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TOPICAL REVIEW

Co-Creating Value With Artificial Intelligence: A Bibliometric Approach to the Use of AI in Open Innovation Ecosystems

DIEGO CORRALES-GARAY, JOSÉ-LUIS RODRÍGUEZ-SÁNCHEZ, AND ANTONIO MONTERO-NAVARRO

Department of Business Economics (Adm., Dir. and Org.), Applied Economics II and Fundamentals of Economic Analysis, Facultad de Ciencias de la Economía y de la Empresa, Universidad Rey Juan Carlos, 28032 Madrid, Spain

Corresponding author: Diego Corrales-Garay (diego.corrales@urjc.es)

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ABSTRACT Open innovation, which blurs the boundaries of organizations using inflows and outflows of knowledge to boost their innovation processes, has transformed the innovation paradigm, evolving from higher degrees of protectionism to cooperative relationships. Nevertheless, frequently the management of the huge amount of information and data generated in an open innovation ecosystem requires the use of information and communication technologies. In this context, artificial intelligence can be a major help to profit from all the opportunities derived from open innovation. Considering the growing body of academic literature dealing with the use of artificial intelligence tools in the context of open innovation environments, the objective of this article is revealing the main references, the academic trends and the hottest topics dealing with this subject, disentangling the knowledge structure of the research through a bibliometric analysis carried out over 63 papers selected from Web of Science database, using both co-word analysis and bibliographic coupling. The recent burst in the academic production anticipates a potentially massive interest in this topic, which is studied by the literature at three different levels (operational, managerial, and social). This study reveals the existence of relevant research opportunities, specially related with the management of the potential conflicts that may stem from the fuzzy ownership of the data generated by an artificial intelligence, and the roles of the different agents in such context.

INDEX TERMS AI, artificial intelligence, bibliometric analysis, innovation ecosystems, OI, open innovation, value co-creation.

I. INTRODUCTION

The term open innovation (OI) was firstly used by the American Professor Henry Chesbrough in 2003. Chesbrough explores the transition of corporations from traditional 'closed innovation' approaches to a more inclusive and collaborative method of fostering innovation (OI) [1]. Therefore, Chesbrough defines OI as ''the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively'' [2].

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Westerman et al. [3] define digital transformation as the use of digital technologies in an organization to radically improve its performance and scope. One of the technologies involved in many processes of digital transformation is Artificial Intelligence (AI) [4], within the context of what has been called the Fourth Industrial Revolution (Industry 4.0) [5], [6].

According to the recent academic literature, the combination of OI and AI enables the creation of new intelligent systems oriented to improve the efficiency of business processes [7], [8], giving birth to new business models [7]. This convergence of AI and OI has caught the attention of the academics, giving birth to a growing body of scientific literature [9], [10], [11], [12].

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Until this moment, just one paper has delivered a review of the literature related with the link between OI and AI [10]. The purpose of that study "is to investigate the research streams of artificial intelligence and digital transformation to provide a deeper understanding of how companies can transform their business processes with artificial intelligence and use artificial intelligence technologies to manage open innovation" [10]. This purpose has led to the inclusion of the term "business model" in the document search, which restricted the analysis to just 23 articles. Though the relationship between OI and AI has a clear impact on business models, there are some other perspectives to analyze this literature that should be considered.

Therefore, there is still a need to study the academic production dealing with OI and AI from a holistic perspective, which can help the academic community to identify the main topics inside this research field, shedding a light on the foreseeable evolution of the research agenda dealing with the use of AI in OI ecosystems.

This article aims to thoroughly analyze the status of the research related to the application of AI technologies in OI ecosystems/processes, in order to disentangle the knowledge structure of this research area, dealing with the following research questions: 1) Which are the main authors and the most important papers dealing with the application of AI technologies in OI ecosystems?; 2) What are the main research topics dealing with the application of AI technologies in OI ecosystems?; 3) Which are the current research trends of AI technologies in OI ecosystems?

The answer to these three questions will be delivered through bibliometric analysis, which can be considered a standard when it comes to understanding the state of the art of a scientific field [13]. The use of bibliometric techniques has solved the problems stemming from traditional literature reviews, increasing the objectivity of the evaluation of academic progress. Specifically, in order to answer the first research question, a productivity analysis of the main sources and authors has been carried out. The second research question is boarded using co-word analysis, while a bibliographic coupling analysis has been carried out to deal with the third one, following the methodological path of previous reviews [14], [15].

After a brief theoretical framework (section II), which digs into the relationship between OI ecosystems and AI, the methodological section of this article (section III) presents the most appropriate bibliometric techniques in order to face the three research questions. The results of the analysis and their discussion are then abridged into section IV. Finally, the conclusions (section V) summarize the main findings of this study.

II. THEORETICAL FRAMEWORK. OPEN INNOVATION, DIGITAL TRANSFORMATION AND ARTIFICIAL INTELLIGENCE

As a result of the use of OI, considering the transparency exhibited in its inputs and outputs, OI has subsequently transformed the innovation paradigm [16], [17], giving birth to a new one that emphasizes the critical role of the exchange of knowledge and resources, both within and between organizations, in order to facilitate innovative activities [18]. Thus, OI can foster business ecosystems [19], while pushing new business strategies [20]. In the words of Alam et al. [21], OI can help to move from egosystems, traditional competitive environments where companies try to grant themselves a complete control over innovative resources, to OI ecosystems, participative contexts where organizations share knowledge resources across their boundaries.

A growing number of studies have found a positive association between OI and business performance, as it leads to a rise in the innovation activities of organizations [22], [23], [24], [25], [26], [27], which can in turn lead to new technological developments, as many academic papers show [28], [29], [30], [31].

According to Schwab [32], digitally transforming an organization goes much further than just digitalizing it, generating on organizational change where people, processes and business model use technology as a value generation tool for all the stakeholders.

OI is taking advantage of the digital transformation of organizations and society, through the development of new technologies [33], [34]. Amongst the different new tools, the potential of AI based technologies to create an adequate context that facilitates the exchange of information and data between different organizations, decisively pushing OI, must be stressed [9], [35].

The deployment of new business analytics capabilities can enhance competitive advantages in firms, optimizing the management of data/information generated by an OI ecosystem [36], [37]. The use of AI tools in OI ecosystems can establish the perfect breeding ground for entrepreneurship [38], [39], as well as contribute to the generation of sustainable applications in the context of OI ecosystems [40], [41].

One of the areas where AI means a major help for OI ecosystems is information and data management. According to Bahoo et al. [42], the combined development of AI along with big data management and the internet of things represents an opportunity for organizations in OI ecosystems, maximizing their efficiency in data collection and processing [23], [43]. Text mining and machine learning AI techniques assist companies in the management of the substantial volume of information released within an OI ecosystem [44]. The implementation of AI developments to explore open access knowledge repositories con also boost an OI ecosystem [45]. Moreover, text mining AI technologies are valuable to identify possible OI partners [46].

The use of AI technologies in the context of OI ecosystems has led to improvements in different areas and industries. It has helped to create new customer experiences in the tourism sector, enabling the development of smart destinations [47], [48]; in the area of healthcare, there have been noteworthy improvements dealing with illness prevention,

diagnostic methods, and the development of novel and more efficient therapies [49], [50], [51]; in the agriculture and food industries, the generation of AI developments can lead to value co-creation and OI ecosystems [43].

Consequently, there is a growing amount of business initiatives and projects related with data and AI, frequently spurred by public administrations [11], and OI ecosystems are pushing the digital transformation of organizations [52], [53], favoring the use of externally generated technologies in organizations [54], [55].

III. METHODOLOGY

A. SELECTION OF DOCUMENTS AND KEYWORDS

To carry out the selection of documents, Web of Science (WoS) database, which is commonly utilized for bibliometric research [56], particularly in the field of social sciences [57], has been used. Table 1 reflects the search strategy used.

TABLE 1. Search protocol.

Period	Type of document	Database	Search Criteria	Keywords
Until search date (9 November 2023)	-Article -Review	-Science Citation Index Expanded -Social Sciences Citation Index -Arts & Humanities Citation Index -Emerging Sources Citation Index	Topic	("open innovation" or open-innovation) and ("artificial intelligence" or artificial-intelligence or "AI")

This search led to an initial selection of 72 academic papers. After a thorough review conducted jointly by the authors of this paper, eliminating those which didn't have a direct relationship with the topic analyzed, a final selection of 63 studies was chosen.

B. EVALUATIVE TECHNIQUES

Evaluative techniques, such as the analysis of the evolution of the number of publications per year, or their classification regarding the journal or author(s), reveal the scientific impact and relevance of a research topic [58]. The concentration of papers in a given number of countries and institutions frequently reveals the degree of maturity of a research topic [59]. So, the use of productivity analysis, an evaluative technique which can be considered the starting point of bibliometric analysis [60], will provide an answer to research question #1 (Which are the main authors and the most important papers dealing with the application of AI technologies in OI ecosystems?). Therefore, a first approach to the literature regarding the use of AI in OI ecosystems will be carried out using some of the most frequent productivity analysis.

C. CO-WORD ANALYSIS

The bibliometric technique of co-word analysis was applied using the SciMAT software [61] to identify various interconnected themes related to OI and AI in the academic literature. This technique enables the identification of the relationships between the themes represented by the keywords found in the papers [62], giving an answer to research question #2 (What are the main research topics dealing with the application of AI technologies in OI ecosystems?).

In that sense, the article keywords were filtered following the criteria applied by Corrales-Garay et al. [63]:

-Initial number of keywords: 458.

-Synonymous terms (e.g., ''Artificial Intelligence'', ''AI'') were grouped as a single keyword.

-Terms that appear in their singular and plural forms (e.g., ''Dynamic Capability'', ''Dynamic Capabilities'') were grouped as the singular form.

-Derived terms (e.g., ''entrepreneurs'' and ''entrepreneurship'') were grouped.

-General terms that don't provide enough information for the study were removed (e.g., ''Framework'', ''Context'', ''Information'').

-Total number of keywords after filtering: 385.

The study is thereafter conducted by computing the co-occurrence matrix and equivalence index [64]. Then, the simple centers algorithm technique has been used to produce keyword subgroups [65]. Finally, thematic networks were established, with a maximum network size of 12 and minimum network size of 3.

Callon et al. [64] proposed using centrality and density measurements to create a strategic diagram that categorizes thematic networks into the following groups: emerging or disappearing topics, more developed and isolated topics, motor topics, and basic and transversal topics.

D. BIBLIOGRAPHIC COUPLING

Bibliographic coupling is one of the most popular bibliometric techniques used to outline the main trends inside a thematic field [66]. Coupling takes place when two papers reference the same document, revealing a more than likely relationship between both works, as they share the same theoretical/empirical bases [57]. Though co-word analysis is more spread amongst the scientific community, coupling shows some advantages, such as a better treatment of the most recent literature, something especially interesting in a research field which can still be considered young. Therefore, bibliographic coupling can be considered an ideal technique to deal with research question #3 (Which are the current research trends of AI technologies in OI ecosystems?), as it helps to identify the hottest research topics in this research field.

A bibliographic coupling analysis was carried out over the selection of 63 papers, using VOS Viewer software [67].

IV. RESULTS AND DISCUSSION

A. MAIN AUTHORS AND KEY SCIENTIFIC CONTRIBUTIONS

Fig. 1 shows the distribution per year of the 63 articles included in the selection, published from 2011 to 2023. The first paper regarding this topic was published in 2011 in the Journal of Universal Computer Science [68], with a limited academic impact, as it has been cited just seven times according to Web of Science Core Collection. After some years of scarce attention of the Research community, the interest in this topic started to grow in 2019, experiencing an exponential growth from 2020, with an extraordinary new impulse in 2023. So, from 2020 on the academic community has experienced a burst in the research regarding the use of AI in OI environments: in these four years, 57 new papers were published, achieving in that period 755 citations (Web of Science Core Collection).

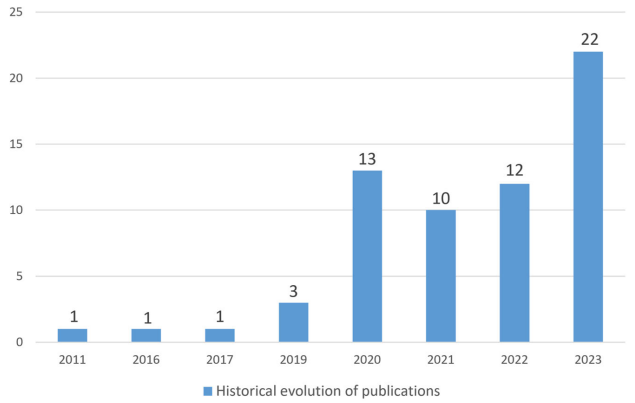


FIGURE 1. Historical evolution of publications.

Two phenomena can explain this evolution, that could be even considered a paradigmatic change. 2020 was a critical year in the digital transformation of many industries, and even of our entire lives, due to the pandemic caused by COVID-19 disease, and the isolation measures derived from it. In a world where the majority of the population, including research professionals, had to work separately, value co-creation became a critical tool, spurring the cooperation of different agents in OI environments sharing their knowledge and data. 2023 was, in turn, the year of AI, which has been the center of the social conversation since the launch of Chat GPT the 20th of November of 2022. The opportunities brought by this new generation of AI based tools couldn't be, and was not, ignored by the researchers, especially in contexts related to innovation such as OI ecosystems.

Table 2 gathers the main journals that have published papers about this topic. Only four of them have included more than one article: Journal of Business Research (JCR Q1), Sustainability (JCR Q2), Business Process Management Journal (JCR Q3) and Science Technology and Society (JCR Q4), while the other 49 journals have just published one study

TABLE 2. Article distribution by journal.

Journal	Number of papers
Sustainability	7
Science Technology and Society	3
Journal of Business Research	2
Business Process Management Journal	2

dealing with the use of AI tools in OI ecosystems. These four journals, as well as most of the publications that have boarded this research stream, are linked with business and management, as well as multidisciplinary sciences, revealing that the main concern about this topic is not technical, but organizational and managerial, as bibliographic coupling will confirm. Regarding the editorials (Table 3), some of the most productive and best positioned companies are also amongst the ones which have published more articles regarding this topic.

TABLE 3. Article distribution by editorial.

Editorial	Number of papers
MDPI	11
Elsevier	8
SAGE	5
Wiley	5
Emerald	3
Routledge	3
Springer	3
Inderscience	3
IEEE	3
Academy of Management	2

The relative lack of maturity of this research topic is revealed by the distribution of the academic production considering the authorship (Table 4). Though a bunch of researchers and academic groups have published more than one article, the majority of them have just authored one, tiptoeing into a topic that appears to be promising in the immediate future. Ferrás-Hernández has taken part in three articles, published in the International Journal of Business Environment, Journal of Cases on Information Technology and Review of Managerial Science, mainly concerned with the application of AI in service management, especially in the tourism industry. Arias-Pérez, who has published two articles dealing mainly with the managerial obstacles to OI related with AI, and Yun, who has mainly dealt with conceptual models regarding the intersection between OI and AI, are also outstanding authors.

The number of citations of a paper is one of the most frequently used ways to measure its impact. In the context of a bibliometric analysis, the most cited studies are normally seminal ones, which act as cornerstones in the development of a research stream. Also, some conceptual or methodological references can be sometimes found amongst the most cited articles [69]. Table 5 gathers the most cited articles devoted to

TABLE 4. Article distribution by author (2 or more papers).

Author	Title	Journal	Year
Ferrás-Hernández	Rethinking Industry 4.0: is there life beyond manufacturing?	International Journal of Business Environment	2020
	Smart Tourism Empowered by Artificial Intelligence: The Case of Lanzarote	Journal of Cases on Information Technology	2020
	Automating profitably together: Is there an impact of open innovation and automation on firm turnover?	Review of Managerial Science	2020
Arias-Pérez	Unlocking agility: Trapped in the antagonism between co-innovation in digital platforms, business analytics capability and external pressure for AI adoption?	Business Process Management Journal	2023
	Flipping the odds of AI-driven open innovation: The effectiveness of partner trustworthiness in counteracting interorganizational knowledge hiding	Industrial Marketing Management	2023
Yun	Not Deep Learning but Autonomous Learning of Open Innovation for Sustainable Artificial Intelligence	Sustainability	2016
	Introduction: Ambidextrous Open Innovation in the 4th Industrial Revolution	Science Technology and Society	2021

TABLE 5. Most frequently cited articles.

Author/s (year)	Journal	N
Himanen *et al.* (2019) [70]	Advanced Science	331
Misra *et al.* (2022) [43]	IEEE Internet of Things Journal	170
Yigitcanlar *et al.* (2020) [73]	Energies	142
Aquilani *et al.* (2020) [74]	Sustainability	48
Dabrowska *et al.* (2022) [75]	R & D Management	47
Hartmann and Henkel (2020) [71]	Academy of Management Discoveries	38
Wang *et al.* (2020) [51]	Current Opinion in Ophthalmology	23
Capozzi *et al.* (2021) [72]	Nutrients	22
Füller *et al.* (2021) [77]	International Journal of Project Management	19
Nylund *et al.* (2020) [7]	Review of Managerial Science	18
Yang *et al.* (2022) [76]	California Management Review	17

the study of the impact of AI tools in OI ecosystems according to the Web of Science Core Collection.

The most cited paper of the sample, Himanen et al. [70], deals with the boost experienced by materials science, pushed by open science movement and the DT of the industry, guided by technologies like AI. OI profits from the same groundings of open science, giving birth to another form of collaboration where the agents open their internal innovation processes letting knowledge circulate and be shared along the ecosystem, boosting internal innovation. As a result, such data platforms offer data and services that can be used both by academics and practitioners. Some other papers amongst the most cited also deal with the role of data management using AI technologies to profit from OI ecosystems [43], [51], [71]. In order to challenge the current consensus about ultra-processed food, Capozzi et al. [72] suggest using an OI perspective, in order to share the data coming from the different agents.

Some other papers are specifically concerned by the social impact of the digital transformation and its interaction with OI environments. Yigitcanlar et al. [73] carry out a literature review dealing with the creation of smarter cities (which could be considered the digital transformation of human habitats), while Aquilani et al. [74] consider that OI could be the transmission belt from the digital transformation of industries and society 5.0. Dabrowska et al. [75], in turn, carried out a comprehensive analysis of digital transformation, being the use of AI in OI ecosystems part of the process of digital transformation.

There is also a concern about value creation and its distribution in OI ecosystems, a context of cooperation where appropriating the profit generated can have additional difficulties. Nylund et al. [7], as well as Yang et al. [76], deal directly with this managerial problem. Crowdsourcing shares some of these value appropriation problems with OI, so Füller et al. [77] develop a crowdsourcing as a service approach that could help to optimize the profitability of crowdsourcing initiatives.

B. MAIN RESEARCH TOPICS

In order to identify the main topics analyzed by the academic literature dealing with OI and AI, a co-word analysis, using SciMAT bibliometric software [61], has been carried out. Fig. 2 shows the strategic diagram generated, where "Artificial Intelligence" is a motor topic; "Dynamic Capability" is a more developed and isolated topic; and "Industry 4.0" is a basic and transversal topic. No emerging or disappearing topics have been identified in this analysis.

-*"Artificial Intelligence"* is a motor topic that presents the highest h-index (14) and includes the highest number of articles (52). In spite of its popularity, there is no universally accepted definition of AI [78]. Following McCarthy, AI is "the science and engineering of making intelligent machines, especially intelligent computer programs. It is related to the similar task of using computers to understand human intelligence, but AI does not have to confine itself to methods that are biologically observable" [79].

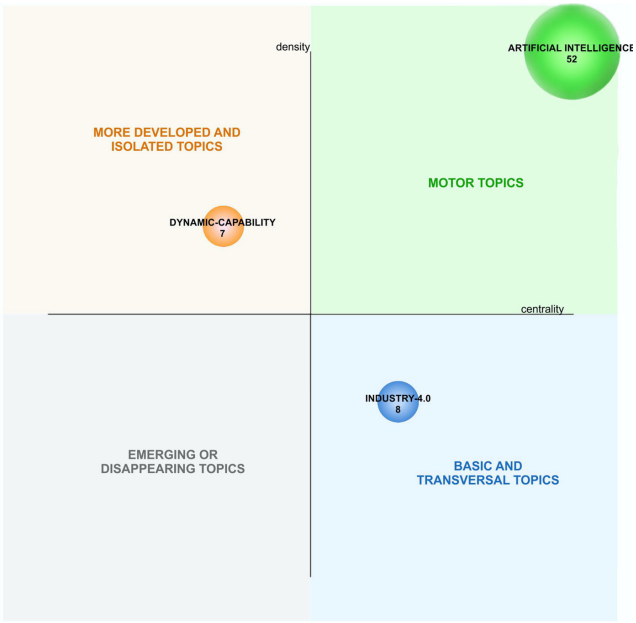


FIGURE 2. Strategic diagram per number of documents.

The analysis of this subnetwork (Fig. 3) reveals a strong link between ''Artificial Intelligence'' and ''Open Innovation'', given the opportunities brought by AI based technologies to foster cooperation and value co-creation amongst different organizations, potentially reinforcing OI ecosystems [9], [35]. So, OI and AI technologies result to be complementary, as OI means a cooperation scheme between different agents, which share their information and data (e.g., ''University''-''Firm'') [48], [80], while AI allow these agents to improve their internal processes profiting from this external information [7], [81], [82]. As it was pointed out in the theoretical framework section, some specific industries (''Health'') are profiting from this interaction [49], [50], [51].

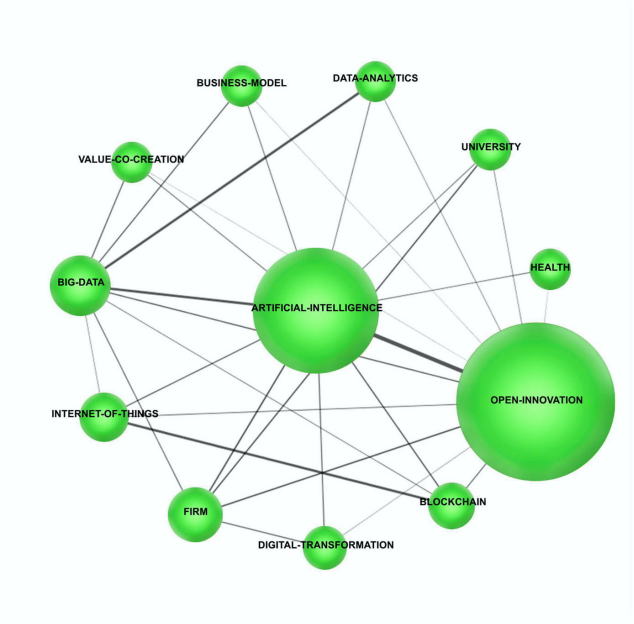


FIGURE 3. "Artificial Intelligence" subnetwork.

''Big Data'' also shows a strong connection with ''Artificial Intelligence'' and ''Data Analytics'', as some new AI applications are improving ''Data Analytics'' processes in organizations and OI ecosystems, facilitating the management of huge quantities of information (''Big Data'') [73], [82], [83], developing big data analytics capabilities. Also, the management of ''Big Data'' can boost ''Open Innovation'' through the creation of new open ''Business Models'', pushing ''Value Co-creation'' processes [74].

The strength of the link between ''Internet of Things'' and ''Blockchain'' is also remarkable, as they are two complementary technological developments associated with Industry 4.0. The data generated by Internet connected devices (''Internet of Things'') can be registered using ''Blockchain'', granting their safety and traceability [43], [84]; this data can, in turn, be processed using AI tools, such as machine learning [43] potentially improving the operational and decision making processes both in organizations and ''Open Innovation'' ecosystems [10]. In this context, the development of ''Artificial Intelligence'' based tools is leading companies (''Firm'') into ''Digital Transformation'' processes, intended to harness and generate competitive advantages [36], [38].

-*''Dynamic Capability''* is a more developed and isolated topic, which includes 7 documents and has an h-index of 3. This term was originally defined as ''the firm's ability to integrate, build, and reconfigure internal and external competences to address rapidly changing environments'' [85].

The three terms included in this subnetwork (Fig. 3) are connected, as firms that use big data and AI technological developments are more likely to develop ''Microfoundations'' of digital dynamic capabilities (''Dynamic Capability'') [54], [82]. The ''Absorptive Capacity'' is, in turn, related with the organization's ability to identify the value of novel knowledge, integrate it, and apply it for commercial purposes [86]. Therefore, ''Absorptive Capacity'' is commonly considered as an inherent dynamic capability [82], [87]. In the context of OI ecosystems, which release huge amounts of data, dynamic capabilities are critical, as they allow organizations to profit from this massive influx of information [82].

-*''Industry 4.0''* is a basic and transversal topic that contains 8 documents and has an h-index of 5. The concept was initially coined in 2011 Hannover Fair [88], [89]. McKinsey & Company [90] state that ''Industry 4.0—also called the Fourth Industrial Revolution or 4IR— is the next phase in the digitization of the manufacturing sector, driven by disruptive trends including the rise of data and connectivity, analytics, human-machine interaction, and improvements in robotics''. Nevertheless, there is still a lack of academic consensus about this concept [91], [92].

The three terms included in this subnetwork (Fig. 4), are linked, as the ''Implementation'' of ''Cyber Physical Systems'' is one of the cornerstones of ''Industry 4.0'' [93], [94] and can eventually lead to Industry 5.0 [94], [95]. In this

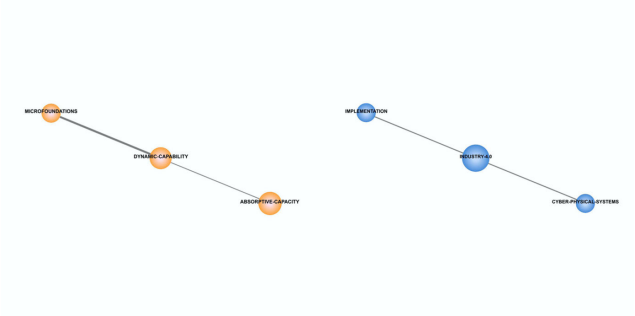


FIGURE 4. "Dynamic Capability" and "Industry 4.0" subnetworks.

context, ''Cyber Physical Systems'' are advanced systems inside Internet of things environment that combine physical and computational capabilities [74]. The Internet of Things, big data and AI are some of the groundings of ''Industry 4.0'' and may lead to what is being called Industry 5.0 [96], [97].

C. CURRENT RESEARCH TRENDS

Fig. 5 shows the results of a coupling analysis including just the papers that have been cited five times at least, criteria that facilitates the connection between the different papers analyzed. The figure reveals the existence of six different clusters of papers dealing with OI and AI. These clusters could be revealing the most important current research trends in the topic analyzed. Nevertheless, after analyzing the contents of the research included in each of these clusters, the main trends in the research in OI and AI could be rearranged into three different levels: Day-to-day level, dealing with the operational concerns and the solution of specific problems; Company level, regarding the organizational concerns, associated with the generation of new management models, especially those oriented to innovation ecosystems and granting value appropriation; and stakeholders' level, which mainly deals with people and society concerns.

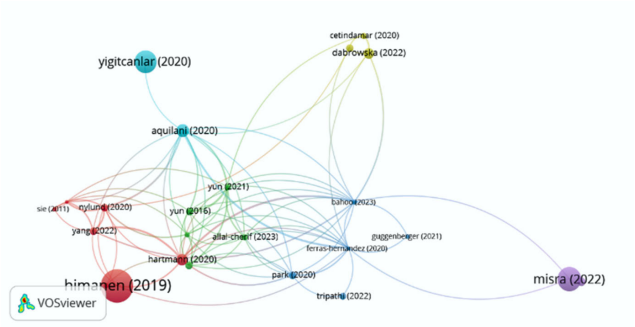


FIGURE 5. Bibliographic coupling analysis.

1) DAY-TO-DAY LEVEL: OPERATIONAL MANAGEMENT

The combination of OI and AI has provided organizations with many new ground-level opportunities, based on the finding and implementation of learning capacities in the context of the digital transformation of companies. Inside this group of papers, we can distinguish between those included in the deep-blue one, concerned with process redesign and process management; and the purple cluster, associated with the application of industry 4.0 to the agriculture and food industry.

Inside the *deep-blue cluster*, and starting from the knowledge of Lean Six Sigma, which has been reckoned as one of the most important quality management systems, Park et al. [8] analyze its challenges to fit in the fourth industrial revolution era, advocating for a new 3S (simple, speedy and smart) paradigm in the use of Lean Six Sigma, and specifically the fit of OI and AI in order to foster a total quality management model directly related to value co-creation. Also linked with operational excellence, Tripathi et al. [98] propose a shop floor management method in the context of industry 4.0, based on OI and lean and smart manufacturing companies, which uses AI and IoT amongst other tools. Ferrás-Hernández [38] explore the opportunities stemming from Industry 4.0, which could be considered a part of a dynamic digital OI ecosystem, in sectors not related with manufacturing.

Two more papers are also included in this cluster. Guggenberger et al. [84] analyze the lessons learnt from the COVID-19 pandemic about how to face future crises. AI and the Internet of Things are remarked by the authors as powerful tools that have shown their potential in the aforementioned scenario. OI can also abridge the distance between research communities that need to share, even being isolated, the value generated by their developments. Finally, Bahoo et al. [42] develop a literature review of the intersection between AI and corporate innovation, including OI.

The *purple cluster* gathers two papers related with the operational application of OI and AI in the specific field of agriculture and food industries. Misra et al. [43], one of the most cited papers in the selection, deliver an overview of the intersection between big data and AI in this economic sector, combining both the data delivered by IoT and the analysis of the information coming from social media, which can be the origin of value co-creation and OI. Capozzi et al. [72], in turn, challenge the monolithic negative perception of ultra-processed food, remarking the need for new paradigms of food evaluation that consider both internal and external factors that are normally not considered in the analysis. To put this vision into practice, they advocate for a collective view, with an OI spirit, which profits from the analytical capacity of AI.

2) COMPANY LEVEL: ORGANIZATIONAL CONCERNS

Industry 4.0, and specifically the link between OI and AI, poses many new managerial challenges for the majority of organizations. This group of papers gathers the green cluster, which includes research about the characteristics of these new managerial models; the yellow cluster, which mostly includes stories about how specific innovative ecosystems have worked; and the red cluster, which deals with one of the

most critical issues regarding OI (and, in this case, its link with AI), which is value appropriation.

Inside the *green cluster*, Füller et al. [77] have observed that both OI and crowdsourcing don't fit easily with traditional innovation structures and management practices. Therefore, they suggest that organizations which want to profit adequately from the opportunities generated by crowdsourcing should develop specific capabilities which could use digital platforms and AI, generating a crowdsourcing as a service approach that would prepare the organization to engage in successive crowdsourcing processes. Allal-Chérif et al. [81] paper deals with the born sustainable companies, organizations that have not adapted to the social requirements of sustainability but were created sustainable. Through the study of the case of Patagonia, the authors stress the importance of open sustainable product innovation, as well as the use of AI and big data to catch up with the changes of the environment, both in environmental and social terms.

The learning process of AI is still a disputed matter. Yun et al. [41] develop a new conceptual autonomous learning model for AI, considering the human bounded rationality established in the studies of Herbert Simon, compensated by the opportunities brought to firms by OI. This model can be, in turn, relevant in order to develop an OI strategy. Some of the authors of the previous study presented in Yun et al. [99] an ambidextrous (both inbound and outbound) model of OI, which could adequately fit the requirements of the current servitisation trend in the context of industry 4.0.

Finally, in the context of mega-bank mergers, Thomas [100] studied the role played by technological convergence, in order to create a competitive advantage for the resulting entities. As the author stresses, technological convergence pushes inter-organizational interactions, which can also result in the creation of OI ecosystems.

The *yellow cluster* gravitates especially in the study of some of these innovative ecosystems. Cetindamar et al. [101] study the knowledge spillovers that have taken place in the field of AI within the entrepreneurial ecosystem of Sidney between 2000 and 2018. An OI ecosystem is considered by the authors the most extreme example of a flexible entrepreneurial ecosystem, where the actions of the organizations included contribute to the generation of a common innovation. Yang et al. [35], in turn, have studied the creation of an AI collaborative business ecosystem in the Chinese fish-farming industry, which gravitates around Celefish, an agricultural science and technology firm. The generation of new knowledge and the OI processes are frequently, especially those oriented to sustainable development. Finally, this cluster also includes a multilevel analysis of the impacts of digital transformation, which goes beyond the organizational level of the analysis, delivered by Dabrowska et al. [75].

The *red cluster* is mainly concerned with the management of value appropriation in the context of OI, where different participants may hold diverse profit expectations. Nylund et al. [7] can raise the optimism, as their study shows how cooperating with suppliers in OI schemes has increased the turnover of firms engaged in industrial automation processes. Nevertheless, finding the factors that may foster or undermine this value creation, as well as value appropriation, are critical issues to be addressed.

As it was pointed out in the productivity analysis, Himanen et al. [70], the most cited article in the selection, remarks the major development experienced by materials science coming from data driven science, pushed by open science movement, public funding and technological tools like AI. Nevertheless, some challenges may be decelerating the scientific advances, being the different perceptions of the appropriability, and the resulting divergent interest of industry and academy, one of the matters to be solved. This goal divergence is also present in the paper of Uribe-Echeberria et al. [102], which shows how Spanish Research and Technology Organizations embrace OI schemes, showing a bigger concern for improving the IT derived technologies and granting their sustainability than for increasing the efficiency and reducing the technological risk. Sie et al. [68] studied the kind of partners needed in innovation networks, finding out that power itself is not the cornerstone for successful cooperation in innovation, but can be useful in some specific combinations of agents.

Hartmann and Henkel [71] stress the importance of data, which has caused the direct implication of some of the larger IT corporations in the development of AI, considering that these data resources give them an interesting complementary asset that can facilitate the appropriation of the value generated by AI research. Finally, based on how IBM failed to appropriate a relevant part of the value generated by IBM Watson Health, Yang et al. [76] propose the use of a strong appropriability regime when working in an OI scheme in order to grant an adequate portion of the value for the company.

3) STAKEHOLDER LEVEL: PEOPLE AND SOCIETY CONCERNS

Apart from its organizational and managerial implications, Industry 4.0 has undeniable impacts on our way of living. Neither our social interactions, nor the places where we live and work, are free from the influence of AI or Internet of Things. OI can deliver an opportunity to build joint value in these social structures. The papers considering the impact of OI and AI in these social structures are included in the *light-blue cluster*.

Smart cities, defined by the authors as "urban locations that are enabled by community, technology, and policy to deliver productivity, innovation, livability, wellbeing, sustainability, accessibility, good governance, and good planning", are analyzed by Yigitcanlar et al. [73]. The paper delivers a review about the role of AI in the generation of knowledge, which may stem from OI schemes. Aquilani et al. [74] focus on the transition to Society 5.0 pushed by Industry 4.0, stressing the role that both OI and value co-creation play in the social translation of this new industrial revolution.

Table 6 sums up the main findings deliver from the analysis.

TABLE 6. Main findings summary table.

Research Questions	Main findings
RQ1. Which are the main authors and the most important papers dealing with the application of AI technologies in OI ecosystems?	Growing trend in the academic literature, pushed by COVID 19 crisis and the popularization of AI (specially since the launching of Chat GPT)
	Certain degree of academic immaturity of the topic, resulting in low degrees of concentration in authors, journals, and editorials
	OI generates huge amounts of data and information. AI can help to process such amounts of data
	Himanen *et al.* (2019), Misra *et al.* (2022) and Yigitcanlar *et al.* (2020) are the most cited papers; Ferrás-Hernández, Arias-Pérez and Yun are the most prolific authors
RQ2. What are the main research topics dealing with the application of AI technologies in OI ecosystems?	"Artificial Intelligence" is a motor topic that presents the highest h-index (14) and includes the highest number of articles, showing a strong link with "Open Innovation"
	The strength of the link between "Internet of Things" and "Blockchain" is also remarkable, as they are two complementary technological developments associated with Industry 4.0
	"Dynamic Capability" is a more developed and isolated topic, and "Industry 4.0" is a basic and transversal topic
RQ3. Which are the current research trends of AI technologies in OI ecosystems?	There are three academic approaches to this topic: an operational one, related with the solution of specific technical problems; a managerial one, related with the appropriation of the rents stemming from shared knowledge; and a social one, which deals with the socio-economic impact of the use of AI in OI environments
	Some of the issues that will be boarded by the literature in the immediate future are the management of potential resource ownership conflicts, the transition to a new cooperative society and the role of the different agents, mainly public administrations

V. CONCLUSION

Dealing with the first research question, the academic literature has reflected the growing importance of the application of AI in OI ecosystems. The pandemic of COVID-19 meant a boost in the digital transformation of societies, leading to more cooperative ways of work, including OI. The burst of AI systems, where the initial release of Chat GPT can be considered the starting point, has increased the awareness and the interest of researchers in the analysis of the opportunities brought by AI to OI environments, revealing that this topic will more than likely experience an exponential development in the immediate future.

The analysis also reveals that the academic concern about the topic is not especially technological, but managerial: the majority of papers are especially interested in aspects like the generation of dynamic capabilities and, through them, competitive advantages. This is not just reflected in the institutions where the authors work, but clearly in the sources where their articles are published. Nevertheless, hot topics like this one frequently show a certain degree of immaturity, which is reflected in extremely low degrees of concentration in authors, journals or even editorials. Though some of the papers have been frequently cited, there could be interesting research gaps to be covered.

The identification of the main research topics (research question #2) has been carried out through co-word analysis. "Artificial Intelligence" appears as a motor topic (and the most relevant one), while "Dynamic Capability" is a more developed and isolated topic, and "Industry 4.0" is a basic and transversal topic. This analysis stresses the complementarity of AI and OI, as the first pushes the second, enabling sharing knowledge processes amongst organizations, generating new opportunities for competitive advantages through the use of external data and innovation.

Bibliographic coupling has revealed the hottest topics related with AI in OI ecosystems (research question #3), which can be summed up in three different approaches: an operational one, which can potentially affect an endless number of industries, solving technical problems; a managerial one, especially concerned with the generation and appropriation of additional rents in OI environments; and a social one, considering that the use of AI to achieve value co-creation can lead to new social habits and habitats, such as smart cities.

The roadmap for new academic research is nearly unexplored, full of new paths and research opportunities to be boarded. Amongst them, this article stresses the importance of managing potential conflicts, derived from the fuzzy ownership of the data and information generated by an AI; a deeper analysis of the transition of a new cooperative society, where OI ecosystems have much to teach and AI much to help; and the role of public administrations, especially in the regulation of generative AI tools.

This paper isn't free of some limitations. The study just considered research included in the Web of Science collection, which might potentially exclude a reduced number of papers. The selection process is mainly objective, but the last filtering step has been delivered by the authors, which could generate some subjectivity. Finally, some of the articles included might have no keywords, which in fact would exclude them from the co-word analysis.

REFERENCES

[1] H. Chesbrough, "The open innovation paradigm," in *Open Innovation: The New Imperative for Creating and Profiting From Technology*. Boston, MA, USA: Harvard Bus. School Press, 2003, pp. 43–62.

[2] H. Chesbrough, "New puzzles and new findings," in *Open Innovation: Researching a New Paradigm*, H. Chesbrough, W. Vanhaverbeke, and J. West, Eds. Oxford, U.K.: Oxford Univ. Press, 2006, pp. 15–34.

[3] G. Westerman, D. Bonnet, and A. McAfee, "The nine elements of digital transformation," *MIT Sloan Manag. Rev.*, vol. 55, no. 3, pp. 1–6, 2014.

[4] K. Kim and B. Kim, "Decision-making model for reinforcing digital transformation strategies based on artificial intelligence technology," *Information*, vol. 13, no. 5, p. 253, May 2022, doi: 10.3390/info13050253.

[5] F. J. Cantú-Ortiz, N. Galeano Sánchez, L. Garrido, H. Terashima-Marin, and R. F. Brena, "An artificial intelligence educational strategy for the digital transformation," *Int. J. Interact. Design Manuf.*, vol. 14, no. 4, pp. 1195–1209, Dec. 2020, doi: 10.1007/s12008-020-00702-8.

[6] J. Rana and Y. Daultani, "Mapping the role and impact of artificial intelligence and machine learning applications in supply chain digital transformation: A bibliometric analysis," *Oper. Manage. Res.*, vol. 16, no. 4, pp. 1641–1666, Dec. 2023, doi: 10.1007/s12063-022-00335-y.

[7] P. A. Nylund, X. Ferras-Hernandez, and A. Brem, "Automating profitably together: Is there an impact of open innovation and automation on firm turnover?" *Rev. Managerial Sci.*, vol. 14, no. 1, pp. 269–285, Feb. 2020, doi: 10.1007/s11846-018-0294-z.

[8] S. H. Park, S. M. Dahlgaard-Park, and D.-C. Kim, "New paradigm of lean six sigma in the 4th industrial revolution era," *Qual. Innov. Prosperity*, vol. 24, no. 1, pp. 1–16, Apr. 2020, doi: 10.12776/qip.v24i1.1430.

[9] T. Broekhuizen, H. Dekker, P. de Faria, S. Firk, D. K. Nguyen, and W. Sofka, "AI for managing open innovation: Opportunities, challenges, and a research agenda," *J. Bus. Res.*, vol. 167, Nov. 2023, Art. no. 114196, doi: 10.1016/j.jbusres.2023.114196.

[10] A. Kuzior, M. Sira, and P. Brożek, "Use of artificial intelligence in terms of open innovation process and management," *Sustainability*, vol. 15, no. 9, p. 7205, Apr. 2023, doi: 10.3390/su15097205.

[11] M. Priestley and E. Simperl, "Open innovation programmes related to data and AI: How do the entrepreneurial orientations of startups align with the objectives of public funders?" *Data Policy*, vol. 4, May 2022, Art. no. e16, doi: 10.1017/dap.2022.8.

[12] J. Arias-Pérez and T. Huynh, "Flipping the odds of AI-driven open innovation: The effectiveness of partner trustworthiness in counteracting interorganizational knowledge hiding," *Ind. Marketing Manage.*, vol. 111, pp. 30–40, May 2023, doi: 10.1016/j.indmarman.2023.03.005.

[13] N. Donthu, W. Reinartz, S. Kumar, and D. Pattnaik, "A retrospective review of the first 35 years of the international journal of research in marketing," *Int. J. Res. Marketing*, vol. 38, no. 1, pp. 232–269, Mar. 2021, doi: 10.1016/j.ijresmar.2020.10.006.

[14] I. Bautista-Bernal, C. Quintana-García, and M. Marchante-Lara, "Research trends in occupational health and social responsibility: A bibliometric analysis," *Saf. Sci.*, vol. 137, May 2021, Art. no. 105167, doi: 10.1016/j.ssci.2021.105167.

[15] T. Poje and M. Zaman Groff, "Mapping ethics education in accounting research: A bibliometric analysis," *J. Bus. Ethics*, vol. 179, no. 2, pp. 451–472, Aug. 2022, doi: 10.1007/s10551-021-04846-9.

[16] D. Corrales-Garay, M. Ortiz-De-Urbina-Criado, and E.-M. Mora-Valentín, "A research agenda on open data impact process for open innovation," *IEEE Access*, vol. 8, pp. 34696–34705, 2020, doi: 10.1109/ACCESS.2020.2974378.

[17] E. K. R. E. Huizingh, "Open innovation: State of the art and future perspectives," *Technovation*, vol. 31, no. 1, pp. 2–9, Jan. 2011, doi: 10.1016/j.technovation.2010.10.002.

[18] A. Abouzeedan and T. Hedner, "Organization structure theories and open innovation paradigm," *World J. Sci., Technol. Sustain. Develop.*, vol. 9, no. 1, pp. 6–27, Apr. 2012, doi: 10.1108/20425941211223598.

[19] I. Cirule, I. Uvarova, and G. Caune, "European trends in business incubation through open innovation approach," *Eur. Integr. Stud.*, vol. 1, no. 16, pp. 111–124, Jun. 2022, doi: 10.5755/j01.eis.1.16.31635.

[20] E. Harison and H. Koski, "Applying open innovation in business strategies: Evidence from Finnish software firms," *Res. Policy*, vol. 39, no. 3, pp. 351–359, Apr. 2010, doi: 10.1016/j.respol.2010.01.008.

[21] M. A. Alam, D. Rooney, and M. Taylor, "From ego-systems to open innovation ecosystems: A process model of inter-firm openness," *J. Product Innov. Manage.*, vol. 39, no. 2, pp. 177–201, Mar. 2022, doi: 10.1111/jpim.12615.

[22] E. L. Alvarez-Aros, C. A. Bernal-Torres, and Y. S. Tovar, "Colaboración externa de la innovación abierta y desempeño financiero de las PYMES en tamaulipas, México," *Revista de Administracao de Empresas*, vol. 62, no. 3, Jun. 2022, Art. no. e2020-0483, doi: 10.1590/s0034-759020220301.

[23] M. Dabić, T. O. Posinković, B. Vlačić, and R. Gonçalves, "A configurational approach to new product development performance: The role of open innovation, digital transformation and absorptive capacity," *Technol. Forecasting Social Change*, vol. 194, Sep. 2023, Art. no. 122720, doi: 10.1016/j.techfore.2023.122720.

[24] M. A. A. M. Harif, M. Nawaz, and W. U. Hameed, "The role of open innovation, hotel service quality and marketing strategy in hotel business performance," *Heliyon*, vol. 8, no. 9, Sep. 2022, Art. no. e10441, doi: 10.1016/j.heliyon.2022.e10441.

[25] S. Majumdarr, S. A. Dasgupta, and R. Farooq, "Open innovation and firm performance in emerging economies: A bibliometric and TCCM analysis review," *Manage. Decis.*, early access, Sep. 2023, doi: 10.1108/MD-10-2022-1484.

[26] A. Nurjanah and E. Ardyan, "Open innovation strategies and SMEs' performance: The mediating role of eco-innovation in environmental uncertainty," *Manage. Syst. Prod. Eng.*, vol. 30, no. 3, pp. 214–222, Sep. 2022, doi: 10.2478/mspe-2022-0027.

[27] S. Ouechtati, K. K. Masmoudi, and C. Slim, "The impact of social capital on open innovation: The Tunisian SMEs case," *Int. J. Innov. Manage.*, vol. 26, no. 1, Jan. 2022, Art. no. 2250001, doi: 10.1142/s1363919622500013.

[28] N. Coco, C. Colapinto, and V. Finotto, "Fostering digital literacy among small and micro-enterprises: Digital transformation as an open and guided innovation process," *R&D Manage.*, vol. 54, no. 1, pp. 118–136, Jan. 2024, doi: 10.1111/radm.12645.

[29] S. Fernandes and G. Castela, "Start-ups' accelerators support open innovation in Portugal," *Int. J. Innov. Learn.*, vol. 26, no. 1, p. 82, Jun. 2019, doi: 10.1504/ijil.2019.100522.

[30] M. Masucci, S. Brusoni, and C. Cennamo, "Removing bottlenecks in business ecosystems: The strategic role of outbound open innovation," *Res. Policy*, vol. 49, no. 1, Feb. 2020, Art. no. 103823, doi: 10.1016/j.respol.2019.103823.

[31] A. Schmidt, T. J. M. Mom, and H. W. Volberda, "Factors influencing technology adoption in a traditional multinational energy company," *Research-Technology Manage.*, vol. 66, no. 5, pp. 36–43, Sep. 2023, doi: 10.1080/08956308.2023.2235535.

[32] K. Schwab, "Impact," in *The Fourth Industrial Revolution*. Sydney, NSW, Australia: Currency, 2017, pp. 28–103.

[33] M. Bogers, H. Chesbrough, and C. Moedas, "Open innovation: Research, practices, and policies," *California Manage. Rev.*, vol. 60, no. 2, pp. 5–16, Feb. 2018, doi: 10.1177/0008125617745086.

[34] H. Jing and G. Qu, "How to promote open innovation in restricted situations? Digital transformation perspective," *Kybernetes*, early access, Jul. 2023, doi: 10.1108/k-05-2023-0825.

[35] X. Yang, D. Cao, J. Chen, Z. Xiao, and A. Daowd, "AI and IoT-based collaborative business ecosystem: A case in Chinese fish farming industry," *Int. J. Technol. Manage.*, vol. 82, no. 2, pp. 151–171, Jun. 2020, doi: 10.1504/ijtm.2020.107856.

[36] J. Arias-Pérez, J. Chacón-Henao, and E. López-Zapata, "Unlocking agility: Trapped in the antagonism between co-innovation in digital platforms, business analytics capability and external pressure for AI adoption?" *Bus. Process Manage. J.*, vol. 29, no. 6, pp. 1791–1809, Oct. 2023, doi: 10.1108/bpmj-10-2022-0484.

[37] J. Arias-Pérez, A. Coronado-Medina, and G. Perdomo-Charry, "Big data analytics capability as a mediator in the impact of open innovation on firm performance," *J. Strategy Manage.*, vol. 15, no. 1, pp. 1–15, Feb. 2022, doi: 10.1108/jsma-09-2020-0262.

[38] X. F. Hernández, "Rethinking Industry 4.0: Is there life beyond manufacturing," *Int. J. Bus. Environ.*, vol. 11, no. 4, pp. 404–416, Nov. 2020, doi: 10.1504/ijbe.2020.111403.

[39] S. L. C. Ottonicar and M. L. P. Valentim, "A indústria 4.0 e a inovação aberta em aceleradoras de startups," *AtoZ: Novas Práticas em Informação e Conhecimento*, vol. 10, no. 3, pp. 1–10, Sep. 2021, doi: 10.5380/atoz.v10i3.81882.

[40] T. Li, J. Luo, K. Liang, C. Yi, and L. Ma, "Synergy of patent and open-source-driven sustainable climate governance under green AI: A case study of TinyML," *Sustainability*, vol. 15, no. 18, p. 13779, Sep. 2023, doi: 10.3390/su151813779.

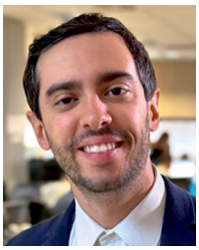
[41] J. Yun, D. Lee, H. Ahn, K. Park, and T. Yigitcanlar, "Not deep learning but autonomous learning of open innovation for sustainable artificial intelligence," *Sustainability*, vol. 8, no. 8, p. 797, Aug. 2016, doi: 10.3390/su8080797.

[42] S. Bahoo, M. Cucculelli, and D. Qamar, "Artificial intelligence and corporate innovation: A review and research agenda," *Technol. Forecasting Social Change*, vol. 188, Mar. 2023, Art. no. 122264, doi: 10.1016/j.techfore.2022.122264.

[43] N. N. Misra, Y. Dixit, A. Al-Mallahi, M. S. Bhullar, R. Upadhyay, and A. Martynenko, "IoT, big data, and artificial intelligence in agriculture and food industry," *IEEE Internet Things J.*, vol. 9, no. 9, pp. 6305–6324, May 2022, doi: 10.1109/JIOT.2020.2998584.

[44] H. Lee, K. Choi, D. Yoo, Y. Suh, S. Lee, and G. He, "Recommending valuable ideas in an open innovation community: A text mining approach to information overload problem," *Ind. Manage. Data Syst.*, vol. 118, no. 4, pp. 683–699, May 2018, doi: 10.1108/imds-02-2017-0044.
[45] A. M. J. Skulimowski and T. Köhler, "A future-oriented approach to the selection of artificial intelligence technologies for knowledge platforms," *J. Assoc. Inf. Sci. Technol.*, vol. 74, no. 8, pp. 905–922, Aug. 2023, doi: 10.1002/asi.24763.
[46] B. Yoon and B. Song, "A systematic approach of partner selection for open innovation," *Ind. Manage. Data Syst.*, vol. 114, no. 7, pp. 1068–1093, Aug. 2014, doi: 10.1108/imds-03-2014-0086.
[47] X. Ferràs, E. L. Hitchen, E. Tarrats-Pons, and N. Arimany-Serrat, "Smart tourism empowered by artificial intelligence: The case of lanzarote," *J. Cases Inf. Technol.*, vol. 22, no. 1, pp. 1–13, Aug. 2022, doi: 10.4018/jcit.2020010101.
[48] C. G. Gómez and L. V. Frías, "Inteligencia artificial y desarrollo sostenible del turismo: El valor de los acuerdos de colaboración," *ESIC Market*, vol. 53, no. 3, p. e281, Dec. 2022, doi: 10.7200/esicm.53.281.
[49] Y. Kamada et al., "SWOT analysis of noninvasive tests for diagnosing NAFLD with severe fibrosis: An expert review by the JANIT forum," *J. Gastroenterol.*, vol. 58, no. 2, pp. 79–97, Feb. 2023, doi: 10.1007/s00535-022-01932-1.
[50] B. S. Kelly, A. Kirwan, M. S. Quinn, A. M. Kelly, P. Mathur, A. Lawlor, and R. P. Killeen, "The ethical matrix as a method for involving people living with disease and the wider public (PPI) in near-term artificial intelligence research," *Radiography*, vol. 29, pp. S103–S111, May 2023, doi: 10.1016/j.radi.2023.03.009.
[51] S. Y. Wang, S. Pershing, and A. Y. Lee, "Big data requirements for artificial intelligence," *Current Opinion Ophthalmol.*, vol. 31, no. 5, pp. 318–323, Sep. 2020, doi: 10.1097/icu.0000000000000676.
[52] A. Abdurrahman, A. Gustomo, E. A. Prasetio, and S. Rustiadi, "Designing an open innovation framework for digital transformation based on systematic literature review," *J. Inf. Syst. Eng. Bus. Intell.*, vol. 8, no. 2, pp. 100–108, Oct. 2022, doi: 10.20473/jisebi.8.2.100-108.
[53] H. Chung and K. Kim, "Can open innovation improve technological outcomes for digital transformation: Structural approach to strategic decisions of Korean ICT SMEs," *Managerial Decis. Econ.*, vol. 44, no. 8, pp. 4404–4421, Dec. 2023, doi: 10.1002/mde.3958.
[54] A. Čirjevskis, "Exploring coupled open innovation for digital servitization in grocery retail: From digital dynamic capabilities perspective," *J. Risk Financial Manage.*, vol. 15, no. 9, p. 411, Sep. 2022, doi: 10.3390/jrfm15090411.
[55] L. Minati, V. Movsisyan, M. Mccormick, K. Gyozalyan, T. Papazyan, H. Makaryan, S. Aldrigo, T. Harutyunyan, H. Ghaltaghchyan, C. Mccormick, and M. Fandrich, "IFLEX: A fully open-source, high-density field-programmable gate array (FPGA)-based hardware co-processor for vector similarity searching," *IEEE Access*, vol. 7, pp. 112269–112283, 2019, doi: 10.1109/ACCESS.2019.2934715.
[56] Z. Liu, Y. Yin, W. Liu, and M. Dunford, "Visualizing the intellectual structure and evolution of innovation systems research: A bibliometric analysis," *Scientometrics*, vol. 103, no. 1, pp. 135–158, Apr. 2015, doi: 10.1007/s11192-014-1517-y.
[57] I. Zupic and T. Čater, "Bibliometric methods in management and organization," *Organizational Res. Methods*, vol. 18, no. 3, pp. 429–472, Jul. 2015, doi: 10.1177/1094428114562629.
[58] C. Michael Hall, "Publish and perish? Bibliometric analysis, journal ranking and the assessment of research quality in tourism," *Tourism Manage.*, vol. 32, no. 1, pp. 16–27, Feb. 2011, doi: 10.1016/j.tourman.2010.07.001.
[59] H. Keathley-Herring, E. Van Aken, F. Gonzalez-Aleu, F. Deschamps, G. Letens, and P. C. Orlandini, "Assessing the maturity of a research area: Bibliometric review and proposed framework," *Scientometrics*, vol. 109, no. 2, pp. 927–951, Nov. 2016, doi: 10.1007/s11192-016-2096-x.
[60] N. Donthu, S. Kumar, D. Mukherjee, N. Pandey, and W. M. Lim, "How to conduct a bibliometric analysis: An overview and guidelines," *J. Bus. Res.*, vol. 133, pp. 285–296, Sep. 2021, doi: 10.1016/j.jbusres.2021.04.070.
[61] M. J. Cobo, A. G. López-Herrera, E. Herrera-Viedma, and F. Herrera, "SciMAT: A new science mapping analysis software tool," *J. Amer. Soc. Inf. Sci. Technol.*, vol. 63, no. 8, pp. 1609–1630, Aug. 2012, doi: 10.1002/asi.22688.
[62] Q. He, "Knowledge discovery through co-word analysis," *Libr. Trends*, vol. 48, no. 1, pp. 133–159, 1999, doi: 2142/8267.
[63] D. Corrales-Garay, M. Ortiz-de-Urbina-Criado, and E.-M. Mora-Valentín, "Knowledge areas, themes and future research on open data: A co-word analysis," *Government Inf. Quart.*, vol. 36, no. 1, pp. 77–87, Jan. 2019, doi: 10.1016/j.giq.2018.10.008.
[64] M. Callon, J. P. Courtial, and F. Laville, "Co-word analysis as a tool for describing the network of interactions between basic and technological research: The case of polymer chemsitry," *Scientometrics*, vol. 22, no. 1, pp. 155–205, Sep. 1991, doi: 10.1007/bf02019280.
[65] M. J. Cobo, A. G. López-Herrera, E. Herrera-Viedma, and F. Herrera, "Science mapping software tools: Review, analysis, and cooperative study among tools," *J. Amer. Soc. Inf. Sci. Technol.*, vol. 62, no. 7, pp. 1382–1402, Jul. 2011, doi: 10.1002/asi.21525.
[66] J. Martyn, "Bibliographic coupling," *J. Documentation*, vol. 20, no. 4, p. 236, Apr. 1964, doi: 10.1108/eb026352.
[67] N. J. van Eck and L. Waltman, "Software survey: VOSviewer, a computer program for bibliometric mapping," *Scientometrics*, vol. 84, no. 2, pp. 523–538, Aug. 2010, doi: 10.1007/s11192-009-0146-3.
[68] R. Sie, M. Bitter-Rijpkema, and P. Sloep, "What's in it for me? Recommendation of peers in networked innovation," *J. Univers. Comput. Sci.*, vol. 17, no. 12, pp. 1659–1672, Aug. 2011, doi: 10.3217/jucs-017-12-1659.
[69] I. Tahamtan, A. S. Afshar, and K. Ahamdzadeh, "Factors affecting number of citations: A comprehensive review of the literature," *Scientometrics*, vol. 107, no. 3, pp. 1195–1225, Jun. 2016, doi: 10.1007/s11192-016-1889-2.
[70] L. Himanen, A. Geurts, A. S. Foster, and P. Rinke, "Data-driven materials science: Status, challenges, and perspectives," *Adv. Sci.*, vol. 6, no. 21, Nov. 2019, Art. no. 1900808, doi: 10.1002/advs.201900808.
[71] P. Hartmann and J. Henkel, "The rise of corporate science in AI: Data as a strategic resource," *Acad. Manage. Discoveries*, vol. 6, pp. 359–381, Apr. 2020, doi: 10.5465/amd.2019.0043.
[72] F. Capozzi, F. Magkos, F. Fava, G. P. Milani, C. Agostoni, A. Astrup, and I. S. Saguy, "A multidisciplinary perspective of ultra-processed foods and associated food processing technologies: A view of the sustainable road ahead," *Nutrients*, vol. 13, no. 11, p. 3948, Nov. 2021, doi: 10.3390/nu13113948.
[73] T. Yigitcanlar, K. Desouza, L. Butler, and F. Roozkhosh, "Contributions and risks of artificial intelligence (AI) in building smarter cities: Insights from a systematic review of the literature," *Energies*, vol. 13, no. 6, p. 1473, Mar. 2020, doi: 10.3390/en13061473.
[74] B. Aquilani, M. Piccarozzi, T. Abbate, and A. Codini, "The role of open innovation and value co-creation in the challenging transition from Industry 4.0 to society 5.0: Toward a theoretical framework," *Sustainability*, vol. 12, no. 21, p. 8943, Oct. 2020, doi: 10.3390/su12218943.
[75] J. Dąbrowska, A. Almpanopoulou, A. Brem, H. Chesbrough, V. Cucino, A. Di Minin, F. Giones, H. Hakala, C. Marullo, A. Mention, L. Mortara, S. Nørskov, P. A. Nylund, C. M. Oddo, A. Radziwon, and P. Ritala, "Digital transformation, for better or worse: A critical multi-level research agenda," *R&D Manage.*, vol. 52, no. 5, pp. 930–954, Nov. 2022, doi: 10.1111/radm.12531.
[76] J. Yang, H. Chesbrough, and P. Hurmelinna-Laukkanen, "How to appropriate value from general-purpose technology by applying open innovation," *California Manage. Rev.*, vol. 64, no. 3, pp. 24–48, May 2022, doi: 10.1177/00081256211041787.
[77] J. Füller, K. Hutter, and N. Kröger, "Crowdsourcing as a service—From pilot projects to sustainable innovation routines," *Int. J. Project Manage.*, vol. 39, no. 2, pp. 183–195, Feb. 2021, doi: 10.1016/j.ijproman.2021.01.005.
[78] P. Mikalef and M. Gupta, "Artificial intelligence capability: Conceptualization, measurement calibration, and empirical study on its impact on organizational creativity and firm performance," *Inf. Manage.*, vol. 58, no. 3, Apr. 2021, Art. no. 103434, doi: 10.1016/j.im.2021.103434.
[79] J. McCarthy. (Nov. 2007). *What is Artificial Intelligence*. [Online]. Available: https://www-formal.stanford.edu/jmc/whatisai.pdf
[80] C. F. Baban, M. Baban, and A. Rangone, "Investigating determinants of Industry–University collaboration in an open innovation context: Comparative evidence from an exploratory study," *Sci., Technol. Soc.*, vol. 26, no. 3, pp. 482–502, Nov. 2021, doi: 10.1177/09717218211020475.
[81] O. Allal-Chérif, J. Costa Climent, and K. J. U. Berenguer, "Born to be sustainable: How to combine strategic disruption, open innovation, and process digitization to create a sustainable business," *J. Bus. Res.*, vol. 154, Jan. 2023, Art. no. 113379, doi: 10.1016/j.jbusres.2022.113379.

[82] M. Pedota, "Big data and dynamic capabilities in the digital revolution: The hidden role of source variety," *Res. Policy*, vol. 52, no. 7, Sep. 2023, Art. no. 104812, doi: 10.1016/j.respol.2023.104812.
[83] Z. Xue, Q. Li, and X. Zeng, "Social media user behavior analysis applied to the fashion and apparel industry in the big data era," *J. Retailing Consum. Services*, vol. 72, May 2023, Art. no. 103299, doi: 10.1016/j.jretconser.2023.103299.
[84] T. Guggenberger, J. Lockl, M. Röglinger, V. Schlatt, J. Sedlmeir, J.-C. Stoetzer, N. Urbach, and F. Völter, "Emerging digital technologies to combat future crises: Learnings from COVID-19 to be prepared for the future," *Int. J. Innov. Technol. Manage.*, vol. 18, no. 4, Jun. 2021, Art. no. 2140002, doi: 10.1142/s0219877021400022.
[85] D. J. Teece, G. Pisano, and A. Shuen, "Dynamic capabilities and strategic management," *Strategic Manag. J.*, vol. 18, no. 7, pp. 509–533, Aug. 1997, doi: 10.1002/(SICI)1097-0266(199708)18:7<509::AID-SMJ882>3.0.CO;2-Z.
[86] W. M. Cohen and D. A. Levinthal, "Absorptive capacity: A new perspective on learning and innovation," *Administ. Sci. Quart.*, vol. 35, no. 1, pp. 128–152, Mar. 1990, doi: 10.2307/2393553.
[87] S. A. Zahra and G. George, "Absorptive capacity: A review, reconceptualization, and extension," *Acad. Manage. Rev.*, vol. 27, no. 2, p. 185, Apr. 2002, doi: 10.2307/4134351.
[88] G. Culot, G. Nassimbeni, G. Orzes, and M. Sartor, "Behind the definition of Industry 4.0: Analysis and open questions," *Int. J. Prod. Econ.*, vol. 226, Aug. 2020, Art. no. 107617, doi: 10.1016/j.ijpe.2020.107617.
[89] S. Luthra and S. K. Mangla, "Evaluating challenges to Industry 4.0 initiatives for supply chain sustainability in emerging economies," *Process Saf. Environ. Protection*, vol. 117, pp. 168–179, Jul. 2018, doi: 10.1016/j.psep.2018.04.018.
[90] McKinsey & Company. (Aug. 2022). *What are Industry 4.0, the Fourth Industrial Revolution, and 4IR*. [Online]. Available: https://www.mckinsey.com/featured-insights/mckinsey-explainers/what-are-industry-4-0-the-fourth-industrial-revolution-and-4ir
[91] E. Hofmann and M. Rüsch, "Industry 4.0 and the current status as well as future prospects on logistics," *Comput. Ind.*, vol. 89, pp. 23–34, Aug. 2017, doi: 10.1016/j.compind.2017.04.002.
[92] E. Oztemel and S. Gursev, "Literature review of Industry 4.0 and related technologies," *J. Intell. Manuf.*, vol. 31, no. 1, pp. 127–182, Jan. 2020, doi: 10.1007/s10845-018-1433-8.
[93] A. Cammarano, V. Varriale, F. Michelino, and M. Caputo, "A framework for investigating the adoption of key technologies: Presentation of the methodology and explorative analysis of emerging practices," *IEEE Trans. Eng. Manag.*, vol. 71, pp. 3843–3866, 2023, doi: 10.1109/TEM.2023.3240213.
[94] E. Hozdić and I. Makovec, "Evolution of the human role in manufacturing systems: On the route from digitalization and cybernation to cognitization," *Appl. Syst. Innov.*, vol. 6, no. 2, p. 49, Apr. 2023, doi: 10.3390/asi6020049.
[95] V. Roblek, M. Meško, and I. Podbregar, "Mapping of the emergence of society 5.0: A bibliometric analysis," *Organizacija*, vol. 54, no. 4, pp. 293–305, Dec. 2021, doi: 10.2478/orga-2021-0020.
[96] S. K. Jagatheesaperumal, M. Rahouti, K. Ahmad, A. Al-Fuqaha, and M. Guizani, "The duo of artificial intelligence and big data for Industry 4.0: Applications, techniques, challenges, and future research directions," *IEEE Internet Things J.*, vol. 9, no. 15, pp. 12861–12885, Aug. 2022, doi: 10.1109/JIOT.2021.3139827.
[97] S. Kumar and R. R. Mallipeddi, "Impact of cybersecurity on operations and supply chain management: Emerging trends and future research directions," *Prod. Oper. Manage.*, vol. 31, no. 12, pp. 4488–4500, Dec. 2022, doi: 10.1111/poms.13859.
[98] V. Tripathi, S. Chattopadhyaya, A. K. Mukhopadhyay, S. Sharma, C. Li, S. Singh, W. U. Hussan, B. Salah, W. Saleem, and A. Mohamed, "A sustainable productive method for enhancing operational excellence in shop floor management for Industry 4.0 using hybrid integration of lean and smart manufacturing: An ingenious case study," *Sustainability*, vol. 14, no. 12, p. 7452, Jun. 2022, doi: 10.3390/su14127452.
[99] J. J. Yun, Z. Liu, and X. Zhao, "Introduction: Ambidextrous open innovation in the 4th industrial revolution," *Sci., Technol. Soc.*, vol. 26, no. 2, pp. 183–200, Jul. 2021, doi: 10.1177/09717218211006969.
[100] A. Thomas, "Convergence and digital fusion lead to competitive differentiation," *Bus. Process Manage. J.*, vol. 26, no. 3, pp. 707–720, Oct. 2019, doi: 10.1108/bpmj-01-2019-0001.
[101] D. Cetindamar, T. Lammers, and Y. Zhang, "Exploring the knowledge spillovers of a technology in an entrepreneurial ecosystem—The case of artificial intelligence in Sydney," *Thunderbird Int. Bus. Rev.*, vol. 62, no. 5, pp. 457–474, Sep. 2020, doi: 10.1002/tie.22158.
[102] R. U. Echebarria, R. L. Dorronsoro, and J. I. I. Lopez, "Open innovation in research and technology organisations: An exploration of the phenomenon," *Dyna*, vol. 95, no. 1, pp. 74–80, Jan. 2020, doi: 10.6036/9166.



DIEGO CORRALES-GARAY received the Ph.D. degree in management from Universidad Rey Juan Carlos, Spain. He is currently an Associate Professor in management with Universidad Rey Juan Carlos. His research has been published in *Government Information Quarterly*, IEEE Access, *Business Process Management Journal*, *The International Journal of Management Education among other journals*. His research interests include open data, open innovation, entrepreneurship, and business models.

JOSÉ-LUIS RODRÍGUEZ-SÁNCHEZ is Ph.D. and Associate Professor of Management at Universidad Rey Juan Carlos, Spain. His research interests include strategic alliances, cooperative agreements, merger and acquisitions, and human resources management. His research has been published in *International Journal of Hospitality Management*, *Finance Research Letters*, *The International Journal of Management Education*, *Heliyon*, *International Journal of Environmental Research and Public Health*, *International Journal of Manpower*, *Journal of Organizational Change Management*, *Frontiers in Psychology among other journals*.

ANTONIO MONTERO-NAVARRO is Ph.D. and Associate Professor of Management at Universidad Rey Juan Carlos, Spain. His research interests include cooperative agreements, human resources management, and financial literacy and inclusion. His research has been published in *Finance Research Letters*, *Research in International Business and Finance*, *International Journal of Environmental Research and Public Health*, *Frontiers in Psychology among other journals*.