The limits of open innovation: Failures, risks, and costs in open innovation practice and theory

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The limits of open innovation: Failures, risks, and costs in open innovation practice and theory

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ABSTRACT

The success of open innovation has been widely acknowledged in both industrial practice and academic research. However, we understand much less about the limits of open innovation. A better understanding of this downside is nevertheless very important as there are still many organizations that struggle when trying to implement an open innovation strategy. At the same time, some research has pointed to decreasing returns to openness, or more generally to the complex relationship between open innovation and (financial) performance. This is why we call for more attention to failures, risks, and costs—and even the “dark side”—in the context of open innovation. In this editorial, we will further introduce this perspective, describe the articles published in this special issue, and offer some suggestions for future research. Overall, we believe that a better understanding of the limits of openness will allow for a more balanced view, thereby further expanding the frontiers of open innovation practice and theory.

1. Introduction

Open innovation as a powerful strategy in industry has long been a part of the academic debate (Dabić et al., 2021). Engineering companies like Intel have diverged from companies like Xerox in the 1980s and 1990s by finding ways to leverage research done by their peers and universities funded by government in the forms of university grants, research centres and internships. Or as Chesbrough (2020) puts it, while the lab used to be our world, it is now the world that is our lab. Nevertheless, despite some positive impact from open innovation, it is also important to look beyond initial success for operational competencies, and for example consider challenges around new product innovations, as there were competitive risks such as the Nokia case (Ciesielska, 2018). Indeed, a recent study revealed an S-shaped relationship between open innovation and financial performance, implying that the benefits of open innovation will not always outweigh the costs (Schaper et al., 2023). In this special issue, we seek to understand the limits of open innovation through the relationship between determinants and outcomes within teams, projects, alliances, or organizations, from the perspective of risk, failure, and cost.

There are several important opportunities for research on the limits of openness. For example, failure of open innovation projects may be as likely as their success, which importantly can have detrimental effects in relation to a failure acceptance culture, and more generally a lack of personal, organizational, project, marketing, consumers or social prerequisites (Bagherzadeh et al., 2021; Brunswicker and Chesbrough, 2018; Lifshitz-Assaf et al., 2018). At the same time, the growing complexity of engineering and technology improvements and the increased responsiveness of society for open innovation practices represent new challenges for open innovation practice and research in...
relation to failure in such innovation processes. Coping with these hurdles forces the engagement of a large pool of expertise. Disciplines like economics, business, law, engineering, sociology, psychology, mathematics, and other sciences and the arts (Robbins and Sandberg, 2023) need to interact to design efficient and safe open innovation structures, strategies and policies.

Learning from failures or predicting possible risks or costs requires multi-disciplinary and multi-scale methods and can decrease the likelihood of decision errors and, eventually, inhibit firm performance. For example, the influence of the distance between operations in multinational corporation and the costs of coordinating geographically dispersed activities of open innovation teams are likely to be considerably more challenging. Furthermore, bringing in other perspectives and new levels or units of analysis will contribute to sharpen our understanding of when open innovation will succeed and when it will fail, thereby offering important insights into future practices and theoretical developments.

The literature on open innovation describes it as an approach to innovation that involves the dimensions inbound (technology exploration), outbound (technology exploitation), and coupled (combining inbound and outbound) (Dahlander and Gann, 2010; Enkel et al., 2009; Huizingh et al., 2011; Yildirim et al., 2022). Most recently, open innovation has been defined as “a distributed innovation process based on purposely managed knowledge flows across organisational boundaries” (Chesbrough and Bogers, 2014: 17). Open innovation has been addressed at multiple levels of analysis (Bogers et al., 2017), from the point of view of research, practices and policies (Bogers et al., 2018), and recent literature calls for better connecting it to strategies more formally (Vanhaverbeke et al., 2017).

While much has been said about the possible benefits of an open approach to innovation, we still lack a clear understanding of the downsides of open innovation (West et al., 2014). However, some of the limits of open innovation have been examined, through for example the lens of decreasing returns to openness (Laursen and Salter, 2006), or cost-increasing effects (Faems et al., 2010; Greco et al., 2018; García-Quevedo et al., 2018; Mention, 2011). Indeed, the recent longitudinal study by Schäper et al. (2023) shows how a delicate balance of benefits and costs lead to an S-shaped relationship between openness and financial performance, which is more pronounced under conditions of high appropriability and environmental dynamism. Nevertheless, deepening our understanding of the (unintended) negative consequences, boundary conditions, or contingencies of open innovation would bring a valuable contribution to the literature, and further inform theory and practice (Torkkeli et al., 2009; von Briel and Recker, 2017; West et al., 2014). This special issue, and its ten contributions, aims to fill this gap by shedding light on open innovation failures, risks, and costs.

2. The contributions of this special issue to the literature on the limits of open innovation: failures, risks, and costs in open innovation practice and theory

We may raise the concern that open innovation, alongside huge opportunities, also comes with a dark side that can lead, at best, to a status quo in terms of value creation, or, at worst, to the co-destruction of value (Salampasis and Mention, 2019; Stefan et al., 2022). This concern highlights the importance of recognizing the dangers of pursuing open innovation. Existing science has given due credence to these hazards by examining various associated risks and uncertainties. This special issue attempts to fill this gap by offering fresh and topical insights on the limits of open innovation, and aims to advance the understanding of the limits of open innovation (Table 1).

The first article of this special issue titled “Diving into the uncertainties of open innovation: A systematic review of risks to uncover pertinent typologies and unexplored horizons” was written by Arun Thirumalesh Madanaguli, Amandeep Dhir, Shalini Talwar, Sascha

Table 1

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<th>Authors</th>
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<tr>
<td>Arun Madanaguli, Amandeep Dhir, Shalini Talwar, Sascha Kraus, Puneet Kaur</td>
<td>Diving into the uncertainties of open innovation: A systematic review of risks to uncover pertinent typologies and unexplored horizons</td>
<td>Open innovation; Systematic literature review; Risks; Value co-creation; Uncertainties</td>
<td>• This review categorizes risks in open innovation into five major risk segments. • Research profile of literature suggests an increasing trend of work on risk in open innovation. • Prominent risks and corresponding risk management steps are summarized. • Risks are mapped to various steps in the innovation process. • A learning-based risk assessment framework for open innovation is advanced. • Transaction theory is used with a resource-based view to understand the cost of open innovation. • The limits to open innovation differ across industries. • Open innovation is more limited in the creative industries than in other industries. • Limits to open innovation increase in international networks.</td>
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<td>B. David Audretsch, Maksim Belitski</td>
<td>The limits to open innovation and its impact on innovation performance</td>
<td>Knowledge sourcing; Transaction costs; Resource-based view; Regional collaboration; Global collaboration; Product innovation</td>
<td>• This study shows the decision-making processes leading to the willingness or reluctance to adopt Open Innovation in SMEs. • Managerial cognitive configurations play an active role when appraising Open</td>
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| Giacomo Marzi, Mohammad Fakhar, Andrea Caputo, Matteo Pellegrini, Božidar Vlačić | Do or do not. Cognitive configurations affecting open innovation adoption in SMEs | Open innovation; Adoption; Decision-making; SME; Cognition; Human side; Rationality; Intuition | • This study shows the decision-making processes leading to the willingness or reluctance to adopt Open Innovation in SMEs. • Managerial cognitive configurations play an active role when appraising Open (continued on next page)
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| M. Dabi et al.                        | Investigating the drivers of failure of research-industry collaborations in open innovation contexts | Open innovation; Research-industry collaborations; Failure; CERN; Big science; Technology innovation | - Multiple case study analysis with a polar sample type of successful and unsuccessful collaborations between CERN and supplier companies.  
- Practical implications for how to effectively manage Big Science. |
| José Ramón Saura, Daniel Palacios Marques; Domingo Ribeiro-Soriano (Saura et al., 2023) | Exploring the boundaries of Open Innovation: Evidence from social media mining Data mining; User-generated content; Sentiment analysis | Open innovation; Social media mining; Social product development; Failure; Limitations; Success factors | - The limits of open innovation by extracting evidence from UGC were explored.  
- 8 topics that provide a glimpse of the limitations of open innovation were identified.  
- 20 limits of open innovation according to UGC have been formulated.  
- Business models and companies’ culture constitutes the main limits of open innovation.  
- 27 research questions for further research on open innovation have been formulated.  
- Viability of open innovation organization depends on its business model deployment.  
- Survivability of open innovation organization depends on its engagement mechanisms.  
- Scalability of open innovation organization depends on the quality of its outcomes.  
- Profitability of open innovation organization depends on its co-governance.  
- A ‘one-size-fits-all’ incentive structure is not optimal in crowdsourcing.  
- Managers should use a flexible incentive structure in crowdsourcing. |
| Kaveh Abhari, Summer McGuckin (Abhari and McGuckin, 2023) | Limiting factors of open innovation organizations: A case of social product development and research agenda | Open innovation; Open innovation organization; Innovation sponsor; Innovation coordinator; Innovation community; Social product development; Failure; Limitations; Success factors | - Science projects in Open Innovation collaborations.  
- We present different managerial decisional paths associated with willingness or reluctance to adopt Open Innovation in SMIs.  
- We examine firms’ open innovation sourcing decisions and project-level performance outcomes.  
- Projects sourced via open innovation are associated with a higher likelihood of termination.  
- Projects in knowledge areas that are familiar to the firm are less likely to be terminated.  
- Familiarity with a project’s knowledge area has a mitigating effect on the risks of external sourcing.  
- Investigation of the failure of research-industry collaborations in the peculiar Open Innovation context of Big Science.  
- Drivers of failures are focalisation and exclusion, short term orientation, competence stand-by, and passive and indirect participation.  
- Multiple case study analysis with a polar sample type of successful and unsuccessful collaborations between CERN and supplier companies.  
- Practical implications for how to effectively manage Big Science.  
- Let me choose what I want: The influence of incentive choice flexibility on the quality of crowdsourcing solutions to innovation problems  
- Crowd sourcing: Field experiment; Innovation problems; Incentives; Solution quality |
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| Jinjie Xue, Yunqi Liu, Zizhen Geng, Hongping Yuan, Lei Chao (Xue et al., 2023) | Why and when do paradoxical management capabilities matter to paradoxical pressure? An empirical investigation of the role of cooperation | Coopetition; Paradoxical management capabilities; Paradoxical pressure; Open innovation | • We studied the paradoxical pressure on managers in open-innovation enterprises at the micro level.  
• We investigated how coopetition affects the relationship between paradoxical management capabilities and studied why and how they affect paradoxical pressure.  
• We examined the components of paradoxical management capabilities and how they affect open-innovation enterprises.  
• We considered the paradoxical pressure on managers in open-innovation enterprises.  
| Kweku Adams, Rexford Attah-Boakye, Honglan Yu, Jeaneth Johansson, Eric Tchouamou & Njoya (Adams et al., 2023) | Female board representation and coupled open innovation (OI); Female board representation; Evidence from emerging market multinational enterprises (EMNEs); Institutional context | | • We use a 2-step system GMM, quantile regressions to validate the results confirming the impact of female board representation and firm’s OI.  
• We examine how coopetition affects the relationship between paradoxical management capabilities and the role of cooperation.  
• We investigate the components of paradoxical management capabilities and studied why and how they affect paradoxical pressure.  
• We consider the paradoxical pressure on managers in open-innovation enterprises.  

Kraus, Thomas Clauss, and Puneet Kaur. The authors identified, synthesised, and critically analysed relevant research papers. Based on this analysis, they presented a literature profile of existing research and five risk typologies in open innovation: data-related risks, individual risks, enterprise-level risks, revenue risks, and other risks. In addition, specific risk management approaches are described for each identified risk. The paper further provides a comprehensive framework for identifying unexplored paths and conceptualizing future research opportunities in this area. From a practical point of view, managers can use this framework as a risk assessment and management tool across the open innovation process. In summary, this review is one of the first of its kind. It provides a valuable synthesis of the latest open innovation risk research, which can be used to meaningfully advance theory and practice in the field.

David Audretsch and Maksim Belitski, in the second article of this special issue titled “The Limits to Open Innovation and its Impact on Innovation Performance”, examine the effects of collaboration with partners across four geographical dimensions, for open innovation activities, on innovation performance, across various industries. Based on transaction cost theory and knowledge appropriation, they focus on the frontiers of open innovation with a resource-based perspective. They test their hypotheses using multi-level generalized models to control for time, region, and fixed unobserved features. The sample includes 19,510 observations and 17,859 companies, with a small panel of 1651 companies, mostly from the UK Innovation Survey and Business Registry. Results show that the frontiers of open innovation vary by knowledge-intensive sector and geographic dimension, and indicate that the creative sector experiences the greatest knowledge collaboration frontiers in domestic and international markets. The authors discussed why and how this happened, and they concluded with theoretical and policy implications.

In the third article titled “Do or do not. Cognitive configurations affecting open innovation adoption in SMEs” Giacomo Marzi, Mohammad Fakhar Manesh, Andrea Caputo, Massimiliano Matteo Pellegrini, and Bozidar Vlačić pointed out that the acceptance of open innovation by small and medium-sized firms (SMEs) frequently hinges on how well it is seen by senior management teams and/or entrepreneurs. Because the openness of SMEs can produce a mixed bag of results, managers must weigh the benefits of boundary-spanning against the difficulties of inter-organizational arrangements and knowledge transfer. Building on the ideas of the dual-process theory, this article focuses on the cognitive settings that affect SMEs’ propensity for or reluctance to adopt open innovation. This is done by looking at how decision-makers think and how they assess the advantages, disadvantages, and organizational resistance of openness, such as the not invented here (NIH) and not-shared-here (NSH) syndromes. In order to shed additional light on the observed range of results, this study investigates 434 participants’ willingness and reluctance to embrace OI, and uses structural equation modelling, complemented with fsQCA.

Lauren Purdy, Hadi Eslami, Kamran Eshghi and Michel Rod, in the fourth article titled “Technology Sourcing and the Dark Side of Open Innovation: Evidence from the Biopharmaceutical Sector” examine how companies in the high-tech industry face complex and critical sourcing decisions for new product development in the highly competitive biopharmaceutical sector. The study applies project-level typologies along the dimensions of project source and project familiarity. Drawing upon the theories of transaction cost economics and knowledge-based view, three hypotheses were empirically tested on a data set of 2971 biopharmaceutical R&D projects from 1985 to 2010. Results indicate that in licensed projects, sourced through inter-organizational partnerships are more likely to be terminated than their counterparts which are internally sourced. Findings further show that projects in domains familiar to the firm are less prone to termination, and evidence that external sourcing risks can be mitigated by selecting projects with fall within knowledge domains that are familiar to the focal firm.

Collaboration between academia and industry is critical for technological innovation. However, the majority of existing research in this

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* Author-provided.
domain has concentrated on the factors that contribute to the success of such collaboration. One of the major barriers to studying this topic is the lack of information about collaboration failures in research-industry settings. In the fifth article titled “Investigating the drivers of failure of research-industry collaborations in open innovation contexts”, Gloria Puliga, Andrea Urbinati, Enrico Maria Franchin, and Stefano Castegnaro, argue that management scholars should delve deeper into failed research-industry collaborations, as these occurrences could have serious consequences and flow on effects such as the anticipated termination of a project, or the disruption of regular business activities. As a result, the authors examine research on failed collaborations in the Big Science context, a unique open innovation environment where research-industry collaboration failures remain largely unexplored. To investigate the drivers of failure in this context, the authors use a multiple case study analysis with a retrospective approach of a polar sample type of six case studies of collaborations between CERN – the world’s largest fundamental research organization – and supplier companies, contrasting three successful collaborations and three failures. By doing so, the authors provide a framework that highlights the main drivers that lead to collaboration failures in this unique open innovation context and provide policy and managerial recommendations for research-industry collaborations in the context of Big Science.

The sixth article by José Ramon Saura, Daniel Palacios-Marques; Domingo Ribeiro-Soriano, titled “Exploring the boundaries of Open Innovation: Evidence from social media mining” analyses user generated content from a sample of 586,348 tweets. Applying sentiment analysis, topic modelling and textual analysis techniques, the authors identify eight topics: two of them expressed negative sentiments, namely Culture and Business Models/Management, three conveyed positive sentiments, captured as Communities, Creative Projects and Ideas and three were neutral, i.e. Entrepreneurship, Teams and Technology. Their findings further strengthen the influence of entrepreneurship as a precursor for open innovation to flourish, and the role of business culture as a key limit of open innovation, due to the lack of flexible models of business organizations. The paper concludes by formulating twenty frontiers of open innovation and 27 research questions for further research on open innovation and discussing the theoretical and practical implications of the research.

Kaveh Abhari, and Summer McGuckin, in the seventh article titled “Limiting factors of open innovation organizations: A case of social product development and research agenda” pointed out how open innovation organizations are becoming increasingly popular, but experience a high failure rate. In this article authors identifies three levels of limiting factors that contribute to this high failure rate: Strategy, Process, and Community. After examining and extending these boundaries through case studies, this paper provides a framework for identifying the success factors of open innovation and their hierarchical relationships. The authors grouped these success factors into six domains: Design, Implementation, Technology, Operations, Community Readiness, and Community Development, and subsequently categorised their relationships into four groups: Deployment, Engagement, Evaluation, and Governance. Further, they offer three sets of propositions related to strategic decisions contributing to open innovation success, technologies and operational necessities as well as community readiness and development. The authors conclude by offering fresh and topical insights on viability, survivability, scalability and profitability of open innovation organizations in perspective of their limitations and provide managerial recommendations around setting goals and strategizing, designing and managing processes and maintaining community. Finally, this article discusses possible research approaches to further develop open innovation organizations.

The eighth paper of this special issue, “Let me choose what I want: The influence of incentive choice flexibility on the quality of crowdsourcing solutions to innovation problems”, by Ehsan Noorozad Moghaddam, Alireza Aliahmadi, Mehdi Bagherzadeh, Stefan Markovic, Milena Micevski, and Fatemeh Saghaﬁ, aims to deepen our understanding on what incentive structures match with participant motives to dedicate resources to crowdsourcing initiatives. While organizations increasingly resort to crowdsourcing to generate solutions for their innovation problems, the quality of these solutions is often low. The authors contend that this misfit stems from the lack of knowledge about what really motivates problem solvers, and argue for a tailored, as opposed to a “one-size-ﬁts-all”, approach to design incentive structures matching the diversity of motives pursued by participants. Based on a between-subject ﬁeld experiment, this empirical research shows that incentive choice flexibility is conducive to participants exerting greater effort, and improves the quality of the solutions generated. Accordingly, the authors argue for flexible incentive structures in crowdsourcing, and advise solution-seeking companies and open innovation intermediaries to offer a suite of incentive options, beyond the usual extrinsic rewards. Such an approach allows participants to self-match the incentives with their own motives, thus indirectly prompting participants to pursue their intrinsic motivations.

The next paper in this special issue, authored by Jinjie Xue, Junqi Liu, Zhiheng Gong, Hongqing Yuan, and Lei Chao, turns our attention to cooperation, and investigates its interplay with paradoxical pressure and management capabilities in the contribution entitled “Why and when do paradoxical management capabilities matter to paradoxical pressure? An empirical investigation of the role of cooperation”. Drawing upon a sample of 231 top and middle managers from ﬁrms involved in cooperative activities, across a range of industries, the authors find that paradoxical cognition has a negative effect on cognitive dissonance, and emotional regulation weakens both emotional ambivalence and cognitive dissonance. Their study contributes to the microfoundations of cooperation and offers practical implications for managers to relieve paradoxical pressure in such contexts.

In the last article of this special issue, Kwaku Adams, Rexford Attah-Boakye, Honglan Yu, Jeaneath Johansson, and Eric Tchoumou Njoya examined the role of female board representation in emerging markets and its impact on open innovation. Drawing upon upper echelon and institutional theories, and empirically analysing 183 multinational enterprises, operating across 10 different industries and active in 16 emerging markets over one decade, the authors uncover a significant positive relationship between female board representation and a ﬁrm’s commitment to coupled open innovation initiatives. They further unveil that institutional factors at the country level, namely control of corruption, governance effectiveness and women parity index, inﬂuence and positively moderate this relationship. Their study extends open innovation literature with knowledge on the role of gender diversity for open innovation in emerging markets, and provides managerial and policy implications in terms of corporate governance structures conducive of open innovation adoption. The authors call for further research to explore how neurocognitive efﬁcacy of management processes can be improved by advocating for gender-diverse boards, in particular in environments where managerial perceptions and cultural beliefs could hamper the promotion of females to top leadership positions.

3. Conclusions

This special issue highlights a number of learnings in relation to how to leverage open innovation.

There are several factors which can be considered as risks. The major risks are data-related risks, individual risks, enterprise-level risks, revenue risks. Strategy, process and community are the three areas requiring the highest attention to avoid failures. Projects that are familiar to the firm are more likely to continue than those that are not. The special issue highlights several other organizational factors requiring further attention. The success of open innovation depends on the knowledge-intensity of the sector and geographical location. At the same time, an entrepreneurial environment welcomes open innovation. This supports the general argument that it is important to better understand the contingencies of open innovation. One size does not fit all
in crowdsourcing, or in open innovation more generally. Tailored solutions are required. Attitudes such as not-invented-here (NIH) and not-shared-here (NSH) have high potential to impact open innovation adoption negatively. Failures in research-industry collaborations have several key learnings to offer.

4. Future research

Firms need to know how to use open innovation to increase revenues, satisfy stakeholders, and reach their goals. However, the available techniques and methods for measuring efficacy, effectiveness and efficiency of open innovation initiatives need to be improved, and the continuous evaluation those questions remains necessary. Complementing existing academic literature, the articles in this special issue propose a common theme with an emphasis on the core aspects of open innovation risks, failures and costs, encouraging companies to learn from their open innovation practices, and to comprehend that learning from risks, threats and unsuccessful experiences may ultimately be beneficial.

The future research agenda in relation to this “dark side” of open innovation may be approached from a number of angles. First, in line with the definition of open innovation as being “a distributed innovation process based on purposively managed knowledge flows across organizational boundaries” (Chesbrough and Bogers, 2014: 17), research can explore different aspects of this process. This may for example be about in which phase – e.g., obtaining, integrating or commercializing (West and Bogers, 2014) – failure is more likely, and where costs tend to be highest. Also, the knowledge flows per se may be considered. For example, applying Dahlander and Gann’s (2010) 2 × 2 matrix of inbound/outbound and pecuniary/non-pecuniary could provide valuable insights on the costs and benefits of open innovation, and assist in understanding trade-offs in open innovation endeavours. Moreover, in line with the commercialization phase of open innovation, it is ultimately the organization’s business model that will determine how robustly it can cope with potential downsides.

Second, as it has been argued that open innovation can be addressed at multiple levels of analysis (Bogers et al., 2017), such a lens could also be applied to the study of the limitations of open innovation. Indeed, it would be particularly useful to understand how cross-level attributes may serve as contingencies for open innovation success or failure. Applying the logic of microfoundations, in which for example individual-level attributes aggregate up to organizational-level outcomes (Felin et al., 2015), it is specifically lower-level issues that may be the hampering factor for achieving higher-level outcomes. Such studies inherently call for multi-disciplinary contributions, bringing concepts, techniques and methods from psychology and cognitive sciences (Stroh et al., 2023). Moreover, considering risks, costs and failures across levels of analysis can allow for a better understanding of the contingencies of open innovation.

Third, a generic perspective on the decreasing returns of open innovation, as originally posited by Laursen and Salter (2006), will ultimately provide a balanced view of the conditions under which open innovation will be most likely to lead to (optimal) performance. Interestingly, Schaper et al. (2023) recently expended this view to argue that medium levels of openness are ideal, and that under certain conditions closed innovation will even be more beneficial (e.g., at low levels of openness). Moreover, given the many tensions that may arise in the face of open innovation success versus failure, this seems to be particularly fertile ground for approaching it from a paradox perspective (Bogers, 2011; Laursen and Salter, 2014; Stefan et al., 2022).

Fourth, the fast-paced development of digital technologies, and their wide-ranging affordances, bring about new questions around their adoption for open innovation initiatives (Bartalier et al., 2023; Bogers et al., 2022; Enkel et al., 2020; Urbinatti et al., 2020). Much remains to be understood on the role of artificial intelligence in collaboratively designing, developing, testing and commercializing novelties, as well as its implications on inter-organizational dynamics, and appropriability mechanisms in open innovation contexts. Research on ethical considerations and risk frameworks to responsibly leverage those technologies in open innovation endeavours would be highly desirable.

Finally, as the open innovation literature matures, the dissemination and implementation of its underlying principles beyond traditional business contexts, to other forms of collective action such as social enterprises, and organizations tackling societal challenges offers unique opportunities to understand its democratisation, and expand our knowledge of its boundary conditions (Ahn et al., 2019; Chesbrough and Di Minin, 2014; McGahan et al., 2021). As such, we hope this special issue will provide inspirations for the next generation of cutting-edge studies on open innovation.

Data availability

No data was used for the research described in the article.

Acknowledgments

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