Open and Digital Innovation: Intellectual Structure, Global Trends, and Future Research Directions

Uchechukwu Nwogu[1][*], Muhammad Faraz Mubarak[1], Marco Cuvero[2] and Richard Evans[1]
[1]Faculty of Computer Science, Dalhousie University, Halifax, NS, Canada
[2]Brunel Business School, Brunel University London, Uxbridge, United Kingdom
*Corresponding Author: E-mail: unwogu@dal.ca

Abstract—**Advancements in open innovation and digital innovation have reshaped how firms manage their innovation processes. This study investigates the intellectual structure of current open innovation and digital innovation research, reporting on a scoping review using bibliometric and science mapping techniques. Through analysis of 261 journal articles published between 2015 and 2025, three research clusters were identified: (1) digital innovation and industrial research, (2) sustainability-driven strategic innovation, and (3) collaborative decision-making. The study highlights the significant growth in academic output and emphasizes the reciprocal relationship between digital transformation and open innovation, particularly within SMEs and platform-based ecosystems. Gaps in current research are identified in the contexts of digital product ecosystems, decision-making in innovation networks, and ethical considerations. This study provides both theoretical and practical insights for innovation management, emphasizing sustainability and platform-centric business models.**

Keywords—*open innovation, digital innovation, industry 4.0, scoping review, digitalization.*

I. INTRODUCTION

Innovation has undergone a major shift over the past two decades, driven by the rapid rise of digital technologies. While traditional innovation has historically been led by tangible-product firms, such as General Electric and Ford, who focus on physical goods and innovation in engineering processes, the emergence of digital technology firms, such as Google, Facebook, and Amazon has redefined the digital ecosystem landscape. These firms draw benefits from engagement with digital platforms, AI, big data, and cloud computing to generate scalable and network-driven innovations that surpass the economic impact of their industrial predecessors [1-4].

Traditionally, firms have relied on closed innovation, keeping Research and Development (R&D) activities in-house to protect their intellectual property and maintain competitive advantage [5–6]. However, globalization and rising technological complexity have exposed the limitations of this approach, prompting a shift toward open innovation. Introduced by Henry Chesbrough in 2003 [1], open innovation promotes collaboration with external partners, such as universities, start-ups, suppliers, and customers, to accelerate innovation processes and enhance technological capabilities [7–8]. This paradigm shift has gained traction in innovation management literature, where collective intelligence, open-source collaboration, and platform ecosystems offer new advantages [9]. Digital platforms further support this shift by enabling co-creation with external stakeholders [2]. Although prior studies have explored aspects of these innovation models, a comprehensive synthesis of key themes, intellectual structures, and emerging trends is still lacking.

Given the growing significance of open innovation in digital innovation contexts, a systematic review of the field is required. This study, therefore, addresses this gap through a scoping literature review using bibliometric and science mapping techniques. It aims to: (i) examine the evolution of open innovation and digital innovation research; (ii) identify key themes and research clusters; and (iii) outline gaps for future research. From a theoretical perspective, the study integrates perspectives from the fields of management, information systems, and organizational studies to provide a framework for understanding open innovation and digital innovation [4]. From a practical perspective, the paper provides policymakers, organizational leaders, and innovation managers with insights to guide digital transformation.

The remainder of this paper is structured as follows. Section II outlines the method used to conduct the scoping review, including data collection, analysis techniques, and science mapping procedures. Section III presents the key findings of the study, including the growth of research on open innovation and digital innovation, intellectual structure, and emerging trends. Finally, the paper discusses theoretical contributions, managerial implications, and future research.

II. METHOD

This study conducts a scoping review to map the current research landscape at the intersection of open innovation and digital innovation. Unlike traditional literature reviews, scoping reviews aim to capture the broad themes, key contributions, and intellectual structures in emerging fields [11–13]. To support this, a bibliometric analysis is performed using metadata from the Scopus database, chosen for its interdisciplinary coverage [14]. In addition, VOSviewer version 1.6.20 [15] was used to visualize and analyze the data.

Scientific output analysis provides a quantitative overview of research activity by examining citation patterns, publication trends, key authors, institutions, funding sources, and country-level research outputs, thereby identifying influential studies and geographic research distribution. Co-authorship analysis helps to identify collaboration networks in the community, while author affiliation data highlights regional hubs of open innovation and digital innovation research [11]. Building on this, science mapping, through keyword co-occurrence analysis, highlights themes, conceptual linkages, and thematic clusters, demonstrating the field's intellectual structure and its evolution. Network analysis helps to visually map these clusters, offering insights into current discourse and trends.

Data collection followed a structured protocol to ensure academic rigor and replicability. The initial dataset was retrieved from Scopus using a search query combining terms related to open innovation (e.g., "open innovation", "collaboration", "co-creation", "participatory innovation") and digital innovation (e.g., "digital innovation", "digital product") within the title, abstracts, and keywords fields.

Then, filters were applied to refine the dataset. The timeframe was limited to 2015-2024, reducing the sample to 621 documents. Subject areas were narrowed to relevant fields (i.e., Computer Science; Business, Management and Accounting; Social Sciences; Engineering; Decision Sciences; and Economics), resulting in a total of 541 records. Only peer-reviewed journal articles published in English were included, producing a final sample of 261 documents. The complete search string used in this study is provided below:

(TITLE-ABS-KEY ("open innovation") OR TITLE-ABS-KEY ("collaboration") OR TITLE-ABS-KEY ("co-creation") OR TITLE-ABS-KEY ("participatory innovation") AND TITLE-ABS-KEY ("digital innovation") OR TITLE-ABS-KEY ("digital product")) AND PUBYEAR > 2014 AND PUBYEAR < 2026 AND (LIMIT-TO (SUBJAREA , "COMP") OR LIMIT-TO (SUBJAREA , "BUSI") OR LIMIT-TO (SUBJAREA , "SOCI") OR LIMIT-TO (SUBJAREA , "ECON") OR LIMIT-TO (SUBJAREA , "ENGI") OR LIMIT-TO (SUBJAREA , "DECI")) AND (LIMIT-TO (DOCTYPE , "ar")) AND (LIMIT-TO (LANGUAGE , "English"))

III. RESULTS

A. Scientific Output

1) Trends in Publications and Citations

Analysis of publication and citation trends demonstrate a growing academic interest in open innovation and digital innovation. From 2015 to 2019, publication volume remained low, reflecting early developments in open innovation and digital innovation studies. However, from 2020 onward, there was a marked rise in research output, driven by Industry 4.0 and the broader adoption of open innovation. The steady growth through 2023 and a peak in 2024 highlight maturation and increasing scholarly engagement. The citation trend mirrors publication growth but with a typical lag, as early studies in emerging fields take time to gain recognition from the academic community. From 2015 to 2019, citations were minimal, reflecting limited research activity. As publications increased, earlier works began to accumulate citations, leading to steady growth from 2020 onward. A notable surge occurred in 2024, aligning with peak publication levels, indicating both reliance on foundational studies and the contribution of new insights. The drop in citations in 2025, despite continued publication, is expected due to the time lag in citation accrual.

These trends reflect the growing interest from researchers in the open innovation and digital innovation fields, with an expanding literature base establishing its foundations. The rise in publications shows active study of new theories, methods, and applications, while citation patterns demonstrate the consolidation of earlier work as key references. The 2024 peak signals growing scholarly engagement, likely paving the way for broader thematic diversity and collaboration. The publication and citation trends are illustrated in Fig. 1.
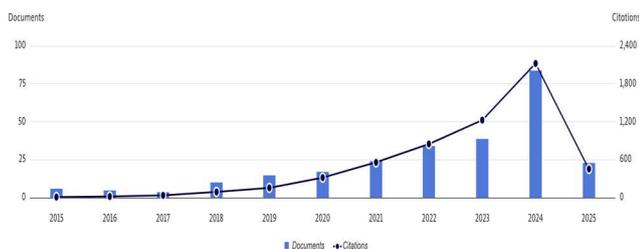

Fig. 1. Trend of publications and citations

With a total of 5,821 citations, the dataset of 261 documents demonstrates considerable scholarly engagement, with researchers extensively referencing existing work to build upon prior findings and proposed frameworks. A notable concentration of influence is observed in the top 10 most cited documents, collectively accounting for 2,179 citations, a substantial 37.43% of the total citations. This suggests that a small but impactful subset of publications has played a pivotal role in shaping the current discourse in open innovation and digital innovation research. These highly cited studies have likely introduced fundamental theories, empirical insights, or methodological advancements that have become central to subsequent research efforts. Further information on these top 10 most cited documents is provided in Table 1.

TABLE I.　HIGHLY CITED DOCUMENTS IN THE FIELD

Year	Paper	Journal	Citations[a]
2017	Embracing digital innovation in incumbent firms: How Volvo Cars managed competing concerns	MIS Quarterly: Management Information Systems	682
2018	Fintech and regtech: Impact on regulators and banks	Journal of Economics and Business	331
2021	A Self-Tuning Model for Smart Manufacturing SMEs: Effects on Digital Innovation	Journal of Product Innovation Management	218
2019	Creating and capturing value from Big Data: A multiple-case study analysis of provider companies	Technovation	193
2020	The digital transformation of SMEs " a new knowledge broker called the digital innovation hub	Journal of Knowledge Management	164
2015	Effective digital collaboration in the construction industry - A case study of BIM deployment in a hospital construction project	Computers in Industry	147
2020	The CAGE around cyberspace? How digital innovations internationalize in a virtual world	Journal of Business Venturing	122
2019	Organising and Managing boundaries: A structuration view of collaboration with Building Information Modelling (BIM)	International Journal of Project Management	110
2023	Blockchain technology and gender equality: A systematic literature review	International Journal of Information Management	107
2017	Can profit and sustainability goals co-exist? New business models for hybrid firms	Journal of Business Strategy	105

a. Citation count as of 20 March 2025

2) Documents by Authors

Analysis of the authors publishing within the fields of open innovation and digital innovation identifies J.Q. Dong as the most significant contributor with five publications, indicating a key role in advancing open and digital innovation research. Other active researchers include J. Arias-Pérez, D. Lepore, C. Sassanelli, S. Terzi, and S. Brunswicker, all with three publications, while A. Crupi, C. Dell'Era, A. Di Minin, and F. Fauzan, each contributing two studies. This distribution reflects a diverse, collaborative, and interdisciplinary research community. Author publication data is presented in Fig. 2.
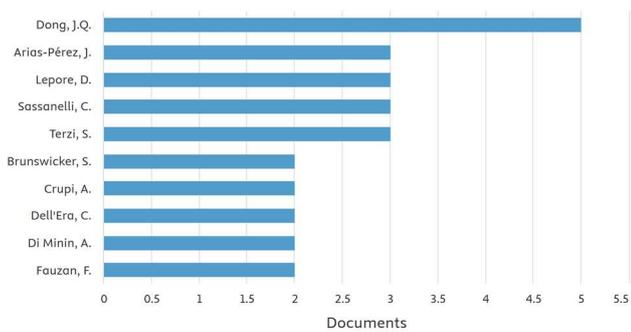
Fig. 2. Multiple documents by authors

3) Documents by Institutions

Analysis of higher education institutions highlights key institutions driving research on open innovation and digital innovation. Politecnico di Milano leads with 10 publications, demonstrating its strong focus on innovation management and digital transformation. The University of Groningen, the University of Sheffield, and Politecnico di Bari follow with five publications each, reflecting active engagement in the field. Other notable institutions, such as Harbin Engineering University, Luleå University of Technology, Queensland University of Technology, Göteborgs Universitet, Universität Bayreuth, and Università degli Studi di Macerata, produced three to four publications each. The range of institutions across Europe, Australia, and China illustrates the global and interdisciplinary nature of this research field. Moreover, the distribution of research across multiple institutions indicates that open innovation and digital innovation is a widely studied field, supported by interdisciplinary and international collaboration. While Politecnico di Milano leads in research output, the contributions of other universities reflect a growing and diverse research ecosystem driving further studies. The institutional publication data is shown in Fig. 3.
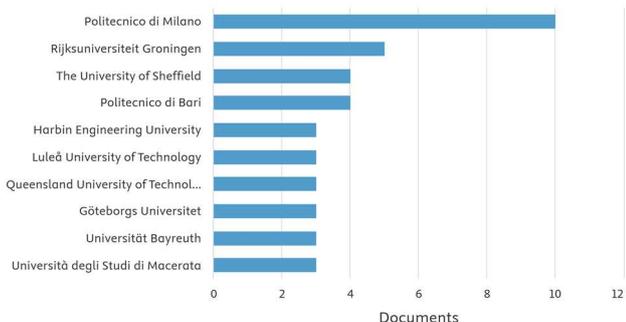

Fig. 3. Active institutions in the field

4) Documents by country

The country-level analysis shows a global spread of research on open innovation and digital innovation. Mainland China leads with over 40 publications produced, reflecting its strong focus on digital transformation, Industry 4.0, and innovation-driven policies. The United States of America, United Kingdom, Germany, and Italy follow with 30-35 publications each, highlighting their established research strengths in digital innovation and open innovation. The U.S.A. stands out in technology entrepreneurship and platform innovation, while the U.K. and Germany contribute significantly to innovation management and policy studies. The strong representation from Italy is largely driven by renowned institutions, such as Politecnico di Milano.

Beyond the top five countries, Indonesia, Spain, Australia, the Netherlands, and Sweden each contributed 10-15 publications, reflecting growing research engagement across both emerging and developed economies. Indonesia's presence suggests rising interest in digital transformation within developing markets, particularly in fintech, e-commerce, and digital governance. Australia, the Netherlands, and Sweden add to the global dialogue with research focused on digital policy, sustainability, and innovation networks. Such a wide geographical distribution of research demonstrates the global relevance of open innovation and digital innovation studies, with both leading and emerging economies contributing to scholarly progress. The diversity of institutions reflects varied technological, economic, and societal perspectives, supporting a dynamic and multifaceted research landscape. Fig. 4 presents the active countries represented in the dataset.
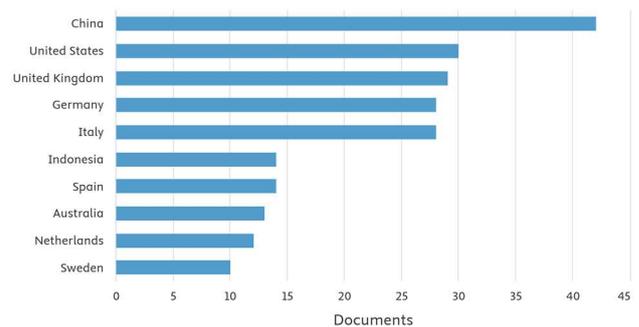

Fig. 4. Active countries in the field

5) Documents by Funding Bodies

The analysis of funding bodies highlights key international bodies supporting research on open innovation and digital innovation. The European Commission is the leading funding provider, reflecting Europe's strong commitment to digital transformation, open innovation, and international collaboration. This aligns with its broader efforts to advance Industry 4.0 through extensive research funding initiatives. The National Natural Science Foundation of China (NSFC) is a major funder in Asia, reflecting China's strategic focus on technological innovation, the digital economy, and smart manufacturing. Horizon 2020 and the UK Research and Innovation (UKRI) fund also play key roles in funding such innovation studies, highlighting the EU and UK's leadership in policy-driven innovation. In addition, China's Ministry of Science and Technology and Ministry of Education are prominent funding bodies, highlighting strong government investment in academic and industrial digital innovation. Horizon 2020's separate listing further emphasizes its targeted support for digital transformation initiatives. Other bodies (e.g., the Australian Research Council) reflect the broad funding landscape, supporting research that links digital innovation with social, economic, and policy studies.

Overall, analysis of the international funding landscape shows that open innovation and digital innovation research is largely supported by governmental agencies, especially in Europe and China, reflecting their strategic focus on digital innovation for economic growth. The prominence of European and Chinese funders highlights this priority, while support from bodies, such as the Australian Research Council, demonstrates expanding international engagement. Funding bodies from the selected papers are shown in Fig. 5.
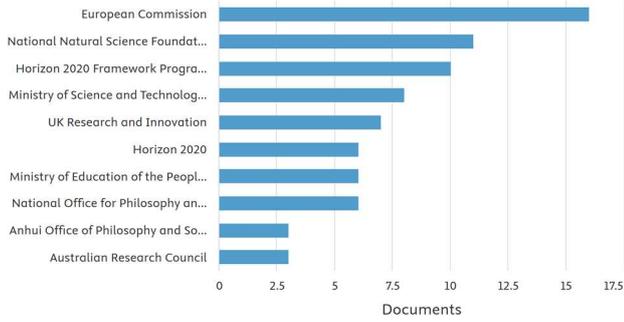
Fig. 5. Main funding bodies for research on open and digital innovation

B. Science Mapping: Cluster Analysis

The intellectual structure mapping identifies three key interconnected thematic clusters that define the open innovation and digital innovation research landscape. Identified through keyword co-occurrence analysis, these research clusters reflect distinct yet related domains, highlighting key concepts, trends, and thematic linkages. The results provide insight into how research streams interact to form a networked foundation for digital innovation studies. As shown in Fig. 6, three clusters were identified: (i) *blue*: core digital innovation research, (ii) *green*: sustainability, strategy, and technological development, and (iii) *red*: a peripheral but essential cluster linking collaboration, digital products, and decision-making. Table 2 summarizes each cluster's structural attributes, including links, strength, and frequency, providing a quantitative view of their influence and connectivity.
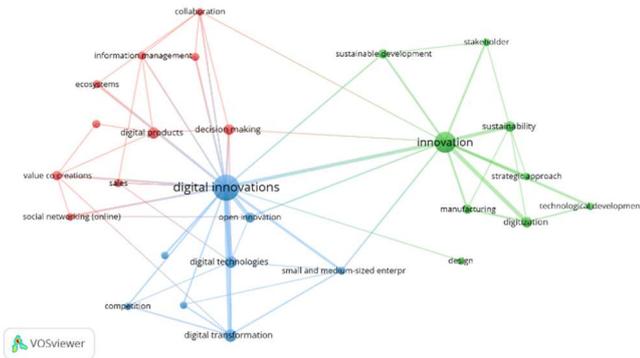

Fig. 6. Clusters on intellectual structure

The blue cluster, forming the core of digital innovation research, has 24 links, a strength of 89, and 50 occurrences. It focuses on digital transformation, open innovation, industrial research, and competition, highlighting strategic and economic impacts of the studies conducted. The green cluster, with 18 links, a strength of 60, and 34 occurrences, centers on sustainability, strategic innovation, and stakeholder-driven development, reflecting global interest in sustainable digital transformation. The red cluster, though smaller (i.e., 17 links, strength of 24, and 9 occurrences), connects collaboration, digital products, and decision-making, offering insights into value co-creation, social networks, and digital ecosystems. Information on nodes and keywords of research clusters is provided in Table II.

TABLE II.   NODES AND KEYWORDS OF RESEARCH CLUSTERS

Cluster 1 (8 items)	**Cluster 2** (9 items)	**Cluster 3** (10 items)
Links: 24 *Cluster strengths: 89* *Occurrences: 50*	*Links: 18* *Cluster strengths: 60* *Occurrences: 34*	*(Decision making)* *Links: 17* *Cluster strengths: 24* *Occurrences: 9*
Competition	Design	Collaboration
Digital innovations	Digitization	Decision making
Digital technologies	Innovation	Digital products
Digital transformation	Manufacturing	Ecosystems
Industrial research	Stakeholder	Information management
Knowledge management	Strategic approach	Product design
Open innovation	Sustainability	Sales, Value co-creations
SMEs	Sustainable development	Social networking (online)
	Technological development	Technological innovation

1) Cluster I: Blue cluster

The blue cluster represents a central and well-connected theme focused on digital innovation, technologies, and their impact on industrial research and competition. With 24 links, a strength of 89, and 50 occurrences, it is a core and highly cited area within the landscape of open innovation and digital innovation research. At the center of the cluster is "digital innovations" which serves as the main node, linking key concepts such as digital transformation, open innovation, digital technologies, and knowledge management. This reflects a research focus on how digital technologies drive innovation and reshape the competitive dynamics of firms. The presence of terms such as "competition" and "industrial research" shows the strategic importance of digital innovation in market positioning and technological advancement. The inclusion of "open innovation" highlights the interdisciplinary nature of this field, emphasizing collaboration and knowledge sharing. The presence of "SMEs" suggests strong interest in how smaller firms adopt digital technologies and practices to remain competitive. The blue cluster is illustrated in Fig. 7.
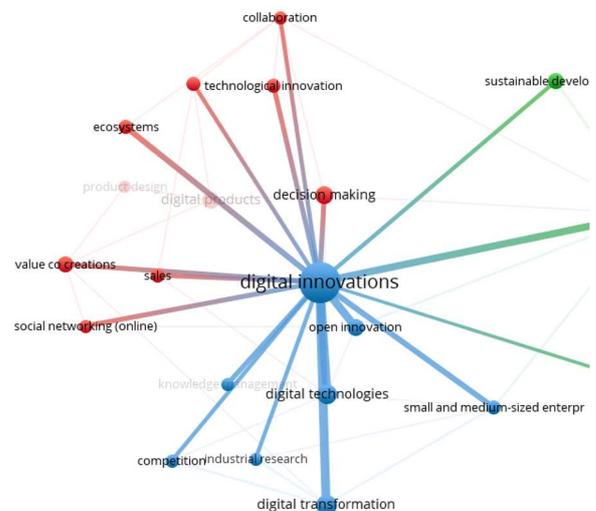

Fig. 7. Blue cluster

Overall, the blue cluster serves as a key pillar in digital innovation research, connecting technological advancements with economic and strategic outcomes. Its high strength and frequency indicate an evolving field that offers key insights into how digital transformation and open innovation drive industrial competitiveness and knowledge management.

2) Cluster II: Green cluster

The green cluster reflects a strategic and sustainability-oriented dimension of innovation, with 18 links, a strength of 60, and 34 occurrences, highlighting its thematic importance. Focused on "innovation," it connects key themes, such as digitization, sustainability, strategy, and technological development, suggesting a focus on how technological and environmental factors influence innovation strategies. The presence of "sustainable development" and "sustainability" highlights a growing focus on eco-friendly, long-term innovation aligned with global policy and industry shifts toward green technologies. The presence of "stakeholder" highlights the need for collaboration in innovation, driven by partnerships among firms, governments, and society, highlighting the important role of open innovation ecosystems in advancing technology.

The green cluster further emphasizes the role of digitization and technological development in shaping sustainable and competitive innovation strategies, aligning with global trends in Industry 4.0, smart manufacturing, and digital integration. Terms such as "manufacturing" and "design" highlight the cluster's focus on practical, industrial applications and efficiency improvements for firms. This cluster reflects a strategic, sustainability-oriented view of innovation, driven by digital transformation, stakeholder collaboration, and industrial adaptation. Its moderate strength and frequency suggest a well-established but growing area of interest. The green cluster is illustrated in Fig. 8.
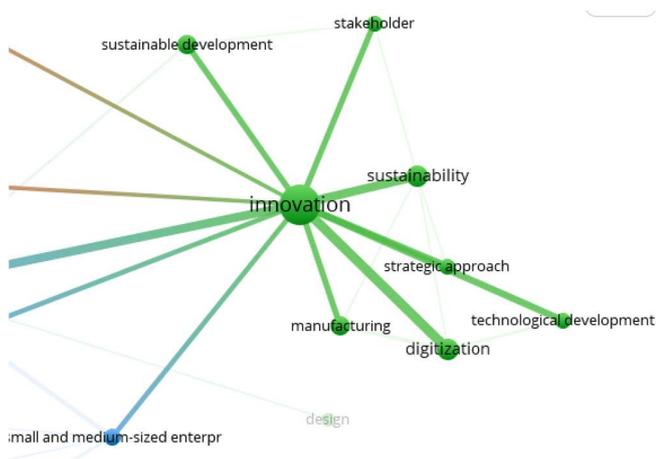

Fig. 8. Green cluster

3) Cluster III: Red cluster

The red cluster represents a peripheral but connected area within open innovation and digital innovation research. With 17 links, a strength of 24, and 9 occurrences, it lacks a dominant core but supports the main digital innovation (blue) cluster. Its links to digital innovation and open innovation suggest a focus on applied, collaborative, and ecosystem-driven aspects of digital transformation. "Decision-making" is a central theme, reflecting interest in how digital products, technology, and collaboration shape innovation processes.

Keywords, such as "digital products", "product design", and "ecosystems", emphasize the role of design and interactive environments in tech-driven markets. Moreover, the presence of "collaboration", "value co-creation", and "social networking (online)" highlights a focus on collaboration, digital engagement and participatory innovation. This aligns with open innovation trends and networked value creation facilitated by digital platforms. Keywords, such as "sales" and "information management", suggest interest in how digital technologies support commercialization and knowledge flows within ecosystems. The red cluster is shown in Fig. 9.

Fig. 9. Red cluster

IV. DISCUSSION

The intellectual structure mapping uncovers a well-defined yet evolving research landscape in open innovation and digital innovation. The three interconnected clusters (i.e., core digital innovation, sustainability-focused strategy, and collaboration-based decision-making) highlight the field's multidimensional nature. Specifically, the blue cluster highlights the central role of digital transformation, open innovation, and industrial research in shaping competition and business models. The green cluster broadens the focus to include sustainability, strategy, and digitization, reflecting growing attention to long-term economic and environmental goals while the smaller red cluster introduces emerging themes around collaborative ecosystems, digital products, and value co-creation, pointing to a rising interest in participatory and networked innovation.

A key insight from this study is the strong link between open innovation and digital transformation, highlighting that digital innovation flourishes in ecosystems embracing external knowledge, collaboration, and openness to collaboration with external stakeholders. The presence of SMEs in the blue cluster and stakeholder engagement in the green cluster shows that innovation now extends beyond large firms, involving broader social and industrial networks. This supports earlier research on platform-based innovation, digital ecosystems, and the democratization of technology.

Despite recent progress, the lower strength and frequency of the red cluster point to gaps in research on digital product ecosystems, information management, and decision-making. While open innovation is well studied in the fields of manufacturing and R&D, its integration with digital collaboration, online platforms, and social networks remains limited. As AI, blockchain, and data-driven models grow in importance, future studies should examine how new digital technologies shape innovation governance, value creation,

and competitive advantage. Moreover, the funding landscape shows that research in this field is largely driven by European and Chinese institutions, notably through the European Commission, Horizon 2020 program, and Chinese national programs. This reflects a strong policy push for digital transformation and open innovation in these regions. However, it also highlights regional disparities, raising questions about investment and research activity elsewhere.

V. IMPLICATIONS

This study offers key theoretical insights into the evolving field of open innovation and digital innovation. The three identified clusters highlight the growing multidisciplinary nature of the field. The strong link between open innovation and digital transformation supports the view that innovation is shifting from firm-centric business models to ecosystem-driven processes shaped by collaboration, stakeholder engagement, and data. This aligns with dynamic capabilities theory, emphasizing the need for firms to adapt and use digital technologies and external knowledge. The growing focus on sustainability also points to the need for an integrated theory of sustainable digital innovation that connects technology with long-term economic and environmental goals.

From a practical perspective, this study offers valuable guidance for leaders, policymakers, and innovation managers navigating digital transformation. The prominence of digital technologies and open innovation in current studies highlights the need for firms to embrace knowledge-sharing, platform-based models, and collaborative ecosystems. The inclusion of SMEs highlights the importance of inclusive strategies that enable smaller firms, including start-ups to compete effectively. In addition, policymakers should support this shift by providing regulatory frameworks and funding that ensure access to digital infrastructure, expertise, and partnerships across firm sizes. Moreover, the red cluster highlights the need for new governance models to manage open knowledge flows, IP rights, and data-driven decision-making within innovation ecosystems. As firms increasingly rely on social networks, digital platforms, and co-creation, innovation management must evolve to incorporate real-time data, user insights, and AI-driven analytics into strategic decision-making.

Lastly, the concentration of research funding provided by governments in Europe and China highlights the critical role of policy in shaping national and regional innovation ecosystems. To reduce disparities and broaden the impact of digital innovation, governments should promote international collaboration and knowledge-sharing. Future research should, therefore, pursue comparative studies across regions to examine how policy, institutions, and market dynamics influence digital transformation and open innovation strategies. By drawing on research from technology management, organizational studies, and policy research, this study provides a comprehensive framework for understanding the evolution and impact of open innovation and digital innovation research. The study's findings highlight the need for adaptive, collaborative, and sustainable business models to ensure that digital transformation remains economically viable and socially inclusive amid rapid technological change.

VI. CONCLUSION

This study has several limitations. First, it relies on journal articles from the Scopus database (published between 2015-2025), excluding other databases, conference papers, industry reports, and grey literature. This may limit coverage of emerging research trends. Future research should, therefore, expand data sources to capture a broader scholarly landscape.

Second, the bibliometric approach emphasizes keyword co-occurrence and citation patterns, providing structural insights but not capturing theoretical depth or empirical nuance. Systematic reviews, meta-analyses, and qualitative content analysis could improve understanding of conceptual frameworks, causal mechanisms, and the impact of key studies. Third, the research and funding are geographically concentrated in Europe and China, with limited input from developing economies. Future studies should, therefore, explore regional differences in digital strategies, policies, and innovation adoption. Comparative cross-country analyses can reveal how institutional, cultural, and economic contexts influence open and digital innovation.

Finally, the social and ethical dimensions of digital innovation remain underexplored in current studies. As issues, such as data privacy, algorithmic bias, digital inclusion, and responsible AI become increasingly important in practice, future research should integrate these concerns into the study of open innovation ecosystems and governance.

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