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Exploring scientific publications by firms: what are the roles of academic and corporate partners for publications in high reputation or high impact journals?

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Abstract

Recent research suggests that firms, particularly in science-based industries, may publish scientific articles in order to achieve strategic goals. This paper explores whether the reputation seen as publications in journals with high impact factors and the impact seen as citations of such scientific publications originating in firms benefit from R&D alliances with different types of partners. Our empirical analysis is based on a unique dataset in pharmaceutical cancer research. We analyze publications originating in biotechnology and pharmaceutical firms, with a comparison of the results to publications that do not involve a firm-based author. Our results indicate that the returns to the number of partners are decreasing and are negative after a turning point. More surprisingly, our results suggest that biotechnology and pharmaceutical firms should focus on establishing R&D alliances with pharmaceutical firms in order to increase the probability of publishing in journals with a high reputation. However, in terms of scientific impact, i.e., forward citations, publications originating in firms do not benefit from having access to different types of alliance partners.

Keywords Research reputation · Research impact · Strategic alliances · Bio-pharmaceutical firms · Corporate publications · Research collaboration

JEL-Classifications L65 · O32

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Introduction

Which strategic alliance partners help firm-based researchers to publish in journals with a high reputation as measured by journal impact factors? Which alliance partners support the firms in publishing articles that have a large impact as measured by large number of forward citations? Some recent literature has acknowledged the contribution of firms to science in general but has also raised concerns that firms contribute less that they previously did to science (Rafols et al. 2014; Arora et al. 2018). Still, it is surprising that few contributions examine the topic of this paper, namely exploring the influence of the number and different types of partners for the reputation and impact of scientific publications originating in firms. Put differently, this paper explores whether the reputation and impact of scientific publications originating in firms benefit from R&D alliances with different types of partners. In line with previous research, journals with a high impact factor are interpreted as journals with a high reputation, while articles with many forward citations are interpreted as having a large impact.

Given the lack of previous literature, we develop our arguments by drawing upon the literature about the economics of knowledge and innovation and applying the concepts to processes leading to scientific publications which involve firms. In accordance with this literature, firms engage in knowledge generation activities such as R&D, which benefit positively from collaboration across organizational boundaries. Collaboration allows the firm to broaden their own knowledge base, by accessing new ideas and insights as well as relevant skills, research techniques, and other resources (Katz and Martin 1997; Rosenkopf and Almeida 2003). Such strategic alliances also provide access to complementary knowledge and complementary assets (Rothaermel 2001; Soh and Subramanian 2014) that support firms' knowledge generation activities. Alliance-related knowledge is integrated into the organization's knowledge base through the dissemination activities of its individual members who build upon this knowledge in their research activities. Collaboration thus provides access to knowledge, promotes a cross-fertilization of ideas, and widens the search space. Our interpretation is that these factors contribute to the novelty and the quality of research at the firm, because these factors can enable the firm-based authors to elaborate on their research questions as well as on their research designs through such collaboration across organizational boundaries. Having a higher degree of novelty and quality in resulting articles should then contribute to the likelihood of that article being published in a journal with a high reputation and/or to be cited.

We go beyond extant literature on firm publishing per se in order to instead examine the reputation and impact of these scientific publications by firm-based authors. This analysis is possible to do in our empirical context, the science-based biotechnology and the pharmaceutical industry. Biotechnology is characterized by small firms often linked to academia, whereas the pharmaceutical industry is characterized by large firms which invest heavily into R&D (McKelvey et al. 2004b; Pisano 2006). Together, they constitute the biotech-pharmaceutical industry, which is characterized simultaneously by intense collaboration activities through strategic alliances as well as strong engagement of firms in the production and publication of more basic scientific knowledge (de Moya-Anegón et al. 2014). More specifically, previous research on this industry has shown that the firm's collaboration with universities and other academic institutions improve the firms' understanding of diseases and of the mechanisms of drug actions, which thereby enables them to do basic science for drug development and engage in the corresponding publication activities (Cockburn and Henderson 1998). In addition, in this industry, biotechnology firms are valuable collaboration partners as they frequently act as technology brokers transferring knowledge originating in academia to pharmaceutical firms (Stuart et al. 2007). Hence, in this industry, both scientific publications as well as strategic alliances to generate knowledge are quite common.

There has been little previous research on the factors that contribute to the reputation as well as the impact of scientific publications by firm-based researchers. However, drawing upon adjacent literature, similar topics have been discussed for academic science in general (Azoulay et al. 2010; Merton 1973). For firm-based authors, the existing literature has identified and discussed several motives why firms in this industry may publish in scientific journals in general. Biotechnology and pharmaceutical companies have been found to follow a firm-wide publication strategy, and they plan the dissemination of their research through scientific publications thoroughly in order to achieve corporate goals (Sismondo 2009). These corporate goals encompass recruiting and retaining talent (Hicks 1995), using publications to block patenting by competitors (Barrett 2002), enhancing the credibility as well as the legitimacy of (clinical) research conducted to support applications for market approval (Balter et al. 2003), or positioning new drugs in the marketplace and supporting firms' marketing activities (Azoulay 2002; Polidoro and Theeke 2012).[1] In addition, some literature has studied the links between firms' contribution to science and their (innovation) performance (Gittelman and Kogut 2003; Simeth and Cincera 2015). Hence, the empirical context is a relevant setting, for our explorative research purpose.

This paper addresses a gap in the literature, namely studying the reputation and impact of scientific publications by firms. We do so by considering existing relevant arguments about collaboration for knowledge generation for science and innovation, in order to analyze publications involving firm-based researchers. Moreover, we distinguish between the contribution of different types of alliance partners to the reputation and impact of scientific publications. Our analysis is based on a unique dataset of scientific articles originating in firms and other organizations which we combine with data on strategic alliances related to these articles in the area of pharmaceutical cancer research. As a point of reference for interpreting our results we analyze a sample of publications that do not involve a firm-based author. We discuss our results in relation to theory, as well as directions for future research. One specific implication is about how firms can benefit from more collaboration with other firms but only for certain corporate goals.

How may alliance partners contribute to publications' reputation and impact?

The strategic question for firms is how alliance partners can influence the reputation and the impact of scientific publications. Within knowledge-based industries, such as the biotechnology and pharmaceutical industry, alliances are predominantly formed to access new knowledge in order to exploit complementarities among the alliance partners (Grant and Baden-Fuller 2004). Thereby, alliances create powerful learning opportunities for firms

[1] It should be noted that biotechnology and pharmaceutical firms can adapt their publication strategy to support their drug candidates under development. Consequently, a large proportion of clinical research has historically remained unpublished. Lee et al. (2008) argue that one reason is that firms are not interested in publishing results that do not support their claims concerning the safety and efficacy of drug candidates and that might negatively affect regulatory authorities' approval decisions.

and enable them to acquire knowledge from their collaboration partners through which they can leverage their own strength and improve the outcome of their knowledge generation activities (Inkpen 1998a). Consequently, connectedness to different alliances partners promotes the generation of new knowledge as expressed in scientific publications (Cockburn and Henderson 1998), also in the case of firm-based authors.

Moreover, existing research also suggests that there may be diminishing returns to the number of partners. The potential returns of collaboration through alliances may diminish with an increasing number of collaboration partners and may ultimately be negative due to the high cost of maintaining a high number of relationships and firms' limited absorptive capacity, as seen in knowledge networks more generally (Deeds and Hill 1996; Rothaermel and Alexandre 2009; Phelps et al. 2012; Grant and Baden-Fuller 2004).

Yet scientific publications involve firm-based authors who can also be seen as individual researchers. Therefore, in order to explain possible returns to firm-based publications, we argue that we need to analyze the firm's knowledge generation and knowledge exchange through activities by the individual members of firms or other organizations (Kim 1993). Following Nonaka (1994), knowledge generation at the firm level is a process in which individual elaboration on specific knowledge elements and various forms of interaction among different individuals within the firm leads to the exchange of alliance-related knowledge and its internalization of this knowledge into the firms' knowledge base. Thus, this individual knowledge moves beyond the individual perspective through its acceptance by other members of the firm and by its use in firm processes (Inkpen 1998b). The exchange of knowledge among the individual members of the firm enables the flow of knowledge through the organization and its sub-units. In addition, the intra-firm knowledge exchange provides access to knowledge that is acquired from external sources or developed in collaboration with partners outside the firm. Hence, at the firm level, we interpret that strategic alliances provide an opportunity for individuals and the firm to engage in the recombination of existing knowledge as well as for the generation of new knowledge.

The arguments presented above indicate that individuals' publication activities are the outcome of a knowledge generation process that synthesizes different, sometimes conflicting views and ideas through dynamic interactions among individuals, the firm or organization, and the environment (Nonaka and Toyama 2002). Knowledge generation is the result of interactions among individual members of the firm. These interactions do not only provide access to the firm's knowledge base but also enhance an individual's knowledge and research related abilities such as the capacity to define a research problem and to apply their individual knowledge to address the problem (Nonaka et al. 2006). Put differently, interactions among individuals create opportunities to access alliance-related knowledge that has been integrated into the firm's knowledge base and to use it in their own publication activities. Hence, firm researchers can discuss this knowledge, to develop it further, and apply it to their own research questions (Inkpen 1998b). We interpret that interactions amongst individual authors inside the firm also provide access to knowledge obtained from outside the firm through strategic alliances.[2]

[2] While this study focuses on strategic alliances as a form of formal collaborations, it should be noted that more informal forms of collaboration such as co-authorships or other forms of professional interaction may be simultaneously present (Liebeskind et al. 1996). These reinforce and complement formal collaborations, since informal collaborations may increase the likelihood of exchanging valuable knowledge. In addition, informal collaborations provide opportunities to access knowledge that is complementary to the firm's knowledge base and to knowledge obtained through strategic alliances. It is also possible that individuals use informal collaborations to get access to redundant knowledge that enables them to cross-check and to verify knowledge obtained internally or through strategic alliances.

The above arguments can be related to the economics of science literature that sees alliance-related knowledge as a beneficial source to impact the individual's knowledge generation and publication activities. More specifically, alliances may provide access to previously widely dispersed and not accessible knowledge, skills, and research techniques (Katz and Martin 1997). In addition, alliances expose individuals to knowledge that is distinct and potentially contradictory to knowledge held within the firm. The discussion of this knowledge promotes a cross-fertilization of ideas that supports publication activities through the development of new research questions (Katz and Martin 1997). Furthermore, alliances can broaden the search space and support the development of new approaches to address existing research problems (Schilling and Green 2011). Following these arguments, our interpretation is that strategic alliances increase the probability of publishing in a journal with a high reputation as they enable a better elaboration of research questions and research designs to address the research questions, which in turn positively contributes to the quality as well as the novelty of research projects. However, having to process and share new, alliance-related knowledge from increasing number of strategic alliance partners may also reduce the benefits of additional partners.

With respect to the relationship between strategic alliances partners and the impact of publication, we follow the literature that finds that articles that are based on collaborative research receive more forward citations (Aksnes 2003; Glänzel and Schubert 2001). One argument suggests that alliances are associated with a higher number of forward citations the research tends to be more novel and provide a higher potential for follow on research (Veugelers and Wang 2019; Foster et al. 2015). We relate this argument to the literature on the relationship between collaboration and scientific impact (Hicks 1995; Gazni and Didegah 2011). Following this stream of literature, strategic alliances provide opportunities to disseminate scientific publications through multiple social networks to different interested parties which positively influences the number of forward citations. Thus, we interpret that strategic alliances provide additional opportunities for firm-based authors to disseminate their published research to their peers in different organizations. It is likely that peers working in similar research areas use these publications in their own research and acknowledge this through a forward citation. However, the literature would also suggest that the benefits of additional alliances partners for forward citations may be decreasing since the fit between the research conducted by firm scientists and the interest of partners and their partners may decrease with an increasing number of alliances.

What is the contribution of alliance partners from academia?

This section delves further into how research originating in firms can benefit from collaborations with academic partners. Given that much existing literature about collaboration between firms and academic partners focuses upon innovation, we use these ideas and relationships about collaboration for innovation but apply them to the specific case of scientific publications. Literature suggests that across a broad set of industries, collaborations with universities and public research organizations are positively linked to firms' ability to invent and to successfully commercialize their inventions in the marketplace (Belderbos et al. 2004; Faems et al. 2005; George et al. 2002; Soh and Subramanian 2014). With respect to firms' knowledge generation activities we expect a similar, positive influence of collaborations between firms and partners from academia.

Universities and public research organizations are key contributors of novel discoveries and new scientific knowledge (Soh and Subramanian 2014). Consequently, strategic alliances with academic partners enable firm-based researchers to internalize valuable academic, more basic rather than applied knowledge, as well as knowledge on new research techniques and instruments into the firms' knowledge base (Perkmann and Walsh 2009; Bekkers and Bodas Freitas 2008; Cohen et al. 2002). This opportunity to internalize academic knowledge seems to be of particular importance within the biotechnology and pharmaceutical industry that is characterized by strong links to scientific knowledge and the rapidly developing, complex and widely dispersed knowledge base (Cockburn and Henderson 1998; McMillan et al. 2000; Chen and Lin 2017). In this industry, alliances with academic partners support the ability of firms and their researchers to build upon and to contribute to contemporary debates which should enhance the likelihood of publications in journals with a high reputation. In addition, alliances with academic partners help firms to address research questions that are of interest for the wider academic community and create impact as expressed by future citations. However, the arguments presented in the general case suggest that the returns of additional alliances with academic partners in terms of reputation and forward citations may be decreasing since firm-based researchers have limited capacities to handle the increasing inflows of academic knowledge, to incorporate them into the firm's knowledge base, and to disseminate them within and beyond the firm.

What is the contribution of alliance partners from industry?

In the context of the biotechnology and the pharmaceutical industry, collaboration between firms exists, especially to access knowledge and to promote innovation. For pharmaceutical firms, collaboration with biotechnology firms provides opportunities to incorporate previously unavailable biotechnological knowledge and competencies into their own knowledge base (Arora and Gambardella 1994; McKelvey 1996; Rothaermel 2000). Biotechnology firms may act as technology brokers that enable the transfer of knowledge originating in academia to pharmaceutical firms and the internalization of transferred knowledge into the firm's knowledge base through pharmaceutical firms' researchers (Stuart et al. 2007). Consequently, pharmaceutical firms have been particularly interested in forming strategic alliances with biotechnology firms to gain access to, and experience with, novel scientific approaches as well as new techniques required in drug development (McKelvey et al. 2004a).

Put differently, this literature suggests that biotechnology firms, through performing research at the knowledge frontier, address research problems that inspire research projects that have a rather high degree of novelty. These novel projects have a considerable potential for publication in journals with a high reputation. At the same time, novel research questions and the use of novel research techniques originating in biotechnology firms are likely to increase the scientific interest in the research and facilitate subsequent projects. Both aspects are likely to contribute to impact in terms of the number of forward citations. However, the returns of additional alliance partners may decrease once these techniques are part of the firm's knowledge base and may ultimately be negative when the cost of coordination and integration of knowledge exceed the additional benefits provided by additional alliances.

On the flip side, for biotechnology firms, alliances with pharmaceutical firms can provide opportunities to get access to competencies and resources they lack (Rothaermel 2001). According to this literature, strategic alliances with pharmaceutical firms provide additional resources that enable firm-based researchers to increase the probability of publishing in high reputation journals. More specifically, firm-based researchers can use additional resources that become available through strategic alliances to increase the scientific soundness of their studies through additional replications and robustness checks. Additional resources can also be invested in equipment that contributes to the scientific rigor of the associated research and experiments. These efforts increase the (perceived) quality of a study which increases the probability of publishing in high reputation journals. At the same time, the opportunity to acquire new materials and to use new methods or techniques contributes to the novelty of a study which, again may contribute to the probability of publishing in journals with a high reputation. Alliances with pharmaceutical firms enable biotechnology firms to internalize applied, clinical knowledge into their own knowledge bases. This knowledge may support their researchers to conduct and to publish research projects with an applied focus that is of interest for a broad scientific audience and may, hence, receive a high number of forward citations. Similar to other partner types, the literature on strategic alliances suggests that the returns of additional strategic alliance partners may decrease with an increasing number of partners.

Data and variable construction

Our empirical analysis is based upon a unique dataset for pharmaceutical cancer research, which comprises data on scientific publications that is combined with data on strategic research and development alliances. The dataset has previously been used for other research questions but not in the context of firm publications (McKelvey and Rake 2016; Rake 2019). Cancer is a growing area of research (Xie 2015) and a vital area for both public and private investment into health care, and an expanding market for pharmaceuticals. Moreover, cancer is one of the leading causes of death worldwide. Each year approximately 8.2 million individuals die because of cancer, and cancer is diagnosed in 14 million new cases. According to the International Agency for Research on Cancer (2014), the number of diagnoses and the number of deaths are expected to rise considerably during the next two decades.

Dependent variables: reputation and impact of scientific publications

Scientific publications provide a reasonably good, albeit only partial, indicator reflecting successful knowledge generation processes (Tijssen 2009). Scientific publications also provide detailed bibliographic information including author affiliations and the type of research activities. We use a list of 30 medical indications in the field of cancer from the BioPharmInsight database.[3] Each indication refers to a condition or disease. This list of medical indications is used to conduct a keyword search in the Web of Science databases (WoS). We further restrict the publication data to areas related to pharmaceutical research, i.e., they have been assigned to the WoS categories "Biochemistry & Molecular Biology," "Biotechnology & Applied Microbiology," "Chemistry, Applied," "Chemistry, Medicinal," "Medicine, Research & Experimental," "Pharmacology & Pharmacy" or "Toxicology."

[3] http://www.biopharminsight.com/index.html. A list of the respective medical indications can be found in Table 6 in the "Appendix".

All publications that are not classified as journal articles have been excluded. We obtain 15,762 articles in scientific journals in the area of pharmaceutical cancer research published between 2001 and 2008.[4] Among these articles, 1005 list at least one biotechnology or pharmaceutical firm as an affiliation.

Publication data from the WoS does not contain standardized author affiliations. Therefore, we manually standardize author affiliations using publicly available information such as the organizations' websites, firm reports, SEC filings as well as business information provided by Bloomberg (McKelvey and Rake 2016). This enables us to identify whether a publication originates in a biotechnology or pharmaceutical firm or other organizations. Organizations' geographical origins have been identified based on the reported address.

We use two different indicators as dependent variables in our analysis. Firstly, we refer to previous research using the journal impact factor as an indicator for scientific reputation (Garfield 2006). Our indicator for reputation is based on the journal impact factor according to the WoS Journal Citation Reports in 2009.

We consider a scientific article in our sample as one that has been published in a journal with a high reputation if the journal belongs to the upper 5% of the impact factor distribution (*Top Journal*). Thereby we follow existing approaches using the upper 5% of a distribution to account for reputation (Lozano et al. 2012; Vanclay 2011).[5]

Secondly, we build an indicator for impact based on the number of forward citations, i.e., the number of citations a journal article has received, since citations reflect recognition by the scientific community (Stephan 1996; Merton 1973). We use a time window of 3 years after publication to obtain the number of forward citations (*Citations*) from the Scopus database.[6] This time window corresponds to the average citation peak of journals publishing original research articles (Amin and Mabe 2002).

Independent variables: Strategic alliances and collaboration

To obtain our independent variables, we account for author affiliations in research and development partnerships based on strategic alliances reported in the ReCap database (Schilling 2009). The ReCap database contains information on alliances in the biotechnology and pharmaceutical industry collected from various sources including press releases, SEC filings, and firm presentations. Strategic alliance data provides us with a reliable indicator for collaboration activities that is not dependent on the publication data used to calculate the dependent variables. Following McKelvey and Rake (2016), we manually standardize author affiliations using publicly available information such as the organizations' websites, firm reports, SEC filings as well as business information provided by Bloomberg. All organizations are assigned to their highest order entity as of 2008. For example, all departments of a university would be assigned to that university. University hospitals are assigned to the university they are affiliated with.[7] Subsidiaries are assigned to the

[4] We focus on articles published between 2001 and 2008 due to the availability of the alliance data form the ReCap database used to construct independent variables.

[5] It has to be noted that impact factor distributions differ across scientific disciplines. Since our study refers to one disease area, we did not introduce impact factor adjustments.

[6] Using the same time window for all publications in our sample avoids the problem that articles published earlier have more time to receive citations.

[7] Following this rule, alliances reporting, e.g. the Dana–Farber Cancer Institute as an affiliation are assigned to Harvard University as well as articles reporting the affiliation as Harvard Medical School.

parent firm if the latter holds more than 50% of the shares. Following this rule, government agencies and laboratories as well as research institutes are assigned to the corresponding umbrella organizations.[8]

For each publication in our sample, we use the ReCap data to calculate the number of unique strategic alliance partners that the authors of each publication are connected to. In doing so, we focus on 954 strategic research and development alliances in the field of cancer research that have been concluded between 1998 and 2007. More specifically, we account resources that are available to the authors of a publication through the strategic R&D alliances that their affiliated organization have entered in during the 3 years before an article is published. Alliances concluded in the years 1998, 1999, and 2000 are used to calculate the number of partners for articles published in 2001. By considering time windows of 3 years, we follow the literature on strategic alliances in the biotechnology and pharmaceutical industry (Stuart et al. 2007) and choose a time window corresponding to the average duration of each drug development phase (DiMasi et al. 2016).

We count the unique number of different types of alliance partners on the publication level. Counting only unique alliance partners implies that a partner is only counted once if this partner has entered multiple alliances with an author affiliation or with different author affiliations listed on an article in the 3 years prior to publication of an article. Similarly, an alliance partner is only counted once if several authors list the same affiliation. Alliances partners that are at the same time listed as author affiliations are not included in the counts of different types of alliances partners. This allows us to disentangle the influence of co-authorships in a specific publication from the influence of different types of alliance partners in an alliance portfolio.

We distinguish the different organizational types of author affiliations' partners in strategic R&D alliances based on the ReCap data. More specifically, *Num. Partners* accounts for the overall number of unique partners the authors of a publication are connected to via their affiliations. In addition, we count the number of different academic institutions (*Num. Academic Partners),* i.e., universities and public research institutes, pharmaceutical firms (*Num. Pharma Partners*), and biotechnology firms (*Num. Biotech Partners*) that are strategic alliance partners the authors of a publication are connected to.[9] Tables 8 and 9 in the "Appendix" report descriptive statistics as well as the correlations. These tables indicate that there are differences with respect to the average number of partners among the samples. Publications in the no-firm sample have on average 1.147 alliance partners in contrast to 3.5065 alliance partners in the firm sample. Similar difference can be observed with respect to specific partner types.

Control variables

For the control variables, literature suggests that the number of authors (*Num. Authors*) and number of different countries of author affiliations (*Num. Countries*) may influence the journal and citations. We control for the year the article is published and whether an article has been published in a journal classified as basic biomedical research by the CHI

[8] Consequently, the different research institutes of the German Max Planck Society are summarized to one institution.

[9] It should be noted that *Num. Partners* is not necessarily the sum of *Num. Academic Partners*, *Num. Pharma Partners*, and *Num. Biotech Partners* as there is a diverse set of other partner types, such as foundations and non-academic healthcare providers, which are not a focus of this study.

classification of journals (*Basic Research)* (Hamilton 2003). With respect to author affiliations, collaboration with global centers of excellence may provide favorable opportunities to publish in high reputation journals and to generate a higher impact in terms of citations. Therefore, we control for co-authorship by at least one of the leading 100 universities according to the 2009 Academic Ranking of World Universities, the so-called Shanghai ranking (*Top University*).

We control for different scientific fields that an article can be assigned to in the WoS. More specifically, we control for the scientific fields "Biotechnology & Applied Microbiology," "Medicine, Research & Experimental," and "Pharmacology & Pharmacy." In the models using the forward citations as dependent variable we control for whether the publication has been published in a journal with a high reputation (*Top Journal*).

Empirical strategy

Our empirical analysis distinguishes different types of partners. Measures of the number of formal R&D collaborations with different types of alliance partners are included in the econometric analysis in order to explain the consequences of collaboration for the reputation and impact of scientific publication.

Consequently, and as outlined in "What is the contribution of alliance partners from industry?" section, the first dependent variable, *Top Journal*, is a binary indicator for whether a scientific article is published in a journal with a high reputation. Accordingly, we use a probit model to estimate the probability of publication in a highly reputable journal given the outcome (*Y*) and a vector of independent variables (*X*):

$$\Pr(Y = 1|X) = \phi(X\beta))$$

We estimate the probit model with Huber-White robust standard errors.

Our second dependent variable is the count of forward citations as a measure for scientific impact of an article. Since the regression-based test proposed by Cameron and Trivedi (1990) indicates the presence of overdispersion in our sample, we use the negative binomial model to estimate the influence of different partner types on forward citations:

$$\Pr(Y = y|\mu, \alpha) = \frac{\Gamma(\alpha^{-1} + y)}{\Gamma(\alpha^{-1})\Gamma(y+1)} \left(\frac{\alpha^{-1}}{\alpha^{-1} + \mu}\right)^{\alpha^{-1}} \left(\frac{\mu}{\mu + \alpha^{-1}}\right)^{y}$$

where y is the count of forward citations, μ is the conditional mean, Γ is the gamma function, and β is the parameter determining the degree of dispersion, allowing that the conditional variance exceeds the conditional mean. We estimate all negative binomial models with Huber-White robust standard errors.

Analyzing partners in relation to the reputation and impact of firms' scientific publications

Before moving to the econometric analysis, we would like to establish empirically the existence of the phenomenon of firms publishing in journals with a high reputation and publishing articles that receive many forward citations. Using publications from universities, research institutes and other no-firm organizations as point of reference, the phenomenon

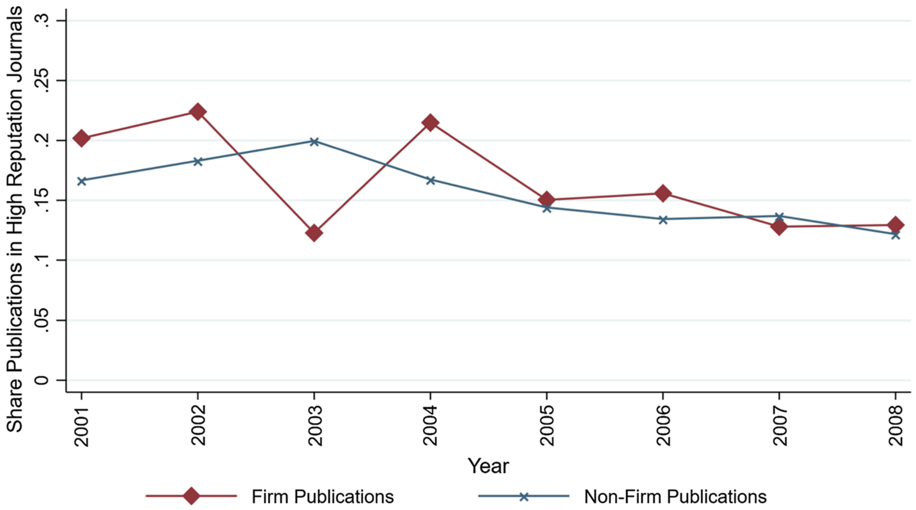

Fig. 1 Share of publications in journals with a high reputation

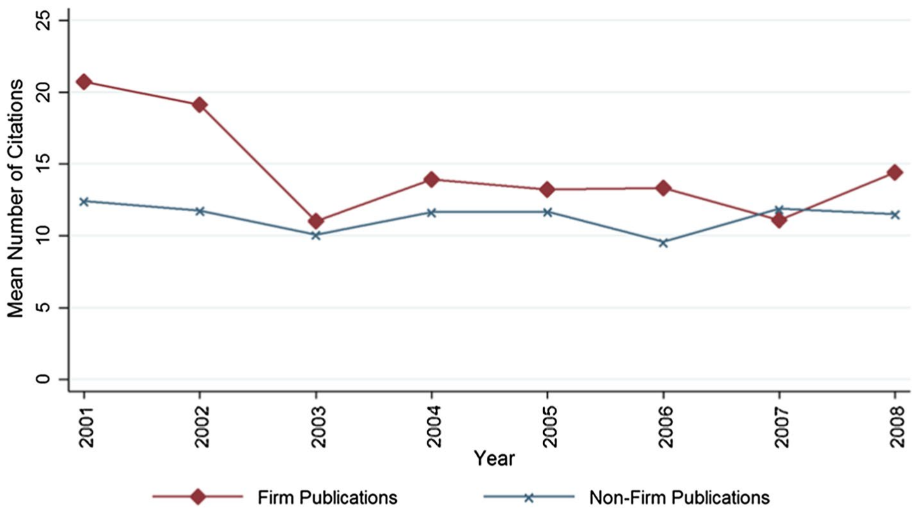

Fig. 2 Mean number of citations

seems marginal. In terms of total publications, only 1005 out of 15,762 articles in our sample list at least one firm as author affiliation. We refer to this sub-sample as firm publications. The sample of no-firm publications contains 14,757 publications that originate in academic institutions, non-academic hospitals and other organizations and have no authors with firm affiliations.

Although a small percentage of publications have firm-based authors, our descriptive analyses presented in Figs. 1 and 2 clearly show that firms do publish in scientific journals with a high reputation and that they publish articles that generate scientific impact. More specifically, Fig. 1 suggests that the share of articles per group published in journals with a high reputation is rather similar for the firm and the no-firm sample. We interpret this finding as a hint in favor of the importance of publications in journals with a high reputation for firms, thereby helping to empirically motivate this study.

The second descriptive analysis presented in Fig. 2 focuses upon the impact of scientific publications, as indicated by forward citations of the published article in the first 3 years after publication. This analysis suggests that firm publications receive on average more citations than no-firm publications although the difference decreased over time. Hence, forward citations are a relevant outcome for firm publications.

In summary, the descriptive results suggest that firms do publish in journals with a high reputation and their publications generate scientific impact through forward citations. The results motivate us to assess whether firms can benefit from their alliance partners with respect to generating scientific impact in terms of forward citations. Consequently, we explore the relationship between alliance partners as well as reputation and impact in more detail in the next section.

Reputation: publications in highly reputable journals

We start our econometric analysis with probit regressions of the no-firm sample as presented in Table 1. We use the no-firm sample as a point of reference for interpreting the results of our analysis of the firm sample which is presented in Table 2. In doing so, our analyses provide further insights into the specific contributions of different types of alliances partners for firms' publication activities as compared to other organizations. For both samples, the results indicate that the number of different partners in R&D alliances (*Num. Partners*) follows an inverted u-shaped relation to the probability of publication in journals with a high reputation. We conduct the test suggested by Lind and Mehlum (2010) to test for the presence of an inverted u-shape. The test results support the presence of inverted u-shaped relations between the number of partners and the probability of publication in highly reputable journals.[10]

Our results also reveal considerable differences between the samples. In the no-firm sample, Table 1 reveals that the number of academic partners (*Num. Academic Partners)* as well as the number of alliance partners classified as biotechnology firms (*Num. Biotech Partners*) show decreasing returns in relation to the probability of publication in journals with a high reputation. We conduct the test by Lind and Mehlum (2010) which supports the presence of an inverted u-shaped. However, the number of alliance partners classified as biotechnology firms (*Num. Biotech Partners*) is not statistically significant if it is introduced together with other partner variables. We find a positive linear association between the number of partners classified as pharmaceutical firms (*Num. Pharma Partners*) and the probability of publication in journals with a high reputation. Again, the statistical significance of this relationship disappears if we introduce *Num. Pharma Partners* together with other variables accounting for the number of alliance partners.

For publications involving firms, our results do not suggest a robust relation between the number of academic partners and the probability of publication in a high reputation journal. We find, however, a curvilinear relationship between the number of partners classified as pharmaceutical firms and the probability of publication in journals with a high

[10] An overview of the results of the test suggested by Lind and Mehlum (2010) for all regression models with squared terms can be found in the "Appendix".

Table 1 Partner types and publications in journals with a high reputation (no-firm sample)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Dependent variable: top journal									
Num. Partners	0.0173***	0.0500***							
	(0.0041)	(0.0108)							
Num. Partners^2		−0.0015***							
		(0.0004)							
Num. Academic Partners			0.0231***	0.0654***					0.0609***
			(0.0050)	(0.0132)					(0.0202)
Num. Academic Partners^2				−0.0026***					−0.0026**
				(0.0007)					(0.0011)
Num. Pharma Partners					0.1139***	0.2127***			0.1165
					(0.0244)	(0.0702)			(0.1104)
Num. Pharma Partners^2						−0.0269			-0.0144
						(0.0175)			(0.0200)
Num. Biotech Partners							0.1508***	0.4401***	-0.1568
							(0.0495)	(0.1054)	(0.1844)
Num. Biotech Partners^2								−0.1594***	0.0381
								(0.0477)	(0.0872)
Num. Authors	0.0721***	0.0722***	0.0721***	0.0725***	0.0722***	0.0721***	0.0725***	0.0726***	0.0725***
	(0.0048)	(0.0048)	(0.0048)	(0.0048)	(0.0048)	(0.0047)	(0.0048)	(0.0047)	(0.0048)
Num. Countries	0.0226	0.0247	0.0216	0.0240	0.0223	0.0224	0.0275	0.0268	0.0234
	(0.0283)	(0.0283)	(0.0282)	(0.0283)	(0.0283)	(0.0283)	(0.0282)	(0.0281)	(0.0283)
Basic Research	0.9174***	0.9170***	0.9175***	0.9185***	0.9197***	0.9181***	0.9179***	0.9194***	0.9186***
	(0.0329)	(0.0329)	(0.0329)	(0.0329)	(0.0329)	(0.0329)	(0.0329)	(0.0329)	(0.0329)
Top University	0.3615***	0.3505***	0.3569***	0.3392***	0.3653***	0.3628***	0.3647***	0.3616***	0.3405***
	(0.0299)	(0.0302)	(0.0300)	(0.0305)	(0.0299)	(0.0300)	(0.0299)	(0.0299)	(0.0308)
Scientific Fields	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Publication years	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table 1 (continued)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Constant	−2.0226***	−2.0211***	−2.0194***	−2.0182***	−2.0264***	−2.0235***	−2.0331***	−2.0331***	−2.0175***
	(0.0656)	(0.0655)	(0.0656)	(0.0655)	(0.0656)	(0.0656)	(0.0655)	(0.0654)	(0.0656)
N	14,757	14,757	14,757	14,757	14,757	14,757	14,757	14,757	14,757
AIC	9963.6375	9956.5968	9960.5477	9949.0042	9959.5080	9959.2816	9971.6513	9966.0753	9954.8737
BIC	10085.2291	10085.7879	10082.1393	10078.1952	10081.0995	10088.4726	10093.2429	10095.2664	10114.4626

Robust standard errors in parentheses

*$p<0.10$; **$p<0.05$; ***$p<0.01$

Table 2 Partner types and publications in journals with a high reputation (firm sample)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Dependent variable: top journal									
Num. Partners	0.0231**	0.0619***							
	(0.0105)	(0.0221)							
Num. Partners^2		−0.0015*							
		(0.0008)							
Num. Academic Partners			0.0267	0.1714**					0.1743**
			(0.0204)	(0.0758)					(0.0807)
Num. Academic Partners^2				−0.0099*					−0.0117**
				(0.0053)					(0.0057)
Num. Pharma Partners					0.0228*	0.0812***			0.0764***
					(0.0131)	(0.0253)			(0.0252)
Num. Pharma Partners^2						-0.0031**			-0.0033**
						(0.0013)			(0.0013)
Num. Biotech Partners							0.1448***	0.0933	0.0422
							(0.0527)	(0.1153)	(0.1164)
Num. Biotech Partners^2								0.0069	0.0095
								(0.0137)	(0.0137)
Num. Authors	0.0412***	0.0423***	0.0430***	0.0422***	0.0431***	0.0451***	0.0437***	0.0440***	0.0439***
	(0.0137)	(0.0138)	(0.0135)	(0.0135)	(0.0136)	(0.0137)	(0.0138)	(0.0138)	(0.0139)
Num. Countries	−0.0073	0.0117	0.0163	0.0117	−0.0082	0.0247	0.0077	0.0087	0.0269
	(0.0676)	(0.0658)	(0.0637)	(0.0647)	(0.0675)	(0.0669)	(0.0653)	(0.0652)	(0.0673)
Basic Research	0.5022***	0.4954***	0.4958***	0.4830***	0.4916***	0.4919***	0.5014***	0.5040***	0.4936***
	(0.1223)	(0.1225)	(0.1209)	(0.1206)	(0.1215)	(0.1218)	(0.1219)	(0.1218)	(0.1226)
Top University	0.2149*	0.1855*	0.2124*	0.1474	0.2273**	0.2109*	0.2168**	0.2239**	0.1342
	(0.1105)	(0.1113)	(0.1092)	(0.1150)	(0.1094)	(0.1100)	(0.1102)	(0.1117)	(0.1186)
Scientific fields	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Publication years	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table 2 (continued)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Constant	−1.2714***	−1.2922***	−1.3216***	−1.2554***	−1.2903***	−1.3556***	−1.3163***	−1.3264***	−1.2912***
	(0.2335)	(0.2319)	(0.2279)	(0.2273)	(0.2334)	(0.2332)	(0.2303)	(0.2319)	(0.2326)
N	1005	1005	1005	1005	1005	1005	1005	1005	1005
AIC	767.8499	766.4331	772.8266	770.8338	770.3070	766.3541	764.7616	766.4360	762.5998
BIC	846.4538	849.9497	851.4305	854.3504	848.9109	849.8707	843.3655	849.9526	865.7674

Robust standard errors in parentheses

*$p < 0.10$; **$p < 0.05$; ***$p < 0.01$

reputation. Conducting the test by Lind and Mehlum (2010) supports the presence of an inverted u-shape relationship. The number of alliance partners classified as biotechnology firms is positively related to the probability of publication in highly reputable journals in model 7 in Table 2 but loses its significance when other partner variables are introduced.

In terms of control variables, the number of authors (*Num. Authors*) is positively related to the probability of publication in journals with a high reputation. International collaboration (*Num. Countries*) does not increase the probability of publication in journals with a high reputation while basic research articles (*Basic Research*) have a higher probability of being published in highly reputable journals. Our results provide some evidence that collaboration with at least one of the leading academic institutions in the world (*Top University*) increases the probability of publication in a journal that has a high reputation.

In order to provide some insights into the magnitude of these relationships, we report marginal effects at the mean in Table 10 for the no-firm and in Table 11 for the firm sample.[11]

Impact: forward citations

This section focuses upon scientific impact of publications by investigating how different types of alliance partners influence the number of forward citations which scientific articles receive. The results of the negative binomial regressions differentiating between no-firm publications in Table 3 and firm publications in Table 4 suggest important differences concerning the role of specific alliance partners in attracting forward citations.

In the sample of no-firm publications, our results presented in Table 3 indicate an inverted u-shaped relation between the total number of different alliance partners (*Num. Partners*) and the number of forward citations as well as between the number of academic partners (*Num. Academic Partners*) and forward citations. The test by Lind and Mehlum (2010) indicates the presence of an inverted u-shape relation, too. Our results do not indicate robust relationships between *Num. Pharma Partners or Num. Biotech Partners* and the number of forward citations in the no-firm sample.

In contrast to these findings, we do not find robust significant associations between different partner types and the number of forward citations in the sample of publications originating in firms. Hence, for publications with firm-based authors, our results do not support arguments suggesting the importance of alliance partners for attracting forward citations.

With regard to the control variables we find that the number of authors is positively related to the number of citations in the firm sample but not in the no-firm sample in Table 3. While the number of countries (*Num. Countries*) and articles published in basic research journals (*Basic Research*) are positively linked to the number of forward citations in the no-firm sample, the corresponding coefficients are not significant in the firm sample. In both samples, publications in scientific journals with a high reputation (*Top Journal*) receive more citations than publications in other journals. Collaboration with researchers from at least one of the leading academic institutions in the world (*Top University*) increases the number of forward citations in the no-firm sample but not in the firm sample.

Information concerning the magnitude of these relationships can be found in Table 12 and in Table 13 that report marginal effects at the mean for the no-firm and the firm sample.

[11] As the computation of marginal effects is based on derivatives, it is not possible to report marginal effects for squared terms.

Table 3 Partner types and forward citations (no-firm sample)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Dependent variable: citations									
Num. Partners	0.0118***	0.0335***							
	(0.0043)	(0.0090)							
Num. Partners^2		−0.0010***							
		(0.0003)							
Num. Academic Partners			0.0145***	0.0422***					0.0442**
			(0.0054)	(0.0098)					(0.0209)
Num. Academic Partners^2				−0.0017***					−0.0020**
				(0.0004)					(0.0008)
Num. Pharma Partners					0.0814***	−0.0025			−0.0558
					(0.0232)	(0.0756)			(0.0990)
Num. Pharma Partners^2						0.0224			0.0294
						(0.0185)			(0.0188)
Num. Biotech Partners							0.0830	0.2941***	−0.1268
							(0.0556)	(0.1003)	(0.1636)
Num. Biotech Partners^2								−0.1157***	0.0404
								(0.0374)	(0.0681)
Num. Authors	0.0067	0.0066	0.0067	0.0067	0.0067	0.0067	0.0071	0.0070	0.0066
	(0.0068)	(0.0068)	(0.0068)	(0.0068)	(0.0068)	(0.0068)	(0.0068)	(0.0067)	(0.0068)
Num. Countries	0.0915***	0.0944***	0.0914***	0.0948***	0.0916***	0.0920***	0.0949***	0.0957***	0.0936***
	(0.0310)	(0.0310)	(0.0310)	(0.0310)	(0.0309)	(0.0310)	(0.0308)	(0.0307)	(0.0311)
Basic Research	0.2018***	0.2008***	0.2016***	0.2014***	0.2045***	0.2056***	0.2007***	0.2022***	0.2044***
	(0.0462)	(0.0463)	(0.0463)	(0.0464)	(0.0463)	(0.0462)	(0.0462)	(0.0463)	(0.0463)
Top Journal	0.6457***	0.6440***	0.6451***	0.6422***	0.6444***	0.6455***	0.6474***	0.6471***	0.6419***
	(0.0367)	(0.0367)	(0.0367)	(0.0367)	(0.0367)	(0.0368)	(0.0367)	(0.0368)	(0.0366)
Top University	0.2247***	0.2169***	0.2221***	0.2104***	0.2284***	0.2311***	0.2271***	0.2254***	0.2146***
	(0.0365)	(0.0367)	(0.0366)	(0.0368)	(0.0365)	(0.0365)	(0.0365)	(0.0365)	(0.0378)

Table 3 (continued)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Scientific Fields	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Publication years	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	1.8936***	1.8947***	1.8948***	1.8955***	1.8909***	1.8883***	1.8856***	1.8846***	1.8949***
	(0.0903)	(0.0900)	(0.0903)	(0.0901)	(0.0904)	(0.0904)	(0.0901)	(0.0900)	(0.0904)
lnalpha	0.7426***	0.7423***	0.7426***	0.7421***	0.7423***	0.7422***	0.7430***	0.7427***	0.7417***
	(0.0263)	(0.0263)	(0.0263)	(0.0264)	(0.0263)	(0.0263)	(0.0263)	(0.0263)	(0.0264)
N	14,757	14,757	14,757	14,757	14,757	14,757	14,757	14,757	14,757
AIC	96675.3580	96673.3656	96675.4645	96671.5084	96671.6088	96672.0724	96680.9792	96678.6136	96673.8583
BIC	96812.1485	96817.7556	96812.2550	96815.8983	96808.3994	96816.4623	96817.7697	96823.0036	96848.6461

Robust standard errors in parentheses

*$p<0.10$; **$p<0.05$; ***$p<0.01$

Table 4 Partner types and forward citations (firm sample)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Dependent variable: citations									
Num. Partners	0.0072	0.0369**							
	(0.0076)	(0.0163)							
Num. Partners^2		−0.0013**							
		(0.0006)							
Num. Academic Partners			0.0150	0.0507					0.0347
			(0.0174)	(0.0640)					(0.0644)
Num. Academic Partners^2				−0.0025					−0.0021
				(0.0039)					(0.0039)
Num. Pharma Partners					0.0059	0.0289			0.0234
					(0.0096)	(0.0190)			(0.0192)
Num. Pharma Partners^2						−0.0014*			−0.0014*
						(0.0008)			(0.0008)
Num. Biotech Partners							0.0645	0.1615**	0.1575*
							(0.0442)	(0.0793)	(0.0841)
Num. Biotech Partners^2								−0.0162**	−0.0165**
								(0.0080)	(0.0080)
Num. Authors	0.0425***	0.0435***	0.0422***	0.0422***	0.0434***	0.0436***	0.0435***	0.0434***	0.0434***
	(0.0133)	(0.0133)	(0.0134)	(0.0134)	(0.0131)	(0.0130)	(0.0131)	(0.0131)	(0.0134)
Num. Countries	0.0221	0.0261	0.0273	0.0285	0.0214	0.0288	0.0190	0.0156	0.0270
	(0.0646)	(0.0631)	(0.0643)	(0.0645)	(0.0646)	(0.0644)	(0.0640)	(0.0643)	(0.0647)
Basic Research	0.0716	0.0568	0.0803	0.0795	0.0673	0.0579	0.0733	0.0630	0.0551
	(0.1215)	(0.1207)	(0.1217)	(0.1218)	(0.1216)	(0.1212)	(0.1214)	(0.1209)	(0.1207)
Top Journal	0.4793***	0.4902***	0.4847***	0.4747***	0.4830***	0.4901***	0.4800***	0.4911***	0.4892***
	(0.1203)	(0.1188)	(0.1191)	(0.1202)	(0.1201)	(0.1187)	(0.1199)	(0.1192)	(0.1189)
Top university	0.1359	0.1239	0.1368	0.1210	0.1383	0.1369	0.1332	0.1292	0.1141
	(0.0929)	(0.0923)	(0.0926)	(0.0933)	(0.0930)	(0.0923)	(0.0923)	(0.0917)	(0.0915)

Table 4 (continued)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Scientific fields	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Publication years	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	2.3404***	2.3398***	2.3291***	2.3384***	2.3310***	2.3218***	2.3446***	2.3608***	2.3569***
	(0.2296)	(0.2282)	(0.2270)	(0.2284)	(0.2283)	(0.2270)	(0.2287)	(0.2298)	(0.2305)
lnalpha	0.7005***	0.6977***	0.7007***	0.7004***	0.7009***	0.6996***	0.6993***	0.6977***	0.6960***
	(0.0589)	(0.0588)	(0.0590)	(0.0589)	(0.0589)	(0.0588)	(0.0589)	(0.0590)	(0.0589)
N	1005	1005	1005	1005	1005	1005	1005	1005	1005
AIC	7053.9701	7053.5098	7054.1462	7055.8620	7054.3265	7055.1969	7052.9654	7053.4858	7060.0339
BIC	7142.3995	7146.8519	7142.5756	7149.2041	7142.7559	7148.5391	7141.3947	7146.8279	7173.0270

Robust standard errors in parentheses

*$p < 0.10$; **$p < 0.05$; ***$p < 0.01$

Robustness checks

We conduct several robustness checks. Following previous research, e.g., Vanclay (2011) and Graham (2008), we examine scientific articles published in journals in the upper 20% of the impact factor distribution. The results for the no-firm sample suggest an inverted u-shaped relationship between the number of partners in R&D alliances and the probability of publication in a high reputation journal. In the firm sample we find a positive association between the total number of partners as well as the number of biotechnology firm partners and the probability of publication in journals with a high reputation. In contrast to the original analysis, this robustness check does not unambiguously support the importance of pharmaceutical firm partners. Instead we find a positive relation between the number of academic partners and publication in journals with a high reputation.

Moreover, we use the impact factor in the year of publication of the focal article to generate the *Top Journal* variable. The results are qualitatively similar to the results of the original analysis. However, we find that the number of academic partners has a robust curvilinear relationship to the probability of publication in journals with a high reputation in both samples in this robustness check. We also considered a different specification of our second dependent variable, the number of forward citations in the first 5 years. The results in the firm as well as in the no-firm sample are similar to the results above.

Additionally, we follow the advocates of analyzing the long-lasting relevance of strategic alliances (Vasudeva and Anand 2011; Stuart 2000) and use time windows of 5 years to account for alliance partners. The corresponding results are largely in line with the results presented above. Using OLS regressions as dependent variables yields results similar to the original analyses. In the OLS regressions we use the natural logarithm of the *Citations* variable and add one to account for the dispersion of the variable and the considerable number of zeros. The natural logarithm of *Citations* plus one is also used in seemingly unrelated regressions that are estimated as additional robustness check. The corresponding results are very similar to the results of the original analyses.

Big pharmaceutical firms may be able to invest more resources in their research projects which may influence the probability of being published in a high reputation journal as well as the number of forward citations. Consequently, we conduct additional regression analyses in which we control whether one of the 50 biggest pharmaceutical or biotechnology firm according to the (Pharmaceutical Executive 2009) have been involved in the focal publication. Our results correspond to those presented above and do not suggest a robust association between the involvement of a big pharmaceutical or biotechnology firm on publication reputation or impact.

Within the empirical context of our study, the lead authors may make the greatest contribution to the publication. Hence, there might be concerns that lead authors, particularly those in firms, differ from their co-authors in terms of the influence within a research project but also with respect to their ability or experience. In order to account for these concerns, we conduct our regression analysis using a sample of first authors with firm affiliations. The corresponding results are qualitatively similar to the results presented above.

Furthermore, we conduct a robustness check that adds a control variable for the most productive authors in terms of the number of publications in our sample. To calculate our control variable, we standardize author names using the Soundex algorithm and add up the number of publications for each author. Based on the number of publications per author, we assign a dummy variable to each article in our two samples that equals one if an author of this article is among the 5% of authors who have the highest number of publications in

Table 5 Summary of regression results

Dependent variable:	High reputation: top journal		Impact: citations	
Sample	No-firm	Firm	No-firm	Firm
Num. Partners	Inverted u-shape	Inverted u-shape	Inverted u-shape	No robust association
Num. Academic Partners	Inverted u-shape	No robust association	Inverted u-shape	No robust association
Num. Pharma Partners	Positive association*	Inverted u-shape	No robust association	No robust association
Num. Biotech Partners	Inverted u-shape*	No robust association	No robust association	No robust association

*not significant when introduced with other alliance partner variables

our dataset. Hence, the dummy variable captures exceptional individual ability to publish as well as outstanding individual experience with the publication and co-authorship process. Both factors may influence whether a publication appears in a journal with a high reputation or generates a lot of impact. The results of this robustness check are very similar to the results of the original analyses in the no-firm as well as in the firm sample.

We investigate the influence of different partner types on the probability of publication in journals with a high reputation as well as on the number of forward citations by using the share of different partner types instead of their count. The results in the no-firm sample are largely consistent with the results above. In particular, our results suggest inverted *u*-shaped relationships for the share of academic partners as well as for the share of pharmaceutical firm partners and the probability of publication in a journal with a high reputation. In the firm sample, we do not find support for a significant relationship between the share of a particular partner type and the probability of publication in a high reputation journal. Using the number of forward citations as dependent variable, we find a positive association for the share of academic partners as well as an inverted u-shaped relationship for the share of pharmaceutical firm partners in the no-firm sample. With an exception for the positive relationship for biotechnology partners in the firm sample, we do not find significant associations for the share of different partner types in this sample.

Discussion and conclusions

In terms of why firms in the biotechnology industry and pharmaceutical industry publish, the existing literature suggests they publish to achieve corporate goals rather than scientific goals. Based on this literature, we set out to explore whether the reputation and impact of scientific publications originating in firms benefit from R&D alliances with different types of partners. Our main results are summarized below in Table 5.

For publications in journals with a high reputation, the overall number of alliance partners increases the probability of being published, but at a decreasing rate in the firm as well as in the no-firm sample. In literature on organizational knowledge, firms and other organizations are able to absorb knowledge obtained through strategic alliances, in a way that links individual knowledge and corporate goals (Nonaka 1994; Kogut and Zander 1992). In line with existing literature, the organizations and the firm-based authors within them have limited capabilities to manage partners, and a wider range of potentially contradictory views and diverse knowledge which sets limits on how to integrate it into the firm's knowledge base (Deeds and Hill 1996; Phelps et al. 2012; Rothaermel and Alexandre 2009). Thus, in line with the existing literature (Nonaka 1994; Inkpen 1998b), we interpret our empirical results to mean that this external knowledge through strategic alliances is absorbed into the corporate knowledge base and disseminated within the firm. Following this literature, the absorption and internal dissemination of external knowledge is supportive for individual researchers in terms of increasing the reputation of their scientific publications.

With respect to the number of forward citations, we find differences depending on the sample. In the firm sample, we do not find an association between the number of alliance partners and the number of forward citations. One explanation may be that academic partners are skeptical about the quality as well as scientific integrity of firm publications and have a lower propensity to cite firm publications. An alternative explanation for firm-based authors is that publications are used for signaling the attributes of products, instead of contributing to later science. Contrary to these findings, our results for the no-firm sample suggest that organizations can benefit from the expansion of their organization's knowledge bases through strategic alliances, which in turn supports publications that receive attention from the academic community and other stakeholders. Furthermore, being in alliances may provide opportunities to disseminate specific publications to a broad range of interested parties, which later cite the article in their own research. There is, however, a decreasing return in the no-firm sample when adding more partners as not all partners may perceive the publication as related to their core areas of interest and cite it in follow-on research.

In terms of collaborations with academic partners, firms do not benefit in publication activities from partnering with academia irrespective of whether reputation or impact are concerned. A possible explanation is that academic partners provide knowledge predominantly related to basic research. On the one hand, firms may benefit from this type of knowledge particularly in their science-based drug discovery activities (Cockburn and Henderson 1998; Perkmann and Walsh 2009). On the other hand, firms may find collaboration with academics as less beneficial for those publications which are more directed to development activities. In that case, a publication would signal the safety and efficacy of a compound and the results are used to convince regulatory authorities and health care providers.

In terms of collaboration with corporate partners, we find intriguing results relative to existing literature. Our interpretation of one finding is the different roles that biotechnology and pharmaceutical firms can play as alliance partners. Both types of firms seem to be of particular importance for increasing the probability of publication in a high reputation journal. In line with the literature, this finding suggests that biotechnology and pharmaceutical firms provide complementary knowledge and complementary assets that are valuable resources for individual researchers once they are integrated into an organization's knowledge base (Arora and Gambardella 1994; McKelvey 1996). Moreover, they can play different roles, as biotechnology firms are frequently the originators of new drugs or new research methods while pharmaceutical firms can, in addition to their own knowledge base, provide financial resources as well as research materials, research techniques or other non-financial resources that contribute to the novelty of a research project (Rothaermel 2001; Soh and Subramanian 2014). We interpret that factors related to complementary assets and financial resources are likely the key ones to increase the likelihood of publication in a journal with a high reputation.

However, we also show that the benefits of additional alliances with pharmaceutical firms for publishing in journals with a high reputation may decrease for firm authors, likely because the inflow of additional knowledge and resources becomes more difficult to manage the higher the number of partners. Another reason may be that with an increasing number of partners the knowledge overlap may increase and learning opportunities may decrease. Particularly biotechnology firms may be important intermediaries that diffuse knowledge originating in academia to their alliance partners. Once this knowledge is integrated into the organizations' knowledge bases and used by the individual researchers, previous collaborations with firms increase the probability of publication in journals with a high reputation. Additionally, our results suggest that pharmaceutical firms are also important disseminators of knowledge generated outside their boundaries, e.g. by academia and other no-firm organizations, through their often large networks of collaborative relations which increases the number of forward citations.

In the firm sample, we do not find support for the idea that a firm's publications in terms of scientific impact benefit from having different types of alliance partners. A possible explanation for this finding is that firm publications may address an audience that does not necessarily engage in own publication activities, such as regulatory authorities as well as physicians and general practitioners prescribing drugs to patients. Similarly, publications originating in firms may be predominantly referenced in patents as previous research has shown that firm researchers pay close attention to discoveries made in firms that are relevant for their own invention activities (Bikard 2018).

Based on our results, we can draw implications for the management of biotechnology and pharmaceutical firms, to help make more explicit choices about partners. If the firm or its researchers want to improve their reputation, i.e., publish in journals with a high reputation, then collaborations through strategic alliances do allow them to access knowledge and other complementary assets. However, the benefits can only be realized up to a threshold, followed by diminishing marginal returns. If the goal is impact, i.e. a high number of later citations, then alliances with other firms or academic institutions in general seem not to be sufficient. Instead, firms should only co-author with the most renowned universities.

Limitations and future research

We acknowledge that our results are limited to our study of a science-based industry, specifically the biotechnology and pharmaceutical industry, which may limit generalizability. We are rather confident that our results hold for collaborations in biotechnology and pharmaceutical research across different disease areas as collaboration and alliance formation are general characteristics of this industry. However, our findings may not be generalizable to contexts that are less science-based nor ones characterized by different collaboration patterns. Our study presents correlations between different types of alliances partners and publication outcomes in terms of reputation and impact. However, our data does not allow for applying more sophisticated methods that allow for the identification of causal effects, but the core ideas also provide potential for future research with other techniques.

Our findings can hopefully open up new trajectories for future research, because we provide some new insights about scientific publications by firms in relation to high reputation and high impact publications. There is a need for research which explicitly tackles reputation and impact in relation to firms. Our analysis shows that the impact of collaborations in general—and with academic and corporate partners specifically—differs substantially in relation to whether we consider the reputation or the impact of scientific publications. We suggest that reputation and impact of scientific publications should be conceptualized and analyzed as two separate outcomes. This can be developed, based upon early literature within bibliometrics within the academic community argued that citations are a poor indicator of intrinsic scientific quality, and citations should instead be interpreted as signaling other strategic, social, and communication struggles and goals (Cole 1989; Cozzens 1989).

We welcome future research which returns to basic issues about the incentives and rewards systems for explaining mechanisms that drive similarities and differences of publishing in high reputation journals as compared to publishing articles which later become highly visible through citations, for firm-based authors specifically. One route may be to use the literature on science as a power game of persuasion and apply those concepts to publications by firms. In this context, future research may also study how alliance partners influence alternative measures of impact in a broader sense, e.g., attention in social media or practitioner journals, that may be of particular relevance for publications originating in firms and their relation to reputation (Bornmann and Haunschild 2017; Zhang and Wang 2018).

To tackle this issue further, there is a need to study how scientific activities within firms actually combine individual goals and corporate goals. Recent research has analyzed the contributions of individual authors (Haeussler and Sauermann 2016), but similar attempts on the organizational-level are largely missing, partly because data is difficult to obtain. We hope that our research may be a first impulse for additional studies exploring whether alliance agreements primarily promote the exchange of ideas and knowledge to individuals or else the provision of additional resources to the overall project. In this context, future research may also explore how ideas and knowledge that become accessible through strategic alliances are disseminated within a firm and integrated into the firm's knowledge base.

Another line of future research is to address in more detail how firms select partners for research projects. We recognize the limitations of our study, that we do not explicitly take this into account. Future research should use appropriate methods to address selection. More specifically, firms may choose alliance partners which have a very high perceived benefit for them and that have a high probability of success, demonstrated e.g., by pilot studies or successful clinical trials. Similarly, individual scientists in firms and universities may choose to engage in projects that are perceived to have high personal benefits for their career, and especially collaborations which may positively influence the probability of being published in a high reputation journal as well as the number of forward citations.

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Appendix

Medical indications

See Table 6.

Table 6 List of medical indications

Angiogenesis	Liver cancer
Bladder cancer	Lung cancer
Bone cancer	Lymphoma
Brain cancer	Melanoma
Breast cancer	Metastasis
Cervical cancer	Mouth or throat cancer
Chemotherapy related	Mucositis
Colon cancer	Multiple myeloma
Endometrial cancer	Non-hodgkin lymphoma
Gastrointestinal cancer	Ovarian cancer
Head and neck cancer	Pancreatic cancer
Hematological cancer	Prostate cancer
Kaposi sarcoma	Radiation related
Kidney cancer	Soft tissue sarcoma
Leukemia	Solid tumors

Variables, descriptive statistics and correlations

See Tables 7, 8 and 9.

Table 7 Variable description

Top journal	Article is published in a journal with a high reputation, i.e., a journal that belongs to the upper 5% of the impact factor distribution
Citations	Number of forward citations in the first 3 years after publication
Num. Partners	Number of unique partners of author affiliations in strategic R&D alliances in the 3 years before an article is published
Num. Academic Partners	Number of unique academic partners of author affiliations in strategic R&D alliances in the 3 years before an article is published
Num. Pharma Partners	Number of unique pharmaceutical firm partners of author affiliations in strategic R&D alliances in the 3 years before an article is published
Num. Biotech Partners	Number of unique biotechnology firm partners of author affiliations in strategic R&D alliances in the 3 years before an article is published
Num. Authors	Number of authors of an article
Num. Countries	Number of different countries listed in author affiliations
Basic research	The journal an article is published in is classified as basic biomedical research by the CHI classification of journals
Top university	At least one of the leading 100 universities worldwide is listed among author affiliations

Table 8 Summary statistics and correlations (no-firm sample)

		Obs.	Mean	Std. Dev.	Min.	Max	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
(1)	Top journal	14,757	0.1529	0.3599	0	1.0000	1.0000									
(2)	Citations	14,757	11.2745	29.2598	0	1187.0000	0.1350***	1.0000								
(3)	Num. Partners	14,757	1.1470	3.0982	0	63.0000	0.0715***	0.0247**	1.0000							
(4)	Num. Academic Partners	14,757	0.5741	2.4738	0	50.0000	0.0789***	0.0301***	0.9817***	1.0000						
(5)	Num. Pharma Partners	14,757	0.0857	0.4977	0	6.0000	0.0679***	0.0254**	0.8776***	0.8477***	1.0000					
(6)	Num. Biotech Partners	14,757	0.0424	0.2499	0	5.0000	0.0537***	0.0142	0.8832***	0.8784***	0.7075***	1.0000				
(7)	Num. Authors	14,757	6.2959	3.4109	1	63.0000	0.1717***	0.0726***	0.1095***	0.1046***	0.0806***	0.0808***	1.0000			
(8)	Num. Countries	14,757	1.1824	0.4797	1	10.0000	0.0955***	0.0574***	0.1452***	0.1397***	0.1173***	0.0960***	0.2332***	1.0000		
(9)	Basic research	14,757	0.4477	0.4973	0	1.0000	0.3428***	0.0653***	0.0442***	0.0453***	0.0292***	0.0331***	0.0494***	0.0636***	1.0000	
(10)	Top university	14,757	0.3020	0.4591	0	1.0000	0.1486***	0.0755***	0.0749***	0.1020***	0.0409***	0.0325***	0.0700***	0.1905***	0.0953***	1.0000

*$p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 9 Summary statistics and correlations (firm sample)

		Obs.	Mean	Std. Dev.	Min.	Max	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
(1)	Top journal	1005	0.1652	0.3715	0	1.0000	1.0000									
(2)	Citations	1005	14.3592	24.7089	0	288.0000	0.1777***	1.0000								
(3)	Num. Partners	1005	3.5065	6.0183	0	47.0000	0.0427	−0.0096	1.0000							
(4)	Num. Academic Partners	1005	0.6308	2.2276	0	19.0000	0.0485	0.0257	0.5465***	1.0000						
(5)	Num. Pharma Partners	1005	2.2796	4.7281	0	40.0000	0.0241	−0.0188	0.8936***	0.1559***	1.0000					
(6)	Num. Biotech Partners	1005	0.3284	1.0018	0	11.0000	0.0655*	0.0190	0.5623***	0.3574***	0.3294***	1.0000				
(9)	Num. Authors	1005	8.1741	3.9140	1	29.0000	0.1617***	0.2067***	0.1371***	0.1482***	0.0855**	0.0634*	1.0000			
(10)	Num. Countries	1005	1.4468	0.8232	1	7.0000	0.0646*	0.0975**	0.1569***	0.0221	0.1787***	0.0357	0.3202***	1.0000		
(11)	Basic research	1005	0.3960	0.4893	0	1.0000	0.3028***	0.1180***	−0.1006**	−0.0403	−0.0961**	−0.0583	0.1007**	0.0153	1.0000	
(12)	Top university	1005	0.3821	0.4861	0	1.0000	0.1190***	0.1037***	0.0935**	0.1479***	0.0358	0.0796*	0.1482***	0.2027***	0.0625*	1.0000

*$p<0.05$, ** $p<0.01$, *** $p<0.001$

Regression tables reporting marginal effects

See Tables 10, 11, 12, 13, 14, 15, 16 and 17.

Table 10 Marginal effects partner types and publications in journals with a high reputation (no-firm sample)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Dependent variable: top journal									
Num. Partners	0.0032***	0.0085***							
	(0.0008)	(0.0018)							
Num. Academic Partners			0.0043***	0.0114***					0.0106***
			(0.0009)	(0.0022)					(0.0035)
Num. Pharma Partners					0.0213***	0.0385***			0.0211
					(0.0045)	(0.0123)			(0.0198)
Num. Biotech Partners							0.0282***	0.0788***	−0.0284
							(0.0093)	(0.0187)	(0.0329)
Num. Authors	0.0135***	0.0135***	0.0135***	0.0135***	0.0135***	0.0135***	0.0136***	0.0136***	0.0135***
	(0.0009)	(0.0009)	(0.0009)	(0.0009)	(0.0009)	(0.0009)	(0.0009)	(0.0009)	(0.0009)
Num. Countries	0.0042	0.0046	0.0040	0.0045	0.0042	0.0042	0.0051	0.0050	0.0044
	(0.0053)	(0.0053)	(0.0053)	(0.0053)	(0.0053)	(0.0053)	(0.0053)	(0.0053)	(0.0053)
Basic research	0.1716***	0.1713***	0.1715***	0.1715***	0.1719***	0.1716***	0.1718***	0.1719***	0.1714***
	(0.0059)	(0.0059)	(0.0059)	(0.0059)	(0.0059)	(0.0059)	(0.0059)	(0.0059)	(0.0059)
Top university	0.0676***	0.0655***	0.0667***	0.0633***	0.0683***	0.0678***	0.0683***	0.0676***	0.0636***
	(0.0056)	(0.0056)	(0.0056)	(0.0057)	(0.0055)	(0.0056)	(0.0056)	(0.0056)	(0.0057)
Scientific Fields	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Publication years	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	14,757	14,757	14,757	14,757	14,757	14,757	14,757	14,757	14,757

Robust standard errors in parentheses

$^{*}p<0.10$, $^{**}p<0.05$, $^{***}p<0.01$

Table 11 Marginal effects partner types and publications in journals with a high reputation (firm sample)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Dependent variable: top journal									
Num. Partners	0.0047**	0.0103***							
	(0.0021)	(0.0033)							
Num. Academic Partners			0.0055	0.0321**					0.0313**
			(0.0042)	(0.0139)					(0.0144)
Num. Pharma Partners					0.0047*	0.0135***			0.0122***
					(0.0027)	(0.0039)			(0.0039)
Num. Biotech Partners							0.0293***	0.0199	0.0099
							(0.0106)	(0.0216)	(0.0215)
Num. Authors	0.0084***	0.0086***	0.0088***	0.0086***	0.0088***	0.0092***	0.0088***	0.0089***	0.0088***
	(0.0027)	(0.0027)	(0.0027)	(0.0027)	(0.0027)	(0.0027)	(0.0027)	(0.0027)	(0.0027)
Num. Countries	−0.0015	0.0024	0.0033	0.0024	−0.0017	0.0050	0.0016	0.0018	0.0054
	(0.0137)	(0.0133)	(0.0131)	(0.0132)	(0.0138)	(0.0136)	(0.0132)	(0.0132)	(0.0134)
Basic research	0.1021***	0.1004***	0.1019***	0.0989***	0.1004***	0.0998***	0.1015***	0.1020***	0.0986***
	(0.0243)	(0.0243)	(0.0243)	(0.0241)	(0.0243)	(0.0243)	(0.0241)	(0.0241)	(0.0239)
Top university	0.0437**	0.0376*	0.0437**	0.0302	0.0464**	0.0428*	0.0439**	0.0453**	0.0268
	(0.0222)	(0.0224)	(0.0222)	(0.0234)	(0.0221)	(0.0221)	(0.0220)	(0.0223)	(0.0236)
Scientific fields	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Publication years	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	1005	1005	1005	1005	1005	1005	1005	1005	1005

Robust standard errors in parentheses

*$p < 0.10$, **$p < 0.05$, ***$p < 0.01$

Table 12 Marginal effects partner types and forward citations (no-firm sample)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Dependent variable: citations									
Num. Partners	0.1327***	0.3471***							
	(0.0483)	(0.0916)							
Num. Academic Partners			0.1640***	0.4456***					0.4623**
			(0.0604)	(0.1011)					(0.2256)
Num. Pharma Partners					0.9189***	0.0365			-0.5459
					(0.2594)	(0.8032)			(1.0726)
Num. Biotech Partners							0.9356	3.1740***	− 1.3807
							(0.6241)	(1.0741)	(1.7906)
Num. Authors	0.0754	0.0740	0.0760	0.0756	0.0752	0.0753	0.0796	0.0790	0.0739
	(0.0757)	(0.0754)	(0.0756)	(0.0756)	(0.0757)	(0.0756)	(0.0752)	(0.0751)	(0.0758)
Num. Countries	1.0326***	1.0651***	1.0309***	1.0696***	1.0340***	1.0387***	1.0703***	1.0788***	1.0558***
	(0.3531)	(0.3533)	(0.3532)	(0.3535)	(0.3522)	(0.3527)	(0.3511)	(0.3497)	(0.3535)
Basic research	2.2765***	2.2645***	2.2743***	2.2719***	2.3070***	2.3203***	2.2632***	2.2806***	2.3060***
	(0.5101)	(0.5099)	(0.5105)	(0.5113)	(0.5104)	(0.5101)	(0.5090)	(0.5096)	(0.5102)
Top journal	7.2857***	7.2637***	7.2782***	7.2428***	7.2718***	7.2863***	7.3014***	7.2979***	7.2415***
	(0.4608)	(0.4604)	(0.4607)	(0.4605)	(0.4610)	(0.4623)	(0.4607)	(0.4615)	(0.4595)
Top university	2.5360***	2.4468***	2.5055***	2.3732***	2.5768***	2.6084***	2.5616***	2.5419***	2.4211***
	(0.4040)	(0.4064)	(0.4049)	(0.4086)	(0.4040)	(0.4039)	(0.4030)	(0.4031)	(0.4202)
Scientific fields	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Publication years	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	14,757	14,757	14,757	14,757	14,757	14,757	14,757	14,757	14,757

Robust standard errors in parentheses

$*p<0.10$, $**p<0.05$, $***p<0.01$

Table 13 Marginal effects partner types and forward citations (firm sample)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Dependent variable: citations									
Num. Partners	0.1033	0.4010**							
	(0.1097)	(0.1864)							
Num. Academic Partners			0.2148	0.6735					0.4528
			(0.2502)	(0.8368)					(0.8432)
Num. Pharma Partners					0.0844	0.3302			0.2468
					(0.1377)	(0.2292)			(0.2321)
Num. Biotech Partners							0.9243	2.1465**	2.0870*
							(0.6392)	(1.0595)	(1.1241)
Num. Authors	0.6094***	0.6236***	0.6041***	0.6052***	0.6216***	0.6250***	0.6233***	0.6222***	0.6218***
	(0.1927)	(0.1932)	(0.1941)	(0.1943)	(0.1901)	(0.1898)	(0.1904)	(0.1913)	(0.1955)
Num. Countries	0.3168	0.3736	0.3919	0.4086	0.3067	0.4130	0.2724	0.2236	0.3873
	(0.9270)	(0.9058)	(0.9239)	(0.9262)	(0.9260)	(0.9248)	(0.9178)	(0.9223)	(0.9289)
Basic research	1.0261	0.8131	1.1502	1.1385	0.9634	0.8290	1.0503	0.9035	0.7894
	(1.7304)	(1.7213)	(1.7342)	(1.7349)	(1.7315)	(1.7271)	(1.7312)	(1.7255)	(1.7220)
Top journal	6.8653***	7.0210***	6.9461***	6.8000***	6.9174***	7.0187***	6.8787***	7.0405***	7.0127***
	(1.7359)	(1.7298)	(1.7251)	(1.7309)	(1.7347)	(1.7254)	(1.7363)	(1.7311)	(1.7284)
Top university	1.9472	1.7740	1.9598	1.7327	1.9803	1.9602	1.9089	1.8526	1.6357
	(1.3366)	(1.3273)	(1.3339)	(1.3388)	(1.3376)	(1.3287)	(1.3291)	(1.3207)	(1.3145)
Scientific fields	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Publication years	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	1005	1005	1005	1005	1005	1005	1005	1005	1005

Robust standard errors in parentheses

$^{*}p<0.10$, $^{**}p<0.05$, $^{***}p<0.01$

Table 14 Utest for partner types and publications in journals with a high reputation (no-firm sample)

		(2)	(4)	(6)	(8)	(9)
Dependent variable: top journal						
Num. Partners	*t* value	3.000				
	$p > \|t\|$	0.001				
Num. Academic Partners	*t* value		3.100			1.920
	$p > \|t\|$		0.001			0.028
Num. Pharma Partners	*t* value			0.750		0.370
	$p > \|t\|$			0.227		0.357
Num. Biotech Partners	*t* value				2.970	0.300
	$p > \|t\|$				0.001	0.381

Table 15 Utest for partner types and publications in journals with a high reputation (firm sample)

		(2)	(4)	(6)	(8)	(9)
Dependent variable: top journal						
Num. Partners	*t* value	1.290				
	$p > \|t\|$	0.098				
Num. Academic Partners	*t* value		1.560			1.870
	$P > \|t\|$		0.060			0.031
Num. Pharma Partners	*t* value			2.010		2.250
	$P > \|t\|$			0.023		0.012
Num. Biotech Partners	*t* value				–	–
	$P > \|t\|$				–	–

Table 16 Utest for partner types and forward citations (no-firm sample)

		(2)	(4)	(6)	(8)	(9)
Dependent variable: citations						
Num. Partners	*t* value	3.190				
	$P > \|t\|$	0.001				
Num. Academic Partners	*t* value		3.960			2.110
	$P > \|t\|$		0.000			0.017
Num. Pharma Partners	*t* value			0.030		0.560
	$P > \|t\|$			0.487		0.287
Num. Biotech Partners	*t* value				2.930	0.480
	$P > \|t\|$				0.002	0.316

Table 17 Utest for partner types and forward citations (firm sample)

		(2)	(4)	(6)	(8)	(9)
Dependent variable: citations						
Num. Partners	*t* value	2.260				
	$P > \|t\|$	0.012				
Num. Academic Partners	*t* value		0.480			0.490
	$P > \|t\|$		0.315			0.312
Num. Pharma Partners	*t* value			1.520		1.220
	$P > \|t\|$			0.065		0.111
Num. Biotech Partners	*t* value				1.900	1.870
	$P > \|t\|$				0.029	0.031

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