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What we know about open innovation, unresolved issues, and a checklist for future research

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Abstract. We synthesize and provide a critical overview of the set of quantitative papers on open innovation which have had an influence on analyses of open innovation in a corporate strategy context. We categorize the literature into a) firms' external search and knowledge sourcing activities, b) absorptive capacity, and c) appropriability. We discuss the firm and individual level contributions to each of these literature streams, identifying those contributions specific to knowledge about open innovation and unresolved issues which represent future research opportunities. In addition, we try to draw some lessons in terms of future challenges for open innovation research in relation to the growth and influence of this domain. Specifically, we discuss some specific problems related to the robustness, validity, reliability, and causal identification of open innovation research, and how these might be overcome through a new research approach. We conclude by proposing a checklist for future quantitative empirical studies of open innovation.

Keywords. Open innovation; critical overview; external search; absorptive capacity; appropriability; the future of open innovation research

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Introduction

Henry Chesbrough's (2003a) seminal book on open innovation sparked several broad and productive streams of research on the firm and individual benefits (and costs) of participation in open innovation. In the present paper, we provide a critical assessment of three of these strands of work, all of which are at the core of developments in this research area. We assess: 1) the determinants of and implications for firm performance of an external search strategy and the contingencies related to this strategy, 2) absorptive capacity problems at the firm level, and 3) appropriability and appropriation issues related to adoption of an open innovation model by business firms (for definitions of appropriability and appropriation , see Hurmelinna-Laukkanen & Yang, 2022). For each of the three streams of research we identify contributions which we consider to be important contributions to knowledge on the topic and also point to what we believe are important unresolved issues that could represent future research opportunities.

The body of work analyzing open innovation is substantial. A full text search on Business Source Ultimate identified 2,750 papers containing the term "open innovation" published in academic journals between January 2003 and July 2023.[1] Figure 1 shows that the number of papers has increased from 6 in 2003 to 266 in 2022 (the last complete year observed). Against the backdrop of a rapidly growing and very large literature, the intention in this paper is not to provide an exhaustive review of the literature or offer a formal meta-analysis or "unifying" assumption in relation to the findings in the literature (for more extensive reviews of the literature, see for instance, Dahlander & Gann, 2010; Dahlander et al., 2021; West & Bogers, 2014). Rather, the aim is to synthesize and provide a critical overview of the subset of what we consider to be the most influential contributions to the

[1] Business Source Ultimate made available by EBSCO, includes 4,300 academic business-relevant journals (mainly within social sciences). See https://www.ebsco.com/products/research-databases/business-source-ultimate (accessed September 13, 2023).

literature analyzing open innovation in relation firms' external search and knowledge sourcing activities, absorptive capacity, and appropriability. Clearly, there are other firm-level research streams but the three areas on which we focus comprise a major strand of work within the much larger firm-level open innovation literature. These three research streams also fit neatly with the topic of Open Innovation, Value Creation and Value Capture of this journal's Special Section in which this paper appears. The activities most closely connected to value creation and value capture are respectively external search and knowledge sourcing and appropriability. Absorptive capacity can be considered as linked to both these activities since it is required to capture the value from the innovative efforts of other firms while also being a precondition for the ability to assimilate external knowledge to increase the focal firm's innovation process (value creation).

Our emphasis on open innovation in relation to firms and their innovation strategies implies that overall our review does not include contributions to the broader open innovation literature for instance, analyses of individual motivations to contribute to the open innovation process (such as, for instance, Harhoff et al., 2003; Jeppesen & Lakhani, 2010). We also do not consider research in this area which does not use the term open innovation. However, we hope that our overview reduces the disconnect and incoherence that have permeated parts of the literature on open innovation which analyzes firm strategies.

Our review also allows us to take a step back and attempt to draw some lessons about the challenges for future open innovation research by identifying more generally under researched areas and proposing ways to increase the research strength of the open innovation domain overall. More precisely, we discuss some problems specific to open innovation research such as its robustness, validity, reliability, and causal identification, and how these might be mitigated with the application of a new and different research approach. On this basis, we propose a checklist for future quantitative empirical studies of open innovation.

Background

The early Schumpeterian model of innovation (1912/1934) assumes that inventions are produced by single individual entrepreneurs. The later Schumpeterian innovation model (1942) focusses on the role of industry R&D and the major part played by large firms. However, since the 1960s, innovation models have tended increasingly to include both firm-level R&D and multiple external sources of knowledge. It was recognized at an early stage that users were important drivers of innovation (Allen, 1977 ; Freeman, 1968; Linder, 1961; Lundvall, 1988; Rosenberg, 1982; von Hippel, 1976). Von Hippel's (1988) influential book contends that innovation arises from many different sources including from those likely to benefit from the innovation, or that create or support an activity that is in their interest. Early research also identified obstacles to external sourcing of ideas and knowledge, including the not-invented-here syndrome, defined as group tendency to believe it has a monopoly over a particularly knowledge field and to reject the ideas of outsiders (Katz & Allen, 1982), and the notion that frequently organizational learning processes are myopic – leading again to the rejection of external ideas (Levinthal & March, 1993).

Although Chesbrough's (2003a; 2006) model of "open innovation" was arguably not the first model to conceive innovation as an interactive, distributed, and open process it was new in the sense that it suggested (and documented) the increasing importance of this phenomenon in business practice around the time of the 2003 book's publication and provided explanations for the increase. Chesbrough's main arguments were that the quality and availability of external knowledge were increasing and that the strategic advantage derived from innovating based on internal R&D was being eroded which was requiring firms to exploit external knowledge in order to innovate. In a very frequently-cited paper published following Chesbrough's (2003a) book, Laursen and Salter (2006) questioned Chesbrough's assumptions about open innovation arguing that since firms are constrained in what they can do although open innovation might

offer sizeable advantages it also entails costs. To support these claims, Laursen and Salter provided some quantitative evidence from UK manufacturing firms, and this paper helped to spur a rich stream of research that quantitively explored different aspects of the Chesbrough model.

A review of three open innovation research streams: External search strategy and open innovation, absorptive capacity, and appropriability

In this section, we review the three important streams of work identified above as included under the umbrella of open innovation. *For each stream*, we set out what we believe have been the most critical contributions to our knowledge of open innovation, and then identify some issues discussed in the current open innovation literature which we consider important but unresolved. To the extent possible we present the material in chronological order which provides a depiction of the evolution over time of each of these three research streams. In each case, we begin by reviewing firm-level contributions followed by a review of the individual-level contributions, including among the latter set of studies, only those which have implications for firm-level open innovation. This sequencing also reflects the general evolution of the open innovation literature which over time has tended towards a greater emphasis on the level of the individual.

External search strategy and open innovation

Contributions to knowledge. There is an important stream of research which focuses mainly on the determinants of and implications for firm performance of an external search strategy and the contingencies affecting this strategy (Cassiman & Valentini, 2016; Köhler et al., 2012; Laursen & Salter, 2006; Leiponen & Helfat, 2010; Love et al., 2014; Srinivasan et al., 2021). This strand of work provides a better understanding of how value creation — and to an extent value capture — are linked to the organization's relationships with a range of external actors.

Laursen and Salter (2006) show that firm innovation performance benefits from openness to external sources of knowledge (via breadth and depth of external search) but that at a certain threshold these returns decrease or turn negative. Laursen and Salter (2006) use attention-based theory of the firm (Ocasio, 1997; Simon, 1947) to explain under- and over-search of external sources of knowledge. Attention-based theory suggests that managerial attention is a scarce and the most precious resource internal to the organization and that the decision to allocate attention to specific activities is a crucial factor for explaining why some firms are able to both adapt to changes in their external environment and introduce new products and processes. Laursen and Salter (2006) apply this theory to argue that poor allocation of managerial attention can lead to the firm participating in too few or too many external and internal communication channels and support their argument based on data from an innovation survey of UK manufacturing firms. Subsequent work on the costs and benefits of external search and collaboration shows that firm-level contingencies can moderate or mediate the relationship between openness and innovation outcomes (e.g. Garriga et al., 2013; Leiponen & Helfat, 2010; Love et al., 2014; Srinivasan et al., 2021; Tether & Tajar, 2008).

Research has shown further that the breadth of external search and its objectives have a mutual effect on innovation performance (Leiponen & Helfat, 2010), and that barriers to innovation could mediate the effect of external search on innovation outcomes (Garriga et al., 2013). Moreover, future search and innovation outcomes could be shaped by prior searches and collaboration activities (Love et al., 2014). Cassiman and Valentini (2016) suggest that the complementarity between buying in and selling knowledge due to the costs associated to external engagement and internal coordination.

Dahlander and colleagues (2016) address the issue of the effect on search breadth efficiency of individual allocation of attention. They use matched survey/patent data to

examine the search behaviors of elite boundary spanners at IBM. They show that individuals who allocated attention to people inside rather than outside the firm were more innovative whilst individuals focused more on external search were more innovative if they allocated attention more to those external sources. This suggests that either a "cosmopolitan" or external search strategy or a "local" or internal strategy is likely to result in successful innovation. In another study using a sample of R&D technologists, Salter and coauthors (2015) showed that alertness and variety related to external search benefit the individual up to the point where increasing integration and approval costs cause negative returns to ideation.

Unresolved issues. It can be seen that much has been learned about external search and open innovation over the past two decades. It would seem that to an extent adoption of an open innovation model is consistent with higher levels of product innovation output but its adoption is accompanied by some limitations and trade-offs. For instance, firms may "over search" externally with the effects differing with the novelty of the innovation and the perceived obstacles and benefits; and individuals need to prioritize their search efforts internally versus externally, and to be mindful of search costs. The literature focuses mostly on the development of innovation theory which accounts for the dynamics of open innovation and external search but has paid relatively little attention to the establishing causality. As a result, we lack causal evidence that adoption of an open innovation model leads to increased individual or firm-level performance.

The paper authored by Lilien et al. (2002) describes an attempt by Eric von Hippel and colleagues to provide causal evidence in relation to lead users, which a critical component of open innovation. They used data obtained from an experiment conducted in 3M to compare the effects of a lead user idea-generation process with more traditional methods. They found that the lead user method potentially improved 3M's innovation capabilities; after five years, product ideas generated by the average lead user project at 3M were projected to achieve

eight times higher sales than forecast for the average contemporaneously conducted "traditional" project. However, similar research designs which are critical for testing causal claims remain underdeveloped with respect to external search and performance.

Absorptive capacity and open innovation

Contributions to our knowledge. Although linked to multiple learning processes, the concept of absorptive capacity proposed initially by Cohen and Levinthal (1990) and adopted by many other studies (see e.g. Bertrand & Mol, 2013; Hoang & Rothaermel, 2010) understands it in terms of internal R&D capabilities. The empirical research carried out by Grimpe and Sofka (2009), Rothaermel and Alexandre (2009) and Berchicci (2013) demonstrate the central role of internal R&D for balancing internal and external innovation activities to maximize innovation output. Similarly, building on a study of high-tech Taiwanese manufacturing firms, Hung and Chou (2013) show that internal R&D positively moderates the relationship between management of inbound open innovation and firm performance.

Escribano et al. (2009) tried empirically to isolate the impact of absorptive capacity on innovation performance, focusing on how it moderated the degree to which external knowledge flows affect innovation output. Escribano and colleagues argued that the role of absorptive capacity was more pronounced in environments characterized by high degrees of turbulence (in terms of the relative importance of new or improved products within an industry compared to economy average) and tight intellectual property rights protection. They provide evidence that the size of the firm's knowledge base positively moderates the impact of knowledge flows on innovation performance. In other words, absorptive capacity matters for the ability to benefit from open innovation. Similarly Zobel (2017) found a positive indirect baseline association between external technological resource access and competitive advantage in product innovation, mediated by the firm's technology-related capabilities and show also that the components of absorptive capacity modify this indirect baseline

relationship. Empirical analysis of the nomological network based on original survey data lends support to these ideas.

Foss et al. (2011) extended the idea of absorptive capacity in the context of open innovation to organizational design and argued that to leverage user and customer knowledge to inform innovation the firm needs to design an appropriate internal supporting organization. They suggested that this could be achieved through the exploitation of some specific organizational practices such as intensive vertical and lateral communication, rewarding employees for sharing and acquiring knowledge, and high levels of delegation of responsibility for decision making. Foss and colleagues posit that high levels of delegation of responsibility for decision making represent an important organizational dimension of Cohen and Levinthal's (1990) notion of outward-looking absorptive capacity, and that intensive vertical and lateral communication and rewarding employees for sharing and acquiring knowledge represent an important organizational dimension of Cohen and Levinthal's idea of inward-looking absorptive capacity. Foss et al. (2011) provide empirical evidence consistent with the idea that the link between customer knowledge and innovation is mediated entirely by organizational practices.

Similarly, Lakemond and colleagues (2016) argued that in addition to knowledge-precursors such as R&D which the literature on open innovation and absorptive capacity shows is important for the integration of external knowledge, the firm's knowledge governance procedures also matter for innovation performance. These authors attribute some of these effects to the ability to handle basic organizational design problems pertaining to agents' motivation and knowledge coordination. They investigate two types of knowledge governance — project management and knowledge matching — in the context of inbound open innovation. Drawing econometric analysis of survey data from a sample of manufacturing firms in Finland, Italy, and Sweden, they show that these governance

procedures contribute positively to collaborative inbound open innovation performance. They find that regardless of partner breadth, knowledge matching appears to matter for open-innovation related performance while in contexts of high levels of partner breadth project management tools matter more.

Moreira et al. (2018) start from idea of distant, externally-developed knowledge being difficult to absorb into the firm's own knowledge. They suggest that high levels of intrafirm inventor network diversity and dense individual inventor networks facilitate absorption of externally sourced knowledge — especially knowledge that is distant from the focal firm's knowledge. They provide evidence in support of these effects based on an event history study of the world's largest technology in-licensing pharmaceutical firms. In a similar study of the relationship between individual-level attributes and firm-level outcomes, Bogers et al. (2018) suggest that employee knowledge and differences in employees' educational backgrounds are associated with firm-level openness. Their empirical results are in line with these suggestions and are based on data from two surveys and a firm register.

At the micro-level, ter Wal et al. (2017) investigate whether individuals should specialize in efforts to improve knowledge absorption or engage in a wider range of activities. They suggest that better assimilation capabilities increase the value of individual external search efforts and improve the utilization of external knowledge, and ultimately increase innovation performance. They propose the idea of "gatekeepers" who by combining external search and assimilation efforts contribute to innovation through the accumulation of greater potential absorptive capacity, and "shepherds" who combine knowledge assimilation and utilization to increase absorptive capacity and innovation.

Unresolved issues. The external search and open innovation literature provides insights into the relationship between absorptive capacity and open innovation and the effect of these two variables on various aspects of innovation performance. However, Chesbrough (2003a)

suggests that appropriability problems and increased availability of high-quality external knowledge in the overall innovation system challenge traditional innovation models based primarily on internal R&D (see also, Appleyard & Chesbrough, 2017). Chesbrough (2003a) believes that adoption of open innovation is aimed at cost saving. He points to the pressure from the reduced ability of firms to profit from their innovations and the continuing need to be innovative and suggests that adoption of an open innovation model is aimed at increasing profit. This would imply that while a degree of absorptive capacity is needed to benefit from open innovation, higher degrees of absorptive capacity do not lead linearly to higher benefits from open innovation. This leads to the mostly unaddressed question of how much and what kind of absorptive capacity is needed to benefit from open innovation (however, see Berchicci, 2013).

Another issue that requires research attention is related to the precursors to absorptive capacity that is knowledge derived from R&D and the firm's knowledge governance process. We need to know how these aspects interact and the effect on open innovation and its outcomes. For instance, is there a certain degree knowledge intensity which produces more successful open innovation outcomes when combined with specific organizational designs/procedures?

Appropriability and open innovation: The openness paradox

Contributions to our knowledge. Managers make their firm open by engaging with a broad set of external actors in their innovation activities but may also have to increasingly protect their own firm's knowledge from being copied by competitors, given the higher exposure to external actors as the firm opens its innovation process. Laursen and Salter (2014) points out that this tension represents an apparent paradox that openness may demand more attention to protection (for an in-depth review of research on the relationship between appropriability and open innovation, see Laursen et al., 2023). This paradox arises because engagement in open

innovation involves interactions with a broad set of external actors but does not reduce the need for the firm to protect its knowledge from potential competitors. Open innovation necessarily requires the involved firms to reveal parts of their inhouse knowledge and some knowledge leakage is inevitable. To mitigate the impacts of knowledge leakages in external collaborations for open innovation, firms use appropriability mechanisms (Arundel, 2001; Cassiman & Veugelers, 2002; Heimann & Nickerson, 2004). However, too strong a focus on appropriability can divert attention from the innovation process and dissuade partners from joining the open innovation effort.

The paradox of openness has been investigated from different perspectives to highlight whether such a tradeoff exists and if so under what conditions (Arora et al., 2016; Wadhwa et al., 2017), and whether sequencing or structuring of open innovation and appropriability efforts would mitigate the problems. It has been suggested that the firm might allow access (make open) only certain parts of its product architecture (Henkel et al., 2014).

In an analysis of the solar industry in North America, Zobel et al. (2016) found a link between patenting and increased number of open innovation relationships involving new entrants. However, they found that the strength of this link seems to vary with the level of technology intensity. While the effect of patenting on openness is strongly positive for technology-intensive relationships, it becomes weaker as the technology intensity decreases, and turns negative in the case of the least technology-intensive relationships. In a related study, Arora et al. (2016) argue that the relationship between openness and patenting (appropriability) is dependent whether or not the firm is technically superior to its rivals and is a market leader. Compared to followers, leading firms are more vulnerable to (unintended) knowledge spillovers during collaboration as, and consequently increased patenting from open innovation is more important for the latter than the former.

Henkel et al. (2014) conducted an empirical study in a segment of the computer components industry. Entry of the open-source operating system Linux, resulted in firms increasingly abandoning their intellectual property rights on software drivers. Their study suggests that a learning process leads component makers to understand that selective waiving of intellectual property rights could benefit their business. Wadhwa et al. (2017) predicted an inverted curvilinear relationship between externally developed R&D and innovation. They explain why at various degrees of external knowledge sourcing the appropriability strategies employed by firms change this relationship. They studied a sample of French manufacturing firms and provide evidence supporting their hypothesis. They found that at lower degrees of external R&D the relationship was moderated by employee retention and secrecy which reduce the benefits of external R&D whereas at higher levels of external R&D the downsides are mitigated.

In a very recent study, Cappelli et al. (2023) proposed that firm engagement in open innovation may be a result of technological competition for the patent during the invention phase. If exposed to technological competition and if the given technology is not the focal firm's core technology, it might try to accelerate the innovation process by exchanging its technologies with the other firms to minimize possible losses from the potentially competing patents.

Foege et al. (2019) examine the tensions at the individual level between sharing and protection in outward open innovation. They used textual and interview data to examine the experience of individual problem-solvers in intermediated crowdsourcing contests. Their textual data came from over 2,000 responses to 5 open-ended narrative questions included in a survey supported by in-depth interviews with some problem solvers. Their findings suggest that the sharing-protecting experienced by individual problem solvers can be costly and how

these individuals try to overcome the paradox of openness through formal and informal value appropriation practices within different configurations, depends on the specific contest.

Unresolved issues. Our knowledge of the relationship between appropriability and open innovation has been extended in the most recent decade. However, in an open innovation context where legal means of intellectual property such as patent protection are often unavailable, knowledge leakages can be a major issue. For example, the firm's tacit and/implicit knowledge assets might be primarily privately owned and are at risk in the open innovation process. Trade secrecy provides only limited protections against losses of knowledge in open innovation contexts. This suggests that the type and attributes of the firm's critical knowledge might reduce the incentives for engagement in open innovation. On the other hand, Arora (1995) showed that even in transactions involving tacit knowhow, firms may be able to mitigate appropriability risks by relying on formal intellectual property protection (such as patents) to protect their knowhow.

The literature in this area tends to focus on formal intellectual property protection; we need more research to provide a better understanding of the complex interactions between informal intellectual property protection (such as secrecy) and formal intellectual property protection (such as patents), adoption and benefits of the open innovation model.

The open innovation process can be considered value creating with appropriability as a key variable in value capture. A substantial part of the open innovation literature treats value creation and value capture separately with only a few papers discussing their interconnections.[2] While the strand of work on the paradox of openness addresses some of these mutual links and tensions, our general understanding of the connections between value creation and value capture in the context of open innovation is poor and involves several

[2] We thank an anonymous reviewer for making this point.

unresolved issues (however, see Chesbrough et al., 2018; Helfat & Quinn, 2006). Therefore, this topic would be an important and potentially fruitful area for future research.

Finally, the relationship between absorptive capacity and appropriability in the context of open innovation is also a potentially important, yet under researched area. For instance, absorptive capacity might determine appropriability strategy, or the two factors might be complements. Research is needed to increase our understanding about this important relationship.

General challenges and new departures

In the foregoing, for each of the three streams of open innovation research (firms' external search and knowledge sourcing activities, absorptive capacity, and appropriability), we identified what we consider to be important but unresolved questions. These areas of uncertainty represent opportunities for future research. In addition to these unresolved issues in the specific research streams addressed in this paper, we believe that the open innovation literature generally faces some challenges which need to be addressed to allow further development of this field. While both the depth and scope of the open innovation literature have increased, we believe more work is need on at least five general areas.

First, early work on open innovation is mostly descriptive or relies on datasets built for other purposes. Over time, customized surveys and tools have been developed but there is no agreement among open innovation research scholars about how to measure open innovation, and there is continuous reliance on the early partial approaches to open innovation. For example, many studies rely on innovation survey data and use external knowledge sources and collaboration to proxy for openness. Innovation survey data are useful in terms of their cumulativeness, comprehensiveness, and coherence but are rough and incomplete representations of the wide set of open innovation practices adopted by firms.

This lack of agreement over how to measure open innovation has led to reuse and repurposing of existing measures to capture open innovation and application of different methods in different studies leading inevitably to inconsistent results. Conformity in relation to a set of robust and valid measures is an urgent need in this research field but will require collaboration and consensus over the development of appropriate measures, and their testing in various contexts over time to ensure their reliability.

Second, the level of analysis in open innovation research is problematic. Open innovation was conceived originally as a set of firm level managerial practices but over time it has been explored at both the individual level and in business unit/divisional, team/project contexts (Du et al., 2014; Salge et al., 2013). Firm level open innovation practices are liable to cascade down through different firm levels, and there may be variations within the firm in the interest in and activities related to open innovation (Bogers et al., 2017). What might be applicable at one firm level may not be appropriate at some other firm levels. Some units might favor open innovation while others might not consider it useful.

Arora et al. (2013) suggest that although the openness of some business units to external actors can benefit the whole firm there may be no incentives for these units to engage in outbound open innovation. Moreover, the relationships among the actors at one level may be shaped by the practices employed at another level. For example, a team's ability to engage in open innovation may be a function of the attitudes and skills of its members and also of the attitudes and practices of the firm division involved. Organizational design can also shape attitudes and behaviors to open innovation; Colombo et al. (2021) show that decentralization is associated with higher engagement in open innovation. Although investigation has begun on how different organization levels and organizational features affect open innovation, we need a much better understanding of how different cross-level interactions and organizational design choices shape observed outcomes.

Third, open innovation refers to a set of managerial practices chosen by the firm's managers in their wider corporate strategy efforts which makes it difficult to hypothesize about the impact of open innovation on firm performance. Many firms engaging in open innovation were already innovative beforehand and had the resources, people, and practices required for innovation. Such interrelated managerial choices are difficult to observe, and the literature often assumes (and often mistakenly) that open innovation is a choice that is distinct from other firm strategies.

It is possible that firms with more competent managers choose open innovation activity because of their greater awareness of the potential of these practices to improve their firms and also because they see these practices as complementing other parts of their firms' efforts. Research often sees open innovation as a discrete strategic choice rather than a managerial approach within a wider strategy whose outcomes are shaped by the attitudes, abilities, and perceptions of managers. We need causal research designs to provide evidence on the association between open innovation and firm outcomes and the impact of open innovation on firm performance. For example, researchers could set up natural or field experiments in which open innovation expertise/effort is either randomly assigned to some agents (firms/teams/individuals) or where some groups are exposed to open innovation expertise/effort for reasons other than their ability.

Fourth, the relationships between the firm and external partners in open innovation are the outcome of a dynamic matching process (Mindruta, 2013). Open innovation activities invariably involve collaboration or engagement between at least two actors who choose whether or not to engage in open innovation with the other party. Their choice may be influenced by a range of hard to observe factors. For example, an individual inventor might decide not to engage with a large firm to avoid appropriation of his or her ideas while a large firm might reject collaboration with a small firm with potentially useful ideas due to fear of

contaminating it internal innovative efforts in the same area (Chesbrough, 2006). Although this "deterrence effect" is referred to in the literature (Alexy et al., 2009; Laursen & Salter, 2014), it is hard to capture empirically. Also, the costs of the search for appropriate open innovation partners can be high, and firms might need to reveal part of their knowledge base to induce cooperation (Alexy et al., 2013). Several firms often lack the time required for the search for suitable university partners (Perkmann & West, 2015) whilst if potential partners are identified there can be extensive coordination costs associated with engagement and collaboration (Lakemond et al., 2016). These coordination costs arise from preparation and agreement over contractual terms and ongoing management of collaboration activities and resolution of any disputes (Kale & Singh, 2009). The challenge for researchers is that we mostly observe realized open innovation activities and do not account for deterrence effects, or the search and/or coordination costs associated with open innovation. Research should focus more on the matching process and the search and coordination costs associated with potential and realized open innovation efforts.

The fifth issue is that not all the costs and benefits from adopting open innovation are accrued by the firm. Although potentially adoption of open innovation will provide the firm with substantial benefits, it will not be the sole beneficiary. Framed in a general business strategy context, Lippman and Rumelt (2003) have suggested that the value created is shared among the owners of various inputs through a process of bargaining over the prices of scarce and valuable resources. In Coff's (1999: 119) seminal work the question posed was: "What if rent from a competitive advantage is appropriated so it cannot be observed in performance measures?" In the context of open innovation this implies that some particular types of employees may benefit from the adoption of an open innovation model due simply to the value of that employee when the firm opens its innovation process to external actors. The open innovation literature often assumes that firms collaborate with external innovation partners in

part to save on R&D costs (Chesbrough, 2003a, 2003b; Chesbrough & Garman, 2009) but focuses mostly on the direct costs of open innovation and external search and ignores the indirect costs of external search (Felin & Zenger, 2020). These indirect costs are linked to increased wage costs or replacement costs for departing workers and challenges the view that firms engage in open innovation to reduce R&D costs.

Laursen and Salter (2020) suggest that an individual's open innovation activities provide him/her with opportunities, a better awareness of the value of the individual's knowledge in other contexts, and increased external visibility. Working on open innovation also allows access to organizational knowledge that can be critical for negotiation and engagement with external parties. Thus, the significant internal bargaining power that individual innovators achieve ultimately increases the likelihood they will exit the firm and take with them valuable proprietary knowledge. To try to reduce this risk the firm might impose contractual conditions on these individuals, but this type of protection is not completely effective. Laursen and Salter (2020) posit that this may give rise to a trade-off between staffing positions related to open innovation tasks with individuals who are the best fit from a value creation point of view, or employees whose loyalty to the firm is well proven who are likely to give more weight to value capture value. Those individuals more fitted to working towards value creation may not be the most dedicated employees and may be more likely to try to exploit their bargaining power. Laursen and Salter suggest that finding the balance in this trade-off will depend on the specific appropriation regime and the generality of the knowledge involved. Although Laursen and Salter's (2020) study could be considered a first step towards a better understanding of who within the organization benefits from open innovation, research in this area is nascent (however, see also Simeth & Mohammadi, 2022).

The above five issues are considered the most critical, but we can add a sixth issue which is that the literature focuses much more on successful open innovation initiatives than

on cases of failed open innovation resulting on a strong *pro-open innovation bias*. This partiality is due to some extent to the availability of evidence. For both researchers and firm managers, successful engagement is easier to document than failed initiatives. Open innovation failures may be concealed to avoid adverse publicity and managerial blame. In terms of research, there may be some reservations about the reporting of failures and its reception by academics and practitioners. Although there are some recent studies of open innovation failure (Cricelli et al., 2023) and firm closure (Holgersson et al., 2023), we need analyses based on careful and systematic information to match cases of success and failure and their differences.

The future of open innovation research — a checklist for researchers

In this section, we discuss the possibilities for future quantitative open innovation research, and the potential for research based on stronger research designs. We propose a checklist of seven aspects which should be considered in all stages of open innovation research and reporting and especially before journal submission. Although all research has some limitations which will attract critique, the papers reviewed for this study are all high quality. Each paper makes a substantial contribution to the open innovation literature by documenting an unfolding phenomenon, deploying clever applications of and extensions to established theories, or by clever use of state-of-the-art research methods (or a combination of all 3). However, there are many other papers presenting research on open innovation that have failed to meet the standards demanded by reviewers for the top journals. It should be noted also that when considering our checklist that the demands journals have regarding the interesting aspect of the phenomenon under investigation — and the application of theories and methods — is ever-increasing.

In our view, it is vital for the advancement of open innovation research that only high-quality open innovation research is published. Our checklist is aimed at improving open

innovation research and increasing the number of papers accepted for publication on the top refereed journals. We are motivated by our experience as editors of *Research Policy* – a leading journal in the innovation studies field which has received a substantial number of open innovation-related submissions since 2016.[3] Although these papers covered a range of open innovation topics and employed diverse sets of measures providing diverse findings, during our periods of editorship papers on this topic achieved lower rates of acceptance than the average submission. This might be due to our expectations as editors but also reflects the fact that many papers on open innovation fail to meet the journal reviewers' standards. We have found that that open innovation submissions include a large proportion of descriptive research with no strong theoretical motivation and/or empirical evidence supporting its novelty and/or significance. Many *Research Policy* reviewers consider these papers negatively and their comments point to the importance of the issues described in this paper.

Our checklist is aimed at trying to increase the quality, robustness, and reliability of open innovation research. The main focus is on research design which is a problem in many open innovation research submissions (see table 1). Changing the research design during the performance of the research will be costly, difficult, or impossible. We identify seven problematic areas (table 1 points A-G) and provide recommendations based on good practice and propose some questions for researchers which would avoid these issues. The problem areas identified are not unique to open innovation research but tend to be more frequent in this domain.

[Table 1, just about here]

Regarding point A on our checklist (see table 1), in the earliest research stages, careful attention needs to be directed to ensuring the proposed open innovation study is well

[3] Keld Laursen served as co-editor of Research Policy 2014-2018, and Ammon Salter has served as co-editor since 2019.

grounded in both prior open innovation research as well as more general management theories and evidence. Too often open innovation studies assume that open innovation is a field onto itself, rather than a part of broader range of management and business economics research. This is reflected in the tendency to use term open innovation to cover a research topic that has already been comprehensively addressed in prior research, such as strategic alliances.

Researchers need to position the research relative to other management and economics (and other) research traditions and theories (or elsewhere) and to try to embed these perspectives in their project. Open innovation research could offer a new direction or theoretical puzzle for an established theoretical perspective or research domain, but this possibility needs to be demonstrated clearly. Although accounts for the emergence of open innovation (as done very well by Chesbrough 2003a, 2003b) it remains a phenomenon rather than a theory. To understand what is important in the open innovation phenomenon requires exploitation and development of conventional theories from relevant fields such as management and economics.

Regarding point B on our checklist, open innovation research often falls short in terms of sampling and pays insufficient attention to representativeness. The research design must include more than just successful cases of open innovation and self-selection into open innovation. Samples should represent a wide range of open innovation experience — positive, negative, and indifferent. Research needs a separate focus to explain the decision to engage in open innovation treating the open innovation decision as one among a set of managerial choices rather than as a discrete choice. We acknowledge the problem related to identifying variables and finding information to explain use but not consequences of open innovation. However, researchers need at least to discuss the implications of self-selection into open innovation and its influence on their study.

Regarding point C on our checklist, open innovation researchers need to pay more attention to the matching among the different actors involved in open innovation (Mindruta, 2013; Mindruta et al., 2015). They should investigate the motivations, incentives, and expectations which increase the willingness of the different actors to collaborate. They should map, measure, and embed these factors in their theoretical and empirical models which would be facilitated by the collection of richer data on external actors and the modeling of each parties' choice set and risks from mutual engagement.

Regarding point D on our checklist, empirical studied should assess the robustness, reliability, and validity of the open innovation measures used and avoid the tendency to rely simply on their use in prior studies. We would encourage researchers to ensure that their project uses "best-in-class" measures of open innovation and to align these to new methods and empirical efforts to demonstrate open innovation behavior. For instance, Lu and Chesbrough (2022) draw on topic modeling to identify and classify open innovation approaches.

Regarding point E on our checklist, a good open innovation research design includes more than the sampling approach; it should also include traceability. We suggest that researchers should pre-register their research and provide pre-analysis plans. This would insure against "p-hacking" and convince other researchers that the research was not reduced to identification and publication of significant results. This approach could also prevent HARKing (Hypothesizing After the Results are Known) which can lead to irreproducibility and the "Replication Crises" identified in many areas of scientific research. Open science approaches allow for exploratory research which in turn allows researchers to identify relationships in their data (Aguinis et al., 2022).

Regarding point F on our checklist, we need more development of causal identification strategies related to open innovation effects. We would encourage natural experiments and

instruments, or individual field experiments to identify different open innovation aspects. Most current research relies on the ex-post construction of matching samples and approaches to try resolve these imbalances. Although these approaches can be helpful they do not alleviate endogeneity concerns (see for instance, Hill et al., 2021). Overcoming endogeneity problems require a strong research design. In the case that this is not feasible, the authors need to be circumspect about the relationships presented and avoid causal language including in the implications for managerial practice.

Regarding the final point on our checklist (point G), researchers should carefully consider the mechanisms driving their results and seek to directly (or indirectly) test these in their research design. Many open innovation studies propose a range of mechanisms but make no attempt to disentangle the drivers of an observed result. This is in part due to the diverse nature of open innovation but may in part is an outcome of lack of engagement with established theory.

Conclusion

On any measure the open innovation research area has been successful in providing a host of new insights into how firms can organize to achieve value creation and capture through external engagement. However, similar to any research area still in early development there is a need to take stock and reflect on what has been learnt and what still remains to be investigated. In this paper, we have highlighted some of the significant findings from quantitative open innovation research on external search, absorptive capacity, and appropriability. We have also pointed to some limitations related to (quantitative) research in this area including insufficient theoretical underpinnings, insufficient exploitation of established theories, reliance on successful open innovation cases and samples, reliance on description rather than explanation, and the poor integration of open innovation in other parts of the firm's corporate and innovation strategy and practices. We have suggested some good

practice and proposed questions which researchers should consider when developing open innovation research projects. Our checklist is not meant to be exhaustive or exclusive but rather is aimed at providing some direction for researchers at the start of their research projects to allow development of more robust, reliable, and causal empirical statements about open innovation.

Conflict of interest statement

On behalf of all authors, the corresponding author states that there is no conflict of interest.

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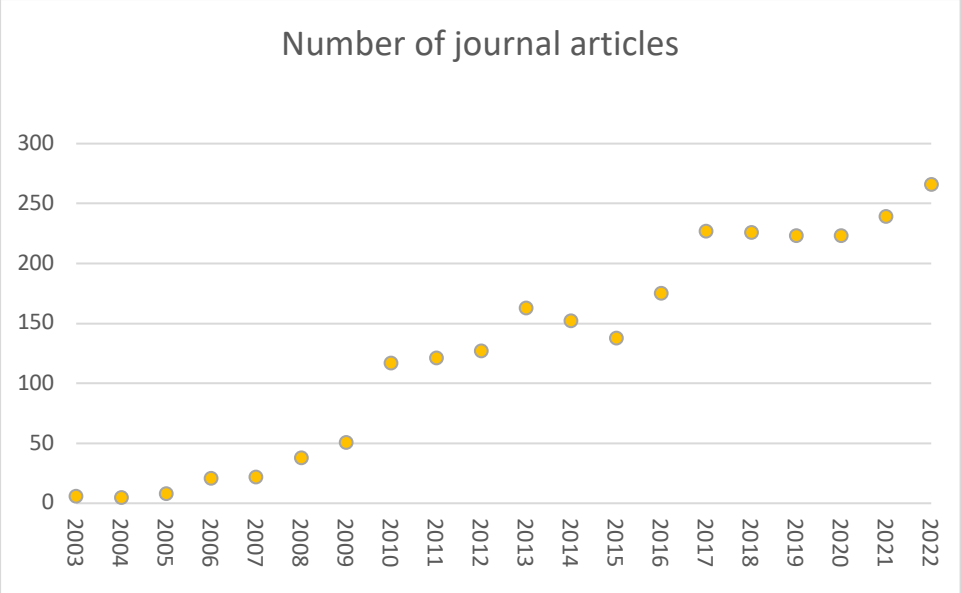

Figure 1: Number of journal articles using the term "open innovation" anywhere in the text.

Table 1. A checklist of open innovation quantitative research projects

Common mistakes	*Good practice*	*Questions to ask myself before starting?*
A. Asserting that open innovation is itself a theoretical perspective and failing to engage with conventional management and economics theories.	Use and modify conventional management and economics theories to better understand the open innovation phenomenon. Consider carefully whether the (theoretical) issue addressed by your open innovation research has been addressed in prior research in some other area and incorporate the relevant perspectives into your research design.	Which main theoretical issues is my open innovation research likely to overlap with? What do conventional theories say about this question? How can my open innovation perspective integrate, address, and extend these theoretical approaches?
B. Focusing only on open innovation cases and only on successful ones.	Account for selection into open innovation and focus on a representative set of activities including a broad range of outcomes. Sample selection should never be based only on successful open innovation.	How do actors select the open innovation projects/ actors/activities to engage in? How does this selection process shape the sample of open innovation activities observed? Is the sample representative of the universe of potential open innovation activities, including failed open innovation?
C. Assuming that identifying, engaging with, and collaborating with open innovation partners is costless.	Give agency to external partners and see their engagement as a choice based on their own goals, attributes, and preferences. Document, describe, and consider the search and coordination costs	What factors lead different actors to engage with each other in open innovation? What are the costs associated with finding and engaging with external partners?

	associated with open innovation.	What are the coordination costs of realizing and sustaining these relationships?
D. Constructing entirely new measures for open innovation unrelated to prior research approaches.	Systematically review and build on published robust and reliable measures of open innovation. Avoid the construction of minor adaptations to existing measures unless necessary.	Are my measures of open innovation reliable, valid, and robust? Was my search for related measures thorough and incorporated in my research design? Is my proposed measure of open innovation a significant improvement on prior measures? Is it possible to demonstrate its greater validity and robustness compared to alternatives?
E. Manipulating the data to identify a significant relationship or p-hacking.	Specify the expected relationships in advance of the empirical data collection. Pre-register the research design and analysis plan on a public registry.	What do I expect to find ex-ante? Can I document the expected relationships? If the expected relationships do not emerge would my study be considered for publication in a high quality journal? Have I pre-registered my empirical design and analysis plan at a public registry?
F. Claiming a causal link between open innovation and firm performance.	Avoid using causal language or making causal claims for an associational study or propose an identification strategy which includes managerial quality and self-selection into open innovation. Do not rely only	Is it possible to identify a representative set of firms at equal risk of adopting and profiting from open innovation? What exogenous variation in open innovation activities

	on matching to claim a causal effect.	between firms does my study identify? Are there any natural/field experiments which could be used to draw causal inferences between open innovation and performance?
G. Failing to discuss and test a range of mechanisms for some outcomes of open innovation or some outcomes that led to open innovation.	Be clear about the mechanism(s) leading to adoption of or the effects of open innovation. Develop an empirical strategy to test (at least indirectly) the focal mechanism(s) and exclude others.	Are the specific mechanisms that leads to my identified open innovation outcomes clear? What empirical evidence can I provide to (directly or indirectly) test the mechanism identified? Can I rule out alternative mechanisms that might explain the same results?