R&D MANAGEMENT

Research Article

50+ years of R&D Management: a retrospective synthesis and new research trajectories

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In 2020, *R&D Management* celebrated 50 years of publication. The present study honors that milestone by conducting a retrospective examination of the research conducted in the journal over time and reflects on its rich history to look forward in the R&D management field. Using bibliometric techniques, we provide a comprehensive analysis of the journal's most prominent topics and themes, as well as its most prolific authors, institutions, and countries. The findings indicate that *R&D Management* has increased its productivity and reputation as measured by the number of published articles and citations per year and expanded its international reach from the initial European-dominated author base. We complement this analysis by performing an in-depth systematic literature review of the most frequently cited papers – annually and of all time – to disentangle the themes and concepts that prominently shaped the progress of the discipline itself. The results suggest that *R&D Management* has progressively widened its field of investigation from an intra-organizational perspective (1970–1992) to an inter-organizational view (1992–2006) and then to an extra-organizational outlook (2006–2018). Finally, based on this history and viewing the contributions from 2019 onwards, we identify an emerging set of research trajectories that we expect will pave the way for the future impact of *R&D Management* and the field at large.

1. Introduction

R&D Management is a leading interdisciplinary academic journal for the fields of R&D and innovation management. It publishes articles that address the interests of both practicing managers and academic researchers in R&D and innovation management. Covering the full range of topics in research, development, design and innovation, and related strategic and human resource issues – from exploratory science to commercial exploitation – the journal regularly publishes articles that also examine social, economic, and environmental implications.

The above paragraph indicates the mission and the scope of the journal, which has remained unchanged for quite some time and resonates with the reasons for its establishment. Since its first issue in October 1970, *R&D Management* became the first academic outlet in Europe to publish novel and significant research on the topic of research and development. At the very beginning, the journal was deliberately conceived as a reference point for managers and professionals.[1] In the editorial of the first issue of *R&D Management*, Founding Editor Alan Pearson argued that 'the initiative came from industry, from people who were aware of the increasing amount of effort that is being put into examining the problems of managing research and development'. After the appearance of only a few issues, the journal began to attract attention among academics and research-interested practitioners. The journal initially published an average of four numbers per year with five articles per volume. Since 2009, the journal has published a multitude of special issues and sections that encouraged submissions on nascent research topics of an exploratory nature, such as open innovation (OI; see Appendix A). In July 2020, Editor-in-Chief Ellen Enkel, who guided and crafted the journal's editorial policy for many years, passed the baton to a team of two Co-Editors-in-Chief Alberto Di Minin (Sant'Anna School of Advanced Studies) and Paavo Ritala (LUT University) and seven Associate Editors.

Over the years, the journal has become widely recognized worldwide. *R&D Management* is published by Wiley and was ranked '3' (with 4* the highest score) in the Innovation category in the Chartered Association of Business School's Academic Journal Guide (AJG) in 2021. It is abstracted and indexed in almost all the major databases, including Scopus, Web of Science, and Journal Citation Reports (La Paz et al., 2020). According to 2021 Clarivate Analytics, *R&D Management* has an impact factor of 5.962, meaning that its total citations in 2021 were 5.962 times the number of articles published in 2019 and 2020. In 2021, Scimago ranked *R&D Management* in the top quartile of most influential sources classified in the Business, Management and Accounting category. According to Scimago Journal & Country Rank 2021, the h-index of *R&D Management* is 108, which means that 108 of the journal's articles received at least 108 citations from authors other than their contributors. Most impressively, the journal's impact factor has grown from 1.857 (2017) to 2.354 (2018), to 2.908 (2019), to 4.272 (2020) and to 5.962 (2021), demonstrating that *R&D Management* has become 'the go-to outlet for novel, rigorous, and impactful research regarding the management of research, development, and innovation' (Di Minin and Ritala, 2021, p. 431).

The *R&D Management* journal is part of a broader ecosystem that includes RADMA (Research and Development Management Association), the R&D Management Conference organized every summer, R&D Management Workshops staged around the world with partner universities and conferences, and the R&D Today website, which provides practitioner-relevant insights and feature articles.

To celebrate *R&D Management's* over 50 years of publishing, this paper offers a comprehensive overview of the journal's key achievements, trends, themes, and trajectories, in order to understand how the journal have evolved with and from its original mission. Such retrospectives are common practice for top journals in innovation field when celebrating an anniversary and/or acknowledging a change in its editorial team. Importantly, Rigby (2016) wrote a retrospective of the first 40 years of *R&D Management*, which our current study extends and complements. Sarin and colleagues conducted a 20-year citation analysis of the knowledge outflow and inflow patterns from the *Journal of Product Innovation Management* (Sarin et al., 2018). Singh et al. (2020) analyzed the evolution of *Technological Forecasting and Social Change*, while Rose et al. (2020) provided a comprehensive overview of 28 years of *Creativity and Innovation Management*. Dabić et al. (2021) summarized the first 40 years of *Technovation*. In light of *R&D Management's* recent 50-year anniversary and editorial succession, it seems appropriate to summarize the journal's key achievements, provide a synthesis of its most important contributions, and offer a glimpse at its future. This approach can support scholars seeking to remain current about topics relevant to the R&D and innovation management fields. Therefore, the present study seeks to systematically assess *R&D Management*'s productivity by addressing the following questions:

- *What are the main topics discussed in R&D Management, and who are the most prolific scholars?*
- *How have the topics of R&D Management articles evolved over the years?*
- *How has R&D Management contributed to initiating and developing new research frontiers?*

To tackle these research questions, the article is structured as follows. In Section 2, we outline our methods and data procedures. In Section 3, we discuss the main achievements of *R&D Management* since its foundation in terms of publication trends, authorship, citations, and reputation; we also provide a descriptive analysis of the journal's most frequently cited

articles and most prolific authors, including their institutional affiliations and countries. In Section 4, we use VOSviewer to perform a co-occurrence analysis showing the most relevant trends and themes appearing in *R&D Management* and assess their evolution over time. Additionally, we qualitatively analyze the evolution of topics by identifying a menu of research trajectories that could assist authors in preparing future submissions to *R&D Management*. Finally, in Section 5, we summarize the main contributions of this study.

2. Methodology

To offer an inclusive synopsis of *R&D Management's* impact and emphasize the most relevant research topics addressed in the journal, we implemented a mixed methods approach relying first on bibliometric techniques and then on a qualitative analysis of the most frequently cited papers for each year. This blended methodological approach is a consolidated exercise suitable for literature reviews that aim to identify contributions to a field by a specific journal (Dabić et al., 2021). Combining bibliometric analysis with qualitative explorations of the most frequently cited articles annually allowed us to provide a more comprehensive and nuanced overview of the findings arising from the data analysis (Zupic and Čater, 2015). Moreover, the mixed methods approach enabled us to understand *R&D Management* publications more deeply, identify their contributions, and chart their trajectories over the years.

For our quantitative approach, we relied on keyword analysis that involved determining the frequency of specific terms in paper titles. We chose titles as the corpus for this procedure to obtain more refined results and avoid the noise and redundancy likely to emerge from the common constructs found in abstracts. Titles are phrased to deliver the papers' key messages powerfully and quickly by depicting the main concepts addressed in the papers. Keyword analysis offered a graphical overview of the contributions and emphasized links between the intellectual and cognitive structures of the themes that have appeared in *R&D Management* over the years (Bellucci et al., 2020). Keyword analysis enabled exemplification of article contents and may be considered 'the knowledge generalization of the full text in a corresponding literature [that] help[s] readers to quickly grasp the core idea, core technique, or core methodology' (Hu et al., 2018, p. 1,031).

On the qualitative side, the systematic analysis of the most frequently cited papers per year grounded the preliminary results obtained by the keyword analysis and the evolution of topic trends, allowing us to explore in greater depth the intellectual contributions made by papers published in *R&D Management* over the last half century. In doing so, we focused on the theoretical backgrounds addressed in study implementation, methodologies, findings, and implications. In this sense, we explored the journal's contributions to different literature streams and its ability to create and contribute to important academic debates. Our approach informed a retrospective analysis of *R&D Management's* support of the development of the R&D and innovation management fields, an assessment of the influences of the scholars appearing in the journal, and a sense of future developments in themes covered by *R&D Management*.

We acknowledge that there are several ways to approach a literature review and thus answer the study's research questions. For instance, a bibliometric analysis could focus on citations, co-citations, and bibliographic coupling to detect the foundations on which later studies were built (Crupi et al., 2021), while a fully systematic literature review could use narrower parameters such as a shorter timespan or a specific topic. Like other literature reviews using a consolidated technique, the importance of this study lies not in the methodology itself but in blending different approaches capable of emphasizing and validating the results (Samiee and Chabowski, 2012; Zupic and Čater, 2015; Marzi et al., 2021). In this study, we used visualization of similarities analysis for keyword co-occurrence and an in-depth literature review. We decided to implement a strategy that offered a wide-ranging perspective on the journal, illustrating to readers the topics covered by *R&D Management* and its impact on developing new frontiers in research related to innovation management.

3. Key contributions in *R&D Management*: a bibliometric study

This section presents the journal's leading bibliometric indicators and achievements. The analysis was conducted in January 2023 on the entire dataset of 1,886 articles published by more than 2,700 authors that appeared in the journal from 1970 to 2022. As Table 1 and Figure 1 show, the number of articles published by *R&D Management* has consistently increased, with an average growth rate of +3.81% and an average of 31 articles annually. In Table 1, the first two columns show the number

Table 1. Descriptive statistics about *R&D Management* production

Year	N° of publications	Mean TC per article	Mean TC per year
1970	11	31,09	0,59
1971	25	4,64	0,09
1972	28	6,07	0,12
1973	48	5,83	0,12
1974	27	2,89	0,06
1975	39	5,05	0,11
1976	32	2,47	0,05
1977	41	9,15	0,20
1978	36	2,89	0,06
1979	38	3,42	0,08
1980	28	2,54	0,06
1981	26	10,38	0,25
1982	24	48,88	1,19
1983	28	8,57	0,21
1984	23	15,52	0,40
1985	49	5,39	0,14
1986	36	14,39	0,39
1987	31	14,32	0,40
1988	35	14,89	0,43
1989	31	18,29	0,54
1990	32	13,44	0,41
1991	30	22,87	0,71
1992	35	55,09	1,78
1993	31	26,00	0,87
1994	35	35,26	1,22
1995	34	18,56	0,66
1996	24	35,00	1,30
1997	25	46,92	1,80
1998	26	48,62	1,94
1999	31	51,87	2,16
2000	31	52,26	2,27
2001	36	48,28	2,19
2002	39	80,62	3,84
2003	35	83,43	4,17
2004	44	60,57	3,19
2005	38	68,61	3,81
2006	36	186,50	10,97
2007	34	55,29	3,46
2008	37	68,92	4,59
2009	34	121,85	8,70
2010	38	102,13	7,86
2011	32	54,63	4,55
2012	33	46,82	4,26
2013	34	32,68	3,27
2014	32	49,06	5,45
2015	33	24,52	3,06
2016	71	27,37	3,91
2017	56	25,14	4,19
2018	43	24,19	4,84
2019	53	19,00	4,75
2020	41	14,24	4,75
2021	40	10,58	5,29
2022	77	3,38	3,38

Table 1. (Continued)

TC: Total Citations.

of articles published per year, the third column displays the mean of total citations per article (MeanTCperArt), and the fourth column the mean of total citations per year (MeanTCperYear).It is worth noting that the growth in published articles, especially in recent years, was partly driven by increasing scholarly interest in the calls for papers issued annually by the journal (see Appendix A). For example, 71 articles were published in 2016, the journal's all-time high. In the same year, the journal issued two special issues, one on 'Transferring Knowledge' and the other on 'Business Model (&) Innovation'. This trend demonstrates the ability of the journal to delve into research trajectories by following a 'comb-shaped' strategy, which offers scholars with diverse research interests linked to R&D and innovation management the opportunity to explore new theoretical frontiers that advance the literature and establish grounds for new research avenues.

While the first two columns in Table 1 reflect the data shown in Figure 1, we see that the average article citations have increased steadily over the years, symbolizing the growing impact of *R&D Management* on the literature. Since its foundation, the journal has published a number of ground-breaking studies that have inspired innovation and management scholars. A general overview of the most impactful papers (see Table 2 and Figure 2 below and Appendices B and C) shows the contributions presented in *R&D Management* and the attention over the years paid to crucial theoretical milestones like the impact of R&D on innovation, collaboration among organizations, the growing interest in SMEs' contribution to innovation, OI, business model innovation, and most recently, the new frontiers of digital technologies.

Table 3 shows the list of the most prolific authors contributing to *R&D Management*. The table illustrates that the most prolific author was Alan Pearson, the journal's founding editor, who contributed to the literature by establishing the principles of R&D management research and their application to different aspects of organizations, such as leadership, patent production, the impact on public policies, and the

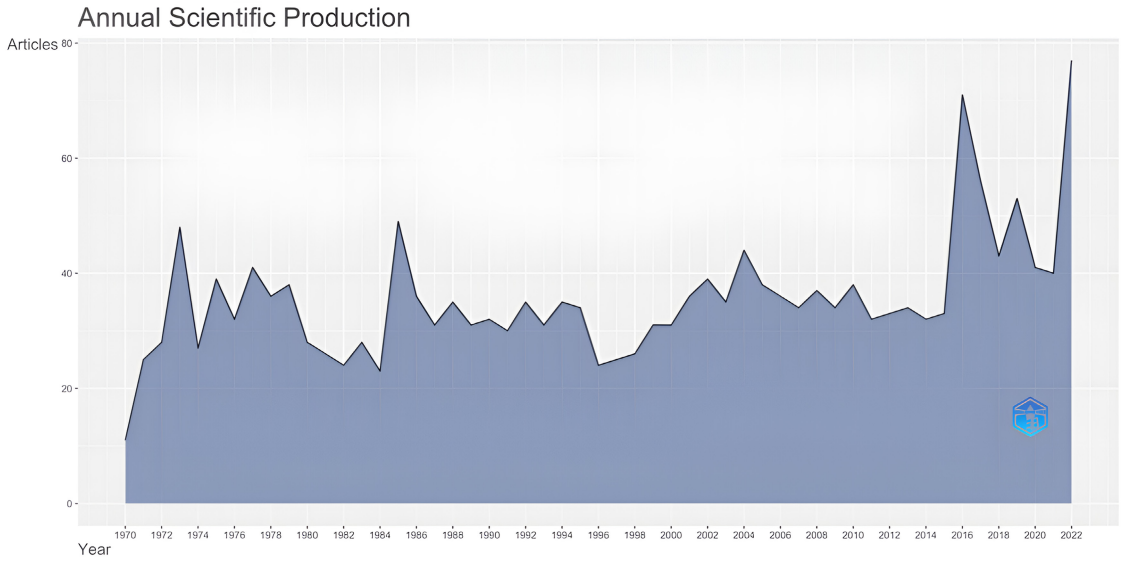

Figure 1. *R&D Management* annual scientific production.

Table 2. *R&D Management* most cited publications

Articles	TC	TC per year	Normalized TC
Enkel et al. (2009)	1,290	86,00	10,59
Chesbrough and Crowther (2006)	1,223	67,94	6,56
Gassmann et al. (2010)	1,034	73,86	10,12
Katz and Allen (1982)	947	22,55	19,38
Rothwell (1992)	903	28,22	16,39
West and Gallagher (2006)	705	39,17	3,78
Gassmann (2006)	698	38,78	3,74
Lüthje and Franke (2003)	609	29,00	7,30
Dodgson et al. (2006)	574	31,89	3,08
Piller and Walcher (2006)	567	31,50	3,04
Schiederig et al. (2012)	484	40,33	10,34
Kim and Wilemon (2002)	403	18,32	5,00
Cooper et al. (2001)	389	16,91	8,06
Prajogo and Ahmed (2006)	375	20,83	2,01
Etzkowitz and Klofsten (2005)	352	18,53	5,13
Lettl et al. (2006)	319	17,72	1,71
Spieth et al. (2014)	315	31,50	6,42
Rothwell and Dodgson (1991)	310	9,39	13,56
Lüthje and Herstatt (2004)	302	15,10	4,99
Ebner et al. (2009)	296	19,73	2,43
Chiang and Hung (2010)	289	20,64	2,83
Lichtenthaler (2009)	287	19,13	2,36
Bonaccorsi and Piccaluga (1994)	285	9,50	8,08
Rohrbeck et al. (2009)	272	18,13	2,23
Kessler et al. (2000)	264	11,00	5,05

commercialization of technologies. The second most prolific author, Oliver Gassmann, offered a leading contribution in linking R&D to topics such as innovation processes, OI, and intellectual property. Finally, the third author in this rank, Derrick F. Ball, made a powerful contribution to R&D management scholarship by

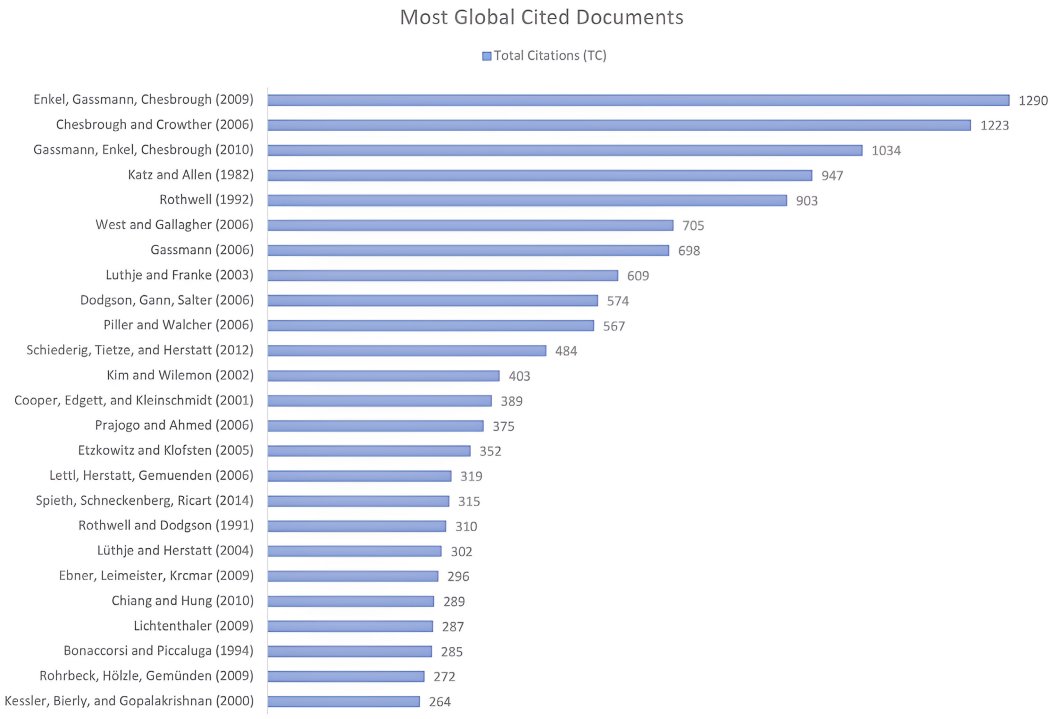

Figure 2. *R&D Management* most frequently cited papers, all-time.

Table 3. *R&D Management* most prolific authors

Authors	Number of articles	Articles fractionalized
Pearson, A.W.	20	11,25
Gassmann, O.	18	7,45
Ball, D. F.	17	12,17
Debackere, K.	14	7,36
Wilkinson, A.	14	12,83
Bergen, S. A.	10	8,33
De Meyer, A.	10	7,50
Allen, T. J.	9	4,70
Chiesa, V.	9	3,25
Di Minin, A.	9	2,56
Frattini, F.	9	2,67
Rothwell, R.	9	6,20
Bessant, J.	8	2,42
Brockhoff, K.	8	6,08
Chesbrough, H.	8	2,65
Fischer, W. A.	8	4,75
Parker, R. E.	8	7,50
Probert, D.	8	2,28
Woods, M. F.	8	3,33
Cooper, R. G.	7	5,00
Enkel, E.	7	2,83
Herstatt, C.	7	2,83
Lee, S.	7	2,08
Lichtenthaler, U.	7	4,83
Manzini, R.	7	2,25

focusing on the importance of R&D professionals at many levels, from universities to the alignment of partners in strategic alliances. Following the analysis of the most prolific authors, we display in Figure 3 the rank of the most common authorial affiliations to highlight the ability of the journal to attract international scholars. As the figure shows, corresponding authors' countries affiliations are spread across the globe, as confirmed by Table 4, which displays contributions by country. Looking at the 10 most prolific countries shows that European nations play a prominent role. However, it is worth noting that beyond the United Kingdom, the most prolific country with 784 articles, countries such as the United States (496) and China (279) occupy important positions. This confirms the growth in global attention that *R&D Management* has attracted. This trend is further confirmed by the presence of countries such as South Korea, Australia, Japan, New Zealand, and India in the top 20.

4. Mapping the field and setting the trajectories

The research topics addressed by *R&D Management* have evolved thanks to contributions that have shaped the evolution of theory over the years (Figure 4 shows the frequency of the most relevant words in titles over time[2]). To display the most significant trends featured

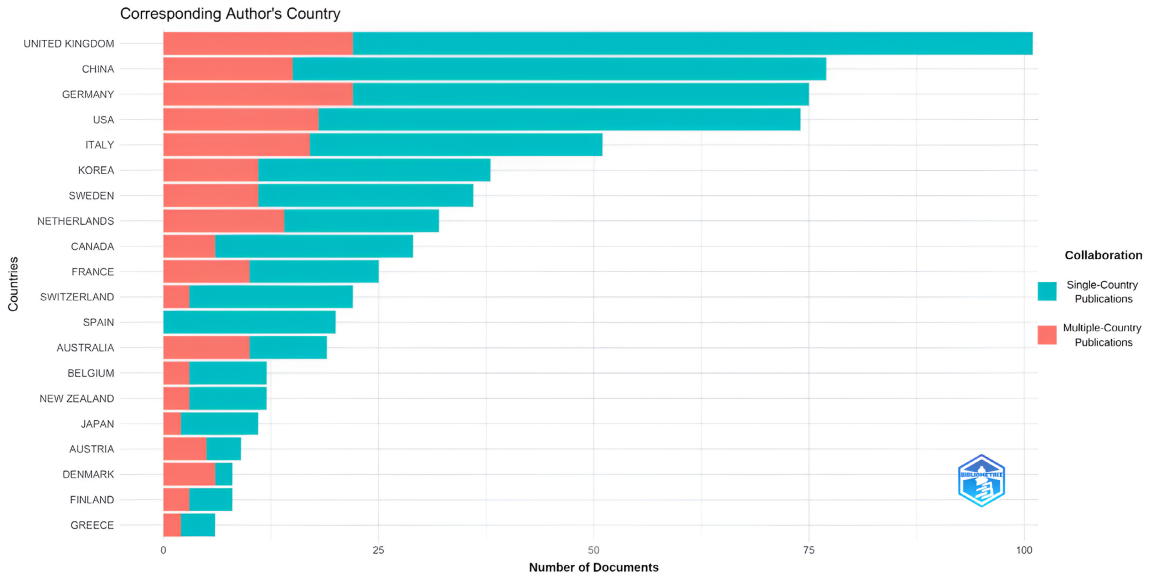

Figure 3. *R&D Management* corresponding authors' countries.

Table 4. Number of documents published by *R&D Management* according to authors' affiliations

Country	Number of documents
UK	784
USA	496
Germany	311
China	279
Italy	214
Netherlands	158
Canada	143
Sweden	134
Spain	118
Switzerland	109
South Korea	90
France	86
Australia	72
Finland	59
Belgium	55
Israel	46
New Zealand	43
Japan	42
India	37
Austria	34
Denmark	33
Brazil	27
Ireland	27
Portugal	23
Poland	13

in *R&D Management* and assess their evolution over time, we analyzed the most relevant keywords in publications' titles (Figure 5). Through a qualitative analysis of the articles and their contents, we identified three time periods where the focus was different: (i) 1970–1992; (ii) 1992–2006; and (iii) 2006–2018. Figure 4 presents the evolution of *R&D Management* topic trends over time and, combined with Figure 5,[3] constitutes the starting point of our qualitative analysis.

As Figure 4 shows, from 1970 to 1992, titles' keywords deal with concepts related to industrial organization and applied industrial research. The second macro trend, from 1992 to 2006, concerns technology management and industrial collaborations, with particular attention to SMEs and universities. During this period, articles also focused on the rising importance of innovation policies and the critical role played by the pharmaceutical sector (big pharma and biotechnology) in fostering inter-firm collaboration. The final period, from 2006 to 2018, shows growing attention to collaborative strategies, especially OI strategies. Increasing attention has also been devoted to topics closely related to collaborative processes such as transfer of knowledge, network creation, and strategic management of intellectual property. Similar patterns emerge from the visualization of similarities analysis shown in Figure 5, which depicts the evolution of recent research interests, along with their linkages. As the Figures 4 and 5 illustrate, the focus of articles in *R&D Management* varies from exploring the dynamics related to 'industrial R&D' toward the greater centrality of 'R&D management' in the late 1980s. Around the turn of the millennium, scholars began focusing on 'product development,' and more recent publications address the innovative strategies linked to collaborative experiences by studying 'business model innovation,' 'absorptive capacity,' 'strategic alliances,' 'OI,' and finally, 'COVID.'

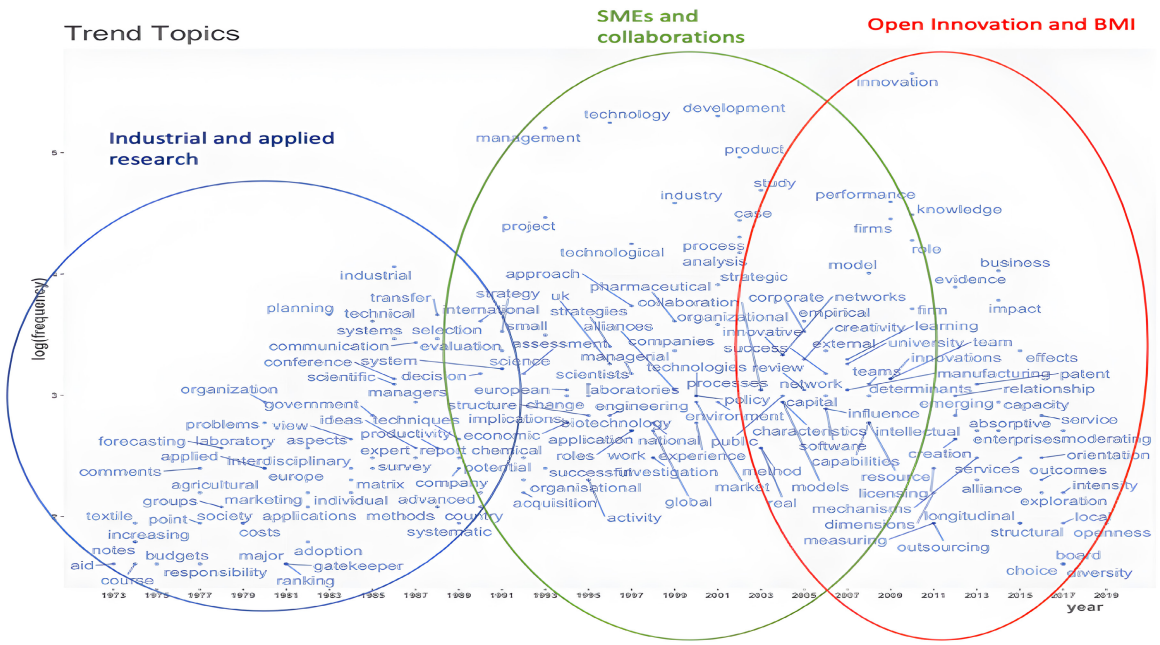

Figure 4. *R&D Management* topic evolution over time.

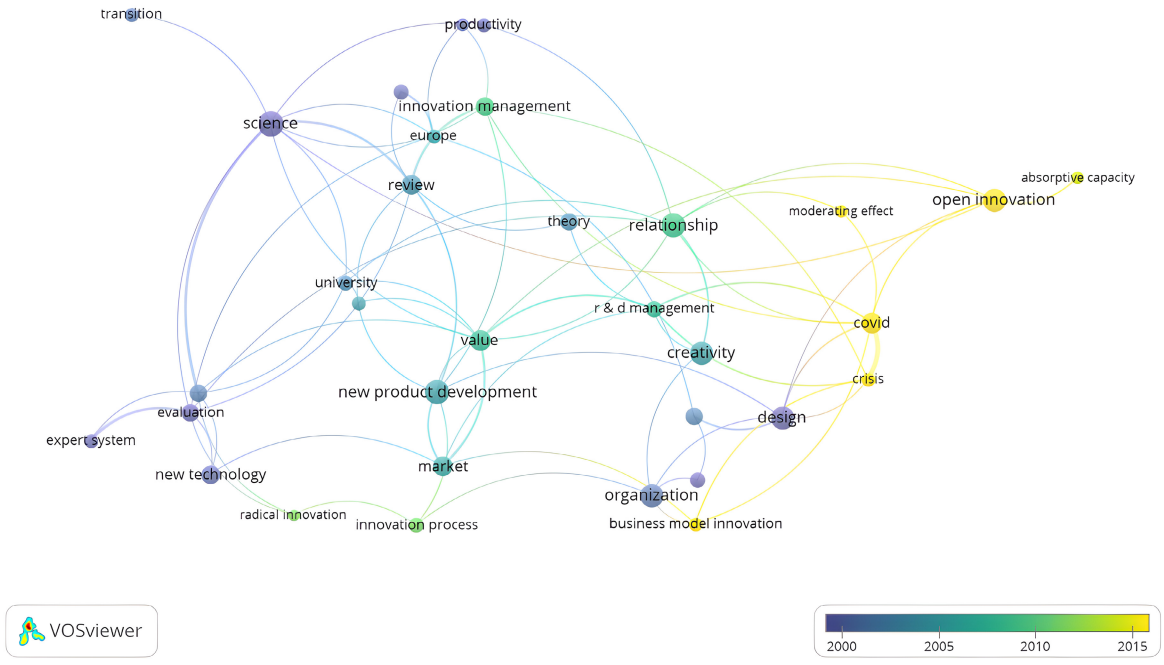

Figure 5. VOSviewer visualization of title keyword co-occurrence.

In addition to offering meaningful insights into the journal's content and research positioning, our analysis also promotes a deeper understanding of the research themes that have informed articles in *R&D Management*. Due to the large changes in historical and sociocultural contexts where R&D is being done (from corporate labs to external partners) and technologies used and developed (from mainly mechanical things, to electromechanical ones, to electronics, and finally to digital) (Godin, 2015), we have reason to believe that the field of R&D Management has similarly morphed and renewed over time (see also Rigby, 2016). Therefore, in the following subsections, we first document this understanding through a qualitative analysis of the journal's contents across the three time periods identified (1970–1992, 1992–2006, and 2006–2018) and then identify a menu of research trajectories that both help detect current

and future trends in innovation and R&D and can assist authors in preparing future submissions to the journal.

4.1. Setting the foundation: intra-organizational R&D management as a field of investigation, internal process, product, creativity, and entrepreneurship (1970–1992)

The 1970s and 1980s were in many ways remarkable decades for R&D and innovation management research.[4] As scholars had earlier established the role of management and management science to understand organization, production, sales and marketing, and internationalization, attention began shifting to the intersection between management, competitive advantage, and innovation. Notably, during the 1970s and 1980s, *R&D Management* was able to 'score' some of the greatest hits of the era. Key concepts had the opportunity to shine, including 'stage gate' (Katz and Tushman, 1981), 'tech entrepreneurship' (Cooper, 1973), 'user-led innovation' (Von Hippel, 1977; Shaw, 1985), 'not-invented-here syndrome' (Katz and Allen, 1982), and 'the dual ladder' (Allen and Katz, 1986).

In this pioneering period, the journal was a key outlet for publication of these breakthrough concepts that paved the way for a new understanding of the role of innovation within an organization. The first papers of *R&D Management* addressed fundamental issues like project selection in R&D laboratories (Bell and Read, 1970), evaluation of communication patterns in R&D projects (Allen, 1970; Evans et al., 1974), and the cost–benefit impacts of technology transfer (Langrish, 1971; Simmonds, 1974).[5]

Beginning in 1975, we note the regular appearance of studies analyzing communication practices in R&D projects. Scholars sought to enrich our understanding of this important topic in R&D laboratories, sometimes by investigating processes of communication (Taylor, 1975), exploring patterns of communication (Pruthi and Nagpaul, 1978), or focusing on communication flows (Hall and Ritchie, 1975). As to the remainder of frequently cited papers from this period, we observe a varied group of issues, some of which can be conceived as triggering the examination of core issues in R&D management for years to come. Examples include new product development (NPD; Cooper and More, 1979), R&D commercialization (Higgins, 1977), and knowledge transfer (Robbins and Milliken, 1976).

It is important to note that all these breakthrough concepts, which now we see cited in many recent *R&D Management* articles, were investigated from a specific angle; namely the intra-organizational perspective. The firm, and in many cases the large incumbent firm, was the cornerstone of these analyses, which largely examined the internal processes and the interaction between internal and external forces.

This perspective also appeared in the second half of this period, in which we see less scholarly interest in communication patterns of R&D projects, with only two authors investigating this issue (Epton, 1981; Tomlin, 1981). Rather, the topic that epitomizes this period is the investigation of new products from different angles – that is, NPD (Liberatore and Titus, 1983), new product performance (Cooper, 1984), and new product processes (Parkinson, 1981; Cooper, 1983). Still, all these topics continued to be viewed as an intra-organizational issue. Moreover, we observe the appearance of creativity as a topic in *R&D management* papers. Creativity audit (Rickards and Bessant, 1980) and teamwork creativity (Geschka, 1983) were the most commonly examined issues.[6] Once again, creativity was focused on managers, employees, and teams inside large organizations. We symbolically close this period with Roy Rothwell's paper in volume 22 (1992), which remains one of the most influential papers ever published by *R&D Management*. In 'Successful Industrial Innovation: Critical Factors for the 1990s,' Rothwell captures the essence of this period in the journal's history, examining how recent research on large organizations had overcome the divide between tech push and demand pull, emphasizing the rise of faster and internally controlled parallel innovation processes.

4.2. Inter-organizational perspective emerges: collaborations, tech transfer, and the role of SMEs (1992–2006)

While the pioneering studies in the journal dealt with key R&D management issues from an intra-organizational standpoint, we observe in the second period a change of perspective. Both practitioners and academics, in that order, understood that a dominant focus on internal processes was insufficient to deal with the ongoing challenges and opportunities emerging in dynamic markets and with new technologies. Rather, they realized that the most relevant locus of innovation was often outside a single organization, thus paving the way for the emergence of an inter-organizational perspective from which innovation processes and products could be analyzed. For instance, Kessler et al. (2000) highlighted the impact of external sourcing strategies on NPD, fully three years before the Chesbrough's landmark book on OI was published in 2003.

Moreover, we find evidence of an inter-organizational perspective in at least three major topics in *R&D Management* at the beginning of the 1990s. The first is collaborations, with R&D and innovation alliances beginning to receive attention from scholars, with regard to, for example, the role of experience (Forrest and Martin, 1992), and alliance characteristics (Håkanson, 1993). Moreover, some themes such as university–industry interorganizational relationships (Bonaccorsi and Piccaluga, 1994) and science park and networking contexts (Rothwell and Dodgson, 1991; Van Dierdonck et al., 1991) began to emerge.

Second, we note inter-organizational articles concerning technology transfer in relation to university–industry relationships, spin-off-entrepreneurship, and intellectual property (Roberts and Malonet, 1996; Chiesa and Piccaluga, 2000; Ernst and Vitt, 2000). These types of topics further demonstrate the gradual shift in focus from large incumbent firm R&D to an interactive and relational approach to R&D and innovation.

Third, scholars began to approach innovation processes from an inter-organizational perspective in the SME context. This advance was significant, as innovation processes and products had generally been studied inside large organizations. In this period, however, we observe the importance of external linkages for innovation processes in SMEs (Rothwell and Dodgson, 1991).

Fourth, while we are now experiencing a hype on sustainability, some of the pioneering papers that were published during those years emphasized the growing attention of R&D toward sustainability and green transition. In this regard, Noci and Verganti (1999) show that, although affected by environmental regulations, SMEs can play an important role in green product innovation. In fact, their paper set the stage for many future investigations around concepts such as green innovation (Schiederig et al., 2012), eco-innovation (Zhang and Walton, 2017), and innovation for sustainability (Seebode et al., 2012). A further key insight of their article lies in having built a contingent framework to support SMEs in the analysis of the drivers of green product innovation and in choosing an R&D strategy that explicitly accounts for the eco-efficiency of product technologies.

Finally, it is worth noting that this period was marked by contributions from scholars from different regions. While in the first period of *R&D Management*, the debate had been shaped by scholars in English-speaking countries (primarily the United Kingdom), more leading contributions were now coming from continental Europe.

4.3. *Extra-organizational perspective takes off: OI and business models (2006–2018)*

The third period brought with it another important change: external sources of technology were no longer opposed to or contrasted with internal ones. Rather, scholars became increasingly aware of the broader range of stakeholders relevant to R&D and innovation, leading to the emergence of an extra-organizational outlook. From this perspective, external actors like customers, suppliers, competitors, and complementors became more consequential for understanding how, why, and with whom organizations innovate. We found evidence of this in at least two key core concepts that epitomized *R&D Management* research for more than a decade: (1) OI and (2) business models.

Beginning in 2006, the journal became a leading destination for remarkable contributions in the OI field. This concept, coined by Chesbrough (2003), was immediately picked up by practitioners but was initially overlooked by scholars. *R&D Management* was among the first academic journals to facilitate scientific debate around the concept (e.g., Chesbrough and Crowther, 2006; Dodgson et al., 2006; West and Gallagher, 2006). The rapidly growing interest in this topic – and the understanding of its importance – was confirmed by special issues on OI (Enkel et al., 2009; Gassmann et al., 2010). The articles in those issues have been cited more than 5,000 times, according to Web of Science. Even more importantly, the articles made key contributions that continue to shape our understanding of OI. Some explored the challenges of OI (West and Gallagher, 2006; Sieg et al., 2010), while others described the distinctions between inbound and outbound OI (Lichtenthaler, 2009). Lastly, other research clarified how OI is implemented or adopted inside organizations (Chesbrough and Crowther, 2006; Rohrbeck et al., 2009; Gassmann et al., 2010). Over the last decade, scholars have continued examining OI in multi-business firms (Moellers et al., 2020), how value is captured in OI (Olk and West, 2020), and the micro-foundations of OI by emphasizing the role played by key individuals' personal traits in innovation (Ahn et al., 2017).

Beyond OI, *R&D Management* emphasized the more customer-facing and organizational aspects of R&D and innovation in the form of business models, which became an increasingly frequent unit of observation; this trend was accelerated by special issues on this topic (Spieth et al., 2014, 2016). Scholars explored how to pursue business model innovation (Khanagha et al., 2014),

provided a state of the art on the topic (Spieth et al., 2014), and offered a conceptualization of core elements and relevant organizational capabilities (Mezger, 2014). More recently, scholars have analyzed the effects of business model innovativeness on customer behavior (Clauss, 2017), how opportunities can be recognized (Guo et al., 2017), and how decision making in business model innovation can be measured (Reymen et al., 2017).

Apart from OI and business models, we found in the pages of *R&D Management* extra-organizational perspectives on four more established concepts in the last two decades. The first is technology transfer and the conceptualization of the quadruple helix (Carayannis et al., 2018). In their widely cited work, Carayannis et al. (2018) introduce regional coopetitive ecosystems as quadruple helix models, in which the innovation system is based on interactions between four major actors: science, policy, industry, and society. Several of the other most frequently cited articles complement these valuable contributions by investigating value creation in quadruple helix models (Cunningham et al., 2018; McAdam and Debackere, 2018; Miller et al., 2018). Taken together, these papers signal the fact that *R&D Management*, which had been a key reference point for the triple helix, continued to be a point of reference in the technology transfer literature.

A second important theme was the continuing focus on green innovation (Schiederig et al. 2012) and the emphasis on internal processes; specifically, the regular attention paid to the processes of learning (Kessler et al., 2000). Literature on green innovation, which emerged toward the end of the second period of *R&D Management* (Noci and Verganti, 1999), was systematized and stimulated, as in the exploratory literature review by Schiederig et al. (2012). Interestingly, this article contains insights that remain highly relevant for today's R&D management landscape, as is shown by recent contributions that add nuance to the environmental and societal aspects of innovation (Ahn et al., 2017; Zhang and Walton, 2017; De Silva and Wright, 2019; Jin et al., 2019).

The third theme is the interaction between R&D and entrepreneurship. In this regard, the characteristics of the high-tech entrepreneur in Lüthje and Franke's (2003) article resemble the taxonomy of 'technical entrepreneurship' offered much earlier by Cooper (1973). The key difference is that decades-old intra-organizational attributes bounced back in a renewed competitive scenario, in which companies are more technologically oriented and have to both cooperate and compete with others to design innovative products.

The fourth theme is exemplified in the work by Piller and Walcher (2006), who showcase the concept of 'idea competitions', a new form of distributed but well-organized innovation. To do so, they blend OI with another established concept in *R&D Management* articles; namely, the user-led innovation of Von Hippel (1977). Thirty years after the notion of user-led innovation was introduced, users remain an important source of innovation for companies in OI and other settings.

4.4. New research frontiers (2019–onward)

Although *R&D Management* articles cover even more aspects of innovation and management than those outlined here, we have qualitatively assessed the major topics that were discussed in the most frequently cited papers in the R&D management field. Considering the evolution of the research themes across the three time periods (1970–1992, 1992–2006, and 2006–2018), we now present a number of directions that have started to appear in *R&D Management* or are likely to appear in its pages in the years to come (see Table 5). These new frontiers give continuity and integrity to the evolution of research themes in R&D management as they emerge from some of the most widely cited recent contributions to the journal (see Figure 6) and of recently opened special issues that help set the direction for new topics. We identify six interesting and increasingly important research frontiers:

1. *Ecosystems and platforms*. Although these topics were already well established in management (Jacobides et al., 2018; Rietveld and Schilling, 2021) and information systems (Constantinides et al., 2018), scholars are increasingly examining how R&D and innovation activities take place in different types of ecosystems and platforms. Ecosystems refers to a set of loosely connected complementary actors that together achieve a higher-order goal or value proposition, such as delivering a new product to markets or generating new entrepreneurial ideas and opportunities (for reviews, see Aarikka-Stenroos and Ritala, 2017; Hakala et al., 2020). Platforms, in their part, refer to digital infrastructures that help to coordinate interactions in multisided markets (Constantinides et al., 2018). Platforms are often (but not always) used to orchestrate an ecosystem, which is why the two topics coincide.[7] Some interesting recent contributions in *R&D Management* relate to the role of the entrepreneurial ecosystem (Buratti et al., 2022) and innovation ecosystems

Table 5. Top 5 most cited papers (2019-onwards)

Year	Studies
2019	Integration capacity and knowledge-based acquisition performance – Lamont et al. (2019)
	Product-service innovation and performance: the role of collaborative partnerships and R&D intensity – Bustinza et al. (2019)
	A rolling stone gathers no moss: the effect of customers' perceived business model innovativeness on customer value co-creation behavior and customer satisfaction in the service sector – Clauss et al. (2019)
	The relationship between innovation culture and innovation outcomes: exploring the effects of sustainability orientation and firm size – Jin et al. (2019)
	Recombination for innovation: performance outcomes from international partnerships in China – Collinson and Liu (2019)
	Financing behavior of R&D investment in the emerging markets: the role of alliance and financial system – Alam et al. (2019)
	The origins of external knowledge inflows and the impact of university technologies – Natalicchio et al. (2019)
2020	The role of digital technologies in open innovation processes: an exploratory multiple case study analysis – Urbinati et al. (2020)
	Open data for open innovation: managing absorptive capacity in SMEs – Huber et al. (2020)
	Complementing open innovation in multi-business firms: practices for promoting knowledge flows across internal units – Moellers et al. (2020)
	The relationship of industry structure to open innovation: cooperative value creation in pharmaceutical consortia – Olk and West (2020)
	Exploring open innovation in the digital age: a maturity model and future research directions – Enkel et al. (2020)
2021	Technological exaptation and crisis management: Evidence from COVID-19 outbreaks – Ardito et al. (2021)
	Frugal innovation in a crisis: the digital fabrication maker response to COVID-19 – Corsini et al. (2021)
	Innovation management in crisis: patent analytics as a response to the COVID-19 pandemic – Guderian et al. (2021)
	Exogenous shocks and the adaptive capacity of family firms: exploring behavioral changes and digital technologies in the COVID-19 pandemic – Soluk et al. (2021)
	Open innovation with Chinese characteristics: a dynamic capabilities perspective Chesbrough et al. (2021)
2022	Open innovation in the face of the COVID-19 grand challenge: insights from the Pan-European hackathon 'EUvsVirus' – Bertello et al. (2022)
	Temporary business model innovation–SMEs' innovation response to the Covid-19 crisis – Clauss et al. (2022)
	Innovation in times of pandemic: The moderating effect of knowledge sharing on the relationship between COVID-19-induced job stress and employee innovation – Montani and Staglianò (2022)
	The contribution of Design Thinking to the R of R&D in technological innovation – Magistretti et al. (2022)
	The impact of Covid-19 on innovation policies promoting Open Innovation – Patrucco et al. (2022)

In 2019 the number of papers is 7 due to the same amount of citations with top 5-7 cited

(Wikhamn and Styhre, 2023), along with studies examining complementary innovation and generativity afforded by digital platforms (Hilbolling et al., 2020). Furthermore, platforms and ecosystems are being integrated with a classic topic in R&D Management – business model innovation (see, e.g., Schmidt and van der Sijde, 2022; Schneckenberg et al., 2022).

2. *Orchestration*. A growing field of study, and related to the previous topic, orchestration is being used to signify the coordination efforts of an ecosystem or platform leader on a set of complementary and loosely connected actors (Radziwon et al., 2022) and to explain how different types of resources and knowledge are coordinated for innovation purposes between different stakeholders and networks (Andersén and Ljungkvist, 2021; Ritala et al., 2023). In an increasingly dynamic environment often characterized by voluntary contributions from complementors and other stakeholders, the orchestration approach plays an important role. Orchestration can be seen as a contemporary mode of coordination that is increasingly needed to complement the classic contractual R&D and innovation networks. In fact, there has been interest to managing informal innovation networks for quite some time in the journal

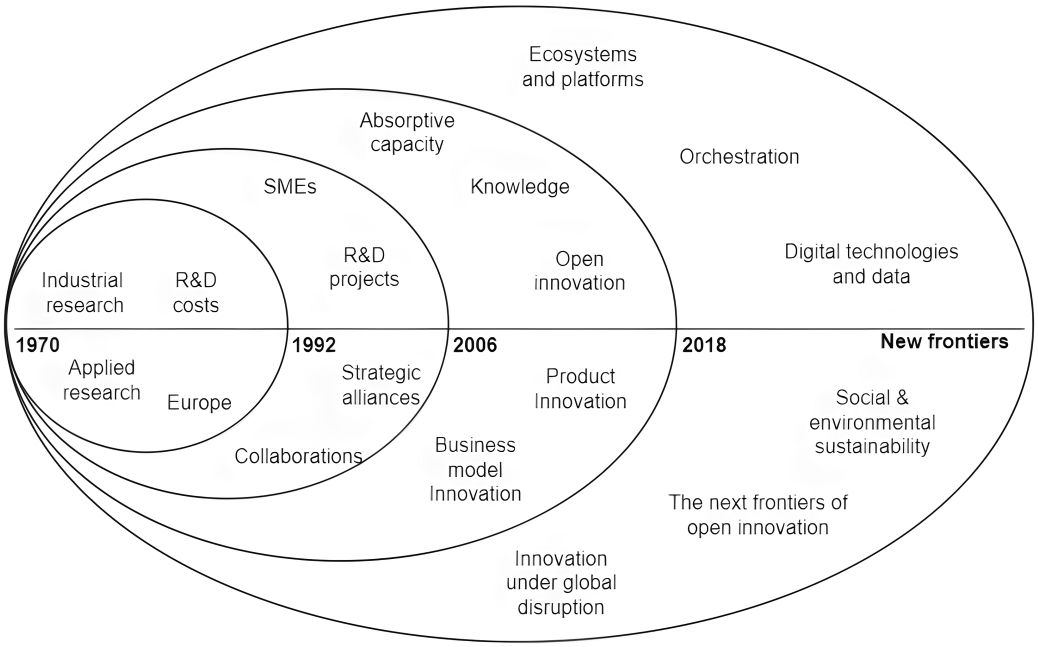

Figure 6. A snapshot of *R&D Management* research trajectories.

(e.g., Van Aken and Weggeman, 2000), and the future research on orchestration will continue to concretize the coordination practices and mechanisms that are relevant in loosely coupled and innovative networks and ecosystems.

3. *Digital technologies and data*. While technologies have always played a big role for scholars and practitioners of R&D, there is something unique about digital technologies that have led management researchers to conclude that new sets of lenses and theories are needed (Yoo et al., 2010). Indeed, digital technologies such as artificial intelligence (AI), advanced analytics, automation and robotics, and digital platforms (see topic 1 above) are changing the landscape of R&D and innovation. The role of digital technologies in organizations has already attracted substantial attention in *R&D Management* (e.g., Urbinati et al., 2020; Dąbrowska et al., 2022). Going forward, it is likely that scholarship will move from broad-based discussions of digital technologies and digital transformation to more specific topics, among which we expect that data in organizations and their innovation processes (including business model innovation) will play a major role. In addition, theorizing and explaining the role of a specific technology such as AI or the Internet of Things will continue to make more distinctive contributions to the broader field of digital transformation.
4. *Social and environmental sustainability*. The themes related to social and environmental sustainability have been covered in the journal for a long time, but recently these themes have picked up new momentum. For instance, the social impact aspects of open innovation were highlighted in a special issue (Ahn et al., 2019), and more recently, the journal hosted a multiple-issue ranging special edition on the role of R&D Management in COVID crisis (Mortara et al., 2022). In terms of environmental sustainability, beyond green innovation (Schiederig et al., 2012) and eco-innovation (Zhang and Walton, 2017), there is an increasingly important discussion of the circular economy when it comes to business model innovation and innovation in general (Lüdeke-Freund et al., 2019; Suchek et al., 2021). While the issue has yet to emerge in *R&D Management* articles, recent papers at the R&D Management Conference and the journal's special issues provide a clear indication that the circular economy, sustainable development, and grand challenges more broadly will take on a more visible role in the journal's scholarship.
5. *The next frontiers of OI*. While the topic is already mature, with almost 20 years of history, scholars are continuing to expand the frontiers of OI. Interestingly, many OI scholars are now exploring the ecosystem perspective, which extends the original inbound and outbound OI to the analysis of broader interactions and synergies within the ecosystem of a firm's partners and complementors (Radziwon et al., 2022; Wikhamn and

Styhre, 2023). Beyond extending the scope of the analysis, OI scholars are also increasingly exploring the role of digital technologies, such as the role of open data in innovation (Huber et al., 2020). OI scholars are also increasingly 'zooming in' – as they are exploring the microfoundations and human factors of OI (Naqshbandi et al., 2023; Xia et al., 2023).

6. *Innovation under global disruption*. Recent frequently cited papers in *R&D Management* unsurprisingly include many contributions that seek to make sense of firms' innovative responses to the COVID-19 pandemic (see also Mortara et al., 2022). However, the pandemic has receded to become a second-tier worry in the face of the increasing division, disruption, and turmoil evident among powerful nations like China, Russia, and the United States, as well as between the Global North and South. These disruptions relate to increasingly stark differences in politics, worldviews, roles, and responsibilities in climate change mitigation, and in the role of governments and private sector. These new and emerging divisions will undoubtedly play a role in disrupting global supply chains and they are also increasingly affecting firm- and country-level decisions on investment and innovation. In this regard, a special issue on collaborative innovation dynamics along the belt and road Chinese initiatives has been published in the journal (Chen et al., 2021). Thus, we expect this theme to be highly relevant going forward, as also witnessed in an ongoing special issue in *R&D Management* (Fu et al., 2023).

5. Conclusions

The present study has offered a bibliometric analysis of the 1,886 publications published in *R&D Management* from 1970 to 2022. The bibliometric analysis reflects the changing managerial practices and processes of R&D and innovation, thereby confirming that the journal had been consistent with its mission over the last 50+ years, while continuously following and anticipating the newest developments. Our analysis offers several research implications and identifies different trajectories to develop future research.

5.1. Implications

R&D Management is a leading interdisciplinary academic journal for research in R&D and innovation management. The analysis conducted in the present study shows that the journal regularly increased the number of articles it published beginning in 2009, partly by commissioning special issues that raised topics of an exploratory nature, as OI was at the time. Second, the journal's impact factor shows that the journal has enjoyed consistent growth in the last decade, demonstrating its centrality to its research fields. Third, an analysis of contributors clearly shows the international relevance of the journal, which now receives submissions from all over the world, from China and other parts of Asia to North America and Europe.

Authors aiming to publish in *R&D Management* should consider positioning their studies in line with the significant research trajectories identified in this study: ecosystems and platforms, orchestration, digital technologies and data, social & environmental sustainability, the next frontiers of OI, and innovation under global disruption. That might result in an instrumental strategy to ensure that references to state-of-the-art research addressing a given topic are adequately covered in R&D management. Furthermore, scholars could decide to explore the implications of the present study in greater depth by delving into one or more dominant trajectories addressed by R&D, as displayed in the co-occurrence analysis. Moreover, the trajectories emerging from our qualitative analysis of the most relevant publications pinpoint the main drivers that shaped the evolution of the different research fields addressed in *R&D Management*. A careful evaluation of these trajectories offers scholars a chance to draw inspiration for future studies that will contribute to the ongoing debate and explore new research avenues. Finally, and naturally, *R&D Management* will continue to welcome work on classic topics like internal R&D, product development processes, and business model innovation while also being receptive to ground-breaking research that does not fit into any of the above trends but could lead to a new research stream in the years to come. Like all topics in management disciplines, themes in the journal will continue to evolve in light of ongoing societal and technological changes.

5.2. Limitations

Given the aim of the study – to explore and synthesize the contents of articles appearing in *R&D Management* since its foundation – there are certain potential weaknesses in terms of theoretical, empirical, and practical exhaustiveness. First, this study is not the first one to review the journal's history and its major achievements and contributions. A 40-year retrospective of *R&D Management* can be found in

the work by Rigby (2016). In the current study, we extend this previous analysis with a more updated and detailed account of the evolution of R&D and innovation management over the last 50+ years. A reader interested in the journal's history would benefit from getting familiar with both perspectives to get a more comprehensive picture.

Second, this study seeks to offer a synthesis of the most significant contributions in terms of knowledge and diffusion offered by *R&D Management*. While the aim is to help scholars to consider topics and approaches in future work, we are not offering an exhaustive exploration of all research developments in *R&D Management* or of the field of R&D and innovation management more broadly. Because of the methodology that we followed, our analysis emphasized topics and research trends that were successfully picked up by scholars in subsequent publications. *R&D Management*, however, hosted many contributions that, in spite of their groundbreaking relevance, did not enjoy the same success neither they became trendsetters through other scholars. For instance, not included in this analysis is the paper written by Bernold (1985). If we observe closely this article, many features of artificial intelligence (AI) that are relevant today can be found in this 'hidden gem' published a long time ago in the pages of *R&D Management*. A deeper analysis of journal's articles that were groundbreaking but did not get much traction would be very interesting.

Third, our data collection was limited to the Scopus database (although the results were cross-checked with Web of Science), which has an effect on the numbers and exhaustiveness of the analysis. In addition, although the study builds initially on a bibliometric-driven data analysis, we also offer a qualitative interpretation of the most relevant publications as well as future research trajectories, which introduces a necessarily interpretive element. Despite these limitations, we believe this study offers a valuable retrospective on the evolution of topics related to R&D and innovation management as they appear in the first 50+ years *R&D Management*, as well as interesting elaboration of potential future research topics.

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Notes

1 *R&D Management* has been, throughout more than 50 years of history, an outlet for research topics that very frequently anticipated research trajectories that became mainstream in the scholarly community. Moreover, if we look at the sequence of topics covered by *R&D Management*, we can immediately note that the journal mirrors the evolution of practitioners' attention in R&D management throughout the years.

2 To ensure graphical readability, we have restricted the maximum number of words per year to five and applied the same restriction to the minimum word frequency. We have not limited the timespan, which covers the entire set of analyzed publications. The

trend topics were identified using Bibliometrix, which employs co-occurrence analysis, topic modeling with Latent Dirichlet Allocation (LDA), and trend analysis. Co-occurrence analysis identifies relationships between words in the documents, and LDA is applied to identify topics and their corresponding word distributions. Hierarchical clustering is used to group similar topics, and line charts display the trend of each topic over time. The graph of the trend topics displays the frequency of each identified topic over a specific period, with the y-axis showing the frequency of the topic in the bibliographic data and the x-axis representing time. The graph identifies topics that are gaining or losing popularity over time and tracks the evolution of different research areas.

[3] Figure 5 shows an occurrence analysis carried out using VOSviewer of keywords in titles and how they have changed over the years.

[4] Although the analysis embraces approximately 20 years, we decided to keep it together because of the emphasis on intra-organizational dynamics. We can however notice two sub-periods that could be easily identified even though they appear intertwined. The first one focuses on project level of analysis (i.e., stage gate); the second one is mainly related to the inter-organizational dynamics (i.e., interactions between R&D departments within an organization).

[5] Of course, we observe other topics (i.e., R&D performance evaluation, problem prediction in R&D laboratories, and project managers' behavior), but we consider them ancillary contributions to the progress of R&D management scholarship in the other periods under observation.

[6] This focus on creativity is the prelude to what later became a core topic of creativity and innovation management in the 1990s.

[7] When discussing platforms, authors in *R&D Management* and other management journals nowadays typically refer to digital platforms enabling interactions in multisided markets, rather than a product platform (e.g., a platform for car manufacturing). Furthermore, while the topics of platform and ecosystem often coincide, many scholars also examine the topic of ecosystems independently from platforms, while others examine ecosystems that are coordinated with the help of a digital platform.

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APPENDIX A
Special issues of *R&D Management* (2009–2022)

Year	Vol.	Issue	Topic	(Guest) editors
2009	39	4	Open R&D and Open Innovation	Enkel, Gassmann, and Chesbrough
2010	40	3	The Future of Open Innovation	Gassmann, Enkel, and Chesbrough
2011	41	1	Outsourcing R&D (Part 1)	Hsuan and Mahnke
2011	41	2	Outsourcing R&D (Part 2)	Hsuan and Mahnke
2013	43	3	Managing R&D, Technology and Innovation in the Process Industries	Lager, Blanco, and Frishammar
2014	44	3	Business Model Innovation	Spieth, Schneckenberg, and Ricart
2016	46	2	Transferring Knowledge Special Issue	Alexander, Neyer, and Huizingh
2016	46	3	Business Model (&) Innovation	Spieth, Schneckenberg, and Matzler
2018	48	1	Beyond 'Triple Helix' toward 'Quadruple Helix' Models in Regional Innovation Systems: Implications for Theory and Practice	McAdam and Debackere
2019	49	1	Industry and International Aspects on R&D Management	Tarba, Bauer, Weber, and Matzler
2019	49	3	Leveraging Open Innovation to improve society: Past achievements and future trajectories	Ahn, Roijakkers, Fini, and Mortara
2020	50	1	Open Innovation in the Digital Age	Enkel, Bogers, and Chesbrough
2020	50	3	Innovation Management Research Methods	Ritala, Schneider, and Michailova
2021a	51	2	Providing solutions in emergencies: R&D and innovation management during Covid-19 (Part-1)	Di Minin, Dooley, Lazzarotti, Manzini, Mortara, and Piccaluga
2021	51	3	The New Silk Road: R&D Networks, Knowledge Diffusions, and Open Innovation	Chen, Di Minin, Minshall, Su, Xue, L, and Zhou
2021b	51	4	Providing solutions in emergencies: R&D and innovation management during Covid-19 (Part-2)	Di Minin, Dooley, Lazzarotti, Manzini, Mortara, and Piccaluga
2022	52	2	Providing solutions in emergencies: R&D and innovation management during Covid-19 (Part-3)	Mortara, Manzini, Dooley, Lazzarotti, Di Minin, and Piccaluga

APPENDIX B
An assessment of the most frequently cited *R&D Management* papers from 1970 to 2022 (listed chronologically)

Authors (Year)	Title	Key aspects of the paper
Allen (1970)	Communication networks in R&D Laboratories	• Importance of informal relations and geographical location for R&D laboratories
Norris (1971)	The accuracy of project cost and duration estimates in industrial R&D	• Analysis of the costs and duration of R&D projects
Farris (1972)	The effect of individual roles on performance in innovative groups	• The role by key individuals within groups on the groups' innovation performance
Cooper (1973)	Technical entrepreneurship: What do we know?	• Explains the drivers for the birth of new technology-driven firms • The drivers include (1) the characteristics of the entrepreneur; (2) the previous employing organization; (3) external influences
Roberts (1974)	A simple model of R&D project dynamics	• Dynamic model of the key factors affecting R&D projects
Allen and Fustfeld (1975)	Research laboratory architecture and the structuring of communications	• Communication between individuals is influenced by the horizontal and vertical structure of a research laboratory

Authors (Year)	Title	Key aspects of the paper
Hayward et al. (1976)	Characteristics and diffusion of technological innovations	• Innovations outside the normal practice take longer to diffuse than other innovations
Rothwell (1977)	The characteristics of successful innovators and technically progressive firms (with some comments on innovation research)	• Factors associated with innovation success, failure, and delay
Killing (1978)	Diversification through licensing	• Role of diversification in a license agreement
Rubenstein and Ettlie (1979)	Innovation among suppliers to automobile manufacturers: An exploratory study of barriers and facilitators	• Federal laws and regulations are the most important barriers and facilitators of automotive suppliers' technological innovation
Gunz (1980)	Dual ladders in research: A paradoxical organizational fix	• R&D organizations can be differently receptive to dual ladders • Dual ladders may solve career problems of an organization but they may also defeat the aims of the system
Katz and Tushman (1981)	An investigation into the managerial roles and career paths of gatekeepers and project supervisors in a major R&D facility	• Gatekeepers are key actors of innovation systems
Katz and Allen (1982)	Investigating the Not Invented Here (NIH) syndrome: A look at the performance, tenure, and communication patterns of 50 R&D Project Groups	• Performance drivers of a large R&D laboratory
Cooper (1983)	The new product process: An empirically-based classification scheme	• Different ways through which a firm can conceive, develop and commercialize a new product
Cooper (1984)	The Strategy-Performance Link in Product Innovation	• New product performance is strictly linked to firm's corporate strategy
Shaw (1985)	The Role of the Interaction between the User and the Manufacturer in Medical Equipment Innovation	• Interaction with users continuously helps firms to develop successful product innovations
Allen and Katz (1986)	The dual ladder: Motivational solution or managerial delusion?	• Empirical assessment of a dual ladder reward system
Cooper and Kleinschmidt (1987)	What makes a new product a winner: Success factors at the project level	• Financial performance, opportunity windows and market share are key dimensions of new product success
Lee et al. (1988)	Technology development processes: A model for a developing country with a global perspective	• Dynamic conceptual model of technology development processes from a global perspective
De Meyer and Mizushima (1989)	Global R&D management	• Best practices of global R&D Management
Gupta and Wilemon (1990)	Improving R&D/Marketing relations: R&D's perspective	• R&D and marketing relationships can be improved through R&D management
Rothwell and Dodgson (1991)	External linkages and innovation in small and medium-sized enterprises	• The role of external linkages for firms' innovation processes
Rothwell (1992)	Successful industrial-innovation: Critical factors for the 1990s	• External relationships and their integration in firms' innovation processes
De Meyer (1993)	Management of an international network of industrial R&D laboratories	• The internationalization of R&D is a tool that improves firms' technical learning capability
Bonaccorsi and Piccaluga (1994)	A theoretical framework for the evaluation of university-industry relationships	• The role of 'relational attribute' in the evaluation of university-industry relationships
Bruce et al. (1995)	Success factors for collaborative product development: A study of suppliers of information and communication technology	• Relative costs and rewards of collaborative product development in the ICT sector

Authors (Year)	Title	Key aspects of the paper
Roberts and Malonet (1996)	Policies and structures for spinning off new companies from research and development organizations	• Spin-off companies from universities are more difficult to establish when venture capital and incubators are scarce
Tidd and Trewhella (1997)	Organizational and technological antecedents for knowledge acquisition and learning	• Organizational and technological antecedents for knowledge acquisition and learning • The antecedents include (1) organization's inheritance and (2) technology characteristics
Boutellier et al. (1998)	Management of dispersed product development teams: The role of information technologies	• Information technologies reduce the disadvantages of dispersed product development teams
Noci and Verganti (1999)	Managing 'green' product innovation in small firms	• SMEs can contribute to green product innovation
Kessler et al. (2000)	Internal versus external learning in new product development: Effects on speed, costs and competitive advantage	• Impact of technology sourcing strategies on NPD performance across different stages
Cooper et al. (2001)	Portfolio management for new product development: Results of an industry practices study	• Different portfolio management techniques (financial methods, business strategy methods, bubble diagrams and scoring models) and their impact on performance
Kim and Wilemon (2002)	Focusing the fuzzy front-end in new product development	• Strategies to manage the fuzzy front end of NPD
Lüthje and Franke (2003)	The 'making' of an entrepreneur: Testing a model of entrepreneurial intent among engineering students at MIT	• Personality traits affect entrepreneurial orientation
Lüthje and Herstatt (2004)	The lead user method: An outline of empirical findings and issues for future research	• Lead users allow firms to minimize NPD risks
Etzkowitz and Klofsten (2005)	The innovating region: Toward a theory of knowledge-based regional development	• A model of knowledge-based regional development and features of the 'triple helix' • The model is articulated along four different stages: (1) inception; (2) implementation; (3) consolidation; and (4) renewal
Chesbrough and Crowther (2006)	Beyond high tech: Early adopters of open innovation in other industries	• Inbound open innovation can be adopted in mature and traditional industries to optimize development execution and to create stepwise change and growth
Dewett (2007)	Linking intrinsic motivation, risk taking, and employee creativity in an R&D environment	• Intrinsic motivation mediates the relationship between creativity and individuals' willingness to take risks
Wu et al. (2008)	Promoting innovation through the accumulation of intellectual capital, social capital, and entrepreneurial orientation	• Firms with higher levels of social capital and entrepreneurial orientation tend to amplify the effects of intellectual capital on innovation
Enkel et al. (2009)	Open R&D and open innovation: Exploring the phenomenon	• Three core processes can be differentiated in open innovation: (1) outside-in process; (2) inside-out process; (3) coupled process
Gassmann et al. (2010)	The future of open innovation	• A special issue editorial outlining different perspectives to open innovation and consolidating the progress in the open innovation literature
Fueller et al. (2011)	Why co-creation experience matters?	• Firms may develop virtual co-creation platforms to foster open innovation
	Creative experience and its impact on the quantity and quality of creative contributions	• A key role is played by consumers' experience
Schiederig et al. (2012)	Green innovation in technology and innovation management – an exploratory literature review	• Distinction between notions of green, ecological, and environmental innovation. New definition of sustainable innovation

Authors (Year)	Title	Key aspects of the paper
Holgersson (2013)	Patent management in entrepreneurial SMES: A literature review and an empirical study of innovation appropriation, patent propensity, and motives	• Patenting is important for SMEs' innovation appropriability
Spieth et al. (2014)	Business model innovation: State of the art and future challenges for the field	• Three major motivations for engaging in business model research: (1) explaining the business; (2) running the business; and (3) developing the business
Ketata et al. (2015)	The role of internal capabilities and firms' environment for sustainable innovation: Evidence for Germany	• Importance of employees' absorptive capacity for sustainable innovation
Cortimiglia et al. (2016)	Business model innovation and strategy making nexus: Evidence from a cross-industry mixed-methods study	• Examines the connection between strategy making process and business model innovation
Clauss (2017)	Measuring business model innovation: Conceptualization, scale development, and proof of performance	• New business model innovation scale • Key dimensions of business model innovation include (1) value creation; (2) value proposition; and (3) value capture
Carayannis et al. (2018)	The ecosystem as helix: An exploratory theory-building study of regional coopetitive entrepreneurial ecosystems as quadruple/quintuple helix innovation models	• Regional coopetitive ecosystems can be seen as quadruple helix models
Bustinza et al. (2019)	Product-service innovation and performance: the role of collaborative partnerships and R&D intensity	• Strategic partnerships enable firms to perform successful product–service innovation in industries with high-R&D intensity
Urbinati et al. (2020)	The role of digital technologies in open innovation processes: an exploratory multiple case study analysis	• Examines managerial actions that firms should take to implement digital technologies in their open innovation processes
Corsini et al. (2021)	Frugal innovation in a crisis: The digital fabrication maker response to COVID-19	• In crisis-contexts, digital fabrication is a key driver of frugal innovation
Bertello et al. (2022)	Open innovation in the face of the COVID-19 grand challenge: Insights from the Pan-European hackathon 'EUvsVirus'	• Hackathons can play a strategic role in the face of grand challenges • They consist of four dimensions: (1) broad scope; (2) participatory architecture; (3) online setting, and (4) community creation

APPENDIX C

An evaluation of the most frequently cited papers in *R&D Management* papers (listed by number of citations)

Authors (Year)	Key aspects of the paper
Enkel et al. (2009)	• Three core processes can be differentiated in open innovation: (1) outside-in process; (2) inside-out process; (3) coupled process
Chesbrough and Crowther (2006)	• Inbound open innovation can be adopted in mature and traditional industries to optimize development execution and to create stepwise change and growth
Katz and Allen (1982)	• Performance drivers of a large R&D laboratory
Rothwell (1992)	• External relationships and their integration in firms' innovation processes are important
Gassmann (2006)	• Trends and streams of open innovation
West and Gallagher (2006)	• Firms may employ four strategies – pooled R&D/product development, spinouts, selling complements and attracting donated complements – to address challenges of open innovation
Piller and Walcher (2006)	• Users are important source of innovation
Lüthje and Franke (2003)	• Personality traits affect entrepreneurial orientation
Dodgson et al. (2006)	• Technological changes may facilitate the adoption of open innovation

Authors (Year)	Key aspects of the paper
Kim and Wilemon (2002)	• Strategies to manage the fuzzy front end of NPD
Cooper et al. (2001)	• Different portfolio management techniques (financial methods, business strategy methods, bubble diagrams and scoring models) and their impact on performance
Schiederig et al. (2012)	• Distinction between notions of green, ecological, and environmental innovation • New definition of sustainable innovation
Etzkowitz and Klofsten (2005)	• A model of knowledge-based regional development and features of the 'triple helix' • The model is articulated along four different stages: (1) inception; (2) implementation; (3) consolidation; and (4) renewal
Prajogo and Ahmed (2006)	• To optimize their innovation capacity, organizations should be more aware of the innovation stimuli
Lettl et al. (2006)	• Users can contribute substantially to the early development phases of radical innovations as inventors and (co)-developers
Rothwell and Dodgson (1991)	• Role of external linkages for firms' innovation processes
Lüthje and Herstatt (2004)	• Lead users allow to minimize NPD risks
Ebner et al. (2009)	• IT-supported idea competitions in virtual communities may leverage the power of crowds
Bonaccorsi and Piccaluga (1994)	• The role of 'relational attribute' in the performance evaluation of university-industry relationships
Kessler et al. (2000)	• Technology sourcing strategies affect NPD performance across different stages
Lichtenthaler (2009)	• Environmental conditions under which outbound open innovation strategies enhance performance • They include (1) the degree of technological turbulence; (2) the transaction rate in technology markets, and (3) the competitive intensity in technology markets
Rothwell (1977)	• Factors associated with innovation success, failure, and delay
Allen (1970)	• Importance of informal relations and geographical location for R&D laboratories
Spieth et al. (2014)	• Three major motivations for engaging in business model research: (1) explaining the business, (2) running the business and (3) developing the business
Chiang and Hung (2010)	• The number of external channels involved in firms' open search affect the degree of radicalness in the firms' innovation processes
Tseng and James Goo (2005)	• Four constructs of intellectual capital (human, organizational, innovation and relationship capital) affect corporate value performance in an emerging economy
Rohrbeck et al. (2009)	• Open innovation ecosystems managed by a multinational company
Enkel and Gassmann (2010)	• Role of cognitive distance for cross-industry open innovation performance
Chen (2004)	• Knowledge attributes, alliance characteristics, and firm's absorptive capacity affect the performance of knowledge transfer • Equity-based alliances generally transfer knowledge more effectively than contract-based alliances
Chiaroni et al. (2010)	• Transition from close to open innovation involves four main dimensions of the firm's organization, i.e., inter-organizational networks, organizational structures, evaluation processes and knowledge management systems
Keupp and Gassmann (2009)	• Risk-related impediments and Information- and capability-related impediments to innovation influence the breadth and depth of open innovation • Four archetypes' users of open innovation: (1) professionals; (2) explorers; (3) scouts, and (4) isolationists
Noci and Verganti (1999)	• SMEs can contribute to green product innovation
Dewett (2007)	• Intrinsic motivation mediates the relationship between creativity and individuals' willingness to take risks
Granstrand et al. (1992)	• Technology diversification is the most promising strategy of technology acquisition
Roberts and Malonet (1996)	• Spin-off companies from universities are more difficult to establish when venture capital and incubators are scarce
Fueller et al. (2011)	• Firms may develop virtual co-creation platforms to foster open innovation • A key role is played by consumers' experience
Chiesa and Piccaluga (2000)	• Academic spinoffs are one of the most promising ways to exploit public research

Authors (Year)	Key aspects of the paper
Wu et al. (2008)	• Firms with higher levels of social capital and entrepreneurial orientation tend to amplify the effects of intellectual capital on innovation
Von Hippel and Von Krogh (2006)	• Free revealing of the detailed workings of novel products and services is a central feature of open innovation. A 'private-collective' model of innovation incentives can be used by innovators
Mahroum (2000)	• Highly skilled persons are driven by different push and pull factors
Hienerth (2006)	• User innovations in open community can be diffused into a commercial and manufacturing community
Thamhain (2003)	• Barriers and enablers of innovation-based performance of R&D teams
Raz et al. (2002)	• Risk management practices are not widely used
Coombs and Bierly (2006)	• Measures to operationalize the technological capability-performance relationship
Sieg et al. (2010)	• Managerial challenges faced by companies working with an innovation intermediary to solve R&D problems
Perkmann et al. (2011)	• A performance measurement system to assess university-industry alliances
Van de Vrande et al. (2006)	• Impact of technological and market uncertainty on governance mode choices adopted in the early stages of new business development
Hayton (2005)	• Top management team human capital, diversity, and organizational reputation affect their entrepreneurial performance
Shenhar et al. (2002)	• High-uncertainty projects must be managed differently than low-uncertainty projects • High-scope projects must be managed differently than low-scope projects
Lichtenthaler and Ernst (2006)	• New typologies of knowledge management syndromes