ACADEMIC-BUSINESS COOPERATIONS IN BIOTECHNOLOGY: WHO COOPERATES WITH FIRMS, AND WHY?

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Abstract

Academic scientists are under increasing pressure to engage in more commercially "relevant" research, through either patenting and licensing research results, or research cooperations. This paper seeks to add to our understanding of academic-business collaborations (contract research, joint research, and consulting) by presenting preliminary results from a novel survey of academic researchers in the life sciences in Denmark. We seek to draw a "profile" of those researchers who cooperate, and why. Expressed in a different way, we would like to determine what researcher characteristics and competencies business, in practice, demands. Both university and hospital scientists were polled. Our most surprising finding is that there is a consistent and highly significant relationship between strong publication records and cooperation, across both researcher groups, and for all forms of cooperation. Our results underline that it is important that scientists be permitted – indeed, encouraged – to continue to operate within the norms of the academic community, where success is measured by the collegiate reputation-based reward system, thereby maintaining a clear division of labor between what scientists do best, and what business does best.

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1. Introduction

With the increasing commercialization of innovations in the life sciences, questions about the dynamics of academic-business collaborations – and the implications for scientific research, the companies, and society – acquire new urgency. Academic scientists are under increasing pressure to engage in more commercially "relevant" research, to redirect their work to applied projects with more immediate, measurable economic pay-offs. Leading institutions have established tech-transfer offices to help their scientists obtain patents and license out the rights. Many governments support different forms of knowledge transfer from academic institutions to business.

But while we have a reasonably good understanding of why companies collaborate with academic researchers (e.g. Berman, 1990, Cohen *et al.*, 2002, Fontana *et al.*, 2006, Monjon and Waelbroeck, 2003, Zucker and Darby, 2001), and the dynamics of this process (e.g. Breschi *et al.*, 2004, D'Este and Patel, 2005, Colyvas *et al*., 2002, Feldman *et al.*, 2002, Meyer, 2006), much less is known about the academic researchers who cooperate with firms. This paper seeks to fill this gap by presenting preliminary results from a novel survey of the collaborative activities of academic researchers in the life sciences in Denmark.

There are two main ways to make academic research more relevant to business. One is to encourage scientists to patent and license out their research (e.g. Thursby and Thursby, 2002, Mowery *et al.*, 2001). Such research must be demonstrably marketable. The other is for scientists to cooperate with firms, the focus of this paper. Here, the research does not have to be directly marketable, but it must be seen by the company as a valuable input to the innovation process.

This paper seeks to draw a "profile" of those researchers who choose to cooperate with companies, and why. How important are publication records, research council grants, previous employment in business, and patent experience? What is the relationship between research motivation and cooperation? Expressed in a different way, we would like to determine what kinds of researcher characteristics and competencies business, in practice, demands.

Researchers who cooperate, we assume, are viewed more positively by business than those who do not.

2. Theoretical background and hypotheses

Scholarship on university-business cooperations is informed by a central “puzzle” (e.g. Dasgupta and David, 1994, Liebeskind *et al.*, 1996, McMillan *et al.*, 2000, Merton, 1973). University scientists work under a collegiate reputation-based reward system based on the norms of open science. Success is tied to priority – coming first in the “race” to publish original research in a reputable journal. Due to the nature of scientific research, a scientist’s effort cannot easily be observed by external monitors. Publication in refereed journals offers a publicly verifiable way for scientists to demonstrate their competencies. Success, for a firm, is defined in terms of market performance. Scientific research is (ideally) long-term and motivated by curiosity. Corporate research is short-term and motivated by the commercial development of research results. While commercial firms are profit-motivated, university researchers have a more complex set of objectives, based on a mixture of scholarly, educational and societal goals and expectations, not least communicating their results to industry (Bercovitz and Feldmann, 2006).

Under the first system, the value of knowledge sharing is emphasized; under the second, the appropriability of knowledge. But to what extent is this always – or even necessarily – the case? For example, might not scientists, in some circumstances, be more highly motivated to enter into joint research with business to be able to engage in cutting edge theoretical research, since they can tap directly into corporate budgets (and not rely on shrinking university budgets)?

Previous research has documented the importance of academic research in firm innovation activities (e.g. Mansfield, 1991, Beise and Stahl, 1999). Firms that have funded university research or cooperated with university researchers in other manners have enjoyed higher rates of innovation and performance (e.g. Berman, 1990, Cohen *et al.*, 1998, Monjon and Waelbroeck, 2003). Scientists have been a key source of ideas in both the invention and innovation process (Cohen *et al*., 2002a,b, Fontana *et al.*, 2003). Companies benefit enormously from the availability of complementary information – in the form of basic scientific knowledge – free of charge (Dasgupta and David, 1994). Public science, particularly very basic research, is especially important in biotechnology (McMillan *et al.*, 2000). In biotechnology, also research collaborations between "star" academic scientists and firm scientists have a positive effect on a wide range of performance measures in firms that engage in them (Daughterty *et al.*, 2006, Zucker, Darby and Brewer, 1998, Zucker and Darby, 2001). Thus it is vital to assess how academic scientists, in practice, contribute to innovation in the life sciences.

We start by referencing a discussion in Dasgupta and David (1994), who explore why a young scientist would not immediately want to be hired by a firm, at higher pay, to do proprietary research. One obvious answer is the benefits of the academic lifestyle. But as Dasgupta and David point out, they may have an additional incentive to continue in open science for a while: to give them the opportunity to publish their findings, thereby signaling their competencies to prospective employers. As researchers grow older, and the costs of deferring the switch to business increases, those best at signaling their competencies will move on to an industrial career, leading to a gradual ageing of the researchers remaining in the universities. This, the authors maintain, is one of the factors that makes the open norm system of academic science vulnerable, and there are no economic forces that operate automatically to maintain dynamic efficiency between the two systems, and the balance between them. Over the longer term, the decline of scientific talent at the universities will negatively affect business as well, reducing the quality of public science inputs into their R&D programs.

But Dasgupta and David do not explore academic-business *cooperations*. In a cooperation, the scientist does not move from an academic institution to a company, but remains an academic, all the while providing a valuable input to a corporate R&D program. Such collaborations would arguably provide a way to reduce the information asymmetries that, according to Dasgupta and David, often limit the effectiveness of the university as a scientific information transfer agent. We were interested to investigate how cooperating academic scientists successfully operate within the norms of two apparently conflicting systems. We ask: Given the differences between academic and industrial research, what distinguishes those researchers who cooperate with business from those who do not?

One explanatory factor might be the researcher's age. We decided to test Dasgupta and David's (1994) underlying assumption that older researchers who remain at academic institutions would be of little interest to companies. Had they wished to pursue a career in business, they would have done so earlier. Or perhaps the companies did not want to hire them. A further argument would be that the older the researcher, the more "socialized" she would be into the collegiate-based reward system, and the more resistant to cooperating with business. Our prediction is that older researchers will be less likely to cooperate with business.

A second central element in constructing our profile concerns publication activities. Arguably, the better the scientist's publication record, the less likely he would be to cooperate. When scientists publish in international journals, their work becomes part of the public domain, freely available to all to learn from and build on. Such researchers might be reluctant in principle to cooperate with companies, for whom the proprietary control of new knowledge is crucial. Similarly, companies looking for research partners might that fear scientists with strong publication records would end up "giving away" research results supported by them to possible competitors. This reasoning is consistent with Dasgupta and David (1994)'s contention that the norms of open science are distinct from the norms of the more "restricted," profit-motivated science practiced by business, with the resultant continuous friction between the academic emphasis on publication, and the corporate emphasis on deferring the disclosure of new knowledge until ways can be found to appropriate it.

Scientists' research priorities are reflected in the journals in which they publish. One might expect to see a greater incidence of cooperation among scientists who mainly publish in journals specializing in applied research than among those who choose journals specializing in basic research. Applied research would arguably also be of greater interest to the companies concerned, and easier to apply in their R&D programs. The companies might additionally be in a better position to evaluate the competencies of scientists in applied fields.

What types of professional activities might lead a scientist to collaborate with business? Again following the thread of our previous arguments, our prediction is that scientists who cooperate would tend to specialize in commercially relevant research. One way to gauge this is whether or not the scientist has received a government research council grant, the purpose of which is to support basic research. Grant recipients, we reckon, would be less likely to cooperate.

Also important is whether or not the scientist has had actual experience in business. Scientists employed in a company prior their current academic position, we predict, will be better attuned to the norms and practices of the business world than those who never worked for a company. And they might have ready access a strong professional network that would facilitate collaboration.

A third possible explanatory factor is previous experiences with patents. In biotechnology, patents are essential to commercializing new products and processes (Liebeskind *et al.*, 1996, McMillan *et al.*, 2000). Only if the firm possesses the patent rights can it be sure that its invention does not infringe an existing patent. Firms typically apply for numerous patents on the same basic invention (products, processes, methods, and uses), and may continue to seek patent protection on further refinements. This leads to the expectation that scientists who have greater understanding of and experience with patenting would be more likely to collaborate with business than scientists who lack such experience.

Finally, we wished to investigate the role of research motivation. Scientists strongly motivated in their own research by the opportunity to pursue cutting-edge research would arguably be less likely to cooperate with companies. Such scientists might well find the commercial demands of the industrial R&D lab too restrictive, and/or find it difficult to integrate their work into the corporate culture of the R&D lab. Scientists strongly motivated by the opportunity to find practical applications for their work would arguably, on the other hand, be more likely to cooperate with companies, since it would them to realize their research ambitions in practice. They would probably also be more attuned to corporate priorities emphasizing the commercialization of research results as quickly as possible.

This picture may be captured by the following eight hypotheses:

H1: Younger scientists are more likely to cooperate with business than older ones

H2: Scientists who publish relatively few articles in refereed journals are more likely to cooperate with business than scientists who publish relatively many articles

H3: Scientists who mainly publish in journals specializing in applied research are more likely to cooperate with business than scientists who mainly publish in journals specializing in basic research

H4: Scientists who have not received a grant from the Danish government's research council are more likely to cooperate with business than scientists who have received a grant

H5: Scientists who have previously worked in a company are more likely to cooperate with business than those who have not

H6: Scientists who have been listed as an inventor on a patent application over the past ten years are more likely to cooperate with business than scientists who have not

H7: Scientists who are not strongly motivated by the opportunity to pursue cutting-edge basic research are more likely to cooperate with business than those who are strongly motivated

H8: Scientists who are strongly motivated to find practical applications for theoretical scientific discoveries are more likely to cooperate with business than those who are not

3. The empirical data

To test these hypotheses, this paper draws on data collected via an Internet-based questionnaire sent to academic researchers in the life sciences in Denmark. The survey was conceived by us and carried out by UNI-C, a government institution which performs statistical analyses for university researchers. We defined "life sciences" according to the U.S. National

Science Foundation, which divides the area into four broad fields: Biological, Environmental Biology, Agricultural Sciences, and Medical Sciences.

To define the relevant population, in October 2005, we sent a letter to the heads of all of the departments and institutions in Denmark that *might* have researchers relevant to our inquiry. We asked them to specify how many scientists at their institutions should be included. They could also decline to participate. In November, 2005, we sent a second letter to the heads of all of the institutions who had indicated they wished to participate, containing individual packets of information for all the scientists they had informed us were relevant (1744 potential respondents in all), and asked them to distribute the packets to these researchers. Each researcher was given an access code and a link to an Internet site, where they could log on and answer the questionnaire.[2] All respondents were guaranteed anonymity, both to us and the heads of their institutions.

The data collection closed at the end of January, 2006. In all, 581 responses were received, yielding a response rate of 33.3%. 43% of our respondents came from universities, 41% from hospitals, and 16% from government research organizations.

As mentioned earlier, the life sciences comprise several disciplines, according to the NSF definition. In this particular analysis, we consider only biological and medical sciences (excluding observations from agricultural and environmental sciences). We also restrict our analysis to researchers in universities and hospitals (excluding observations from government research organizations). Finally, we have excluded junior researchers, limiting our sample to senior researchers, who we expect would have the best understanding of and experience with academic-business collaborations, and who are themselves in control of the collaboration

[2] The basic questionnaire consisted of seven main sections: (1) General information about you and your work (age, academic degree, position), (2) Your academic research (field of research, publications, grants received, research motivation) (3) Academic-business cooperation (nature and frequency of cooperation, motivation to cooperate), (4) Role of patents in the life sciences (patenting and licensing activity, motivations to patent and license), (5) The technology transfer office (utilization and assessment of TTO); (6) Effects of patenting on research on your field (attitudes towards patents), (7) Concluding comments (opportunity for further comments). Scientists who answered that they had cooperated with business were asked to answer questions in two additional sections: (8) Characteristics of the joint research activity (nature of the cooperation, characteristics of the business partner, and if applicable, terms of the contract), (9) Patenting activity in the joint research project (who was listed on the application, assessment of the patenting activity). In this paper, we have only analyzed questions from Sections 1, 2 and 3.

(junior researchers might be pushed into collaborations with senior colleagues). With these restrictions, the analyzed sample consists of 264 observations.

4. Design of the empirical study

In our statistical model, we apply a simple, linear function and regress a number of variables describing the scientist on the three variables capturing the cooperative behaviour we seek to analyze. The three types of cooperation are drawn from a section of questions containing a total of thirteen different types of cooperation. The ones analyzed here are among the four most frequently reported, and they represent three distinctly different types of collaboration. Table 1 presents the variables and their summary statistics, not only for the target sample, but also for the entire survey sample.

(Table 1 about here)

The table clearly indicates that cooperative behaviour is different in universities and hospitals. Hospital scientists frequently do contract research, more than a quarter of them repeatedly. They also more frequently consult with companies, but interestingly enough, scientists at universities and hospitals engage in the same rate of joint research projects. This suggests that hospital scientists possess some immediately useful knowledge or skills, while they are not more interesting for companies than their university colleagues when it comes to joint research projects.

The independent variables are selected from the survey questions in order to allow for an analysis of our eight hypotheses. The set of variables applied in this analysis consists of the following: **Age**, **Publications**, **Publications in basic research journals**, **Research council grants**, **Prior employment in business**, **Patent inventor** and two motivational variables, **The opportunity to pursue cutting-edge basic research**, and **The opportunity to find practical applications for basic scientific discoveries**. Some deserve a comment.

Publications are measured as the (self-reported) number of published articles in refereed journals, either as author or co-author, over the past ten years. We used the square root of this number to reduce the effect of high values. Publications in basic research journals are measured by the percentage of a scientist's articles published in journals specializing in basic research. Research council grants counts the number of grants obtained from a Danish government research councils of at least DKK 100,000 (approximately 13,000 euros) over the past ten years, registered in three categories: "three times or more", "once or twice" and "no". Prior employment in business registers if the scientist has over the past ten years been employed full-time at least for one year in a private firm. The patent inventor variable registers if the scientist has been listed as an inventor on a patent during the past ten years.

Finally, the two motivational variables are drawn from a section of ten factors possibly motivating the scientist for doing research in general. Answers are given on a 7-point Likert scale from "not at all important" to "very important". The opportunity to pursue cutting-edge basic research has a mean value of 5.6 (7 being "very important") for senior university scientists and 4.9 for hospital scientists. The opportunity to find practical applications for basic scientific discoveries has a mean value of 4.9 for university scientists and 5.1 for hospital colleagues. As expected, scientists in the two institutions see their role as researchers as different. University scientists are clearly more interested in basic scientific discoveries, but it should be noted that university researchers show almost same interest in applying these discoveries as do their hospital counterparts.

With ordinal dependent variables, an ordered probit regression is the natural choice. Table 2 reports the results of the same model applied to the three different types of cooperation, and run for the three samples: We do this first for all senior university and hospital researchers within biological and medical sciences. Then this sample is split into the two subgroups of universities and hospitals. In total, nine regressions are shown. The number of observations is lower than in Table 1 due to missing answers on the independent variables.

(Table 2 about here)

The model varies considerably in explanatory power. Without over-emphasizing the importance of the pseudo-R^2, it seems to be better at explaining the behaviour of hospital scientists. While not very successful in explaining university scientists' contract research and consulting, it does better in explaining their participation in joint research projects. The reason for the former observation probably extends beyond the simple problem of choosing the "right" explanatory factors. Most likely, it is a result of a much larger variation in the behaviour of university scientist than amongst scientists at hospitals. To establish homogeneous samples, we limited the sample to senior scientists working in the same scientific fields. This apparently was to some degree possible in hospitals but much less so in universities. We suggest that this difference is inherent to the two types of institutions: universities probably are much more heterogeneous by nature. As a general note, efforts to explain university activities may therefore simply be more demanding.

5. Results of the empirical study

As regards the age of the researcher, while we found no significance for university researchers, we determined that older hospital scientists were more likely to cooperate with business in all of the three forms investigated: contract research (10% significance level), joint research (5%) and consulting (5%). A possible explanation is that older researchers have more extensive networks, or are more well-known professionally by firms. It also suggests that accumulated clinical experience is highly valued by business.

Interestingly, this result contradicts the finding of a previous related empirical study (Bercovitz and Feldman, 2003) of scientists from Duke and Johns Hopkins Universities who participated in technology transfer activity (admittedly a different focus than our own). They determined that "experience years" (the number of years since the last graduate degree was obtained) had a negative effect on participation in technology transfer: the probability of a researcher disclosing an invention decreased by about 1% for each year since the completion of graduate study.

Neither hypothesis with regard to publication was confirmed, but for different reasons. As regards Hypothesis 2, for university researchers, the more the publications, the more likely they were to engage in contract research (5%), joint research (1%), and consulting (10%). For hospital researchers, the more likely they were to engage in contract research (1%), joint research (1%), and consulting (1%).[3] By contrast, the results for Hypothesis 3, across the board, are not significant.

Both results are surprising. Even though the number of publications is an (admittedly imperfect) measure of the scientist's skills, it serves as a signal of competence. Perhaps, the importance of publications reflects the search activities of companies seeking to identify potentially interesting academic partners (Fontana *et al.,* 2006). Companies simply want to work with the best. It may indicate a willingness on the part of the companies to support these scientists in pursuing their academic publishing objectives. While there is no comparable study of this issue in the literature, as far as we can see, it is supported by related studies (Louis *et al*, 1989, Etzkowitz, 1983), who found that the individual scientist's publication rate in refereed journals is positively related to entrepreneurial behaviour.

This interpretation is particularly interesting in light of our results for Hypothesis 3. What we seem to have uncovered is a marked and significant relationship between strong publication records *per se* and cooperation – but that it does not matter whether the scientist publishes in journals specializing in basic or applied research. As regards joint research projects, business seems to find university scientists more attractive as partners when they do basic research (though not statistically significant). A possible interpretation may concern the nature of research in the life sciences, where the boundaries between basic and applied research are often blurred (Lehrer and Asakawa, 2004). Alternatively, our results again suggest that companies are equally interested in both types of research, depending on the context, but what really matters for the choice of academic partner is the academic performance.

[3] An analysis of the marginal effects of publications on the three dependent variables shows a fundamental dichotomy between cooperating at all and not cooperating. The marginal effects of publications on the possibility of cooperating "once or twice" is positive in all situations. For universities the effect is approximately of the same size as for the "three times or more". The effect of a higher publication rate for university scientists is thus not more cooperation, but cooperation at all. However, for hospitals, more publications also predicts more cooperation.

Our three hypotheses on other professional activities were generally confirmed by the tendencies in the data. For Hypothesis 4, only two findings were significant: Hospital researchers who received research grants were less likely to engage in contract research (5%), and university researchers were less likely to engage in consulting (10%). This may suggest that in these two cases, respondents see research grants as an alternative means of financing their research.

There was only one significant relationship as regards prior employment in business (Hypothesis 5): university researchers were more likely to engage in joint research with business (10%). This may indicate that scientists who move from business to academics made a deliberate choice, preferring to work within the academic norm system. Yet if they wished, they could still draw on their previous business connections to cooperate. However, the general lack of significance suggests that prior experience with business cannot substitute other factors, such as research performance.

Our expectation for Hypothesis 6 was strongly borne out by the data. University researchers listed on patent applications were more likely to engage in contract research (10%), joint research (1%), and consulting (10%); hospital researchers so listed were more likely to engage in contract research (1%), joint research (1%), and consulting (1%).[4] As an important methodological precautionary remark, it should be noted that patents are often a direct result of either contract research or joint research projects. It might well be that patenting experience cannot be taken as a qualifying competence offered to companies *ex ante*, but a simple result of a cooperation. However, even though this problem is not likely for consulting activities, the results are rather similar.

Finally, our hypotheses regarding the link between research motivation and cooperation produced mixed results. The researcher's motivation to pursue cutting-edge research and the tendency to cooperate with business (Hypothesis 7) was significant in only one way: hospital researchers were less likely to engage in consulting (5%). The finding for Hypothesis 7 is intriguing. The general lack of significance may suggest that many scientists find that

[4] The marginal effects of patenting on cooperation shows perfectly the same patterns as reported above for publications. For universities, patenting predicts cooperation (as opposed to no cooperation), while at hospitals, patenting leads to more cooperation.

cooperating with a firm perhaps does offer them the opportunity to pursue cutting edge theoretical research. It suggests that – at least in the life sciences – an expressed interest in pursuing cutting-edge basic research does not lead scientists to hide away in their ivory towers. Such scientists are as open to collaboration with companies and as attractive to companies as their fellow scientists, especially in joint research projects.

Two highly significant results emerged from Hypothesis 8. Hospital scientists who were strongly motivated by the opportunity to find practical applications for their research were more likely to engage in both contract research (1%) and consulting (1%). This finding supports our previous finding (Hypothesis 4) that hospital researchers who received research grants were less likely to engage in these forms of cooperation. Together, they suggest that hospital scientists may have a strong preference for finding practical applications for their research, which they can best realize by performing contract research (and not via support from research grants).

Several larger patterns emerge from our data. For both contract research and consulting, it is easier to "pin down" the predictors of hospital researchers' cooperation. The number of publications, patent experience, and the opportunity to find practical applications for their research are strongly (1% significance) linked to hospital researchers' tendency to cooperate with business. For university researchers, not only are there fewer predictors, but the significance is typically lower.

Interestingly, the two groups display a more similar pattern for joint research. In both cases, number of publications, and being listed on a patent application, are strong predictors of the likelihood of cooperation. For hospitals, age is also a predictor, and for university researchers, prior employment in business, but again, at lower levels of significance.

6. Discussion and conclusions

Generally speaking, our most important findings concern the very strong links between a researcher's publication record and experience with patents, and the proclivity to cooperate with business. We also found a generally more consistent pattern for hospital scientists than for university scientists.

A limitation of this study concerns the basic nature of anonymous questionnaire surveys: there is no way to independently verify our results. While we accept that this can be a disadvantage, we believe that it is outweighed by the advantage that scientists could answer our questions (some of which involved confidential matters) without fear of being identified individually.

Though our work is still preliminary, it is worth speculating as to what some of the implications might be. To our knowledge, very few studies have probed whether or not university and hospital researchers exhibit different cooperative profiles. An exception is Garrett-Jones *et al*. (2005), who compare the risks and rewards of academic and government researchers. While the latter group does not correspond precisely to our category "hospital researchers," they overlap, in that Danish hospital researchers are all publicly employed. Garrett-Jones *et al*. argue that the reward systems and performance measures for university researchers are still founded largely on "discovery," while those for government researchers are based upon "application." This supports the findings of our survey; hospital researchers are more focused on applied research than university researchers.

Louis *et al.* (2001) made a survey of 4,000 clinical and non-clinical life sciences faculty in forty nine U.S. research universities. Clinical faculty, they found, were more dependent on industry funding, and were more involved in bringing a product to market. Non-clinical faculty were more likely to be personally involved in commercializing their research, and participating in pre-market commercialization of their research findings. Both groups contributed equivalently to the research mission of their universities, as measured by publications in peer reviewed journals. This study, too (while based on a slightly different sample), supports our findings.

Studies of the relationship between patents and publishing (e.g. Zucker, Darby and Armstrong, 2002, Zucker and Darby, 2001) have determined that scholars who publish more are also likely to patent more. Our analysis has found the same positive relationship between publishing and research collaboration. This apparent strong link between publishing, patenting, and cooperation with business could profitably be explored by further research.

Publication in refereed journals is the best indicator we have of high quality research. Our study demonstrates that firms, by their choice of academic partner, recognize the value of excellent academic records. Many governments, nevertheless, have begun to favor certain types of research, channeling research grants into prioritized areas. Our results suggest that this is the wrong way to go.

Our conclusion is similar to that drawn by Dasgupta and David (1994) – though for a different reason. Dasgupta and David argued that it is vital that universities both create an attractive working environment, and compensate their best researchers adequately, so as to keep them, as part of the broader effort to maintain the balance between the norms of open science and the norms of business. But the two systems, which both reinforce and greatly enrich one another, must be kept distinct. Our analysis demonstrates that business itself prefers to cooperate with highly reputed academic scholars, whose strong publication records place them squarely within the norms of open science.

This study underlines the importance of permitting –indeed encouraging – scientists to continue to operate within the norms of the academic community, where success is measured by the collegiate reputation-based reward system. Academic and business contributions to cooperations must be seen as complementary activities, where each party draws upon, and contributes to, the strengths of the other. Scientists must continue to be free to choose their areas of research, thereby maintaining a clear division of labor between what scientists do best, and what business does best.

Table 1 Dependent variables

	Three times or more	Once or twice	No	*N*
You carried out contract research for a firm				
All respondents	12.1%	20.5%	67.4%	571
Senior researchers	14.8%	22.9%	62.3%	385
Senior researchers in biological and medical sciences at universities or hospitals	15.9%	24.2%	59.9%	264
Senior researchers in biological and medical sciences at universities	6.5%	26.8%	66.7%	138
Senior researchers in biological and medical sciences at hospitals	26.2%	21.4%	52.4%	126
You worked with company researchers within the framework of a cooperative research project				
All respondents	13.2%	27.7%	59.1%	575
Senior researchers	17.1%	31.4%	51.6%	386
Senior researchers in biological and medical sciences at universities or hospitals	18.9%	28.8%	52.3%	264
Senior researchers in biological and medical sciences at universities	18.8%	29.7%	51.5%	138
Senior researchers in biological and medical sciences at hospitals	19.1%	27.8%	53.2%	126
You served as a consultant to a firm on a private basis				
All respondents	8.6%	21.7%	69.7%	571
Senior researchers	11.5%	29.3%	59.2%	382
Senior researchers in biological and medical sciences at universities or hospitals	14.1%	31.2%	54.8%	263
Senior researchers in biological and medical sciences at universities	9.5%	33.6%	56.9%	137
Senior researchers in biological and medical sciences at hospitals	19.1%	28.6%	52.4%	126

Table 2: Ordered PROBIT regressions

Dependent variable	Contract research						Joint research						Consulting					
	All		Universities		Hospitals		All		Universities		Hospitals		All		Universities		Hospitals	
N	212		110		102		212		110		102		211		109		102	
	Coef.	Prob.	Coef.	Prob.	Coef.	Prob.	Coef.	Prob.	Coef.	Prob.	Coef.	Prob.	Coef.	Prob.	Coef.	Prob.	Coef.	Prob.
Independent variables																		
*** Age**	+ 0,0033	0,740	- 0,0180	0,171	+ 0,0331	0,073	+ 0,0037	0,707	- 0,0139	0,267	+ 0,0394	0,025	+ 0,0133	0,179	+ 0,0032	0,798	+ 0,0361	0,047
*** Publications (sqroot)**	+ 0,1690	0,000	+ 0,1282	0,029	+ 0,1966	0,000	+ 0,1716	0,000	+ 0,1604	0,005	+ 0,1466	0,005	+ 0,1605	0,000	+ 0,0997	0,069	+ 0,1773	0,001
*** Publications in basic research journals**	- 0,0037	0,155	- 0,0034	0,395	+ 0,0026	0,591	+ 0,0036	0,165	+ 0,0059	0,127	+ 0,0060	0,195	- 0,0003	0,917	+ 0,0025	0,510	+ 0,0036	0,443
*** Research council grants**	- 0,2241	0,081	+ 0,1695	0,432	- 0,4547	0,014	- 0,1943	0,126	- 0,0843	0,669	+ 0,2558	0,147	- 0,0798	0,522	- 0,3819	0,053	+ 0,1104	0,516
*** Prior employment in business**	- 0,0350	0,920	+ 0,0524	0,902	+ 0,6312	0,390	+ 0,3790	0,283	+ 0,7112	0,087	- 0,4090	0,587	+ 0,1491	0,661	+ 0,4370	0,274	- 0,7934	0,317
*** Patent inventor**	+ 0,7341	0,000	+ 0,4853	0,074	+ 1,6637	0,000	+ 0,8122	0,000	+ 0,7229	0,006	+ 1,2189	0,001	+ 0,6305	0,002	+ 0,4535	0,086	+ 1,1274	0,002
*** Opport. to pursue basic res.**	- 0,0525	0,367	- 0,1448	0,128	- 0,1250	0,152	+ 0,0343	0,551	+ 0,0339	0,713	+ 0,0135	0,866	- 0,0745	0,196	+ 0,0210	0,817	- 0,1866	0,028
*** Opport. to find practical appl.**	+ 0,0799	0,134	- 0,0546	0,482	+ 0,2823	0,002	+ 0,1019	0,056	+ 0,1109	0,156	+ 0,0849	0,292	+ 0,1711	0,002	+ 0,1453	0,060	+ 0,2239	0,010
Pseudo R2		0,12		0,07		0,26		0,14		0,13		0,21		0,12		0,08		0,23

Coloring:
Significant on a 1% level
Significant on a 10% level

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