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Do publication activities of academic institutions benefit from formal collaborations with firms?

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ABSTRACT

While the existing literature has focused predominantly on how firms can benefit from collaborations with academic institutions such as universities and research institutions, this study explores whether the proportion of (formal) collaborations with different types of firm partners in strategic R&D alliances is associated with publications originating in academic institutions. The empirical analysis is based on a unique dataset of publications in pharmaceutical cancer research. The results suggest that the share of collaborations with industry partners has an inverted u-shaped relationship with the reputation of the journal in which an article originating in an academic institution is published. The share of alliances with pharmaceutical firms shows a similar inverted u-shaped pattern, suggesting that research originating in academic institutions can only benefit from alliances with pharmaceutical firms through resource inflows up to a threshold.

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Introduction

During the last decades, the so-called third mission of academic institutions – their contribution to economic and regional development and industry activities, as well as more broadly to society – has gained renewed interest among academics, practitioners, and policy makers (Martin, 2003, 2012). A core argument within this context is that collaboration in research and development (R&D) between academic institutions and firms is particularly important for generating knowledge spillovers from academia to industry (D'Este & Patel, 2007). These knowledge spillovers build on the notion of a division of labour in knowledge production. Following the economics of knowledge literature, academic institutions such as universities and research institutes predominantly engage in basic research while firms primarily engage in applied research (Arrow, 1962; Nelson, 1959). This literature assumes that it is difficult for firms to appropriate the benefits of basic research, which reduces their incentive to engage in basic research and leads to a focus on research and development activities that are more applied. Based on this rationale, interactions between academia and firms are traditionally perceived as a unidirectional form of collaboration where academic institutions conduct basic research, which is then transferred to industry. Firms build upon this transferred knowledge with applied research and commercialise it through their innovation activities

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(Perkmann et al., 2013). Particularly in biomedical sciences, research collaborations play an important role in the transfer of knowledge from academia to industry, where it is commercially exploited by firms (Bekkers et al. 2008; Meyer-Krahmer & Schmoch, 1998).

In contrast to these arguments and findings, a stream of literature suggests that academic institutions can benefit from knowledge that originates in firms. More specifically, collaborative relationships between academic institutions and industry are informative for researchers in academia because they distribute new ideas from industry to academia and support development of new questions for academic research (D'Este & Perkmann, 2011). In addition, formal collaborations with industry partners provide opportunities for academic institutions to acquire additional resources (Gulbrandsen & Smeby, 2005; Tartari & Breschi, 2012). Hence, collaboration between academic institutions and industry partners supports development of new research areas and enables researchers to advance the state of knowledge in established research areas through studies that could not otherwise be conducted. The benefits of collaboration with industry partners not only increases the number of publications originating in academic institutions but may also add to the novelty and quality of academic research, facilitating publications in journals that are highly reputable within the academic community.

In contrast to this rather positive view, researchers have raised concerns that collaboration with firms has a negative association with academic research and publication activities. These concerns emphasise that firms may force researchers in academia to keep studies and the corresponding findings secret, to withhold selected results, or to delay publication to protect firms' commercial interests (Blumenthal et al., 1996; Czarnitzki et al., 2015; Evans, 2010). Despite these concerns and potential publication restrictions enforced by firms, most contributions do not suggest a negative relationship between (formal) research collaborations and academic publication activities in terms of output and impact (National Research Council, 2011). However, analyses of the relationship between formal collaborations with industry and the reputation of academic publications are rather scarce and show inconclusive results (Abramo et al., 2009; Lebeau et al., 2008).

Therefore, this study focuses on publications originating in academia, that is, universities and other academic research institutions, and explores whether the scope of (formal) collaborations with different types of alliance partners is related to the reputation of the journal in which an article is published. Because the reward system in academia builds on recognition for academic achievements that is linked to publication in academic journals and the reputation of these journals within the academic community, studying the relationship between (formal) collaboration and the reputation of the journal the corresponding article is published in is important (Merton, 1957; Stephan, 2012; Van Dalen & Henkens, 2005). Several countries, including Italy, Norway, and the United Kingdom, have incorporated this principle into formal evaluations of the research performance of academic institutions. In these countries, evaluating academic institutions is not based only on the quantity of academic research output but also considers bibliometric indicators of the reputation or prestige of the academic journals, such as journal impact factors (Aagaard et al., 2015; Bertocchi et al., 2015; Moed, 2008). Since evaluation outcomes are often linked to resource allocation decisions, research performance valuations provide strong incentives for academic institutions to develop research excellence through publications in highly regarded journals (Hicks, 2012). In addition to evaluations by governments, other public and private organisations such as accreditation bodies, media, or consultancies publish academic institution rankings. While the emphasis on research may differ among rankings, several well-established rankings stress the importance of publications in highly reputable journals that are considered the leading academic outlets in the corresponding disciplines (Olcay & Bulu, 2017; Vernon et al., 2018). Hence, publications in journals that are highly reputable can improve an academic institution's position in these rankings. Academic institutions perceive their positions in these rankings as crucial for their marketing strategies and expect that improvements lead to reputational gains and higher recognition, which aids them in attracting (international) students and faculty (Olcay & Bulu, 2017).

These arguments suggest that publications in highly reputable journals are important factors in increasing the recognition and support resource allocations of academic institutions. Against this background, an important question is whether the scope of formal collaborations with industry can help academic institutions achieve their objectives in terms of publications in highly reputable journals. The scope of collaboration with a specific partner type refers to the share of this partner type among all alliance partners that are associated with academic publications. Put differently, the scope of collaboration is operationalised as the proportion of a specific type of alliance partner among the alliances associated with journal articles. Hence, the scope of alliances with a specific partner type accounts for opportunities to access knowledge from a wider alliance portfolio of institutions involved in publications.

This study contributes to the debate on the relationship of collaboration with industry and the research output of academic institutions. It disentangles the relationships for different types of alliance partners based on the reputation of the journal an article is published in. The objective of this study is to go beyond number of publications as an indicator of collaboration performance and focus instead on the journal reputation as an important outcome for universities and research institutes and an important form of recognition for academic achievements.

The empirical context of this study is the science-based biotechnology and pharmaceutical industry, which is characterised by intense collaborative activities through strategic alliances, including alliances between firms and academic institutions. While biotechnology consists pre-dominantly of small firms that are often linked to academia and act as technology brokers, pharmaceutical firms are often large firms that make significant investments in R&D (McKelvey et al., 2004; Pisano, 2006; Stuart et al., 2007). These industry characteristics provide an ideal case for exploring the relationship between the proportions of alliances with different partner types and publication outcomes in terms of reputation. The subsequent sections further explore the literature on the relationship between different partner types and the reputations of academic publications and present empirical analyses.

Alliance partners and publication outcomes

Organisational perspectives on strategic alliances and knowledge generation

Although the literature on strategic alliances and knowledge generation has predominantly focused on the firm perspective, many arguments developed in this literature can be applied to knowledge generation in academic institutions. Following this literature, strategic alliances proxy for the organisation's connectedness within and beyond its own industry, which has been found to be linked to knowledge generation in terms of scientific publications (Cockburn & Henderson, 1998). This contribution is likely to be based on powerful learning opportunities created by strategic alliances that enable organisations to access and acquire new knowledge from their collaboration partners. Based on this knowledge, organisations can leverage their existing knowledge and generate new (scientific) knowledge (Inkpen, 1998b).

Although strategic alliances are conducted at the organisational level, knowledge generation and knowledge exchange require considering the individual members of an organisation (Kim, 1993). At the organisational level, the process of knowledge generation is based on elaborations of specific knowledge elements by an organisation's individual members. In the context of academic institutions, these elaborations are facilitated through knowledge sharing based on the expectation that researchers in academic institutions behave according to the norm of open science (Haeussler, 2011). This norm supports disclosure and sharing of knowledge among researchers in academic institutions through multifaceted formal and informal interactions and allows for re-use of knowledge in their peers' future research activities (Merton, 1973). Hence, it is the researchers' individual efforts that enable internalisation of knowledge elements into an organisation's knowledge base (Nonaka, 1994). The integration of knowledge into an organisation's knowledge base happens through its acceptance by other members of the organisation, as well as through its application and use in future research activities (Inkpen, 1998a).

Knowledge is transmitted through the organisation and its sub-units by its exchange among the organisation's individual members, which also provides access to external knowledge originally developed outside the organisations' boundaries. In academic institutions, knowledge can be transmitted through the organisation via specific requests to share knowledge acquired through strategic alliances with peers, such as information about research techniques or research materials. Knowledge acquired from strategic alliances can be transmitted through the organisation via research talks and other means of peer communication (Haeussler et al., 2014). In particular, the latter form of knowledge transmission enables individual researchers to discuss alliance partners' knowledge, develop it further, share it with additional researchers within their organisation, and, hence, integrate it into the organisation's knowledge base (Inkpen, 1998a; Nonaka, 1994). This integration of knowledge accessed through strategic alliances into the organisational knowledge base enables individual researchers within a specific academic institution to apply this knowledge in their own research projects.

Organisations can support the integration of external knowledge into their knowledge base by managing the diversity of their alliance portfolio through simultaneous collaborations with different partners to maximise the benefits in terms of learning as well as access to knowledge and other resources (Jiang et al., 2010). Hence, alliance portfolios that balance the proportions of different organisational types make knowledge from different sources available to an organisation's members and enable its transmission and integration within the organisation (Katz & Martin, 1997). Academic institutions can develop collaboration strategies that balance the share of different types of alliance partners on the organisational level. In doing so, they can provide support and incentivise the establishment of (formal) collaborations with specific types of partners to make knowledge from a diverse set of partners available to its researchers. This knowledge may have direct benefits, as it may help address academic challenges and solve research problems. In addition, balancing the shares of different types of partners across strategic alliances can provide access to knowledge that contradicts existing views. These contradictions may lead to productive conflicts, which could support a cross-fertilisation of ideas that enhance the quality as well as the novelty of research (Katz & Martin, 1997). As a consequence, the research may be published in journals that are highly regarded within the academic community.

Alliances with industry partners

The arguments presented above suggest that organisations should balance their alliance portfolios, including the scope of collaboration with firms, to maximise the benefits arising from collaborations. For academic institutions, this raises the question of whether and to what extent they should engage in formal collaborations with industry partners. From the perspective of academic institutions, collaborations with industry partners are attractive when the collaborative work supports academic research activities (D'Este & Perkmann, 2011). More specifically, the literature has identified three main benefits of collaborations between academic institutions and industry partners: inspiring new research questions, knowledge exchange, and access to additional resources.

Particularly in applied areas of research, industry partners and the challenges they face in their R&D activities inspire academic research agendas (D'Este & Perkmann, 2011). Hence, a percentage of firm partners in an alliance portfolio associated with academic research projects can be beneficial, particularly in applied areas. In these areas, academic researchers conduct research that industrial firms consider particularly promising and where academic contributions can open up opportunities for future technological developments (Balconi & Laboranti, 2006). In the biotechnology and pharmaceutical industry, biotechnology firms are often considered as performing research at the knowledge frontier. Hence, the problems they face in their R&D activities may inspire research projects in academia that, due to the science-based nature of the industry and high degree of project novelty, are associated with considerable potential for publication in journals that are highly reputable. In addition, firms that focus on more applied research often face challenges applying scientific achievements in their R&D processes. Examining the underlying reasons for these challenges opens new opportunities for academic research and publications.

Second, it has been argued that a certain share of collaborations with industry can benefit academic institutions as they provide access to knowledge. More specifically, academic institutions collaborate with industry, particularly with distinguished industrial R&D labs, because academics believe there are great opportunities to learn from their peers in industry. Therefore, they welcome opportunities to get involved in industrial R&D projects even if these projects have a more applied nature as they often lead to academically valuable follow-on projects (Perkmann & Walsh, 2009; Rosenberg, 1991). Firms that have a strong focus on advancing knowledge related to their core technologies are often small (Santoro & Chakrabarti, 2002). In the biotechnology and pharmaceutical industry, biotechnology firms are characterised as operating at the knowledge frontier in their areas of research. They act as providers of new knowledge, technology, research methods, and materials, as well as new compounds that provide opportunities for developing new pharmaceuticals (Malerba & Orsenigo, 1996; McKelvey et al., 2004). Furthermore, biotechnology firms provide access to knowledge by acting as knowledge brokers, enabling the transfer of knowledge from one organisation to another (Stuart et al., 2007).

Hence, strategic alliances provide opportunities to access knowledge produced by firms and engage in mutually beneficial knowledge exchanges that support academic research (Meyer-Krahmer & Schmoch, 1998). Through these knowledge exchanges, academic researchers are exposed to new knowledge generated in firms that enables the development of academically intriguing and unexplored research questions and linking these to existing literature streams. Such research questions are of particular interest to highly reputable academic journals that want to attract studies that advance the state of knowledge and contribute to developing the corresponding research area while, at the same time, being clearly linked to existing contributions and may as a result be less affected by biases against novelty in academic publications (Wang et al., 2017).

In addition, collaborations with industry partners provide opportunities to field test theories (Lee, 2000). Taken together, the inflow of knowledge developed in industry as well as opportunities to field test theories may increase a study's novelty and quality. Hence, these studies may be published in journals with better reputations.

Third, academic institutions collaborate with industry partners when these activities provide access to additional resources (Tartari & Breschi, 2012). It is not uncommon for academic institutions to receive industry funding for specific research projects or to advance the development of existing prototypes and concepts (Stephan, 2012). Formal collaborations such as strategic alliances are often associated with considerable payments that may at least partially depend on whether the underlying research project reaches milestones defined in the alliance contract (Robinson & Stuart, 2007). For academic institutions, collaboration with industry provides opportunities to obtain additional research funding that can be used to support research and publication activities (Gulbrandsen & Smeby, 2005). Funds obtained from industry partners can be used to expand the resources available for research, such as by hiring additional graduate students and research assistants or acquiring research materials and lab equipment (Lee, 2000). In addition, industry collaborations may provide access to technical facilities, specific research equipment, or materials that would not otherwise be available. Funding and access to other resources required in academic research, such as research materials, techniques, or funding that facilitates research that could not otherwise have been conducted by academic institutions, are predominantly made available by large firms focusing their collaborative efforts on research support relationships (Santoro & Chakrabarti, 2002). In the context of this study, predominantly large pharmaceutical firms that are established industry players have R&D budgets of considerable size and can support academic institutions through research funds or providing other resources (Schuhmacher et al., 2016). Smaller biotechnology firms may provide specific research materials, tools, or compounds, but smaller firms are often too resource-constrained to provide significant financial support for academic research activities.

Based on these arguments, a larger share of industry partners among the alliances associated with research provides greater opportunities for academic institutions to obtain additional resources that can be invested in research and publication support. Additional resources acquired through collaborations with industry partners may support development of new studies that would not have been possible without the collaboration. An increasing number of studies provide opportunities to increase the number of publications as more studies can be submitted to academic journals. In addition, the availability of additional resources through collaborations with industry partners can also increase the quality of existing and ongoing studies (Melin, 2000). More specifically, the availability of (additional) research materials or lab equipment may improve the quality of the analyses, for example, through additional (auxiliary) analyses to assess the robustness of the findings or through the use of research designs and equipment that allow for more accurate measurements. All these factors are likely to be associated with a study's quality and, hence, should support publication in journals with better reputations. In addition, resources that become available through collaborations with industry partners can provide access to specific equipment or materials that enable studies with a high degree of novelty and significant contributions to the literature. Hence, having a certain share of industry partners is likely to increase the chances of publication in journals that are highly reputable.

These arguments suggest that, initially, a moderate scope of collaborations with industry partners associated with academic research projects can support the publication activities of academic institutions. However, literature that analyses the relationship between collaboration and research or innovative outcomes at the firm level suggests returns from collaborative activities may be decreasing or even negative after they reach a tipping point (Berchicci, 2013; Hottenrott & Lopes-Bento, 2016). Laursen and Salter (2006) suggest collaborations with external partners are initially beneficial, as they provide access to new knowledge and additional resources. However, if firms engage in too many collaborative activities, the costs of searching and managing external sources of knowledge exceed the benefits.

These findings at the firm-level are also reflected in literature suggesting that a large share of industrial partners may ultimately have negative effects on publications originating in academia. More specifically, industry partners often control intellectual property originating from collaborative research projects and restrict the exchange and communication of data or research results associated with these projects (Stephan, 2012). These restrictions are important for industrial partners to ensure they can achieve their corporate goals and secure the benefits of the research activities they have supported; however, these restrictions often have negative consequences for academic partners' publications (Czarnitzki et al., 2015). Communication restrictions may increase with the scope of collaborations with industry partners and have negative consequences for academic publications (Blumenthal et al., 1996). With a high proportion of (formal) collaborations with industry partners, academic institutions are more likely to face communication restrictions, while these restrictions affect more of their research projects. The restrictions may limit opportunities to seek feedback from peers and delay submission of the related research to academic journals. While the former aspect may be negatively related to a study's quality, the latter aspect may reduce a study's novelty. In addition, some communication restrictions demanded by industry partners may infringe on the requirements of highly reputable journals in terms of avoiding conflicts of interest and data availability. Therefore, the corresponding studies may not be eligible for publication in journals with high reputations.

Research by universities and research institutes may be initially stimulated by exposure to the industry's R&D problems, the emergence of new ideas for academic research, and the availability of additional resources and additional funding (Banal-Estañol, et al., 2015). For academic institutions, a high proportion of collaborations with industry partners provides access to many diverse ideas and industrial R&D problems. However, many of these problems may have comparatively low scientific or technological content or could be classified as routine tasks, shifting academic research output towards applied research (Banal-Estañol et al., 2015; Banal-Estañol et al., 2013; Manjarrés-Henríquez et al., 2009). With most highly reputable journals focusing on basic research and a rather high level of novelty (Seglen, 1997), the potential for publishing applied research and routine activities in reputable academic journals appears to be limited.

Academic institutions with a large share of industry partners run the risk of collaborating with many partners that have limited or no expertise publishing in highly reputable journals. These collaborations are less beneficial for academic institutions because they are likely to decrease the quality of the corresponding research output in terms of impact factor adjusted publications (Banal-Estañol et al., 2013). In addition, a large proportion of industry partners may reduce the attention and time academic institutions and their academic staff can spend on other research projects (Banal-Estañol et al., 2015). Consequently, there might be a crowding out of studies with high probability of publication in highly reputable journals by industry projects that require attention but have lower probability of publication in well-respected journals.

Taken together, it is likely that after initially positive effects on publication outcomes in terms of journal reputation, an increasing scope of collaborations with industry partners is negatively related to publication outcomes.

Data

Data and variable construction

This study's empirical analysis uses data from different sources, including data regarding scientific publications and strategic research and development alliances in pharmaceutical cancer research. Currently, over 8 million individuals die because of cancer each year and more than 14 million new cases are diagnosed, making cancer one of the leading causes of death worldwide (International Agency for Research on Cancer, 2014). With both numbers expected to increase in the future, cancer is a large and expanding market for pharmaceuticals and a disease area that has received attention among health professionals, policymakers, and bio-pharmaceutical companies. This has led to considerable investments in pharmaceutical cancer research from both public and private sources (Mowery et al., 2010).

Within the economics of science literature and the literature on innovation studies, scientific publications are an accepted and widely used indicator of the production of new scientific knowledge that reflects the successful completion of the knowledge generation process (Tijssen, 2009). Moreover, scientific publications provide detailed bibliographic information, which allows for detailed analyses.

The data for this study builds upon a list of 30 medical indications (conditions or diseases) in the field of cancer from the BioPharmInsight database.[1] A keyword search in the Web of Science databases (WoS) was conducted based on this list of medical indications. The results of the keyword search were restricted to publication data in areas related to pharmaceutical research; in other words, 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'. Publications that are not classified as journal articles and articles that list at least one author with firm or other non-academic affiliation were excluded. Articles co-authored by firms were excluded as they may differ from non-co-authored articles. In addition, focusing on articles that originate in academic institutions and are not co-authored by firms allows study of the relationships of different alliance partner types and publication outcomes in terms of journal reputation independent of potential additional exchanges through co-authorship. The dataset contains 5,726 journal articles in the area of pharmaceutical cancer research that originate in universities or research institutes. These articles were published between 2003 and 2008 in 362 different journals.

Author affiliations have been manually standardised to exclude publications from the analysis that are co-authored by firm researchers. Manual standardisation was required because data from the WoS does not contain standardised author affiliations. The standardisation was based on publicly available information, such as organisation web-sites, firm reports, and SEC filings, as well as business information provided by Bloomberg (McKelvey & Rake, 2016).

Dependent variables: journal reputation of a publication

This study builds upon literature that uses journal impact factors and similar measures as indicators of reputation. As a general rule, journals with high impact factors include those with the best reputations (Garfield, 2006). Indicators for journal impact come from the CWTS Journal Indicators.[2] More specifically, this study uses impact per publication (IPP) as the dependent variable. The IPP is similar to a journal impact factor and is calculated as the number of forward citations of articles published in a journal in the previous three years received in a specific year divided by the number of articles published in that journal in the past three years.

$$IPP_j = \frac{\sum_{t=-3}^{t=-1} forward\ citations\ to\ articles\ in\ journal\ j}{\sum_{t=-3}^{t=-1}\ articles\ in\ journal\ j}$$

Since the IPP does not account for different citation patterns among scientific fields, the source normalised impact per paper (SNIP) is used as an alternative dependent variable. The SNIP can be interpreted as a journal's average number of citations per publication, with each citation weighted inversely proportional to the number of active references in the citing publication and the proportion of publications with at least one reference in the citing journal in the previous three years (Waltman et al., 2013). The SNIP corrects for differences in citation practices among scientific fields based on the characteristics of the sources of a journal citation (Moed, 2010; Waltman et al., 2013).

Hence, the SNIP does not require an explicit specification of scientific field boundaries. The SNIP assumes that a journal is in a field characterised by a high average number of citations if it is cited by publications with lengthy reference lists. This implies that one should expect a rather high number of citations per publication (Waltman et al., 2013). The SNIP is calculated as

$$SNIP = \frac{3}{m}\sum_{i=1}^{n}\frac{1}{p_i r_i}$$

where m refers to the number of publications in a journal, n denotes the number of citations received by a journal, r_i accounts for the number of references that appeared in the journal's subject field in the three preceding years, and p_i denotes the proportion of publications that have at least one citation in the previous three years (Waltman et al., 2013).

Independent variables: strategic alliances and partner types

Strategic research and development alliances reported in the ReCap database were used to develop the independent variables (Schilling, 2009). The ReCap database collects information on alliances in the biotechnology and pharmaceutical industry from various sources, such as press releases, SEC filings, and firm presentations. Data on strategic alliances that are used in this study are restricted to research and development alliances in the field of cancer research entered into between 1998 and 2007.[3] Strategic alliance data provide a well-established and reliable indicator for collaboration activities that is independent of the co-authorship relationships in the publication data that have been used to develop this study's dependent variables. The procedure outlined in McKelvey and Rake (2016) is followed to manually standardise the organisations that are author affiliations and organisations involved in strategic alliances based on publicly available information such as organisation websites, firm reports, and SEC filings, as well as business information provided by Bloomberg. This procedure assigns each reported author affiliation and each organisation mentioned as an alliance partner to its highest order entity as of 2008. More specifically, all departments of a university are assigned to that university and university hospitals are assigned to the university with which they are affiliated. Subsidiaries are assigned to their corresponding parent firm if the parent firm owns more than 50% of the shares.

The strategic alliance data are used to calculate the number of unique strategic alliance partners connected to the authors of each publication in the sample (*Num. Partners*). This approach accounts for wider alliance portfolios that can be used by authors to access knowledge that can be integrated into the knowledge bases of their affiliations and, hence, used in their own research. Accounting for this wider alliance portfolio allows for a broader perspective of knowledge access, going beyond the contributions of the organisations involved in specific publications through co-authorship (McKelvey & Rake, 2018). This accounts for knowledge and other resources a publication's authors can access through the strategic R&D alliances of their affiliations in the three years before an article is published. Hence, the variable *Num. Partners* is an aggregate count at the publication level. Restricting the count of alliance partners to organisations not listed as author affiliations disentangles the association between different types of alliance partners and publication outcomes from that of co-authorship relationships. Following the strategic alliance literature in the biotechnology and pharmaceutical industry (Stuart et al., 2007), *Num. Partners* is calculated based on time windows of three years prior to the publication year.[4] The time windows correspond to the average length of each phase in the drug development process (DiMasi, et al., 2016).

I calculate the share of different partner types in a publication's alliance portfolio to investigate each partner type's contribution to the reputation of the journal an associated article is published in. More specifically, I calculate the share of firm partners (*Sh. Firm Partners*) by counting the number of firms listed as alliance partners in the alliance portfolio associated with a specific publication (*Num. Firm Partners*), divide this count by the total number of partners (*Num. Partners*), and multiply the result by 100:

$$Sh.\ Firm\ Partners = \frac{Num.\ Firm\ Partners}{Num.\ Partners} * 100$$

Along similar lines, I calculate the share of pharmaceutical firms as alliance partners (*Sh. Pharma Partners*) as well as the share of biotechnology firms as alliance partners (*Sh. Biotech Partners*). It is important to note that *Sh. Pharma Partners* and *Sh. Biotech Partners* do not necessarily add up to 100% since academic institutions may have alliances with other types of firms and other non-firm organisations, e.g., medical care providers or non-profit organisations. The use of specific partner type shares accounts for the scope of collaboration with these partner types within in the alliance portfolio associated with a specific publication; it shows to what extent alliances associated with a specific publication are concentrated on a specific partner type.

Control variables

I control for several publication-related aspects that may, according to the literature, be associated with publishing in journals with rather high or rather low reputations. More specifically, I control for the number of co-authors of an article (*Num. Authors*), as well as for the number of different countries of author affiliations (*Num. Countries*). I employ the CHI classification of journals (Hamilton, 2003) to account for articles published in journals that publish predominantly basic biomedical research (*Basic Research*). Collaborations with researchers working at distinguished institutions and global centres of excellence may be related to the probability of publication in highly reputable journals. Consequently, I control for whether a co-author of an article reports an affiliation with one of the leading 100 universities according to the 2009 Academic Ranking of World Universities, the so-called Shanghai ranking (*Top University*). In addition, I control for the scientific areas 'Biotechnology & Applied Microbiology', 'Medicine, Research & Experimental', and 'Pharmacology & Pharmacy,' as well as for the publication year and medical indication.

Table A2 in the appendix provides brief descriptions of all variables and Table A3 in the appendix provides an overview of the descriptive statistics, as well as sample correlations.

Results

The dependent variables *IPP* and *SNIP* can take on values that are very close to zero. Very small values of *IPP* and *SNIP* are rounded to two decimal places with 0.00 as the minimum in the CWTS Journal Indicators database. The values of both dependent variables are roughly continuously distributed over positive values. Linear models do not fully account for the specific structures of the dependent variables. Therefore, the empirical analysis is based on Tobit regressions, which can accommodate this data structure.

The regression results presented in Table 1 (*IPP*) and Table 2 (*SNIP*) show very similar associations between academic institution scope of collaboration with firms and the reputation of the journal the corresponding article is published in. More specifically, the results suggest the share of firm partners (*Sh. Firm Partners*) has an inverted u-shaped relationship with *IPP* and *SNIP*. This implies that the share of firm partners has a positive association with the reputation of the journal the article is published in but with decreasing returns. In addition, the positive association holds only up to an inflection point of around twenty-nine percent for *SNIP* and approximately thirty-one percent for *IPP*. Shares of firm partners beyond this level are negatively associated with the reputation of the journal the corresponding article is published in.

With respect to the different types of firm partners, I find a similar pattern. *Sh. Pharma Partners* as well as *Sh. Biotech Partners* show an inverted u-shaped relationship with both *IPP* and *SNIP*. The squared terms of both partner shares indicate that the positive relationship with the journal reputation measure is decreasing and becomes negative after an inflection point, which is between around twenty-seven percent (*SNIP* and *Sh. Biotech Partners*) and thirty percent (*IPP* and *Sh. Pharma Partners*). The coefficients for *Sh. Biotech Partners* lose their statistical significance at conventional levels once they are introduced into the analysis simultaneously with the share of pharmaceutical partners. A potential reason for this finding is the relatively high correlation of these two variables.

With respect to the control variables, I find that collaborations with multiple authors as indicated by *Num. Authors* and collaborations across different countries as indicated by *Num. Countries* are associated with the reputation of the journal an article is published in. The same applies to basic research. Articles appearing in journals that predominantly publish basic research according to the CHI journal classification tend to have higher *IPP* and higher *SNIP* scores. Finally, my results suggest that collaborations with the leading global academic institutions are positively associated with the reputation of the journal the corresponding paper is published in.

I conduct several auxiliary analyses to assess the robustness of the results. I use journal impact factors obtained from the Journal Citation Reports associated with the Web of Science database. The corresponding results are consistent with the previous results. Since one stream of literature has argued that alliances may be relevant for organisations over several years (Stuart, 2000; Vasudeva & Anand, 2011), I use time windows of five years to account for the share of different partner types. The results of this robustness check support the findings in the original analyses. Moreover, one may argue alliances with firms that are exclusively dedicated to research relate to academic institution publication activities in a different way than research and development alliances. The latter alliances may include collaborations that have a more applied nature. To calculate

Table 1. Firm partner types and IPP.

Dependent Variable: IPP	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Sh. Firm Partners		0.0215***	0.0628***					
		(0.0052)	(0.0157)					
Sh. Firm Partners^2			−0.0010***					
			(0.0003)					
Sh. Pharma Partners				0.0251***	0.0791***			0.0731***
				(0.0070)	(0.0214)			(0.0255)
Sh. Pharma Partners^2					−0.0013***			−0.0012**
					(0.0005)			(0.0006)
Sh. Biotech Partners						0.0206**	0.0775***	0.0128
						(0.0084)	(0.0281)	(0.0330)
Sh. Biotech Partners^2							−0.0014**	0.0000
							(0.0006)	(0.0007)
Num. Authors	0.1827***	0.1819***	0.1810***	0.1823***	0.1811***	0.1825***	0.1820***	0.1811***
	(0.0198)	(0.0197)	(0.0196)	(0.0197)	(0.0197)	(0.0197)	(0.0197)	(0.0196)
Num. Countries	0.3271***	0.3010***	0.2788***	0.3055***	0.2812***	0.3207***	0.3074***	0.2802***
	(0.1064)	(0.1073)	(0.1080)	(0.1070)	(0.1081)	(0.1067)	(0.1075)	(0.1082)
Basic Research	1.6990***	1.6898***	1.6835***	1.6876***	1.6815***	1.6987***	1.6904***	1.6823***
	(0.1041)	(0.1040)	(0.1038)	(0.1041)	(0.1040)	(0.1040)	(0.1038)	(0.1039)
Top University	1.1154***	1.0718***	1.0839***	1.0752***	1.0929***	1.1068***	1.1072***	1.0870***
	(0.0844)	(0.0857)	(0.0858)	(0.0858)	(0.0859)	(0.0845)	(0.0846)	(0.0861)
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Scientific Area Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Medical Indication Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	1.7851***	1.8048***	1.7970***	1.8263***	1.8273***	1.7686***	1.7537***	1.8154***
	(0.2916)	(0.2912)	(0.2910)	(0.2915)	(0.2913)	(0.2917)	(0.2919)	(0.2926)
Sigma	2.8524***	2.8461***	2.8434***	2.8471***	2.8443***	2.8506***	2.8490***	2.8436***
	(0.0818)	(0.0818)	(0.0817)	(0.0818)	(0.0818)	(0.0818)	(0.0817)	(0.0818)
N	5726	5726	5726	5726	5726	5726	5726	5726
AIC	28313.3559	28289.9902	28281.3956	28294.0641	28284.8456	28308.2001	28303.8900	28286.0115
BIC	28592.7724	28576.0594	28574.1176	28580.1333	28577.5676	28594.2693	28596.6120	28,592.0390

Robust standard errors in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 2. Firm partner types and SNIP.

Dependent Variable: SNIP	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Sh. Firm Partners		0.0035***	0.0124***					
		(0.0011)	(0.0033)					
Sh. Firm Partners^2			−0.0002***					
			(0.0001)					
Sh. Pharma Partners				0.0038***	0.0149***			0.0131**
				(0.0014)	(0.0044)			(0.0053)
Sh. Pharma Partners^2					−0.0003***			−0.0002**
					(0.0001)			(0.0001)
Sh. Biotech Partners						0.0039**	0.0153**	0.0040
						(0.0018)	(0.0062)	(0.0074)
Sh. Biotech Partners^2							−0.0003**	−0.0000
							(0.0001)	(0.0002)
Num. Authors	0.0347***	0.0346***	0.0344***	0.0346***	0.0344***	0.0347***	0.0346***	0.0344***
	(0.0041)	(0.0041)	(0.0041)	(0.0041)	(0.0041)	(0.0041)	(0.0041)	(0.0041)
Num. Countries	0.0826***	0.0784***	0.0736***	0.0794***	0.0744***	0.0814***	0.0788***	0.0741***
	(0.0227)	(0.0229)	(0.0230)	(0.0229)	(0.0231)	(0.0228)	(0.0229)	(0.0231)
Basic Research	0.2304***	0.2290***	0.2276***	0.2287***	0.2275***	0.2304***	0.2287***	0.2275***
	(0.0231)	(0.0231)	(0.0231)	(0.0231)	(0.0231)	(0.0231)	(0.0231)	(0.0231)
Top University	0.2366***	0.2296***	0.2322***	0.2306***	0.2342***	0.2350***	0.2351***	0.2330***
	(0.0179)	(0.0182)	(0.0182)	(0.0182)	(0.0182)	(0.0179)	(0.0180)	(0.0182)
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Scientific Area Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Medical Indication Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	0.7521***	0.7553***	0.7536***	0.7583***	0.7586***	0.7490***	0.7460***	0.7556***
	(0.0637)	(0.0636)	(0.0636)	(0.0637)	(0.0636)	(0.0638)	(0.0638)	(0.0640)
Sigma	0.6088***	0.6080***	0.6074***	0.6082***	0.6077***	0.6085***	0.6082***	0.6075***
	(0.0172)	(0.0172)	(0.0172)	(0.0172)	(0.0172)	(0.0172)	(0.0172)	(0.0172)
N	5726	5726	5726	5726	5726	5726	5726	5726
AIC	10654.4238	10641.7670	10632.8691	10645.7479	10637.3600	10650.7139	10647.1820	10638.9547
BIC	10933.8403	10927.8362	10925.5911	10931.8171	10930.0820	10936.7831	10939.9040	10944.9822

Robust standard errors in parentheses.
$^*p < 0.10$, $^{**} p < 0.05$, $^{***} p < 0.01$.

the share of different firm partner types, I take this argument into account by using only collaborations classified as research alliances. The corresponding results are presented in Tables A4 and A5 in the appendix. The results for *Sh. Firm Partners* and *Sh. Pharma Partners* are qualitatively largely similar to the results of the original analysis. However, the results for *Sh. Biotech Partners* are less robust than in the original analysis.

As the number of authors may be correlated with the share of different firm partner types, for an additional analysis, I exclude articles with very large author teams. More specifically, articles at the upper end of the distribution in terms of the number of authors (articles with more than 12 authors) were excluded in this robustness check.[5] The corresponding results are qualitatively similar to the results of the original analysis.

In an auxiliary analysis, I further evaluate whether the size of industry partners, and hence, the availability of additional resources for research, drive the link between the share of pharmaceutical firms among the alliance partners of universities and research institutes and journal reputation. More specifically, I calculate the share of alliance partners that belong to the world's 50 biggest pharmaceutical or biotechnology firms according to the Pharmaceutical Executive (2009). The corresponding results suggest that the share of partners classified as big pharmaceutical or biotechnology firms has an inverted u-shaped relationship with reputation for *SNIP* and *IPP*. As the number of author affiliations involved in an academic article may influence the results, I conduct an auxiliary analysis on a sub-sample consisting of academic articles of authors from one single affiliation. The corresponding results for *Sh. Pharma Partners* are qualitatively similar to the original results, whereas in this particular subsample, the results for *Sh. Firm Partners* and *Sh. Biotech Partners* suggest a linear rather than a curvilinear relationship to *IPP* or *SNIP*.

Discussion and conclusions

The existing literature has predominantly analysed collaborations between academic institutions, such as universities and research institutes, and firms from the firm perspective. This literature suggests that firms benefit from these collaborations because they obtain access to scientific knowledge that, once integrated into the firm's knowledge base, aids firms in solving scientific and technological challenges and achieving their corporate objectives by exploiting knowledge that originated in academia in their commercial activities (Bekkers et al., 2008; Perkmann et al., 2013). While this literature suggests firm core businesses benefit from collaborations with academia, there has been much less emphasis on analysing whether collaborations with industry partners benefit university and research institute core activities – scientific publications. This study addresses this gap in the literature by exploring whether the scope of (formal) collaborations with different types of alliance partners is associated with the reputations of university or research institute scientific publications.

The empirical analysis is based on a unique sample of publications related to biopharmaceutical cancer research, and suggests that the share of formal collaborations with industry partners has an inverted u-shaped relationship with the reputation of the journal the corresponding article is published in. Hence, the share of R&D alliances with industry partners has a positive relationship with reputation, up to a threshold. However, if the scope of collaborations with industry partners becomes too high, in other words, the share of alliances with firms exceeds the threshold, the returns in terms of publishing in reputable journals become negative.

The initially positive association between the share of collaborations with industry partners and the reputation of the journal an article originating in an academic institution is published in can be interpreted based on the existing literature. Initially, universities and research institutes benefit from the inflow of new knowledge and research ideas, as well as from additional resources that may become available through a moderate share of formal collaborations with industry partners (D'Este & Perkmann, 2011; Melin, 2000; Meyer-Krahmer & Schmoch, 1998). Pharmaceutical firms in particular can provide additional (financial) resources that can be invested in research (Gulbrandsen & Smeby, 2005; Lee, 2000). Some firms have world-class R&D labs that contribute to basic research and provide valuable knowledge via partnerships with academic institutions (Rosenberg, 1991).

Based on this literature, I suggest that publications originating in academic institutions can benefit from a moderate share of collaborations with industry partners through three mechanisms. First, collaborations with industry partners can inspire new research questions based on problems firms face in their R&D activities. These problems can stimulate research in areas that have not previously been the focus of academic research and are of interest to highly reputable journals. Second, industry partners can contribute in-depth knowledge in their areas of expertise. Although the results for biotechnology firms are somewhat less robust than the results for pharmaceutical firms, the nature of firm R&D activities suggests that predominantly biotechnology companies support the novelty of academic research. Hence, collaborations with industry partners are associated with the novelty of academic research projects that are particularly attractive to well-respected journals. Third, industry partners provide additional resources that can be invested in a research project's quality, which makes a study more appealing to highly reputable journals. Due to the size of their R&D endeavours, additional financial and knowledge resources are likely to be the main contribution of pharmaceutical companies to academic research, although they can also support development of new research questions.

However, if the share of collaborations with industry partners becomes too large, the association with the reputation of the journal an article is published in becomes negative. The existing literature suggests that collaboration with industry partners frequently implies restrictions and controls with respect to communicating results and sharing data (Blumenthal et al., 1996; Stephan, 2012). In addition, collaborations with industry partners may reduce the attention and time effectively spent on academically promising research projects (Banal-Estañol et al., 2015).

To interpret this study's results, the findings in the existing literature suggest that academic institutions are more likely to face communication restrictions as the share of industry partners increases. These communication restrictions can reduce a study's scientific quality and soundness, as they may reduce opportunities to obtain feedback for improving a study through sharing and discussing results within the academic community. In addition, a study's quality may suffer if attention is drawn away from a project's actual research tasks due to the increasing complexity of managing alliances and their contractual terms. In addition, a large proportion of collaborations with (biotechnology) firms are likely to require managing diverse knowledge inflows and research ideas that draw attention away from the underlying research. A high proportion of alliances with pharmaceutical firms may lead to dependence on the resources they provide. To maintain and attain additional resources, research project design must focus on the interests of pharmaceutical firms. These interests may be of a more applied nature, which makes it difficult to publish in highly reputable journals as they predominantly focus on basic research (Seglen, 1997).

Based on these results, academic institutions and their individual researchers must be mindful of the potential consequences of formal collaborations with firms on their publication outputs. Since these outputs are increasingly used as measures of scientific achievement by governments as well as other public and private bodies, a moderate scope of collaborations with industrial partners can be beneficial in supporting publications in journals that have high reputations. However, academic institutions need to be aware that the relationship between collaborations with industry partners and publication outputs in terms of journal reputation may become negative after a certain threshold. Hence, it is important to design a portfolio of collaborations that balances different partner types and allows building on the specific contribution each type makes to academic research activities.

While this research provides some insights into the relationship between (formal) collaboration activities with industry partners in research projects originating in universities and research institutes and the reputation of the associated publications, it has some limitations that may be addressed in future research. This study has identified correlations, but the underlying data does not allow for identification of causal effects. This limitation may be addressed in future research. Moreover, future research may look at the phenomenon from different perspectives, for example, from the perspective of individual researchers or research groups involved in strategic alliances and other forms of collaboration with industry partners.

This study has focused on a science-based industry that is well known for intense collaborations between academic institutions and firms. It would be interesting to study whether findings similar to those of this study can be found in other contexts. While this study has focused on strategic alliances as a formal form of collaboration with firms, future research may also consider informal ways of collaboration. In this context, future research should assess which contributions specific partners make to academic research and how these contributions are linked to publications in academic journals. Finally, it must be acknowledged that, despite their importance, publications are only a partial indicator of knowledge generation. Hence, future research may study the relationship between collaboration with industry partners and different types of scientific outputs. This future research may include analyses that assess the importance of collaboration with industry partners to generate patents that originate in academic institutions and the use of these patents in industrial applications. Another avenue for future research may address whether collaboration with industry partners helps academic institutions attract additional research funding from other sources and how this relates to academic publication activities. Despite these limitations, this study should be seen as a starting point, encouraging further research on whether and how collaborations between academia and different types of firm partners are associated with the scientific output of universities and research institutes.

Notes

1. Table A1 in the appendix provides an overview of the medical indications used to build the dataset.
2. http://www.journalindicators.com/.
3. The main analyses build on alliance data from 2000 to 2007 whereas a robustness check uses data from 1998 to 2007.
4. Hence, alliances concluded in the years 2005, 2006, and 2007 are used to calculate Num. Partners for articles published in 2008.
5. It should be noted that around 95% of the articles in the dataset have 12 or fewer authors.

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Appendix

List of medical indications

Table A1. 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
Haematological Cancer	Prostate Cancer
Kaposi Sarcoma	Radiation Related
Kidney Cancer	Soft Tissue Sarcoma
Leukaemia	Solid Tumors

Variable description, summary statistics, and correlations

Table A2. Variable description.

IPP	Impact per publication
SNIP	Source normalised impact per paper
Sh. Firm Partners	Share of firm partners of author affiliations in strategic R&D alliances in the three years before an article is published.
Sh. Pharma Partners	Share of pharmaceutical firm partners of author affiliations in strategic R&D alliances in the three years before an article is published.
Sh. Biotech Partners	Share of biotechnology firm partners of author affiliations in strategic R&D alliances in the three 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 A3. Summary statistics and correlations.

		N	Mean	SD	Min.	Max.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1)	SNIP	5726	1.1226	0.6590	0.00	5.8020	1.0000								
(2)	IPP	5726	3.9755	3.2231	0.00	27.6890	0.9417***	1.0000							
(3)	Sh. Firm Partners	5726	2.4733	9.0204	0.00	66.6667	0.0809***	0.1027***	1.0000						
(4)	Sh. Pharma Partners	5726	1.5860	7.0200	0.00	50.0000	0.0733***	0.0944***	0.8327***	1.0000					
(5)	Sh. Biotech Partners	5726	0.8786	4.9771	0.00	50.0000	0.0432**	0.0532***	0.6287***	0.0991***	1.0000				
(6)	Num. Authors	5726	6.3809	3.3332	1.00	63.0000	0.2005***	0.2221***	0.0355**	0.0287*	0.0177	1.0000			
(7)	Num. Countries	5726	1.2269	0.5088	1.00	5.0000	0.1409***	0.1377***	0.0875***	0.0814***	0.0377**	0.2328***	1.0000		
(8)	Basic Research	5726	0.5070	0.5000	0.00	1.0000	0.1852***	0.3147***	0.0468***	0.0414**	0.0282*	0.0278*	0.0305*	1.0000	
(9)	Top University	5726	0.3823	0.4860	0.00	1.0000	0.2043***	0.2145***	0.1231***	0.1216***	0.0494***	0.0421**	0.1500***	0.0735***	1.0000

*p < 0.10, ** p < 0.05, *** p < 0.01.

Results for research alliances

Table A4. Firm partner types and IPP for research alliances.

Dependent Variable: IPP	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Sh. Firm Partners		0.0189***	0.0664***					
		(0.0051)	(0.0162)					
Sh. Firm Partners^2			−0.0012***					
			(0.0004)					
Sh. Pharma Partners				0.0230***	0.0759***			0.0680***
				(0.0066)	(0.0205)			(0.0221)
Sh. Pharma Partners^2					−0.0013***			−0.0012**
					(0.0005)			(0.0005)
Sh. Biotech Partners						0.0138	0.0804***	0.0278
						(0.0084)	(0.0309)	(0.0326)
Sh. Biotech Partners^2							−0.0017**	−0.0005
							(0.0007)	(0.0007)
Num. Authors	0.1827***	0.1823***	0.1810***	0.1822***	0.1810***	0.1828***	0.1819***	0.1809***
	(0.0198)	(0.0197)	(0.0196)	(0.0197)	(0.0197)	(0.0198)	(0.0197)	(0.0196)
Num. Countries	0.3271***	0.3014***	0.2782***	0.3043***	0.2817***	0.3226***	0.3144***	0.2806***
	(0.1064)	(0.1074)	(0.1079)	(0.1072)	(0.1081)	(0.1066)	(0.1069)	(0.1081)
Basic Research	1.6990***	1.6886***	1.6831***	1.6865***	1.6807***	1.6983***	1.6931***	1.6801***
	(0.1041)	(0.1040)	(0.1038)	(0.1041)	(0.1040)	(0.1041)	(0.1039)	(0.1039)
Top University	1.1154***	1.0740***	1.0910***	1.0775***	1.0992***	1.1080***	1.1085***	1.0941***
	(0.0844)	(0.0859)	(0.0860)	(0.0859)	(0.0861)	(0.0845)	(0.0846)	(0.0863)
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Scientific Area Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Medical Indication Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	1.7851***	1.7971***	1.7850***	1.8248***	1.8145***	1.7690***	1.7360***	1.7946***
	(0.2916)	(0.2913)	(0.2910)	(0.2917)	(0.2914)	(0.2923)	(0.2929)	(0.2936)
Sigma	2.8524***	2.8476***	2.8442***	2.8476***	2.8448***	2.8517***	2.8499***	2.8444***
	(0.0818)	(0.0818)	(0.0817)	(0.0818)	(0.0818)	(0.0818)	(0.0817)	(0.0818)
N	5726	5726	5726	5726	5726	5726	5726	5726
AIC	28313.3559	28296.0421	28284.4117	28296.2196	28286.8117	28312.4842	28307.5029	28289.4367
BIC	28592.7724	28582.1113	28577.1337	28582.2888	28579.5337	28598.5534	28600.2248	28595.4642

Robust standard errors in parentheses.
*$p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A5. Firm partner types and SNIP for research alliances.

Dependent Variable: SNIP	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Sh. Firm Partners		0.0030***	0.0133***					
		(0.0010)	(0.0034)					
Sh. Firm Partners^2			−0.0003***					
			(0.0001)					
Sh. Pharma Partners				0.0034**	0.0144***			0.0122***
				(0.0013)	(0.0043)			(0.0047)
Sh. Pharma Partners^2					−0.0003***			−0.0002**
					(0.0001)			(0.0001)
Sh. Biotech Partners						0.0028	0.0171**	0.0079
						(0.0019)	(0.0068)	(0.0074)
Sh. Biotech Partners^2							−0.0004**	−0.0002
							(0.0001)	(0.0002)
Num. Authors	0.0347***	0.0346***	0.0343***	0.0346***	0.0344***	0.0347***	0.0345***	0.0343***
	(0.0041)	(0.0041)	(0.0041)	(0.0041)	(0.0041)	(0.0041)	(0.0041)	(0.0041)
Num. Countries	0.0826***	0.0786***	0.0735***	0.0792***	0.0745***	0.0817***	0.0800***	0.0743***
	(0.0227)	(0.0229)	(0.0230)	(0.0229)	(0.0231)	(0.0228)	(0.0228)	(0.0231)
Basic Research	0.2304***	0.2288***	0.2276***	0.2286***	0.2274***	0.2303***	0.2292***	0.2272***
	(0.0231)	(0.0231)	(0.0231)	(0.0231)	(0.0231)	(0.0231)	(0.0231)	(0.0231)
Top University	0.2366***	0.2301***	0.2338***	0.2310***	0.2355***	0.2352***	0.2353***	0.2344***
	(0.0179)	(0.0182)	(0.0182)	(0.0182)	(0.0182)	(0.0179)	(0.0179)	(0.0182)
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Scientific Area Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Medical Indication Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	0.7521***	0.7540***	0.7514***	0.7580***	0.7559***	0.7489***	0.7418***	0.7506***
	(0.0637)	(0.0636)	(0.0636)	(0.0637)	(0.0637)	(0.0639)	(0.0641)	(0.0643)
Sigma	0.6088***	0.6082***	0.6075***	0.6083***	0.6077***	0.6086***	0.6083***	0.6076***
	(0.0172)	(0.0172)	(0.0172)	(0.0172)	(0.0172)	(0.0172)	(0.0172)	(0.0172)
N	5726	5726	5726	5726	5726	5726	5726	5726
AIC	10654.4238	10645.7849	10633.7693	10647.1569	10638.2706	10653.8955	10648.8139	10640.3352
BIC	10933.8403	10931.8542	10926.4913	10933.2261	10930.9926	10939.9647	10941.5359	10946.3627

Robust standard errors in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.