Project Leadership and Society 6 (2025) 100181

Contents lists available at ScienceDirect

Project Leadership and Society

journal homepage: www.sciencedirect.com/journal/project-leadership-and-society

Review

The confluence of project and innovation management: A scientometric analysis of emerging trends and research frontiers

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ARTICLE INFO

Keywords:
Project management
Project governance
Innovation management
bibliometric review
Scientometric analysis

ABSTRACT

The convergence of project management (PM) and innovation management (IM) has become an increasingly significant research domain, yet a comprehensive scientometric analysis of their intersection remains underexplored. This study bridges this gap by conducting a two-decade scientometric analysis (2003–2023) of 521 articles retrieved from Web of Science (WOS), Scopus, and PubMed. Using bibliometric techniques and CiteSpace visualization, key research trends, collaborative networks, and emerging fields within PM-IM literature are identified. The findings reveal three dominant disciplinary pillars—management, engineering, and business—-shaping the PIM domain, while collaboration across institutions and countries remains sparse. Furthermore, foundational research landmarks, particularly the influence of the Stage-Gate system and dynamic capabilities in innovation-driven projects are revealed. The analysis highlights three dominant research streams: (1) managing project uncertainty in high-VUCA environments, (2) innovation-driven project methodologies, and (3) applications of PIM across diverse sectors. Furthermore, emerging research frontiers indicate increasing interest in artificial intelligence (AI), agile product management, and digital transformation in innovation projects. By providing a structured overview of the PM-IM confluence, this study offers valuable insights for researchers, policymakers, and industry professionals aiming to navigate the evolving landscape of project-based innovation.

1. Introduction

The convergence of project management (PM) and innovation management (IM) has been increasingly recognized as a critical area of research, given the rising complexity of modern projects and the demand for structured yet flexible management approaches (Davies et al., 2018). Traditional PM approaches have long provided structured mechanisms for project execution (Silva and Gil, 2013), yet they often struggle to accommodate the uncertainty and iterative nature of innovation-driven projects (Cooper, 1990; Eisenhardt and Tabrizi, 1995). As highlighted by Davies et al. (2018), managing projects that emphasize innovation requires a balance between structured governance frameworks and adaptive capabilities, a challenge that has led to the development of hybrid approaches such as Agile-Stage-Gate models (Cooper and Sommer, 2018). These shifts present the necessity of a scientometric review to map the evolving research landscape at the intersection of PM and IM, identifying key trends, collaborations, and emerging frontiers in this interdisciplinary field.

In practical settings, PM is widely utilized in various organizations, particularly where innovation is a priority (Filippov and Mooi, 2009). This adoption is driven by the necessity for organizations to identify and leverage the key factors contributing to project success (Honorato and De Melo, 2023). Facing intense industry competition and fluctuating consumer preferences, organizations are increasingly adopting innovative PM strategies to effectively navigate these challenges (Young et al., 2012). In today's dynamic and agile environment of product development, the integration of innovative practices PM is essential for maintaining market competitiveness. Given their complexity and risk, projects that emphasize innovation require careful and prudent management to avoid potentially significant adverse outcomes (Pinto et al., 2011).

In recent years, the fields of PM and IM have witnessed significant transformations driven by technological advancements, increasing complexity in organizational needs, and the emergence of agile and adaptive management frameworks (Highsmith, 2009). The growing emphasis on digital transformation and the adoption of artificial

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https://doi.org/10.1016/j.plas.2025.100181
Received 25 June 2024; Received in revised form 10 March 2025; Accepted 25 March 2025
Available online 28 March 2025

intelligence, agile methodologies, and data-driven decision-making highlight a shift toward more flexible and responsive management approaches within both disciplines (Kerzner, 2022). As organizations navigate high-VUCA (volatility, uncertainty, complexity, and ambiguity) environments, the need to integrate innovative solutions into structured PM processes has become paramount (Davies, 2014). Despite these advancements, existing literature has predominantly examined PM and IM as separate domains, with limited exploration of their theoretical and practical intersections.

In addition, the PM-IM intersection has traditionally been explored within the context of product development, recent advancements in both fields indicate a more extensive application across services and process innovation (Cantamessa and Montagna, 2016). The demand for agile, adaptable management approaches is equally pertinent in service-based sectors, where innovation often involves reimagining customer experiences, optimizing service delivery, and implementing digital solutions that enhance operational efficiency (Tomala and Senechal, 2004). Service innovation thus relies on PM frameworks to coordinate complex initiatives, manage stakeholder expectations, and deliver impactful outcomes (Randhawa and Scerri, 2015). Similarly, process innovation—the improvement of organizational workflows and methodologies—has increasingly come to the forefront in sectors such as manufacturing, healthcare, and logistics, where efficiency, speed, and quality are critical (Salerno et al., 2015). Here, the integration of PM and IM enables structured approaches to streamline processes, reduce waste, and drive continuous improvement (Bibarsov et al., 2017a,b).

This study addresses this gap by conducting a scientometric review, a methodology that leverages quantitative analysis and visual mapping to evaluate publication trends, collaborative networks, and thematic developments within a research field. A scientometric approach is particularly relevant now, as the convergence of PM and IM reflects the increasingly interdisciplinary nature of managing innovation-driven projects (Keegan and Turner, 2002). Through a comprehensive analysis of publications over the past two decades, this study aims to offer a structured analysis of the academic evolution within the PIM domain, highlighting research synergies, landmark contributions, and frontier fields, such as AI and agile PM. The findings will reveal the current landscape of interdisciplinary research in PM and IM and also identify critical areas where future research could contribute to the development of more integrated management practices.

The primary objective of this study is to elucidate the convergence within the PIM domain by examining (1) the 20-year evolution of publication statistics and disciplinary distribution, (2) collaborative networks among countries, institutions, and researchers, and (3) the evolution of research advancements, dominant themes, and frontier fields as identified through keyword analysis. By addressing these objectives, this study seeks to bridge the gap in current literature, offering a foundational understanding of how project and IM intersect to drive strategic and operational innovation.

2. Background

2.1. Project Management

The prominence of PM in both academic and organizational contexts is growing. In the current economically challenging environment, it is crucial for entities to define success criteria and devise competitive strategies (Oliveira Lucena et al., 2019). From a historical perspective, PM has evolved significantly in the mid-20th century, shifting from case-specific methodologies to standardized approaches applicable across various complex sectors such as defence, construction, and IT (Davies, 2014). The inception of modern management practices can be traced back to this era, marked by pivotal developments like the Programme Evolution and Review Technique (PERT) (DOD and NASA, 1962) and the Critical Path Method (CPM) by Kelley (1961) Kelley (1961).

Despite the availability of these techniques and a standard such as PMBOK (APM, 2019), studies indicate that many PM practices are suboptimal (Khalife et al., 2021). Factors contributing to inefficiency include complex project information leading to decision-making delays and project complexity resulting in ineffective outcomes, according to Sanders (2007) and Rivera and Kashiwagi (2016). Consequently, organizations are exploring innovative strategies to enhance project success (Doskočil, 2016).

With this respect, innovation gets increasingly vital in PM, particularly in a dynamic business environment (Randolph and Posner, 1988). Traditional PM, often based on predictable models, may struggle to adapt to changing economic and business needs (Morris, 2013). While conventional risk management strategies are suitable for predictable projects, they are less effective for innovative endeavours with unforeseen uncertainties (Sommer et al., 2009). Innovative projects necessitate flexible strategies that can adapt to unexpected challenges (Davies, 2014).

Given the uncertainties and complexities inherent in innovative environments, traditional PM approaches often fall short (O'Connor and Rice, 2013). This has led to the development of new theories and practices. The 'optimization school' (Lenfle and Soderlund, 2019), design thinking (Ben Mahmoud-Jouini et al., 2016), and agile PM methods (Young et al., 2012) are prominent examples of these new approaches, aimed at enhancing adaptability and responsiveness in PM.

2.2. Innovation management

Innovation, as defined in the third edition of the Oslo Manual (Gault, 2013), encompasses the introduction of novel or significantly improved products, processes, marketing strategies, and organizational methods in business practices, workplace structures, or external relations. This broad definition highlights that innovation extends beyond products to include various organizational processes. From a macro perspective, innovation is viewed as a transformative process where an advanced product or new process replaces its predecessor (Tidd, 2001). Realizing these innovations necessitates not only financial commitment but also the integration of knowledge (Guerra Betancourt et al., 2013). Thus, an innovation project is both a transformative journey and an innovative venture, potentially leading to significant outcomes and pioneering solutions (Salerno et al., 2015).

In academic discourse, IM covers diverse areas including technological innovation, process innovation, open innovation, and product development (Cooper, 1990; Shea, 2005; Bogers et al., 2018a,b; Tidd and Bessant, 2020). The study of innovation spans various academic fields, focusing on uncertainties in developing and commercializing new products, processes, or services (Dodgson and Gann, 2011). Innovation is crucial for businesses to thrive in ever-evolving technological and market environments (Goldhar, 1994). Therefore, research in this field often involves contingency theory and organizational design, exploring how organizations adapt to uncertainty, complexity, and change. Projects or matrix structures are seen as effective in overcoming these challenges (Mentzer, 1987). Moreover, organic organizational structures, known for their flexibility, are deemed conducive to innovation (Burns and Stalker, 1994).

In PM, innovation is often underrepresented in mainstream literature due to the differences between innovative and traditional projects (Tomala and Senechal, 2004). Innovation project approaches, which deal with uncertainties and complexities, contrast with traditional projects which are focused on implementing existing decisions (Russo et al., 2017). Innovation in projects can be categorized as incremental, radical, or intermediate, correlating with derivative, breakthrough, and platform projects (Wheelwright and Clark, 1992). Various management strategies have been proposed to handle these types of projects. Ansoff (2007) suggests managing proactive and reactive expectations in innovation projects, while Bibarsov et al. (2017) advocate combining long-term management tools with scientific principles such as selective management and goal orientation. Additionally, Shenhar and Dvir (2007) proposed an adaptive PM model to enhance innovation and manage VUCA challenges in a highly turbulent environment (Bennett and Lemoine, 2014).

2.3. Confluence of innovation and project management

The theoretical connections between PM and IM have been disclosed through an in-depth review and synthesis. Innovation and PM have historically followed their own distinct theoretical and practical trajectories, but in the twenty-first century, the exchange and convergence of ideas between the two disciplines have become more prominent (Kapsali, 2011a,b).

Silva and Gil (2013) argue that innovation and contemporary PM are intrinsically linked. To transition ideas into tangible products, one must amalgamate both market and technical insights, delineating them into comprehensive technical and economic specifications. Often, this transition is facilitated through adept PM. Davies (2014) emphasizes that there is a strong relationship between innovation and projects, with projects often viewed as the innovation engine for sustaining and growing an organization's existing activities. Therefore, organizations also use projects to develop new products, launch entrepreneurial ventures, and implement strategies (Keegan and Turner, 2002).

With this respect, PIM has evolved to address the growing need for flexibility, sustainability, and technological adaptation across industries (Ciric et al., 2018). One significant development is the widespread adoption of agile PM, a methodology initially developed for software development but now widely applied across various sectors, including manufacturing and services (Highsmith, 2009). Agile PM emphasizes iterative progress, rapid adaptation to changes, and close collaboration with stakeholders, making it particularly suitable for innovation projects characterized by uncertainty and fast-evolving requirements (Brandl et al., 2021). Research suggests that agile frameworks enhance innovation processes by allowing for real-time feedback and adaptive planning, thus aligning project outcomes more closely with organizational goals (Olszewski, 2023).

Sustainability has also emerged as a central theme within both PM and IM, particularly as organizations seek to reduce their environmental footprint and respond to stakeholder demands for sustainable practices (Szabó, 2016). Studies by Artto et al. (2021) and Wu and Chen (2021) have highlighted the integration of sustainability considerations into PM as essential for promoting responsible innovation. Sustainable PM encompasses practices such as lifecycle assessment, resource efficiency, and the adoption of circular economy principles, all of which align with the objectives of IM to create long-term, socially responsible value (Chawla et al., 2018).

Digital transformation represents another major trend reshaping PM and IM, particularly through the integration of technologies such as AI, machine learning, and digital twins (Gonçalves et al., 2023). These technologies enable project managers to leverage data-driven insights for predictive analytics, enhance decision-making processes, and optimize resource allocation (Allal-Cherif et al., 2021). For instance, Oliveira et al. (2023) demonstrated how AI-based PM systems can support complex innovation initiatives by enhancing risk management and facilitating interdisciplinary collaboration. Digital transformation not only enhances the operational efficiency of PM but also drives innovation by enabling new forms of service delivery and customer engagement (Barbosa and Saisse, 2019).

Recent literature also highlights the social and transformative dimensions of PM and IM, reflecting a growing awareness of the roles these disciplines play in addressing broader societal challenges and driving organizational change (Goggin et al., 2019). These dimensions emphasize not only the outcomes of projects but also their ethical, social, and community impacts, aligning with a more holistic view of project success beyond traditional metrics like cost, time, and scope (Young, 2015).

Socially-oriented PM has gained traction, especially in public sector and community-driven projects, where stakeholder engagement, inclusivity, and equitable outcomes are crucial (Young, 2015). Research by Brunet and Forgues (2019) underscores the importance of collective sensemaking and participatory decision-making in projects that have a significant impact on local communities, such as infrastructure, education, and healthcare projects. This trend reflects a shift toward recognizing the social license of projects, particularly those that intersect with environmental and community interests.

Transformative PM, which focuses on projects as mechanisms for change within organizations and society, is also receiving attention as organizations increasingly seek to address issues like sustainability, diversity, and digital inclusivity (Cha et al., 2018). Studies by Wu and Chen (2021) and Terrien et al. (2016) have illustrated how transformative PM approaches foster a culture of innovation and adaptability, empowering organizations to address systemic issues such as climate change and digital access. These projects often serve as pilot initiatives for broader organizational transformation, offering insights and frameworks that can be scaled across operations.

The convergence of PM and IM is most evident in contexts where projects are not merely operational but are essential vehicles for innovation and strategic growth (Geraldi et al., 2008). As PM practices evolve to accommodate innovation's unpredictable nature, there is a growing need for frameworks that integrate the control-oriented aspects of PM with the adaptive, iterative processes characteristic of innovation.

One key area of convergence is the role of agile PM, which brings together structured project controls and the flexibility required for innovation (Peege and Tshabalala, 2021). Agile methodologies emphasize iterative development, cross-functional collaboration, and customer feedback, all of which align with the goals of IM to rapidly adapt to changing market needs and technological advancements (Conforto et al., 2014). Studies suggest that agile PM fosters a dynamic environment conducive to experimentation and learning, critical components for innovation-driven projects (Olszewski, 2023).

Another significant overlap lies in risk and uncertainty management. Unlike traditional projects, innovation projects are marked by high levels of uncertainty, requiring project managers to adopt more adaptive approaches to risk (Bowers and Khorakian, 2014). Research by Sicotte and Bourgault (2008) and Kapsali (2011a,b) demonstrates that PM's structured risk assessment tools, when integrated with IM's adaptive strategies, can better address the multifaceted risks associated with innovation projects. This integration allows project teams to identify, mitigate, and respond to risks more effectively, aligning with IM's emphasis on resilience and flexibility in the face of uncertainty.

Dynamic capabilities also signify the convergence of PM and IM, as organizations increasingly focus on projects as a means to build competitive advantage (Patrício et al., 2021). Dynamic capability theory, rooted in IM, emphasizes the ability of organizations to adapt and respond to change—a principle that has begun to permeate PM through practices like continuous learning and adaptive planning (Gomes et al., 2021). The cross-pollination of dynamic capabilities from IM to PM highlights the strategic role that projects play in enabling organizations to innovate and maintain agility in volatile environments.

Existing research in the field of IM focuses on the innovation models in various industries. Examples include innovation projects in the manufacturing industry, open innovation in the pharmaceutical industry, and the IM model in the aerospace industry (Schuhmacher et al., 2013; Vrchota and Řehoř, 2019; Honorato and De Melo, 2023). There are also a number of bibliometric reviews of IM studies in the areas of evolution and models, techniques, and professionalisation (Hidalgo and Albors, 2008a,b; Lopes et al., 2016; Robbins and O'Connor, 2023a,b). To date, there has been no comprehensive literature review addressing the project-based context within IM, marking a notable gap in current research.

2.4. *Research gaps and objectives*

By conducting a thorough review of the existing literature, intriguing patterns in academic research and corresponding research gaps can be discerned. Firstly, with regards to the research focus, numerous studies have demonstrated that conventional PM approaches are frequently ill-suited for innovation contexts characterised by highlevels of VUCA (Fridgeirsson et al., 2021; Wang, 2022 #10)}. Although the significance of PM in the context of innovative product and technology development is acknowledged, scholarly research has predominantly concentrated on the creation of PM models rather than specifically addressing innovation projects and the management of innovation within projects.

Furthermore, with regards to the advancement of convergence within the research domain, the literature review reveals a notable shift. In contrast to previous eras, where the literature pertaining to project and IM largely progressed independently in terms of its theoretical and practical development, recent years have witnessed a significant convergence and intermingling of concepts between innovation and PM (Filippov and Mooi, 2009). A research gap exists within the emerging field of convergence, as no comprehensive review has been conducted to compile and analyse the published literature.

Project-based innovation is inherently dynamic and requires the ability to adapt to changing market and technological conditions (Eisenhardt and Martin, 2000). The dynamic capabilities framework provides a theoretical lens to understand how organizations leverage PM structures to drive innovation while remaining flexible. Similarly, the Stage-Gate model (Cooper, 1990) has been widely applied in product development projects, yet its adaptation in PM-IM research remains underexplored. Given the increasing complexity of innovation-driven projects, the need for VUCA-oriented PM strategies (Bennett and

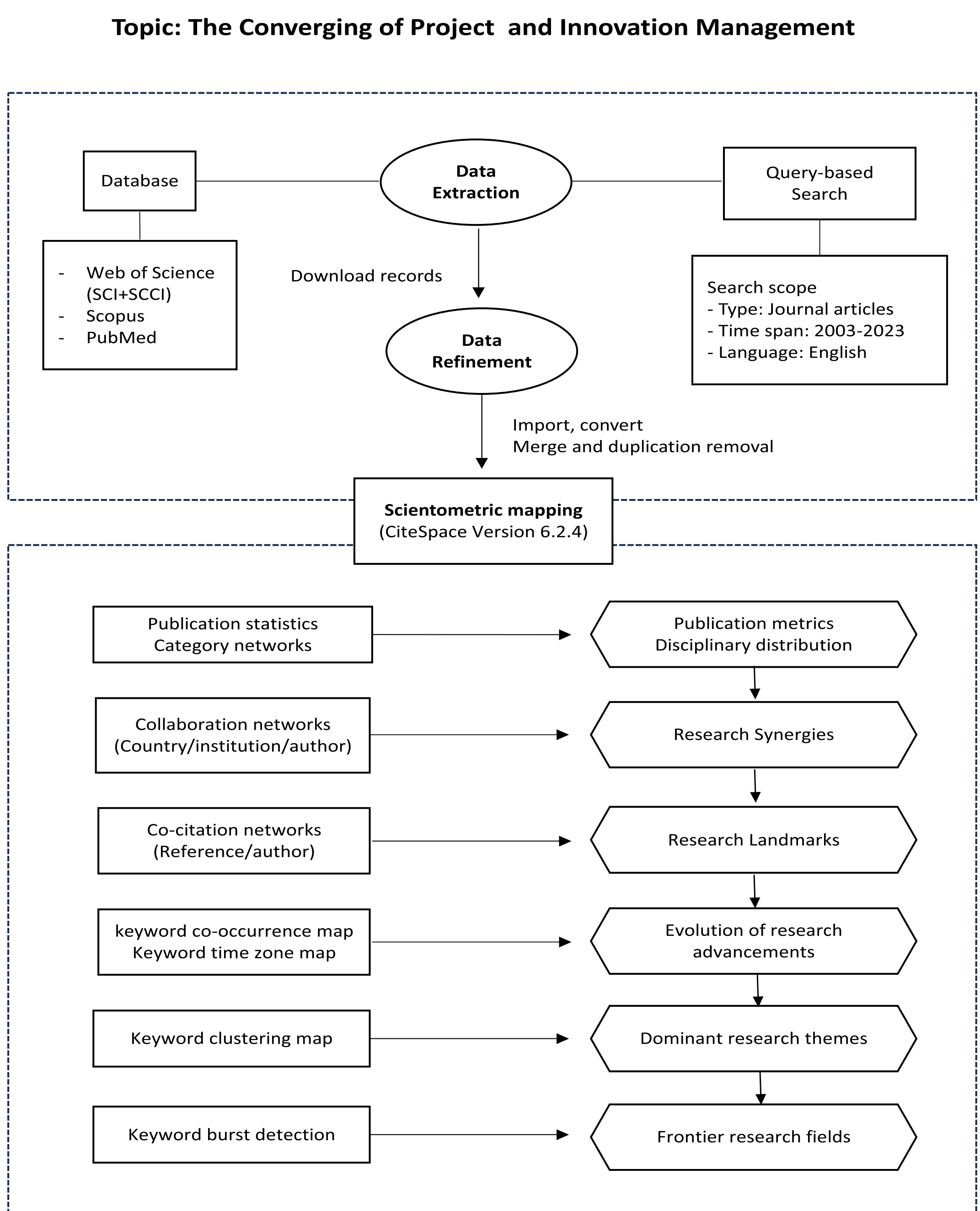


Fig. 1. Review methodology.

Lemoine, 2014) has emerged as a critical area of study. Despite the relevance of these theoretical frameworks, existing bibliometric reviews have not examined their influence in shaping PM-IM research trajectories (Hidalgo and Albors, 2008; Lopes et al., 2016).

Furthermore, existing literature reviews have largely examined these domains in isolation, without addressing their confluence in a structured manner. Several bibliometric studies have explored PM and IM independently (Hidalgo and Albors, 2008{Lopes et al., 2016 #41; Robbins and O'Connor, 2023a,b), yet they fail to investigate how these fields interact, evolve together, and influence interdisciplinary research directions. Furthermore, past reviews have focused primarily on PM methodologies (Turner, 2016) or innovation ecosystems (Bogers et al., 2018a,b), overlooking how project-based innovation is managed across industries. To date, no comprehensive review has mapped the scientometric *evolution* of the PM-IM intersection, analyzed collaboration networks, or identified emerging research frontiers.

To address the identified research gaps, this study aims to elucidate the convergence within the project and innovation management (PIM) domain by examining publications from the past two decades. Specifically, the study sets out to accomplish the following objectives.

(1) Provide an overview of the 20-year evolution of the PIM domain, emphasizing publication statistics and disciplinary distribution.
(2) Undertake a network analysis to uncover collaborative patterns across various countries, institutions, and individual researchers.
(3) Recognize research landmarks with highly-cited references and authors.
(4) Discover the evolution of research advancements, the dominant research themes, and the frontier research fields by a series of keywords analysis.

3. Review methodology

The data extraction and refinement process, as illustrated in Fig. 1, follows a multi-step approach to ensure the accuracy, reliability, and relevance of the dataset for analyzing the PM-IM intersection. The bibliometric analysis was used as a quantitative research method to review the published literature in a particular Knowledge domain, while scientometric mapping was applied to visualise the findings. Bibliometric analysis serves as a prevalent method for quantitatively assessing the current landscape and identifying gaps within a specific field. It leverages attributes from publications—such as titles, keywords, citations, and other metadata—to evaluate the impact, productivity, and collaboration of scholars, institutions, and countries (Abbasi et al., 2011). Scientometric analysis, complemented by visual mapping, offers a robust, replicable, and adaptable technique for tracing emerging trends and pinpointing pivotal contributions in a field (Chen et al., 2012).

Fig. 1graphically presents the core methodologies employed in this research.

The adoption of the aforementioned methodology in this study offers several key advantages. Firstly, bibliometric analysis serves as a quantitative tool to trace the developmental trajectory of a discipline. It helps elucidate the present developmental status, evolving trends in the PIM field, and exposes the logical associations and inherent links within the existing literature (Jin et al., 2019). Second, through Scientometric analysis, the internal structure of the PIM field can be revealed through text mining, whereas the influence and contribution of publications can be examined through citation analysis (Bornmann and Leydesdorff, 2014). Thirdly, by analysing scientometric maps, the intrinsic connections between various disciplinary boundaries can be clarified and the gaps in interdisciplinary research can be mined, thereby informing the research directions of future scholars in the field of PIM (Hu and Zhang, 2017).

In view of the deep mining and data compatibility processing capabilities, CiteSpace was chosen as the data analysis software for this review. CiteSpace has a distinct advantage in deep mining due to its unique time slicing capability. By performing spatial and temporal analyses, the knowledge evolution process, historical span range, and development trend of the research field can be displayed in the time dimension, enabling researchers to track the hotspots of disciplinary research and to trace the lineage of the discipline's development. CiteSpace can also identify important papers in the field of PIM by displaying the timeline of reference co-occurrence and analysing the literature co-citation (Zhang et al., 2023). In addition, by locating burst words, grouping diverse analysis nodes by category, and labelling Burst keyword groupings, CiteSpace identifies scholars and organizations collaborating to locate rapidly expanding research topics (Galante et al., 2014).

To ensure comprehensive coverage of research in PIM, this study selected Web of Science (WOS), Scopus, and PubMed, three widely used bibliographic databases known for their interdisciplinary scope. WOS and Scopus are frequently used in scientometric studies on management and innovation due to their extensive indexing of high-impact journals in business, engineering, and social sciences (Donthu, 2021; Merigó and José, 2019). PubMed, although primarily a biomedical database, was included to capture research on project-based innovation in healthcare and life sciences, reflecting the increasing cross-disciplinary relevance of PM-IM methodologies (Montoya-Torres et al., 2023). This approach aligns with previous bibliometric studies that leverage multiple databases to ensure robust and representative research coverage (Zupic and Čater, 2015). Together, WoS, Scopus, and PubMed provide a comprehensive and diverse dataset, capturing both foundational and emerging research across disciplines that intersect with PIM. This selection is aligned with the study's objective to map interdisciplinary research trends and identify research synergies that are representative of the field.

The dataset was refined based on specific inclusion and exclusion criteria to ensure relevance and quality.

- Inclusion Criteria: Only peer-reviewed journal articles published in English between 2003 and 2023 were included, as journal articles undergo rigorous peer review and are generally of higher quality and academic impact. The time frame aligns with the study's focus on the evolution of PM and IM over the past two decades.
- Exclusion Criteria: Book reviews, editorials, conference proceedings, and non-peer-reviewed publications were excluded to maintain data consistency and reliability. Articles not directly addressing PM, IM, or their intersections, as indicated by keywords and abstracts, were also excluded to ensure the dataset remained focused on the study's objectives.
- Validation of Dataset: To verify the final dataset's quality, a random sampling of articles was manually checked to confirm relevance and thematic alignment with PIM. Additionally, a comparison of citation patterns between included and excluded articles helped ensure that excluded data points did not introduce significant bias.

To assure the accuracy of the literature scope, this study used a query-based search method to conduct a preliminary scoping search in the database. The next step, following the selection of a suitable combination of target databases, is the dataset acquisition. This phase was divided into two major segments. The first is to conduct a preliminary search on the relevant literature in the field of PIM using the database's search engine, and the second is to perform advanced data extraction on the results of the preliminary search by adjusting the data cleaning function of the search engine filters and CiteSpace. Fig. 2 depicts the dataset's generation process and outcomes.

The selection and combination of keywords were carefully considered to capture the interdisciplinary scope of PM and IM research while ensuring precision in the search query. The keywords and their combinations were designed to balance inclusivity with specificity, recognizing the nuances between terms like 'project management' and 'project governance.'

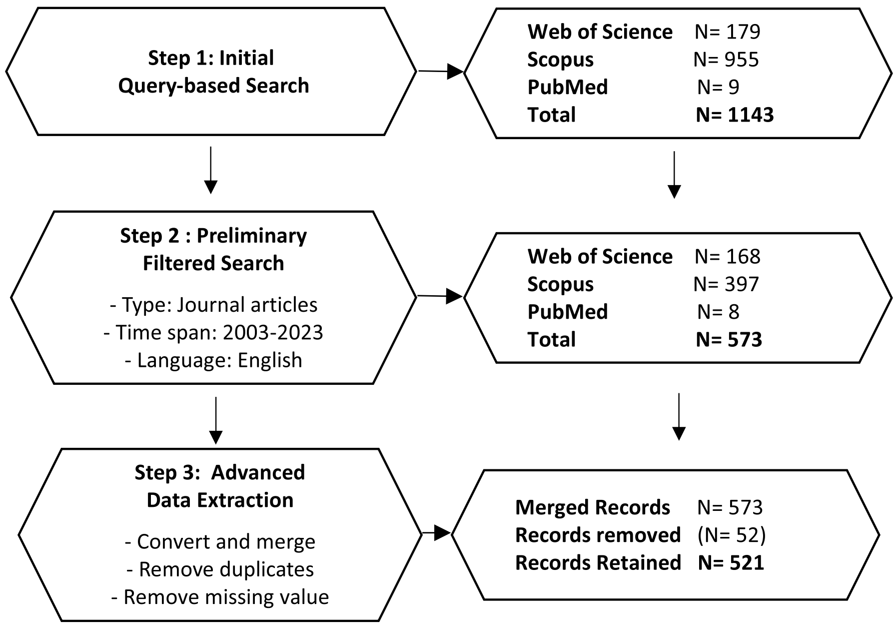


Fig. 2. Process of data extraction.

1. Keyword Selection Strategy:

The core terms 'project management' and 'innovation management' were selected as they represent the primary domains under investigation. However, to capture the diverse terminologies used within these fields, relevant synonyms and related terms were included. 'Project governance' was included as it represents an important subset of PM, specifically focusing on oversight and decision-making frameworks, which are often central to managing complex and innovation-driven projects (Muller, 2017). While 'project governance' is distinct from 'project management,' it is inherently linked to PM processes, especially in high-stakes and innovation-oriented contexts where governance structures influence project outcomes. Similarly, the terms 'innovation project' and 'innovation project management' were used to encompass various perspectives on managing innovation within projects, ensuring that articles on innovation initiatives within project settings were captured.

2. Keyword Combination Design:

Boolean operators were applied to create combinations that reflect the intersections of PM and IM. For example, ('project management' OR 'project governance') AND ('innovation management' OR 'innovation project') allowed us to identify studies that explore governance issues within innovation projects as well as those that focus on broader PM practices in innovation contexts. Recognizing the complexity and distinct nuances of each term, multiple iterations of query design and testing were conducted to ensure that the search captured a comprehensive yet relevant dataset. Each combination was tested in the databases, and adjustments were made to refine the focus and avoid oversimplifying or conflating distinct concepts.

3. Refinement of Search Scope:

After initial queries were performed, results were reviewed to assess relevance. Articles that were not focused on PM or IM but appeared due to overlapping terms (e.g., governance in unrelated fields) were excluded during data cleaning. This iterative refinement helped ensure the keyword combinations were sufficiently broad to capture interdisciplinary research but precise enough to avoid irrelevant results.

The primary preliminary data search procedure was applied (1) by analysing and summarising the most cited research papers on PIM in the literature review. "Project management" and "Innovation management" were determined to be the two most significant topics in PIM. (2) To assure accuracy, the search query used the Boolean operators "AND", "OR", and "NOT" to connect the logical relationships between terms. Boolean operators "AND" "OR" "NOT" connect the logical relationship between terms in the Search query, and the search scope for literature information is set to the topic, keywords, and abstract. (3) The search terms "Project management" and "Innovation management" were used, and fewer than 100 documents were returned. There were fewer than 100 documents retrieved. Hence, to expand the term's scope, the synonyms of "Project management" and "Innovation management" were adopted to expand the search query, resulting in the subsequent query. Incorporating synonyms of "project management" and "innovation management" into the search query yielded the following result: ("project management" OR "project governance") AND ("innovation management" OR "innovation project" OR "innovation project" OR "project innovation") AND ("innovation management" OR "innovation project" OR "innovation project" OR "project innovation") AND ("innovation management" OR "innovation project" OR "innovation project" OR "innovation project"). ("project innovation")). The final Search query used across the three databases is integrated in Table 1. The accumulation of data occurred on August 31, 2023, as the time point. After combining the search results from the three databases, the preliminary data search yielded 1143 valid literature information sets.

Table 1
Search queries.

Database	Search Query
WOS	TS = (("project management" OR "project governance") AND ("innovation management" OR "innovation project" OR "innovative project" OR "project innovation"))
Scopus	(TITLE-ABS-KEY ("innovation management" OR "innovation* project" OR "project innovation") AND TITLE-ABS-KEY ("project management" OR "project governance")) AND (LIMIT-TO (DOCTYPE, "ar")) AND (LIMIT-TO (LANGUAGE, "English"))
Pubmed	("project management"[Title/Abstract] OR "project governance" [Title/Abstract]) AND ("innovation management"[Title/Abstract] OR" project innovation"[Title/Abstract] OR "innovation project" [Title/Abstract] OR "innovative project"[Title/Abstract])

Table 2
The top 10 list of Subjects of most frequently occurring categories.

Rank	Category	Year	Count	Centrality
1	MANAGEMENT	2003	103	0.41
2	ENGINEERING	2003	48	0.48
3	BUSINESS	2006	47	0.22
4	GREEN & SUSTAINABLE SCIENCE & TECHNOLOGY	2015	10	0
5	EDUCATION	2012	8	0.08
6	SOCIAL SCIENCES	2011	6	0.08
7	INFORMATION SCIENCE & LIBRARY SCIENCE	2010	4	0
8	COMPUTER SCIENCE	2005	4	0
9	TRANSPORTATION	2015	3	0
10	HISTORY	2011	2	0.13

Based on the results of the preliminary data search, the researcher screened, excluded, and extracted the dataset of relevant PIM literature. In this investigation, the primary procedure for advanced data extraction was as follows. This investigation was limited to journal articles and excluded book reviews, editorials, and conference papers. This is due to the fact that journal articles are typically regarded as being of higher quality and significance than other categories of publications (Zheng et al., 2016). This study analyzes PM-IM research over a 20-year period (2003–2023), aligning with established bibliometric review practices that track long-term scholarly trends (Cobo and Manuel, 2011; Donthu, 2021). The selection of this timeframe is theoretically justified based on two key considerations. The early 2000s marked the formalization of agile methodologies (Beck et al., 2001) and the growing recognition of innovation as a project-based process (Davies et al., 2018). Over the past two decades, rapid advancements in digital transformation, AI-driven PM, and sustainability-oriented innovation have significantly influenced PM-IM convergence (Geraldi and Söderlund, 2018). A 20-year window enables a structured analysis of these transformative developments.

Moreover, previous bibliometric reviews in PM and innovation (Merigó and José, 2019; Zupic and Čater, 2015) have used similar or longer timeframes (15–25 years) to capture research evolution comprehensively. This timeframe ensures that early foundational research, as well as recent emerging trends, are both adequately analyzed. Thus, a 20-year period provides a balanced perspective on the longitudinal evolution of PM-IM research, allowing for the identification of historical milestones, current trends, and future research frontiers. Ultimately, only journal articles published in English were incorporated. By applying the above three screening criteria, a total of 573 items of literature were ultimately retained.

3.1. Procedure in CiteSpace

A total of 573 bibliographic records retrieved from the database search were acquired and subsequently imported into CiteSpace for the purpose of file format conversion, data merging, elimination of duplicate records, and removal of records with missing values. Following a subsequent iteration of data cleansing, a total of 521 bibliographic records were acquired for the purpose of conducting scientometric analysis. This study utilized four primary types of Bibliometric analysis approaches offered by CiteSpace.

1) Collaborative network analysis, encompassing author collaboration, country collaboration, and research institution collaboration,
2) Co-occurrence network analysis, including keyword co-occurrence, subject term co-occurrence, and subject category co-occurrence,
3) Co-citation network analysis, involving literature co-occurrence, author co-occurrence, and journal co-occurrence; and
4) Co-reference network analysis, encompassing literature co-occurrence, author co-occurrence, and journal co-occurrence.

This study also acquired three visualization views, namely Cluster View, Time-Line View, and Time-Zone View, by the aforementioned bibliometric analysis. One of the visualization techniques, known as Cluster View, provides a comprehensive representation of the distribution of research fields from diverse viewpoints. In contrast, the Time-Line View and Time-Zone View concentrate on illustrating the temporal evolution and interrelationships of research areas (Chen et al., 2012). Considering the adopted methodology, the validity of the applied measurements and the reliability as to the consistency of the measurements upon repetition (Chen and Manley, 2014) were achieved.

4. Results and findings

Initiated by the analysis of publication statistics, this section delves into the scientometric outcomes. These encompass co-occurrence Networks within the research categories, collaboration networks among researchers, co-cited networks, and keyword-related networks.

4.1. Time series segments of publication statistics

The volume of publications serves as a pivotal benchmark for discerning a field's developmental trajectory and prognosticating future directions. As illustrated in Fig. 3, the orange line chart represents the annual incremental volume, while the blue bar chart denotes the cumulative amount. The blue exponential curve illustrates the trendline fitted through regression analysis.

Undeniably, the PIM field has experienced growth, as the ascending trend in cumulative publications testifies. The growth trend aligns with the escalating interest from scholars in both interdisciplinary and cross-disciplinary studies. Between 2003 and 2023, the PIM field has witnessed the release of an estimated 551 articles, reviews, and conference proceedings. Despite this study only encompassing data from the initial seven months in 2023, a projection using linear regression estimates the total at 46 publications.

A polynomial regression model was applied to this cumulative data, producing a second-order polynomial, also visualized in Fig. 3. The coefficient of determination, R-squared, quantifies the goodness-of-fit for the regression model. Values nearing 1 signify high model accuracy. With an R-squared of 0.9962, our model robustly captures the year-on-year escalation in PIM publications.

As delineated, an annual account of publications, the cumulative count, and a trendline curve provide an overarching view of the literature landscape. Overall, the trajectory of publications within the PIM domain follows an upward trend. Delving deeper, this evolutionary trend can be demarcated into three discernible phases including emerging phase, developing phase, and exploring phase.

First, from 2003 to 2012, deemed as the 'Emerging Phase,' the annual publication frequency exhibited variability. A modest average of 16 publications annually during this decade suggests that PIM, still nascent in its nature, had yet to pique substantial scholarly interest. Subsequently, the period from 2013 to 2018, labelled the 'Developing Phase,' experienced a more robust publication. Here, annual publications consistently exceeded 20, culminating in a notable spike of 37 articles in 2014. The upward trend correlates with findings from the literature review, indicating a growing scholarly interest in cross-disciplinary research. Lastly, the 'Exploration Phase' spans from 2019 to 2023. During this time, the surge in publication was pronounced, averaging 49 articles annually. This surge highlights the growing significance of PIM research, emphasizing its evolution as a central area of academic inquiry and suggesting its potential future trajectory.

4.2. Co-occurrence networks in research categories

In scientometric analysis, "category co-occurrence" typically refers to the simultaneous appearance or co-presence of two or more categories within a particular article (Lee and Su, 2010). The analysis of

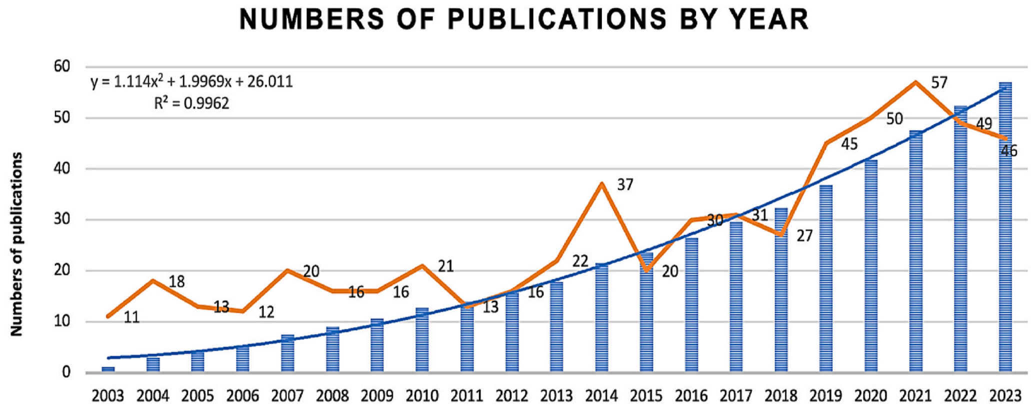


Fig. 3. Publication statistics in time series segments.

co-occurrence in research categories benefits in identifying both cross-disciplinary and inter-disciplinary subjects within the PIM field. Furthermore, observing the dynamic progression of these disciplines can provide future researchers with explorative direction.

The “count” in Table 2 refers to the frequency of a subject co-occurred with others. The “centrality” refers to “Betweenness centrality” which measures the number of times a subject act as a bridge along the shortest path between two other subjects. In the context of category co-occurrence, it indicates the interconnectivity of a subject as intermediation. Hence, a node’s centrality highlights its significance and influence within the network (Abbasi et al., 2011).

In Fig. 4, each node signifies a category within the PIM domain. Larger nodes denote more frequent occurrence of that subject, whereas the lines connecting nodes represent interdisciplinary studies. Surprisingly, the visualization indicates the Health Care as an island of the subject, isolated from the network of the other research categories. This is identified as the area of no intersection with the subject network. A thicker line suggests higher frequency of interdisciplinary research. Annotations in the upper left of the figure, specifically “N = 33, E = 47″, reveal that there are 33 nodes and 47 links. This implies a limited variety of disciplines within the field and infrequent disciplinary crossovers.

Disciplinary analysis provides invaluable insights into core and intersecting disciplines within the PIM domain. Tracking the evolution of these disciplines guides the delineation of prospective research trajectories. Figure 4. presents co-occurrence networks for subject categories, where Table 2 catalogues the prominent indicators for the ten most dominant subjects in PIM publications.

Fig. 4and Table 2 illustrate the predominant subject areas within PIM field, highlighting the disciplinary intersections that support this confluence. The subjects Management, Engineering, and Business emerge as central pillars, reflecting their foundational role in both PM and IM. Management provides theoretical and methodological frameworks vital to the organization and execution of projects, while Engineering contributes technological methodologies essential for advancing innovation. Business, in turn, offers financial and market insights crucial to transforming innovation into competitive advantage. Together, these statistics contextualize how PM and IM draw upon interdisciplinary knowledge to address complex organizational and technological challenges, underscoring the broad disciplinary basis of the PM-IM confluence. By identifying both central and peripheral disciplines within PIM, Fig. 4 and Table 2 also point to potential research gaps, suggesting opportunities for future interdisciplinary studies that could enrich the convergence of PM and IM.

The nodes accentuated by a purple spotlight indicating high centrality detected in recent years, meanwhile suggesting sustained future research potential. Unexpectedly, a purple spotlight and robust centrality are observed on the “History” node. This is largely attributed to studies that have investigated innovation initiatives through cultural and historical lenses. Responsible innovation necessitates that innovators consider the wider socio-ethical and socio-economic

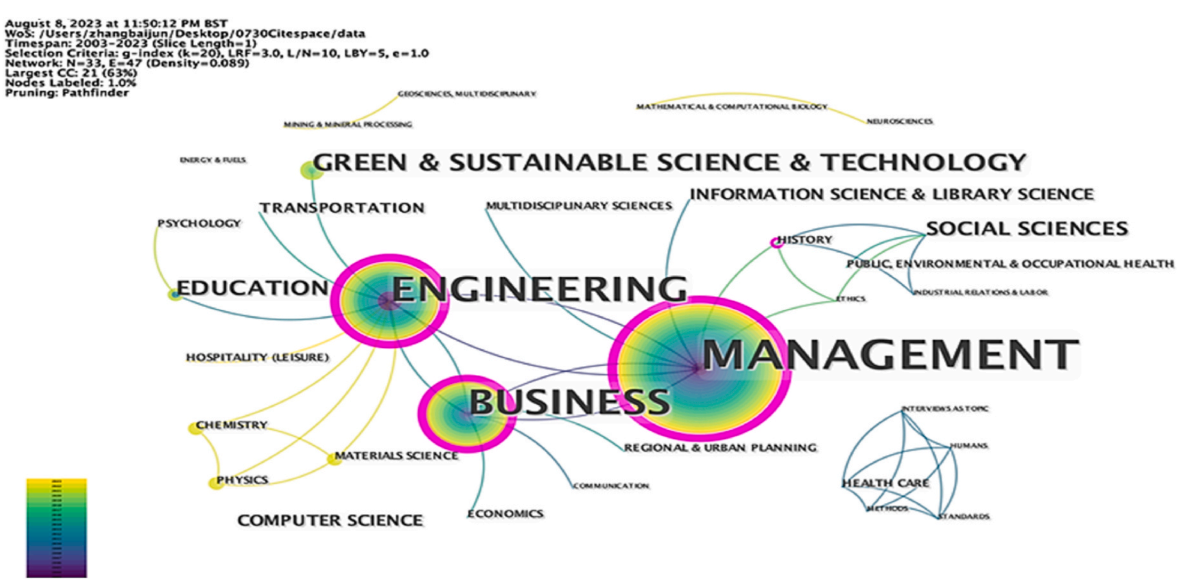


Figure 4. Co-occurrence networks in research categories.

implications (Flipse and van de Loo, 2018). Therefore, the prospective research endeavours may continue converging at the intersections of history within PIM field.

4.3. Collaboration networks of research

Collaboration networks of research reveal the interconnections and centrality of research in terms of countries, authors and institutions.

4.4. Co-operation networks for countries

Fig. 5. Co-operation networks for countries in which the nodes denote countries or regions, with their sizes reflecting the volume of published articles. Lines connecting nodes represent mutual cooperation: the thicker the line, the stronger the collaborative ties. Line colours shift from blue to yellow, symbolizing the time span from 2003 to 2023. Specific parameters and other relevant details are provided in the text notes situated in the upper left corner of Fig. 5.

Table 3 details the ten countries or regions producing the most publications. The "count" refers to the frequency of a country co-operated with others the while the "centrality" measures the level of direct collaborations a country has. most countries in the top ten are developed countries, while Brazil and China, positioned sixth and ninth, are developing nations.

4.5. Co-operation networks for institutions

The institutional co-operation network was visualized as Fig. 6. Table 4 enumerates the top five most prolific institutions. The "count" refers to the number of times an institution collaborated with other while the "Centrality" measures the level of intermediation an institution has on the transfer of information or collaboration between other institutions.

In Fig. 6, the most collaboration-centered institutions could be identified based on the relative size of nodes. The inter-institutional collaboration strength is also depicted, where multiple links between institutions signal more robust partnerships.

Notably, the leading five institutions, in terms of publication count, are academic entities (Table 4). The University of São Paulo, Ecole

Table 3
The top 10 list of countries with the most publications.

Rank	Country	Start Year	Count	Centrality
1	UNITED STATES	2003	68	0.36
2	GERMANY	2003	56	0.24
3	UNITED KINGDOM	2003	55	0.48
4	SPAIN	2004	54	0.23
5	FRANCE	2004	44	0.14
6	BRAZIL	2007	39	0
7	NETHERLANDS	2005	33	0.1
8	RUSSIA	2014	28	0
9	CHINA	2005	27	0.07
10	AUSTRALIA	2003	25	0.13
10	CANADA	2006	25	0.01

Polytech, and Delft University of Technology take the top three positions with 16, 12, and 11 publications, respectively. Node colours elucidate the consistent activity levels of institutions in the PIM field, providing insights into their publication timelines. For instance, while Delft University of Technology pioneered research in PIM, its momentum seems to have slowed recently. In contrast, the University of São Paulo, despite its late entry into the research arena in 2010, has showcased a continuous stream of contributions. Furthermore, the zero centrality indicates the zero level of intermediation of the identified institutions on the transfer of information or collaboration with other institutions.

The collaboration between researchers is a hallmark of academic endeavors, often bolstering academic productivity (Hosseini et al., 2018). In CiteSpace, the visualization of author collaboration networks can be achieved by selecting "author" as the node type, as depicted in Fig. 7.

Within this framework, each node signifies a distinct author, with the node size expanding in proportion to the number of articles authored. The connections between nodes reveal collaborations between authors. For example, there is a green triangle on the left segment, which represents a collaborative research effort among three authors: Dhondt, Orij, and Gaspersz, culminating in a joint publication. Furthermore, an author's prominence within the network can be discerned from the font size of their name.

Table 5 enumerates the top three researchers based on the count of

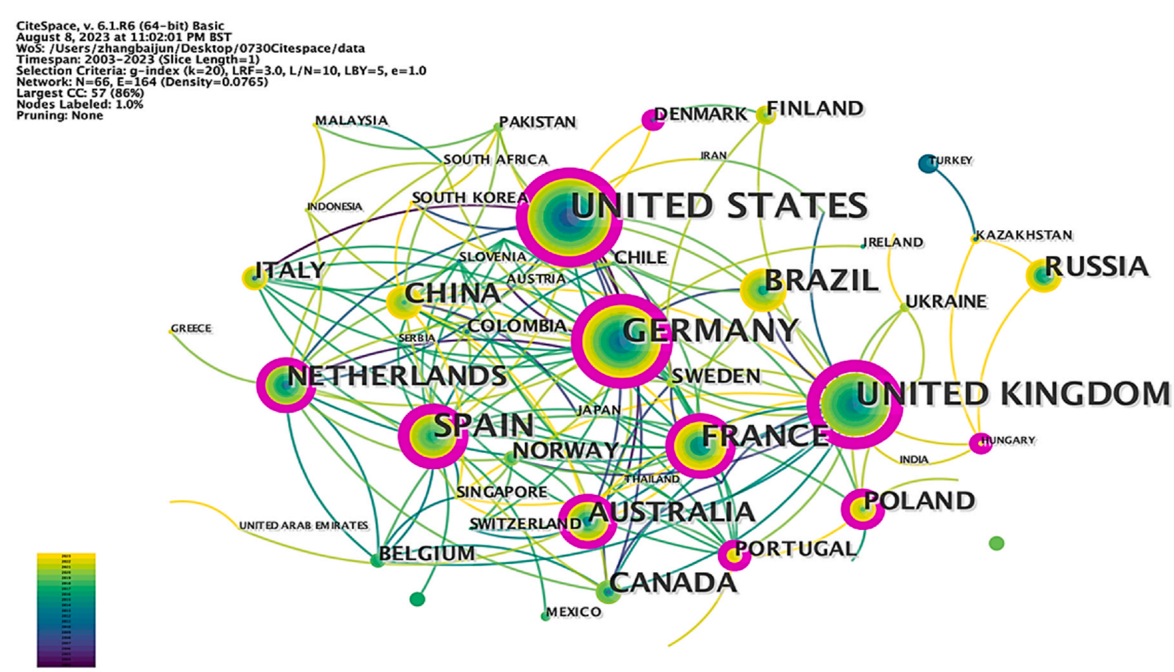


Fig. 5. Co-operation networks for countries.

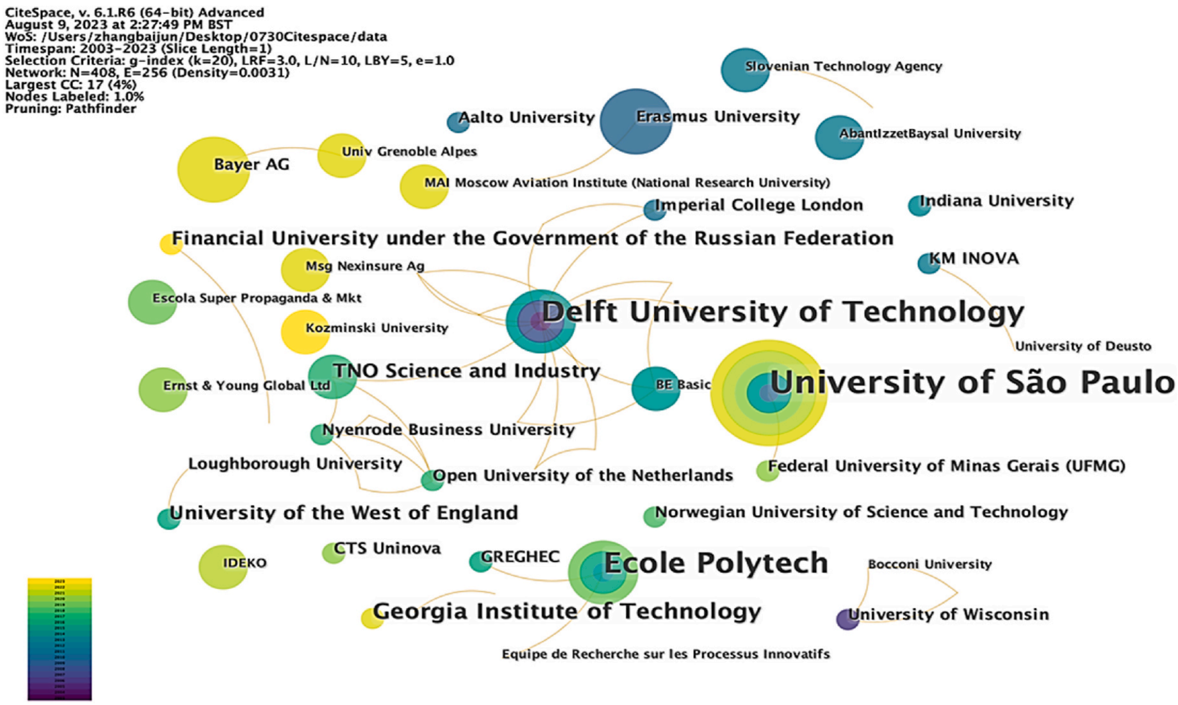


Fig. 6. Co-operation networks for institutions.

Table 4
The top 5 list of the most productive institutions.

Rank	Institution	Year	Count	Centrality
1	University of São Paulo	2010	16	0
2	Ecole Polytech	2008	12	0
3	Delft University of Technology	2005	11	0
4	Georgia Institute of Technology	2013	6	0
5	TNO Science and Industry	2008	4	0
5	Financial University under the Government of the Russian Federation	2017	4	0
5	University of the West of England	2005	4	0
5	Centre de Recherche en Gestion	2009	4	0

collaborated publications. A closer look divulges that among all the contributors, Hoegl, M. took the initiative to publish earliest and currently leads with a total of six publications — the zenith in this cohort. Yet, the distribution of publications among researchers seems to be relatively uniform, with most of them authoring fewer than five articles.

In overall, research synergies of PIM is analyzed through a series analysis of collaboration networks based on multiple countries (Fig. 5), various institutions (Fig. 6) and distinct authors (Fig. 7). Landmark nodes with large size and groups of interlinked hub nodes are identified in each type of networks to discover the dynamic collaborations in the domain of PIM.

From a national standpoint, Fig. 5 highlights that the USA, Germany, and the UK possess the most nodes linked to other countries, along with the highest centrality. These statistics suggest that these nations are pivotal hubs in this research domain, with significant emphasis on PIM. While countries like Brazil and Russia boast a notable number of publications, their limited interconnections with other active countries suggest a dearth of international collaboration.

Regarding the institutions, Fig. 6 reveals the patterns of collaboration between publishing institutions. The prevalence of interlinkages signifies the degree of cooperation. Notably, Delft University of Technology emerges as a central figure, evident from the myriads of connections originating from its node. Contrarily, the University of São Paulo, despite being a prolific publisher over the past two decades, demonstrates a conspicuous absence of collaborations. Alarmingly, the centrality for all top ten institutions falls below 0.01, indicating their restricted influence within this research sphere. This underscores a compelling need to bolster inter-institutional collaborations.

In relation to authors, a discernible trend in PIM research is the tenuous collaboration among authors. Fig. 7, with its 426 nodes and 288 links, manifests a strikingly low density, underscored by a value of 0.0032. The zero centrality across all nodes further accentuates this sparse connectivity. Nonetheless, a closer examination of the author partnership networks reveals pockets of collaborations. While the overarching network might seem fragmented, localized clusters of authors exhibit robust collaborative dynamics. Notable groupings include an early collective comprising six authors, inclusive of Burger, B; a quartet with Slama, A; and a more contemporary trio featuring Dhondt, S. These localized collaboration clusters, despite the broader fragmentation, point to the existence of vibrant research teams within the PIM domain.

4.6. Co-cited networks

4.6.1. Reference co-citation analysis

References serve as a window into the knowledge sources and knowledge domain of a publication. Within bibliometrics, analysing references stands as a prevalent practice as a greater number of citations typically suggests that the literature occupies a pivotal position in its area of study (Culnan et al., 1990). In the context of scientometric, the concept of citation extended to co-citation. Co-citation occurs when two articles are both cited by a third one. The frequency of such co-citations often suggests the depth of the relationship between the two articles (Chen, 2004).

In CiteSpace, selecting "Cited Reference" as the node type, the Networks of co-cited references was yielded as in Fig. 8. This mapping reveals 163 nodes and 223 links, with a network density of 0.0176. Notably, Fig. 8 lacks discernible Landmark and Hub nodes, hinting at a relatively weak interrelation among the literature. To delve deeper into pinpointing seminal literature and tracing knowledge sources, the

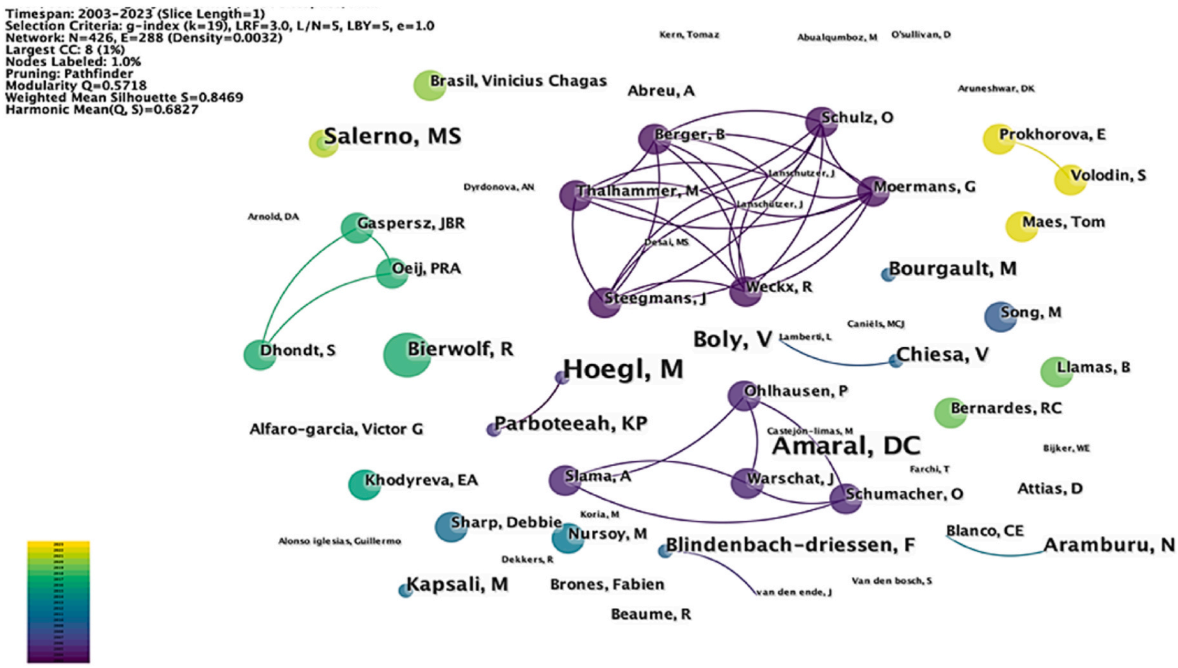


Fig. 7. Author partnership networks.

Table 5
The top 3 list of the most productive researchers.

Rank	Author	Year	Count	Centrality
1	Hoegl, M	2003	6	0
2	Amaral, DC	2010	5	0
3	Salerno, MS	2020	4	0
3	Boly, V	2009	4	0

ensuing section generates and analyzes co-cited author mapping.

4.7. Co-cited author mapping

This section delves into a co-cited author analysis, which augments the co-cited reference study from the prior section. Both approaches aim to pinpoint the seminal literature in the field. When two authors are jointly cited within a single publication, an author co-citation relationship is established (Chen et al., 2010). This network seeks to highlight scholars who are frequently cited, recognizing their wide

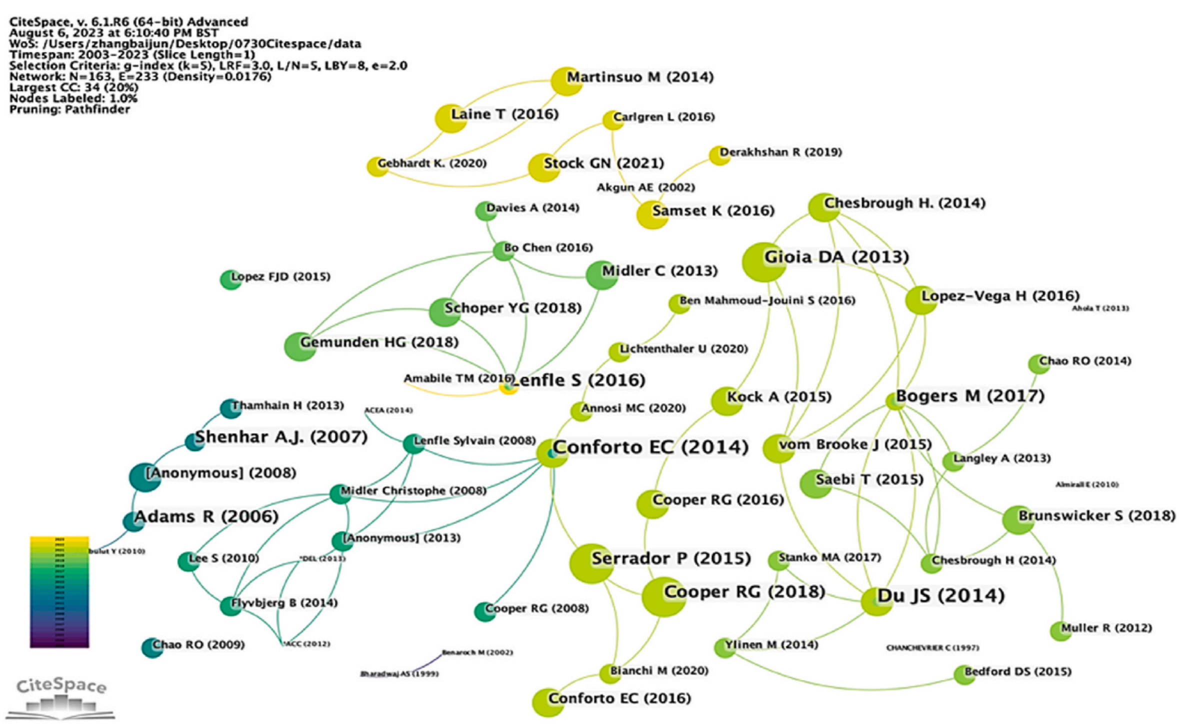


Fig. 8. Networks of co-citated reference.

acknowledgment within the research domain. Hence, a co-cited author map was generated by choosing "Cited author" as the node type, as depicted in Figure. Here, larger nodes signify authors whose works have garnered numerous citations. The node colour aligns with the year the author released the respective literature. Importantly, a thick purple periphery on nodes indicates a strong centrality, suggesting the author wields a potent influence.

From Fig. 9, COOPER RG, EISENHARDT KM, and SHENHAR AJ emerge as the trio with the most citations in the PIM realm. Table 6 delineates the citation counts and centrality metrics associated with the top 3 most influential researchers. Notably, COOPER RG and EISENHARDT KM's nodes flaunt the most pronounced fuchsia outline, underscoring their significant influence in the field.

Table 6
The top 3 list of most influential researchers.

Rank	Cited Author	Year	Count	Centrality
1	COOPER RG	2008	36	0.87
2	EISENHARDT KM	2011	21	0.34
3	SHENHAR AJ	2008	15	0.28

4.8. Keyword co-occurrence networks

Keywords illuminate the central themes of scholarly articles, and through analyzing their co-occurrence and clustering, the research hotspots can be uncovered (Lee and Su, 2010). In the context of PIM, mapping keyword frequencies alongside their chronological occurrences provides insights into the field's evolving trends. This study used keyword clustering to pinpoint core research areas and evaluated "burst" keywords to identify emerging research frontiers.

4.9. Keyword co-occurrence analysis

The Keyword co-occurrence network visualization can be seen in Fig. 10. With "N = 150, E = 219″ of indication in its notes, the network comprises 150 keywords and 219 links, suggesting robust keyword interactions. Table 7 presents a curated list of significant keywords based on the frequency after combining relevance and synonymous terms.

Analysis of the keyword's frequency and centrality from Fig. 10 and Table 7 reveals that terms such as project management, innovation management, and innovation project are prevalent. Apart from these, significant nodes include new product development, project performance, knowledge management, and open innovation, pinpointing them as PIM research focal points. Hub nodes like best practice, conceptual framework, and dynamic capability serve as crucial connectors between various research areas. Notably, terms with a pink outer ring, such as conceptual framework and incremental innovation, suggest that future trends may lean towards framework establishment, improved management, and incremental innovation.

In CiteSpace, the Keyword co-occurrence network aids in creating a keyword time-zone map. Here, keywords were plotted across time segments, with each time slice set to 1 year (Fig. 11). This representation enabled the authors to identify when each keyword first appeared in the PIM literature. The node size signifies the keyword's frequency across all literature, while the links provide insights into the progression of research.

The keyword time-zone map (Fig. 11) showcases three distinct phases of keyword concentration: (1) Emerging Stage: This phase sees the integration of PM with the nuances of innovation projects. The knowledge of IM becomes prominent, leading to specialized research. (2) Development Stage: Research in this phase underscores the interconnectedness of projects, emphasizing that they are not isolated entities but function within organizational processes. During this period, PIM research pivots to strategies like supporting organizational innovation through knowledge management, dynamic capability, collaboration, and design thinking. (3) Exploring Stage: This phase branches out into newer research areas, including the use of artificial intelligence techniques, decision aids, and fostering spaces conducive to creativity.

To delineate the chronological progression of research developments within the intersecting domains of PIM and based on the keyword time-zone map (Fig. 11), the research trajectory can be segmented into three distinct phases: the "emerging phase" (2003–2009), the "development phase" (2010–2018), and the "exploring phase" (2019–2023).

During the emerging phase, scholars specializing in 'Project Management' began to identify and examine the distinct attributes of 'innovation projects', differentiating them from traditional ones. Researchers have deliberated to establish a universally accepted 'Conceptual Framework' to consolidate intricate theories. Later, the

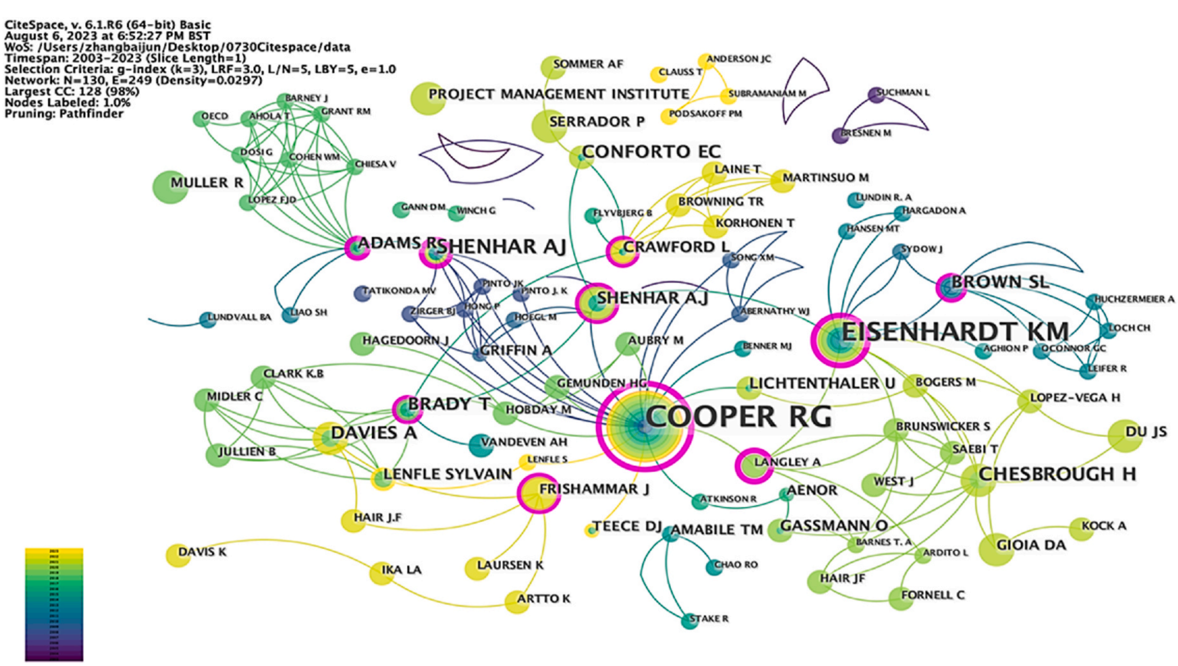


Fig. 9. Co-cited author mapping.

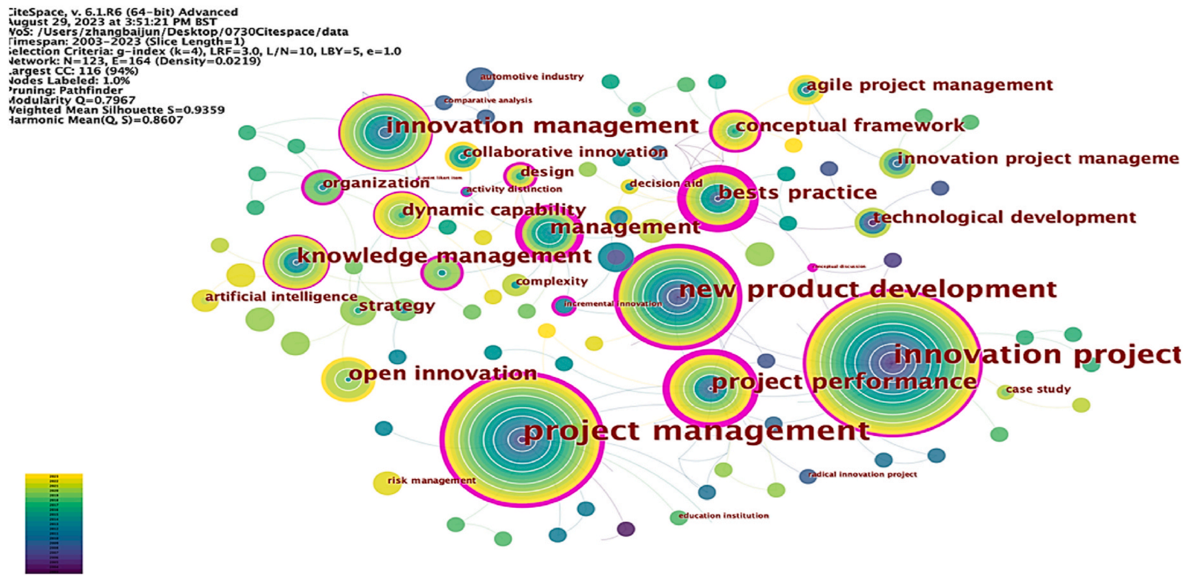


Fig. 10. Keyword co-occurrence networks.

Table 7
The list of representative keywords.

Rank by frequency	Keyword	Year	Count	Centrality
1	project management	2004	118	0.55
2	innovation project	2004	89	0.47
3	new product development	2003	53	0.29
4	project performance	2006	34	0.2
5	innovation management	2009	34	0.17
6	knowledge management	2010	26	0.09
7	open innovation	2014	23	0
8	management	2013	22	0.1
9	bests practice	2003	21	0.11
10	conceptual framework	2003	15	0.07
11	dynamic capability	2016	14	0.07
12	technological development	2004	13	0.02
13	innovation project management	2010	11	0.06
14	strategy	2016	11	0.02
15	agile project management	2008	11	0

Keyword time-zone map.

developmental phase underscored the realization that innovation projects are pivotal components within the 'Organization'. Insights from 'Strategy', 'Dynamic Capability', and 'Knowledge Management' coalesced into the realm of PIM. In this most recent exploring phase, the research landscape has broadened to encompass a variety of emerging dimensions, notably the fusion of "Artificial intelligence", "Decision aid" mechanisms, and "task execution strategy".

4.10. Keyword clustering

Keyword clustering maps derived from CiteSpace offer invaluable insights into predominant research trends and trajectories (Lee and Su, 2010). Within the current analysis, the Log Maximum Likelihood algorithm was employed, producing a distinctive Keywords clustering map (Fig. 12).

Resulting metrics of Modularity value (Q): 0.7967 and Silhouette value: 0.9359, (Chen et al., 2010), affirm the independence and determinacy of the clustering, specifically when Q surpasses 0.3 and the Silhouette exceeds 0.5. As illustrated in Figure, the clusters, ranging from #0 to #10, encompass distinct research dimensions: #0 information technology, #1 Innovation project management, #2 Global R&D, #3 SME firms, #4 Project planning and controlling, #5 Product development, #6 Informal governance, #7 Agile project management, #8 Open innovation, #9 Decision aid, #10 School administrator.

The diverse magnitude of clusters mirrors the eclectic research concentrations and the breadth of scholarly literature during varying periods. Significant interconnections are discernible between clusters, most notably between #2 & #6 and clusters #0 & #5. In contrast, clusters like #3 and #10 retain a unique scholarly identity. Table 8 enumerates top terms in each cluster, discerned through the application of the LLR (Log-Likelihood Ratio) method. This metric delineates the integrative relevance of a cluster via its constituent elements. A profound examination of keyword clustering and seminal themes is reserved for the next section.

4.11. Keyword timeline graph

Drawing upon the keyword clustering analysis, the keyword timeline graph elucidates the evolutionary trajectory of research orientations within this domain. This graphical representation offers a comprehensive visualization, charting the progression and metamorphosis of focal keywords within the research landscape.

Utilizing parameters consistent with the prior clustering exploration, the timeline graph delineates the dynamic shifts of varied keywords under the umbrella of the 11 predominant thematic clusters (Fig. 13). Apart from the timeline graph, another form of graphical interpretation, the keyword landscape graph (refer to Appendix 1), illustrates the temporal evolution of keyword frequencies by ridgeline plot. As a complementary evidence, emergent trends and patterns of keywords evolution become discernible.

Yearly demarcations are prominently positioned atop the timeline graph. The chromatic variations of interconnecting lines — transitioning from blue to green, yellow, and culminating in red — symbolize the chronological sequence wherein multiple thematic keywords concurrently manifested, either intra-cluster or inter-cluster.

The span of the illuminated timeline for each cluster serves as an indicator of its sustained research activity. Gauging by the hues, it can be surmised that both Cluster #7 "Agile Project Management" and Cluster #9 "Decision Aid" have emerged as pivotal, garnering sustained scholarly attention in recent years (Fig. 13).

By consolidating insights from the cluster results and a thorough examination of related literature, the prevailing research trends can be segmented into three overarching research themes, which are

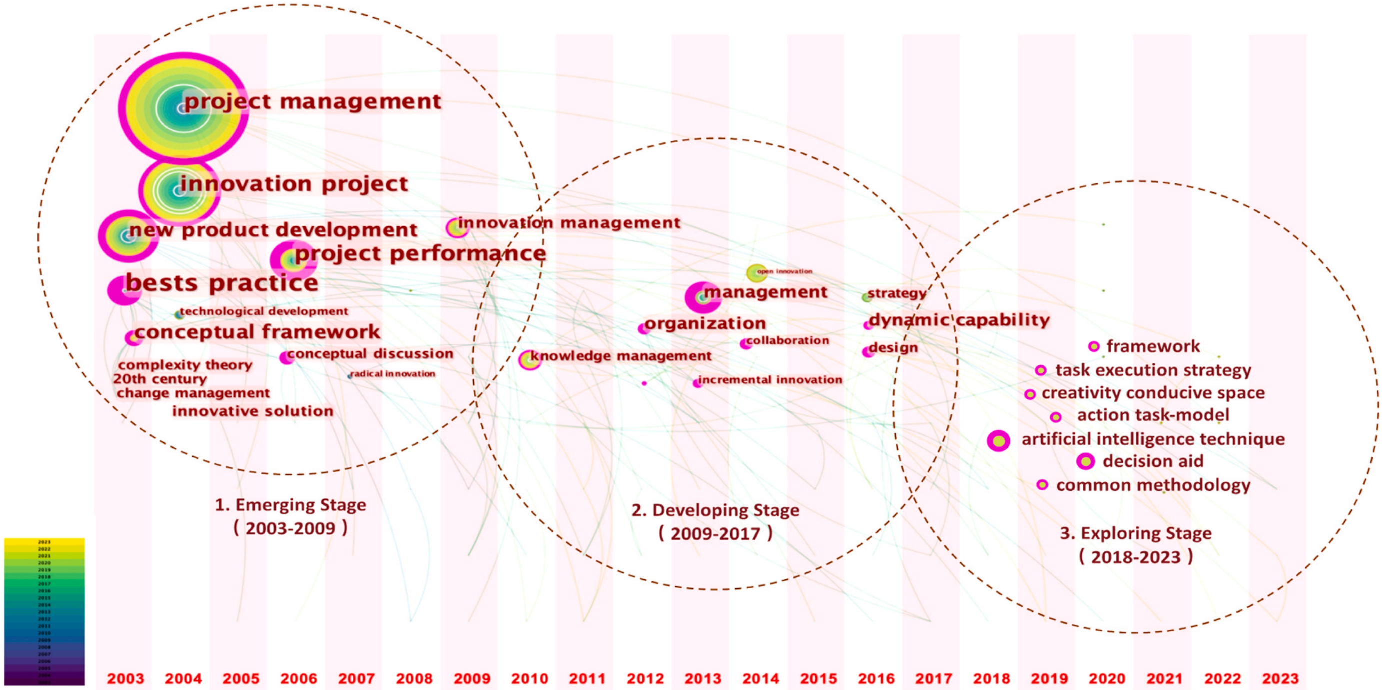


Fig. 11. Keyword time-zone map.

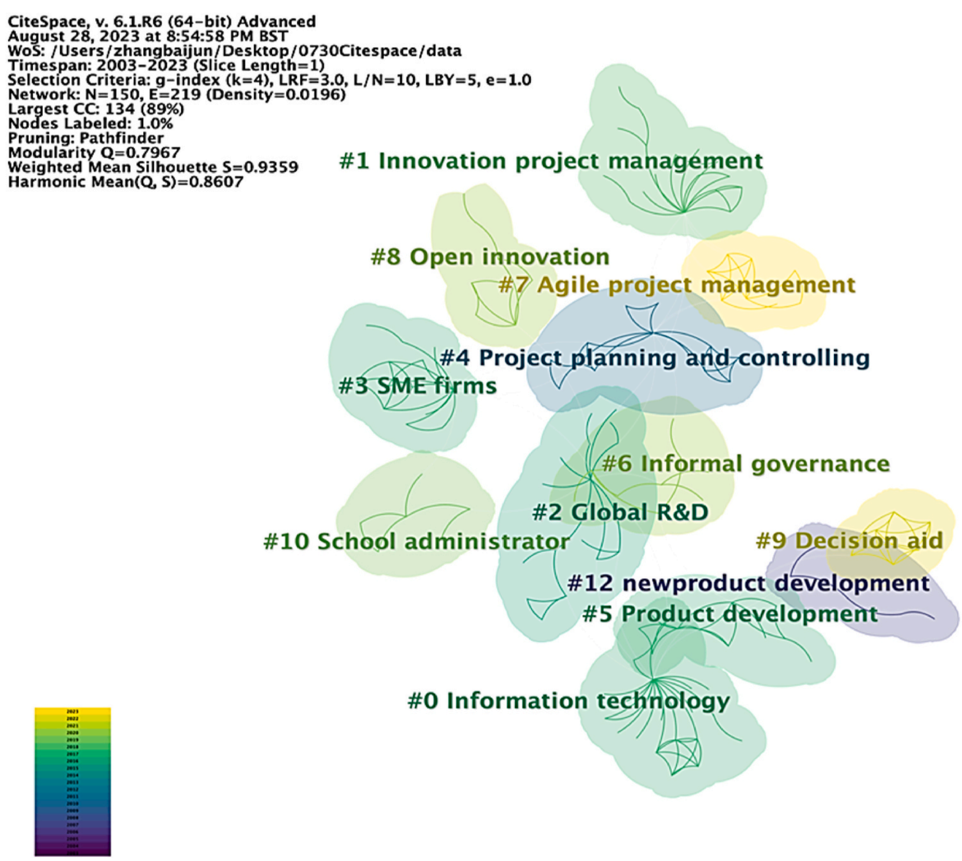


Fig. 12. Keywords clustering map.

elaborated in Table 9.

The dominant research theme in the first category seeks to manage VUCA in innovation endeavours by employing systematic measurement, astute decision-making, and adaptive organizational restructuring. The second dominant research category delves into several facets including technology-driven development, informal governance mechanisms, and the incorporation of open innovation strategies. The third research theme underscores the application of management strategies across

Table 8
Top terms in keywords clusters.

ID	Cluster Label	Size	Dominant research theme
#0	Information technology	21	Information technology; Simulation; Risk management; Communication; Interaction;
#1	Innovation project management	17	Innovation Project management; Success; Technology; Projects; Human factors;
#2	Global R&D	16	Global R&D; Interdisciplinary; Innovation in emerging markets; Global R&D projects; Innovation process;
#3	SME firms	13	Small- and medium-sized firms; Positive affect; Strategic partnerships; Innovation management;
#4	Project planning and controlling	13	Project planning and controlling; Capability; Escalation; Project management office; Innovative product projects;
#5	Product development	11	Product development; Technological innovation; Human resources/Operations interface; Manufacturing;
#6	Informal governance	10	Informal governance; One-way carsharing; Innovation planning; Inter-organizational governance;
#7	Agile project management	8	Agile project management; Service-dominant logic; Cooperative innovation project; Knowledge sharing;
#8	Open innovation	8	Open innovation; Social and ethical aspects; Empirical research; Transition; R&D project;
#9	Decision aid	6	Decision aid; Project task model; Uncertainty management;
#10	School administrator	6	School administrator; Organizational performance; Project success; Case study;

diverse contexts. It is our consciousness that this division of three themes is subject to debates.

4.12. *Keyword burst*

Burst words, characterized by their pronounced frequency fluctuations within specific time intervals, act as indicators of evolving subject trends. These words, undergoing significant mutative trends, are detected based on their surge in occurrences during a defined span. The foundation of this predictive approach stems from the emergent word monitoring algorithm pioneered by Kleinberg (Khalid et al., 2022).

The three colours of grey, blue, and red in keyword bursts have specific meanings. The grey colour generally represents keywords that are not currently experiencing a significant surge in usage. These keywords might be consistently used over time or may not be the focus of recent or emerging research trends. The blue colour typically indicates keywords that are currently experiencing a burst. A burst in this context refers to a sudden and significant increase in the usage of a particular keyword within a set period. This suggests that the topic associated with the keyword is gaining attention and is possibly an emerging trend or focus area on the research field. The red colour is used to highlight the most recent keywords that are experiencing a burst. This signals that

Table 9
Dominant research themes.

No	Dominant theme	Cluster members
1	Approaches to manage VUCA	#1 Innovation project management; #5 Product development, #9 Decision aid, #4 Project planning and controlling
2	Innovation initiatives in project management	#0 information technology; #6 Informal governance; #7 Agile project management; #8 Open innovation
3	Applications in Multifaceted Scenarios	#2 Global R&D; #3 SME firms; #10 School administrator

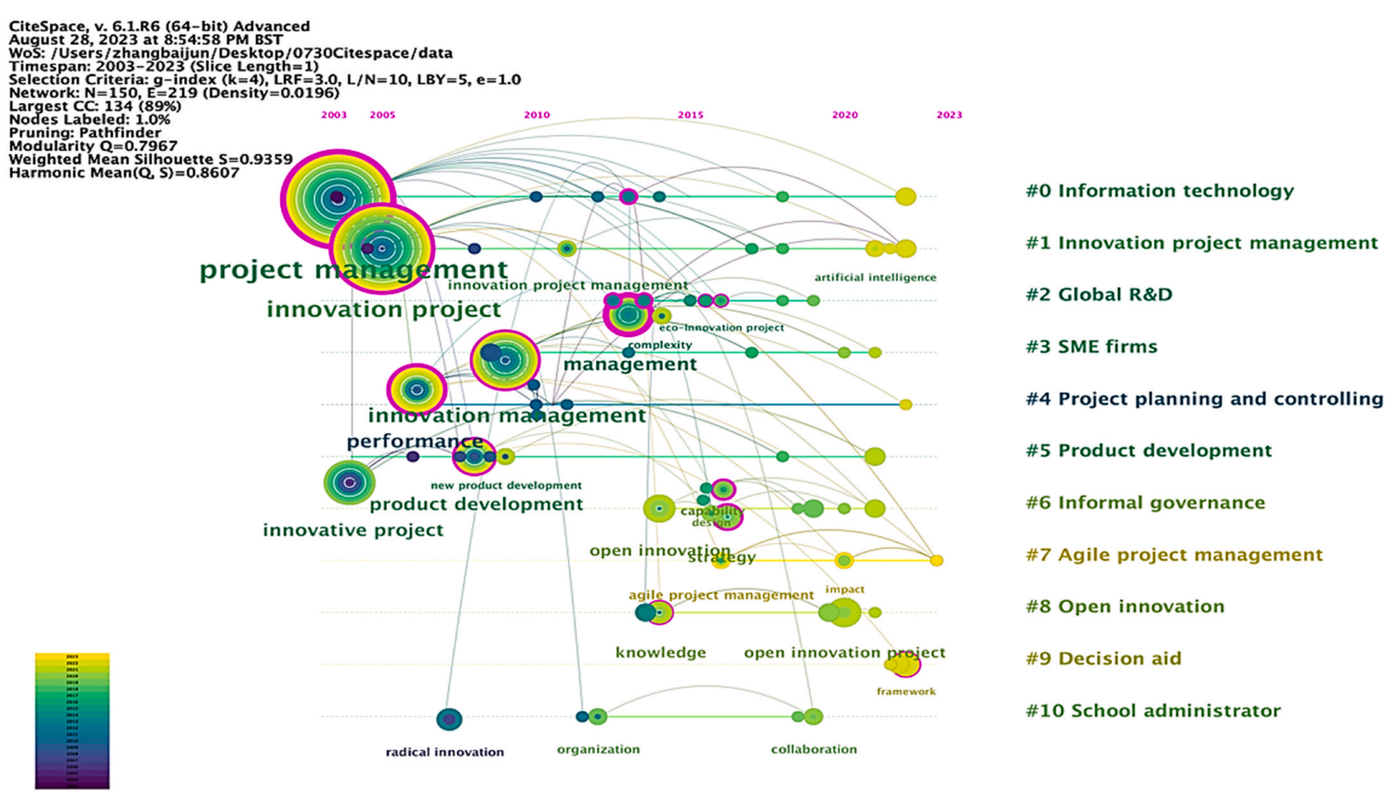


Fig. 13. Keyword timeline graph.

these topics are not only emerging but are also of current and immediate interest within the research community. Utilizing CiteSpace, a compilation of 15 keywords manifesting significant 'burst' characteristics was discerned, as depicted in Fig. 14.The duration of each keyword's burst prominence is denoted by the extent of its corresponding red line segment. A remarkable observation is the persistent prominence of all burst keywords across successive years. The timeframe from 2007 to 2023 saw a diversified array of research within the PIM domain. The pronounced intensity of keywords such as "Management," "Strategy," and "Open Innovation" underscores their centrality in scholarly endeavours.

Mapping these burst keywords against the three temporal phases offers corroborative insights.

- Emerging Phase: The preliminary phase exhibited a constrained breadth, highlighted solely by the burst term "Radical Innovation".
- Developing Phase: This period marked an expansion in research volume and diversity, introducing burst terms such as "Management," "Strategy," and "Eco-Innovation."
- Exploring Phase: Mirroring a steep incline in both burst word occurrences and publication metrics, this phase foregrounded concepts such as "Collaboration," "Knowledge," and "Agile Project Management" as pivotal research subjects.

Over extended periods, it is revealed that previously prominent terms like "radical innovation" are fading on historical stage, while emergent terms including "Artificial intelligence" and "Agile project management" are gaining prominence. This shift might be prompted by emerging technologies. For example, the swift advancement of digitization and artificial intelligence could have steered recent research to explore how these forefront technologies fuel innovation, diverging from conventional understandings of foundational innovation. Moreover, as research progresses, scholars might introduce fresh terminologies such as 'disruptive innovation' or 'open innovation' which might have superseded 'radical innovation' as primary research interests.

4.13. Findings summary

The Results section presents a detailed analysis of the data, with particular focus on publication trends, collaboration networks, co-cited networks, and keyword co-occurrence networks. To enhance clarity and relevance, the findings are organized to underscore the most impactful insights and their implications for the field of PIM.

5. Publication trends (2003–2023)

Fig. 3 illustrates a significant increase in publications over the 20-year period, with three distinct phases: emerging (2003–2012), developing (2013–2018), and exploring (2019–2023). This upward trend highlights the growing academic and practical interest in PIM, with a notable surge in recent years. This surge aligns with the broader industry shift toward digital transformation, agile methodologies, and sustainability in PM (Artto et al., 2021). The increase in publication frequency reflects the field's maturation and suggests that PIM is becoming an essential research domain for managing complexity and innovation. This trend indicates a strong foundation of knowledge for future research and practical applications.

Fiugure 4visualizes the results of these co-occurrence networks and Table 2 details the indicators related to the top ten most frequently occurring subjects.

6. Collaboration networks among countries and institutions

Figs. 5 and 6 reveal collaboration patterns, identifying the United States, Germany, and the United Kingdom as central contributors. Institutions like Delft University of Technology and the University of São Paulo are also prominent, though collaboration between institutions remains limited. This finding points to a need for more inter-institutional and international partnerships to enhance knowledge sharing and cross-disciplinary innovation. Enhanced collaboration could foster the development of more integrated and globally relevant PIM frameworks, especially as organizations increasingly address global challenges such as climate change and sustainable development.

7. Co-cited networks and landmark literature

The co-cited author and reference networks identify seminal works and influential researchers, such as Cooper's (1990) work on the Stage-Gate system and Eisenhardt's research on dynamic capabilities. These findings underscore the foundational role of structured PM methodologies and dynamic capabilities in shaping PIM. Recognizing these foundational works highlights the theoretical underpinnings that PIM builds upon, particularly the need for adaptable frameworks that combine structured management with flexibility for innovation. This

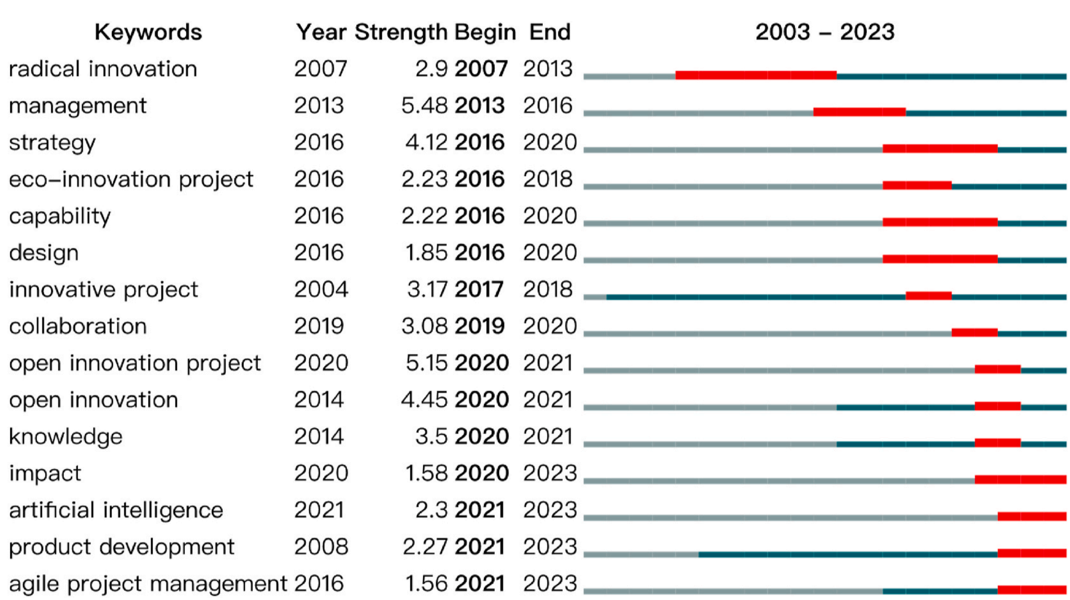


Fig. 14. The list of top 15 Keywords with the strongest citation bursts.

finding reinforces the importance of grounding PIM in both theory and practical adaptability.

8. Keyword Co-occurrence and emerging research themes

Fig. 10 and Table 7 present keyword co-occurrence networks, revealing three dominant research themes: managing VUCA environments, implementing innovation initiatives, and applying PIM in multifaceted scenarios. Key terms such as 'agile project management,' 'dynamic capability,' and 'open innovation' highlight the current focus areas within PIM. These thematic clusters suggest that future research should continue exploring agile and adaptive approaches within PIM, particularly in high-uncertainty environments. The prominence of keywords related to digital and sustainability also indicates the field's shift toward addressing modern organizational challenges, positioning PIM as a vital framework for navigating complexity and rapid change.

9. Discussion

9.1. Research landmarks

The citation frequency of a publication is a significant indicator of its quality and prominence within academic circles. A higher citation count often signifies the publication's status as a foundational work in its research field (Culnan et al., 1990). In this context, three highly-cited publications and two preeminent researchers have been identified as landmarks in the research landscape.

9.1.1. Highly-cited landmark literature

In the realm of PIM,the article "Agile–Stage-Gate for Manufacturers" (Cooper and Sommer, 2018) stands as the most referenced piece. This work introduced, for the first time, a method that integrates agile methodologies with the stage-gate system. Research indicated that this approach enhances the developmental efficiency of product projects in the manufacturing sector. Building on this, Brandl et al. (2021) applied the same methodology to the automation industry, further substantiating its capacity to deliver both stability and agility.

As the leading lights, Stanko et al. (2017) presented a comprehensive review of award-winning research focusing on open innovation mechanisms in their paper, "Under the Wide Umbrella of Open Innovation". Guertler and Sick (2021a) deduced from their investigations that applying open innovation in PM facilitates SMEs (Small and Medium Enterprises) in effective partner search and selection. This sentiment is complemented by Cheah and Ho (2021), who further attested to the positive implications of open innovation in augmenting the commercial performance of public research organizations. Parallel to Stanko's work, the article "The Research Landscape of Open Innovation" (Bogers et al., 2018a,b) delved into established perspectives within the open innovation realm. Subsequently, Urbinati et al. (2020), while differentiating between innovative projects and conventional R&D ventures, referenced these landmark studies.

Highly-cited landmark researchers.

Through examination of the key nodes, two landmarks emerge with marked centrality, suggesting that these two authors – COOPER RG and EISENHARDT KM – not only boast a high frequency of citations but also possess seminal literature influential in academic circles. Cooper's scholarly pursuits are anchored in the methodologies of product development and IM. His insights into the Stage-Gate system shed light on the integration of enhanced decision-making, perpetual refinement, and open innovation into the process. Cooper and Sommer (2018) delved into the amalgamation of Agile PM with the Stage-Gate system, underscoring its potential to expedite market response and bolster development efficiency. Validating Cooper's stance, Conforto et al. (2014) confirmed the adaptability of this hybrid model across non-software sectors. Brandl et al. (2021) subsequently evidenced the model's capability to concurrently ensure stability and agility, especially when implemented in the automation industry.

In contrast, Kathleen's research trajectory is entrenched in product development and the evolving proficiencies of businesses. Pioneering research by (Brown and Eisenhardt, 1995) formulated a model delineating the determinants of successful product development. Later works emphasized the pivotal role of dynamic capability in fostering product development, steering strategic decisions, and forming alliances amidst market flux (Brown and Eisenhardt, 1995). Building on these findings, O'Connor and Rice (2013) asserted the indispensability of dynamic capability to navigate the uncertainties intrinsic to ground breaking innovation projects.

9.2. Evolution of research advancements

In line with the three-phase segmentation of the research trajectory, the chronological progression of research in the intersecting domains of PIM, is discussed following the sequence of the emerging phase, the developing phase, and the exploring phase. During the emerging phase, scholars rooted in PM started recognizing and investigating the unique characteristics of innovation projects, distinguishing them from their conventional counterparts. Merging insights from IM, research efforts were channelled to understand this distinctiveness. A noteworthy observation is the frequent alignment of innovation projects with new product development processes, prompting scholars to explore this overlap. Consequently, advancements were made in improving product and service development project performance, specifically through multi-dimensional uncertainty management in innovation projects, as highlighted by (Sicotte and Bourgault, 2008).

The developing phase marked an acknowledgment that innovation projects weren't isolated endeavours but essential cogs in the organizational machinery, driving strategic imperatives and streamlining operational processes (Maniak and Midler, 2014). The scholarship of this period revolved around varied avenues to navigate the intricacies of managing innovation projects. Some predominant research angles encompassed knowledge management (Saenz et al., 2012), dynamic capabilities (Gomes et al., 2021), collaborative strategies (Brunet and Forgues, 2019), and design-centric approaches (Ben Mahmoud-Jouini et al., 2016).

In this most recent exploring phase, the research canvas has expanded to incorporate an array of novel avenues, including the integration of artificial intelligence, decision support tools, and nuanced task execution strategies. An essential observation is the synthesis of keywords from this phase with burst keywords, offering invaluable insights into the frontier of contemporary research.

In conclusion, these phases encapsulate the evolutionary journey of research in the convergence domain of PIM, with each phase building upon its predecessor, thus enriching the academic repository.

9.3. Dominant research themes

In the same vein, the prevailing research trends can be segmented into three overarching research themes, which are approaches to manage uncertainty, innovation initiatives in PM, and applications in multifaceted scenarios.

9.4. Approaches to managing project uncertainty

This theme seeks to manage uncertainty in innovation endeavours by employing systematic measurement, astute decision-making, and adaptive organizational restructuring. Kapsali (2011a,b) emphasized the pivotal role of mapping uncertainty in the planning, communication, and oversight phases of systematic innovation PM. Sicotte and Bourgault (2008) identified five prevalent types of uncertainty in projects: technical, project-specific, market-driven, ambiguity and complexity. Each type influences the performance of product development projects in distinct ways. By integrating an understanding of these uncertainties with targeted task execution strategies, Maes et al. (2022) posited that project outcomes can be optimized. Additionally, Artto et al. (2011) underscored the centrality of the PM office in steering project planning and oversight, advocating for organizations to embrace an embedded matrix structure.

9.5. Initiatives in innovation project management

The second dominant research category delves into several facets including technology-driven development, informal governance mechanisms, and the incorporation of open innovation strategies. Herstatt and Lettl (2004) contended that the integration of technology spurs development, with the execution of these initiatives being influenced by variances in innovation expectations, levels, and industry dynamics. Kumar et al. (2008) revealed the indispensability of capability for organizations aiming to harness a competitive edge via innovation endeavors. On the governance front, Terrien et al. (2016) highlighted the pivotal role of informal structures, such as public-private collaborations, in catalyzing transport innovation—illustratively, within the paradigm of one-way car sharing. Parallelly, the concept of open innovation emerges as a strategic choice for R&D endeavors. As Urbinati et al. (2020) elucidated, tapping into the knowledge pools, capabilities, and resources of external entities epitomizes an open innovation model, augmenting in-house R&D operations.

9.6. Project management in multifaceted scenarios

The third research theme underscores the application of management strategies across diverse contexts. Terrien et al. (2016) analyzed the role of public-private partnerships in advancing transport innovation. Kumar et al. (2008) pinpointed pivotal factors in the hospitality and tourism sectors that drive technological capabilities via innovation projects. Within educational settings, recent evidence suggests innovative curricula foster knowledge exchange and boost new product development initiatives (Wu and Chen, 2021). Moreover, examining small and medium-sized enterprises (SMEs), M. Guertler and Sick (2021b) highlighted the indispensable role of PM in open innovation, especially when navigating intricate stakeholder relationships and selecting appropriate collaborators.

9.7. Frontier research fields

In the previous section, the keyword burst analysis revealed that AI, product development and agile PM are three research frontiers in the convergent domain of PIM.

9.8. Research frontier: artificial intelligence

The research within AI underscores its burgeoning role in both PM and innovation domains. AI transcends the boundaries of merely optimizing and automating routine processes, ushering in strategic avenues that equip businesses for enhanced decision-making in volatile contexts (Allal-Cherif et al., 2021). For instance, AI has been employed to innovate PM platforms, streamlining processes, refining sourcing functions, and recalibrating strategies in buyer roles and supplier relationship management, all while promoting interdisciplinary collaboration. A pivotal study by Oliveira et al. (2023) integrated Self-organizing maps with Bayesian networks, offering a sophisticated approach to organizational modelling in innovation-driven PM. This innovative modelling fosters precise trend forecasting and project simulations, fortifying risk and uncertainty management. Additionally, AI's footprint is evident across sectors such as architecture and software development, and in systems including knowledge management and decision support, as illuminated by bibliometric insights (Mesa Fernández et al., 2022).

In summary, AI is evolving into an indispensable tool and strategy within the spheres of PIM. As the horizon of AI research expands, its applicative potency in the pragmatic management of innovation endeavours is poised to be a focal point of future studies.

9.9. Research frontier: product development

Based on the recent publications' analysis, prevailing research trends encompass disruptive innovation projects, innovative curricular design, and the application of design thinking. Zubizarreta et al. (2021) crafted a business sustainability management framework to navigate disruptive innovation projects, aiming to ensure organizational longevity and sustainability. Przybilla et al. (2022) argued that implementing design thinking in digital innovation projects augments demand identification and the capacity for tailored product offerings. Furthermore, a pioneering perspective in education was introduced by Wu and Chen (2021), emphasizing the role of an inventive curriculum in fostering knowledge dissemination and innovation within the realm of new product development.

Emerging research trajectories are anticipated to underscore the strategies for steering innovation undertakings in volatile business landscapes, particularly through lenses like disruptive innovation, digital transformation, and organizational learning. Furthermore, education, punctuated by curriculum design, is poised to be acknowledged as a pivotal catalyst for spurring innovation and novel product conception.

9.10. Research frontier: agile product management

Upon reviewing the literature, scholars have conceptualized innovative approaches for agile product management. Olszewski (2023) posited that agile PM can foster creativity within teams via five spaces conducive to creativity: spaces for fostering social interactions, spaces dedicated to learning, adaptive spaces, explorative spaces, and those prioritizing team members' well-being. Moreover, Brandl et al. (2021) presented a hybrid management framework that assimilates agile PM attributes, specially crafted for conventional manufacturing. This approach, by adopting adaptive agile practices, equips professionals to tackle emerging technical challenges with an effective fusion of stability and agility.

In summary, the trajectory of agile PM research is inclining towards an approach that is simultaneously dynamic, adaptable, and people-centric. The emphasis is palpably on fostering value creation, nurturing team creativity, and enhancing agility to adeptly dynamic business terrains. Prospective studies might delve into the practical application of these principles across diverse industries to bolster innovation and the PM prowess of firms.

Fig. 15 culminates an integrative understanding of how two seemingly distanced disciplines converge, it is not a close-loop framework. The model is predicated on the premise that effective management of projects is not linear but is an iterative process that benefits from feedback and adaptive strategies.

Our PIM model provides an opportunity to identify and synthesize existing theoretical frameworks in both PM and IM and propose a new integrated theoretical framework that captures the intersections, overlaps, and interdependencies between these two domains. It has explored scientometric aspects of measuring innovation in PM and developed metrics and indicators for defining and assessing innovation-related performance within the project context. Furthermore, by depicting the temporal aspects of innovation within a project life cycle, it develops a theoretical understanding of how innovation processes evolve over time and how PM practices need to adapt accordingly. The next theoretical contribution this PIM has made regards technology and digital transformation in PIM - the impact and role of emerging technologies in enhancing innovation capabilities within projects. Our PIM model poises the interplay between innovation ecosystems and project networks – it has started to lay a theoretical foundation for understanding how projects fit into larger innovation ecosystems and how they can leverage external networks for innovation.

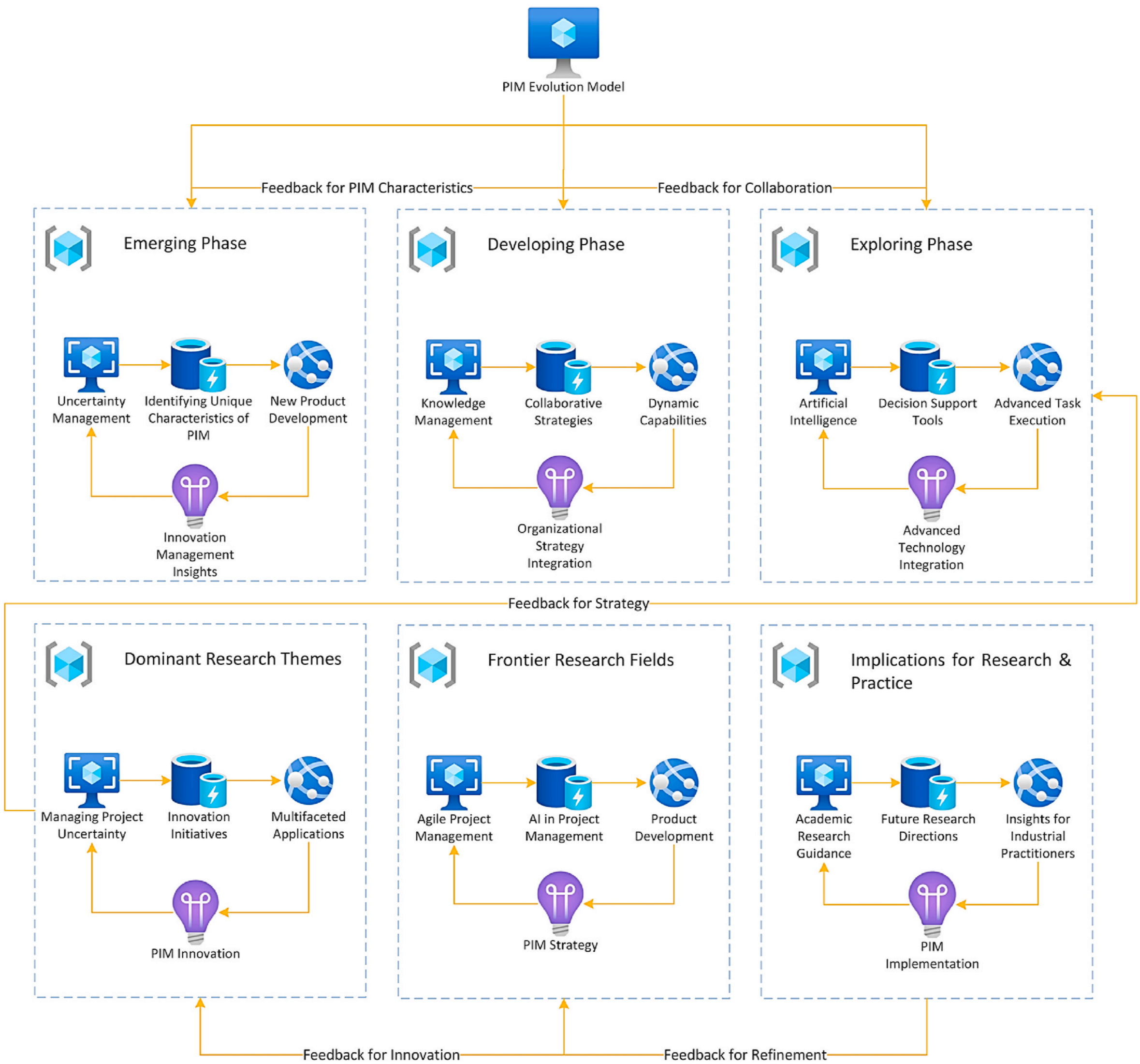


Fig. 15. PIM evolution model.

The integration of organizational strategies ensures that PIM is not isolated from the broader business objectives. The dominant research themes underpinning PIM involve managing project uncertainty, spearheading innovation initiatives, and overseeing multifaceted applications. These themes are critical for the continuous innovation that PIM seeks to achieve. The framework highlights agile PM, AI in PM, and product development as the frontier fields that are pushing the boundaries of what PIM can accomplish. These are the strategic areas where PIM can provide competitive advantage and operational excellence.

In the **Emerging Phase**, the foundational frameworks of PM, such as structured methodologies (e.g., PRINCE2, PMBOK), were adapted to accommodate early-stage innovation projects. These frameworks were grounded in predictability and control, elements that were later identified as restrictive in dynamic, innovation-driven environments.

The **Developing Phase** represents a significant shift as scholars and practitioners began incorporating agile and adaptive methodologies to enhance flexibility in managing uncertainty. During this phase, IM's influence on project methodologies became more prominent, as evidenced by the incorporation of concepts such as dynamic capabilities and knowledge management. This phase solidifies the confluence of PIM as it brings to light the interdependencies between the two fields, suggesting that successful innovation requires both structured project governance and adaptability.

The **Exploring Phase** expands on this convergence by integrating advanced technologies, particularly AI and machine learning, to enhance PM capabilities in high-VUCA (volatility, uncertainty, complexity, and ambiguity) environments. AI applications, such as predictive analytics and decision-support systems, have introduced data-driven decision-making into the PIM domain, enabling more precise forecasting, risk assessment, and optimization. Agile PM also re-emerges here as a key theme, indicating a trend toward iterative, people-centered project approaches that accommodate the rapid changes inherent in innovative processes.

The **feedback cycles** represent iterative learning processes that occur as PIM practices evolve. These cycles capture the adaptive nature of PIM, where insights from one phase feed into the next, facilitating continuous refinement and responsiveness to changing industry needs. For example, agile methodologies, initially adopted in the developing phase, are continually enhanced and integrated with emerging technologies like artificial intelligence in the exploring phase, highlighting an ongoing feedback loop where past practices inform new approaches (Conforto et al., 2014).

These cycles also illustrate how PM and IM draw on each other's strengths. For instance, PM frameworks provide structured methodologies that help operationalize innovative ideas, while IM introduces adaptive and flexible strategies that influence PM approaches to complex, innovation-driven projects (Gomes et al., 2021). The feedback cycles suggest that advancements in one field reinforce and enhance capabilities in the other, creating a self-reinforcing loop of growth and refinement.

Fig. 15 ultimately presents PIM not as a linear process but as an iterative, feedback-driven framework that incorporates elements of traditional PM while evolving toward a more integrated, dynamic model capable of supporting continuous innovation. This iterative nature highlights the role of agile frameworks, real-time data integration, and organizational adaptability as essential for future research and practice in the field. As PIM continues to evolve, this framework suggests that research could benefit from exploring the synergistic effects of emerging technologies, agile methods, and cross-disciplinary collaboration.

This study's findings offer significant insights into the evolution and convergence of PIM, providing both theoretical and practical implications. By comparing these results with existing literature, this discussion emphasizes the unique contributions of this study while drawing connections to broader trends in the field.

The identification of agile PM as a dominant theme aligns with prior studies emphasizing agility's role in fostering flexibility and responsiveness in complex projects (Conforto et al., 2014). While previous research primarily focused on agile's impact in software development, this study shows its broader applicability across diverse PIM contexts, including process and product innovation. This finding supports and extends recent studies by showing how agile principles are now integral to managing high-uncertainty projects across sectors.

Similarly, the emergence of dynamic capabilities as a critical theme reinforces the findings of Teece (2007) and Davies et al. (2014), who argued that dynamic capabilities allow organizations to reconfigure resources in response to environmental changes. This study contributes uniquely by illustrating how dynamic capabilities intersect with PM to create adaptable PIM frameworks, positioning them as central mechanisms for innovation resilience and sustainability. Furthermore, the analysis of collaboration networks among countries and institutions reveals a lack of inter-institutional partnerships in the PIM field, a gap previously noted by Brunet and Forgues (2019) in their study of PM research silos. This study adds to the conversation by demonstrating how interdisciplinary collaboration could enhance PIM's ability to address global challenges, such as climate change and digital inclusion, by combining insights from diverse academic and cultural contexts.

These findings suggest that PIM can be framed as an iterative, learning-oriented framework that continuously integrates insights from PM and IM. This aligns with theories of organizational learning (Argyris and Schön, 1996), proposing that PIM's evolution depends on feedback loops that enable adaptive responses to complex environments. By conceptualizing PIM as a non-linear, cyclic process, this study extends the theoretical understanding of PIM as a dynamic and responsive domain, rather than a static set of practices. Additionally, the integration of sustainability and social impact within PIM reflects a theoretical shift toward responsible innovation (Stilgoe et al., 2013). This study highlights how PIM frameworks are increasingly incorporating environmental and social considerations, reinforcing the need for theoretical models that address both economic and ethical aspects of project and innovation outcomes.

10. Conclusion

This study conducted a comprehensive and visual scientometric analysis on 521 pieces of literature from three databases: WOS, Scopus, and PubMed. The objective of this study was to elucidate the convergence within the PMI research domain based on publications over the past two decades. The results of this study can offer insights for both industrial practitioners' decision-making and academic researchers' future research trajectories. The main conclusions of the research corresponding to each research objective are summarized as below.

Publication metrics reveal a rising trend in the cumulative number of papers within the PMI domain. The remarkable surge in publications over the past five years markedly outpaces that of earlier periods. This suggests that the field is evolving into a focal area of research, drawing increased interest and scrutiny from scholars. Consequently, the domain of PIM holds promising research potential. The disciplinary distribution indicates that Management, Engineering, and Business are the three predominant subject areas in the PIM field. Beyond these core disciplines, the knowledge landscape of PIM demonstrates potential intersections with a diverse array of disciplines, encompassing History, Healthcare, Neuroscience, Biology, Geoscience, and Computer Science.

The analysis of Research Synergies indicates that collaborative dynamics exist among multiple countries, various institutions, and distinct researchers. From a geographical standpoint, the United States, Germany, and the United Kingdom are at the forefront of collaborative research efforts in this domain, underpinning a significant emphasis on PIM innovation and management. The developed evidence on the authorship networks consistently indicates that collaboration among authors within the PIM research sphere is relatively sparse, with enduring collaborative relationships yet to be firmly established.

Research Landmarks were demarcated by three highly-cited papers and the contributions of two prominent researchers. "Agile–Stage-Gate for Manufacturers" study emerges as the most frequently cited work. Likewise, the articles "Under the Wide Umbrella of Open Innovation" and "The Open Innovation Research Landscape" are paramount in the PIM sphere, both offering insightful reviews of established perspectives. As a result, Cooper Rg and Eisenhardt Km stand out as researchers with considerable academic influence with primary focus on the Stage-Gate system. In contrast, Eisenhardt Km focuses on product development and dynamic capacities in organizations.

The progression of research in the field has been delineated into three distinct stages based on the prevalence of specific keywords. The first emerging phase saw researchers identifying the unique attributes of innovation projects relative to traditional ones. The secondary developing phase addressed diverse facets of managing innovative projects. The third exploring phase characterized by probing the cutting-edge realms of research encompassing areas such as artificial intelligence methodologies, decision-support tools, and task execution paradigms. The dominant research themes were divided into three distinct domains based on their interrelations within unique clusters. The first area focuses on managing uncertainty in creative projects through prudent measurement, decision-making, and organisational modifications. The second category focuses on the investigation of many efforts, including technology, informal governance, and open innovation. In the third domain, research focuses on the applicability of PIM concepts in complex situations.

Frontier research fields are gravitating towards AI, product development and agile product management. Future AI research is positioned for effective incorporation into concrete innovation endeavours. Regarding product development, emerging trend emphasized on aligning the dynamic environment with considerations of disruptive innovation, digital transformation, and organisational learning. As for agile product management, the application across a variety of industries appeared to remain as the research frontier, enhancing both innovation initiatives and project effectiveness within organizations.

By mapping publication trends, collaboration networks, and thematic developments, the study highlights key areas of convergence and identifies emerging trends that shape the future of PIM. The findings contribute to the academic understanding of PIM by offering an integrated perspective on its evolution. The study identifies agile PM, dynamic capabilities, and sustainability as core themes, suggesting that PIM is shifting toward adaptive, resilient frameworks capable of responding to high-VUCA environments. This research extends prior work by synthesizing these elements within a longitudinal analysis, providing a clearer view of how PM and IM integrate in response to modern organizational demands. Additionally, the study introduced an evolution model that highlights the iterative, feedback-driven nature of

PIM. This model contributes to theoretical discussions on dynamic capabilities and organizational learning, positioning PIM as a cyclical, learning-oriented framework that evolves through adaptive feedback loops.

The study's findings suggest specific strategies for integrating PM and IM practices to better manage complex, innovation-driven projects. For practitioners, adopting hybrid frameworks that combine structured project methodologies with agile, flexible approaches can facilitate innovation while maintaining control over project objectives. This dual approach is particularly relevant for organizations managing high-uncertainty projects, as it supports rapid adaptation to changing requirements without sacrificing project discipline. The collaboration network analysis presents the need for more inter-institutional and cross-disciplinary partnerships. Practitioners can benefit from building collaborative networks that draw on diverse expertise, especially for projects addressing global challenges like climate change, digital transformation, and sustainable development. Organizations should consider forming alliances with universities, research institutions, and global stakeholders to enhance knowledge sharing and innovation capacity.

Given the study's findings on the importance of agile PM and dynamic capabilities, practitioners should foster organizational cultures that encourage flexibility, continuous learning, and experimentation. By incorporating agile methodologies and dynamic capabilities into project workflows, organizations can better navigate the uncertainties of innovation-driven projects and maintain a competitive edge. For academic researchers, the study suggests investigating high-VUCA sectors, such as healthcare, infrastructure, and technology, where PIM practices are particularly relevant. Exploring how PIM frameworks perform in these complex environments can provide further insights into best practices and refine theoretical models.

While this study provides valuable insights into the convergence of PM and IM, several limitations must be acknowledged to provide a balanced perspective on the findings. This study relies on data from WoS, Scopus, and PubMed. While these databases are comprehensive, they may exclude relevant studies from other platforms or non-indexed publications, potentially introducing selection bias. Additionally, publications from certain regions or languages other than English may be underrepresented, which could limit the diversity and representativeness of the dataset (Zupic and Čater, 2015).

Bibliometric methods often emphasize highly cited articles, which can result in over-representation of well-established research at the expense of emerging, niche, or less frequently cited studies. This citation bias may obscure the contributions of innovative but less visible research, especially recent works that have yet to accrue significant citation counts (Moed, 2005). While keyword analysis provides useful insights into thematic trends, it is inherently limited by the variability and ambiguity of author-assigned keywords. Terms like "project management" and "project governance" may be inconsistently applied across studies, potentially affecting the accuracy of thematic clusters and the interpretation of interdisciplinary connections.

Future studies could incorporate additional databases, such as IEEE Xplore or regional databases, and include non-English publications to enhance the comprehensiveness and global representation of the dataset. This would provide a more inclusive view of PIM research, particularly from regions underrepresented in current scientometric analyses. To reduce reliance on citation counts, future research could explore alternative impact metrics, such as altmetrics or usage-based indicators, which may better capture emerging research and topics with high societal or practical relevance. These alternative metrics could offer a more holistic view of PIM's impact, encompassing both academic influence and industry relevance. The current study identifies emergent trends, such as agile PM, digital transformation, and sustainability. Future research could conduct more focused studies on each of these themes to understand their distinct impacts on PM and IM. For example, further investigation into the role of digital transformation in PIM could examine how AI, machine learning, and digital twin technologies are transforming project workflows and decision-making processes. As organizations increasingly operate in high-VUCA environments, future research could explore how PIM frameworks evolve to support resilience and adaptability in such settings. Examining specific case studies or longitudinal datasets within sectors like healthcare, public infrastructure, and environmental sustainability could provide valuable insights into how PIM adapts to rapidly changing conditions.

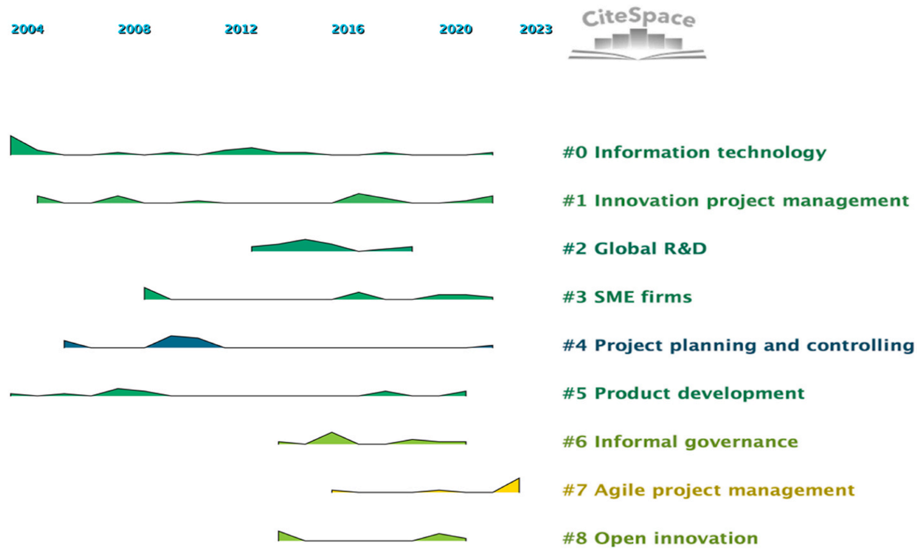
CRediT authorship contribution statement

Lihong Zhang: Writing – review & editing, Supervision, Project administration, Conceptualization. **Saeed Banihashemi:** Writing – review & editing, Writing – original draft, Visualization, Validation. **Yujue Zhang:** Writing – original draft, Visualization, Software, Investigation, Formal analysis, Data curation. **Song Chen:** Writing – review & editing, Validation.

Declaration of competing interest

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

Appendix 1: Keyword Landscape Plot



Data availability

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

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