



Why do firms publish? A systematic literature review and a conceptual framework

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ABSTRACT

In this paper, we address the question of ‘*Why do firms publish scientific papers?*’. Research examining the competitive advantages that firms accrue from investment in R&D has provided evidence that such efforts can be associated with the voluntary disclosure of research findings in scientific publications. This form of scientific openness occurs despite potentially undermining the value-capturing process by generating knowledge spillovers and hindering the use of other instruments for protecting intellectual property (patents and secrecy). Our understanding of what leads firms to engage in scientific publishing remains relatively limited, however. We address this gap by presenting a systematic review of 164 studies examining firm publishing. We then develop a conceptual framework that outlines five incentives for firms to engage in publishing: (i) accessing external knowledge and resources; (ii) attracting and retaining researchers; (iii) supporting IP strategies; (iv) building the firm's reputation; and (v) supporting commercialization strategies. Mechanisms that relate incentives to publish to firms' major stakeholders – i.e. academia, industry, investors, users, and institutions – are also outlined in the framework. We conclude by setting out an agenda for future research.

1. Introduction

Why do firms disclose the outcomes of their R&D efforts in scientific publications? Since the 1990s, research has yielded extensive empirical evidence that firms publish many of their R&D results in scientific journals (e.g. Arora et al., 2018; Godin, 1996; Hicks et al., 1994; Narin and Rozek, 1988; Tijssen, 2004). Despite the fact that these disclosures can generate unintended knowledge spillovers and hinder firms' ability to fully capture the returns from their R&D (Arrow, 1962; Dasgupta and David, 1994; Nelson, 1959), we lack a systematic understanding of what incentives underlie the decision by firms to engage in scientific publishing. This paper aims to address this gap by developing a conceptual framework that outlines the incentive structure for private organisations to disclose the outcomes of their R&D efforts in scientific publications.

Scholars in science policy and innovation studies, economics of innovation, and the management of technology and innovation more generally have devoted much effort to understanding the R&D process

(e.g. Audretsch and Feldman, 1996; Griliches, 1979; Jaffe, 1986; Mansfield, 1968). Within this body of literature, the ‘R’ element has also received considerable attention. Research has explored the motivations for private organisations to invest in basic research, and the productivity gains that derive from this investment as a consequence of better access to upstream knowledge sources (Gambardella, 1992; Nelson, 1959; Rosenberg, 1990) and an enhanced capacity to absorb external knowledge (Cohen and Levinthal, 1990; Cockburn and Henderson, 1998). A few empirical studies have provided evidence that private investment in basic research can also be associated with scientific openness, in particular with firms disclosing knowledge of potential commercial value in scientific publications (e.g. Arora et al., 2018; Hicks et al., 1994; Koenig, 1983; Narin and Rozek, 1988; Tijssen, 2004). This phenomenon extends beyond science-based sectors (e.g. Csomós and Tóth, 2016; Godin, 1996; McMillan et al., 2014; Simeth and Raffo, 2013), and has been found to have a positive impact on firms' innovative outcomes (Almeida et al., 2011; Cassiman et al., 2008; Jong and Slavova, 2014)

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and market value (Pellens and Della Malva, 2018; Simeth and Cincera, 2016).

The conceptual work by Hicks (1995) can be considered as perhaps the first attempt to examine systematically what motivates firms to engage in the production of scientific publications. This seminal study argued that firms decide on what knowledge to disclose, and that scientific publishing enables firms to signal their tacit (unpublished) knowledge, to build sufficient credibility to engage with the academic research community, to retain and recruit leading researchers since contributing to publications is a rewarding activity for many individuals (e.g. with regard to building their technical reputation, or helping them when changing jobs), and to fulfil regulatory requirements in some industries. More recent work has added to these motivations, suggesting that the academic background of founding members (Ding, 2011), threats of product substitution (Polidoro and Theeke, 2012), opportunities to exclude competitors from patent races (Baker and Mezzetti, 2005), complementarity between patents and publications as value-appropriation mechanisms (Gans et al., 2017), and low levels of knowledge spillovers and effective appropriability regimes (Simeth and Raffo, 2013) are all factors that may contribute to a firm's decision to publish in scientific journals. Although the literature examining firm publishing has considerably grown since Hicks's (1995) conceptual work, our understanding of the incentive structure that underlies a firm's decision to engage in disclosure in scientific journals remains rather fragmented. While Hicks's (1995) article was produced at a time when there were few empirical studies on the phenomenon, more recent research has often examined the motivations for firms to publish not as the main focus of investigation, but in relation to other industrial and firm-level dynamics (e.g. the innovative and financial performance of firms, the development of research capabilities, university-industry collaborations) and drawing on a range of theories, frameworks, and concepts. These include studies building on institutional theory (Gitelman and Kogut, 2003; Nelson, 2016; Sauermann and Stephan, 2013), signalling theory (Polidoro, 2013; Spencer, 2001), the resource-based view of the firm (Alexy et al., 2013; Tijssen, 2004), economics of science (Sauermann and Roach, 2014; Stern, 2004), absorptive capacity (Arora et al., 2018; Simeth and Cincera, 2016), and open science (Ding, 2011; Simeth and Raffo, 2013). As a result, we still lack a fine-grained and comprehensive understanding of what incentives lead firms to engage in disclosure in the form of publications in scientific journals.

Our paper attempts to fill this gap by addressing the question of 'Why do firms publish scientific papers?'. We develop a conceptual framework of firms' incentives to pursue scientific publications on the basis of a systematic review of 164 studies on the theme. Five categories of incentives constitute the 'pillars' of this framework. These are: (i) accessing external knowledge and resources; (ii) attracting and retaining researchers; (iii) supporting IP strategies; (iv) building the firm's reputation; and (v) supporting commercialization strategies. The framework builds on previous research on firm publishing and links the five incentives to a number of firms' stakeholders – i.e. academia, industry, investors, users, and institutions – on the basis of a variety of mechanisms (e.g. stimulating collateral research, signalling discoveries and competences, extending patent races, supporting regulatory approval).

The remainder of the paper is organised as follows: Section 2 describes the method and data of our review; Section 3 outlines the five categories of incentives for firms to engage in scientific publishing and the resulting conceptual framework; Sections 4 presents an agenda for future research; Section 5 concludes.

Table 1

Search terms to identify studies examining firm publishing.

Terms		
	corporate science disclos* knowledge knowledge disclos* selective revealing strategic publi**	
company companies corporate* firm* industr* multinational* R&D research & development research and development sector*	Within 7 words	academi* article* academi* paper* academi* output* academi* research academi* knowledge basic research conference article* conference paper* conference proceedings meeting abstract* open science proceedings article* proceedings paper* publication* publishing scien* article* scien* paper* scien* output* scien* research scien* knowledge

Notes: * represents the wildcard to account for a term variation. 'Within 7 words' indicates that the two groups of terms could be separated by no more than seven words; we tested for searches with a larger (or smaller) number of words between groups of keywords, but these searches retrieved a larger proportion of false positives (or excluded some true positives).

Source: Authors' elaboration.

2. Review: methods and data

In this section, we will first describe the search strategy and the inclusion criteria we develop to identify studies examining firm publishing. We will then present descriptive statistics of this literature and outline the main emerging lines of research. We will conclude by describing the coding process we performed to delineate firms' incentives to publishing.

2.1. Search strategy and sample

We examine research on firm publishing by adopting a systematic review approach to ensure replicability in the selection and review of the studies. The review process involves few stages: from sampling and selecting studies relevant to the review, to coding and synthesizing this research work (Tranfield et al., 2003). We first identified studies on firm publishing on the basis of the keywords outlined in Table 1. These terms were searched in the titles, abstracts, and lists of keywords of publication records indexed in the Web of Science (WoS) Core Collection. Our query returned an initial sample of 7805 articles and reviews in the English language – the full query is reported in the Appendix A.

Our search strategy aimed to maximize the recall of potentially relevant studies, in order to obtain a comprehensive representation of the literature on firm publishing. The initial sample of studies therefore included a relatively large number of false positives. To address this issue, we developed three inclusion criteria that we assessed by examining the abstracts and, when necessary, the full text of publications.

More precisely, a study was included in the review if the study met at least one of the following criteria: (i) it analyses the scientific publication activity of firms or industrial sectors; (ii) it develops publication-based indicators to characterise certain dimensions of a firm's R&D activity (e.g. R&D capabilities, firm-university collaborations); or (iii) it makes explicit reference to incentives for firms to engage in scientific disclosure. It is worth noting that we excluded from the review studies that focused on understanding firms' involvement in basic research but without explicitly considering the activity of publishing (a classic example of this is Rosenberg, 1990). This process led to a sample of 118 studies from which we identified a further 46 relevant studies from the lists of cited references.¹ Therefore, our review is based on a total sample of 164 studies.

2.2. An overview of extant research

Research interest on firm publishing has grown in the last two decades (Fig. 1): 81.7 % of the 164 studies in the sample were published from the year 2000 onwards. These contributions are included in 68 academic journals with *Research Policy*, *Scientometrics*, and *Industrial and Corporate Change* being the most frequent journals (Table 2). The sample of journals is distributed across a broad range of research fields (see Table S1 in the Appendix C), thus suggesting that firm publishing has been examined from a variety of research perspectives, but also pointing to the need to systematize a literature that remains relatively fragmented.

The largest majority of studies examined firm publishing from an empirical perspective (80.5 %), while the remaining studies focussed on conceptual aspects of the phenomenon (16.5 %) or on the development of economic models (3.0 %). More than half of the empirical studies (55.0 %) examined the private contribution to scientific publishing at the level of the firm, while the remainder focused on other units of analysis (e.g. collaborations, individual researchers, sectors, publications, patents, publication-patent pairs).

A very limited number of empirical studies at the level of the firm examined industrial contributions to scientific publishing using samples covering multiple sectors and countries (see Table 3). The largest proportion of studies focussed on a single sector (68.1 %) or country (72.2 %). Single-sector studies analysed firm publishing in industries characterised by relatively high levels of R&D intensity, such as pharmaceuticals, biotechnology, and chemicals, while single-country studies have built mostly on samples of firms located in Japan, the United States, or the United Kingdom. With few exceptions (Belenzon and Pataconi, 2014; Csomós, 2017; Csomós and Tóth, 2016), studies examining firms' publishing on the basis of global and multi-sector samples of firms rely on relatively small samples (<200 firms) from no more than three sectors (Godin, 1996; Hicks et al., 1996; Lim, 2004).

The review of the literature on firm publishing reveals three interconnected research streams. First, considerable effort has been made to map and characterise firm publishing (e.g. Hicks et al., 1994; Narin and Rozek, 1988; Tijssen, 2004) – related studies are summarized in Table B1 in Appendix B. While pioneering studies provided evidence of an increasing contribution of firms to scientific publishing (Godin, 1996; Halperin and Chakrabarti, 1987), more recent research efforts have suggested that this contribution has declined as a result of firms relying more extensively on public institutions' basic research (Arora et al., 2018; Rafols et al., 2014; Tijssen, 2004). Yet whether firm publishing is in decline or not remains an open question as growth is observed in certain industries (Pellens and Della Malva, 2018; Sachini et al., 2020)

and research areas (Liu et al., 2020; Hartmann and Henkel, 2020).

Mapping efforts have also examined co-authorship data to trace firms' boundary-spanning activities in the scientific community (e.g. university-industry linkages) and R&D collaboration networks (e.g. Abramo et al., 2009; Hicks et al., 1996; Liebeskind et al., 1996; Tijssen, 2009; Tijssen and Korevaar, 1997). The analysis of citation data, in contrast, has revealed that a considerable proportion of references in firms' publications are to publications produced by public institutions (McMillan and Hamilton, 2000; Tijssen and Van Leeuwen, 2006) as well as that firms' publications can exert an impact on subsequent R&D activities similar to, or in some cases superior to, publications generated by universities (Narin and Rozek, 1988; Spencer, 2001).

It is worth highlighting that the group of studies that have contributed to mapping firms' involvement in the production of scientific publications also comprises studies that have relied on publication data to examine phenomena related in some respect to firm publishing. These include studies using publication records to map knowledge co-creation in clusters (Moodysson, 2008) and firms' R&D strategies (Ramani, 2002), to delineate samples of industrial researchers (Rappa and Debackere, 1992; Debackere and Rappa, 1994), to identify 'core scientists' within firms (Furukawa and Goto, 2006a, 2006b), and to analyse the links between firms and 'star scientists' (Hess and Rothaermel, 2011).

Second, research has examined the implications of publishing for firms' performance – related studies are summarized in Table B2 in Appendix B. This line of research has provided evidence that a firm's publishing activity is positively correlated with the firm's innovative output as reflected in the number of forward citations that the firm's patents receive (Arora et al., 2018; Gambardella, 1992; Halperin and Chakrabarti, 1987), the scope of these citations (Cassiman et al., 2008), and the number of patent families granted to the firm (Almeida et al., 2011). The industry context (Lim, 2004), the presence of 'bridging scientists' in the firm (Gittelman and Kogut, 2003), and the collaboration with 'star scientists' (Zucker et al., 2002) contribute to explain this relationship. A positive relationship also exists between firm publishing and financial performance in terms of market valuation (e.g. Decarolis and Deeds, 1999; Pellens and Della Malva, 2018; Simeth and Cincera, 2016). However, recent studies have suggested that the private benefits that firms extract from internal research (as measured by the levels of scientific publishing) have declined over time (Arora et al., 2018).

Finally, research on firm publishing has examined the process of scientific disclosure – related studies are summarized in Table B3 in Appendix B. Scientific disclosure by firms has been analysed adopting the lens of open science, whereby the process of knowledge accumulation relies on disclosure and diffusion of knowledge for other researchers to build on (Dasgupta and David, 1994). When knowledge falls within the so-called Pasteur's Quadrant (Stokes, 1997), i.e. when it has both scientific and commercial potential, conflicting institutional logics and major challenges in achieving an effective balance between openness and appropriation can emerge (Kinney et al., 2004; Nelson, 2016; Sauerermann and Stephan, 2013; Schmitt, 1961; Simeth and Lhuillery, 2015). Within this research stream, studies have identified a number of factors that make a firm more likely to disclose knowledge in scientific publications. These include the presence of founding members with an academic background (Ding, 2011), the existence of products that can substitute for the firm's own product (Polidoro and Theeke, 2012), complementarity between patents and publications as mechanisms for capturing value (Gans et al., 2017), an effective appropriability regime with low levels of knowledge spillovers (Simeth and Raffo, 2013), uncertainty in the selection of partners and high cost of knowledge search (Alexy et al., 2013), and the availability of government funding to collaborate with academic researchers (Chai and Shih, 2016). This line of research has also outlined how scientific openness is a critical element of a firm's IP strategy to affect prior art. Strategic scientific disclosures, namely *defensive publishing*, can exert a major impact on patent races (e.g. Bar, 2006; Della Malva and Hussinger, 2012; Johnson, 2014;

¹ Most of the studies that were snowballed from the initial sample included, in their full text, at least one of the keywords reported in Table 1. However, these studies were not identified by our query since WoS searches do not extend to the full text of publications. It is also worth noting that we excluded papers included in working paper series in our selection process.

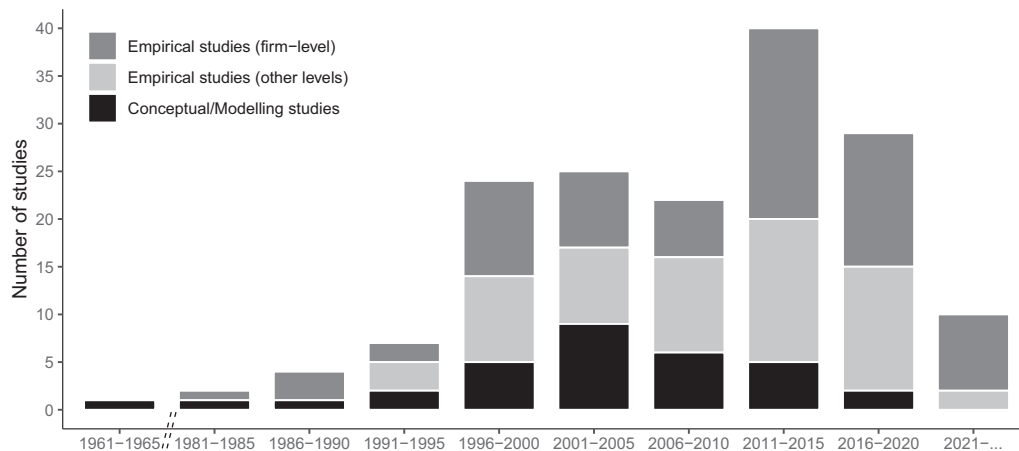


Fig. 1. Studies on firm publishing included in the review by type (N = 164).

Source: Authors' elaboration.

Table 2

Number of studies examining firm publishing by journal (N = 164).

Journal	Number of studies	Proportion of studies
Research Policy	31	18.9 %
Scientometrics	23	14.0 %
Industrial and Corporate Change	7	4.3 %
Research Evaluation	6	3.7 %
Management Science	5	3.0 %
R&D Management	5	3.0 %
Strategic Management Journal	5	3.0 %
Organization Science	4	2.4 %
Drug Discovery Today	3	1.8 %
Journal of Technology Transfer	3	1.8 %
Technology Analysis & Strategic Management	3	1.8 %
Academy of Management Journal	2	1.2 %
Academy of Management Perspectives	2	1.2 %
European Management Review	2	1.2 %
IEEE Transactions on Engineering Management	2	1.2 %
Industry and Innovation	2	1.2 %
Journal of Economic Behavior & Organization	2	1.2 %
Journal of Economics & Management Strategy	2	1.2 %
Journal of Informetrics	2	1.2 %
Journal of Product Innovation Management	2	1.2 %
Michigan Law Review	2	1.2 %
Science and Public Policy	2	1.2 %
Technological Forecasting and Social Change	2	1.2 %
Other journals (<2 studies)	45	27.4 %
Total	164	100.0 %

Source: Authors' elaboration.

Table 3

Firm-level studies examining firm publishing by sector and country focus (N = 72).

		Country		All studies
		Single	Multi	
Sector	Single	35	14	49 (68.1 %)
	Multi	17	6	23 (31.9 %)
	All studies	52 (72.2 %)	20 (27.8 %)	72 (100.0 %)

Source: Authors' elaboration.

Parchomovsky, 2000; Sternitzke, 2010). We will discuss this phenomenon more in detail later in the paper.

Despite the fact that research on firm publishing has significantly increased our understanding of the process of scientific disclosure, limited efforts have been made to outline the incentive structure that triggers scientific disclosure by firms. Our paper seeks to fill this gap on the basis of the systematic review of extant literature on firm publishing.

2.3. Delineating incentives for firms to publish

We examined the studies in our sample to identify research work that discussed incentives for firms to disclose knowledge in scientific publications. We used a thematic coding approach (Miles et al., 1994). First, we performed a microanalysis (Strauss and Corbin, 1998), sentence by sentence, of the full text of all the studies in the sample to identify quotes outlining or providing evidence (for example, by citing previous research works) on what motivates firms to engage in the production of scientific publications, i.e. quotes addressing our core research question ‘Why do firms publish scientific papers?’

Second, we generated a list of first-order codes by standardising the quotes extracted from the studies in our sample. In this process, we maintained first-order codes as close as possible to the language used in the corresponding quotes to preserve information potentially relevant to the understanding of firm publishing (e.g. actors, processes, outcomes) and to the subsequent consolidation of these codes into higher-level codes. We identified 427 first-order codes extracted from 95 out of the 164 studies in our sample, i.e. 57.9 % of the studies discussed or referred to at least one motivation for firms to disclose scientific knowledge in publications.

Third, we compared and contrasted first-order codes to collapse them into more abstract conceptual categories. This process was carried out separately by the members of the research team, but it was also iterative since we regularly met to compare and harmonise emerging categories. We revisited the literature to resolve any discrepancy in the coding structure.² This process led to some broad and some specific codes (e.g. Grodal, 2018; Saldaña, 2013). Broad codes described, in

² Our coding process built on many iterations and is of an emergent nature. We were therefore not able to assess the interrater reliability. However, the systematic approach undertaken to code the studies in our sample and the diversity of perspectives provided by the coders aimed to minimize the risk of introducing a bias in our analysis (e.g. Ladge et al., 2012; Smith et al., 2019).

general terms, what motivates a firm to engage in scientific publishing,³ while specific codes provided more detailed explanations of these motivations. For example, some studies argued that firms engage in publishing to ‘access external knowledge and resources’ (broad code), others pointed out that publishing allows a firm to ‘stimulate an open culture among competitors/suppliers’, hence, to access knowledge and resources that are external to the firm (specific code). This emergent pattern suggests the former as dealing with broader themes related to motivations for firms to publish, while the latter relate more to specific mechanisms (Hernes, 1998) associated with each broader motivation. We also noticed that broad codes clustered around the different phases of a firm's R&D and value-capturing process. As a result, this analysis led to the delineation of five themes or overarching categories of incentives – i.e. (i) accessing external knowledge and resources; (ii) attracting and retaining researchers; (iii) supporting IP strategies; (iv) building the firm's reputation; and (v) supporting commercialization strategies – and 17 mechanisms underlying these categories. The resulting coding structure is reported in Table S2 in the Appendix C. We then used the delineated categories of incentives as lenses to re-examine systematically the literature. This enabled us to cross-validate the coding structure and to identify stakeholder groups involved in each incentive and mechanism. Incentives, stakeholder groups, and mechanisms are the key elements of the conceptual framework that we will present in the next section.

3. Firms' incentives to publish

In this section, we present the five categories of incentives for firms to publish that emerged from the systematic review/coding of the literature along with the corresponding mechanisms. While each category of incentive has sufficient theoretical traction and distinct mechanisms to be considered separate, a certain level of overlap between different categories inevitably exists as a result of the interdependency between the phases of the R&D and value-capturing process. Also, as summarized in Fig. 2, some incentives have been discussed by a larger number of studies, some are mainly mentioned in empirical studies, others have been at the heart of conceptual and modelling work. We conclude this section by presenting a conceptual framework that indicates how each type of incentive relates to firms' major stakeholder groups through the corresponding mechanisms.

3.1. Accessing external knowledge and resources

A considerable number of studies examining firm publishing have argued that firms contribute to scientific articles because this provides access to complementary and geographically dispersed knowledge as well as to knowledge not codified in scientific publications (e.g. Cockburn and Henderson, 1998; Hicks, 1995; Liebeskind et al., 1996; Tijssen, 2009; Zucker et al., 2002). These studies account for 35.4 % of the total sample of studies and are mostly empirical (Fig. 2). In line with the literature on university-industry collaboration, this research refers to upstream knowledge in universities, public research labs, research institutes or more generally research communities and networks. Interactions with other academic and industrial researchers help to improve a firm's capacity to recognize and absorb knowledge as well as to assess the quality and fit of knowledge created elsewhere (e.g. Almeida et al., 2011; Cohen and Levinthal, 1990; Ding, 2011; Simeth and Cincera, 2016; Zahringer et al., 2017). These interactions also include engaging in the co-production of new knowledge with researchers external to the firm. These collaborations expose the firm's researchers to critical learning opportunities to stay at the forefront of a

field (Kinney et al., 2004), and provide them with early access to novel discoveries (Stern, 2004) and technologies that may be critical to the development of new products (Hayter and Link, 2018), while remaining less binding than other forms of inter-organisational relationships such as technological alliances (Alexy et al., 2013; Almeida et al., 2011).

Three mechanisms embody this incentive: (i) *sharing open science norms and values*, (ii) *stimulating collateral research*; and (iii) *nurturing an open culture among competitors/suppliers*. First, publishing is evidence that the firm embraces open science norms and values rather than pursuing non-disclosure and claiming control over the IP of the disclosed knowledge (e.g. Cockburn and Henderson, 1998; Simeth and Raffo, 2013; Tijssen, 2004). The production of scientific knowledge is institutionally constructed and organised. It is governed by a priority-based reward system that rejects non-disclosure and tight control over intellectual property in favour of rapid dissemination and public scrutiny (Dasgupta and David, 1994; Merton, 1957). Also, according to Rosenberg (1990), the performance of basic research can be conceived as an ‘admission ticket’ for a firm to access scientific knowledge and resources that are embedded in academic networks. Scientists are therefore more likely to share information and research material (e.g. data, details on laboratory processes, preliminary research findings) with the firm's researchers when these are expected to reciprocate and are perceived to share the norms and values of open science (Haeussler, 2011). Conversely, the academic community may ‘punish’ the firm's researchers not involved in scientific disclosure by excluding them from the community and scientific networks (e.g. McMillan et al., 1995, 2014; Schmitt, 1961).

Second, a firm's publications can also generate sufficient interest to trigger research organisations to conduct collateral research (Hicks, 1995), thus stimulating the production and accumulation of follow-on knowledge on specific scientific and technical problems the firm faces (e.g. Alexy et al., 2013; Huang, 2017; Nelson, 2016). This mechanism is strategically important when the firm has limited knowledge and resources to investigate specific problems since the firm benefits from lower R&D costs (Archambault and Larivière, 2011; Liebeskind et al., 1996), or the problem might be judged too risky to investigate (Almeida et al., 2011).

Finally, a firm's scientific openness has implications beyond academia. Publishing and other forms of selective revealing can nurture an open culture in the industry in which the firm operates, thus stimulating competitors and suppliers to reciprocate in knowledge sharing and to engage in an open science strategy (e.g. Alexy et al., 2013; Pénin, 2007; Tijssen, 2004). This also discourages firms from not engaging in scientific disclosures since firms engaged in open science may ‘punish’ free riders by halting disclosures for a given time period (Pénin, 2007).

3.2. Attracting and retaining researchers

Human capital represents a critical asset for a firm to perform R&D and to improve its capabilities (e.g. Cohen and Levinthal, 1990; Stephan, 1996). Researchers bring knowledge and capabilities to the R&D process as well as access to social and professional networks that the firm can leverage to establish linkages with other research communities (e.g. Liebeskind et al., 1996; Murray, 2004; Zucker et al., 2002). Publishing could significantly foster a firm's ability to manage human capital, in particular to attract and retain researchers, talents, and new promising graduates (e.g. Gittelman and Kogut, 2003; Hicks, 1995; Pénin, 2007; Stern, 2004; Schmitt, 1961). This incentive is discussed in 33.5 % of the complete sample of studies, with the majority of those research works being empirical (Fig. 2).

Four mechanisms underlie this incentive: (i) *demonstrating researchers' capabilities*, (ii) *accumulating social capital*, (iii) *extracting wage discounts*, and (iv) *monitoring researchers' performance*. First, engagement in scientific disclosure helps a firm's researchers to demonstrate their capabilities and to gain a technical reputation and prestige in their epistemic communities (e.g. Hayter and Link, 2018; Merges, 2004;

³ This was often the case of studies making statements about motivations for firms to engage in publishing by citing previous research and without elaborating on their statements.

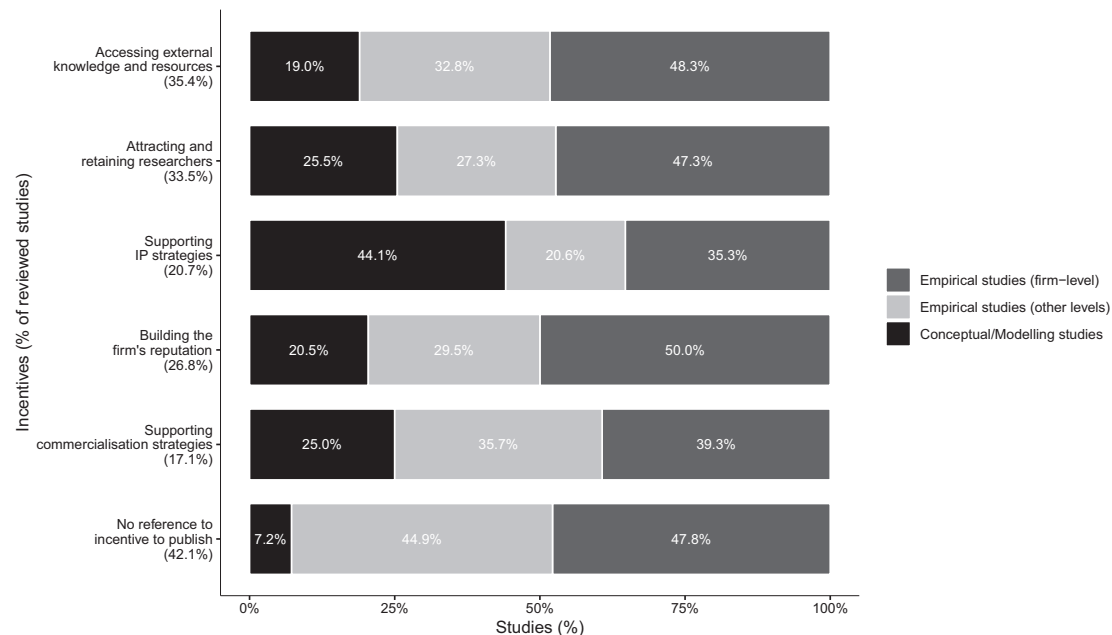


Fig. 2. Studies by type and incentive for firms to publish (N = 164). A study can address more than one incentive.
Source: Authors' elaboration.

Schmitt, 1961). Publishing the results of their research efforts is an “intrinsically rewarding” activity (Hicks, 1995). It fulfils their personal and professional aspirations. Also, a firm that supports publishing is perceived as a *science-minded* employer (Pénin, 2007). Scientific disclosure can therefore be conceived as an in-kind form of compensation for these reputational gains (Lichtman et al., 2000). This facilitates the recruitment and retention of highly regarded researchers (e.g. ‘star scientists’), who, in turn, can attract other talented people eager to work with them (Hess and Rothaermel, 2011; Penders and Nelis, 2011).

Second, and related to the previous mechanism, a firm that allows its researchers to publish some of the outcomes of their research enables these researchers to accumulate social capital within the wider research community as they collaborate with academic scientists and other industrial researchers (e.g. Hsu et al., 2021; Liu and Stuart, 2014; Nahapiet and Ghoshal, 1998; Nelson, 2016). While this allows the firm's researchers to maintain and expand their personal networks, it also provides them with opportunities to build trust with scientists in other research organisations, and hence to access and transfer knowledge that is unpublished and tacit (Furukawa and Goto, 2006a; Hicks, 1995).

Third, a firm that shows openness can also be a way to extract wage discounts. In his seminal work on how a firm's publication strategy can attract talented researchers, Stern (2004) argued that “scientists pay to be scientists”: by analysing a sample of postdoctoral biologists completing a job search, the study found a firm's science orientation to be negatively related to wage levels. This suggests that for some scientists, maintaining a reputation in the scientific community and taking advantage of research opportunities is more important than monetary compensation. In this regard, Sauermann and Roach (2014) found that firms are likely to pay an additional amount, namely the “price of publishing”, when they restrict researchers from publishing the results of their research. This ‘price’ is higher for individuals who consider themselves to be particularly gifted from a research perspective or who have trained in a highly ranked institution.

Finally, publications provide a cost-effective means for monitoring the performance of a firm's researchers as research outputs can be linked with researchers' promotion or financial rewards (e.g. Baker and Mezzetti, 2005; Cockburn and Henderson, 1998; Frederiksen, 2004). Liu and Stuart (2014) found that in the biopharmaceutical industry laboratory employees who publish more receive greater financial compensation (in

the form of year-end bonuses) and greater organisational resources. This mechanism extends beyond a firm's boundaries as publications enable the firm to benchmark its researchers with the performance of researchers in other firms also pursuing an open science strategy and to identify prospective industrial researchers to employ.

3.3. Supporting IP strategies

Various studies have examined publishing as a key component of a firm's strategy to establish legal property rights for their inventions, and to manage and protect its IP portfolio (Godin, 1996; Nelson, 1990). A firm can strategically disclose pre-patenting information in publications to alter prior art, thus de facto limiting or preventing rivals from patenting the disclosed invention. Such a phenomenon has been described as *defensive publishing*⁴ – also referred to as *pre-emptive publication* (Parchomovsky, 2000), *strategic disclosure* or *strategic publication* (Lichtman et al., 2000), and *defensive disclosure* (Bar-Gill and Parchomovsky, 2003). Of the total sample of reviewed studies, 20.7 % refer to this incentive. A significant proportion of these studies are conceptual or present a modelling effort, meaning that this incentive has been empirically examined the least (Fig. 2).

Four mechanisms underlie the structure of this incentive: (i) *extending patent races*, (ii) *reducing expected patent value*, (iii) *broadening patent scope*, and (iv) *preventing the privatization of inventions*. First, a laggard in a patent race can pursue a defensive publishing strategy to extend the patent race (e.g. Baker and Mezzetti, 2005; Barrett, 2002; Parchomovsky, 2000). Defensive publications can push the leading rival to invest additional resources in R&D until sufficient progress has been made over prior art. This investment requires time, thus increasing the laggard's chances of narrowing the technical gap with respect to competitors who were previously ahead in the race. A laggard is more likely

⁴ The main focus of this article is on defensive publishing as observed in the form of scientific publications. Della Malva and Hussinger (2012) provided evidence that a firm's scientific publications challenge the novelty of patent applications more than other forms of defensive publishing that the firm can pursue (e.g. presentations at conferences, articles in technical bulletins, catalogues, leaflets).

to pursue defensive publishing as its chances to leapfrog the leading rival decline (Lichtman et al., 2000), or as the leading firm gets closer to winning the race (Bar, 2006). Such a strategy can, however, be a double-edged sword for the laggard: defensive publications may provide the leading firm with critical information to accelerate its R&D without necessarily reducing the patentability of the invention (Eisenberg, 2000).

Second, the leader of a patent race can pursue a defensive publishing strategy to cause the laggard to race less vigorously or even to force the laggard out of the race (e.g. Baker and Mezzetti, 2005; Lichtman et al., 2000). Disclosures by the leading firm can provide the laggard with key information to reduce the gap, but they also reduce the expected value of the patent the laggard aims to race for or provide the laggard with critical information to estimate the technical gap from the leading firm, possibly encouraging the laggard to abandon the race. The leading firm is, however, less likely to disclose relevant information when the laggard and the leader can reach a private agreement (Parchomovsky, 2000).

Third, selective and strategic scientific disclosures can shape prior art so as to broaden existing patents in terms of technological and geographical scope, thus complementing patenting or trade secrets (e.g. Colson, 2001; Rinner, 2003). Depending on the rate of technological progress in a sector (Arundel, 2001), when a firm holds patents protecting its core inventions, publications around these inventions increase the scope of the associated patents. Publications alter prior art, thus making it more difficult for rivals to patent inventions that represent incremental advances to the firm's core inventions (e.g. obvious extensions or components). In a similar vein, by disclosing knowledge in publications, the firm reduces the patentability of its inventions on a global scale rather than just in the jurisdictions where its patents are granted. Publishing therefore enables the firm to stake out IP rights and protect its inventions without incurring the considerable costs associated with 'blanket-patenting' (Rinner, 2003) and/or 'global patenting' (Colson, 2001). This dual strategy is especially effective when it is relatively easy to invent around the firm's core inventions (Johnson, 2014). It is, however, worth noting that a firm can also strategically combine narrow scope patents with disclosures in publications to reduce the space to invent around patents, thus increasing the licensing revenues (Bar-Gill and Parchomovsky, 2003). With disclosures in publications, the firm gives away secrets and a share of future profits to create incentives for other firms to develop incremental improvements on its original inventions. This, in turn, favours the adoption of the original invention along with the potential licensing revenues associated with it.

Finally, defensive publishing is a cost-effective IP mechanism for a firm to prevent the privatization of its inventions so to exploit freely the outcomes of its R&D or to operate in a market without the threats that rivals may pose (e.g. Johnson, 2014; Parchomovsky, 2000). For example, in 1994, Merck's decision to disclose data on expressed human gene sequences in the public domain prevented the privatization of genes that could otherwise have blocked Merck's subsequent drug development for cardiovascular diseases and cholesterol (Pisano, 2006). Although the costs of keeping the invention secret are also relatively low, secrecy may still not fully protect the firm from losing its freedom to commercialize its invention. Reverse engineering, mobility of researchers, and modern business intelligence tools can provide rivals with the opportunity to obtain patents to exclude the firm from the market (Pénin, 2007) or to prevent it from profiting from litigation (Johnson, 2014). In both cases, defensive publishing enables firms to benefit from their own innovations in several markets in a less costly manner compared to other alternatives.

3.4. Building the firm's reputation

Publishing enables a firm to build up its reputation, thus increasing the firm's prestige, corporate image, and credibility as a knowledge producer and innovator (e.g. Almeida et al., 2011; Arora et al., 2018; Nelson, 1990; Penders and Nelis, 2011). The open nature of

publications, and their relatively ease of access and diffusion, make this form of research output a powerful mean for firms to send a signal that can reach a range of receivers in the wider world. When a reputable scientific journal accepts a firm's article for publication, the journal certifies that the content of the article has been the subject of scrutiny from a credible third party, namely the scientific community. According to signalling theory, this certification generates a signal that provides stakeholders with a proxy of the firm's attributes that would not otherwise be directly observable, hence reducing uncertainty in the process of evaluating the firm (Podolny, 1993; Spence, 1974). This form of incentive is addressed in 26.8 % of the reviewed studies with the majority of these studies being empirical research work (Fig. 2).

Three mechanisms structure this incentive: (i) *signalling discoveries and competences*, (ii) *increasing credibility to access private/public funding*, and (iii) *disseminating scientific and technical standards*. First, publications enable a firm to signal discoveries and competences. These signals reach academic and professional networks, hence increasing the firm's reputation in these communities. Publication enables potential academic and industrial partners (e.g. universities, suppliers, competitors) to draw inferences about the firm's scientific and technological capabilities, quality of scientific findings, and tacit and unpublished knowledge (e.g. Hicks, 1995; Nelson, 1990; Polidoro, 2013; Spencer, 2001).

Second, a firm's publications contribute to establish the credibility needed to access private and public funding (e.g. Arora et al., 2021; Eisenberg, 2000; Hayter and Link, 2018; Nelson, 2016; Stephan, 1996). In line with the previous mechanism, publications signal that the firm is capable of generating knowledge of potential commercial value. This, in turn, can attract capital from investors – such as venture capitalists, stockholders, and shareholders – to fund the firm's future R&D efforts (Eisenberg, 2000). For example, Simeth and Cincera (2016) found evidence of a positive impact of publishing on the firm's market value. In the case of small firms or start-ups, scientific publishing represents a more cost-effective signalling mechanism than patenting to attract the attention of potential investors (Belenzon and Pataconi, 2014). In the same vein, reputational and credibility gains derived from publishing also enable a firm to access financial resources available in the public domain such as grants, subsidies, or contracts from public institutions or funding bodies (e.g. Simeth and Raffo, 2013; Stephan, 1996; Tijssen, 2004).

Finally, a firm can pursue a publication strategy to diffuse its scientific or technical standards (e.g. protocols for clinical trials, products, services) within the wider academic and industrial research communities (e.g. Hartmann and Henkel, 2020; Hsu et al., 2021; Simeth and Raffo, 2013; Tijssen, 2004). Publications signal a firm's scientific proficiency, thus making strategic spillovers more likely and helping the firm to enhance its reputation and prestige to diffuse its innovations (Li et al., 2015; Spencer, 2001). This, in turn, increases the compatibility with related products and reduces the cost of adoption of the firm's innovations, potentially generating network effects and decreasing production costs (Pénin, 2007).

3.5. Supporting commercialization strategies

The last category of incentives for firms to publish concerns the commercialization process. Publications provide 'certified signals' that not only increase a firm's reputation, but also support the firm's commercialization efforts (e.g. Godin, 1996; Nelson, 1990). The open nature of scientific publications signals to prospective customers a firm's new products and/or services and mitigates any uncertainty about the value of these (Podolny, 1993; Spence, 1974). Of the reviewed studies, 17.1 % discussed how scientific disclosures in publications relate to a firm's commercialization strategy. The majority of research contributions on this incentive are empirical, too (Fig. 2).

The following mechanisms support this incentive: (i) *signalling new products and/or services and their quality*; (ii) *supporting claims about products/services*, and (iii) *supporting regulatory approval*. First,

publications signal a firm's products/services and can function as 'certified signals' about the quality of these (e.g. Arora et al., 2021; Huang, 2017; Polidoro and Theeke, 2012). Scientific disclosures provide publicity and generate interest in the firm's products/services so as to accelerate the commercialization process or even open up new markets for the firm (e.g. Bergenholtz, 2014; Simeth and Lhuillery, 2015). This is especially true in the case of 'sophisticated' or 'professional' customers who monitor scientific journals to find suitable and specialized products. For example, publications can stimulate the diffusion of a drug by advertising its effectiveness and safety to doctors and hospitals (e.g. Azoulay, 2002; Hicks, 1995; Simeth and Raffo, 2013; Sismondo, 2012). This strategy is particularly effective when a firm contributes to articles in top-tier journals: doctors and other decision makers are likely to consider the firm's knowledge disclosures and claims in such journals to be more reliable than the information included in the firm's marketing and promotional material (Smith et al., 2005, p.364). It is also worth noting that publications exert different effects on the sales of drugs depending on the type of publication, and the specific drug that the publication is promoting. For instance, Slejko et al. (2018) provided evidence that different types of scientific publications (e.g. clinical evidence, and health economics and outcomes research publications) can be used to promote different types of claims (clinical benefits, and cost-related benefits). This, in turn, affects the purchase decision of different types of stakeholders (e.g. physicians, government and health technology assessment bodies, medical insurance companies), and eventually influences the sales of different types of drugs (characterised by various levels of branded vs. generic competition).⁵

Second, the journal peer-review process to which scientific publications are subject provides credibility to the claims a firm makes about its products and services (e.g. Bergenholtz, 2014; Friesike et al., 2015), hence increasing the likelihood of attracting further investment as well as supporting the diffusion of products and services. In doing so, the firm reduces the uncertainty that surrounds its products as well as the superiority of its products when compared to potential substitutes (Polidoro and Theeke, 2012). Penders and Nelis (2011) examined a leading multinational food company and provided evidence of how the company has engaged in a publication-based strategy of credibility to align the knowledge about their products with the scientific consensus so as to improve the credibility of health claims about its products.

Finally, in some sectors (e.g. pharmaceuticals, biotechnology, chemicals) publishing scientific evidence is instrumental to obtaining approval from regulatory agencies for the commercialization of products (e.g. Azoulay, 2002; Hartmann and Henkel, 2020; Polidoro and Theeke, 2012). Publications provide scientific evidence in support of the claims associated with a firm's products, thus increasing the chances of receiving a positive assessment (e.g. Rafols et al., 2014; Simeth and Raffo, 2013). In the pharmaceutical industry, publishing is part of the so-called "drug lifecycle". Sternitzke (2010) examined a sample of new molecular entities approved by the Food and Drug Administration (FDA) between 1999 and 2004 and found that, on average, each drug in the sample was accompanied by about 19 publications and 23 patents, and that pharmaceutical firms developed strategies combining both patents

and publications to obtain drug approval, stimulate commercialization, and influence the adoption rate of the drug.

3.6. A conceptual framework

We set out an integrative conceptual framework for analysing the incentives for firms to engage in scientific publishing in Fig. 3. There are three main elements in our framework: (i) incentives for a firm to publish, (ii) a firm's R&D process and its stakeholders, and (iii) mechanisms that underlie the structure of incentives. We aim to address the question of 'Why do firms publish scientific papers?' at the micro-level. To do so, our framework also indicates how mechanisms link incentives to the firm's stakeholders, and the implications of publishing on the firm's R&D and value-capture processes.

We identified each element of the framework on the basis of the review and analysis presented earlier. Stakeholders are actors and institutions that exert a major role on firms' R&D and value-capture efforts; they provide knowledge, resources, and human capital for the firm's R&D process, and they represent recipients of the firm's innovative outputs. They encompass: (i) *academia*, i.e. research organisations (such as universities, public labs, and research centres); (ii) *industry*, i.e. a firm's suppliers, competitors, partners and potential collaborators as well as industrial researchers employed at the firm or in other industrial organisations; (iii) *investors* in the private and public spheres (e.g. research funders, venture capitalists, foundations); (iv) *users* such as consumers and professionals (for example, in the pharmaceutical sector, these include doctors, clinics, hospitals, and medical insurance groups); and (v) *institutions* which are represented by organisational actors such as regulatory bodies, governmental departments, and professional associations.

This conceptual framework reveals that a firm's scientific disclosures in publications serve multiple purposes by building on various mechanisms often interacting with more than one stakeholder group. Also, the framework outlines that the five incentives for a firm to publish are not mutually exclusive. Synergies can be expected to emerge among the incentives. For example, a firm can decide to publish the findings of its R&D efforts to broaden the scope of a patented invention, while at the same time signalling the quality of the invention and the firm's high levels of technological competence to investors. Similarly, a firm publishing in top-tier journals can attract talented researchers, while building up the credibility needed to compete for public research funding. Moreover, the importance of these incentives may vary within firms, especially in the case of large firms working in multiple markets that involve the use of a portfolio of technologies. The same firm may experience stronger or weaker incentives to publish depending on the characteristics of the technology or invention (e.g. its uncertainty or its pervasiveness), its stage of development (e.g. emerging, mature), or the strength of the patent system by which the technology is protected. However, as we discuss in the next section, more research is needed to increase our understanding of how incentives and associated mechanisms complement or substitute each other.

4. Towards a research agenda

The systematic review of extant research on firm publishing and the resulting conceptual framework presented in Fig. 3 enable us to outline a number of important areas where further research is required to expand our knowledge of the incentive structure underlying firms' decisions to engage in scientific disclosures, and to provide managerial and policy insights on the phenomenon. In this section, we discuss the main opportunities for future research.

⁵ Research has provided evidence that some firms engage in 'ghostwriting' practices to enhance the marketing influence that scientific publications can exert on the commercialization of their products (e.g. Fugh-Berman, 2010; Glenna and Bruce, 2021; Sismondo, 2009; Steinman et al., 2006). To do so, these firms hire professionals (e.g. writing firms, academic authors) to produce scientific publications that can promote the efficacy and safety of their products, and hence the regulatory approval and the adoption of their products. However, we preferred not to include ghostwriting as a mechanism within the incentive to publish to support commercialization strategies because ghostwriting does not result in scientific publications involving firms' industrial researchers in the list of authors. It is therefore not 'firm publishing' as defined in this paper. It is also worth noting that only a very limited number of studies (5 out 164, i.e. about 3 %) in our sample explicitly refer to ghostwriting.

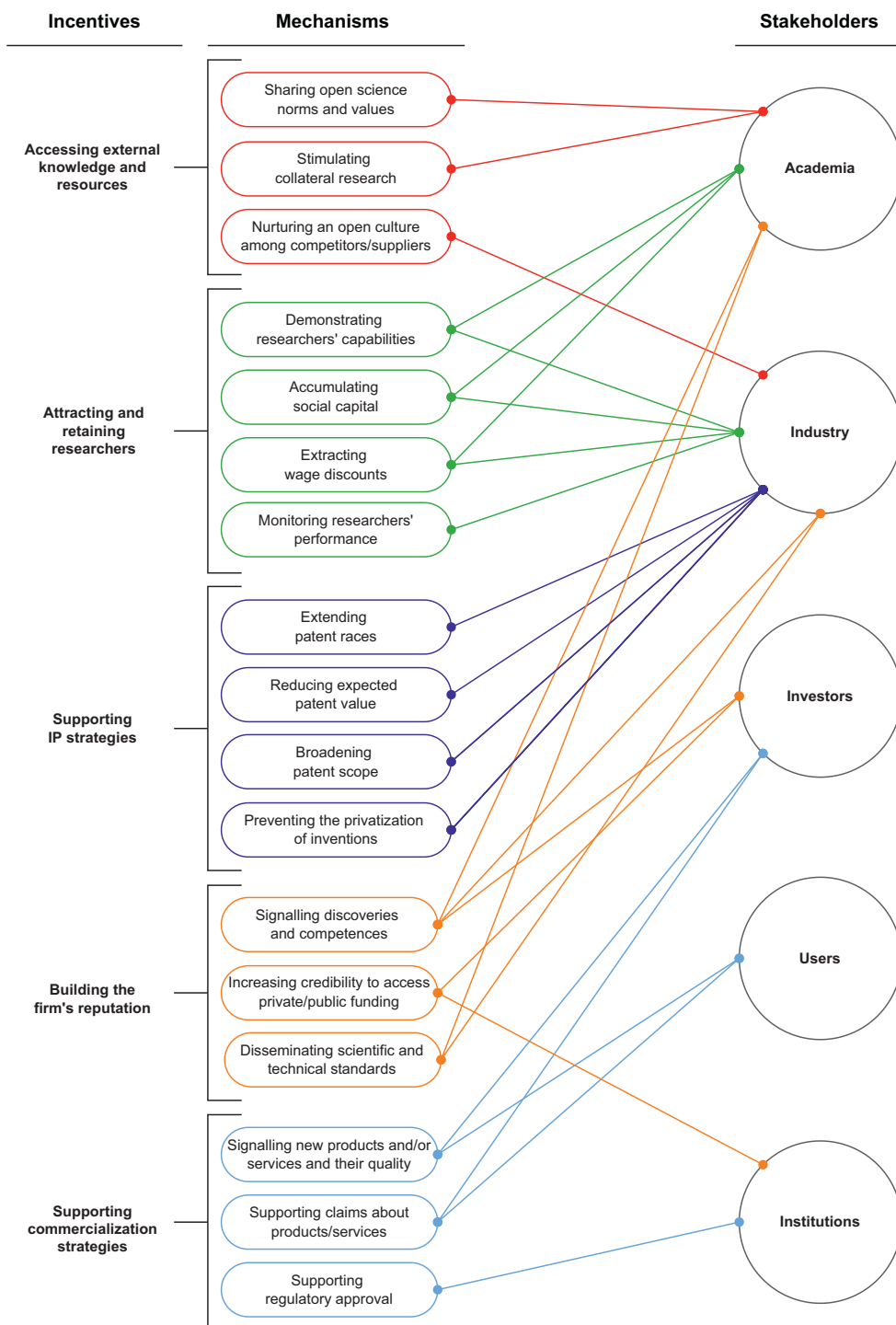


Fig. 3. Conceptual framework on firms' incentives to publish, mechanisms and stakeholders. The stakeholder groups include (i) *academia* (e.g. academic researchers, universities, public labs, research centres); (ii) *industry* (e.g. industrial researchers, suppliers, competitors, partners, potential collaborations); (iii) *investors* (e.g. research funders, venture capitalists, foundations); (iv) *users* (e.g. consumers, professionals); and (v) *institutions* (e.g. regulatory bodies, governmental departments, and professional associations).

Source: Authors' elaboration.

4.1. Incentives to publish: strength and synergies

Our review found that the empirical focus of research on firm publishing has been limited to a relatively small number of sectors. Some studies have paid considerable attention to examining scientific disclosure in sectors characterised by relatively high levels of R&D intensity, such as pharmaceuticals, biotechnology, and chemicals (e.g. Gambardella, 1992; Gittelman and Kogut, 2003; Hicks, 2000; McKelvey and Rake, 2016; Tijssen, 2009). This describes a research 'paradigm' where the more a firm is engaged in R&D activities, the more the firm is expected to be involved in producing scientific publications. However,

recent studies have provided evidence that the disclosure of private R&D findings in scientific publications is also a feature of sectors characterised by a relatively low R&D intensity (e.g. Arora et al., 2018; Csomós and Tóth, 2016; Simeth and Cincera, 2016). As a result, extant research provides insufficient grounds to extrapolate on the strength of firms' incentives to publish and how this varies across sectors – we have limited understanding of the specificity of the mechanisms represented in Fig. 3. Following the lead of previous works at the level of the individual (e.g. McMillan and Deeds, 1998; Sauermann and Roach, 2014), surveys examining the incentives to publish at the level of industrial researchers can contribute to building a more comprehensive

understanding of the extent to which some incentives to publish are more prominent in certain sectors but less so in others. These efforts may also reveal incentives and mechanisms that extant research has yet to reveal. A major empirical challenge here, however, is to delineate and operationalise a sample of industrial researchers that is representative of different industries and that also includes researchers who are not involved in publishing. In this regard, approaches that build on data extracted from professional network platforms such as LinkedIn may be worth exploring (e.g. Baruffaldi et al., 2017; Breschi et al., 2018).

In the same vein, publishing by firms has mostly been analysed by looking at large corporations, while only a few studies have examined publishing by small and medium-size firms. For example, Chai and Shih (2016) found that Danish small and medium-size firms contribute to a larger number of scientific publications when they receive government funding to collaborate with academic researchers, suggesting that publishing is a means for these firms to expand their knowledge base. Similarly, Li et al. (2015) found that US small and medium-size firms in nanotechnology were more likely to contribute to scientific publications when these required accessing public science and when focusing on the development of technologies with relatively low levels of complexity. These studies provide important insights on the understanding of small and medium-size firms' publication activity. However, more research is needed in this area as scientific publications can be a particularly cost-effective mechanism for IP protection and signalling for small and medium-size firms when compared to patenting (e.g. Colson, 2001; Rinner, 2003). Thus, increasing our understanding of how the strength of incentives for firms to publish varies by type of firm and what are the implications of publishing for these firms is another important avenue for future research.

Finally, we argued that the incentives to disclose scientific knowledge in publications are not mutually exclusive. A firm can pursue a strategy based on scientific disclosure to achieve several objectives and to reach multiple stakeholders. Yet, we have limited understanding and empirical evidence of potential complementarity and substitution effects among the various incentives. Incentives have been often examined in isolation from one another on the basis of 'uncoordinated' research efforts building on a range of theories, frameworks, and concepts. Our framework, however, outlines how firms' incentives to pursue a scientific disclosure strategy are intrinsically connected to the R&D process and value-capturing efforts. Increasing our understanding of complementarity and substitution effects, and which sector- and firm-level characteristics lead to the emergence of such effects (Milgrom and Roberts, 1995), can therefore provide important insights for managers and policy-makers.

4.2. Empirical challenges and opportunities

The study of firm publishing presents a number of empirical challenges, which offer opportunities for future research in light of the increasing availability of science, technology and innovation data. First, the literature on *defensive publishing*, which underlies a number of mechanisms related to publishing as a strategic tool for firms to support their IP strategies, has outlined how publications enable a firm to complement its patents by increasing appropriability opportunities – for instance, by reducing the risk that competitors will patent around the firm's inventions (e.g. Bar-Gill and Parchomovsky, 2003; Johnson, 2014) – as well as to challenge competitors in patent races (e.g. Baker and Mezzetti, 2005; Parchomovsky, 2000). Although this research has provided detailed explanations of the processes and mechanisms involving patenting, publishing, and secrecy, it has mostly relied on conceptual, modelling, or case-study research (see Fig. 2). Significant quantitative efforts have, in contrast, gone into examining scientific literature cited in patents (i.e. Non-Patent Literature) as a knowledge source for firms' inventions/patents (e.g. Harhoff, 2002). Yet, this body of literature has mostly treated publications as a proxy of scientific knowledge that goes into the creation of inventions (patents), thus neglecting the interplay

between publications and patents as a proxy of a firm's IP strategy. Increasing access to publication and patent data, and in particular to the full text of these documents, provides novel opportunities to explore defensive publishing on a large scale by examining patent-publication citation links (e.g. Marx and Fuegi, 2020) or by using text-mining techniques (e.g. Kelly et al., 2020). For instance, Natural Language Processing (NLP) can be used to identify and study longitudinally clusters of patents and publications around a given technology, the private actors involved in the development of these, and the effectiveness of defensive publishing across technological areas and countries characterised by different appropriability regimes.

Second, while the engagement of academic scientists in patenting and commercialization has been analysed from a variety of angles (e.g. Dietz and Bozeman, 2005; Lam, 2011; Lissoni, 2010; Scellato et al., 2015), much less is known about industrial researchers who engage in scientific disclosures. Only a few studies have examined firm publishing from the perspective of industrial researchers. These studies have focussed on the relationship between a firm's openness and industrial researchers' wages (Stern, 2004), on patterns of knowledge exchange between academic scientists and industrial researchers (Rappa and Debackere, 1992), on industrial researchers' tactics to balance the tensions deriving from sharing knowledge and secrecy (Nelson, 2016), and on the impact of the industrial researchers that are most active in publishing on innovation (Furukawa and Goto, 2006b; Hess and Rothaermel, 2011). Yet at the level of the firm, our understanding of which individual-level characteristics increase the likelihood of an industrial researcher engaging in scientific disclosure in academic journals is limited. Future research opportunities lie in understanding how industrial researchers' characteristics such as gender, educational background and mobility, contribute to explaining the phenomenon of firm publishing.

Third, examining firms' engagement in scientific publishing requires undertaking a bibliometric analysis to identify private organisations listed in authors' affiliation addresses. However, the coverage of publication databases has been the subject of much debate in the scientometric and bibliometric community. Systematic comparisons of databases such as Web of Science (WoS), Scopus, MEDLINE/PubMed, and more recently Dimensions, Microsoft Academic, and Crossref have outlined coverage biases in terms of research areas, languages, citation links, and document types (e.g. Mongeon and Paul-Hus, 2016; Singh et al., 2021; Visser et al., 2021). Higher or lower levels of scientific disclosure associated with certain firms and sectors could therefore be the result of a different publishing behaviour, but also a reflection of the journals and document types that are indexed in the selected database. For example, Scopus's coverage of conference papers – a type of research output that is particularly relevant for tracing firms' publications in computer science – is broader than that of WoS (Visser et al., 2021); yet WoS indexes a larger number of meeting abstracts – another prominent research output in life sciences and biomedicine (Visser et al., 2021). In the same vein, even the simple counting of publications requires making methodological choices and assumptions. On the one hand, some studies (e.g. Arora et al., 2018; Hartmann and Henkel, 2020; Hicks et al., 1996; Spencer, 2001) examined firms' publications adopting a full counting approach – i.e. counting each publication as one for a firm, no matter the number of co-authoring organisations involved in the publication. On the other hand, in light of the steady increase of the average number of authors per publication (e.g. De Solla Price, 1963; Fanelli and Larivière, 2016; Wuchty et al., 2007), some studies have fractionalised the number of publications (e.g. Larivière et al., 2018; Narin and Rozek, 1988; Tijssen et al., 1996), assuming that each organisation involved in a publication contributes equally to the publication. Yet evidence suggests that the observed patterns of firm publishing may be sensitive to this choice (Narin and Rozek, 1988). These challenges indicate the need to triangulate multiple publication databases and to use multiple indicators (e.g. full vs. fractional counting) as well as the need for more systematic research to understand how the observed firms' publishing behaviour

may be sensitive to the selection of the data source and quantification approach. Also, publication data may underestimate the role of firms in the production of scientific knowledge. Firms decide what to disclose in publications as well as perhaps funding extramural research to influence the direction of research efforts (e.g. to stimulate collateral research) without necessarily co-authoring publications. A systematic analysis of the information reported in 'funding acknowledgments' and 'disclosure of conflicts of interests' sections (e.g. Grassano et al., 2017; Wang and Shapira, 2011) together with data on firms' involvement in publications may therefore help to provide a more comprehensive map of the contribution by firms to basic research.

Finally, the geographical mapping of multinational corporations' R&D activities has been at the core of research examining what drives the location choices of R&D investment (e.g. Abramovsky et al., 2007; Kumar, 2001; Narula and Santangelo, 2009). Scholars have addressed this empirical challenge by proxying the location of R&D activities on the basis of the multinational corporations' ownership structures and, in particular, using the geographical location of subsidiaries classified with an activity code related to R&D (Siedschlag et al., 2013); on the basis of the information reported in multinational corporations' reports and insights gathered from interviews (Colovic and Mayrhofer, 2011); or building on the inventors' addresses reported in multinational corporations' patents (Le Bas and Sierra, 2002; Gkotsis et al., 2016). Despite the key role of scientific disclosures in a firm's R&D process, data on the affiliation addresses reported in industrial researchers' publications have been relatively unexplored to locate R&D (Csomós and Tóth, 2016). These data offer a complementary strategy to determine the multinational corporations' location choices with regard to R&D activities, especially in sectors where patent documents only capture to a limited extent the R&D efforts and strategies of firms.

5. Concluding remarks

This paper has addressed the question of 'Why do firms publish scientific papers?' in a systematic manner. We have developed a conceptual framework for understanding the incentives for firms to engage in scientific disclosure by drawing on 164 studies that have mapped the phenomenon of firm publishing, examined the implications of scientific disclosure for the innovation and financial performance of firms, and discussed the conditions that lead firms to pursue an open science strategy. This research spans science policy and innovation studies, economics of innovation, and the management of technology and innovation more generally. Thus, firm publishing has been examined by building on a number of theories, frameworks, and concepts and on studies conducted at different levels of analysis.

Our framework represents a first attempt to provide a coherent conceptual base to the understanding of firm publishing. The framework builds on five categories of incentives for firms to publish – (i) accessing external knowledge and resources; (ii) attracting and retaining researchers; (iii) supporting IP strategies; (iv) building the firm's reputation; and (v) supporting commercialization strategies – and specifies the mechanisms that relate these incentives to major stakeholders involved in a firm's R&D and value-capturing efforts (see Fig. 3). The framework also provides a conceptual base to expand our knowledge of firms' engagement in scientific disclosures. The previous section outlined a number of opportunities for future research: from increasing our understanding of how incentives to publish operate in different sectors; to examining the emergence of complementarity and substitution effects; and exploring the use of publication records to map with more granularity firms' IP strategies, the geographical locations of private R&D activities, and the contribution firms make to basic research notwithstanding the bibliometric challenges associated with the coverage biases of different publication databases. While our framework provides managers and policy-makers with a tool to understand firms' publication

strategies and the implications of publishing, addressing the research gaps outlined above could provide important insights and the evidence needed for more informed decision-making. For example, understanding whether there are synergies between incentives to publish can inform a firm's managers about how best to target their human capital and resources towards scientific disclosure activities. Similarly, the presence of complementarity and substitution effects among incentives represents an important input for policy-makers to design interventions to support firms' R&D and value-capturing efforts, while favouring the accumulation of public knowledge with the disclosure of findings generated by private R&D investment. Moreover, a deeper understanding of the incentive structure for firms to publish can shed light on what underlies the decline of private publishing evidenced by recent studies (Arora et al., 2018; Rafols et al., 2014). Is the decline caused by a weakening of particular incentives and associated mechanisms?

In summary, extant research has made important contributions to increase our understanding of *why firms publish scientific papers*. These efforts have, however, advanced knowledge in a relatively 'uncoordinated' manner. Examining the motivations for firms to publish has often not been a core focus of investigation, with firms' publications being examined in relation to other industrial and firm-level dynamics or used to derive proxies of firms' scientific/technological capabilities. The present paper has undertaken a systematic literature review to take stock of extant research on firm publishing and to put forward a coherent conceptual framework that allows scholars and practitioners to address the complexity of firm publishing, thereby advancing our knowledge on the dynamics of this important phenomenon.

CRedit authorship contribution statement

Daniele Rotolo: Conceptualization, Formal analysis, Visualization, Writing – original draft, Writing – review & editing. **Roberto Camerani:** Conceptualization, Formal analysis, Methodology, Writing – review & editing. **Nicola Grassano:** Conceptualization, Data curation, Formal analysis, Writing – review & editing. **Ben R. Martin:** Conceptualization, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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Appendix A

We identified an initial sample of studies potentially focussed on firm publishing by querying WoS. The query reported below was performed on 7 February 2022.

(TS=(“corporate science” OR “disclos* knowledge” OR “knowledge disclos*” OR “selective revealing” OR “strategic publi*”) OR TS=((“company” OR “companies” OR “corporate*” OR “firm*” OR “industr*” OR “multinational*” OR “R&D” OR “research & development” OR “research and development” OR “sector*”) NEAR/7 (“academi* article*” OR “academi* paper*” OR “academi* output*” OR “academi* research” OR “academi* knowledge” OR “basic research” OR “conference article*” OR “conference paper*” OR “conference proceedings” OR “meeting abstract*” OR “open science” OR “proceedings article*” OR “proceedings paper*” OR “publication*” OR “publishing” OR “scien* article*” OR “scien* paper*” OR “scien* output*” OR “scien* research” OR “scien* knowledge”))) AND LA = “English” AND DT=(“article” OR “review”).

Appendix B

Table B1

Studies *mapping and characterising* firm publishing - studies referring to incentives to publish are in **bold**.

Study	Type	Aim	Analytical level	Data (observation period) ^a
Halperin and Chakrabarti (1987)	Empirical	To examine the relationship between firms' characteristics and publication output	Firm	225 US firm (1975–1983)
Narin and Rozek (1988)	Empirical	To evaluate the contribution of US pharmaceutical firms to biomedical research	Firm	300 US firms in pharmaceuticals (1973–1985)
Rappa and Debackere (1992)	Empirical	To examine the information and knowledge exchange patterns between academic and industrial researchers	Researcher	720 academic and industrial researchers in neural network (1988–1989)
Debackere and Rappa (1994)	Empirical	To examine the information and knowledge exchange patterns between academic and industrial researchers	Researcher	210 academic and industrial researchers in electronic propulsion and reduced instruction set computers (1984–1990)
Hicks et al. (1994)	Empirical	To examine the participation of firms in scientific research	Firm	28 Japanese firms (1980–1989)
Cockburn and Henderson (1996)	Empirical	To study the interaction between public and private sectors	Collaboration	35,813 publications authored by 10 US firms in pharmaceuticals (1980–1994), case studies and field interviews
Godin (1996)	Empirical	To assess the extent to which publication data proxy firms' involvement in science	Firm	199 firms (1980 and 1989)
Hicks et al. (1996)	Empirical	To examine firms' research output and collaboration pattern	Firm	34 EU and Japanese firms in the pharmaceutical, chemical-pharmaceutical and electronics sectors (1980, 1984, 1989)
Katz and Hicks (1996)	Empirical	To examine the contribution of different actors to the production of research	Research system	376,226 publications authored by UK organisations (1981–1991)
Liebeskind et al. (1996)	Empirical	To examine how new biotechnology firms (NBFs) access scientific knowledge	Firm	Two case studies of US firms in biotechnology (–)
Melin and Persson (1996)	Empirical	To assess the extent to which co-authorship data proxy firms' collaborations	Collaboration	Co-authorship data of one university (Umea University), one country (Sweden), and the top-25 countries in terms of publication output (1993)
Penan (1996)	Empirical	To map R&D strategies in a research field	Publication	11,000 publications on Alzheimer's disease therapy from 119 scientific journals (1988–1992)
Tijssen et al. (1996)	Empirical	To map firms' scientific publication activity	Sector	1315 publications authored by Dutch private organisations (1993–1994)
Hicks and Katz (1997)	Empirical	To examine the evolution of informal scientific and technical networks	Collaboration	Co-authorship data between UK research institutions (universities, research councils, industry, etc.) (1981–1994)
Katz and Martin (1997)	Conceptual	To assess the extent to which co-authorship data proxy firms' collaborations	Collaboration	–
Tijssen and Korevaar (1997)	Empirical	To map public/private R&D networks	Collaboration	Collaboration (co-authorship, co-patenting, R&D contracts,) between 44 R&D organisations (universities, public research labs and firms) in catalysis field in the Netherlands (1991–1993)
Cockburn and Henderson (1998)	Empirical	To examine the interface between for-profit and publicly funded research	Collaboration	Co-authorship data of 20 pharmaceutical firms (1980–1994)
Hicks (2000)	Empirical	To map a firm's co-authorships and citation pattern	Firm	One case study of a US firm in chemicals (1981–1995)
McMillan and Hamilton (2000)	Empirical	To map firms' publishing and patenting citation patterns	Firm	13 US firms in pharmaceutical (1981–1993)
Okubo and Sjöberg (2000)	Empirical	To map firms' scientific publication activity	Firm	413 Swedish firms and 517 industrial units in these firms (1986, 1994)
Spencer (2000)	Empirical	To examine country-level differences in firms' behaviours on appropriating and sharing scientific knowledge	Firm	94 US and Japanese firms in flat panels (1960–1989)
Spencer (2001)	Empirical	To examine the contribution of academic and corporate research to subsequent industrial R&D activities	Publications	800 publications in flat panel displays authored by US and Japanese academic or industrial researchers (1969–1989)
Murray (2002)	Empirical	To map the co-evolution of scientific and technological networks in an emerging area	Patent	76 patents and 158 papers in the US biotechnology industry (1991–2001)
Ramani (2002)	Empirical	To examine firms' R&D strategies, knowledge base and sales	Firm	24 Indian firms in pharmaceutical/biotechnology (1970–1994)
Calvert and Patel (2003)	Empirical	To map university-industry collaborations	Collaboration	Co-authorship data between UK firms and universities (1981–2000)
Frederiksen (2004)	Empirical	To map a firm's co-authorships and citation pattern	Sector	1750 publications authored by Danish firms (1996, 1998, 2000)

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Table B1 (continued)

Study	Type	Aim	Analytical level	Data (observation period) ^a
Tijssen (2004)	Empirical	To map trends of top R&D investors' publication activity in international scientific and technical journals	Sector	Scientific articles produced by private actors in pharmaceuticals/biotechnology and semiconductors (1996–2003)
Altwater-Mackensen et al. (2005)	Empirical	To map the scientific and technological outputs of 7 German regions	Region	Patents and publications by private and public German institutions (1995–2000)
Furukawa and Goto (2006a)	Empirical	To examine the role of industrial core scientists in the innovation process	Firm	10 Japanese firms in electronics largest by R&D spending (1987–2002)
Furukawa and Goto (2006b)	Empirical	To examine the role of industrial core scientists in the innovation process	Firm	5 Japanese firms in pharmaceuticals largest by R&D spending (1987–2002)
Lundberg et al. (2006)	Empirical	To assess the extent to which co-authorship data proxy university-industry collaborations	Collaboration	Collaboration (co-authorship and funding data) between Karolinska Institutet and industry (436 firms) (1982–2003)
Tijssen and Van Leeuwen (2006)	Empirical	To map the knowledge flows (citations) between public and private actors	Citation	Scientific articles produced by private actors (1996–2003)
Calero et al. (2007)	Empirical	To map firms' co-authorship patterns	Firm	378 bio-pharmaceuticals firms (1996–2001)
Klitkou et al. (2007)	Empirical	To examine collaboration networks and actors' prominence in these networks	Collaboration	Co-authorship/Co-patenting in the fuel cell field in Norway (1990–2002)
Sun et al. (2007)	Empirical	To examine university-industry collaborations	Collaboration	Co-authorship data between Japanese research institutions (1981–2004)
Moodysson (2008)	Empirical	To examine knowledge co-creation in clusters	Region	32 Swedish industrial researchers in biotechnology (–)
Abramo et al. (2009)	Empirical	To examine public-private research collaborations	Collaboration	Co-authorship data between Italian firms (791) and universities (68) (2001–2003)
Tijssen et al. (2009)	Empirical	To assess the extent to which firms' scientific research is globalised	Firm	10 EU firms in pharmaceuticals (2004–2006)
Tijssen et al. (2009)	Empirical	To map which universities are the 'best' providers of research services to the business sector	Collaboration	Co-authorship data between the top-350 universities by publication output and firms (2002–2006)
Sun and Negishi (2010)	Empirical	To propose new publication-based indicators to measure the relationship among sectors	Publication	1,277,823 publications (1981–2006)
Archambault and Larivière (2011)	Empirical	To map firms' patterns of scientific publication and patenting activity	Firm	5585 Canadian firms (1980–2005)
Bhattacharya and Packalen (2011)	Empirical	To examine the mechanisms that drive the direction of scientific research (market demand vs. public benefit)	Medical research	About 16 million biomedical drug-related publications (1960–2005)
Hess and Rothaermel (2011)	Empirical	To examine complementarity and substitution effects between alliances and star scientists	Firm	108 firms in pharmaceuticals (1974–2003)
Perianes-Rodríguez et al. (2011)	Empirical	To examine firms' role in the process of scientific development and innovation	Firm	50 Spanish firms (1995–2005)
Powell and Sandholtz (2012)	Empirical	To assess where new organisational forms come from and how bundles of practices are combined in science and technology-based ventures	Firm	26 US firms in biotechnology (1975–1981)
Tijssen (2012)	Empirical	To examine public-private research collaborations	Collaboration	Co-authorship data between public-private actors (2006–2010)
Chang (2014)	Empirical	To map firms' publication activity	Firm	1134 Taiwanese firms (1982–2011)
de Moya-Anegón et al. (2014)	Empirical	To examine the position of private sector institutions in bibliometric rankings	Sector	About 27,000 public and private research institutions (2003–2011)
Rafols et al. (2014)	Empirical	To examine firms' cognitive shifts and collaboration networks	Firm	15 EU and US large firms in pharmaceuticals (1995–2009)
Gök et al. (2015)	Empirical	To assess the extent to which firms' websites proxy firms' R&D activities	Firm	296 UK firms in green goods (2004–2012)
Kim and Kim (2015)	Conceptual	To propose performance indices capable of measuring private construction firms' R&D performance	Project	–
Minguillo et al. (2015)	Empirical	To map research activities within support infrastructures	Science Park	82 UK science parks (1975–2010)
Minguillo and Thelwall (2015a)	Empirical	To examine the collaboration patterns of organisations based in science parks	Collaboration	Co-authorship data of organisations located in UK Science Parks (1975–2010)
Minguillo and Thelwall (2015b)	Empirical	To examine which type of innovation support infrastructures help higher education institutions to achieve	Support infrastructure	66 UK innovation support infrastructures (1975–2010)
Olmeda-Gómez et al. (2015)	Empirical	To examine public-private research collaborations	Collaboration	Co-authorship data between Spanish research institutions (5160 of which 1211 private institutions) (2003–2011)
Arencibia-Jorge et al. (2016)	Empirical	To assess the publication activity of an industrial cluster	Firm	11 research institutions in the “BioCubaFarma” industry and 15 international firms in biopharmaceuticals (2003–2013)
Belderbos et al. (2016)	Empirical	To assess the extent to which a firm's scientific absorptive capacity impacts on the benefits the firm accrues from direct and indirect collaborations with universities	Firm	33 pharmaceutical firms in US, EU and Japan (1995–2002)
Chai and Shih (2016)	Empirical	To examine the relationship between university-industry funding and firms' innovation	Firm	330 Danish firms (2005–2010)
Chang et al. (2016)	Empirical	To examine individuals and research institutions' publishing and patenting activity in a field	Collaboration	Co-authorship/Co-patenting data of 325 institutions (research organisations and firms) and 627 researchers in fuel cell (1991–2000)
Csomós and Tóth (2016)	Empirical	To map which cities are the major control points and centres of firms' R&D	Firm	2000 firms in the “2014 Forbes 2000” (publications in the Scopus database up to March 2015)
Giunta et al. (2016)	Empirical	To examine factors that shape university-industry interactions	Collaboration	Co-authorship data between university and firms in biopharmaceuticals in Italy (2004–2010)

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Table B1 (continued)

Study	Type	Aim	Analytical level	Data (observation period) ^a
Csomós (2017)	Empirical	To map which cities are centres of firms' R&D	Firm	2500 firms in the "2015 EU Industrial R&D Investment Scoreboard" (1980–2014)
Erden (2017)	Empirical	To examine university spinoffs' publishing and patenting strategies	Firm	100 firms in pharmaceuticals/biotechnology/life sciences (2000–2007)
Arora et al. (2018)	Empirical	To examine firms' involvement in basic research	Firm	4608 US firms (1980–2006)
Larivière et al. (2018)	Empirical	To map industry and government's contribution to scientific research	Sector	28 M publications (1980–2014) and 5 M US patents (1976–2014)
Vestal and Danneels (2018)	Empirical	To assess how access to local knowledge impact on firms' innovativeness	Firm	1903 US firms in nanotechnology (1995–2004)
Alpaydin (2019)	Empirical	To examine the geographical scope of university-firm collaborations	Firm	One case study of a Norwegian firm in oil and gas (2008–2016)
Arts and Veugelers (2020)	Empirical	To study individual R&D scientists within firms and how their motives relate to the rate and nature of their inventive output	Researcher	464 Belgian researchers with a PhD in science or engineering (2005)
Fabiano et al. (2020)	Empirical	To examine the financial public and private support publications authored by founding members of 'drug originator' firms received	Publication	91 UK firms in biopharmaceuticals (1996–2016)
Hartmann and Henkel (2020)	Empirical	To map and explain the rise of corporate science in AI	Publication	16,176 articles from AI conferences (2004–2016), patents in AI, acquisition of AI startups, and data in AI top scientists' careers, and their motivations
Liu et al. (2020)	Empirical	To explore the role of firms as authors and funders of research on GM maize	Publication	7382 publication in the GMOs field (1986–2015)
McKelvey and Rake (2020)	Empirical	To study the impact of R&D alliances with different types of partners on publication	Publication	15,762 publications in pharmaceuticals (2001–2008)
Sachini et al. (2020)	Empirical	To investigate the scientific publications of defence firms	Firm	169 Greek firms in defence (1987–2020)
Schuhmacher et al. (2020)	Empirical	To describe the use of AI application in pharmaceutical R&D	Publication	417 publications of 21 pharmaceutical companies (2014–2019)
Colen et al. (2021)	Empirical	To examine the impact of collaborating with star scientists on firms' invention performance	Firm	60 pharmaceuticals firms (1995–2002)
Krieger et al. (2021)	Empirical	To establish whether firms' basic research has declined or not	Firm	1647 German firms (2008–2016)
McManus et al. (2021)	Empirical	To assess the impact of non-academic and industry publications	Country/Sector	54 countries and 10 sectors (2013–2018)
Pohl (2021)	Empirical	To understand academic–corporate collaborations	Collaboration	403,102 academic–corporate co-publications (2015–2019)
Schuhmacher et al. (2021)	Empirical	To analyse the link between R&D input and output in the pharmaceutical sector	Firm	14 pharmaceuticals firms (1999–2018)

Source: Authors' elaboration.

^a The geographical (industrial sector) focus is not reported if the data sample includes more than three countries (industrial sectors).

Table B2

Studies examining the *implications of publishing* on firms' performance - studies referring to incentives to publish are in **bold**.

Study	Type	Aim	Analytical level	Data (observation period) ^a
Allen (1983)	Conceptual	To examine how firms' disclosure may affect the pace and direction of technical change	Firm	–
Koenig (1983)	Empirical	To examine the relationship between bibliometric indicators and research performance	Firm	24 US firms in pharmaceuticals (1970–1974)
Narin et al. (1987)	Empirical	To explore the link between corporate patent, patent citation, and several other indicators of corporate performance (including scientific productivity)	Firm	17 US pharmaceutical companies (1973–1982)
Gambardella (1992)	Empirical	To examine the relationship between firms' in-house scientific research and firms' ability to exploit external scientific knowledge	Firm	20 US firms in pharmaceuticals (1973–1986)
Henderson and Cockburn (1994)	Empirical	To assess the importance of competence as a competitive advantage for firms	Research program	3210 research programs in 10 EU and US large pharmaceutical firms (1975–1988)
McMillan et al. (1995)	Modelling	To examine how a firm's scientific information openness impacts the firm's stock of technical knowledge	Firm	–
Decarolis and Deeds (1999)	Empirical	To examine the relationship between organisational knowledge and firms' performance	Firm	98 US firms in biotechnology (1982–1992)
Cockburn et al. (2000)	Empirical	To examine the diffusion of 'science-driven' drug discovery practices and their role as source of firms' competitive advantage	Firm	26 US firms in pharmaceuticals (1964–1990;1980–1997)
Deeds (2001)	Empirical	To examine the relationship between a firm's R&D intensity, technical capabilities and absorptive capacity, and entrepreneurial wealth	Firm	80 US firms in biotechnology (1982–1993)
Azoulay (2002)	Empirical	To assess the extent to which marketing and scientific evidence influence the diffusion of innovations	Drug market	4 US pharmaceutical drugs (1977–1993)
Zucker et al. (2002)	Empirical	To examine whether co-authorships between a firm's researchers and 'star' scientists predict the firm's success	Firm	324 US firms in biotechnology (1976–1991)
Balter et al. (2003)	Conceptual	To outline what is the impact of firm publishing on firms' commercial outputs	Firm	–
Bhattacharya and Meyer (2003)	Empirical	To examine the linkages between science and technology and the relationship between patenting and publishing in firms	Firm	20 firms in thin film technology (1997)

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Table B2 (continued)

Study	Type	Aim	Analytical level	Data (observation period) ^a
Gittelman and Kogut (2003)	Empirical	To examine the relationship between patents and publications	Firm	116 US firms in biotechnology (1988–1994)
Lim (2004)	Empirical	To examine the relationship between basic research, applied research and innovation	Firm	84–111 firms (when considering merges) in pharmaceuticals and semiconductors (1981–1997)
Murray (2004)	Empirical	To examine the role of academic scientists in entrepreneurial firms in terms of human and social capital	Firm	12 US firms in biotechnology (2001–2002)
D'Este (2005)	Empirical	To examine factors that shape firms' knowledge base and whether these factors can represent a source of heterogeneity within industries	Firm	32 Spanish firms in pharmaceuticals (1981–2000)
Smith et al. (2005)	Conceptual	To outline the risks arising from the publication of clinical trials for marketing purpose	Firm	–
Muller and Pénin (2006)	Modelling	To examine the role of knowledge disclosure on the formation of innovation networks	Firm	–
Mahlich (2007)	Empirical	To assess the influence intangible capital has on stock market capitalization	Firm	34 Japanese firms in pharmaceuticals (1987–1998)
Cassiman et al. (2008)	Empirical	To examine how a firm's science linkages and closeness to science affect the quality of the inventions the firm produces	Patent	1186 patents of 79 Belgian firms (1995–2001)
Sismondo (2009)	Conceptual	To inform about a conference of an international association of publication planners	Firm	–
Spielmanns and Parry (2010)	Conceptual	To assess the extent to which publications represent a marketing tool for pharmaceutical firms	Firm	–
Sternitzke (2010)	Empirical	To examine different aspects of the innovation activity in the pharmaceutical sector using bibliometric data of approved drugs	Drug market	64 US FDA-approved pharmaceutical drugs (1999–2004)
Almeida et al. (2011)	Empirical	To examine how publication co-authorship involving a firm's researchers affect the inventions patented by the firm	Firm	149 US and EU biotechnology firms (1990–2003)
Penders and Nelis (2011)	Empirical	To examine how firms produce 'credibility claims'	Firm	One case study of a Dutch firm in food (2008–2010)
Sismondo (2012)	Conceptual	To outline how knowledge is accumulated, shaped, and deployed in an industry	Firm	–
Tegarden et al. (2012)	Empirical	To examine the impact of firm publishing on the firms' ability to explore/exploit R&D investment in emerging technologies	Firm	695 US firms in fiber-optics (1976, 1979, 1982, 1985, 1988, 1991, 1994)
Wang and Shapira (2012)	Empirical	To examine what are the benefits of partnering with universities startups	Firm	230 US firms in nanotechnology (1996–2005)
Polidoro (2013)	Empirical	To examine how scientific and regulatory certifications affect competition in emerging fields	Drug market	20,473 rival-mechanism-year of US FDA-approved pharmaceutical drugs (1980–2004)
Subramanian et al. (2013)	Empirical	To examine the impact of heterogeneity in a firm's scientific human capital on the firm's patent performance	Patent	222 biotechnology firms and associated patents (10,646), publications (100,375), and alliances (11,718) (1980–2000)
Belenzon and Pataconi (2014)	Empirical	To examine how size affects a firm's ability to take advantage from invention	Firm	14,899 firms (1978–2006)
Bergenholtz (2014)	Empirical	To examine how expert users' references to a firm's technology in scientific journals impact on the performance of the firm	Signal	27 interviews with firms' managers and star scientists in natural sciences (2011–2012)
Jong and Slavova (2014)	Empirical	To examine the impact that a firm's publishing and collaboration activities with universities exert on the firm's innovation output	Firm	160 UK firms in biotechnology (1988–2009)
Liu and Stuart (2014)	Empirical	To examine the link between publication and rewards	Firm	One case study of a US firm in biotechnology (2001–2007)
McMillan et al. (2014)	Empirical	To outline a game theoretic model for firms' scientific openness/secretcy	Firm	118 US firms (1992–1999)
Soh and Subramanian (2014)	Empirical	To examine how the benefits of R&D collaborations between firms and universities are influenced by firms' R&D focus	Patent/Product	222 biotechnology firms and associated patents (10,646), publications (100,375), and alliances (11,718) (1980–2000)
Erden et al. (2015)	Empirical	To examine how the reputation of a firm's knowledge stock impacts on the firm's performance	Firm	167 firms in pharmaceuticals/biotechnology/life sciences (2003–2007)
McKelvey and Rake (2016)	Empirical	To examine how collaboration affects innovation outcomes	Firm	325 pharmaceutical firms (1998–2004, 2004–2008)
Simeth and Cincera (2016)	Empirical	To examine the impact of firms' scientific activities on their stock market valuation	Firm	9920 US firms (1996–2006)
Zahringer et al. (2017)	Empirical	To examine the relationship between quality of academic knowledge and quality of industrial innovation	Patent	8908 patents from 434 US firms in life sciences (1971–2007)
Pellens and Della Malva (2018)	Empirical	To examine firms' involvement in scientific research and its implications for firms' valuation of knowledge assets	Firm	267 US firms in semiconductors (1980–2007)
Slejko et al. (2018)	Empirical	To assess the effect of different kinds of publications on firms' sales	Drug market	3 US pharmaceutical drug markets (2003–2013)
Zahra et al. (2018)	Conceptual	To examine the factors that limit a firm's ability to commercialize its science	Firm	–
Abramo et al. (2021)	Empirical	To assess the scholarly impact of the Italian private sector research	Firm	26,025 Italian publications involving firms (2010–2017)
Arora et al. (2021)	Empirical	To examine how a firm's investment in research is used in the firm's internal invention process and related to spillovers to rival firms	Firm	3807 US firms (1980–2015)
Hsu et al. (2021)	Empirical	To examine the impact of publishing on firms' market value	Firm	1632 Chinese firms (2006–2015)
Leten et al. (2021)	Empirical	To study how internal basic research can increase the innovative performance of a firm	Firm	50 pharmaceuticals firms (1995–2015)

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Table B2 (continued)

Study	Type	Aim	Analytical level	Data (observation period) ^a
Slavova (2021)	Empirical	To study the relationship between university-industry alliances and co-publications between firms and academia	Firm	190 US therapeutic biotechnology firms (2003–2010)

Source: Authors' elaboration.

^a The geographical (industrial sector) focus is not reported if the data sample includes more than three countries (industrial sectors).

Table B3

Studies examining the *process of scientific disclosure* - studies referring to incentives to publish are in **bold**.

Study	Type	Aim	Analytical level	Data (observation period) ^a
Schmitt (1961)	Conceptual	To examine the benefits that engagement in open scientific communications provide to firms	Not applicable	–
Nelson (1990)	Conceptual	To examine how capitalism can be considered as an engine of technical progress	Not applicable	–
Hicks (1995)	Conceptual	To examine why firms publish papers in refereed scientific journals	Firm	–
Stephan (1996)	Conceptual	To examine the reward structure of science, and the economics of science	Not applicable	–
Zucker and Darby (1997)	Empirical	To examine the process by which incumbents are or are not supplanted by entrants in the face of an external technological discontinuity	Firm	One case study of a US firm in pharmaceuticals (1997)
McMillan and Deeds (1998)	Empirical	To examine the impact of a firm's reputation for openness in the recruitment of scientists	Researcher	65 US students in biomedicine (1998)
Eisenberg (2000)	Conceptual	To examine the limitations of defensive publishing	Firm	–
Lichtman et al. (2000)	Modelling	To outline the incentives for strategic disclosure	Firm	–
Parchomovsky (2000)	Conceptual	To outline the role and implications of preemptive publication in patent races	Firm	–
Colson (2001)	Conceptual	To outline an IP strategy for firms to sustain their competitive advantage	Firm	–
Barrett (2002)	Conceptual	To outline the phenomenon of defensive publishing as part of a company IP strategy	Firm	–
Bar-Gill and Parchomovsky (2003)	Conceptual	To propose a theory to explain why firms move from patenting to publishing	Firm	–
Rinner (2003)	Conceptual	To outline patenting and defensive publishing as complementary strategies	Firm	–
Kinney et al. (2004)	Conceptual	To outline the balance and tensions industrial researchers face when these are willing to disclose knowledge in publications	Firm	–
Merges (2004)	Conceptual	To outline the firms' defensive publishing as a property-pre-empting mechanism	Firm	–
Stern (2004)	Empirical	To examine the relationship between wages and firms' scientific orientation	Researcher	63 US researchers with a Ph.D. in biology (1998–1999)
Baker and Mezzetti (2005)	Conceptual	To outline why firms disclose research outputs to patent offices	Firm	–
Bar (2006)	Modelling	To examine the use of publications as a defensive tool in patent races	Firm	–
Pénin (2007)	Conceptual	To review literature on firms' open knowledge disclosure strategies	Firm	–
Mukherjee and Stern (2009)	Conceptual	To assess which conditions support an open science strategy over secrecy	Researcher	–
Bromfield and Barnard (2010)	Empirical	To examine the balance between different IP mechanisms (patents and publications)	Firm	One case study of a South African firm in chemicals (1955–2005)
Ding (2011)	Empirical	To examine whether the educational and professional background of a firm's founder(s) influence the firm's decision to pursue an open science strategy	Firm	512 US firms in biotechnology (1969–2000)
Della Malva and Hussinger (2012)	Empirical	To examine whether firms' scientific publications are an effective patenting preemption mechanism	Patent	6226 EPO patent applications in semiconductors (1995–2000)
Polidoro and Theeke (2012)	Empirical	To examine how competitive conditions affect the likelihood that a firm publishes scientific articles about its innovation	Drug market	New US FDA-approved pharmaceutical drugs (1983–2004)
Alexy et al. (2013)	Conceptual	To examine how firms adopt selective revealing strategies and what factors influence this choice	Firm	–
Sauermann and Stephan (2013)	Empirical	To assess the extent to which institutional logics differ between academia and industry	Researcher	5018 US academic and industrial researchers in life and physical sciences (2003)
Simeth and Raffo (2013)	Empirical	To examine the determinants for a firm to pursue an open science strategy	Firm	2512 French firms in manufacturing (1999–2007)
Johnson (2014)	Modelling	To examine why firms choose defensive publishing over patenting and trade secrecy	Firm	–
Sauermann and Roach (2014)	Empirical	To examine what “price” scientists assign to publishing opportunities in industrial R&D	Researcher	1927 US Ph.D. candidates in science and engineering (2010)
Friesike et al. (2015)	Conceptual	To outline open science as a new research paradigm	Firm	–
Li et al. (2015)	Empirical	To examine small firms' scientific publishing patterns and the antecedents of these patterns	Firm	250 US firms in nanotechnology (1990–2012)

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Table B3 (continued)

Study	Type	Aim	Analytical level	Data (observation period) ^a
Simeth and Lhuillery (2015)	Empirical	To examine factors that influence firms' scientific disclosure capabilities	Firm	2517 French firms (2008–2009)
Nelson (2016)	Empirical	To examine how scientists manage the tension between sharing and secrecy	Researcher	46 US industrial researchers and 58 oral histories in biotechnology and digital audio (1992–2012)
Gans et al. (2017)	Conceptual	To examine a firm's knowledge disclosure strategies	Project	–
Huang (2017)	Empirical	To examine how IPR uncertainties shape a firm's strategy of knowledge appropriation and access	Citation	1279 patent-publication citations from 362 firms in genomics (1988–2005)
Hayter and Link (2018)	Empirical	To examine firms' motivations to publish innovative ideas before commercialization	Firm	1301 US firms (1992–2001)

Source: Authors' elaboration.

^a The geographical (industrial sector) focus is not reported if the data sample includes more than three countries (industrial sectors).

Appendix C. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.respol.2022.104606>.

References

- Abramo, G., D'Angelo, C.A., Di Costa, F., Solazzi, M., 2009. University-industry collaboration in Italy: a bibliometric examination. *Technovation* 29 (6–7), 498–507.
- Abramo, G., D'Angelo, C.A., Di Costa, F., 2021. The scholarly impact of private sector research: a multivariate analysis. *J. Informetrics* 15 (3), 101191.
- Abramovsky, L., Harrison, R., Simpson, H., 2007. University research and the location of business R&D. *Economic Journal* 117 (519), C114–C141.
- Alexy, O., George, G., Salter, A.J., 2013. Cui bono? The selective revealing of knowledge and its implications for innovative activity. *Acad. Manag. Rev.* 38 (2), 270–291.
- Allen, R.C., 1983. Collective invention. *J. Econ. Behav. Organ.* 4 (1), 1–24.
- Almeida, P., Hohberger, J., Parada, P., 2011. Individual scientific collaborations and firm-level innovation. *Ind. Corp. Chang.* 20 (6), 1571–1599.
- Alpaydin, U.A.R., 2019. Exploring the spatial reach of co-publication partnerships of multinational enterprises: to what extent does geographical proximity matter? *Reg. Stud. Reg. Sci.* 6 (1), 281–298.
- Altqvist-Mackensen, N., Balicki, G., Bestakowa, L., Bocatus, B., Braun, J., Brehmer, L., Brune, V., Eigemeier, K., Erdem, F., Fritsch, R., Jacobs, A., Klingsporn, B., Kosinski, M., Kuntze, J., Lee, J.-R., Osterhage, A., Probst, M., Risch, T., Schmitt, T., Stock, G.W., Sturm, A., Weller, K., Werner, K., 2005. Science and technology in the region: the output of regional science and technology, its strengths and its leading institutions. *Scientometrics* 63 (3), 463–529.
- Archambault, E., Larivière, V., 2011. Scientific publications and patenting by companies: a study of the whole population of Canadian firms over 25 years. *Sci. Public Policy* 38 (4), 269–278.
- Arencibia-Jorge, R., Corera-Alvarez, E., Chinchilla-Rodríguez, Z., de Moya-Anegón, F., 2016. Scientific output of the emerging Cuban biopharmaceutical industry: a scientometric approach. *Scientometrics* 108 (3), 1621–1636.
- Arora, A., Belenzon, S., Pataconi, A., 2018. The decline of science in corporate R&D. *Strateg. Manag. J.* 39 (1), 3–32.
- Arora, A., Belenzon, S., Sheer, L., 2021. Knowledge spillovers and corporate investment in scientific research. *Am. Econ. Rev.* 111 (3), 871–898.
- Arrow, K., 1962. Economic welfare and the allocation of resources for invention. In: Groves, H.M. (Ed.), *The Rate and Direction of Inventive Activity: Economic and Social Factors*. Princeton University Press, Princeton, NJ, pp. 609–626.
- Arts, S., Veugelers, R., 2020. Taste for science, academic boundary spanning, and inventive performance of scientists and engineers in industry. *Ind. Corp. Chang.* 29 (4), 917–933.
- Arundel, A., 2001. The relative effectiveness of patents and secrecy for appropriation. *Res. Policy* 30 (4), 611–624.
- Audretsch, D.B., Feldman, M.P., 1996. R&D spillovers and the geography of innovation and production. *Am. Econ. Rev.* 86 (3), 630–640.
- Azoulay, P., 2002. Do pharmaceutical sales respond to scientific evidence? *J. Econ. Manag. Strateg.* 11 (4), 551–594.
- Baker, S., Mezzetti, C., 2005. Disclosure as a strategy in the patent race. *J. Law Econ.* 48 (1), 173–194.
- Balter, W., Skelton, M., Safir, P.O., 2003. The P's and Q's of publication planning. *Pharm. Exec.* 23 (5), 130.
- Bar, T., 2006. Defensive publications in an R&D race. *J. Econ. Manag. Strateg.* 15 (1), 229–254.
- Bar-Gill, O., Parchomovsky, G., 2003. The value of giving away secrets. *Va. Law Rev.* 89 (8), 1857–1895.
- Barrett, B., 2002. Defensive use of publications in an intellectual property strategy. *Nat. Biotechnol.* 20 (2), 191–193.
- Baruffaldi, S.H., Di Maio, G., Landoni, P., 2017. Determinants of PhD holders' use of social networking sites: An analysis based on LinkedIn. *Research Policy* 46 (4), 740–750.
- Belderbos, R., Gilsing, V.A., Suzuki, S., 2016. Direct and mediated ties to universities: “scientific” absorptive capacity and innovation performance of pharmaceutical firms. *Strateg. Organ.* 14 (1), 32–52.
- Belenzon, S., Pataconi, A., 2014. How does firm size moderate firms' ability to benefit from invention? Evidence from patents and scientific publications. *Eur. Manag. Rev.* 11 (1), 21–45.
- Bergenholtz, C., 2014. Second-hand signals: how and why firms are being referenced in scientific publications. *Eur. Manag. Rev.* 11 (2), 159–171.
- Bhattacharya, J., Packalen, M., 2011. Opportunities and benefits as determinants of the direction of scientific research. *J. Health Econ.* 30 (4), 603–615.
- Bhattacharya, S., Meyer, M., 2003. Large firms and the science-technology interface: patents, patent citations, and scientific output of multinational corporations in thin films. *Scientometrics* 58 (2), 265–279.
- Breschi, S., Lissoni, F., Miguelez, E., 2018. Return migrants' self-selection: evidence for Indian. In: NBER Working Paper, No. 24809, pp. 1–52.
- Bromfield, T., Barnard, H., 2010. The evolution of the intellectual property management strategy of an emerging multinational: learning the purpose of patenting and scientific publications. *IEEE Trans. Eng. Manag.* 57 (1), 118–131.
- Calero, C., Van Leeuwen, T.N., Tijssen, R.J., 2007. Research cooperation within the biopharmaceutical industry: network analyses of co-publications within and between firms. *Scientometrics* 71 (1), 87–99.
- Calvert, J., Patel, P., 2003. University-industry research collaborations in the UK: bibliometric trends. *Sci. Public Policy* 30 (2), 85–96.
- Cassiman, B., Veugelers, R., Zuniga, P., 2008. In search of performance effects of (in) direct industry science links. *Ind. Corp. Chang.* 17 (4), 611–646.
- Chai, S., Shih, W., 2016. Bridging science and technology through academic-industry partnerships. *Res. Policy* 45 (1), 148–158.
- Chang, Y.-W., 2014. Exploring scientific articles contributed by industries in Taiwan. *Scientometrics* 99 (2), 599–613.
- Chang, Y.-W., Huang, M.-H., Yang, H.-W., 2016. Analysis of coactivity in the field of fuel cells at institutional and individual levels. *Scientometrics* 109 (1), 143–158.
- Cockburn, I., Henderson, R., 1996. Public-private interaction in pharmaceutical research. *Proc. Natl. Acad. Sci.* 93 (23), 12725–12730.
- Cockburn, I., Henderson, R., 1998. Absorptive capacity, coauthoring behavior, and the organization of research in drug discovery. *J. Ind. Econ.* 46 (2), 157–182.
- Cockburn, I.M., Henderson, R.M., Stern, S., 2000. Untangling the origins of competitive advantage. *Strateg. Manag. J.* 21 (10/11), 1123–1145.
- Cohen, W.M., Levinthal, D., 1990. Absorptive capacity: a new perspective on learning and innovation. *Adm. Sci. Q.* 35 (1), 128–152.
- Colen, L., Belderbos, R., Kelchtermans, S., Leten, B., 2021. Reaching for the stars: when does basic research collaboration between firms and academic star scientists benefit firm invention performance? *J. Prod. Innov. Manag.* 39 (2), 222–264.
- Colovic, A., Mayrhofer, U., 2011. Optimizing the location of R&D and production activities: trends in the automotive industry. *Eur. Plan. Stud.* 19 (8), 1481–1498.
- Colson, T.J., 2001. Leveraging the power and value of intellectual property. *Ivey Bus. J.* 65 (6), 29.
- Csomós, G., 2017. Mapping spatial and temporal changes of global corporate research and development activities by conducting a bibliometric analysis. *Quaestiones Geographicae* 36 (1), 65–77.
- Csomós, G., Tóth, G., 2016. Exploring the position of cities in global corporate research and development: a bibliometric analysis by two different geographical approaches. *Journal of Informetrics* 10 (2), 516–532.
- Dasgupta, P., David, P.A., 1994. Toward a new economics of science. *Res. Policy* 23 (5), 487–521.
- de Moya-Anegón, F., López-Illescas, C., Moed, H.F., 2014. How to interpret the position of private sector institutions in bibliometric rankings of research institutions. *Scientometrics* 98 (1), 283–298.
- De Solla Price, D.J., 1963. *Little Science, Big Science*. Columbia University Press, New York, US.

- Debackere, K., Rappa, M.A., 1994. Technological communities and the diffusion of knowledge: a replication and validation. *R&D Manag.* 24 (4), 355–371.
- Decarolis, D.M., Deeds, D.L., 1999. The impact of stocks and flows of organisational knowledge on firm performance: an empirical investigation of the biotechnology industry. *Strateg. Manag. J.* 20 (10), 953–968.
- Deeds, D.L., 2001. Role of R&D intensity, technical development and absorptive capacity in creating entrepreneurial wealth in high technology start-ups. *J. Eng. Technol. Manag.* 18 (1), 29–47.
- Della Malva, A., Hussinger, K., 2012. Corporate science in the patent system: an analysis of the semiconductor technology. *J. Econ. Behav. Organ.* 84 (1), 118–135.
- D'Este, P., 2005. How do firms' knowledge bases affect intra-industry heterogeneity? *Res. Policy* 34 (1), 33–45.
- Dietz, J.S., Bozeman, B., 2005. Academic careers, patents, and productivity: industry experience as scientific and technical human capital. *Res. Policy* 34 (3), 349–367.
- Ding, W.W., 2011. The impact of founders' professional-education background on the adoption of open science by for-profit biotechnology firms. *Manag. Sci.* 57 (2), 257–273.
- Eisenberg, R.S., 2000. The promise and perils of strategic publication to create prior art: a response to professor parchomovsky. *Michigan Law Rev.* 98 (7), 2358.
- Erden, Z., 2017. The publishing and patenting strategies of successful university spinoffs in the biopharmaceutical industry. *Drug Discov. Today* 22 (1), 5–9.
- Erden, Z., Klang, D., Sydlar, R., von Krogh, G., 2015. How can we signal the value of our knowledge? Knowledge-based reputation and its impact on firm performance in science-based industries. *Long Range Plan.* 48 (4), 252–264.
- Fabiano, G., Marcellusi, A., Favato, G., 2020. Public-private contribution to biopharmaceutical discoveries: a bibliometric analysis of biomedical research in UK. *Scientometrics* 124, 153–168.
- Fanelli, D., Larivière, V., 2016. Researchers' individual publication rate has not increased in a century. *PLOS ONE* 11 (3), e0149504.
- Frederiksen, L.F., 2004. Disciplinary determinants of bibliometric impact in Danish industrial research: collaboration and visibility. *Scientometrics* 61 (2), 253–270.
- Friesike, S., Widenmayer, B., Gassmann, O., Schildhauer, T., 2015. Opening science: towards an agenda of open science in academia and industry. *J. Technol. Transfer.* 40 (4), 581–601.
- Fugh-Berman, A.J., 2010. The haunting of medical journals: how ghostwriting sold "HRT". *PLoS Med.* 7 (9), e1000335.
- Furukawa, R., Goto, A., 2006a. Core scientists and innovation in Japanese electronics companies. *Scientometrics* 68 (2), 227–240.
- Furukawa, R., Goto, A., 2006b. The role of corporate scientists in innovation. *Res. Policy* 35 (1), 24–36.
- Gambardella, A., 1992. Competitive advantages from in-house scientific research: the US pharmaceutical industry in the 1980s. *Res. Policy* 21 (5), 391–407.
- Gans, J.S., Murray, F.E., Stern, S., 2017. Contracting over the disclosure of scientific knowledge: intellectual property and academic publication. *Res. Policy* 46 (4), 820–835.
- Gittelman, M., Kogut, B., 2003. Does good science lead to valuable knowledge? Biotechnology firms and the evolutionary logic of citation patterns. *Manag. Sci.* 49 (4), 366–382.
- Giunta, A., Pericoli, F.M., Pierucci, E., 2016. University-industry collaboration in the biopharmaceuticals: the Italian case. *J. Technol. Transfer.* 41 (4), 818–840.
- Gkotsis, P., Hernández, H., Vezzani, A., 2016. Estimating territorial business R&D expenditures using corporate R&D and patent data. In: *JRC Technical Report, European Commission. EUR 28126EN*. <https://doi.org/10.2791/147601>.
- Glenna, L., Bruce, A., 2021. Suborning science for profit: Monsanto, glyphosate, and private science research misconduct. *Res. Policy* 50 (7), 104290.
- Godin, B., 1996. Research and the practice of publication in industries. *Res. Policy* 25 (4), 587–606.
- Gök, A., Waterworth, A., Shapira, P., 2015. Use of web mining in studying innovation. *Scientometrics* 102 (1), 653–671.
- Grassano, N., Rotolo, D., Hutton, J., Lang, F., Hopkins, M.M., 2017. Funding data from publication acknowledgments: coverage, uses, and limitations. *J. Assoc. Inf. Sci. Technol.* 68 (4), 999–1017.
- Griliches, Z., 1979. Issues in assessing the contribution of research and development to productivity growth. *Bell J. Econ.* 10 (1), 92–116.
- Grodal, S., 2018. Field expansion and contraction: how communities shape social and symbolic boundaries. *Adm. Sci. Q.* 63 (4), 783–818.
- Haeussler, C., 2011. Information-sharing in academia and the industry: a comparative study. *Res. Policy* 40 (1), 105–122.
- Halperin, M.R., Chakrabarti, A.K., 1987. Firm and industry characteristics influencing publications of scientists in large American companies. *R&D Manag.* 17 (3), 167–173.
- Harhoff, D., 2002. Citations, family size, opposition and the value of patent rights. *Res. Policy* 1596 (1–21), 1343.
- Hartmann, P., Henkel, J., 2020. The rise of corporate science in AI: data as a strategic resource. *Acad. Manag. Discov.* 6 (3), 359–381.
- Hayter, C.S., Link, A.N., 2018. Why do knowledge-intensive entrepreneurial firms publish their innovative ideas? *Acad. Manag. Perspect.* 32 (1), 141–155.
- Henderson, R., Cockburn, I., 1994. Measuring competence? Exploring firm effects in pharmaceutical research. *Strateg. Manag. J.* 15 (S1), 63–84.
- Hernes, G., 1998. Real virtuality. In: Hedström, P., Swedberg, R. (Eds.), *Social Mechanisms: An Analytical Approach to Social Theory*. Cambridge University Press, Cambridge, MA, pp. 74–101.
- Hess, A.M., Rothaermel, F.T., 2011. When are assets complementary? Star scientists, strategic alliances, and innovation in the pharmaceutical industry. *Strateg. Manag. J.* 32 (8), 895–909.
- Hicks, D., 1995. Published papers, tacit competencies and corporate management of the public/private character of knowledge. *Ind. Corp. Chang.* 4 (2), 401–424.
- Hicks, D., 2000. 360 degree linkage analysis. *Res. Eval.* 9 (2), 133–143.
- Hicks, D., Ishizuka, T., Keen, P., Sweet, S., 1994. Japanese corporations, scientific research and globalization. *Res. Policy* 23 (4), 375–384.
- Hicks, D., Katz, S., 1997. A national research network viewed from an industrial perspective. *Rev. Econ. Ind.* 79 (1), 129–142.
- Hicks, D.M., Isard, P.A., Martin, B.R., 1996. A morphology of Japanese and European corporate research networks. *Res. Policy* 25 (3), 359–378.
- Hsu, D.H., Hsu, P.H., Zhao, Q., 2021. Rich on paper? Chinese firms' academic publications, patents, and market value. *Res. Policy* 50 (9), 104319.
- Huang, K.G.-L., 2017. Uncertain intellectual property conditions and knowledge appropriation strategies: evidence from the genomics industry. *Ind. Corp. Chang.* 26 (1), 41–71.
- Jaffe, A.B., 1986. Technological opportunity and spillovers of R&D: evidence from firms' profits, profits, and market value. *Am. Econ. Rev.* 76 (5), 984–1001.
- Johnson, J.P., 2014. Defensive publishing by a leading firm. *Inf. Econ. Policy* 28 (1), 15–27.
- Jong, S., Slavova, K., 2014. When publications lead to products: the open science conundrum in new product development. *Res. Policy* 43 (4), 645–654.
- Katz, J.S., Hicks, D.M., 1996. A systemic view of British science. *Scientometrics* 35 (1), 133–154.
- Katz, J., Martin, B.R., 1997. What is research collaboration? *Res. Policy* 26 (1), 1–18.
- Kelly, B., Papanikolaou, D., Seru, A., Taddy, M., 2020. Measuring technological innovation over the long run. In: *NBER Working Paper Series*, No. 25266, pp. 1–68.
- Kim, H.B., Kim, Y.S., 2015. Performance indices for quantitative measurement of R&D results in private construction companies. *KSCE J. Civ. Eng.* 19 (4), 814–830.
- Kinney, A.J., Krebbers, E., Vollmer, S.J., 2004. Publications from industry. Personal and corporate incentives. *Plant Physiol.* 134 (1), 11–15.
- Klitkou, A., Nygaard, S., Meyer, M., 2007. Tracking techno-science networks: a case study of fuel cells and related hydrogen technology R&D in Norway. *Scientometrics* 70 (2), 491–518.
- Koenig, M.E., 1983. A bibliometric analysis of pharmaceutical research. *Res. Policy* 12 (1), 15–36.
- Krieger, B., Pellens, M., Blind, K., Gruber, S., Schubert, T., 2021. Are firms withdrawing from basic research? An analysis of firm-level publication behaviour in Germany. *Scientometrics* 126, 9677–9698.
- Kumar, N., 2001. Determinants of location of overseas R&D activity of multinational enterprises: the case of US and Japanese corporations. *Res. Policy* 30 (1), 159–174.
- Ladge, J.J., Clair, J.A., Greenberg, D., 2012. Cross-domain identity transition during liminal periods: constructing multiple selves as professional and mother during pregnancy. *Acad. Manag. J.* 55 (6), 1449–1471.
- Lam, A., 2011. What motivates academic scientists to engage in research commercialization: 'gold', 'ribbon' or 'puzzle'? *Res. Policy* 40 (10), 1354–1368.
- Larivière, V., Macaluso, B., Mongeon, P., Siler, K., Sugimoto, C.R., 2018. Vanishing industries and the rising monopoly of universities in published research. *PLOS ONE* 13 (8), e0202120.
- Le Bas, C., Sierra, C., 2002. 'Location versus home country advantages' in R&D activities: some further results on multinationals' locational strategies. *Res. Policy* 31 (4), 589–609.
- Leten, B., Kelchtermans, S., Belderbos, R., 2021. How does basic research improve innovation performance in the world's major pharmaceutical firms? *Ind. Innov.* 29 (3), 1–29.
- Li, Y., Youtie, J., Shapira, P., 2015. Why do technology firms publish scientific papers? The strategic use of science by small and midsize enterprises in nanotechnology. *J. Technol. Transfer.* 40 (6), 1016–1033.
- Lichtman, D., Baker, S., Kraus, K., 2000. Strategic disclosure in the patent system. *Vanderbilt Law Rev.* 53 (6), 2175–2217.
- Lieskind, J.P., Oliver, A.L., Zucker, L.G., Brewer, M.B., 1996. Social networks, learning, and flexibility: sourcing scientific knowledge in new biotechnology firms. *Organ. Sci.* 7 (4), 428–443.
- Lim, K., 2004. The relationship between research and innovation in the semiconductor and pharmaceutical industries (1981–1997). *Res. Policy* 33 (2), 287–321.
- Lissoni, F., 2010. Academic inventors as brokers. *Res. Policy* 39 (7), 843–857.
- Liu, C.C., Stuart, T., 2014. Positions and rewards: the allocation of resources within a science-based entrepreneurial firm. *Res. Policy* 43 (7), 1134–1143.
- Liu, X., Zhu, D., Guo, Y., 2020. Exploring the role of companies in scientific research: a case study of genetically modified maize. *Tech. Anal. Strat. Manag.* 33 (4), 1–16.
- Lundberg, J., Tomson, G., Lundkvist, I., Skår, J., Brommels, M., 2006. Collaboration uncovered: exploring the adequacy of measuring university-industry collaboration through co-authorship and funding. *Scientometrics* 69 (3), 575–589.
- Mahlich, J., 2007. The Japanese pharmaceutical industry in transition: has higher research orientation resulted in higher market value? *Asian Bus. Manag.* 6 (1), 75–94.
- Mansfield, E., 1968. *Industrial Research and Technological Innovation*. Longmans, Green and Co., London.
- Marx, M., Fuegi, A., 2020. Reliance on science: worldwide front-page patent citations to scientific articles. *Strateg. Manag. J.* 41 (9), 1572–1594.
- McKelvey, M., Rake, B., 2016. Product innovation success based on cancer research in the pharmaceutical industry: co-publication networks and the effects of partners. *Ind. Innov.* 23 (5), 383–406.
- McKelvey, M., Rake, B., 2020. Exploring scientific publications by firms: what are the roles of academic and corporate partners for publications in high reputation or high impact journals? *Scientometrics* 122 (3), 1323–1360.
- McManus, C., Baeta Neves, A.A., Prata, A.T., 2021. Scientific publications from non-academic sectors and their impact. *Scientometrics* 126 (11), 8887–8911.

- McMillan, G., Deeds, L., 1998. The role of reputation in the recruitment of scientists. *R&D Manag.* 28 (4), 299–304.
- McMillan, G., Hamilton III, R.D., 2000. Using bibliometrics to measure firm knowledge: an analysis of the US pharmaceutical industry. *Tech. Anal. Strat. Manag.* 12 (4), 465–475.
- McMillan, G., Klavans, R.A., Hamilton, R.D., 1995. Firm management of scientific information: some predictors and implications of openness versus secrecy. *R&D Manag.* 25 (4), 411–419.
- McMillan, G.S., Mauri, A., Casey, D.L., 2014. The scientific openness decision model: “gaming” the technological and scientific outcomes. *Technol. Forecast. Soc. Chang.* 86, 132–142.
- Melin, G., Persson, O., 1996. Studying research collaboration using co-authorships. *Scientometrics* 36 (3), 363–377.
- Merges, R.P., 2004. A new dynamism in the public domain. *Univ. Chicago Law Rev.* 71 (1), 183–203.
- Merton, R., 1957. Priorities in scientific discovery: a chapter in the sociology of science. *Am. Sociol. Rev.* 22 (6), 635–659.
- Miles, M.B., Huberman, A.M., Saldaña, J., 1994. *Qualitative Data Analysis an Expanded Sourcebook*. Sage Publications, Thousand Oaks.
- Milgrom, P., Roberts, J., 1995. Complementarities and fit strategy, structure, and organizational change in manufacturing. *J. Account. Econ.* 19 (2–3), 179–208.
- Minguillo, D., Thelwall, M., 2015a. Research excellence and university–industry collaboration in UK science parks. *Res. Eval.* 24 (2), 181–196.
- Minguillo, D., Thelwall, M., 2015b. Which are the best innovation support infrastructures for universities? Evidence from R&D output and commercial activities. *Scientometrics* 102 (1), 1057–1081.
- Minguillo, D., Tijssen, R., Thelwall, M., 2015. Do science parks promote research and technology? A scientometric analysis of the UK. *Scientometrics* 102 (1), 701–725.
- Mongeon, P., Paul-Hus, A., 2016. The journal coverage of Web of Science and Scopus: a comparative analysis. *Scientometrics* 106 (1), 213–228.
- Moodysson, J., 2008. Principles and practices of knowledge creation: on the organization of “buzz” and “pipelines” in life science communities. *Econ. Geogr.* 84 (4), 449–469.
- Mukherjee, A., Stern, S., 2009. Disclosure or secrecy? The dynamics of Open Science. *Int. J. Ind. Organ.* 27 (3), 449–462.
- Muller, P., Pénin, J., 2006. Why do firms disclose knowledge and how does it matter? *J. Evol. Econ.* 16 (1–2), 85–108.
- Murray, F., 2002. Innovation as co-evolution of scientific and technological networks: exploring tissue engineering. *Res. Policy* 31 (8), 1389–1403.
- Murray, F., 2004. The role of academic inventors in entrepreneurial firms: sharing the laboratory life. *Res. Policy* 33 (4), 643–659.
- Nahapiet, J., Ghoshal, S., 1998. Social capital, intellectual capital, and the organizational advantage. *Acad. Manag. Rev.* 23 (2), 242–266.
- Narin, F., Noma, E., Perry, R., 1987. Patents as indicators of corporate technological strength. *Res. Policy* 16 (2–4), 143–155.
- Narin, F., Rozek, R.P., 1988. Bibliometric analysis of U.S. pharmaceutical industry research performance. *Res. Policy* 17 (3), 139–154.
- Narula, R., Santangelo, G.D., 2009. Location, collocation and R&D alliances in the European ICT industry. *Res. Policy* 38 (2), 393–403.
- Nelson, A.J., 2016. How to share “a really good secret”: managing sharing/secret tensions around scientific knowledge disclosure. *Organ. Sci.* 27 (2), 265–285.
- Nelson, R.R., 1959. The simple economics of basic scientific research. *J. Polit. Econ.* 67 (3), 297–306.
- Nelson, R.R., 1990. Capitalism as an engine of progress. *Res. Policy* 19 (3), 193–214.
- Okubo, Y., Sjöberg, C., 2000. The changing pattern of industrial scientific research collaboration in Sweden. *Res. Policy* 29 (1), 81–98.
- Olmeda-Gómez, C., Ovalle-Perandones, M.A., de Moya-Anegón, F., 2015. Analysis of research collaboration between universities and private companies in Spain based on joint scientific publications. *Inf. Res.* 20 (4), 67–84.
- Parchomovsky, G., 2000. Publish or perish. *Michigan Law Rev.* 98 (4), 926–952.
- Pellens, M., Della Malva, A., 2018. Corporate science, firm value, and vertical specialization: evidence from the semiconductor industry. *Ind. Corp. Chang.* 27 (3), 489–505.
- Penan, H., 1996. R & D strategy in a techno-economic network: Alzheimer's disease therapeutic strategies. *Res. Policy* 25 (3), 337–358.
- Penders, B., Nelis, A.P., 2011. Credibility engineering in the food industry: linking science, regulation, and marketing in a corporate context. *Sci. Context.* 24 (4), 487–515.
- Pénin, J., 2007. Open knowledge disclosure: an overview of the evidence and economic motivations. *J. Econ. Surv.* 21 (2), 326–348.
- Perianes-Rodríguez, A., Olmeda-Gómez, C., Ovalle-Perandones, M.A., Chinchilla-Rodríguez, Z., Moya-Anegón, F., 2011. R&D collaboration in 50 major Spanish companies. In: *Aslib Proceedings*, 63. Emerald Group Publishing Limited, pp. 5–27.
- Pisano, G., 2006. Profiting from innovation and the intellectual property revolution. *Res. Policy* 35 (8), 1122–1130.
- Podolny, J., 1993. A status-based model of market competition. *Am. J. Sociol.* 98 (4), 829–872.
- Pohl, H., 2021. Internationalisation, innovation, and academic–corporate co-publications. *Scientometrics* 126 (2), 1329–1358.
- Polidoro, F., 2013. The competitive implications of certifications: the effects of scientific and regulatory certifications on entries into new technical fields. *Acad. Manag. J.* 56 (2), 597–627.
- Polidoro, F., Theeke, M., 2012. Getting competition down to a science: the effects of technological competition on firms' scientific publications. *Organ. Sci.* 23 (4), 1135–1153.
- Powell, W.W., Sandholtz, K.W., 2012. Amphibious entrepreneurs and the emergence of organizational forms. *Strateg. Entrep. J.* 6 (2), 94–115.
- Rafols, I., Hopkins, M.M., Hoekman, J., Siepel, J., O'Hare, A., Perianes-Rodríguez, A., Nightingale, P., 2014. Big Pharma, little science? *Technol. Forecast. Soc. Chang.* 81 (January), 22–38.
- Ramani, S.V., 2002. Who is interested in biotech? R&D strategies, knowledge base and market sales of Indian biopharmaceutical firms. *Res. Policy* 31, 381–398.
- Rappa, M.A., Debackere, K., 1992. Technological communities and the diffusion of knowledge. *R&D Manag.* 22 (3), 209–220.
- Rinner, T.E., 2003. Protecting minor improvements on core patents: complementing traditional patent protection with strategic disclosure. *John Marshall Rev. Intellect. Prop. Law* 2 (2), 398.
- Rosenberg, N., 1990. Why do firms do basic research (with their own money)? *Res. Policy* 19 (2), 165–174.
- Sachini, E., Sioumalas-Christodoulou, K., Chrysomallidis, C., Siganos, G., Karampekios, N., 2020. Identifying the intellectual capital of Greek defence firms. *Science outputs and industrial considerations. Defence and Peace Economics* 1–20.
- Saldaña, J., 2013. *The Coding Manual for Qualitative Researchers*, Second edition. Sage Publications, London.
- Sauermann, H., Roach, M., 2014. Not all scientists pay to be scientists: PhDs' preferences for publishing in industrial employment. *Res. Policy* 43 (1), 32–47.
- Sauermann, H., Stephan, P., 2013. Conflicting logics? A multidimensional view of industrial and academic science. *Organ. Sci.* 24 (3), 889–909.
- Scellato, G., Franzoni, C., Stephan, P., 2015. Migrant scientists and international networks. *Res. Policy* 44 (1), 108–120.
- Schuhmacher, A., Gatto, A., Hinder, M., Gassman, O., 2020. The upside of being a digital pharma player. *Drug Discov. Today* 25 (9), 1569–1574.
- Schuhmacher, A., Willis, L., Kuss, M., Kandelbauer, A., Hinder, M., Gassmann, O., 2021. R&D efficiency of leading pharmaceutical companies—a 20-year analysis. *Drug Discov. Today* 26 (8), 1784–1789.
- Schmitt, R.W., 1961. Why publish scientific research from industry? *Res. Manag.* 4 (1), 31–41.
- Siedschlag, I., Smith, D., Turcu, C., Zhang, X., 2013. What determines the location choice of R&D activities by multinational firms? *Res. Policy* 42 (8), 1420–1430.
- Simeth, M., Cincera, M., 2016. Corporate science, innovation, and firm value. *Manag. Sci.* 62 (7), 1970–1981.
- Simeth, M., Lhuillery, S., 2015. How do firms develop capabilities for scientific disclosure? *Res. Policy* 44 (7), 1283–1295.
- Simeth, M., Raffo, J.D., 2013. What makes companies pursue an Open Science strategy? *Res. Policy* 42 (9), 1531–1543.
- Singh, V.K., Singh, P., Karmakar, M., Leta, J., Mayr, P., 2021. The journal coverage of web of science, scopus and dimensions: a comparative analysis. *Scientometrics* 126 (6), 5113–5142.
- Sismondo, S., 2009. Ghosts in the machine: publication planning in the medical sciences. *Soc. Stud. Sci.* 39 (2), 171–198.
- Sismondo, S., 2012. Medical publishing and the drug industry: is medical science for sale? *Learned Publ.* 25 (1), 7–15.
- Slavova, K., 2021. When firms embrace science: university alliances and firm drug development pipeline. *J. Prod. Innov. Manag.* 39 (2), 265–279.
- Slejko, J.F., Basu, A., Sullivan, S.D., 2018. Returns to scientific publications for pharmaceutical products in the United States. *Health Econ.* 27 (2), 282–293.
- Smith, A.N., Watkins, M.B., Ladge, J.J., Carlton, P., 2019. Making the invisible visible: paradoxical effects of intersectional invisibility on the career experiences of executive black women. *Acad. Manag. J.* 62 (6), 1705–1734.
- Smith, R., Jefferson, T., Frizelle, F., Haug, C., Hoey, J., 2005. Medical journals are an extension of the marketing arm of pharmaceutical companies. *PLoS Med.* 2 (5), e138.
- Soh, P.H., Subramanian, A.M., 2014. When do firms benefit from university–industry R&D collaborations? The implications of firm R&D focus on scientific research and technological recombination. *J. Bus. Ventur.* 29 (6), 807–821.
- Spence, M., 1974. *Market Signaling: Information Transfer in Hiring and Related Screening Processes*. Harvard University Press, Cambridge, MA.
- Spencer, J.W., 2000. Knowledge flows in the global innovation system: do US firms share more scientific knowledge than their Japanese rivals? *J. Int. Bus. Stud.* 31 (3), 521–530.
- Spencer, J.W., 2001. How relevant is university-based scientific research to private high technology firms? A United States–Japan comparison. *Acad. Manag. J.* 44 (2), 432–440.
- Spielmanns, G.I., Parry, P.I., 2010. From evidence-based medicine to marketing-based medicine: evidence from internal industry documents. *J. Bioethical Inq.* 7 (1), 13–29.
- Steinman, M.A., Bero, L.A., Chren, M.-M., Landefeld, C.S., 2006. Narrative review: the promotion of gabapentin: An analysis of internal industry documents. *Annals of Internal Medicine* 145 (4), 284–293.
- Stephan, P.E., 1996. The economics of science. *J. Econ. Lit.* 34 (3), 1199–1235.
- Stern, S., 2004. Do scientists pay to be scientists? *Manag. Sci.* 50 (6), 835–853.
- Sternitzke, C., 2010. Knowledge sources, patent protection, and commercialization of pharmaceutical innovations. *Res. Policy* 39 (6), 810–821.
- Strauss, A., Corbin, J., 1998. *Basics of Qualitative Research Techniques*. Sage Publications, London.
- Stokes, D.E., 1997. *Pasteur's Quadrant*. Brookings Institution, Washington, DC.
- Subramanian, A.M., Lim, K., Soh, P.H., 2013. When birds of a feather don't flock together: different scientists and the roles they play in biotech R&D alliances. *Res. Policy* 42 (3), 595–612.
- Sun, Y., Negishi, M., Nishizawa, M., 2007. Coauthorship linkages between universities and industry in Japan. *Res. Eval.* 16 (4), 299–309.

- Sun, Y., Negishi, M., 2010. Measuring the relationships among university, industry and other sectors in Japan's national innovation system: a comparison of new approaches with mutual information indicators. *Scientometrics* 82 (3), 677–685.
- Tegarden, L.F., Lamb, W.B., Hatfield, D.E., Ji, F.X., 2012. Bringing emerging technologies to market: does academic research promote commercial exploration and exploitation. *IEEE Trans. Eng. Manag.* 59 (4), 598–608.
- Tijssen, R.J.W., 2009. Internationalisation of pharmaceutical R&D: How globalised are Europe's largest multinational companies? *Tech. Anal. Strat. Manag.* 21 (7), 859–879.
- Tijssen, R.J.W., Korevaar, J.C., 1997. Unravelling the cognitive and interorganisational structure of public/private R&D networks: a case study of catalysis research in the Netherlands. *Res. Policy* 25 (8), 1277–1293.
- Tijssen, R.J.W., 2004. Is the commercialisation of scientific research affecting the production of public knowledge?: Global trends in the output of corporate research articles. *Res. Policy* 33 (5), 709–733.
- Tijssen, R.J.W., 2012. Co-authored research publications and strategic analysis of public-private collaboration. *Res. Eval.* 21 (3), 204–215.
- Tijssen, R.J.W., Van Leeuwen, T.N., 2006. Measuring impacts of academic science on industrial research: a citation-based approach. *Scientometrics* 66 (1), 55–69.
- Tijssen, R.J.W., van Leeuwen, T.N., Korevaar, J.C., 1996. Scientific publication activity of industry in the Netherlands. *Res. Eval.* 6 (2), 105–119.
- Tijssen, R.J.W., Van Leeuwen, T.N., Van Wijk, E., 2009. Benchmarking university-industry research cooperation worldwide: performance measurements and indicators based on co-authorship data for the world's largest universities. *Res. Eval.* 18 (1), 13–24.
- Tranfield, D., Denyer, D., Smart, P., 2003. Towards a methodology for developing evidence-informed management knowledge by means of systematic review. *Br. J. Manag.* 14 (3), 207–222.
- Vestal, A., Danneels, E., 2018. Knowledge exchange in clusters: the contingent role of regional inventive concentration. *Res. Policy* 47 (10), 1887–1903.
- Visser, M., van Eck, N.J., Waltman, L., 2021. Large-scale comparison of bibliographic data sources: Scopus, Web of Science, Dimensions, Crossref, and Microsoft Academic. *Quant. Sci. Stud.* 2 (1), 20–41.
- Wang, J., Shapira, P., 2011. Funding acknowledgement analysis: an enhanced tool to investigate research sponsorship impacts: the case of nanotechnology. *Scientometrics* 87 (3), 563–586.
- Wang, J., Shapira, P., 2012. Partnering with universities: a good choice for nanotechnology start-up firms? *Small Bus. Econ.* 38 (2), 197–215.
- Wuchty, S., Jones, B.F., Uzzi, B., 2007. The increasing dominance of teams in production of knowledge. *Science* 316, 5827.
- Zahra, S.A., Kaul, A., Bolívar-Ramos, M.T., 2018. Why corporate science commercialization fails: integrating diverse perspectives. *Acad. Manag. Perspect.* 32 (1), 156–176.
- Zahringer, K., Kolympiris, C., Kalaitzandonakes, N., 2017. Academic knowledge quality differentials and the quality of firm innovation. *Ind. Corp. Chang.* 26 (5), 821–844.
- Zucker, L.G., Darby, M.R., 1997. Present at the biotechnological revolution: transformation of technological identity for a large incumbent pharmaceutical firm. *Res. Policy* 26 (4–5), 429–446.
- Zucker, L.G., Darby, M.R., Armstrong, J.S., 2002. Commercializing knowledge: university science, knowledge capture, and firm performance in biotechnology. *Manag. Sci.* 48 (1), 138–153.