

# The innovation journey and crossroads of sustainability, resilience and human-centeredness: a systematic literature review

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Innovation  
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## Abstract

**Purpose** – This study aims to undertake a comprehensive analysis of innovation models, tracing their evolution from Innovation 1.0 to Innovation 4.0 and introducing the concept of Innovation 5.0. It explores the intersection between innovation models and the principles of sustainability, resilience and human-centeredness, providing insights into their implications for Industry 5.0, and their potential to foster a resilient ecosystem amidst challenges and multiple crisis.

**Design/methodology/approach** – To achieve this objective, the authors used a systematic literature review approach, considering academic articles on Innovation 4.0, Industry 5.0 (specifically in the context of innovation) and helix models of innovation. The authors conducted thematic analysis and content analysis, followed by keyword co-occurrence analysis, enabling us to systematically synthesize and interpret the relevant literature.

**Findings** – The results conclude that Innovation 5.0 is a new paradigm for innovation that fosters broader societal engagement, and emphasizes sustainability, resilience and human-centeredness. Innovation 5.0 is evolving, but it has the potential to transform the way we produce, consume and live. Using insights from the sextuple helix model, this research leverages media and ICT as sixth helix vital role of knowledge sharing, digital transformation, innovation ecosystem and next industrial revolution in this process.

**Originality/value** – This study contributes to the ongoing discourse on exploring Innovation 5.0 through the sextuple helix model, offering a fresh perspective on innovation models and their collaborative potential. Its contribution lies in providing practical insights into the transition to Innovation 5.0, emphasizing the need for sustainability, regulatory support and awareness while also offering clear recommendations for future research.

**Keywords** Innovation evolution, Innovation 5.0, Industry 5.0, Sextuple helix model of innovation, Resilient innovation

**Paper type** Literature review

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## 1. Introduction

The cyclical relationship between technological progress and innovation is a dynamic interplay shaped by societal, technological and organizational changes (Sun *et al.*, 2022). It involves a continuous loop where technological advancements drive innovation, and in turn, innovation fuels further technological progress. The recent industrial revolution shows how technological progress and new ideas have transformed industry, stressing the link between both concepts. The last stages of industrial revolutions have coined the notion of Industry 4.0, as a technology-driven industrial paradigm shift that may lead to layoffs, and the notion of Industry 5.0, more focused on human, environmental and social components (Jafari *et al.*, 2022).

In addition, multiple articles studied innovation from various perspectives, some of them focusing on the description of how innovation evolves (Streitz *et al.*, 2022). Notably, these discussions are related to and trace the evolution of helix models from the foundational triple helix to more complex structures such as quadruple and quintuple helix models. These models emphasize different levels of collaboration between different societal units, facilitating and accelerating innovation, enhancing the integration of knowledge, resources and expertise from various sectors, and ultimately leading to the development of more innovative and impactful solutions, products and services (Carayannis *et al.*, 2012). The proposed sextuple helix model, with its sixth helix representing the role of media and ICTs, seeks to evolve innovation models while addressing ongoing debate about the specific nature of this helix (Wahana *et al.*, 2022). This aligns with the principles of open innovation, which emphasizes the dissemination of technological information, where the role of media and ICT is crucial (Gupta *et al.*, 2017).

However, further research is needed to conceptualize and understand the evolving innovation models and their practical implications (Aslam *et al.*, 2020), specifically under the lens of Industry 5.0 that focuses on minimizing environmental impact, enhances adaptability to disruptions and prioritizes human well-being and societal equity. This tripartite focus of Industry 5.0 is referred as resilient, human-centered and sustainable, for its environmental, social and economic implications (Ivanov, 2023). By studying the evolution of innovation models and drawing insights from the transition of Industry 4.0 to Industry 5.0, this study delves into the nascent concept of Innovation 5.0, conducting a systematic literature review of related concepts that comprised Innovation 4.0, the role of innovation in Industry 5.0 and the sextuple helix model, which expands on the quintuple helix model by adding the helix of media and ICT (Carayannis *et al.*, 2012). Therefore, our study addresses these research questions (RQs):

- RQ1. What are the prevalent themes in the literature related to the nascent concept of Innovation 5.0?
- RQ2. How the analysis of the evolution of innovation models and the shift to Industry 5.0 impact in the conceptualization of Innovation 5.0?
- RQ3. How Innovation 5.0 can be understood in the light of the sextuple helix model?

This study provides a detailed description of evolution of innovation adding to the literature on innovation models. The sextuple helix model helps conceptualize Innovation 5.0, revealing its consequences for companies and their industries. Our research on the transition from Innovation 4.0 to Innovation 5.0 can reshape current paradigms in innovation theory and practice in the field of innovation models examined in this study.

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## 2. Conceptual framework

The recent debate on the conceptualization of Innovation 5.0 rests on the evolution of innovation models, which shows the progression from Innovation 1.0 to 4.0 (Costa and Matias, 2020; Hafkesbrink and Schroll, 2011), where each stage reflects technological advancements and societal impacts, culminating in a collaborative and forward-thinking approach to Innovation 5.0. The historical development of innovation models is deeply connected with the different stages of industrial revolutions (Reischauer, 2018), as well as the different helix models (Leydesdorff, 2000). These models, starting from the triple helix, which emphasizes collaboration between academia, industry and government (Leydesdorff, 2000), have expanded over time. The quadruple helix includes civil society, whereas the quintuple helix includes environmental spheres (Carayannis *et al.*, 2022). The inclusion of media and ICT as sixth helix would encompass the broader societal context in which innovation occurs (Wahana *et al.*, 2022).

Regarding innovation models, the first stage in their evolution starts with the traditional approach of closed innovation or Innovation 1.0, wherein companies relied solely on internal research and development (Hafkesbrink and Schroll, 2011). This approach evolved into the open innovation paradigm or Innovation 2.0, which advocates for the integration of external ideas and collaborations (Chesbrough, 2006). Throughout our conceptualization process, insights are derived from the open innovation theory, which posits that the primary method of encouraging additional innovation entities to participate and advance innovation is through the disclosure of technological information (Gao *et al.*, 2020; Gupta *et al.*, 2017; Zhang and Ming, 2023).

In a later stage, Innovation 3.0, or embedded innovation, was defined by Hafkesbrink and Schroll (2011) as a firm's essential competence to synchronize organizational structures, processes and culture with open collaborative learning processes in surrounding communities, networks and stakeholder groups. The new innovation paradigm integrates varied external and internal information, including talents and technical capabilities for commercial use.

Innovation 4.0 refers to a paradigm shift in which sustainable innovation is driven by the establishment of dynamic and collaborative ecosystems. This approach integrates digitalization, technological start-ups, open innovation and supportive policies, leveraging the collective potential of various stakeholders such as community, academia, industry, government and the public. The key features include a multi-layered effect on regional development, a focus on smart and responsible innovation cycles and a commitment to green governance for a sustainable and collaborative future (Costa and Matias, 2020; Olesiński and Rzepka, 2021).

By incorporating Industry 5.0 approach within the sextuple helix model, a robust theoretical foundation is established to comprehend the evolving landscape of innovation and contribute to the conceptualization of Industry 5.0's innovative paradigm. Industry 5.0 is focused on a tripartite division, which considers its orientation toward a more sustainable, resilient and human-centered approach to innovation, which encompasses integration of sustainable practices, development of systems and processes that can withstand disruptions and adapt to changing circumstances, ensuring the well-being of individuals and communities throughout the innovation process (Ghobakhloo *et al.*, 2022; Ivanov, 2023; Nahavandi, 2019; Sindhwani *et al.*, 2022).

## 3. Methodology

We conducted a systematic literature review adopting the PRISMA guidelines to ensure a transparent, structured and comprehensive approach (Kitchenham, 2004).

3.1 Search strategy

Because WoS and Scopus journals overlap and produce similar result (Gao *et al.*, 2020; Salim *et al.*, 2019), we chose Scopus considering its broad and interdisciplinary coverage and strong bibliometrics aligning with our research goals to reduce redundancy. The search of publications through Scopus was conducted with a refinement period from April 1, 2023, to December 24, 2023. No search period was specified; however, earliest identified articles were published in 2006. The search involved three topics, as Figure 1 shows: all articles pertaining to Innovation 4.0, all articles related to Industry 5.0 that explicitly discussed or explored innovation and the articles on helix models of innovation. We combined these queries with Boolean operators, control keyword associations in search queries for consolidating information retrieval. We followed a tried-and-true keyword identification and search term creation process (Aromataris and Riitano, 2014) along with wildcard “innovat\*” and broader searches to ensure we retrieved all relevant papers.

3.2 Data extraction and quality assessment

We used PRISMA recommendations as a globally recognized and highly followed set of guidelines for reporting systematic reviews and meta-analyses particularly in the domain of business management. In the process of data extraction and quality assessment, we identified the articles, and afterward, applied a process of screening, eligibility and inclusion. As exhibited in Figure 2, the total number of articles retrieved from Scopus using the aforementioned keywords in title, abstract and keywords were 871. From them, 620 articles were excluded because they did not belong to the selected subject areas (business management and accounting, economics, econometrics and finance), they were not articles or reviews published in peer-reviewed journals or conference proceedings or were not written in English. The titles and abstracts of the remaining articles were screened to exclude those not mainly focused on innovation (34 articles were excluded by identifying those lacking keywords or title terms directly related to innovation concepts), or not addressing innovation evolution issues (16 articles were excluded by examining the abstracts of remaining articles to assess whether they discussed the dynamic nature of innovation and its patterns). The remaining 201 articles were eligible for full-text assessment. While some of the articles discussed innovation and evolution, they did so within the context of specific domains, such as human resource management or digital platforms (Cooke, 2018); therefore, after full-text review, 13 more articles were excluded for being considered irrelevant or insignificant to provide insights on the broader evolution of innovation across industries and sectors. Bibliometric, thematic and content analyses were conducted on the 188 articles that composed the final sample.

3.3 Analytical strategy

We used VOSviewer and Biblioshiny software for bibliometric analysis, encompassing keyword co-occurrence analysis, publication overview, annual scientific production and country collaboration maps. VOSviewer is commonly used for visualizing and analyzing

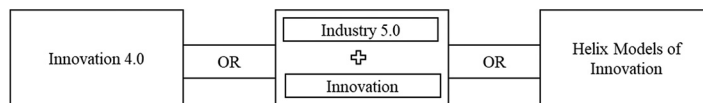
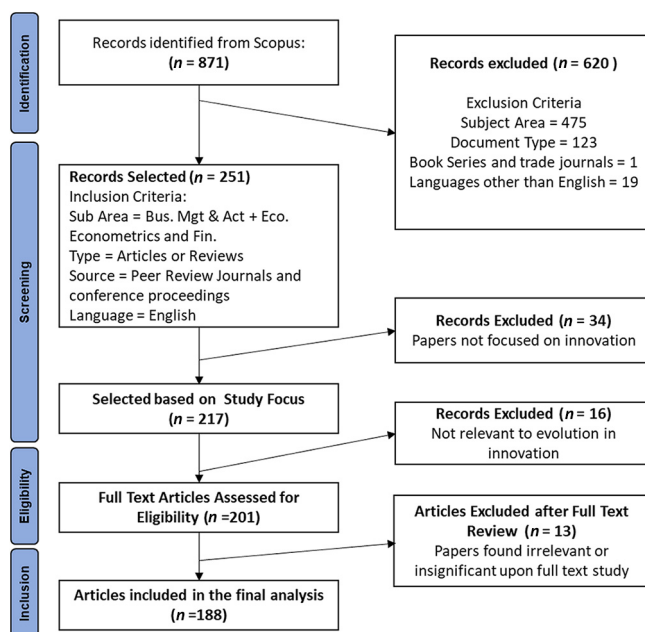


Figure 1.  
Keywords

Source: Authors' own creation



Source: Authors' own creation

Figure 2.  
PRISMA

bibliometric networks, while Biblioshiny provides interactive tools for bibliometric exploration (Di Vaio *et al.*, 2022).

For co-occurrence analysis, we considered all keywords of all the papers in our data set, because they include both author keywords and predefined ones, grouping some words, if necessary, to provide a more holistic understanding of each paper's scope, while in the title and abstracts, these terms can appear separately provoking higher confusion. By merging duplicates, synonyms and reconciling singulars and plurals within the database's Excel sheet, redundancy within the clusters identified from co-occurrence analysis was significantly managed.

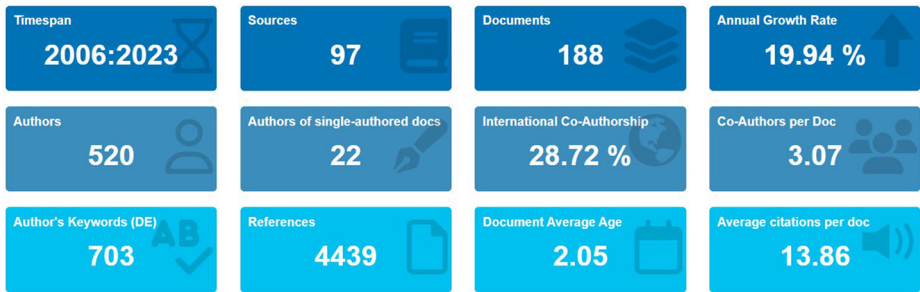
For thematic analysis, we meticulously analyzed the co-occurrence network's data using manual coding and an Excel spreadsheet to identify and understand relevant and emerging innovation themes. An organized summary that highlighted overlapping or related themes was created by categorizing each theme in its unique characteristics and context. We identified themes that could be considered overlapped, but they were differentiated, if possible, based on their respective focus, depth and perspective. A thorough coding procedure, developed in an iterative way by all the co-authors of this research assisted in separating the themes within each group.

Following thematic analysis, an in-depth content analysis was conducted on the text data extracted from the selected literature in each group of papers. Analyzing characteristics and current implications of each theme helped predict innovation evolution. The process examined Innovation 5.0 prerequisites, challenges and opportunities. This meticulous examination served to enhance our comprehension toward the nascent concept of Innovation 5.0.

#### 4. Results and discussion

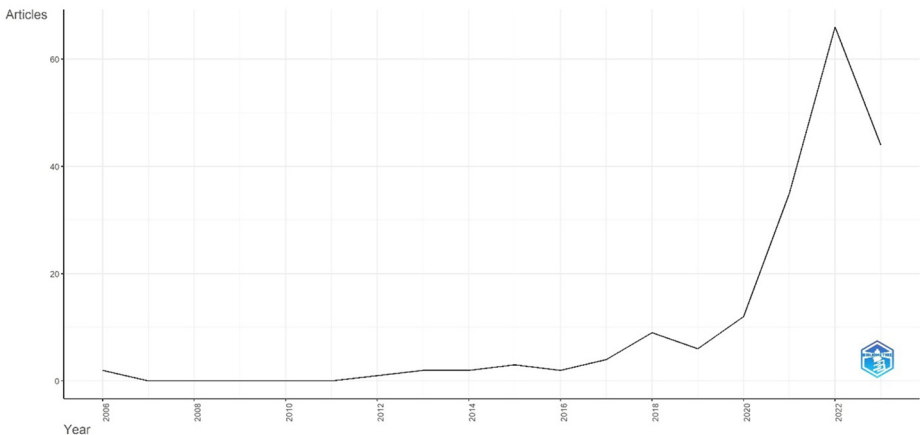
Before addressing the RQs, we conducted a comprehensive bibliometric analysis to provide a thorough overview of the selected literature. Figure 3 explains the overview of the 188 articles collected, including international co-authorship that indicates 28.72%, with an average of 3.07 co-authors per document and more than 13.86 citations. Additionally, Figure 4 describes the evolution in number of articles published revealing a notable surge post-2020, and a decrease in 2023, which may be partially explained by data collection period ending on December 24, 2023, potentially undercounting the actual number of annual published works. This surge might indicate a pivotal moment or a shift in the field, potentially influenced by global events, technological advancements or emerging trends.

The provided three-column plot (Figure 5) effectively depicts the distribution of authors, keywords and affiliations in the relevant research domain explaining the field’s progress, its global impact reach and interconnectedness and what opportunities exist for further collaboration and knowledge exchange. It highlights the prominence of prolific authors like Carayannis, Campbell and Leydesdorff, who have contributed to multiple research articles. Additionally, the recurring keywords like open innovation, Industry 4.0 and 5.0 and the triple helix underscore the significance of these concepts in the field. These findings are



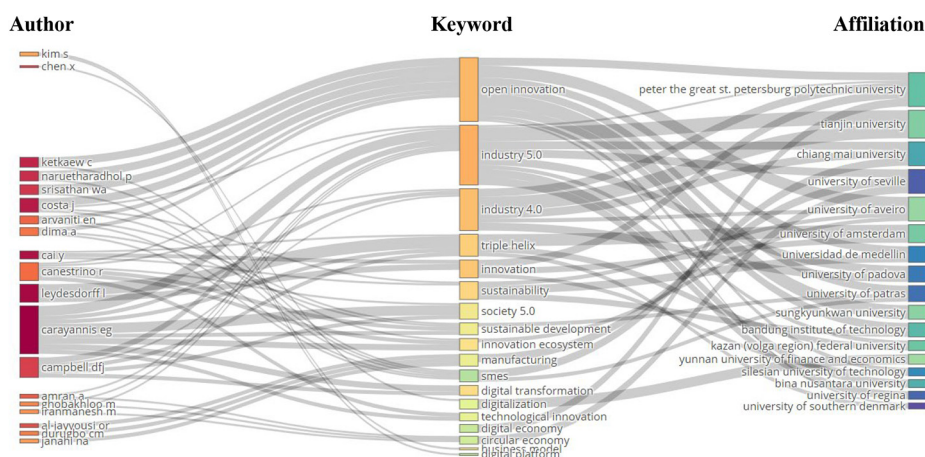
**Figure 3.**  
Overview of the articles selected

**Source:** Authors’ own creation



**Figure 4.**  
Annual scientific production

**Source:** Authors’ own creation



**Figure 5.**  
Three-field map:  
author, keyword,  
affiliation

**Source:** Authors' own creation

further supported by the affiliations associated with these keywords, indicating the involvement of diverse institutions, such as Tianjin University and Polytechnic University of Peter the Great in Sant Petersburg, in these areas of research.

Examining author collaborations across countries is crucial because it explains research breadth and depth and reflects the global impact of the domain. Table 1 illustrates collaboration among at least two countries and shows that authors from the UK and Brazil jointly contributed to four articles. Authors from Italy, on the other hand, engaged in more extensive collaboration, with eight articles involving partnerships with The Netherlands, the UK and the USA, as detailed below (Carayannis *et al.*, 2023). Corresponding authors from USA and China are also collaborating with other authors from Austria and the UK in different scientific research.

#### 4.1 Prevalent themes

Through the keyword co-occurrence analysis, we identified prevalent themes to better understand innovation evolution and the emergence of the new notion of Innovation 5.0.

Corresponding authors' country	Collaborating authors' country	Frequency
UK	BRAZIL	4
ITALY	UK	3
ITALY	USA	3
USA	AUSTRIA	3
CHINA	UK	2
CHINA	USA	2
FINLAND	NORWAY	2
FRANCE	SPAIN	2
ITALY	THE NETHERLANDS	2
MALAYSIA	AUSTRALIA	2

**Table 1.**  
Author  
collaborations across  
countries

**Source:** Authors' own creation

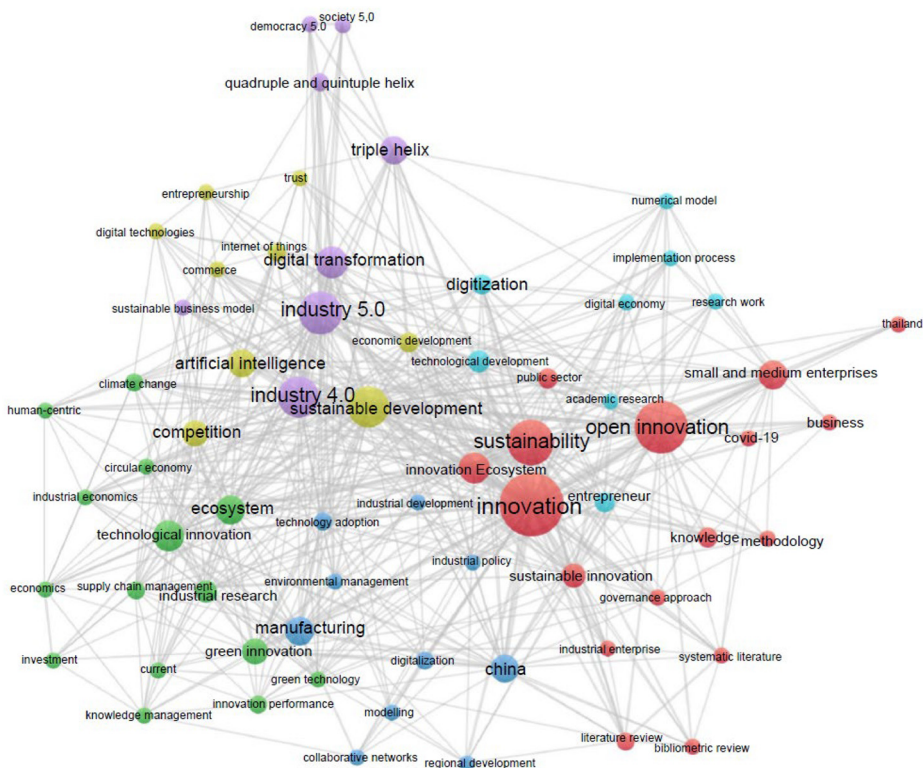
Using keywords used at least three times, we found a network of 67 items assembled in six different clusters (Figure 6). Cluster 1 (Red) has 17 items, with innovation being the biggest. With 15 keywords, the second (Green) cluster emphasizes technological innovation. Cluster 3 (Blue) emphasizes manufacturing and industrial development. Cluster 4 (Yellow) covers sustainable development. Cluster 5 (Purple) covers Industry 4.0 and 5.0, whereas cluster 6 (Light Blue) includes digitization and digital economy, among others.

A meticulous analysis of academic data identified key innovation themes and their role in shaping innovation evolution. A forward-looking approach assessed the potential contribution of each theme to Innovation 5.0, considering current trends and developments. Table 2 summarizes the key themes, cluster overviews and main authors.

These themes emphasize the sustainability, resilience and human-centeredness for innovation and will guide further evolution for 21st-century challenges.

#### 4.2 Evolution of innovation models

To understand the evolution of innovation models, a structured content analysis was developed on the text data emerged from the categorization of the data set. This method helped understand innovation's evolution and shift to Innovation 5.0. The content analysis revealed the generalization in the use of the "5.0" extension in terms like "Democracy 5.0" or "Society 5.0" (Cluster 5 purple), which signifies a progression toward the establishment of



**Figure 6.**  
Keyword  
co-occurrence  
analysis

Source: Authors' own creation



Key themes	Brief explanation and potential role toward Innovation 5.0	Dominant references
Innovation and sustainability	Cluster 1 (Red) focuses on the power of open innovation to drive collaborative and transformative change toward sustainability. It highlights how open innovation transcends traditional boundaries and fosters partnerships between diverse stakeholders, enabling the development of innovative solutions that address pressing societal challenges and contribute to a more equitable and prosperous future	(Costa and Moreira, 2022; Gao <i>et al.</i> , 2020; Kalmakova <i>et al.</i> , 2021; Lin and Xie, 2023; Phonthanukitithaworn <i>et al.</i> , 2023)
Human-centered green transformation	Cluster 2 (Green) explores the intersection of human-centered principles, green innovation, ecosystem and technological advancements to foster a paradigm shift toward sustainable development. It emphasizes the need for technological innovation that not only prioritizes environmental protection but also enhances human well-being and societal prosperity	(Carayannis <i>et al.</i> , 2023; Costa and Moreira, 2022; Jiao <i>et al.</i> , 2021; Liu <i>et al.</i> , 2022; Di Vaio <i>et al.</i> , 2022; Yin and Yu, 2022; Zeng <i>et al.</i> , 2022)
Production revolution	This cluster (Blue) highlights the convergence of technology, digitalization and collaboration in transforming manufacturing processes toward more efficient, sustainable and interconnected production ecosystems that enable mass customization	(Janahi <i>et al.</i> , 2022; Jiao <i>et al.</i> , 2021; Reischauer, 2018; Salim <i>et al.</i> , 2019; Yuan <i>et al.</i> , 2022)
Sustainable entrepreneurship	This cluster (Yellow) explores how digital technologies are transforming the entrepreneurial landscape and driving commerce innovation, with sustainable development and AI as key drivers. It examines how digital tools, platforms and ecosystems facilitate entrepreneurship	(Carayannis <i>et al.</i> , 2023; Kluza <i>et al.</i> , 2021; Kolade and Owoseni, 2022; Di Vaio <i>et al.</i> , 2022)
Industrial transformation	Cluster 5 (Purple) explores the complex interplay between societal, democratic and industrial transformations, examining their interconnected evolution and the role of helix models in understanding and navigating these shifts. It emphasizes the impact of digital technologies, the relevance of Industry 4.0 and emergence of Industry 5.0 and the importance of sustainable business models in shaping the future	(Carayannis <i>et al.</i> , 2023, 2022)
Digital economy	The last cluster (Light Blue) explores the transformative impact of digitization. It examines how digital technologies are empowering entrepreneurs to create, scale and sustain innovative ventures, driving growth and innovation in the digital economy	(Bigliardi and Filippelli, 2022; Gu <i>et al.</i> , 2021; Zeng <i>et al.</i> , 2022)

**Table 2.**  
Keyword co-occurrence clusters

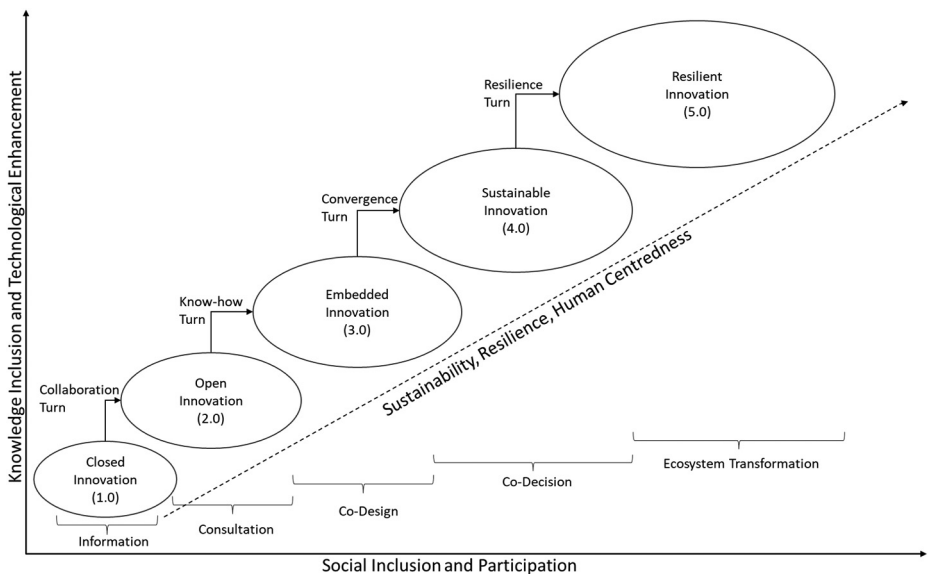
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more sustainable, equitable and participatory societies through the integration of cutting-edge technologies (Carayannis *et al.*, 2023, 2022). Innovation 5.0 is set to evolve from its predecessors, beginning with “closed innovation” or “Innovation 1.0,” moving to “open innovation” or “Innovation 2.0,” followed by the concept of “embedded innovation” or

“Innovation 3.0” and tech integrated or sustainable Innovation 4.0. Each model of innovation made significant contributions to the businesses and societies for creating and developing new ideas.

Industry 5.0 is focused on the integration of human intelligence to facilitate a production process that is more collaborative, holistic, inclusive and sustainable, with a greater emphasis on human-centered approaches (Ghobakhloo *et al.*, 2022). Following recommendations of Olesiński *et al.* (2021) on Innovation 4.0, Innovation 5.0 will align with the principles of Industry 5.0, focusing on enhanced contributions to the businesses and societies for idea creation and development, involving more stakeholders for this purpose. Figure 7 explains this process of innovation evolution, where Innovation 5.0 marks an evolution beyond Innovation 3.0 and 4.0, introducing a transformative and resilience-oriented approach that surpasses traditional open innovation models. Unlike its predecessors, Innovation 5.0 integrates a holistic ecosystem, surpassing the quintuple helix model by incorporating societal, economic and environmental dimensions. It envisions innovation as a collective, global endeavor, dedicated to addressing humanity’s most pressing challenges.

Despite the strong connection between Industry 5.0 and Innovation 5.0, they maintain distinctive characteristics. While previous industrial revolutions have undergone concurrent phases of innovation, perfect synchronization was not always observed. Industry 3.0 was characterized by the introduction of technological advancements such as computers and automation; on the other hand, Industry 4.0 underwent a digital transformation with the integration of artificial intelligence (AI) and the internet of things (Ferrás-Hernández, 2020). This led to the emergence of “open innovation” and “digital innovation” in tandem with Innovation 4.0.



**Figure 7.**  
Emergence of  
Innovation 5.0

**Source:** Authors’ own creation based on foundational concepts by Hafkesbrink and Schroll (2011), Streitz *et al.* (2022)

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Likewise, the emergence of Industry 5.0 has a direct impact on the development of Innovation 5.0, which in turn affects the innovation ecosystem by emphasizing the importance of human intelligence while leveraging technological advancements (Olesiński and Rzepka, 2021). The fundamental tenet of “5.0” is the prudent use of cutting-edge technologies to foster the development of more sustainable and ethical societies. This marks the advent of innovation that prioritizes human needs, fosters inclusivity and promotes sustainability and resilient ecosystems in the times of multiple crisis (Romero and Stahre, 2021).

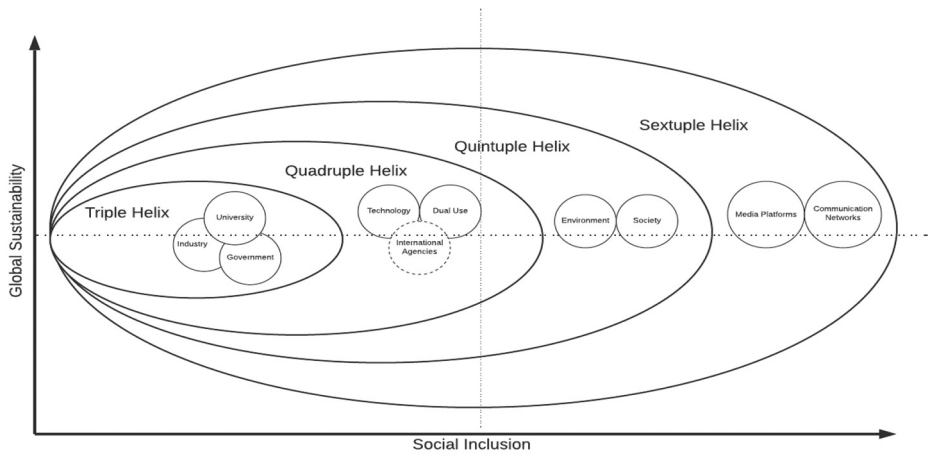
Industry 5.0 emphasizes human–machine harmony, and Innovation 5.0 promotes an innovation ecosystem that values human intelligence and ingenuity while harnessing technological progress. Innovation models have evolved alongside industrial paradigms during the industrial revolutions (Olesiński and Rzepka, 2021). The emergence of Industry 5.0 and Innovation 5.0 represents a significant shift in our socio-technical systems toward a transformative phase. They combine technological advancement with social equity, ecological responsibility and a deep understanding of human engagement in innovation. Innovation 5.0 may address our complex social, economic, technological and environmental interdependencies.

#### *4.3 Unravelling Innovation 5.0 through sextuple helix model*

Comprehending same content analysis, keyword co-occurrence analysis and themes identified previously, it is found that the foundations of Innovation 5.0 lie in its predecessor, Innovation 4.0, and that it combines several key elements for sustainable innovation. The extensive use of helix models in innovation studies evidences their significance toward the understanding of innovation ecosystem (Etzkowitz and Leydesdorff, 1995; Leydesdorff, 2013). These models serve as the structural backbone, providing a holistic lens through which we navigate the complex interplay of diverse stakeholders in shaping the foundational concept of Innovation 5.0 (Cai, 2022). Through the sextuple helix model, we draw upon the open innovation theory, which advocates the advancement of innovation through the disclosure of technological information (Gupta *et al.*, 2017; Zhang and Ming, 2023). Previous literature has studied the sextuple helix model in the context of societal engagement for innovation evolution (López-Rubio *et al.*, 2021). Figure 8 shows the development of the different helix models, incorporating more varied stakeholders and focuses, in each step of evolution, widening their sustainability and social inclusion approach.

The sixth helix, which includes media and ICT, represents digital and traditional channels that facilitate the exchange and collaboration of information during the innovation process (Wahana *et al.*, 2022). These platforms, which include social media, digital collaboration tools, news outlets, professional networks and ICT, are recognized as a distinct helix due to their essential role in accelerating the distribution of information, fostering collaboration and supporting open innovation practices.

Innovation 5.0 is characterized by distinctive features when viewed through the sextuple helix model. First, it encourages broader societal engagement by involving citizens, communities and civil society organizations in the innovation process, through media and ICT ensuring alignment with societal needs and values. Second, it harnesses the power of media and ICT to facilitate seamless communication, collaboration and knowledge sharing among stakeholders, thereby accelerating the innovation pace. Third, there is a reinforced emphasis on sustainability within Innovation 5.0, with a dedicated focus on addressing climate change, promoting environmentally conscious innovation and fostering sustainable development. Fourth, Innovation 5.0 emphasizes resilience, building systems that can



**Figure 8.**  
Sextuple helix model  
of innovation

**Source:** Authors' own creation modified from Carayannis et al. (2012), Carayannis and Campbell (2009), Carayannis and Kaloudis (2010)

handle unexpected problems. It strengthens socio-economic and environmental systems to navigate uncertainty, crises and fast transitions. Through resilience, Innovation 5.0 envisions a future where innovation fulfils current needs and protects communities and ecosystems against unforeseen shocks, creating long-term stability and adaptation. Finally, it adopts a human-centered approach, prioritizing the development and implementation of technologies for the collective benefit, with a specific focus on social inclusion, equity and fairness.

## 5. Conclusion

This systematic literature review has shed light on the evolution of innovation models and emergence of Innovation 5.0 by providing a comprehensive overview of the innovation landscape. We have investigated pervasive themes in the literature on innovation and the profound implications they have for the evolution of this innovative paradigm. Acknowledging the intricate interplay between these transformative forces, we also investigated the role of Industry 5.0 in shaping the trajectory of Innovation 5.0, recognizing that Innovation 5.0 is a new paradigm for innovation that emphasizes sustainability, resilience and human-centeredness. Innovation 5.0 entails a broader concept than Industry 5.0, as far as Innovation 5.0 can be applied to all sectors, not just industry, but Industry 5.0 constitutes the perfect context to understand its conceptualization and implications. Finally, Innovation 5.0's revolutionary capacity to improve society has been examined using the sextuple helix model. With its focus on inclusive co-creation, sustainability and true-cost pricing, Innovation 5.0 promises to transform innovation.

### 5.1 Practical implications and future of innovation

Innovation 5.0 holds the potential to revolutionize our way of life, fostering a more sustainable, resilient and human-centered future. By understanding its transformative power, we can guide organizations and governments in shaping this new era. The research suggests that organizations can enhance innovation through collaboration platforms,

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government partnerships and digital tools. Governments can support manufacturing companies' green R&D efforts through incentives, tax breaks and institutional guarantees. Organizations can embrace Innovation 5.0 by strengthening corporate governance, establishing standardized internal control systems and maintaining flexibility.

Innovation is a continuous process, making it challenging to predict the future with certainty. However, based on our analysis, we anticipate that the future of innovation will be characterized by human-centric design, collaborative and open innovation, data-driven insights, sustainability and environmental consciousness. These trends will pave the way for personalized solutions, expanded value creation opportunities and a more open and democratized innovation ecosystem. While this study focuses on Innovation 5.0, the identified themes suggest that Innovation 6.0 may adopt a holistic approach, leveraging the transformative power of emerging technologies to promote human well-being and sustainable prosperity while addressing existential risks posed by natural disasters, climate change or technological advancements with unforeseen consequences.

### 5.2 Limitations and future research

Potential publication bias, limited access to unpublished research and concerns about study quality are key limitations. Combining the Scopus database with others could also enhance comprehensiveness. Furthermore, the conceptual development of Innovation 5.0 relies significantly on an analysis of existing literature and authors' personal understanding, which lacks empirical validation.

We propose to explore how media and ICT platforms can be designed to support collaboration among a diverse group of stakeholders and how such platforms can be used to manage and track the progress of open innovation and their financial and non-financial benefits with respect to sustainability, resilience and human-centeredness. Further, cross-cultural studies may explain how culture affects Innovation 5.0 perception and implementation. Other empirical studies, such as case studies and longitudinal research, that monitor the transition of firms using Innovation 5.0 may give significant insights across sectors.

### References

- Aromataris, A. and Riitano, D. (2014), "Constructing a search strategy and searching for evidence. A guide to the literature search for a systematic review", *American Journal of Nursing*, Vol. 114 No. 5, pp. 45-56, doi: [10.1097/01.NAJ.0000446779.99522.f6](https://doi.org/10.1097/01.NAJ.0000446779.99522.f6).
- Aslam, F., Aimin, W., Li, M. and Rehman, K. Ur. (2020), "Innovation in the era of IoT and industry 5.0: absolute innovation management (AIM) framework", *Information*, Vol. 11 No. 2, doi: [10.3390/info11020124](https://doi.org/10.3390/info11020124).
- Bigliardi, B. and Filippelli, S. (2022), "Sustainability and open innovation: main themes and research trajectories", *Sustainability*, Vol. 14 No. 11, doi: [10.3390/su14116763](https://doi.org/10.3390/su14116763).
- Cai, Y. (2022), "Neo-triple helix model of innovation ecosystems: integrating triple, quadruple and quintuple helix models", *Triple Helix*, Vol. 9 No. 1, pp. 76-106, doi: [10.1163/21971927-bja10029](https://doi.org/10.1163/21971927-bja10029).
- Carayannis, E.G. and Campbell, D.F. (2009), "Mode 3' and 'quadruple helix': toward a 21st century fractal innovation ecosystem", *International Journal of Technology Management*, Vol. 46 Nos 3/4, pp. 201-234, doi: [10.1504/IJTM.2009.023374](https://doi.org/10.1504/IJTM.2009.023374).
- Carayannis, E.G. and Kaloudis, A. (2010), "21st century democratic capitalism: a time for action and a time to lead", *International Journal of Social Ecology and Sustainable Development*, Vol. 1 No. 1, doi: [10.4018/jsesd.2010010101](https://doi.org/10.4018/jsesd.2010010101).

- 
- Carayannis, E.G., Barth, T.D. and Campbell, D.F. (2012), "The quintuple helix innovation model: Global warming as a challenge and driver for innovation", *Journal of Innovation and Entrepreneurship*, Vol. 1 No. 1, pp. 1-2, doi: [10.1186/2192-5372-1-2](https://doi.org/10.1186/2192-5372-1-2).
- Carayannis, E.G., Campbell, D.F. and Grigoroudis, E. (2022), "Helix trilogy: the triple, quadruple, and quintuple innovation helices from a theory, policy, and practice set of perspectives", *Journal of the Knowledge Economy*, Vol. 13 No. 3, pp. 2272-2301, doi: [10.1007/s13132-021-00813-x](https://doi.org/10.1007/s13132-021-00813-x).
- Carayannis, E.G., Canestrino, R. and Magliocca, P. (2023), "From the dark side of industry 4.0 to society 5.0: looking 'beyond the box' to developing human-centric innovation ecosystems", *IEEE Transactions on Engineering Management*, pp. 1-17, doi: [10.1109/TEM.2023.3239552](https://doi.org/10.1109/TEM.2023.3239552).
- Chesbrough, H.W. (2006), *Open Innovation: The New Imperative for Creating and Profiting from Technology*, Harvard Business School Press, MA, MA.
- Cooke, P. (2018), "Generative growth with 'thin' globalization: Cambridge's crossover model of innovation", *European Planning Studies*, Vol. 26 No. 9, pp. 1815-1834, doi: [10.1080/09654313.2017.1421908](https://doi.org/10.1080/09654313.2017.1421908).
- Costa, J. and Moreira, A.C. (2022), "Public policies, open innovation ecosystems and innovation performance. Analysis of the impact of funding and regulations", *Journal of Open Innovation: Technology, Market, and Complexity*, Vol. 8 No. 4, doi: [10.3390/joitmc8040210](https://doi.org/10.3390/joitmc8040210).
- Costa, J. and Matias, J. (2020), "Open innovation 4.0 as an enhancer of sustainable innovation ecosystems", *Sustainability*, Vol. 12 No. 19, doi: [10.3390/su12198112](https://doi.org/10.3390/su12198112).
- Etzkowitz, H. and Leydesdorff, L. (1995), "The triple helix – University-industry-government relations: a laboratory for knowledge based economic development", *EASST Review*, Vol. 14, pp. 14-19.
- Ferrás-Hernández, X. (2020), "Rethinking industry 4.0: is there life beyond manufacturing?", *International Journal of Business Environment*, Vol. 11 No. 4, pp. 404-416, doi: [10.1504/IJBE.2020.111403](https://doi.org/10.1504/IJBE.2020.111403).
- Gao, H., Ding, X.H. and Wu, S. (2020), "Exploring the domain of open innovation: Bibliometric and content analyses", *Journal of Cleaner Production*, Vol. 275, doi: [10.1016/j.jclepro.2020.122580](https://doi.org/10.1016/j.jclepro.2020.122580).
- Gu, Y., Hu, L., Zhang, H. and Hou, C. (2021), "Innovation ecosystem research: Emerging trends and future research", *Sustainability*, Vol. 13 No. 20, doi: [10.3390/su132011458](https://doi.org/10.3390/su132011458).
- Gupta, A., Dey, A. and Singh, G. (2017), "Connecting corporations and communities: towards a theory of social inclusive open innovation", *Journal of Open Innovation: Technology, Market, and Complexity*, Vol. 3 No. 3, doi: [10.1186/s40852-017-0062-3](https://doi.org/10.1186/s40852-017-0062-3).
- Hafkesbrink, J. and Schroll, M. (2011), "Innovation 3.0: embedding into community knowledge - collaborative organizational learning beyond open innovation", *Journal of Innovation Economics and Management*, Vol. 7 No. 1, pp. 55-92, doi: [10.3917/jie.007.0055](https://doi.org/10.3917/jie.007.0055).
- Ivanov, D. (2023), "The industry 5.0 framework: Viability-based integration of the resilience, sustainability, and human-centricity perspectives", *International Journal of Production Research*, Vol. 61 No. 5, pp. 1683-1695, doi: [10.1080/00207543.2022.2118892](https://doi.org/10.1080/00207543.2022.2118892).
- Jafari, N., Azarian, M. and Yu, H. (2022), "Moving from industry 4.0 to industry 5.0: What are the implications for smart logistics?", *Logistics*, Vol. 6 No. 2, doi: [10.3390/logistics6020026](https://doi.org/10.3390/logistics6020026).
- Janahi, N.A., Durugbo, C.M. and Al-Jayyousi, O.R. (2022), "Exploring network strategies for eco-innovation in manufacturing from a triple helix perspective", *Cleaner Logistics and Supply Chain*, Vol. 4, doi: [10.1016/j.clscn.2022.100035](https://doi.org/10.1016/j.clscn.2022.100035).
- Jiao, H., Yang, J., Jiang, C. and Yu, J. (2021), "Openness and technological innovation: the moderating effect of information technology adoption and political ties", *International Journal of Emerging Markets*, Vol. 18 No. 10, doi: [10.1108/IJOEM-12-2020-1547](https://doi.org/10.1108/IJOEM-12-2020-1547).
- Kalmakova, D., Bilan, Y., Zhidebekkyzy, A. and Sagiyeva, R. (2021), "Commercialization of conventional and sustainability-oriented innovations: a comparative systematic literature review", *Problems and Perspectives in Management*, Vol. 19 No. 1, pp. 340-353, doi: [10.21511/ppm.19\(1\).2021.29](https://doi.org/10.21511/ppm.19(1).2021.29).

- Kitchenham, B. (2004), *Procedures for Performing Systematic Reviews*, Keele University, Keele.
- Kluza, K., Ziolo, M. and Spoz, A. (2021), "Innovation and environmental, social, and governance factors influencing sustainable business models - meta-analysis", *Journal of Cleaner Production*, Vol. 303, doi: [10.1016/j.jclepro.2021.127015](https://doi.org/10.1016/j.jclepro.2021.127015).
- Kolade, O. and Owoseni, A. (2022), "Employment 5.0: the work of the future and the future of work", *Technology in Society*, Vol. 71, p. 102086, doi: [10.1016/j.techsoc.2022.102086](https://doi.org/10.1016/j.techsoc.2022.102086).
- Leydesdorff, L. (2000), "The triple helix: an evolutionary model of innovations", *Research Policy*, Vol. 29 No. 2, pp. 243-255, doi: [10.1016/S0048-7333\(99\)00063-3](https://doi.org/10.1016/S0048-7333(99)00063-3).
- Leydesdorff, L. (2013), "Triple helix of University-Industry-Government relations", in Carayannis, E.G. (Ed.), *Encyclopedia of Creativity, Invention, Innovation and Entrepreneurship*, Springer, New York, NY, doi: [10.1007/978-1-4614-3858-8\\_452](https://doi.org/10.1007/978-1-4614-3858-8_452).
- Lin, B. and Xie, Y. (2023), "Impacts of digital transformation on corporate green technology innovation: do board characteristics play a role?", *Corporate Social Responsibility and Environmental Management*, doi: [10.1002/csr.2653](https://doi.org/10.1002/csr.2653).
- Liu, J., Qian, Y., Chang, H. and Forrest, J.Y.L. (2022), "The impact of technology innovation on enterprise capacity utilization—evidence from China's Yangtze river economic belt", *Sustainability*, Vol. 14 No. 18, doi: [10.3390/su141811507](https://doi.org/10.3390/su141811507).
- López-Rubio, P., Roig-Tierno, N. and Mas-Tur, A. (2021), "A research journey from national systems of innovation to national systems of entrepreneurship: introducing the sextuple helix", *International Journal of Innovation and Technology Management*, Vol. 18 No. 8, doi: [10.1142/S0219877021300081](https://doi.org/10.1142/S0219877021300081).
- Nahavandi, S. (2019), "Industry 5.0—a human-centric solution", *Sustainability*, Vol. 11 No. 16, doi: [10.3390/su11164371](https://doi.org/10.3390/su11164371).
- Olesiński, Z. and Rzepka, A. (2021), "Evolution of management towards innovation 4.0 during the covid-19 pandemic", *Sustainability, Technology and Innovation 4.0*, Routledge, pp. 317-332.
- Phonthanukithaworn, C., Srisathan, W.A., Ketkaew, C. and Naruetharadhol, P. (2023), "Sustainable development towards openness SME innovation: taking advantage of intellectual capital, sustainable initiatives, and open innovation", *Sustainability*, Vol. 15 No. 3, doi: [10.3390/su15032126](https://doi.org/10.3390/su15032126).
- Reischauer, G. (2018), "Industry 4.0 as policy-driven discourse to institutionalize innovation systems in manufacturing", *Technological Forecasting and Social Change*, Vol. 132, pp. 26-33, doi: [10.1016/j.techfore.2018.02.012](https://doi.org/10.1016/j.techfore.2018.02.012).
- Romero, D. and Stahre, J. (2021), "Towards the resilient operator 5.0: the future of work in smart resilient manufacturing systems", *Procedia CIRP*, Vol. 104, pp. 1089-1094, doi: [10.1016/j.procir.2021.11.183](https://doi.org/10.1016/j.procir.2021.11.183).
- Salim, N., Ab-Rahman, M.N. and Abd-Wahab, D. (2019), "A systematic literature review of internal capabilities for enhancing eco-innovation performance of manufacturing firms", *Journal of Cleaner Production*, Vol. 209, pp. 1445-1460, doi: [10.1016/j.jclepro.2018.11.105](https://doi.org/10.1016/j.jclepro.2018.11.105).
- Streitz, N.A., Riedmann-Streitz, C. and Quintal, L. (2022), "From 'smart-only' island towards lighthouse of research and innovation", *Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, Vol. 13325 LNCS, Springer Science and Business Media Deutschland GmbH, pp. 105-126, doi: [10.1007/978-3-031-05463-1\\_8](https://doi.org/10.1007/978-3-031-05463-1_8).
- Sun, X., Qian, J., Wang, Z., Miao, J. and Chai, Y. (2022), "Future of networked information society: a deeply interconnected 'primitive society'", *International Journal of Crowd Science*, Vol. 6 No. 4, pp. 178-183, doi: [10.26599/IJCS.2022.9100023](https://doi.org/10.26599/IJCS.2022.9100023).
- Vaio, A., Hassan, R., D'Amore, G. and Tiscini, R. (2022), "Responsible innovation and ethical corporate behavior in the Asian fashion industry: a systematic literature review and avenues ahead", *Asia Pacific Journal of Management*, doi: [10.1007/s10490-022-09844-7](https://doi.org/10.1007/s10490-022-09844-7).

- 
- Wahana, H.D., Ilham, M., Kusworo, K., Mansyur, M. and Maryani, D. (2022), "The effect of quintuple helix in increasing creativity and innovation to competitive advantage the creative village in Bandung municipality west Jawa province", *Budapest International Research and Critics Institute-Journal*, Vol. 5, pp. 3123-3133.
- Yin, S. and Yu, Y. (2022), "An adoption-implementation framework of digital green knowledge to improve the performance of digital green innovation practices for industry 5.0", *Journal of Cleaner Production*, Vol. 363, doi: [10.1016/j.jclepro.2022.132608](https://doi.org/10.1016/j.jclepro.2022.132608).
- Yuan, C., Liu, W., Zhou, G., Shi, X., Long, S., Chen, Z. and Yan, X. (2022), "Supply chain innovation announcements and shareholder value under industries 4.0 and 5.0: evidence from China", *Industrial Management and Data Systems*, Vol. 122 No. 8, pp. 1909-1937, doi: [10.1108/IMDS-12-2021-0802](https://doi.org/10.1108/IMDS-12-2021-0802).
- Zeng, J., Chen, X., Liu, Y., Cui, R. and Zhao, P. (2022), "How does the enterprise green innovation ecosystem collaborative evolve? Evidence from China", *Journal of Cleaner Production*, Vol. 375, doi: [10.1016/j.jclepro.2022.134181](https://doi.org/10.1016/j.jclepro.2022.134181).
- Zhang, B. and Ming, C. (2023), "A patent portfolio value analysis based on intuitionistic fuzzy sets: an empirical analysis of artificial intelligence for healthcare", *Journal of Open Innovation: Technology, Market, and Complexity*, Vol. 9 No. 3, doi: [10.1016/j.joitmc.2023.100124](https://doi.org/10.1016/j.joitmc.2023.100124).

#### Further reading

- Carayannis, E.G. and Campbell, D.F. (2010), "Triple helix, quadruple helix and quintuple helix and how do knowledge, innovation and the environment relate to each other? A proposed framework for a trans-disciplinary analysis of sustainable development and social ecology", *International Journal of Social Ecology and Sustainable Development*, Vol. 1 No. 1, pp. 41-69, doi: [10.4018/jsesd.2010010105](https://doi.org/10.4018/jsesd.2010010105).
- Morteza, G., Iranmanesh, M., Morales, M.E., Nilashi, M. and Amran, A. (2022), "Actions and approaches for enabling industry 5.0-driven sustainable industrial transformation: a strategy roadmap", *Corporate Social Responsibility and Environmental Management*, Vol. 30 No. 3, pp. 1473-1494, doi: [10.1002/csr.2431](https://doi.org/10.1002/csr.2431).

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