z_i^{'}\alpha + \epsilon_i \tag{3}$$

where the vector α is a vector of unknown parameters and ϵ_i are the logistically distributed errors reflecting stochastic attractiveness differences. The relationship between the unobserved attractiveness of cooperation, a_i^*, and the observed ordinal scale A_i can be expressed as follows

$$\begin{aligned} A_i &= 1 \; if \; a_i^* \leq \mu_1 \\ &= 2 \; if \; \mu_1 < a_i^* \leq \mu_2 \\ &\vdots \\ &= 5 \; if \; \mu_4 \leq a_i^* \end{aligned}$$

where μ_j are unknown parameters (cut-points) to be estimated. These parameters must satisfy $\mu_1 < \mu_2 < \ldots < \mu_5$ in order for the probability of each category to be positive. As for the binary logit model, the marginal effects of the explanatory variables on the probabilities are not equal to the estimated coefficient. The estimated coefficient of an explanatory variable reflects the change of the *log odds ratio* of two categories if the respective variable changes by one unit. In contrast, the marginal effect of an variable on the probability of a certain category does not only depend on the estimate of the respective parameter but also on the estimates of the cut-points and the other parameters as well as on the values of all explanatory variables. However, the sign of a coefficient in an ordered logit model does at least provide information about the sign of the effect of the respective variable on the end response categories.[2]

A2: Robustness Checks

We conduct several additional estimations to check the robustness of our results.[3] Since scientists were asked in the follow-up survey whether they cooperated with private firms during their time at Max Planck – not counting the last six months –, this allows us to distinguish between scientists who cooperated solely before their employment at Max Planck Institutes and scientists who cooperated when working for Max Planck Society. We use this information to construct a dummy variable which takes on the value one if a scientist cooperated when working for Max Planck Society – not counting the last six months – and zero otherwise. This dummy variable is included as an additional explanatory variables in Model 1c to control for unobserved effects which may influence the individual intentions to cooperate in the future. This does further reduce potential endogeneity problems. Estimation results confirm our previous findings and suggest that the marginal effect of the attractiveness of cooperation on planned cooperation is still positive and statistically significant. This indicates that cooperation attractiveness is a strong and robust predictor of cooperation behavior. Again, we find no evidence for direct effects of reputational reward, income opportunity, and time demand on planned cooperation activities whereas problems arising from private firms' confidentiality requirements and assumed non-applicability of research results for industrial purposes significantly reduce the probability of future cooperation activities with private firms.

[2] Yet, it does not provide information about the sign of the effect on any other particular category and about the magnitude of marginal effects. Therefore, marginal effects have to be calculated for each category separately.

[3] In order to save space we will only briefly describe these checks and their results.

Several scientists who participated in the initial survey have not been surveyed in the Follow-Up survey. Some refused to participate in the follow-up survey while others where not accessible. In order to deal with a potential self-selection problem , i.e. probability of response depends on scientists' characteristics, which may result in biased results, we follow Heckman (1979) and estimate a selection equation where the probability of response is explained by scientists' personal characteristics. Based on these regressions we calculated Mills ratio and used it as an explanatory variable for the probability of having ongoing cooperation activities. The estimated coefficient of mills ratio is statistically insignificant which suggests that self-selection is not a major problem.

LIT: [A1] Heckman, J. (1979). Sample selection bias as a specification error. *Econometrica*, 47(1), p. 153–161.

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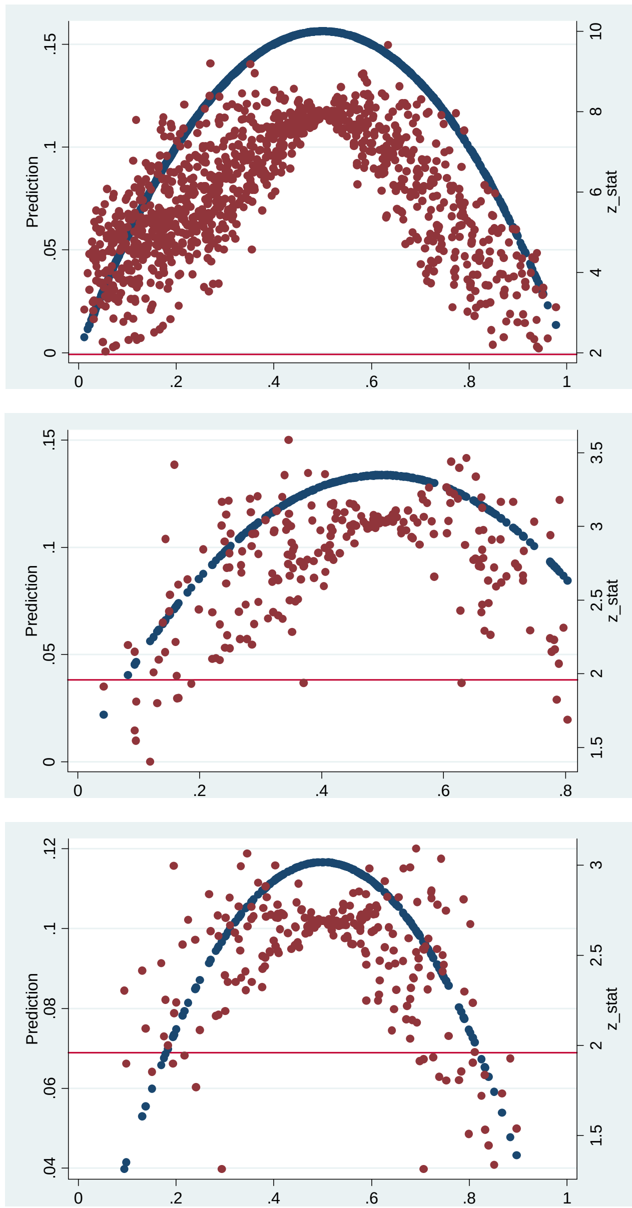

Figure 1: Marginal Effects of Attractiveness of Cooperation on Cooperation Experience, Subsequent Cooperations, and Planned Cooperations

Table 1: Measurement of Variables: Initial survey wave

Min	Measurement of Variables: Initial Survey Variables			Max
0: no	*Cooperation Experience* "A number of researchers and research groups cooperate on research projects with private firms. This can include cooperative research, contract research, or a joint research venture Have you ever cooperated or are you currently cooperating on research with or for firms in the private sector?"			1: yes
1: not attractive at all	*Cooperation Attractiveness* "Imagine a scale from 1 to 5, with 1 meaning 'not attractive at all', 2 'not attractive', 3 'either attractive', 4 'attractive' and 5 'highly attractive'. On this scale, to what degree is joint research with private companies an attractive idea to you?"			5: highly attractive
1: strongly disagree	*Open science identity* "My research results should be freely accessible to any other researchers and businesses."			5: stronly agree
1: strongly disagree	*Reputation: Commercialization* "Commercialization activities increase the reputation of a scientists in my scientific community."			5: stronlgy agree
1: strongly disagree	*Basic research focus in group* "My research group focuses on basic research which is not suitable for commercialization."			5: strongly agree
1: strongly disagree	*Commercialization common in research field* "Commercialization activities are common in my field of research."			5: strongly agree
5-pt scale 1: strongly disagree	2: disagree	3: neutral	4: agree	5: strongly agree

Table 2: Measurement of Variables: Follow-up survey wave

Min	Measurement of Variables: Follow-up survey Variables			Max
	Subsequent Cooperation			
0: no	"Have you been engaged in research cooperation during the last six months?"			1: yes
	Cooperation during Max Planck			
0: no	"Have you been engaged in research cooperation during your time at Max Planck, not counting the last six months?"			1: yes
	Planned Cooperation			
0: no	"Do you have concrete plans to engage in research cooperation in the next 2 years?"			1:yes
	Benefits and obstacles of cooperation (2nd wave)			
	Reputation: Cooperation			
1: strongly disagree	"Experience in research cooperation increases the scientific reputation of a researcher."			5: strongly agree
	Income opportunity			
1: strongly disagree	"Research cooperations greatly increase personal income opportunities of researchers."			5:strongly agree
	Time costs			
1: strongly disagree	"Doing cooperative research is time-consuming and therefore reduces the time for my personal scientific research."			5: strongly agree
	Cost sharing			
1: strongly disagree	"Research cooperations already helped me to share the costs of research project with private firms."			5: strongly agree
	Confidentiality			
1: strongly disagree	"In research cooperations confidentiality is a problem for researchers since industrial partners wish or contractually enforce that results will not get published."			5: strongly agree
	Different approaches: academia – industry			
1: strongly disagree	"Coordination in research cooperations is problematic since research approaches and methods of private firms differ from my research approaches and methods."			5: strongly agree
	No commercial application			
1: strongly disagree	"My current research is not applicable for industrial purposes."			5: strongly agree
5-pt scale				
1: strongly disagree	2: disagree	3: neutral	4: agree	5: strongly agree

Table 3: Sample Descriptives on Scientists' Cooperation Behavior

Initial Survey	Cooperator Share	Cooperators Mean att. value cooperation	Non-cooperators Mean att. value cooperation	Difference t-test
Total Sample (1176)	39.97% (470)	3.672	3.086	***
MPS Section				
Life Science (501)	42.71% (214)	3.710	3.3366	***
Chemistry, Physics (570) & Technology	40.71% (232)	3.668	2.964	***
Humanities (105)	22.86% (24)	3.375	2.605	**

Follow-Up Survey	before MPS	Cooperation during MPS	last 6 months	planned cooperation
Cooperator Sample (240)	49.58% (119)	78.33% (188)	43.75% (105)	52.08% (125)
MPS Section				
Life Science (115)	44.35% (51)	73.04% (84)	44.35% (51)	52.17% (60)
Chemistry, Physics (111) & Technology	54.95% (61)	84.68% (94)	43.24% (48)	52.25% (58)
Humanities (14)	50.00% (7)	71.43% (10)	42.85% (6)	50.00% (7)

Notes: The total sample of the initial screening survey comprises 1176 scientists. The follow-up sample contains 240 scientists. In column 1 the number of scientists belonging to each section is given in brackets. The t-test presented in the sample of the initial screening survey compares whether the attractiveness levels of scientists having cooperated in the past and scientists without cooperation experience are statistitically significant. The asterisks ***,**,* indicate respectively a significant difference at the 1, at the 5 and at the 10 per cent level.

Table 4: Summary Statistics: Independent Variables

	Total Sample (Initial survey) Mean	St. Dev.	Cooperators (Follow-Up survey) Mean	St. Dev.
Variables				
Individual Perceptions on commercialization(5-pt. scales)				
Reputation: commercialization	2.985	1.060		
Open science identity	3.964	0.994		
Basic research focus in group	3.327	1.150		
Commercialization is common in research field	2.560	1.048		
Benefits and obstacles of cooperation(5-pt. scales)				
Reputational reward			3.392	1.033
Income opportunity			2.029	1.080
Cost sharing			3.320	1.310
Time costs			2.800	1.032
Confidentiality			3.538	1.116
Different approaches (academia-industry)			3.104	1.052
No commercial application			2.554	1.327
Demographic characteristics				
age (years)	38.941	9.769	42.621	10.208
industry work experience (yes-no)	0.162	0.390	0.221	0.415
german citizenship	0.567	0.496	0.763	0.426
female	0.237	0.426	0.121	0.327
years worked for MPS	6.717	7.649	9.433	8.723
Research Position				
Post-doctoral researcher	0.688	0.464	0.475	0.500
Group leader	0.263	0.440	0.450	0.499
Director	0.049	0.217	0.075	0.264
Research Field				
Life Science Section	0.426	0.495	0.479	0.501
Chemistry, Physics and Technology Section	0.485	0.500	0.463	0.500
Humanities Section	0.089	0.285	0.058	0.235

Notes: The total sample (initial survey) comprises 1176 scientists. The sample of the cooperators (Follow-Up survey) comprises 240 scientists.

Table 5: Cooperation Behavior: Cooperation Experience – Model 1a

	(1)	(2)	(3)	(4)	(5)	(6)
	coeff.	marg. eff.	coeff.	marg.eff.	coeff.(D)	marg. eff. (D)
Cooperation attractiveness	0.625***	0.111***	0.630***	0.111***	0.818***	0.154***
	(0.089)	(0.014)	(0.095)	(0.015)	(0.165)	(0.033)
Reputation: commercial.			-0.071	-0.013	-0.092	-0.017
			(0.079)	(0.014)	(0.166)	(0.030)
Open science identity			-0.196**	-0.035**	-0.676***	-0.131***
			(0.078)	(0.014)	(0.178)	(0.033)
Basic research focus	-0.157**	-0.028**	-0.133**	-0.024**	-0.611***	-0.117***
in group	(0.066)	(0.012)	(0.065)	(0.012)*	(0.117)	(0.021)
Commercialization	0.301***	0.054***	0.294***	0.053***	0.562***	0.107***
common in research field	(0.078)	(0.013)	(0.077)	(0.013)	(0.175)	(0.034)
Age (log of years)	1.286***	0.233***	1.324***	0.238***	1.299***	0.239***
	(0.412)	(0.075)	(0.407)	(0.074)	(0.406)	(0.075)
Time at MPS/age	1.592**	0.288**	1.669**	0.300**	1.358*	0.250*
	(0.744)	(0.131)	(0.751)	(0.131)	(0.749)	(0.136)
Industry work experience	0.617***	0.115***	0.602***	0.112***	0.601***	0.115***
(*yes-no*)	(0.181)	(0.035)	(0.181)	(0.034)	(0.188)	(0.037)
German citizenship	0.668***	0.123***	0.641***	0.117***	0.514***	0.096***
	(0.150)	(0.029*	(0.147)	(0.028)	(0.147)	(0.029)
Female	-0.239	-0.043	-0.250	-0.045	-0.271	-0.050
	(0.200)	(0.036)	(0.203)	(0.036)	(0.196)	(0.035)
Group leader	0.689***	0.130***	0.676***	0.127***	0.638***	0.123***
	(0.179)	(0.034)	(0.178)	(0.034)	(0.170)	(0.033)
Director	0.530*	0.099*	0.534*	0.099*	0.512*	0.097*
	(0.296)	(0.056)	(0.298)	(0.056)	(0.291)	(0.056)
Constant	-8.776***		-8.001***		-6.128***	
	(1.518)		(1.529)		(1.456)	
PhD dummies	yes		yes		yes	
Section dummies	yes		yes		yes	
Log likelihood	- 633.04		-629.14		-644.78	
McFadden's R^2	0.200		0.205		0.185	
Adjusted Count R^2	0.315		0.334		0.302	

Notes: Robust standard errors which are adjusted for intracluster correlation within Max Planck institutes are reported in parentheses. The asterisks *, ** and *** denote significance at the 10, 5 and 1 percent level respectively. Number of observations 1176.

Table 6: Cooperation Behavior: Subsequent Cooperation – Model 1b

	(1)	(2)	(3)	(4)	(5)	(6)
	coeff.	marg. eff.	coeff.	marg. eff.	coeff.(D)	marg.eff.(D)
Cooperation attractiveness	0.535***	0.112***	0.478*	0.087*	0.517	0.105
	(0.193)	(0.035)	(0.276)	(0.044)	(0.336)	(0.069)
Reputational reward			-0.035	-0.006	0.274	0.055
			(0.175)	(0.032)	(0.331)	(0.068)
Income opportunity			-0.372**	-0.068**	-0.167	-0.033
			(0.187)	(0.031)	(0.516)	(0.103)
Time costs			-0.248*	-0.045*	-0.502	-0.101*
			(0.131)	(0.024)	(0.316)	(0.061)
Cost sharing			0.370***	0.067***	0.709***	0.143***
			(0.108)	(0.017)	(0.252)	(0.052)
Confidentiality			-0.151	-0.028	-0.649*	-0.133*
			(0.157)	(0.029)	(0.352)	(0.070)
Different approaches			0.189	0.035	0.111	0.022
(academia – industry)			(0.169)	(0.030)	(0.379)	(0.076)
No commercial application			-0.544***	-0.099***	-1.277***	-0.252***
			(0.163)	(0.026)	(0.454)	(0.075)
Basic research focus	-0.036	-0.008	0.198	0.036	0.204	0.041
in group	(0.135)	(0.029)	(0.146)	(0.026)	(0.242)	(0.049)
Commercialization	0.375***	0.079***	0.368**	0.067**	0.560*	0.115*
common in research field	(0.134)	(0.027)	(0.164)	(0.029)	(0.327)	(0.068)
Age (log of years)	-1.749*	-0.373*	-1.972*	-0.361*	-1.989*	-0.400*
	(1.053)	(0.214)	(1.141)	(0.196)	(1.061)	(0.206)
Time at MPS/age	1.459	0.311	1.748	0.320	1.851	0.372
	(1.507)	(0.317)	(1.595)	(0.285)	(1.467)	(0.293)
Industry work experience	0.117	0.025	0.473	0.087	0.228	0.046
(*yes-no*)	(0.318)	(0.068)	(0.342)	(0.063)	(0.393)	(0.080)
German citizenship	0.562	0.118	0.212	0.039	0.344	0.069
	(0.349)	(0.075)	(0.431)	(0.079)	(0.381)	(0.078)
Female	-0.128	-0.027	-0.169	-0.031	-0.085	-0.017
	(0.576)	(0.122)	(0.636)	(0.116)	(0.529)	(0.106)
Group leader	0.521*	0.110*	0.281	0.052	0.289	0.058
	(0.313)	(0.066)	(0.315)	(0.058)	(0.338)	(0.069)
Director	1.421**	0.295***	1.267*	0.229*	1.560**	0.301***
	(0.635)	(0.112)	(0.752)	(0.120)	(0.652)	(0.107)
Constant	2.886		5.357		6.620*	
	(-3.629)		(-4.303)		(-3.939)	
PhD dummies	yes		yes		yes	
Section dummies	yes		yes		yes	
Log likelihood	-147.59		-130.23		-140.57	
McFadden's R^2	0.103		0.208		0.145	
Adjusted Count R^2	0.219		0.381		0.210	

Notes: Robust standard errors which are adjusted for intracluster correlation within Max Planck institutes are reported in parentheses. The asterisks *, ** and *** denote significance at the 10, 5 and 1 percent level respectively. Number of observations: 240.

Table 7: Cooperation Behavior: Planned Cooperation – Model 1c

	(1)	(2)	(3)	(4)	(5)	(6)
	coef.	marg.eff.	coef.	marg.eff.	coef.(D)	marg.eff.(D)
Cooperation attractiveness	0.466***	0.101***	0.360**	0.071**	0.630**	0.129**
	(0.168)	(0.033)	(0.184)	(0.034)	(0.317)	(0.062)
Reputational reward			-0.106	-0.021	0.103	0.021
			(0.141)	(0.028)	(0.265)	(0.054)
Income opportunity			-0.149	-0.029	0.348	0.070
			(0.172)	(0.034)	(0.618)	(0.121)
Time costs			-0.109	-0.022	-0.207	-0.042
			(0.160)	(0.032)	(0.352)	(0.072)
Cost sharing			0.141	0.028	0.289	0.059
			(0.120)	(0.024)	(0.280)	(0.057)
Confidentiality			-0.328**	-0.065***	-0.984***	-0.207***
			(0.133)	(0.025)	(0.286)	(0.059)
Different approaches			-0.056	-0.011	-0.299	-0.061
(academia–industry)			(0.163)	(0.032)	(0.261)	(0.053)
No commercial application			-0.401***	-0.079***	-1.299***	-0.273***
			(0.147)	(0.028)	(0.433)	(0.081)
Basic research focus	0.078	0.017	0.266*	0.053*	0.556	0.109*
in group	(0.152)	(0.033)	(0.148)	(0.028)	(0.348)	(0.066)
Commercialization	0.437***	0.095***	0.464**	0.091***	0.532	0.109
common in research field	(0.151)	(0.030)	(0.183)	(0.033)	(0.341)	(0.068)
Age (log of years)	-0.505	-0.111	-0.735	-0.145	-0.864	-0.176
	-1.173	(0.257)	-1.214	(0.240)	-1.184	(0.241)
Time at MPS/age	0.463	0.102	0.821	0.162	1.070	0.218
	-1.392	(0.304)	-1.350	(0.265)	-1.316	(0.263)
Industry work experience	-0.302	-0.066	-0.209	-0.041	-0.277	-0.056
(*yes-no*)	(0.347)	(0.076)	(0.401)	(0.079)	(0.409)	(0.083)
German citizenship	0.517*	0.114*	0.288	0.057	0.398	0.082
	(0.293)	(0.066)	(0.329)	(0.066)	(0.320)	(0.065)
Female	0.348	0.076	0.348	0.068	0.436	0.088
	(0.384)	(0.081)	(0.415)	(0.079)	(0.408)	(0.078)
Group leader	0.683**	0.149**	0.522	0.103	0.505	0.103
	(0.341)	(0.071)	(0.342)	(0.065)	(0.334)	(0.065)
Director	1.083	0.222	1.008	0.191*	1.334**	0.251**
	(0.730)	(0.128)	(0.664)	(0.113)	(0.650)	(0.103)
Constant	-1.863		1.827		2.553	
	(-4.224)		(-4.352)		(-4.511)	
PhD dummies	yes		yes		yes	
Section dummies	yes		yes		yes	
Log likelihood	-150.69		-138.83		-141.69	
McFadden's R^2	0.093		0.164		0.147	
Adjusted Count R^2	0.235		0.365		0.330	

Notes: Robust standard errors which are adjusted for intracluster correlation within Max Planck institutes are reported in parentheses. The asterisks *, ** and *** denote significance at the 10, 5 and 1 percent level respectively. Number of observations: 240.

Table 8: Cooperation Attractiveness: Attitudes towards Commercialization – Model 2a

	(1)	(2)	(3)	(4)
	baseline	baseline (D)	extended	extended (D)
Reputation:	0.593***	1.119***	0.455***	0.865***
commercialization	(0.059)	(0.124)	(0.058)	(0.125)
Open science identity	-0.283***	-0.658***	-0.144***	-0.498****
	(0.055)	(0.139)	(0.053)	(0.265)
Basic research focus			-0.346***	-0.840***
in group			(0.068)	(0.141)
Commercialization			0.197***	0.187
common in research field			(0.055)	(0.129)
Age (log of years)			-0.422	-0.388
			(0.372)	(0.352)
Time at MPS /age			-0.005	-0.011
			(0.012)	(0.011)
Industry work experience			0.425***	0.425***
(*yes-no*)			(0.147)	(0.151)
German citizenship			-0.561***	-0.576***
			(0.155)	(0.151)
Female			-0.163	-0.163
			(0.124)	(0.128)
Group leader			-0.152	-0.168
			(0.149)	(0.151)
Director			0.006	-0.040
			(0.286)	(0.278)
PhD dummies	yes	yes	yes	yes
Section dummies	yes	yes	yes	yes
Log likelihood	-1625.28	-1643.79	-1535.77	-1553.91
McFadden's R^2	0.050	0.040	0.103	0.092
AIC	2.774	2.806	2.651	2.682

Notes: Robust standard errors which are adjusted for intracluster correlation within Max Planck institutes are reported in parentheses. The asterisks *, ** and *** denote significance at the 10, 5 and 1 percent level respectively. AIC: Akaike Information Criterion. Number of observations: 1176.

Table 9: Cooperation Attractiveness: Attitudes towards Cooperation – Model 2b

	(1) baseline	(2) baseline (D)	(3) extended	(4) extended (D)
Reputational reward	0.302**	0.837***	0.223	0.833***
	(0.133)	(0.240)	(0.144)	(0.252)
Income opportunity	0.406***	0.991**	0.340**	0.811*
	(0.113)	(0.408)	(0.148)	(0.476)
Time costs	-0.385***	-0.630**	-0.365**	-0.636**
	(0.118)	(0.246)	(0.146)	(0.255)
Cost sharing	0.170*	0.473*	0.179	0.367
	(0.095)	(0.245)	(0.111)	(0.297)
Confidentiality	-0.052	-0.131	-0.100	-0.277
	(0.111)	(0.234)	(0.113)	(0.259)
Different approaches	-0.146	-0.269	-0.103	-0.136
(academia–industry)	(0.124)	(0.266)	(0.143)	(0.282)
No commercial application	-0.205**	-0.354	-0.201*	-0.184
	(0.093)*	(0.280)	(0.110)	(0.292)
Basic research focus in group			-0.122	-0.717***
			(0.150)	(0.265)
Commercialization common			0.259**	-0.307
in research field			(0.128)	(0.312)
Age (log of years)			0.297	-0.180
			(0.794)	(0.758)
Time at MPS / age			-0.002	-0.002
			(0.023)	(0.025)
Industry work experience			0.769**	0.804**
(*yes-no*)			(0.350)	(0.342)
German citizenship			-0.776***	-0.729***
			(0.297)	(0.260)
Female			-0.334	-0.320
			(0.406)	(0.365)
Group leader			-0.505**	-0.515*
			(0.235)	(0.285)
Director			-0.727	-0.563
			(0.553)	(0.542)
PhD dummies	yes	yes	yes	yes
Section dummies	yes	yes	yes	yes
Log likelihood	-290.03	-297.02	-273.027	-278.986
McFadden's R^2	0.070	0.048	0.125	0.106
AIC	2.509	2.567	2.509	2.558

Notes: Robust standard errors which are adjusted for intracluster correlation within Max Planck institutes are reported in parentheses. The asterisks *, ** and *** denote significance at the 10, 5 and 1 percent level respectively. AIC: Akaike Information Criterion. Number of observations: 240.