

A Human-Centered Digital Transformation: A Bibliometric Analysis of Society 5.0 and Industry 5.0

Abdullah Zübeyr Akman¹ , Meral Erdirençelebi² 

¹Dr. Necmettin Erbakan University, Ereğli Kemal Akman Vocational School, Department of Finance and Banking, Konya, Türkiye

²Assoc. Prof. Necmettin Erbakan University, Faculty of Applied Sciences, Department of Banking, Konya, Türkiye

ABSTRACT

The concepts of Society 5.0 (S5.0) and Industry 5.0 (I5.0) have emerged in recent years as part of the digital transformation landscape, influenced by the advent of Industry 4.0. S5.0 represents a smart society approach rooted in digital transformation, originating in Japan, while I5.0 stems from European studies. This study explores the evolving research landscape surrounding S5.0 and I5.0 by conducting a bibliometric analysis using the Web of Science database, thereby illuminating potential avenues for future studies. The analysis includes studies in which both concepts are keywords, revealing an increasing trend in awareness, scholarly output, and citation counts over time. Notably, Japan and China emerged as prominent contributors, with Nahavandi S. (2019) identified as the most cited author. Engineering emerges as the researched field in connection with these concepts. Furthermore, it becomes evident that S5.0 and I5.0 are closely linked to terms such as artificial intelligence, digital transformation, Industry 4.0, internet of things, sustainability, machine learning, and Economy 5.0/Education 5.0. It is anticipated that these concepts will assume a more comprehensive role in the business landscape, driven by technological advancements and social developments in the coming years.

Keywords: Society 5.0, Industry 5.0, Bibliometric Analysis, VOSviewer, R Studio

JEL Code: M10, M15, O32

Introduction

Since the inception of the first industrial revolution, technological advancements have been abundant, shaping the path of both individuals and societies. Notably, the advent of the Industry 4.0 revolution has ushered in new opportunities, particularly in manufacturing and productivity. However, criticisms have emerged regarding Industry 4.0's exclusive focus on digital technologies within the sphere of manufacturing and productivity (Ghobakhloo, 2020). In response, a recent assertion advocated the use of digital technologies for the benefit of humanity (Harayama, 2018).

The focal point of discussion in this study is Society 5.0 (S5.0). S5.0 is a conceptual framework aimed at harnessing digital technologies to benefit across a spectrum of areas ranging from education and healthcare to economy and governmental institutions, thereby facilitating the emergence of a highly sophisticated society structure. Rapid and substantial advancements in communication and information technologies have created new concepts. Innovations such as artificial intelligence (AI), the Internet of Things (IoT), robotics, cloud computing, and augmented reality have profoundly impacted both social structures and business processes. Consequently, a new social structure, referred to as S5.0 or the “super-smart society,” is gradually unfolding in the 21st century. This framework is rooted in the evolutionary path of preceding society models, which are denoted as Society 1.0 through 4.0. Society 1.0 refers to a hunter-gatherer society, Society 2.0 corresponds to an agricultural society, Society 3.0 represents the industrial era, and Society 4.0 signifies the information society. Each societal iteration emerges due to innovations and transformations within the previous social structure. Society 4.0, often referred to as the information society, is built on interconnected computer networks, facilitating global information accessibility. This interconnectedness has significantly eased worldwide information access, underscoring the paramount of “knowledge and its dissemination” within this social paradigm. The genesis of S5.0 is anchored in the endeavor to enhance human welfare and expand the realm of comfort in human life. The effort to establish a balance between the virtual (digital) domain and the physical world, coupled with the quest for resolving challenges faced by

Corresponding Author: Abdullah Zübeyr Akman E-mail: abdullahzubeyrakman@gmail.com

Submitted: 16.09.2023 • **Revision Requested:** 27.10.2023 • **Last Revision Received:** 11.12.2023 • **Accepted:** 13.03.2024



This article is licensed under a Creative Commons Attribution-NonCommercial 4.0 International License (CC BY-NC 4.0)

societies with aging populations, particularly prominent in Japan, has expedited the formation of this societal structure (Akman, 2023).

The concept of Industry 5.0 (I5.0) has been divided into sustainable, resilient, and human-centric categories by the European Commission. I5.0 represents a forward-thinking paradigm for the future of the industry, aimed at fostering a human-centric, sustainable, and resilient manufacturing and productivity system (Breque et al., 2021). It offers a visionary perspective on the evolving path of the industry landscape. The I5.0 framework promotes the agility and adaptability of systems through the incorporation of flexible and adaptive technologies (Huang et al., 2022). The concept of S5.0 or I5.0 stands as one whose merits and demerits are yet to be discerned, owing to its novelty as a social construct. In fact, initial academic studies reveal a tendency to use these terms interchangeably. The intersection of interrelatedness of both structures emerging from digital transformation has only recently begun to take shape. Consequently, this study has been undertaken to examine recent research in the literature concerning S5.0 and I5.0.

Since the concepts of S5.0 and I5.0 remain unclear, this article addresses the following questions:

- What constitutes S5.0?
- What defines I5.0?
- What differentiates S5.0 from I5.0?
- What underlying principles do S5.0 and I5.0 share?

To achieve this objective, an analysis of academic studies concerning S5.0 and I5.0 was conducted using the Web of Science (WoS) database, employing bibliometric analysis techniques.

Theoretical Background

What Constitutes Society 5.0?

The concept of S5.0 has garnered increased attention in recent years across various fields, including management, education, health, and industries such as business, economy, energy, and tourism. This emergence is attributed to various factors, including the COVID-19 pandemic, natural disasters, and the shift from abundant to scarce manufacturing and productivity resources, prompting a redirection of focus from efficiency and effectiveness to sustainability within the corporate sector. Sustainability, underscored by the imperative of a habitable planet, lies at the core of S5.0, offering a framework to address social and environmental challenges (Duman, 2022). Central to the essence of S5.0 is the notion of “technology for society” (Er et al., 2021), signifying a concerted effort to leverage technological advancements for societal benefit.

Unlike historical shifts and renaming of societies occurring over extended periods, contemporary society constructions witness more rapid transformations. Technology, an inherent aspect of social evolution, plays a crucial role in catalyzing social changes through successive industrial revolutions. In the context of aggregate growth and economic development, technology assumes a crucial position, serving as the primary force influencing the path of the corporate world in the current era (Dawson & Andriopoulos, 2009).

S5.0, often referred to as the “super-smart society,” encompasses a model in which the impacts of digitalization and AI on social processes are comprehensively evaluated. It embodies a concerted endeavor to achieve the maximum level of triple interaction among humans, machines, and robots, thereby aiming for collective growth and development (Deguchi et al., 2020). This vision of S5.0 delineates a future society characterized by integrating a diverse array of new technologies across all sectors and social activities. It envisions not only economic developments, particularly those aligned with the Sustainable Development Goals outlined by the United Nations but also the provision of solutions to prevailing societal challenges (Keidanren, 2016). In other words, S5.0 entails the pervasive utilization of digital technologies across all areas, such as education, healthcare, and the economy, while prioritizing the common good. Consequently, it emerges as a conceptual framework aimed at creating a super-smart society. Japan, a vanguard of technological innovation, stands as an early proponent and adopter of the philosophy underpinning a super-smart society (Mavrodieva & Shaw, 2020). The Japanese government defines S5.0 as a human-centered society that can balance economic progress with solving social problems using a system that integrates the virtual and physical worlds (Yulianto, 2021).

What Defines Industry 5.0?

I5.0 represents a future-looking industrial concept characterized by human-centered, flexible, and sustainable manufacturing and productivity systems and services, aiming to transcend the limitations posed by Industry 4.0 (Breque et al., 2021; Leng et al., 2022). The European Commission introduced “I5.0: Towards a Sustainable, People-Centered, and Resilient European Industry” on January 4, 2021, following collaborative workshops with stakeholders (Breque et al., 2021). This seminal report advocates for the reevaluation of companies’ roles and functions within society, emphasizing three fundamental values for I5.0: human-centeredness, sustainability, and resilience (Xu et al., 2021).

Unlike its predecessor, Industry 4.0, I5.0 places people above automation, prioritizing humanity in its operations (Theorin et al., 2017). With the framework of I5.0, the hierarchical order is distinctly delineated: people take precedence, followed by processes, with technology occupying a subordinate position. This human-centric approach underscores the principle that even the most advanced technologies should not supersede human welfare (Fukuyama, 2018). Notably, I5.0 includes unmanned systems designed to augment human capabilities, collectively referred to as unmanned technologies. Using the foundations laid by Industry 4.0, I5.0 harnesses smart machines to streamline processes and enhance efficiency, thereby optimizing the contributions of skilled employees (Ruiz-De-La-Torre et al., 2022). In contrast to the productivity- and efficiency-centric ethos of Industry 4.0, I5.0 embraces the ideals of “smart” and “sustainability.” This shift is evidenced by the adoption of terms such as “smart” and “sustainability” to characterize societal development within I5.0, transcending traditional business paradigms (e.g., smart tourism and agriculture) (Carayannis & Morawska-Jancelewicz, 2022; Mourtzis et al., 2023). Consequently, I5.0 serves as more than a mere industrial evolution; it emerges as a catalyst for societal advancement, epitomizing the ethos of a super-smart society akin to S5.0.

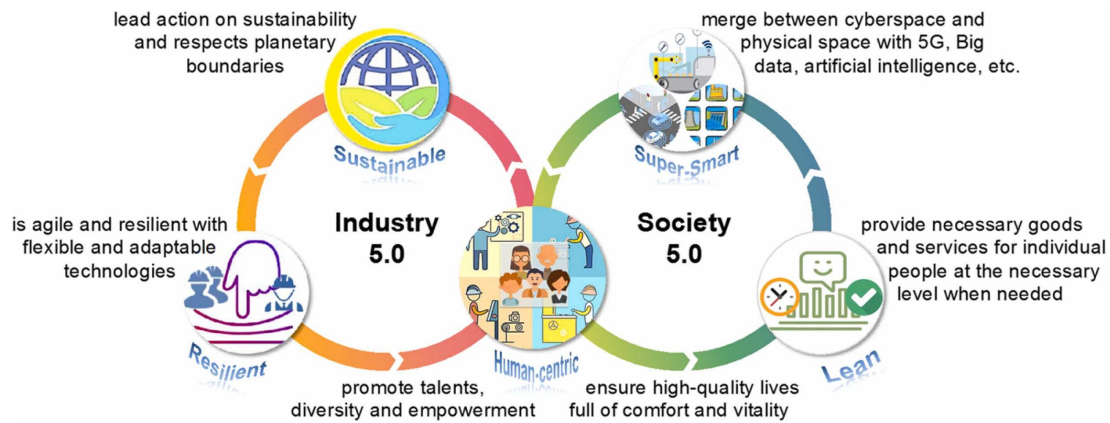


Figure 1. The relationship between I5.0 and S5.0

Source: (Huang, et al. 2022).

As shown in Figure 1, both S5.0 and I5.0 exhibit a strong orientation toward people. In I5.0, for instance, the integration of advanced technology serves to enhance employee skills while actively involving them in business processes, thus placing individuals at the forefront through both internal and external customer-centric approaches. Similarly, S5.0, like its industrial counterparts, revolves around the creation of value, underscoring a shared emphasis on human-centricity (Huang et al., 2022). Moreover, flexibility stands out as a key element in both paradigms. While I5.0 underscores the necessity of flexibility across all business processes, S5.0 advocates for structural adaptability to ensure human comfort and convenience. Furthermore, both I5.0 and S5.0 are profoundly influenced by technological advancements, with innovation serving as the driving force behind their developments (Huang et al., 2022). In addition, ecological sustainability emerges as a prominent focus area for both contracts, reflecting a shared commitment to environmental stewardship.

Given the novelty of these concepts, the literature on these subjects remains relatively limited, predominantly comprising theoretical articles and empirical studies. Below are some examples of studies in the literature addressing these emerging paradigms.

Gladden (2019) adopted an anthropological and posthumanist perspective in their analysis of S5.0, utilizing secondary data. The author delves into the position of S5.0 members and proposes the emergence of two distinct human types: technological and nontechnological. This study elucidates how the formation of human types in S5.0 differs from those observed in the transition from Society 1.0 to 4.0, delineating six distinct categories: “(1) ‘natural’ biological human beings, (2) artificially augmented human beings, (3) metahuman, (4) Epihuman, (5) parahuman, and (6) nonhuman beings.”

Serpa and Ferreira (2019) examined the relationship between S5.0 and sustainable digital innovations within the realm of social processes. Employing document analysis, this study examined relevant studies across various databases, yielding significant insights. Key findings highlight the emergence of significantly new technologies associated with S5.0, the identification of a digital ecosystem, and the elucidation of the intricate relationship between S5.0, sustainability, and innovation, particularly within the context of digital social innovation.

Potočan et al. (2020) sought to elucidate how S5.0 reconciles with Industry 4.0 and proposed a Corporate Social Responsibility (CSR) model aimed at addressing economic and social problems. Innovation emerged as a central theme in their study, with a

focus on using advanced technology for responsible economic growth within the framework of S5.0. This study advocates for the integration of environmental, social, and economic dimensions into CSR models in alignment with the principles of S5.0, aiming to address social issues at the local level.

In a related vein, Eren (2020) explores the concepts of S5.0 and Education 5.0 within the digital world. This study underscores the significance of Education 5.0 in the digital age for both students and teachers, emphasizing the transformative role of technology in the educational sector. Central to the discussion is the vital role of education in nurturing informed and knowledgeable individuals, which is a prerequisite for the realization of S5.0. This study highlights the multifaceted importance of education from various perspectives.

Saracel and Aksoy (2020) offer a comprehensive overview of S5.0, delving into the historical context of industrial revolutions and elucidating the societal evolution leading to S5.0. They underscore the imperative of integrating technology into human life within this framework, highlighting the increasing significance and application scope of areas such as AI, IoT, education, digitalization processes, and the evolving work environment due to technological advancements.

Deguchi et al. (2020) asserted that S5.0 will give rise to cyber-physical areas, emphasizing its character as a data-driven and super-smart society marked by frequent technological developments.

Carayannis et al. (2020) attempted to connect fusion energy with S5.0 and I5.0 within the energy sector, advocating for global research and development initiatives in fusion energy to harness its potential significance on a global scale.

Holroyd (2020) examines the relationship between technological innovation and the super-smart society envisioned by S5.0, particularly focusing on Japan's conceptual background, logic, policies, and programs associated with S5.0. This study underscores the formation of a super-smart society, particularly through national innovation strategies, where technological advancements take center stage.

In his study, Ari (2021) evaluates S5.0 from different perspectives, offering insights into the instruments and potential outcomes integral to its realization. He views S5.0 as an extension of Industry 4.0, portraying it as an approach aimed at enhancing people's quality of life.

Their study is grounded on the Quintuple Helix Model (QHM), a framework designed to describe the collective interaction among universities, government, industry, the environment, and civil society in knowledge creation (Carayannis & Campbell, 2009; Carayannis & Campbell, 2014), Carayannis and Morawska-Jancelewicz (2022) highlight the transformative impact of digitalization on universities. They argue that integrating the principles of S5.0 and I5.0 into university strategies and policies holds the key to maximizing the benefits of digital transformation for both academia and society at large. Furthermore, they emphasize that such integration can engender sustainable policies.

In a similar vein, Grabowska et al. (2022) found a strong link between I5.0 and Industry 4.0, with an increasing number of studies. In addition, the I5.0 concept is closely related to sustainability and unmanned factories. Echoing this perspective, Dautaj and Rossi (2022) delved into the intertwined dynamics of S5.0 and I5.0, prompting a comprehensive examination of 170 articles sourced from the Scopus database. Their bibliometric analysis scrutinizes the differences and similarities between S5.0 and I5.0, shedding light on their interplay and implications.

Meanwhile, Lin and Xie (2023) ascertain in their investigation that digital transformation catalyzes innovation, exerting a pronounced influence on various sections. Notably, their findings reveal that state-owned energy enterprises stand to reap greater benefits from digitalization than their counterparts in other industries. The emergent sub-dimensions of S5.0, derived from extant literature, include key aspects such as sustainability, agility, human-centricity, innovation, social innovation, productivity, and awareness. Similarly, the sub-dimensions of I5.0 revolve around a human-centric perspective, resilience, and sustainability (Akman, 2023). Considering all the studies in the literature, it becomes clear that both S5.0 and I5.0 are human-centric technological transformations, emphasizing that technological advancements should invariably serve the betterment of humanity.

Materials and Methods

Bibliometric analysis stands as a sophisticated quantitative tool that is instrumental in extracting the behavior and dynamics aspects of a knowledge domain, thereby serving as a cornerstone in literature review methodologies (Kapoor et al., 2018). This study sheds light on the research conducted on the concepts of S5.0 and I5.0 while fostering a bibliometric perspective within this scope. To comprehensively depict the evolving trends and potential research avenues within this subject area, bibliometric and network visualization methodologies were deployed to study the relationship between articles and keywords (Marchiori & Franco, 2020). The analysis delved into various dimensions, including the contributions of journals, organizations, and nations, as well as publication dynamics, significant developments in the field of study, prominent scholars and collaborations, and prevailing trends (Us et al., 2023).

Notably, bibliometric analysis offers the distinct advantage of circumventing the subjective biases inherent in traditional literature

reviews (Della et al., 2019). To execute the bibliometric analysis, the bibliometric R package and Visualization of Similarities (VOSviewer) version 1.6.18 software were employed. The process commenced with systematic search, collection, and preprocessing of publications pertinent to the research subject. Subsequently, the collected data underwent rigorous analysis and visualization using a variety of bibliometric techniques. As outlined by van Eck and Waltman (2009), scientometric exploration entailed the creation of visualizations including density, keyword distribution, and clusters.

During the literature review, a structured three-step research approach known as PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) was employed, a methodology also used by esteemed scholars such as Chandra and Walker (2019), Dabić et al. (2020), and Palumbo et al. (2021). These three steps comprise: i) data collection: selecting studies published in reputable scientific journals indexed in the WoS database; ii) data cleaning: meticulously reviewing the titles and abstracts of the selected studies and excluding those not suitable in terms of content; and iii) primary analysis: conducting an in-depth examination of the included studies within the scope of the study objective (Roblek et al., 2021).

For this study, searches within the WoS database were conducted using the keywords “TITLE-ABS-KEY ‘S5.0’ or ‘I5.0.’” The search parameters included all scientific subjects, with “all language” selected as the search language, “all” selected as the source type, and “article” specified as the document type. The data obtained within the framework were analyzed using VOSviewer version 1.6.18 software (van Eck & Waltman, 2022) in conjunction with RStudio software (Guleria & Kaur, 2021). VOSviewer provides a variety of intuitive visualizations for evaluating bibliometric maps (Geng et al., 2020), thereby facilitating a clear understanding of the outcomes (Abdollahi et al., 2021). Moreover, the document type was restricted to articles, given their focus on research and statistical applications. Within the article type, both research and review articles were included. The methodological process of this study is shown in Figure 2.

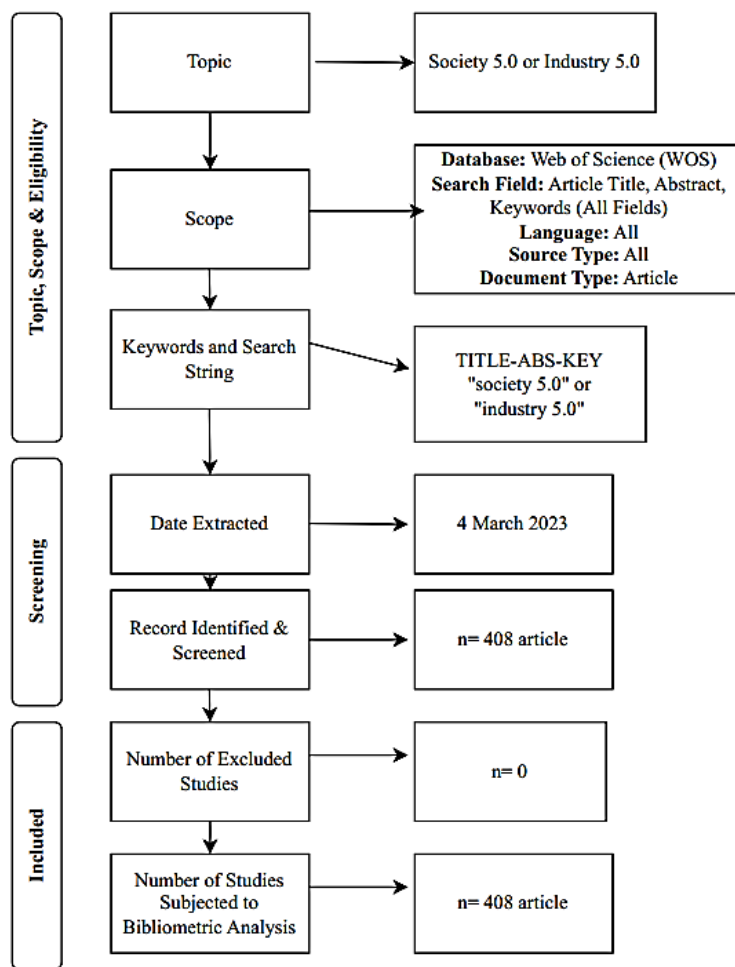


Figure 2. Bibliometric analysis process using the PRISMA method

Source: (Reproduced by the author using Shahidan et al., 2021).

Following the PRISMA method, the methodological framework of the study involved a search process, culminating in the

identification of a total of 408 pertinent studies concerning the concepts of S5.0 and I5.0. Subsequently, the study endeavored to address the following questions within the scope of the study:

- Q1: What is the general landscape of S5.0 and I5.0 studies?
- Q2: How have S5.0 and I5.0 studies evolved over the years?
- Q3: What are the demographics in terms of the number of countries, authors, and citations in S5.0 and I5.0?
- Q4: What are the emergent visual representations depicting relationships within the realms of S5.0 and I5.0?
- Q5: What projections can be made regarding the future trajectory of relationships and concepts pertaining to S5.0 and I5.0?
- Q6: What are the patterns of worldwide collaborations concerning S5.0 and I5.0?
- Q7: What is the anticipated trajectory of S5.0 and I5.0 research and which concepts are most salient in this regard?

Findings

The findings and visuals obtained within the study’s scope are presented below, adhering to the following sequence: initial numerical graphs precede Rstudio results, followed by visual results obtained from the Vosviewer version 1.6.18 software. The study includes a comprehensive analysis of the most studied year, source, country, document, and author information. In addition, included the most explored field, keyword analysis, co-authorship (author and country), Cluster Analysis of Concepts, Three-field Plot, Countries’ Collaboration World Map, and Thematic Map visualizations.

Number of Studies and Citations by Years

A total of 408 studies have been published in the WoS database on the topics of S5.0 and I5.0 in the past seven years. Figure 3 presents the numbers of studies and citation counts by year related to these topics. The first studies on both S5.0 and I5.0 emerged in 2016. Over the years, there has been a consistent increase in the number of studies and citations related to these topics. The number of studies, which was only one in 2016, has shown an upward trend in recent years. In particular, in 2022, 220 studies were conducted, making a significant increase. Similarly, the number of citations has been steadily rising, with 2145 citations realized in 2022. In total, the 408 studies were cited 2633 times, with 2447 citations occurring without self-citation. Additionally, 3926 citations were provided, with 3299 citations given without self-citation. On average, there were 9.62 citations per study. The H-index for this dataset was 30. Overall, these findings indicate a growing interest in and study of both concepts over the years. There has been a notable surge in studies on these concepts, particularly since 2020.

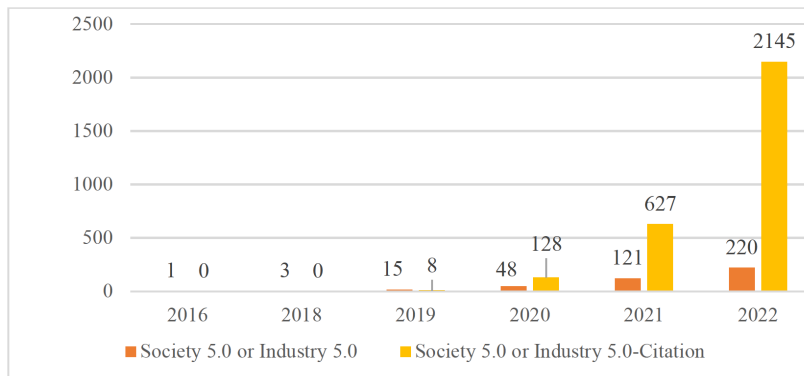


Figure 3. Number of publications and citations by years

Figure 4 shows the most widely cited references for both S5.0 and I5.0. Prominent journals include Sustainability (with 31 articles), Sensors (with 16 articles), IEEE Access (with 14 articles), Applied Sciences-Basel (with 12 articles), and IEEE Transactions on Industrial Informatics (also with 12 articles).

Results by Country

Figure 5 illustrates the number of studies conducted by authors based on their countries, either independently or in collaboration with authors from other countries. Understanding national and international collaborations is crucial for advancing science, as cooperation within the international community plays a crucial role in scientific advancement (Khan et al., 2022). Scientific cooperation stands as one of the most significant elements in facilitating the participation of both developing and developed countries in the research spectrum. In terms of the ranking by Corresponding Author’s Countries, Japan secured the top position

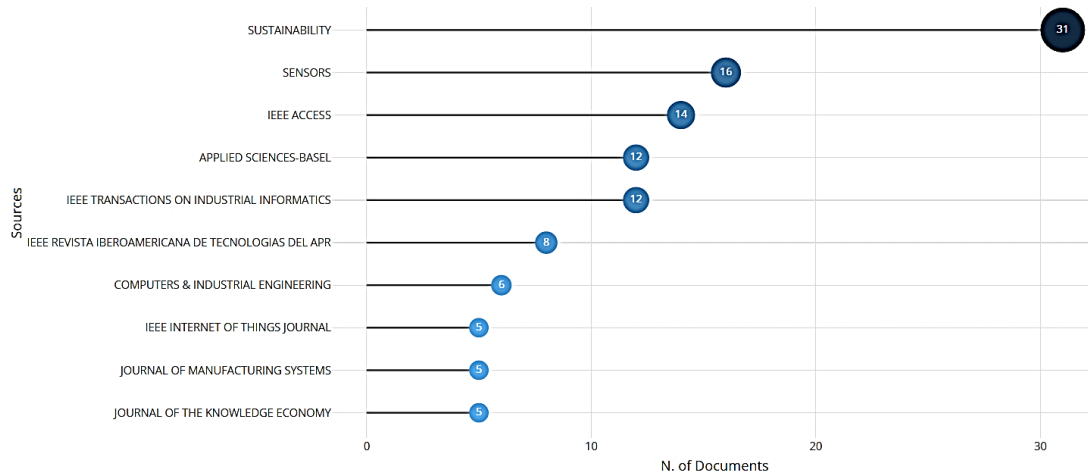


Figure 4. Sources with the most widely cited references for both S5.0 and I5.0

with 94 articles, followed by China with 34 articles, Italy with 24 articles, and India with 20 articles. When considering Countries’ Scientific Production, Japan leads with 255 articles, followed by China with 106 articles, India with 84 articles, Italy with 64 articles, and the United States with 53 articles. The leading contributors to articles in the fields of S5.0 or I5.0 are Japan, China, Italy, India, and the United States. The prevalence of S5.0 studies in Japan is understandable, given that it is the country where the S5.0 concept originated (Keidanren, 2016). Notably, China, Japan, and the United States emerged as the most cooperative countries. Meanwhile, Japan, Italy, and India stand out as the countries with the highest individual contributions to publications.

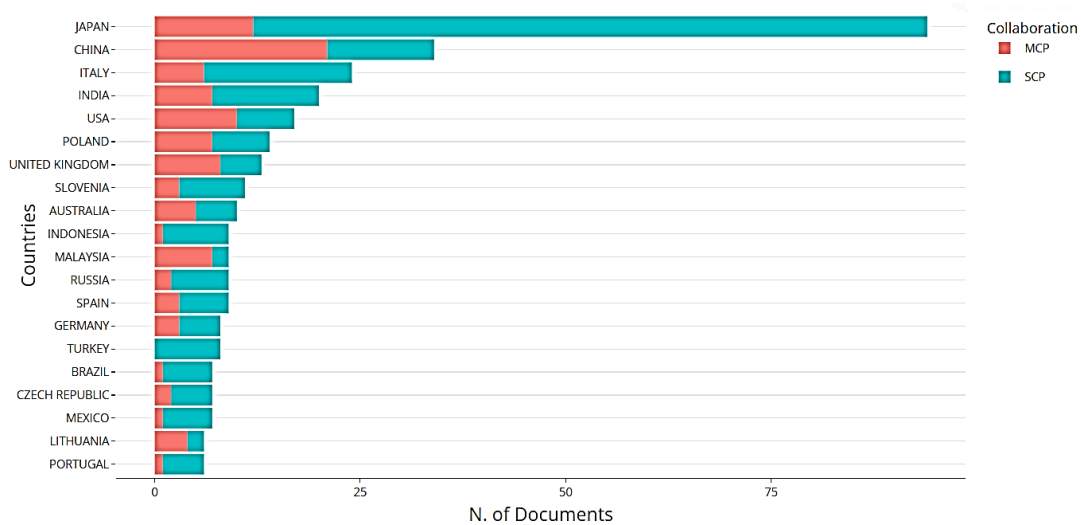


Figure 5. Corresponding author’s countries

*MCP: Multiple Country Publications, SCP: Single Country Publications

In Figure 6, the issue is addressed in terms of the number of citations to studies across various countries. Notably, the countries with the highest number of citations are China (466 citations), Japan (460 citations), the United States (369 citations), Australia (368 citations), and Italy (314 citations). It is evident that China and Japan stand out as pioneers in these concepts, as reflected in both their innovative approaches and the substantial number of citations they have accumulated.

Most Global Cited Documents

The most cited authors and their works are shown in Figure 7, these include: Nahavandi S. (2019 - 244 citations), Maddikunta P. (2022 - 202 citations), Xu X. (2021 - 179 citations), Longo F. (2020 - 96 citations), and Fukuda K. (2020 - 87 citations). The first four rows are associated with the I5.0 concept, whereas the fifth row is related to the S5.0 concept. More studies and citations on both S5.0 and I5.0 are expected in the future (Dautaj & Rossi, 2022).

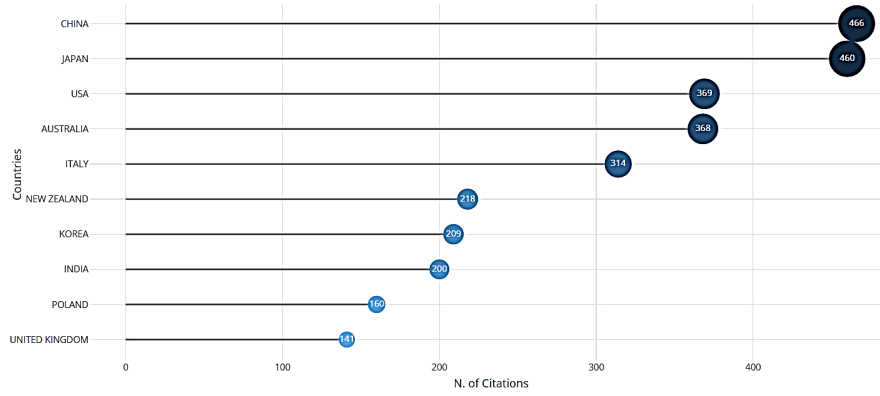


Figure 6. Most cited countries

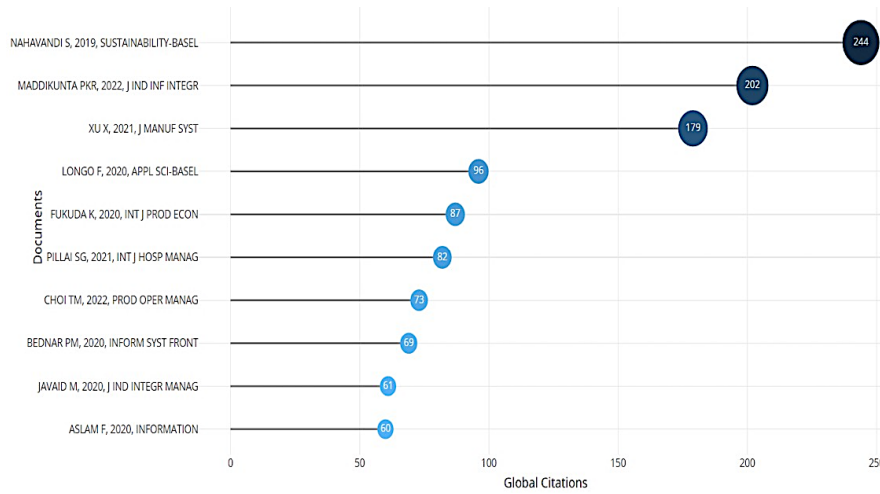


Figure 7. Most globally cited documents

Table 1 lists the most cited studies related to the concepts given. Notably, the foremost cited works are Nahavandi (2019, 244 TC, 48.80 TC per Year), Maddikunta et al. (2022, 202 TC, 101.00 TC per Year), and Xu et al. (2021, 179 TC, 59.67 TC per Year).

Table 1. Most cited documents

No.	Authors	Articles	TC	TC per Year
1	Nahavandi (2019)	“Industry 5.0-A Human-Centric Solution”	244	48.80
2	Maddikunta et al. (2022)	“Industry 5.0: A survey on enabling technologies and potential applications”	202	101.00
3	Xu et al. (2021)	“Industry 4.0 and Industry 5.0-Inception, conception and perception”	179	59.67
4	Longo et al. (2020)	“Value-Oriented and Ethical Technology Engineering in Industry 5.0: A Human-Centric Perspective for the Design of the Factory of the Future”	96	24.00
5	Fukuda (2020)	“Science, technology and innovation ecosystem transformation toward society 5.0”	87	21.75
6	Pillai et al. (2021)	“COVID-19 and hospitality 5.0: Redefining hospitality operations”	82	27.33
7	Choi et al. (2022)	“Disruptive Technologies and Operations Management in the Industry 4.0 Era and Beyond”	73	36.50
8	Bednar and Welch (2020)	“Socio-Technical Perspectives on Smart Working: Creating Meaningful and Sustainable Systems”	69	17.25
9	Javaid et al. (2020)	“Industry 5.0: Potential Applications in COVID-19”	61	15.25
10	Aslam et al. (2020)	“Innovation in the Era of IoT and Industry 5.0: Absolute Innovation Management (AIM) Framework”	60	15.00

Source: Generated by the Author.

Authors with the Most Studies

The ranking of authors with the highest number of studies on the concepts in the literature is shown in Table 2. Accordingly, the sequence of the authors who have conducted the most studies on the subject is as follows: Miyaji A. (13 articles), Noda S. (8 articles), De Zoysa M. (7 articles), Inoue T. (7 articles), and Ishizaki K. (7 articles).

Table 2. Authors with the most studies

No.	Authors	Record Count	% of 408
1	Miyaji A.	13	3.17%
2	Noda S.	8	1.96%
3	De Zoysa M.	7	1.72%
4	Inoue T.	7	1.72%
5	Ishizaki K.	7	1.72%
6	Carayannis E.G.	6	1.47%
7	Ishiguro H.	6	1.47%
8	Nakagawa Y.O.	6	1.47%
9	Endoh T.	5	1.23%
10	Gelleta J.	5	1.23%

Areas with the Most Studies

The fields with the highest number of studies related to the concepts are shown in Figure 8. Within the literature, a significant number of studies on the concepts were conducted in the following fields: “148 studies in Engineering, 121 in Computer Science, 52 in Science Technology Other Topics, 47 in Business Economics, and 39 in Environmental Sciences Ecology.” It is evident that there is greater interest in the concepts from engineering fields, whereas the interest in business economics fields has yet to reach the desired level.

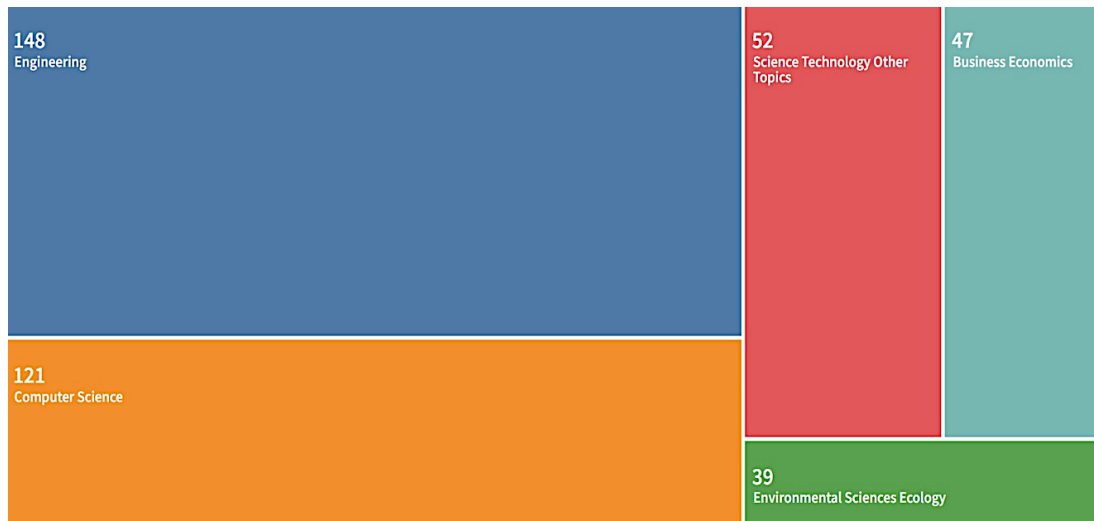


Figure 8. The most studied areas related to concepts

Analytics and Network Visualizations

Citation analysis, bibliometric analysis, co-citation analysis, co-authorship analysis, and keyword analysis stand out as some of the most often used analysis techniques in bibliometric research, often facilitated by Vosviewer 1.6.18 software. Notably, bibliometric and keyword analysis emerges as the most frequently utilized method. Below are all the evaluations conducted in accordance with these analyses.

Keywords/Co-occurrence Analysis

Within the scope of the study, Figure 9 illustrates the most preferred keyword group by authors in the literature, with a thorough keyword analysis conducted. Notably, the keywords “S5.0, I5.0, Industry 4.0, and AI” emerge as the most frequently used. The prominence of the concept of S5.0, ranking first, indicates a greater prevalence of studies related to this topic compared to others. Furthermore, a temporal analysis revealed that early studies predominantly revolved around S5.0, I5.0, and Industry 4.0. However, in subsequent years, the focus shifted toward topics such as industries, smart manufacturing, smart cities, IoT, digital transformation, security, and other related topics.

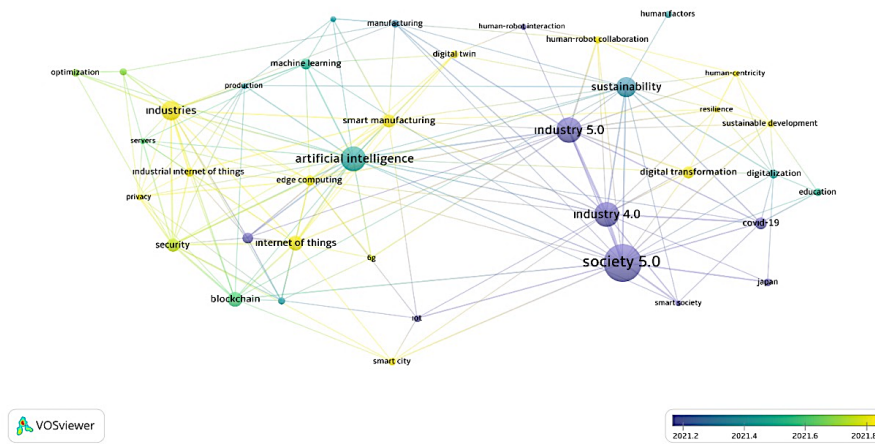


Figure 9. Keywords Related to the Concepts of S5.0 and I5.0

Co-authorship Analysis

In Figure 10, a co-authorship analysis was conducted to examine the collaboration patterns among authors. The collaborations were categorized into four different groups. Notably, the prominent author in the red group is Wang, Lihui; the prominent authors in the blue group are Wang, Baicun and Zheng, Pai; the prominent authors in the green group are Sha, Weinan, and Liu, Qiang; and the prominent author in the yellow group is Mourtzis, Dimitris.

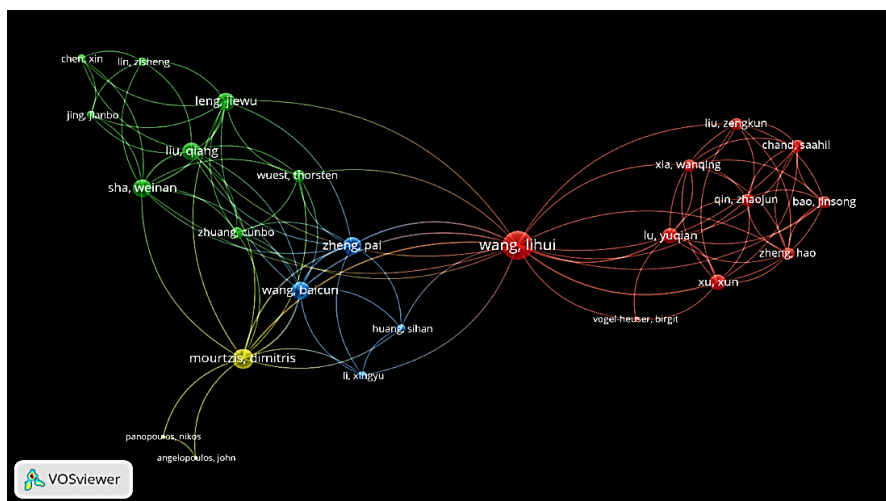


Figure 10. Co-authorship-authors

Within the scope of this study, Figure 11 illustrates the co-authorship country visualization. Notably, countries such as Japan, China, India, the United States, and Italy prominently emerged in terms of author collaborations. This observation underscores their active involvement in international research collaborations within the studied domain.

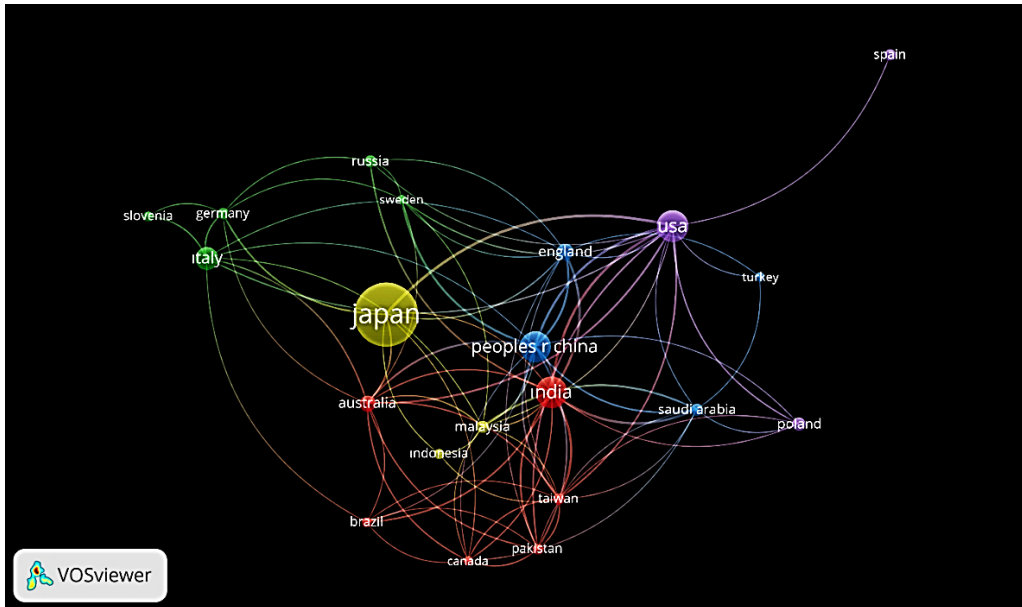


Figure 11. Co-authorship-country

Citation Analysis

In Figure 12, the most cited authors are depicted, and categorized into three groups: green, red, and blue. Notably, the prominent authors within these groups are as follows: Carayannis, Elias; Wang, Lihui; Xu, Xun; Lu, Yuqian; Haleem, Abid.

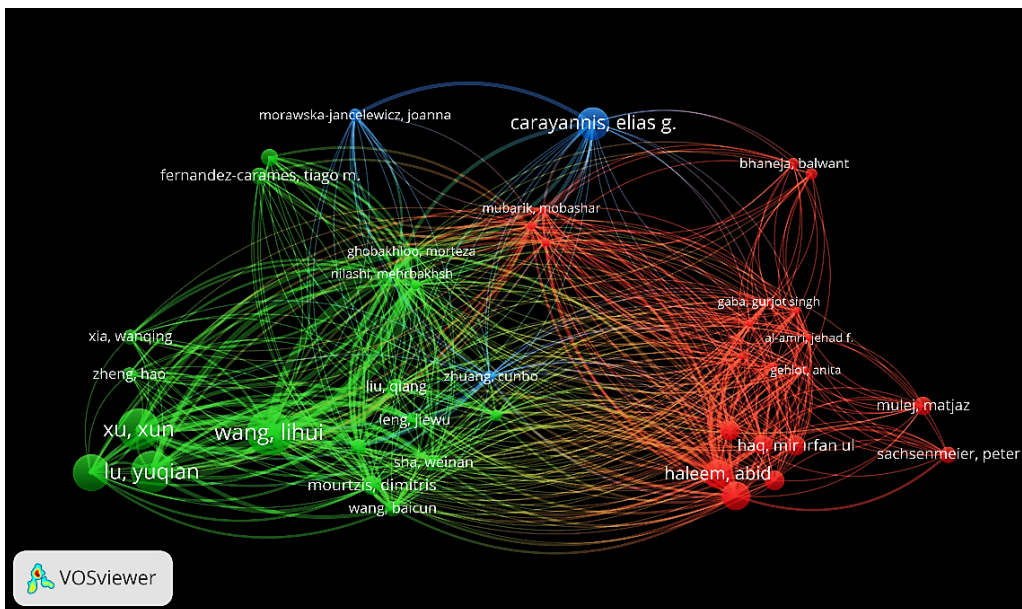


Figure 12. Citation-authors

Conceptual Structure Map

Figure 13 delineates three distinct sets of S5.0 and I5.0 categories along with their corresponding variables. Within this context, multiple vertical and horizontal dimensions are analyzed in the conceptual map. Specifically, the green group represents an energy- and information-intensive cluster. The red group is predominantly focused on management, Industry 4.0, digital transformation, and digital technologies. On the other hand, the blue group is centered around cyber-physical systems and sustainability.

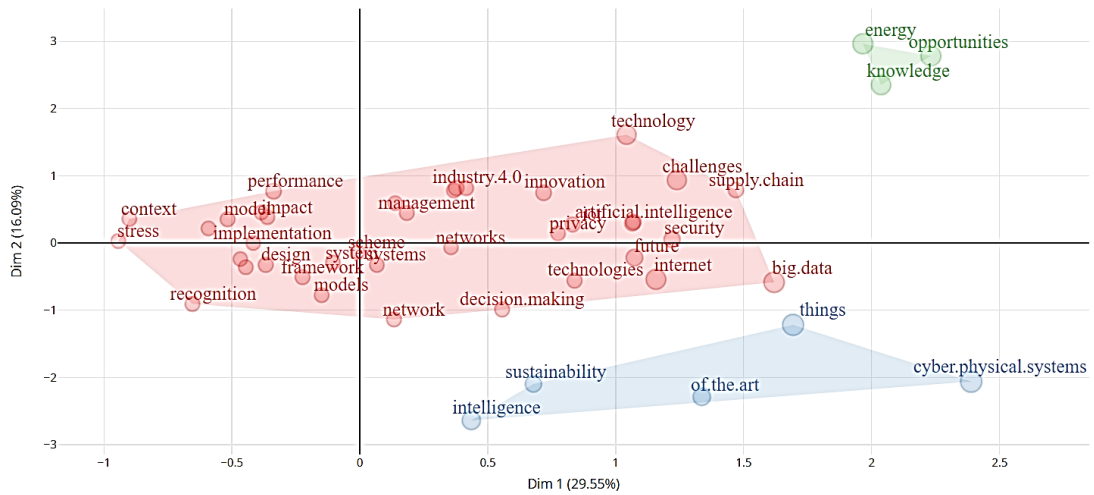


Figure 13. Cluster Analysis of Concepts

A Three-field Plot

Figure 14 presents a three-field plot analysis, where key terms are depicted on the left side, followed by countries in the middle, and the most referenced works on the right. According to the figure, the concept of S5.0 is primarily associated with Japan, with the most connected author being Shiroishi (2018). Conversely, the concept of I5.0 is strongly linked to China, with the most connected authors being Nahavandi (2019) and Özdemir (2018). Additionally, other notable concepts include AI, sustainability, and Industry 4.0. Among the top countries mentioned are China, India, Japan, and the United States. Remarkable cited authors include Nahavandi (2019), Özdemir (2018), Fukuyama (2018), and Shiroishi (2018).

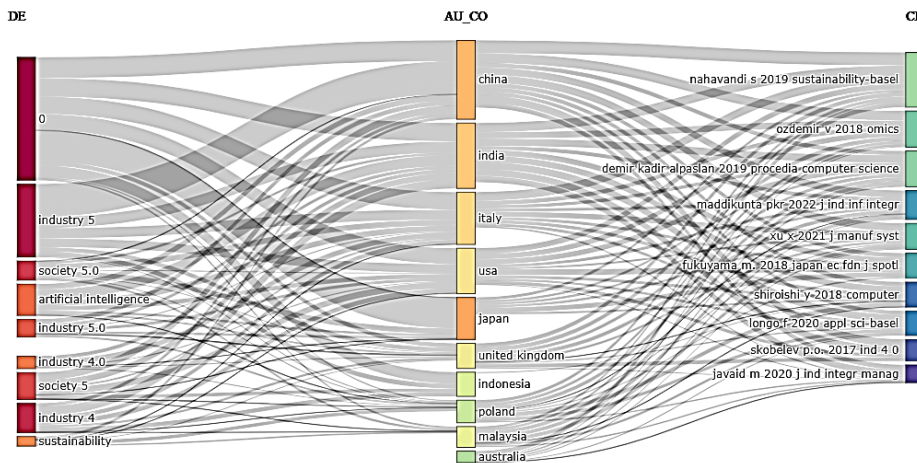


Figure 14. Three-field Plot

Thematic Map

Thematic mapping, as illustrated in Figure 15, facilitates the visualization of four different theme typologies: “niche themes, motor themes, emerging or declining themes, and basic themes” (Caust and Vecco, 2017). This categorization is based on the authors’ keywords. Niche themes represent themes with high intensity but insignificant external links, hence possessing limited importance for the field (low centrality). Emerging or declining themes encapsulate topics of either emerging or declining significance. Motor themes are characterized by both high centrality and intensity, signifying their crucial role within the field. Basic themes, on the other hand, denote core and cross-cutting themes, relating to general topics that cut across various research

areas within the field (Della Corte et al., 2019). According to Figure 15, the identified motor themes include I4.0-5.0, S5.0, AI, and IoT. Niche themes are logistics and technology. The basic themes are S5.0, I45.0-5.0, sustainability, and digital transformation.

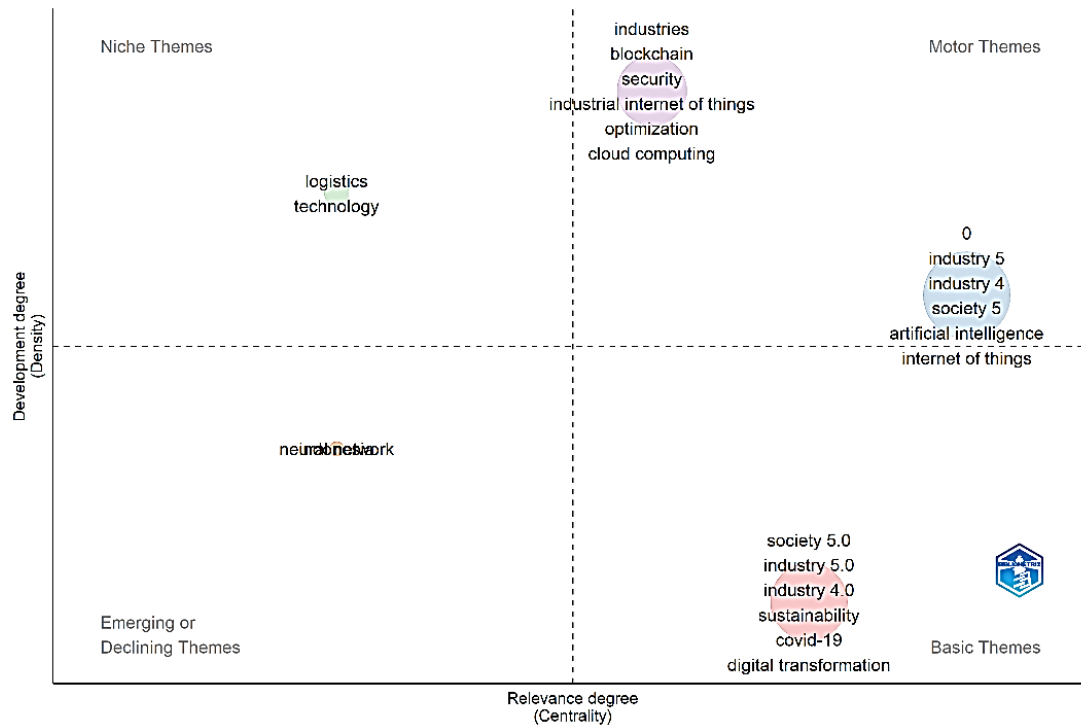


Figure 15. Thematic map

Conclusion

Bibliometric studies serve as guiding tools for researchers interested in a particular field, providing valuable insights and knowledge about concepts and their future trends. The importance of bibliometric research has been increasingly recognized in recent years. Consequently, this study takes a combined look at the S5.0 and I5.0 concepts, revealing a map or visualization of these concepts.

Researchers and practitioners agree that societies' knowledge, competencies, and skills are becoming increasingly valuable, indicating a move to the next stage of progress. While the concept of I4.0 is widely accepted and continuously advanced, its successor "I5.0" has not yet been embraced by all organizations since its introduction (Sułkowski et al., 2021). Indeed, S5.0 has emerged as a concept that aims to reconcile economic advancement by addressing societal challenges through a robust integration of the cyber-physical realm. Moreover, Sułkowski et al. (2021) introduced the notion of Economy 5.0, which pertains to the collaborative efforts of society and individuals in the realms of innovation, creativity, and competitiveness to identify distinctive approaches for value creation within economic structures.

The PRISMA method was employed as the bibliometric analysis procedure for the purposes of this study. A total of 408 articles were included in the study's scope after the WoS database using the S5.0 and I5.0 search criteria. The survey only covered works written in English. RStudio software and VOSviewer version 1.6.18 software were used to analyze and display the data.

Alongside the concept of S5.0 and I5.0, the notion of Economy 5.0 (Sułkowski et al., 2021) has also been defined. I5.0 signifies the progression of economic developments alongside digital technologies. At this point, it becomes imperative for concepts such as Economy 5.0 to evolve concurrently with S5.0 and I5.0. Moreover, in addition to S5.0 and I5.0, emerging concepts such as Education 5.0 (Eren, 2020; Er et al., 2021; Togo & Gandidzanwa, 2021) and Logistics 5.0 (Trstenjak, Opetuk, Đukić & Cajner, 2022) have begun to surface. With the evolution of these concepts, the business landscape will witness changes and transformations. In this context, it is crucial to augment studies on both S5.0 and I5.0 concepts and unveil their reflections in the business world. Consequently, the demands and expectations of customers will evolve due to the development of digital technologies. Furthermore, businesses will undergo shifts in their responsibilities toward both their employees and society, engaging in production and service activities while prioritizing environmental preservation. Moreover, businesses often encounter concepts such as sustainability, education, healthcare, elderly care, and environmental conservation, thereby aiming to mitigate environmental pollution.

The limitations of this research include the sole reliance on data from the WoS database and the focus solely on articles. As

a recommendation for future studies, concluding new bibliometric analyses in languages other than English would enrich the languages, especially in countries like Japan, China, and India, which contribute significantly to publications on the subject matter.

Peer Review: Externally peer-reviewed.

Author Contributions: Conception/Design of Study- A.Z.A., M.E.; Data Acquisition- A.Z.A.; Data Analysis/Interpretation- A.Z.A.; Drafting Manuscript- A.Z.A., M.E.; Critical Revision of Manuscript- A.Z.A., M.E.; Final Approval and Accountability- A.Z.A., M.E.

Conflict of Interest: Authors declared no conflict of interest.

Financial Disclosure: Authors declared no financial support.

ORCID:

Abdullah Zübeyr Akman 0000-0001-6392-1884
Meral Erdirençelebi 0000-0002-7705-6067

REFERENCES

- Abdollahi, A., Rejeb, K., Rejeb, A., Mostafa, M.M. & Zailani, S. (2021). Wireless Sensor Networks in Agriculture: Insights From Bibliometric Analysis, *Sustainability*, 13(21), 1-22. <https://doi.org/10.3390/su132112011>
- Akman A. Z. (2023). The Role of the Interaction Between Digital Transformation and Organizational Culture in Society 5.0 Structuring: A Field Study, *Doctoral Thesis*. Necmettin Erbakan University Institute of Social Sciences, Konya.
- Ari, E. S. (2021). Super Smart Society: Society 5.0. *Dokuz Eylul University the Journal of Graduate School of Social Sciences*, 23(1), 455-479. <http://dx.doi.org/10.16953/deusosbil.808359>
- Breque M., De Nul L. & Petridis A. (2021). Industry 5.0: Towards A Sustainable, Humancentric and Resilient European Industry. Publications Office of the European Union.
- Carayannis E.G. & Campbell, D.F.J. (2009). Mode 3 and Quadruple Helix: Toward a 21st century fractal innovation ecosystem. *International Journal of Technology Management*, 46, (3/4), 201-234. <http://doi:10.1504/IJTM.2009.023374>.
- Carayannis, E.G. & Campbell, D.F.J. (2014). Developed democracies versus emerging autocracies: Arts, democracy, and innovation in Quadruple Helix Innovation systems. *Journal of Innovation and Entrepreneurship*, 3, 1-12. <http://doi:10.1186/S13731-014-0012-2>.
- Carayannis E. G., Draper J. & Bhaneja B. (2020). Towards Fusion Energy in The Industry 5.0 and Society 5.0 Context: Call for a Global Commission for Urgent Action on Fusion Energy. *Journal of the Knowledge Economy*, 12(4), 1891-1904. <https://doi.org/10.1007/s13132-020-00695-5>
- Carayannis, Elias G. & Morawska-Jancelewicz, J. (2022). The Futures of Europe: Society 5.0 and Industry 5.0 as Driving Forces of Future Universities. *Journal of the Knowledge Economy*, 13, 1-27. <https://doi.org/10.1007/s13132-021-00854-2>
- Caust, J. & Vecco, M. (2017). Is UNESCO World Heritage Recognition a Blessing or Burden? Evidence from Developing Asian Countries. *Journal of Cultural Heritage*, 27, 1-9. <https://doi.org/10.1016/j.culher.2017.02.004>
- Chandra, Y. & Walker, R. M. (2019). How Does A Seminal Article in Public Administration Diffuse and Influence the Field? Bibliometric Methods and the Case of Hood's "A Public Management for All Seasons?". *International Public Management Journal*, Vol. 22(5), 712-742. <https://doi.org/10.1080/10967494.2018.1498817>
- Dabić, M., Vlačić, B., Paul, J., Dana, L. P., Sahasranamam, S. & Glinka, B. (2020). Immigrant Entrepreneurship: A Review and Research Agenda. *Journal of Business Research*, 113, 25-38. <https://doi.org/10.1016/j.jbusres.2020.03.013>
- Dawson P. & Andriopoulos C. (2009). *Managing change, creativity and innovation*. England, Sage Publications Limited.
- Dautaj M & Rossi M. (2022). Towards a New Society: Solving the Dilemma Between Society 5.0 and Industry 5.0 In 18th IFIP International Conference, O. Canciglieri Junior et al. (Eds.): PLM 2021 (pp. 523-536).
- Deguchi A., Hirai C., Matsuoka H., Nakano T., Oshima K., Tai M. & Tani S. (2020). What is society 5.0?. In *Society 5.0: A People-centric Super-smart Society* (First Edit, 1-188), Springer Open. https://doi.org/10.1007/978-981-15-2989-4_9
- Della Corte, V., Del Gaudio, G., Sepe, F. & Sciarelli, F. (2019). Sustainable tourism in the open innovation realm: A bibliometric analysis. *Sustainability*, 11(21), 1-18. <https://doi.org/10.3390/su11216114>
- Duman, M. Ç. (2022). Society 5.0: Human-focused digital transformation, *Journal of Social Policy Conferences*, 82, 309-336. <https://doi.org/10.26650/jspc.2022.82.1008072>
- Er H., Turan S. & Kaymakçı S. (2021). Evaluation of the development of the society 5.0 process and its impact on education. *Adiyaman University Journal of Social Sciences*, 14(39), 27-66. <https://doi.org/10.14520/adyusbd.993699>
- Eren, Z. (2020). Toplum 5.0 ve dijital dünyada toplumsal dönüşüm ve eğitim 5.0. D. Akçay & E. Efe (Eds.), In *Digital Transformation and Processes* (pp.169-206).
- Fukuyama, M. (2018). Society 5.0: Aiming for a new human-centered society. *Special Article, Jpn. Spotlight*, 27, 47-50.
- Geng, D., Feng, Y. & Zhu, Q. (2020). Sustainable design for users: a literature review and bibliometric analysis. *Environ. Sci. Pollut. Res.*, 27(24), 29824-29836. <https://doi.org/10.1007/s11356-020-09283-1>

- Ghobakhloo, M. (2020). Industry 4.0, digitization, and opportunities for sustainability. *Journal of Cleaner Production*, 252, 1-21. <https://doi.org/10.1016/j.jclepro.2019.119869>
- Gladden, M. E. (2019). Who will be the members of Society 5.0? Towards an anthropology of technologically posthumanized future societies. *Social Sciences MDPI*, 8(5), 1-39. <https://doi.org/10.3390/socsci8050148>
- Grabowska, S., Saniuk, S. & Gajdzik, B. (2022). Industry 5.0: Improving humanization and sustainability of Industry 4.0, *Scientometrics*, 127(6), 3117-3144. <https://doi.org/10.1007/s11192-022-04370-1>
- Guleria, D. & Kaur, G. (2021). Bibliometric analysis of ecopreneurship using VOSviewer and RStudio Bibliometrix, 1989–2019. *Library Hi Tech*, 39(4), 1001-1024. <https://doi.org/10.1108/LHT-09-2020-0218>
- Harayama, Y. (2018). Society 5.0: Aiming for a new human-centered society. Japan's science and technology policies for addressing global social challenges. *Hitachi Review*, 66(6), 556-557.
- Holroyd, C. (2020). "Technological innovation and building a 'Super Smart' society: Japan's vision of society 5.0", *Journal of Asian Public Policy*, 1-14.
- Huang, S., Wang, B., Li, X., Zheng, P., Mourtzis, D. & Wang, L. (2022). Industry 5.0 and Society 5.0-Comparison, complementation and co-evolution. *Journal of Manufacturing Systems*, 64, 424-428. <https://doi.org/10.1016/j.jmsy.2022.07.010>
- Kapoor, K.K., Tamilmani, K., Rana, N.P., Patil, P., Dwivedi, Y.K. & Nerur, S. (2018). Advances in social media research: Past, present and future. *Inf. Syst. Front.*, 20, 531-558. <https://doi.org/10.1007/s10796-017-9810-y>
- Keidanren (Japan Business Federation) (2016). Toward realization of the new economy and society. reform of the economy and society by the deepening of Society 5.0, *Keidanren Publisher*, Tokyo.
- Khan, U., Khan, H. U., Iqbal, S., & Munir, H. (2022). Four Decades of Image Processing: A Bibliometric Analysis. *Library Hi Tech*, Vol. ahead-of-print No. ahead-of-print. <https://doi.org/10.1108/LHT-10-2021-0351>
- Leng, J., Sha, W., Wang, B., Zheng, P., Zhuang, C., Liu, Q., ... & Wang, L. (2022). Industry 5.0: Prospect and retrospect. *Journal of Manufacturing Systems*, 65, 279-295. <https://doi.org/10.1016/j.jmsy.2022.09.017>
- Lin, B. & Xie Y., (2023). Does digital transformation improve the operational efficiency of Chinese power enterprises?, *Utilities Policy*, 82, 1-11. <https://doi.org/10.1016/j.jup.2023.101542>
- Mavrodieva, A.V. & Shaw R., (2020). Disaster and climate change issues in Japan's society 5.0-a discussion. *Sustainability*, 12(5), 1-17. <https://doi.org/10.3390/su12051893>
- Marchiori, D. & Franco, M., (2020). Knowledge transfer in the context of interorganizational networks: Foundations and intellectual structures. *J. Innov. Knowl.*, 5, 130-139. <https://doi.org/10.1016/j.jik.2019.02.001>
- Mourtzis, D., Angelopoulos, J. & Panopoulos, N., (2023). The future of the human-machine interface (HMI) in Society 5.0. *Future Internet*, 15(5), 1-25. <https://doi.org/10.3390/fi15050162>
- Palumbo, R., Manesh, M. F., Pellegrini, M., Caputo, A. & Flamini, G., (2021). Organising a sustainable smart urban ecosystem: Perspectives and insights from a bibliometric analysis and literature review. *Journal of Cleaner Production*, 297, 1-15. <https://doi.org/10.1016/j.jclepro.2021.126622>
- Potočan, V., Matjaž M. & Nedelko Z. (2020). Society 5.0: Balancing of Industry 4.0, economic advancement and social problems. *Kybernetes*, 50(3) 794-811. <https://doi.org/10.1108/K-12-2019-0858>
- Roblek, V., Meško, M. & Podbregar, I. (2021). Mapping of the emergence of Society 5.0: A bibliometric analysis. *Organizacija*, 54(4), 293-305. <https://doi.org/10.2478/orga-2021-0020>
- Ruiz-De-La-Torre, A., Rio-Belver, R. M., Guevara-Ramirez, W. & Merlo, C. (2022). Industry 5.0 and human-centered approach: Bibliometric review. In *The International Conference on Industrial Engineering and Industrial Management* (pp. 402-408). Cham: Springer International Publishing. https://doi.org/10.1007/978-3-031-27915-7_71
- Saracel, N. & Aksoy I. (2020). Society 5.0: Super smart society. *Social Sciences Research Journal (SSRJ)*, 9(2), 26-34.
- Serpa, S. & Ferreira, C. M. (2019). Society 5.0 and sustainability digital innovations: A social process. *Journal of Organizational Culture, Communications and Conflict*, 2, 1-14.
- Shahidan, N. H., Latiff, A. S. A. & Wahab, S. A. (2021). Moving towards Society 5.0: A bibliometric and visualization analysis. In *Society 5.0: First International Conference, Society 5.0 2021*, Revised Selected Papers 1 (pp. 93-104). Springer International Publishing.
- Sułkowski, L., Kolasińska-Morawska, K., Seliga, R. & Morawski, P. (2021). Smart learning technologization in the Economy 5.0-the polish perspective. *Applied Sciences*, 11, 1-19. <https://doi.org/10.3390/app11115261>
- Theorin, A., Bengtsson, K., Provost, J., Lieder, M., Johnsson, C., Lundholm, T. & Lennartson, B. (2017). An event-driven manufacturing information system architecture for Industry 4.0. *International Journal of Production Research*, 55, 1297-1311. <https://doi.org/10.1080/00207543.2016.1201604>
- Togo, M. & Gandidzanwa, C. P. (2021). The role of Education 5.0 in accelerating the implementation of SDGs and challenges encountered at the University of Zimbabwe. *International journal of Sustainability in Higher Education*, 22(7), 1520-1535. <https://doi.org/10.1108/IJSHE-05-2020-0158>
- Trstenjak, M., Opetuk, T., Đukić, G. & Cajner, H. (2022). Logistics 5.0 implementation model based on decision support systems, *Sustainability*, 14(11), pp 1-19. <https://doi.org/10.3390/su14116514>
- Us, Y., Pimonenko, T. & Lyulyov, O. (2023). Corporate social responsibility and renewable energy development for the green brand within SDGs: A meta-analytic review. *Energies*, 16(5), 1-18. <https://doi.org/10.3390/en16052335>
- Van Eck N. & Waltman L. (2009) Software survey: VOSviewer, a computer program for bibliometric mapping. *Scientometrics*, 84(2), 523-538. [10.1007/s11192-009-0146-3](https://doi.org/10.1007/s11192-009-0146-3)
- Xu, X., Lu, Y., Vogel-Heuser, B. & Wang, L. (2021). Industry 4.0 and Industry 5.0-Inception, conception and perception. *Journal of Manufacturing*

Systems, 61, 530-535. <https://doi.org/10.1016/j.jmsy.2021.10.006>

Yulianto, M. M. (2021). The needs of training to improve teacher competence in preparing Society 5.0. *Technium Social Sciences Journal*, 20(1), 275-286.

How to cite this article

Akman, A.Z., Erdirençelebi, M. (2024). A human-centered digital transformation: a bibliometric analysis of society 5.0 and industry 5.0. *Istanbul Management Journal*, 96, 1-16. <http://doi.org/10.26650/imj.2024.96.1361480>