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Rethinking innovation through industry and society 5.0 paradigms: a multileveled approach for management and policy-making

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Abstract

Purpose – Industry 4.0 defines the application of digital technologies on business infrastructure and processes. With the increasing need to take into account the social and environmental impact of technologies, the concept of Society 5.0 has been proposed to restore the centrality of humans in the proper utilization of technology for the exploitation of innovation opportunities. Despite the identification of humans, resilience and sustainability as the key dimensions of Society 5.0, the definition of the key factors that can enable Innovation in the light of 5.0 principles has not been yet assessed.

Design/methodology/approach – An SLR, followed by a content analysis of results and a clustering of the main topics, is performed to (1) identify the key domains and dimensions of the Industry 5.0 paradigm; (2) understand their impact on Innovation 5.0; (3) discuss and reflect on the resulting implications for research, managerial practices and the policy-making process.

Findings – The findings allow the elaboration of a multileveled framework to redefine Innovation through the 5.0 paradigm by advancing the need to integrate ICT and technology (Industry 5.0) with the human-centric, social and knowledge-based dimensions (Society 5.0).

Originality/value – The study detects guidelines for managers, entrepreneurs and policy-makers in the adoption of effective strategies to promote human resources and knowledge management for the attainment of multiple innovation outcomes (from technological to data-driven and societal innovation).

Keywords Industry 5.0 (I5.0), Society 5.0, Innovation 5.0, Structured literature review (SLR), Technocentric view, Human-centric view, Policy-making

Paper type Literature review

1. Introduction

With the gradual demise of the specific to Industry 4.0 technocentric view on technology (Lasi *et al.*, 2014), the onset of the Industry 5.0 (I5.0) paradigm emphasizes the need to integrate the human-centric, environmental and social aspects in our thinking about technology, progress and innovation. As a government-led initiative, Industry 4.0 stipulated approaches to

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economic policy-making driven by technology. In contrast, the follow-up initiative, i.e. Industry 5.0, promoted by various bodies of the European Union (EU) (Breque *et al.*, 2021), seeks to add human, environmental and social aspects back into the equation by restoring the centrality of people and the need to attain resilience and sustainability goals when trying to stimulate innovation and well-being of society at large (Enang *et al.*, 2023; Jafari *et al.*, 2022).

The focus on human-centric solutions is a means of counterbalancing the specific to Industry 4.0. overemphasis on technology and technological component of innovation. Accordingly, a comprehensive understanding of concepts and paradigms of Industry 5.0 and Innovation 5.0 requires that the human being is placed squarely in the equation.

The application of Industry 5.0 technologies to business strategies, models and process can have some negative aspects, such as security risks and privacy issues (Lee *et al.*, 2014). Therefore, a first effort to overcome the criticalities of this process has been accomplished through the proposition of Society 5.0 paradigm (CSTI, 2016; Fukuyama, 2018). The latter involves the balance of economic, technological and social outcomes and promotes the role of skills, knowledge and of the participation of multistakeholders in the development of innovation (Aslam *et al.*, 2020).

Society 5.0 is a new paradigm that defines the proper exploitation of technological innovation by leveraging on smart technologies to forecast the ideal form of future smart society (Fukuda, 2020). According to this perspective, it is imperative that research analyses the relationships between physical space and cyberspace to understand how advances in information and communication technology (ICT) can be leveraged to bring opportunities for growth and development in the social space to properly balance economic and technological developments with the resolution of social problems.

However, despite the increasing diffusion of research on Industry and Society 5.0, there is still the need to conceptualize the key dimensions of 5.0 paradigm, intended as a broader concept that can encompass technological dimension (I5.0) and the cultural, social and human factors identified by Society 5.0 (Konno, 2020). In addition, extant research does not explore the redefinition of innovation in line with 5.0 principles (De Felice *et al.*, 2021) and does not analyze the impact of some factors, enabled by Industry 5.0 and that can act as mediating variables in the relationship between Society 5.0 and Innovation 5.0, such as skills, knowledge and capabilities, stakeholder engagement and to apply a multileveled perspective to this issue (Carayannis *et al.*, 2017; Cillo *et al.*, 2019).

For these reasons, a structured literature review (SLR, Guthrie and Murthy, 2009; Dumay, 2014) is performed to: (1) identify the core domains of the 5.0 research to conceptualize the key dimensions of the 5.0 paradigm; (2) shed light on the key drivers for the development of Innovation 5.0; (3) detect implications and research avenues for future studies.

The analysis highlights the need to overcome the technocentric on Innovation 5.0 and to apply a new systems-based view grounded on knowledge creation, continuous improvement and the attainment of proactiveness as drivers for antifragility and the potential constant renewal of value generated over time (Carayannis *et al.*, 2022; Corvello *et al.*, 2023a).

The results of the research allow at introducing a multidimensional conceptual framework for Innovation 5.0 based on the integration of technological, human, cultural and social dimensions that identifies the levers for stimulating different shades of innovation (from supply chain to business model, from sustainable-oriented to social innovation).

In this way, the study provides theoretical insights about the dimensions that can foster the development of Innovation 5.0 by overcoming the technocentric view. Starting from the need to apply a new all-encompassing perspective, the paper detects the potential factors that can influence innovations mechanisms (for each of the four dimensions: technological, human, knowledge-based and social) and seeks to shed light on the topics that need to attract more research in the future: human-centric solutions, resilience and antifragility, societal innovation.

The study offers alternative perspectives to technocentric approach and analyses the key dimensions that may lead to an integrated human/technological/social and knowledge-based approach to the study of innovation management in 5.0 research. The identification of the key drivers to combine technocentric and human-centric innovation to support socioeconomic growth can provide managers and policy-makers with insights regarding the evolution of industries as well as input on strategies and practices useful in exploiting the potential of Industry 5.0 for the prosperity of the society at large. In this way, research avenues can be outlined based on the application of the framework across fields, industries (e.g. education, smart cities) and domains (e.g. supply chain management, business model innovation, knowledge management).

The argument in this paper is structured as follows: In the next section, a brief overview of the literature on Industry and Society 5.0 is provided. In Section 3, the methodology employed to perform the SLR is elaborated. Results are presented in section 4. Against this backdrop, an innovation management framework is proposed and discussed. Conclusion and future research directions follow.

2. Related work: Industry 5.0 and Society 5.0

Industry 4.0 (I4.0) defines the technological revolution that took place in industries, business models, strategies and processes (Lasi *et al.*, 2014; Rüßmann *et al.*, 2015) through the application of big data analytics, artificial intelligence (AI), Internet of Things (IoT), digital twins, etc. (Hermann *et al.*, 2016; Ozkan-Özen, 2020) to improve production and raise product and service quality.

Despite the need to conceptualize and map the digital technologies available in contemporary market and society, I4.0 research focuses on the impact of technology on industry and manufacturing rather than seeking to broaden the perspective in view of advancing sustainability and well-being (Gladden, 2019).

Hence, to address the limitations of the 4.0 approach, the Industry 5.0 (I5.0) paradigm has been introduced. The latter emphasizes the need to integrate human-centric view with thinking about "machines" (the epitome of technology) not only to boost competitiveness and innovation but also to take into account the social and environmental impact of technology. The emphasis on human–machine interaction highlights the need to promote people's empowerment for the creation of personalized products and services (Visvizi, 2023).

Starting from this human-centric approach, Society 5.0 (Savanevičienė *et al.*, 2019) has been proposed to further extend the perspective by analyzing the implications related to the merging of cyber and physical space on environment, sustainability, resilience and society.

Society 5.0 has been defined in the "5th Science and Technology Basic Plan" by the Government of Japan. The Plan suggests the need for the creation of a Super-smart society (Saxena *et al.*, 2020; Tavares *et al.*, 2022) to improve well-being and the quality of life by exploiting the potential of technologies to tackle social challenges and to enrich human behavior (rather than threatening it) through the humanization of industrial 4.0 production.

Society 5.0 detects the human-centered and social implications of the integration of technologies into the daily lives of people and society (Akin and Akyol, 2021) by understanding how to leverage the technological opportunities of 4.0 for social change.

Industry 5.0 and Society 5.0 should not be intended as opposite or alternative concepts but can be viewed as two parallel constructs that seek to define multisided effect of digital transformation by focusing on different aspects. For instance, technology is considered as a key lever for transformation and innovation in both Industry and Society 5.0; however, even if the first concept (I5.0) is a part of the second and the two concepts are strictly interrelated, digitalization of the industry is an essential part of Society 5.0 and advancements in technology can have a social impact. On the other hand, the transformation of society can lead to the proposition of new technology.

The relevance of human component is acknowledged in both Industry and Society 5.0, but the first investigates mainly the role of technology in production, supply chain management, digitalization of services, whereas Society 5.0 adopts a system of systems approach to observe how encapsulated social, political and economic subsystems can cocreate value (Carayannis *et al.*, 2022).

Industry 5.0 analyzes the development of resilience in smart industry and manufacturing to tackle the uncertainty of contemporary economic and social context, whereas Society 5.0 analyzes how social structures can be transformed through the redesign of social space and the integration of cyber and physical dimension.

Despite the increasing diffusion of 5.0 research, there is still the need to conceptualize the key dimensions of 5.0, intended as a broader paradigm that can encompass technological factor (I5.0) and the cultural, social and human dimensions brought to light by Society 5.0 (Konno, 2020).

In addition, an innovation management framework that observes the benefits offered from Industry 5.0 (new service and product development, continuous improvement) and that pinpoints the key enabling factors empowered by Society 5.0 for the codevelopment of innovation has not been yet proposed (Aslam *et al.*, 2020; Akkaya *et al.*, 2021). Hence, extant research does not adequately observe how human-centered products and services obtained through the application of 5.0 technologies can create value and, thus, innovative outcomes for customers, businesses and society.

For these reasons, an SLR (Guthrie and Murthy, 2009; Dumay, 2014) is performed to reveal the key dimensions of Industry and Society 5.0 paradigm (that encompasses both Industry and Society 5.0) that should be integrated to encourage the development of a 5.0 Innovation.

3. Methodology

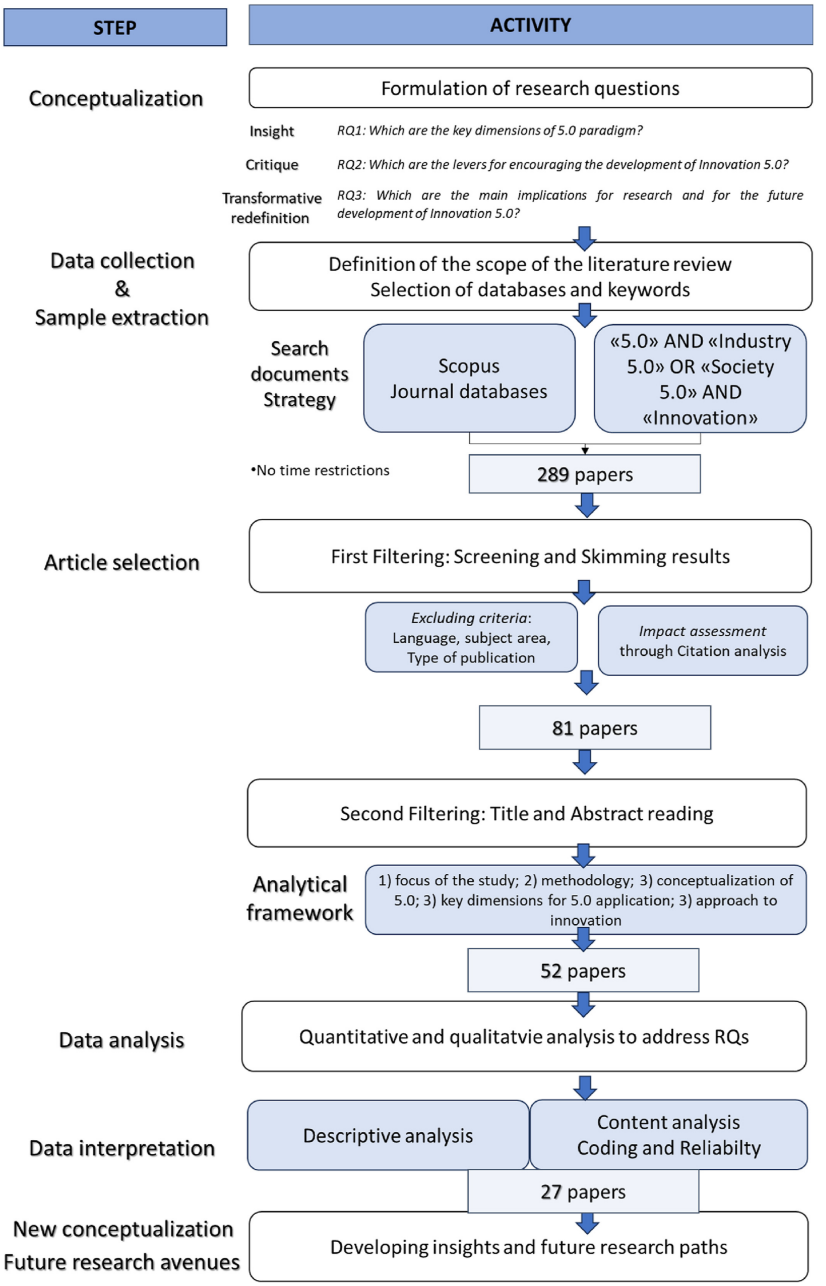
SLR can be considered as a suitable technique to perform critical reviews and identify the key trends and foci that can contribute to conceptualize an issue and to map the research avenues for future studies in different fields (Massaro *et al.*, 2016) by introducing reliable outcomes through coding processes and qualitative interpretation. The concept-centricity of this protocol can allow at critically defining the multiple shades of the phenomena investigated by providing the possibility of redefining and transforming extant conceptualizations to propose new ones (Secundo *et al.*, 2020). Over time, SLR has been applied in cross-disciplinary fields such as accounting (Guthrie and Parker, 2011), human capital accounting (Guthrie and Murthy, 2009; Guthrie *et al.*, 2012), intellectual capital (Dumay, 2014) and knowledge management (Manhart and Thalmann, 2015; Massaro *et al.*, 2015).

Since Industry 5.0 is still a nascent and fragmented concept, the diverse aspects and the impact on innovation have not been yet explored by leading extant research, practitioners and managers to be unaware of the different conceptual shades of the issue. In this sense, SLR is a technique that permits to offer an in-depth understanding of variables previously not analyzed and to identify the different semantic dimensions that define 5.0 paradigm, by shedding light critically the impact of both Industry and Society 5.0 on innovation.

To develop the research design for SLR, the approaches proposed by Webster and Watson (2002), Guthrie and Murthy (2009), Dumay (2014), Massaro *et al.* (2016) have been combined to design a research protocol based on six phases, illustrated in Figure 1 and described in the following subparagraphs.

3.1 Step 1: conceptualization and definition of research questions

In this stage, the rationale behind the SLR should be specified by highlighting why the issue requires urgent investigation (see paragraph 2) and, starting from these motivations and from the lacks identified in literature, by formulating research questions.



Source(s): Authors' elaboration

Figure 1.
The key steps of the SLR research design for data collection and analysis

The aim is to map and assess the existing conceptualization of Industry and Society 5.0 and the impact on Innovation to identify future research needs (Dixon-Woods, 2011; Dumay *et al.*, 2016) by adopting a critical approach to develop new research avenues.

Extant scholars that employ SLR (Massaro *et al.*, 2016) report that three key aims should be pursued by critical research (Alvesson and Deetz, 2000): (1) *insights*: the "what," to inspect the semantic shades of a concept to assess the state of the art to define the issue as conceptualized until now; (2) *critique*: the "why," a critical analysis based on a specific field, which focuses on the relationship with other constructs, the effect on other related variables, e.g. in this case the impact on innovation; (3) *transformative redefinition*: to synthesize the results obtained in order to reframe and transform extant conceptualizations to propose new ones in an original conceptual framework.

Hence, based on the identification of the gaps in extant research and on the willingness to comply with the three foci suggested in literature, the research questions of the study are.

RQ1. Which are the key dimensions of the 5.0 paradigm?

RQ2. Which are the levers for encouraging the development of Innovation 5.0?

RQ3. Which are the main implications for research and for the future development of Innovation 5.0?

Based on these objectives, different boundaries, classifications, and codes are identified to detect some filters and parameters to extract and select the most relevant articles.

3.2 Step 2: data collection and sample extraction

To obtain a first sample of articles, the keyword search has been performed through Scopus database and journal databases (10 journals with a focus on Innovation and 10 journals with a focus on management), which can ensure more accurate research results (Massaro *et al.*, 2016) and can also help exclude irrelevant articles. Scopus has been adopted since it seems to be a complete database which includes most of the papers indexed in other databases, such as Emerald or Web of Science (Dumay and Cai, 2014; Thelwall, 2018).

The search string employed is: "5.0" AND "Industry 5.0" OR "Society 5.0" AND "Innovation." The first sample of articles returned by the database included 289 documents (204 articles, 78 conference papers, 7 books).

The analysis focuses on the collection of articles from peer-reviewed journals in order to select papers specialized in a particular field. Since Industry 5.0 is an emerging research area, other emerging sources such as conference papers are employed, since also works in progress can offer valuable insights on the issue. For the same reason, no time restriction has been established and the research has not been limited to a given period.

3.3 Step 3: article selection and data skimming

In the third stage, after the application of research filters (excluding criteria such as language, subject area, type of publication), the impact of the article has been assessed through citation analysis to further skim the sample and obtain 81 papers. Citation analysis has been assessed through the number of citations received (Google Scholar) and the citations per year (CPY) index (Dumay, 2014).

Then, the titles and abstracts are examined to delete papers that do not address the research questions and to determine the final sample of articles included (Secundo *et al.*, 2020).

The analytical framework is based on the following dimensions, that have been used to assess the pertinence of the studies with the research aims: (1) focus of the study; (2) methodology; (3) conceptualization of 5.0; (4) key dimensions for 5.0 application; (5) approach to innovation.

After reading the abstracts of the 81 papers, 29 papers were excluded to compose a final sample of 52 articles (27 articles, 9 book chapters, 13 conference papers, 3 books) that consider simultaneously Industry 5.0 and Society 5.0 with a focus on Innovation and that have been maintained in the study for further analysis (see Figure 1).

More accurate research within titles, abstracts and keywords has been carried out to further skim the sample and to include in the analysis only the papers that focus simultaneously on Industry 5.0 or Society 5.0 and Innovation.

3.4 Step 4: data analysis with coding, reliability assessment, enrichment of the framework

The fourth step consists in the analysis of the final sample of papers through descriptive analysis and through a coding process aimed at analyzing the state of the art of the literature, its evolution in time and its impact based on some variables identified for each research questions.

As for descriptive analysis, tables and statistical analysis (frequency distribution and charts) are created to offer bibliographic information on current literature and on its evolution and to disclose the underlying themes and relationships between the different variables. The studies in the sample are classified by authorship, number of citations, common keywords and topics, adopted methodologies.

Coding aims at identifying the most relevant features in the studies and to code them to finally reconnect the with the macrocategories and concepts deriving from literature, for each research question, to enrich and broaden extant conceptualizations or introduce new ones.

Three researchers read independently the papers based on both abstracts and full texts of the articles to discuss and make preliminary classifications by recording the codes on a separate spreadsheet. Then, two authors manually coded all the papers while one author checked the coding for consistency.

The advantage of manual coding is that concepts with similar meaning such as, for instance, "humanity," "human resources," "skills" and "employees" can be understood in their true sense and coded accordingly (Watson and Webster, 2020). Thus, manual coding allowed researchers to use implicit knowledge of the situation so they could effectively interpret idiomatic and metaphorical text and complex subordinate phrases.

A clustering and conceptualization of the key topics and subdimensions emerged from the articles is performed through content analysis (Krippendorff, 2004; Guthrie *et al.*, 2004). Third-type qualitative content analysis (Losito, 1996) aims at extracting from texts few categories of contents to connect the raw data with the variables identified in literature to identify new conceptual categories. Texts are the unit of analysis in which the different variables have been detected to notice the absence or presence of a given feature.

To assess reliability, Krippendorff's α has been employed to avoid bias and to reach a high degree of accordance between researchers' perception and evaluation of data and to attain a cocreation of common shared results (Krippendorff, 2013). After the attribution of a dichotomic score related to the presence (1) and the absence (0) of a given subdimension (e.g. knowledge management) related to a given variable (e.g. focus of the study domain), the scores of each researcher for the subdimensions have been compared to establish the degree of agreement and disagreement. The values of α can vary between 0 and 1, where 0 is the maximum level of discrepancy and 1 is the maximum level of correspondence. For all the subdimensions, α reached a value greater than 0.6, which shows a high degree of agreement on the interpretation of the interviews and a general reliability of the final evaluation of researchers. The coding and content analysis allow at further skimming the final sample of articles to identify clusters of papers with common features and research areas. The results produced 4 clusters and 27 papers out of the 52 analyzed.

A flexible coding approach has been adopted to let new categories emerge during the analysis iteratively. As it can be noticed in the final framework (see Figure 3), new

subdimensions have been specified for each dimension through the new insights discovered during the reading and coding of the papers.

3.5 Step 5: data interpretation and discussion of results

A concept-centric approach has been adopted to conceptualize the key issues emerged from the analysis for each variable in order to identify new subdimensions and produce new conceptualization.

Sense-making (Armitage and Keeble-Allen, 2008) has been performed through an interpretative approach based on hermeneutic paradigm that (1) identifies some variables for each research questions (through deduction); (2) reconnects the data collected with the subdimensions of analysis (through induction) to produce new conceptualization by highlighting the relationships between concepts (Webster and Watson, 2002) and broadening the classification employed for the analysis according to a meta-synthesis view (Watson and Webster, 2020). Hence, this analytical approach mediates between induction and deduction through abductive processes (Dulock and Holzemer, 1991).

Critical skills have been applied through an open-minded approach that leads researchers, starting from the possession of some guidelines, beliefs and personal knowledge, to develop the ability to manage large sets of data (Hart, 1999) and to be constructive in order to extract new connections between existing elements, new ideas and reveal new concepts to be explored.

The results permit to develop a conceptual framework which suggests the key outcomes of Innovation 5.0, enabled by the integration of the key dimensions of Industry and Society 5.0, that need to be further inspected in future research and the key strategic drivers to be implemented to encourage the development of innovative outcomes.

3.6 Step 6: theory contribution and development of future research paths

The last step is based on the enrichment of theoretical and practical knowledge on the issue and on the development of critical and managerial guidelines that can provide the rights skills to introduce new ways of doing and changes in business, management, governance, policy-making, etc.

By emphasizing understudied or overrated topics, some gaps and areas of concerns can be identified by encouraging future research to develop given aspect, designing new research paths and questions and introducing some call for research. For instance, by detecting the most common research methods to explore an issue, suggestions for the adoption of new techniques (or maybe for the combination of extant and new techniques) can provide research with justification to employ specific research methods, theory and conceptual frameworks in future studies.

4. Findings

The final sample of 27 articles has been explored through a preliminary descriptive analysis (characteristics of the articles, citation analysis, key research areas, etc.) Then, a cluster analysis has been conducted, first, through bibliographic coupling with VosViewer and, second, through a content analysis of the extracted texts. The findings of the descriptive analysis (paragraph 4.1) and of cluster analysis (paragraph 4.2) are discussed in the following subparagraphs.

4.1 Descriptive analysis

The descriptive analysis is based on the classification of the articles in the sample by number of publications per year, number of citations, research fields, analysis of the most influential

authors, common keywords from which 4 clusters have been derived and analyzed through content analysis.

Figure 2 shows the distribution of the articles over the years (from 2018 to 2023). The analysis reveals a constant growth of the contributions which then culminated in 2022, by confirming the continuous expansion of the theme, especially after the advent of disruptive events, as the substantial growth after the development of global health emergency in 2020 shows.

Table 1 shows the most cited ten papers in the sample by revealing some preliminary macroareas in which Innovation 5.0 is studied: industrial management (three papers), sustainability (three papers) and knowledge management (four papers). Moreover, it can be

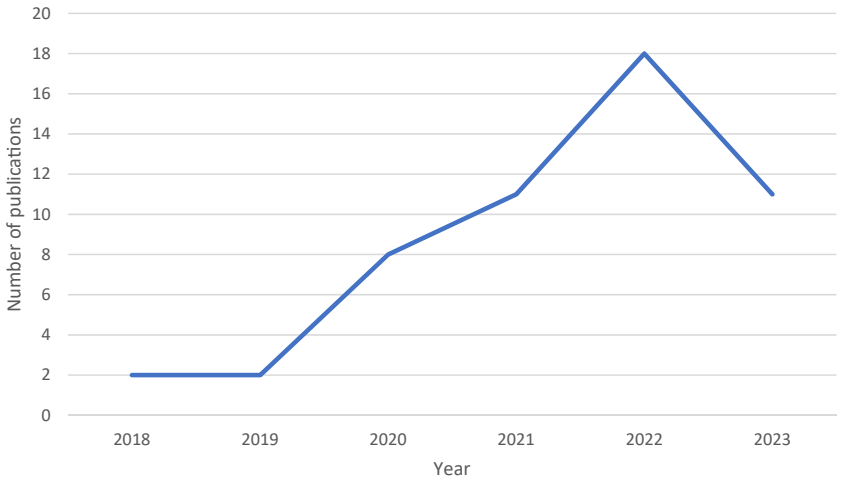


Figure 2.
Number of publications over the year

Source(s): Authors' elaboration

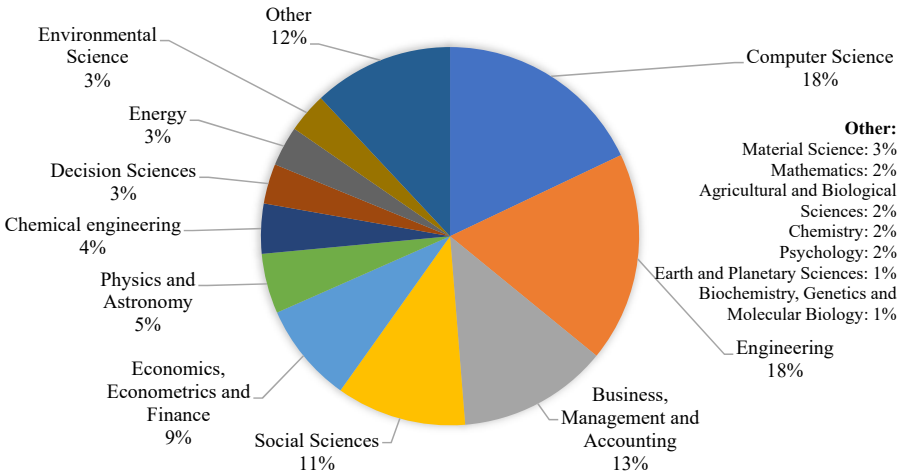


Figure 3.
The key research areas of paper in the sample

Source(s): Authors' elaboration

Author(s)	Title	Journal	Citations
Javaid *et al.* (2020)	Industry 5.0: Potential applications in COVID-19	Journal of Industrial Integration and Management	89
Potočan *et al.* (2020)	Society 5.0: balancing of Industry 4.0, economic advancement and social problems	Kybernetes	63
Acioli *et al.* (2021)	Applying Industry 4.0 technologies in the COVID–19 sustainable chains	International Journal of Productivity and Performance Management	63
Carayannis *et al.* (2022)	The Futures of Europe: Society 5.0 and Industry 5.0 as Driving Forces of Future Universities	Journal of the Knowledge Economy	55
Yin and Yu (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	54
Aquilani *et al.* (2020)	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	54
Akundi *et al.* (2022)	State of Industry 5.0—Analysis and Identification of Current Research Trends	Applied System Innovation	51
Carayannis *et al.* (2022)	Smart Environments and Techno-centric and Human-Centric Innovations for Industry and Society 5.0: A Quintuple Helix Innovation System View Towards Smart, Sustainable, and Inclusive Solutions	Journal of the Knowledge Economy	35
Carayannis *et al.* (2022)	Helix Trilogy: the Triple, Quadruple, and Quintuple Innovation Helices from a Theory, Policy, and Practice Set of Perspectives	Journal of the Knowledge Economy	33
Carayannis *et al.* (2021)	Democracy of Climate and Climate for Democracy: the Evolution of Quadruple and Quintuple Helix Innovation Systems	Journal of the Knowledge Economy	32

Source(s): Author's elaboration

Table 1.
The ten most cited articles in the sample

confirmed that the most significant production started from 2020. These findings demonstrate that the advent of pandemic has significantly contributed to the development of 5.0 research, due to the need to conceptualize some key drivers to address societal changes in times of uncertainty.

As Table 2 reveals, the most influential article, as resulted from the estimation of CPY (the ratio between the number of citations and the time passed between the publication date and the end of the analysis period) is the paper by Carayannis and Morawska; Jancelewicz (2022) with 55 citations, which ranks fourth in the list of most cited papers. CPY measures the impact over time and the article is one of the most influential when referring to Society 5.0 classification and to the implications for innovation management.

The publications of Yu (2022) and Akundi *et al.* (2022) published in the same year of the first article, are in the second and third place with 54 and 51 citations respectively.

The first is a fundamental study for the exploration of Industry 5.0 impact on innovation, whereas the second one is a literature review that maps the contemporary and future trends in 5.0 literature, which probably significantly inspired the study landscape. The last in the ranking is the article by Carayannis and Campbell (2021) with 32 citations and 16 CPY index.

The analysis of the key research areas in the sample (see Figure 3) reveals that the conceptualization of Innovation 5.0 is anchored to the techno-centric view, since the two key

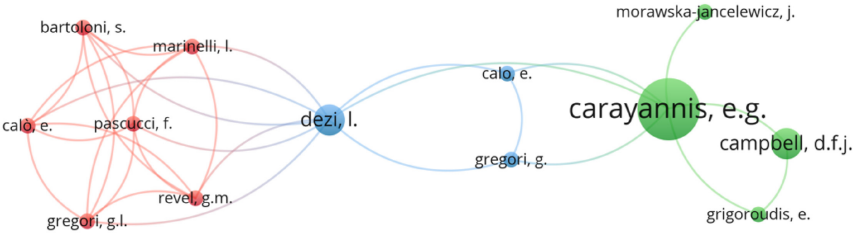
Author(s)	Title	Year	Cited by	CPY	Ranking CPY
Javaid, Haleem, Singh, Raina, Suman	Industry 5.0: Potential applications in COVID-19	2020	89	29.66	7
Potočan, Mulej, Nedelko	Society 5.0: balancing of Industry 4.0, economic advancement and social problems	2021	63	31.5	6
Acioli, Scavarda, Reis	Applying Industry 4.0 technologies in the COVID–19 sustainable chains	2021	63	31.5	6
Carayannis, Morawska-Jancelewicz	The Futures of Europe: Society 5.0 and Industry 5.0 as Driving Forces of Future Universities	2022	55	55	1
Yin, Yu	An adoption-implementation framework of digital green knowledge to improve the performance of digital green innovation practices for industry 5.0	2022	54	54	2
Aquilani, Piccarozzi, Abbate, 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	2020	54	18	8
Akundi, Euresti, Luna, Lopes, Edinbarough	State of Industry 5.0—Analysis and Identification of Current Research Trends	2022	51	51	3
Carayannis, Dezi, Gregori, Calo	Smart Environments and Techno-centric and Human-Centric Innovations for Industry and Society 5.0: A Quintuple Helix Innovation System View Towards Smart, Sustainable, and Inclusive Solutions	2022	35	35	4
Carayannis, Campbell, Grigoroudis	Helix Trilogy: the Triple, Quadruple, and Quintuple Innovation Helices from a Theory, Policy, and Practice Set of Perspectives	2022	33	33	5
Carayannis, Campbell	Democracy of Climate and Climate for Democracy: the Evolution of Quadruple and Quintuple Helix Innovation Systems	2021	32	16	9

Source(s): Authors' elaboration

Table 2.
Top ten authors and articles per citations and per CPY

fields that explore the issue are engineering (18%) and computer science (18%). Hence, the focus is on the application of 5.0 technologies to information systems and industry. However, the studies in the field of business, management and accounting rank third (13%) and social studies rank fourth (11%), by showing that there is a growing number of contributions in the managerial and economic and social area that are starting to conceptualize the need to integrate the relevance of technology with human's intervention (skills and knowledge) to study the innovation opportunities and social impact deriving from Industry and Society 5.0.

Through VosViewer, the most influential authors in the sample have been analyzed. Figure 4 presents the 13 top-ranked authors and how they are correlated among the various authors in 5.0 literature. The findings reveal that the most influential author is Carayannis, with the most contributions (3 papers) and the most cited works (see Table 2). The Figure also shows coauthorship that has been obtained from the bibliographic coupling analysis that reveals the strength of the closeness based on the number of references in each paper after running 10 interactions. The coauthors of Carayannis (the author with most papers) act as



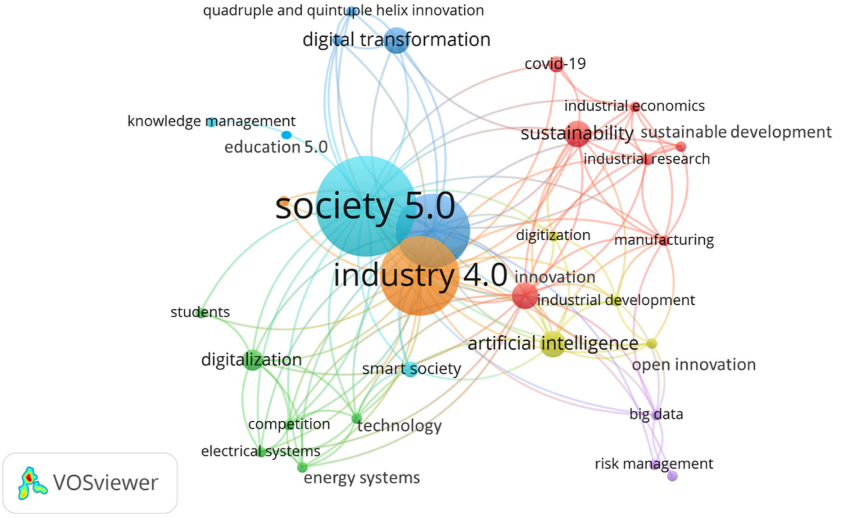
Source(s): Authors' elaboration

Figure 4.
Cluster of intersected literature

bridges in the network, since they are related to the most influential authors and are at the same time in connection with other authors.

Through VosViewer, an investigation of the most common topics in the sample has been performed through a cluster analysis that employs bibliographic coupling and analyzes the type and frequency of keywords used and the emergent topic areas, based on the intersection of the references included in the sample. The links between the articles and topics have been estimated by including only papers which cited the same references in the bibliography and considering only articles that have minimum two references in common. The bibliographic analysis reveals the strength of the closeness according to the number of references in each paper after running 10 interactions.

As depicted in Figure 5, the analysis discloses 6 clusters (red, violet, yellow, green, blue and light blue), which have been recategorized into 4 clusters, due to the high correspondence



Source(s): Authors' elaboration

Figure 5.
The intersection of key topics

and closeness of topics of yellow, red and violet clusters, which deal with the analysis of the impact of 5.0 technology on industry and manufacturing. Hence, the 4 clusters identified are: (1) *red*: industry and manufacturing, which analyzes the implications of 5.0 technologies application to manufacturing, smart industry and supply chain management; (2) *light blue*: human-centered view, which assesses the key skills and education and training strategies needed to enrich human capital for a proper activation of technologies; (3) *green*: social impact of I5.0, which explores the role of connections, collaborations and actors' engagement in the resolution of social issues; (4) *blue*: knowledge management that examines how 5.0 can change knowledge management processes (KMPs) as key enablers of innovation.

4.2 Cluster analysis through coding

The four clusters identified through bibliometric analysis have been, then, explored through content analysis, coding and hermeneutic interpretative approach to extract new concepts, subdimensions and enablers of Innovation 5.0 for each group of studies.

As reported in Table 3, the results show a Krippendorff's alpha over 0.8 (Krippendorff, 2013) for each macrocategory of analysis identified in the analytical framework. It follows that the results of the analysis can be considered reliable.

The coding has been performed by three authors who coded the same articles in each cluster independently. It can be noticed that the methodology and the aims of the studies are

Categories- broad code	Variables – sub-codes	Results	Krippendorff's alpha
Aim	Conceptualizing key dimensions of 5.0	7	*0.945*
	Design of a conceptual framework	11	
	Conceptualizing key dimensions of Innovation 5.0	2	
	Define future trends of research	4	
Focus of the study-domain	Industrial	6	*0.899*
	Manufacturing	1	
	Knowledge management	6	
	Innovation Management	4	
	Sustainable business models	1	
	Smart society	4	
	Smart cities	1	
	Education	4	
Methodology	Conceptual	7	*1.000*
	Literature review	12	
	Qualitative approach	5	
	Quantitative approach	3	
Key dimensions of 5.0	Technological focus	8	*0.946*
	Human	5	
	Social	6	
	Resilience	4	
	Government support	2	
	Environmental	2	
Definition-conceptualization of Innovation 5.0	Analytical approach	12	*0.848*
	Critical approach	8	
	Synthesis approach	7	
Approach to innovation	Techno-centric	7	*0.910*
	Social	7	
	Human-centric	6	
	Systemic	7	

Table 3. Categories and variables used for coding, summary of results and reliability

Source(s): Authors' elaboration

the categories which gained the highest degree of concordance, since these are less dependent on the subjectivity of researchers. On the contrary, the key dimensions of innovation are the variables with the lowest degree of concordance, since not all studies explicitly identify Innovation 5.0 and its dimensions and, therefore, the interpretative and individual work of the researchers has been greater.

A synthetic overview of cluster analysis, based on the key dimensions identified in the analytical framework (aim, focus of the studies, methodology, key dimensions of 5.0, conceptualization of Innovation 5.0, approach to innovation), is provided in Table 4. The different clusters not only show different foci but also different conceptualizations of 5.0 and different approaches to innovation (see paragraphs 4.2.1 and 4.2.4 for a detailed description). For instance, the first cluster focuses on the analysis of technology impact on smart manufacturing and industry, by permitting to detect a technocentric view on innovation (mainly technological and process innovation). The other clusters reveal the gradual shift toward a broader view which promotes in each group different variables (human, society, knowledge) but with the common adoption of a systems perspective.

Moreover, as for the methodology, the most used technique is the systematic literature review and the conceptual approach. However, in the social cluster there is a prevalence of use of qualitative techniques, by confirming that the analysis of the social impact of a phenomenon can be better performed through in-depth investigations of a given context.

Table 5 shows the final list of articles included in each cluster, which will be analyzed separately in the following subparagraphs according to the different categories of analysis.

4.2.1 Cluster 1: industry and manufacturing. The papers in the first cluster analyze the disrupting impact of I4.0 technologies on industry strategies to understand how technologies can connect people and things (Frederico, 2021) and develop effective human–computer interactions.

According to these studies, technological advancements should be balanced with human empowerment, but the focus of the research included in the cluster is on the mapping of the different technologies (Rowan, 2023) that can boost supply chain resilience, flexibility and optimization, and productive and manufacturing processes (Akundi *et al.*, 2022).

The key dimensions of 5.0 (RQ1) are technology (intelligent devices and systems), people (human capital, skills and knowledge) and environment (renewable integration, circular economy). Even if the role of humans is examined, the effect of digital technologies is totalizing in every sphere (Internet of everything): from education to social safety, climate change and environment.

Studies that seek to propose a systems conceptualization of Society 5.0 are not present in the cluster, since this concept is considered just as the natural result of the application of 4.0 technological ecosystem (Gurjanov *et al.*, 2020)

As for the approach to Innovation 5.0 (RQ2), the two main kinds of innovation investigated are (1) *technological innovation*, as the result of the application of 4.0 technologies on the interactions of humans and machines (Majernik *et al.*, 2022); (2) *process innovation*, considered as the improvement of resources efficiency, workforce optimization and waste reduction (Ghobakhloo *et al.*, 2023); (3) *sustainable innovation*, applied to manufacturing practices, operations and revenue streams.

Hence, human's interactions are acknowledged as a variable that undergoes the effect of technologies (Bosovska *et al.*, 2022) and that can be threatened and potentially be replaced (Cannavacciuolo *et al.*, 2023) rather than an active enabler of Society 5.0.

4.2.2 Cluster 2: human-centered view. The studies in the second cluster focus on the relevance of human component as a necessary condition for the emergence of Society 5.0 and as an active enabling factor of innovation, rather than as a variable that can simply coexist with technology application. A humanistic view can transcend the application of technology (Lantada, 2020), by enveloping technological ecosystem and becoming a necessary condition

Table 4.
Synthesis of cluster analysis

	Keywords	Focus of the studies	Methodology	Key dimensions of 5.0 (RQ1)	Definition-conceptualization of innovation 5.0	Approach to innovation (RQ2)
Cluster 1 Red	Smart Industry, Smart manufacturing, Supply chain management, disruptive technologies, flexibility, resilience	Mapping the different 4.0 technologies that can boost supply chain resilience, flexibility and optimization	Conceptual papers Literature reviews	- Technologies - People - Environment	- Technological innovation - Process innovation - Sustainable innovation	*Techno-centric view* Society 5.0 is just the result of the application of 4.0 technologies
Cluster 2 Light blue	Education, ecosystems, open innovation, learning orientation, skills, creativity	Human component as a necessary condition/active enabler for Society 5.0	Literature reviews	- Technologies - Skills - Social inclusion	- Open innovation - Data-driven innovation	*Humanistic and systems view*
Cluster 3 Green	Growth, citizens, science and research, human-centric innovation, inclusivity, social interactions	The integration of humans and technology can address social problems	Qualitative research	- Physical and cyber space - Human resources - Government	- Social innovation	*Systemic and systematic approach*
Cluster 4 Blue	Knowledge creation, Knowledge management, Power capital, Digital social innovation, ecosystems, users-driven innovation	Smart 5.0 society (digital-human centric) can enable knowledge creation and co-creation that can foster users-driven innovation	Conceptual papers Qualitative research	- Human-technology interactions - Knowledge (Power capital) - Environment and society	- Social innovation as process and outcome - Digital Social Innovation	*Users-driven approach*

Source(s): Authors' elaboration

	Authors/Year	Title	Journal
Cluster 1 Industry and manufacturing (Red)	Frederico (2021)	From Supply Chain 4.0 to Supply Chain 5.0: Findings from a Systematic Literature Review and Research Directions	Logistics
	Rowan (2023)	The role of digital technologies in supporting and improving fishery and aquaculture across the supply chain – Quo Vadis?	Aquaculture and Fisheries
	Majernik *et al.* (2022)	Sustainable Development of the Intelligent Industry from Industry 4.0 to Industry 5.0	Advances in Science and Technology Research Journal
	Gurjanov *et al.* (2020)	The smart city technology in the super-intellectual Society 5.0	Journal of Physics
	Ghobakhloo *et al.* (2023)	Industry 5.0 implications for inclusive sustainable manufacturing: An evidence-knowledge-based strategic roadmap	Journal of Cleaner Production
	Bosovska *et al.* (2022)	Models of the Industrial Revolution 5.0	IEEE 2022 Proceedings
	Cannavacciuolo *et al.* (2023)	Technological innovation-enabling industry 4.0 paradigm: A systematic literature review	Technovation
	Akundi *et al.* (2022)	State of Industry 5.0—Analysis and Identification of Current Research Trends	Applied System Innovation
Cluster 2 Human-centered view (Light blue)	Lantada (2020)	Engineering Education 5.0: Continuously Evolving Engineering Education	International Journal of Engineering Education
	Nikum (2022)	Answers to the Societal Demands with Education 5.0: Indian Higher Education System	Journal of Engineering Education Transformations
	Tavares *et al.* (2022)	The Challenges and Opportunities of Era 5.0 for a More Humanistic and Sustainable Society—A Literature Review	Societies
	Aquilani *et al.* (2020)	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
	Aslam *et al.* (2020)	Innovation in the Era of IoT and Industry 5.0 Absolute Innovation Management (AIM) Framework	Information
	Del Giudice *et al.* (2023)	The "bright" side of innovation management for international new ventures	Technovation
Cluster 3 Social impact (Green)	Základník and Putnová (2019)	Digital society – opportunity or threat? Case studies of Japan and the Czech republic	Acta–Universitatis Agriculturae et Silviculturae Mendelianae Brunensis
	Calp and Bütüner (2022)	Society 5.0: Effective technology for a smart society	Artificial Intelligence and Industry 4.0 (Book)
	Gandasari *et al.* (2020)	Discourse Analysis: The Impact of Industrial Revolution 4.0 and Society 5.0 in Indonesia	International Journal of Advanced Science and Technology
	Shukla, Singh (2023)	Industry 5.0 and Digital Innovations Antecedents to Sustainable Business Model	Transformation for Sustainable Business and Management Practices (Book)
	Bartoloni *et al.* (2022)	Towards designing society 5.0 solutions: The new Quintuple Helix – Design Thinking approach to technology	Technovation

(*continued*)

Table 5.
The key clusters in the sample

	Authors/Year	Title	Journal
Cluster 4 Knowledge management (Blue)	Carayannis *et al.* (2022)	The Futures of Europe: Society 5.0 and Industry 5.0 as Driving Forces of Future Universities	Journal of the Knowledge Economy
	Lattanzio *et al.* (2022)	European Union Conceptualisation of Industry 5.0: Opportunities and Challenges for Transdisciplinary Engineering	Transdisciplinarity and the Future of Engineering (Book)
	Carayannis *et al.* (2022)	Helix Trilogy: the Triple, Quadruple, and Quintuple Innovation Helices from a Theory, Policy, and Practice Set of Perspectives	Journal of the Knowledge Economy
	Carayannis *et al.* (2022)	Smart Environments and Techno-centric and Human-Centric Innovations for Industry and Society 5.0: A Quintuple Helix Innovation System View Towards Smart, Sustainable, and Inclusive Solutions	Journal of the Knowledge Economy
	Fujii *et al.* (2018)	A Consideration of Service Strategy of Japanese Electric Manufacturers to Realize Super Smart Society (SOCIETY 5.0)	Knowledge Management in Organizations (Book)
	Cillo *et al.* (2022)	Rethinking companies' culture through knowledge management lens during Industry 5.0 transition	Journal of Knowledge Management
	Konno and Schillaci (2021)	Intellectual capital in Society 5.0 by the lens of the knowledge creation theory	Journal of Intellectual Capital

Table 5. **Source(s):** Author's elaboration

for the development of innovation. Thus, technology *per se* is not sufficient to create innovative outcomes in a 5.0 Society.

Two studies in the cluster (Lantada, 2020; Nikum, 2022) conceptualize the human dimension through the proposal of Education 5.0 by also introducing some enablers for open innovation. The promotion of talent's creativity and the enhancement of students' skills are considered as essential elements for value creation, transformation and social innovation (Nikum, 2022).

According to Tavares *et al.* (2022), education system can increase the effectiveness of technology that can be realized only through skills enhancement, through the ability to adapt to a changing labor market and through the establishment of a culture of innovation.

Hence, education can be considered as an ecosystem that brings together technologies, knowledge and social innovation through the integration of Industry 5.0 and Society 5.0.

The key dimensions of 5.0 (RQ1) are: (1) *technologies* (reread through a service orientation that focuses on digitalization and personalization); (2) *skills* (enabled through learning processes based on mentoring, training, research, skills enhancement); (3) *social inclusion* (collaborations across networks and between public–private sectors for well-being and job equality, Aslam *et al.*, 2020; Bartoloni *et al.*, 2022).

The approach to Innovation (RQ2) is broadened to espouse a systems view. Innovation hubs, communities and the collaboration between companies, universities and research centers (which can foster training and the creation of learning environment) are considered as key levers for educational innovation, which is considered as open innovation (Lantada, 2020; Corvello *et al.*, 2017), based on the collaboration between research system, education system and labor system (Nikum, 2022).

Moreover, innovation can be developed through the active engagement of users (customers, students, citizens) in service codesign and value and knowledge cocreation (Aquilani *et al.*, 2020; Tavares *et al.*, 2022). Big data is considered essential in value cocreation

processes, since it can be transformed into key resources and potential new knowledge. Data-driven innovation can be the result of the promotion of talent and skills development and of entrepreneurial orientation.

4.2.3 Cluster 3: social impact. The third cluster is composed of studies that broaden the human dimension to conceptualize the importance of people and the impact on quality of life, welfare and well-being (Základsník and Putnová, 2019). The intersection between technology-centered and human-based solutions can help address social issue; therefore, the combination of technology and human ability can contribute to tackle social problems and pursue growth for citizens (Shukla and Singh, 2023). Therefore, technological and human dimensions, the core of the first two clusters, are enablers of social outcomes.

Economic development should be balanced with the resolution of social and environmental problems (Calp and Bütüner, 2022) through the inclusion of users in value cocreation and through the constant collection of their feedbacks to align with their needs.

The key dimensions of 5.0 (RQ1) are (1) *physical and cyberspace*; (2) *human resources* (literacy of students, expertise of managers, etc.); (3) *government*, that can promote research (for employment and job opportunities) and welfare (Gandasari *et al.*, 2020).

According to the studies in this cluster, 5.0 Society should be based on smart and intelligent systems that interconnect digital structures and infrastructures, skills promotion and training to advance society by increasing sustainability and reducing potentially unemployment, poverty, pollution, etc.

The enhancement of social interactions between different kind of stakeholders and the creation of social entrepreneurship projects can introduce innovative ways to support community's growth (Bartoloni *et al.*, 2022; Corvello *et al.*, 2023b).

The approach to Innovation (RQ2) shifts from a technology-oriented view to human-centric innovation for the creation of social outcomes. Moreover, technological development and the constant valorization of human component cannot only address social issues but can enable continuous improvement and transformation. Thus, innovation can be systemic and systematic and can contribute the creation of new social structures, values and order.

4.2.4 Cluster 4: knowledge management. The fourth cluster is based on studies that investigate the role of KMPs in the development of Society 5.0 and that advance a systems' view on innovation.

Three papers employ the framework of Quintuple Innovation Helix to conceptualize the need to design a human-centered and users-driven innovation ecosystem based on knowledge creation and application to boost innovation process (Carayannis and Morawska; Jancelewicz, 2022; Carayannis *et al.*, 2022).

The different phase of KMPs can be matched with the steps of innovation development: starting from the enrichment of actor's knowledge and from the exchange of technical and managerial expertise in the ecosystem new solutions can be created (Carayannis and Morawska; Jancelewicz, 2022). Knowledge transfer can be enabled by technology, physical and virtual systems to set up a knowledge-driven organizational culture (Cillo *et al.*, 2022)

The key dimensions of 5.0 (RQ1) are: (1) *human–technology interactions*: empowering people can activate technology and gain a proactive attitude; (2) *knowledge*: in the form of expertise, tacit knowledge, digital culture (rather than "simply" hard and technical skills) that can create, in turn, a power capital (Carayannis and Morawska; Jancelewicz, 2022); (3) *environment and society*: collaborations among stakeholders (and above all universities) can pursue territorial well-being (Lattanzio *et al.*, 2022).

By borrowing the theoretical lens of service-dominant logic, Fujii *et al.* (2018) identify tacit knowledge in value cocreation that can give birth to knowledge cocreation, as a key lever for Society 5.0.

The approach to Innovation (RQ2) is based on the synergy of digital and human dimensions to determine, through value cocreation and the coevolution of advanced

knowledge systems, the development of social innovation. Social innovation is intended both as a process, deriving from the intentional actions of stakeholders that pursue the resolution of social problems, and as an output, to introduce social solutions created through cooperation and education programs (Carayannis *et al.*, 2022). Moreover, the shift from technocentric to human-centric approach can give birth to digital social innovation (DSI) that can support green and digital transition (twin transition) to enable transformative change through the joint action of education (based on smart and inclusive learning system), research, public engagement and leadership.

5. Discussion: a conceptual framework for innovation 5.0

The results of the SLR reveal that Society 5.0 is a concept that envelops technological (Industry 5.0), human, social and knowledge-based dimensions (RQ1). The synergistic combination of these dimensions, through the application of 4.0 technologies, can be triggered by human's skills and knowledge creation that can produce, in turn, multiple innovation outcomes, ranging from technological and process innovation to data-driven innovation and social innovation (RQ2).

Hence, Innovation 5.0 can be conceptualized as the complex and multileveled process deriving from the implementation of a technological ecosystem that should be effectively activated by empowered and skilled human resources for the creation of new value and knowledge.

The interpretation of the final sample of articles highlights that to encourage the (co-) development of Innovation 5.0, companies, institutions and organizations should combine a technological dimension (the use of 4.0 technologies, tools and analytics) with human dimension (hard and soft skills, digital culture, creativity and investment in talent development), knowledge-based (value and knowledge cocreation) and social dimension (new values of inclusivity to challenge social issues). Starting from the findings obtained through coding and data interpretation, for each macrodimension of analysis and for each cluster different subdimensions that can act as enablers of Innovation 5.0 are identified (see the text not in bold in Figure 6) through interpretative processes based on substruction.

The critical reelaboration of findings can allow at introducing a conceptual framework (see Figure 6) that can be considered as a theoretical foundation for inspiring future research that aim at conceptualizing Innovation 5.0.

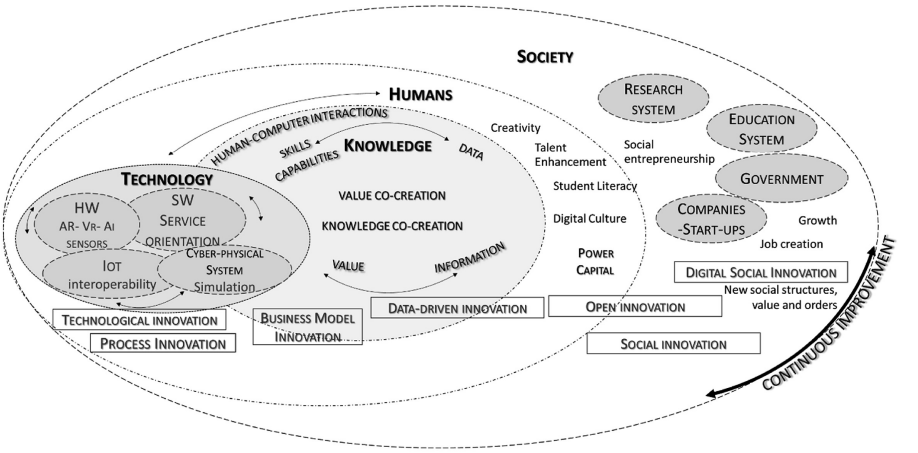


Figure 6.
A multileveled conceptual framework for Innovation 5.0

Source(s): Authors' elaboration

As for technological dimension, a synthesis of the different contributions included in the first cluster (1) hardware (AI, virtual reality, sensors); (2) software (servitization, systems integration); (3) cyber-physical system CPS (that combine computing, networking and physical processes mainly for smart machines and storage systems, Bag *et al.*, 2018); (4) IoT (cognitive computing, machine learning, cloud computing and other optimization algorithms for interoperability). This system can give birth to *technological innovation*, intended as the result of the application of technology for the enhancement of transparency, scalability, responsiveness and flexibility of the supply chain and for collecting real-time insight. Moreover, *process innovation* stems from an integrated set of actions to improve smart manufacturing through workforce optimization, simplification of operations and predictive maintenance.

Knowledge can act as the key intervening variable that can improve the human–technology interactions. The data collected through technologies can be analyzed and turned into information, value and potential knowledge (Troisi *et al.*, 2021). Through circular processes of knowledge acquisition, sharing, creation and use, actors can exchange and renew their expertise by creating a power capital, which can enable users-driven innovation. The application of innovative outcomes in the key mechanisms that lead value creation can give birth to *business model innovation* (Tavares *et al.*, 2022); at the same time, by improving the transition from raw data to information, value and knowledge, *data-driven innovation* can be generated (Aquilani *et al.*, 2020).

Human dimension can be promoted through an integrated set of strategies and actions aimed at improving talents' and students' hard and soft skills, by promoting a digital culture that can enhance the willingness to adopt technology and raise the creativity and entrepreneurial orientation of youngsters. In this way, a power capital can be created that can engage users and talent in the codesign of services, in value cocreation and in the codevelopment of an *open innovation* (Lantada, 2020) in a common digital space.

At a social level, lastly, the collaboration between economic system (industry and start-ups), institutions (government), research system (academy) and education system can introduce innovative ways for addressing social issues through the joint efforts of actors that reciprocally improve well-being, job opportunities and growth (*social innovation*). This mission-oriented innovation, based on the active role of citizen, can support the emergence of digital and green transition (*digital social innovation*), by producing change in the ecosystem, by spreading in it a constant transformational state based on continuous improvement (the bidirectional arrow in the Figure).

5.1 Key implications for future research directions

The conceptual framework introduced in Figure 6 can permit to develop key insights for future research by identifying different kinds of implications for the four clusters identified (RQ3). Hence, this paragraph seeks to address RQ3 by discussing how the key findings can shed light on the directions of Innovation 5.0 research according to a multileveled approach.

The development of the framework can possibly contribute to lay the theoretical foundations for conceptualizing Innovation 5.0 by offering a new perspective on existing knowledge encouraging the research for connections between different dimensions of analysis. Thus, in line with the key goals of SLR, the interpretation of previous literature according to a synthesis and concept-centric standpoint (Watson and Webster, 2020) can allow not only at elaborating a conceptual framework but also at identifying research opportunities and avenues from which it can be derived managerial implications, policy and strategic recommendations for each cluster.

5.1.1 Implication 1: broadening the technocentric view on resilience. The research reveals that the articles that analyze the environmental impact and resilience focus essentially on a technocentric approach in which Society 5.0 is considered as the result of the application of

Industry 4.0 to supply chain management, production and manufacturing processes (Gurjanov *et al.*, 2020).

Hence, future research can further explore the opportunities offered by IoT, AI and cobots to address social, economic and environmental issues and to develop social innovation rather than concentrating exclusively on technological innovation. There is the need to identify how digital technologies (4.0) can tackle social problems in order to conceptualize the transition from Industry 4.0 to Society 5.0. Therefore, technological focus is not limited *per se* but should start from the assumption that the use of technology can be targeted at meeting social expectations (e.g. the resolution of climate change, geopolitical instability, energy waste, data security, sustainability).

Even if the studies in the technological area analyze the impact of technologies on resilience and sustainability the role of human-centricity in this process is underrated (Ivanov, 2023). In fact, these contributions tend to examine these topics separately (Dolgui *et al.*, 2020) or focus on the field of supply chain management and Smart factory or manufacturing.

There is the need to investigate the emergence of resilience in Society 5.0 according to an ecosystems standpoint that considers humans as the link between the application of technology and the development of innovation, by broadening the technocentric perspective. Resilience, sustainability and human-centricity, in fact, are considered as drivers for viability in Society 5.0. For instance, the implications of a resilient supply chain and of sustainable way of production on human–machine interactions and social welfare could be explored. In addition, value creation and the effect of technologies on business models redesign can be explored by conceptualizing resilient and sustainable value cocreation in 5.0 ecosystems. Moreover, the exploration of the potential relationship between resilience and the development of a proactive entrepreneurial attitude can be further investigated to conceptualize antifragility, intended as the ability to turn crisis into opportunities for growth (Taleb, 2012), in 5.0 companies.

5.1.2 Implication 2: human resources management for the creation of digital capital and data-driven innovation. Due to the relationship between human resources promotion strategies and the development of a Society 5.0 (Lantada, 2020; Nikum, 2022), future research can observe and identify the different kinds of training strategies and of skills that should be nurtured to optimize human contribution to Innovation 5.0.

As for education field, which is the key context of analysis of the studies in the second cluster, there is the need to explore the proper structures, incentives and mechanisms to develop digital literacy, to remove any barriers in the access and use of technology to include students and talents in the codevelopment of open innovation. Moreover, new didactic strategies and methodologies for inclusive learning and the creation of a smart, flexible and adaptive technology-enhanced learning (TEL) environment that effectively use technologies, AI and digital transformation can be examined (Visvizi *et al.*, 2023).

Moreover, extant research does not categorize the different kind of skills that should be nurtured through training strategies to permit a useful exploitation of the innovation opportunities offered by technologies and data analytics (Visvizi *et al.*, 2022). For this reason, the data analysis capabilities (Gupta and George, 2016) needed to reread human resources management in 5.0 era can be studied. By mapping the given kinds of hard and soft skills that should be promoted to develop data-driven innovation, not only the key drivers for innovation in a digital 5.0 era can be assessed, but one of the key obstacles for the creation of digital capital, the inadequacy of the technical skills possessed by human resources, can be challenged.

Digital transformation requires new approaches to human resources management, to skills and knowledge management through the adoption of new business, entrepreneurial and educational strategies. However, the barriers to the use of technology cannot be related

exclusively to the lack of digital competence and digital access but also to the psychological resistance to the use of technology. For this reason, exploring the psychological, behavioral and cognitive dimension of the willingness to use technology is essential for the identification of the obstacles to the use of technology that can prevent the codevelopment of innovation. Future research can categorize the different factors (psychological, social, functional, knowledge-based) that can enable the proper mindset to adopt technology efficiently (Williams *et al.*, 2015) by revealing the impact of some constructs usually employed in management research to assess technology acceptance, such as the unified theory of acceptance and use of technology, technostress (Tarafdar *et al.*, 2007) or technology anxiety (Powell, 2013). In the era of digital citizenship, there is the need to assess how citizenship education can be created to enable job opportunities and democratize the access to technologies.

5.1.3 Implication 3: leveraging phygital space for societal innovation. The studies included in the third cluster focus on the identification of the key enabling dimensions of social innovation in line with a systems view and an open innovation approach.

However, to fully analyze the real impact of Industry 5.0 on sustainability (Shukla and Singh, 2023), as in the definition of Fukuyama (2018), the social dimension of analysis should be broadened to conceptualize societal innovation, which extends the scope of innovation process and innovation management strategies to the policies, norms, regulations and social structures that should be transformed to nurture innovation. The role of collaborations between industry, government, science, education can enhance the creation of a collective intelligence that can improve intellectual and social capital by creating innovation (Konno and Schillaci, 2021).

The establishment of social networks can create phygital ecosystems that integrate physical and virtual space to enable green and digital transition to meet societal needs. Thus, there is the need to explore the key drivers for designing resilient physical/digital social structures that can bring together private, public and social stakeholders to develop opportunities for innovation, enhance skills and capabilities, pursue well-being and maintain competitiveness in a complex and constantly changing technological, political, social, cultural and economic system. By exploring the implications of a phygital world on Society 5.0 can allow at understanding the effects of phygital transformation on social roles, on inclusion, sustainable development and citizen engagement. Future research directions can be identified for the smart city research in which the ways in which phygital can modify citizen's commitment, democratic dynamics and the relationship with government can be identified (Del Vecchio *et al.*, 2023).

Moreover, by broadening the perspective to analyze city's phygital space the strategic drivers and actions that should be implemented by policy-making to control the negative effect of technologies (data privacy, cybersecurity) can be assessed. The potentiality offered by technologies such as AI and data analytics can be explored to identify the guidelines that can help realize sustainable development through a human–machine and people-centric management of urban spaces and a more effective governance of cities and territories. In this perspective, a proper balance of physic and digital world and of technological and human dimensions can enable the improvement of well-being and the attainment of social outcomes. Studies that adopt a systems and sociotechnical view can be encouraged to analyze the entrepreneurial, managerial, leadership and policy-making strategies to exploit the possibilities offered by Society 5.0 according to a cross-disciplinary standpoint.

5.1.4 Implication 4: conceptualizing knowledge management processes and power capital for digital social innovation. The studies in the fourth cluster consider value cocreation and knowledge cocreation as two intervening variables that can modify human–computers interaction by leading to the transformation of the data and information collected into new knowledge. For this reason, there is the need to further analyze the relationship between

knowledge and value cocreation in the creation of open innovation and social innovation (Polese *et al.*, 2022) in the context of Society 5.0.

The results of the study open new directions for knowledge management research. Even if the role of 4.0 technologies and AI in the creation of new knowledge has been acknowledged (Carayannis and Morawska;Jancelewicz, 2022), future research can reread KMPs, intended as the process of acquisition, sharing, storage and use of knowledge in the light of Society 5.0 key dimensions. A service ecosystems approach (Lusch and Vargo, 2014) can be employed to assess how technologies can redefine value cocreation process and the different phases of KMPs that can be matched, in turn, with the phases of innovation process. A service ecosystems perspective can be a valuable systemic and interpretative framework that can permit to understand the impact that the integration of technology with the human, cultural and social dimensions can have on knowledge management (Al Mansoori *et al.*, 2020).

Moreover, future studies can explore the strategies to empower people's engagement and self-efficacy in order to improve the attainment of a knowledge-driven organizational culture (Cillo *et al.*, 2022) that can help the integration of technology in KMPs and the adoption of an adaptive organizational behavior. In this way, a reductionist view of human resources management can be overcome and its link with KMPs can be further explored.

The concept of power capital, intended as the result of the active engagement of people in an innovation ecosystem that can develop social innovation, can be investigated to detect the strategies for the creation of a smart and inclusive education approach that can promote the improvement of life-long learning at an ecosystems level and to improve the ability of the ecosystem to survive changes. In this way, the systems conceptualization of DSI (DSI) can be proposed to understand the strategies that education system, government and companies should promote to enable twin transition and social transformation through research and development, public engagement, social entrepreneurship and a proactive leadership.

Table 6 synthesizes the different research avenues deriving from the analysis for each cluster.

6. Conclusion

The study seeks to advance interpretative lens to rethink innovation through the 5.0 paradigm and reveal the mechanisms to fully exploit the possibilities offered by the Industry 5.0 and Society 5.0 paradigms. SLR was employed to identify the dimensions that define Innovation 5.0. To this end, against the backdrop of the extant literature on the subject, the relationship between Industry 5.0 and Society 5.0 was elaborated. As a result, the key levers underpinning the development of innovation were pointed to and implications for future research outlined. The analysis sheds light on the need to adopt new strategies and practices that combine technological/digital capital with a human-centric view, knowledge and social capital.

The findings allow at elaborating a conceptual framework that detects the enablers of Innovation 5.0, that can be developed across the 5.0 technological infrastructure (technology), activated by empowered human capital (human beings/talent) that interact with technology to collect data and extract value for new knowledge cocreation (knowledge) that can produce social outcomes (society). Moreover, by disclosing the need to broaden extant conceptualization of innovation, the analysis shed light on the shift Industry 5.0 to Society 5.0.

The results reveal that research on Society 5.0 is in the early stages and, in some cases, it is considered just as the natural evolution of 4.0. At the same time, Innovation 5.0 has not been yet conceptualized but some key enablers can be identified and inserted in a multileveled framework that shows how technocentric view can be overcome through human resources management, KMPs and actor's engagement and talent development to create a phygital space in which social innovation is pursued.

	New emerging questions for research
Technology	How can resilience investigation be extended beyond the supply chain management and Smart Industry field?
	How can transparency and cybersecurity issues be addressed?
	How can the transition from Industry 4.0 to Society 5.0 be conceptualized to analyze the impact of technologies on social issues?
	How can business models be redesigned to develop resilient and sustainable 5.0 ecosystems?
Human	Which are the key strategies to promote skills development and human resources in Society 5.0?
	Which are the main technology-enhanced learning (TEL) strategies and methodologies to develop digital literacy and Education 5.0?
	Which are the skills and capabilities that can be promoted to build digital capital for the development of data-driven innovation? How can data-driven innovation be conceptualized?
	How can the barriers to 5.0 technology adoption be overcome?
Social	How can the conceptualization of social innovation in Society 5.0 be broadened to conceptualize societal innovation?
	How can resilient phygital social structures be designed to develop innovation?
	Which is the impact of phygital space on smart cities and digital citizenship?
	Which are the key entrepreneurial, managerial and policy-making strategies to encourage innovation development through phygital space?
Knowledge	Which is the relationship between knowledge and value co-creation and how can these processes be redesigned in Society 5.0?
	Which are the strategies to attain a knowledge-driven organizational culture?
	How can power capital be developed in Society 5.0 and which is the impact on digital social innovation (DSI)?
	Which are the innovation management strategies s to enable twin transition in 5.0 Society?

Source(s): Author's elaboration

Table 6. Findings for RQ3: new insights and future research directions for Innovation 5.0 conceptualization

From a theoretical standpoint, the study can contribute to guide future research that aims at conceptualizing Innovation 5.0 by revealing that some key issues need to be addressed: (1) a narrow view on resilience, which is studied only in supply chain management and smart manufacturing; (2) the concept of digital capital and data-driven innovation; (3) the need to identify human resources management strategies; (4) the design of phygital space for conceptualizing societal innovation; (5) the exploration of value cocreation and knowledge cocreation to develop power capital and develop a systems conceptualization of innovation (which ranges from technological innovation to data-driven innovation and societal innovation).

The identification of the key enabling factors of Innovation 5.0 can contribute to the advancement of the current state of the field (5.0 research and innovation management research). Detecting the influential mechanisms that can lead from the adoption of 5.0 technology to knowledge creation (as an intervening variable)—which can produce, in turn, different shades of innovation (from technological to data-driven and DSI)—can help scholars and practitioners clarify the strategies to improve value creation, manage skills and human resources and select external knowledge, by laying the theoretical foundations for an innovation management framework.

Moreover, by introducing a multileveled perspective that encompasses Industry and Society 5.0 to conceptualize Innovation 5.0, this study provides a new theoretical interpretation perspective on the multidimensionality of digital social innovation (Yin and Yu, 2022) in the era of twin transition.

Moreover, key insights for managers and policy-makers are proposed by encouraging them to identify some strategies to address the potential negative impact of technology (lack of digital skills and culture, of the willingness to use technology, potential threats such as privacy and security). By identifying the potentiality and the key enablers of the integration between technology, humans and society, the study detects some guidelines to inspire

education managers, entrepreneurs, leaders and governance in the adoption of effective training strategies for skills enhancement and digital literacy. Exploring the relevance of phygital space building can also improve city manager's understanding of the ways in which citizen engagement can be strengthened to enhance democracy in the access to technology and include actors in the resolution of social and societal issues.

The illustration of the mechanisms to boost innovation throughout technological, human, cultural and social system can help policy-makers recognize the need to design ecosystem-oriented innovation policies (Laasonen *et al.*, 2020) with outcome orientation based on the strategic partnerships between citizens, companies, public and nongovernmental organizations to challenge system's complexity. A conceptual framework on Innovation 5.0 that reveals the preconditions and the structures for the emergence of innovation in social space can inspire the adoption of new policies instruments in line with a multileveled approach to Governance 5.0 aimed at cocreating multiple benefits for industry, knowledge, society and economy. Hence, the framework proposed can encourage the development of a new broadened perspective on innovation system that can guide policy-makers in the implementation of Research and Innovation (R&I) policies that should consider simultaneously the role of corporate citizenship, democratic access to technology, cultural beliefs, innovation agencies and intermediaries and sociotechnical features.

This value-oriented conception of society can be applied by policy-makers through the promotion of the social aspects identified in the framework (transparency, participation, digital literacy, education 5.0). The practical application of these enabling factors allows to readapt innovation activities, adjust competencies and the modalities of selection of actors and stimulate entrepreneurship through innovative instruments and structures such as open innovation labs and hubs or experimental spaces which can foster a more agile approach (European Commission, 2022).

The study has some limitations related to the definition of keywords and to the adoption of research filters, which led the researchers to stop selecting articles based on their experience and prior knowledge rather than on fixed criteria. Therefore, as the conceptualization of Society 5.0 and Innovation 5.0 expands, future studies might broaden this research to observe more specific aspect of innovation management.

The conceptual framework identified can be considered as a first exploratory step that can inspire future research and that cannot be generalized. Future research can start from the results proposed in the study to apply the classification of the different dimensions of Innovation 5.0 and the different enablers detected for each dimension to specific industries (education, healthcare, tourism, etc.) or to observe networked configurations such as clusters, innovation hubs, etc.

Moreover, to confirm the validity of the conceptual dimensions identified in the framework, future qualitative and quantitative research can be performed. The dimensions can be operationalized to perform case studies based on semi-structured interviews or observation. Then, quantitative methodology can be employed to assess the existence of the different enablers of innovation and of the different innovation outcomes through techniques such as multiple regression or structural equation modeling. In this way, the statistical relationships between Innovation 5.0 and some key antecedents (technology acceptance, digital skills, digital culture, data-driven culture, digital entrepreneurship, etc.) and other managerial variables (value cocreation, knowledge creation, sustainability, etc.) can be tested.

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