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Comparison of Industry 4.0, Industry 5.0, and Related Political Initiatives Using Bibliometric Data

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Abstract:

Purpose: This research investigates key global initiatives related to Industry 4.0, such as Industry 5.0, Society 5.0, Made in China 2025, and the Advanced Manufacturing Partnership (AMP). The aim is to define their scope from an academic perspective, exploring their interconnections and relevance within the context of digital and green transformation in major industrial economies.

Design/methodology/approach: We adopted a bibliometric analysis (BA) approach to analyze existing literature on the selected industrial initiatives. The paper follows this approach, introducing novelties in the method such as the semantic classification of the author keywords. Three research questions were formulated, and a methodology was designed to investigate the characteristic topics within each industrial initiative.

Findings: The findings reveal that Industry 4.0 remains the most prominent theme in academic discourse. However, Industry 5.0 has shown a strong upward trend since its inception. Keyword analysis indicates that both Industry 4.0 and Industry 5.0 are predominantly technology-driven, though Industry 5.0 places greater emphasis on human interaction and sustainability. In contrast, Society 5.0, Made in China 2025, and the Advanced Manufacturing Partnership (AMP) have less relevance in the academic literature.

Originality/value: This research contributes to the academic understanding of global industrial policies by systematically comparing major initiatives. We propose a methodology to analyze the content of each industrial initiative based on a structured analysis of author keywords, offering valuable insights into these initiatives. By synthesizing a large body of literature, the study establishes a foundation for further research on the evolution of Industry 4.0 and Industry 5.0.

Keywords: advanced manufacturing partnership, Industry 4.0, Industry 5.0, keyword analysis, made in China 2025, Society 5.0

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1. Introduction

Advances in technology and digitization have significantly transformed the industrial paradigm. Collaboration between public, private, and academic sectors has facilitated the study of how new technologies impact a country's economy in industrial, economic, and social terms (Chen, 2017). Notably, the industrial sector plays a crucial role in generating high-quality employment and wealth. Following the economic crises of 2008 and the COVID-19 pandemic in 2020, the importance of industry has grown, as it has proven to bolster national economic resilience in the face of disruptive situations (Magro, 2022).

In this context, and following the German Industry 4.0 concept, it is not surprising that several programs have emerged from various national administrations in recent decades (Wang, 2018). These programs aim to define, outline, and promote some of the most significant innovations in the industrial and social sectors within the framework of Industry 4.0. Kuo, Shyu and Ding (2019) identify several of these programs, including Made in China 2025, Taiwan's Productivity 4.0, the Advanced Manufacturing Partnership (AMP) in the USA, and Society 5.0 in Japan. On the other hand, Industry 5.0 has emerged as an evolution of Industry 4.0, introducing a human-centered and sustainable perspective to industrial transformation. While Industry 4.0 prioritized technological efficiency and digital transformation, Industry 5.0 emphasizes workers' skills and their collaboration with machines and robots, while promoting environmentally responsible production (Zizic, Mladineo, Gjeldum & Celent, 2022). The European Union, Japan and the United States are already moving towards this model, with the aim of aligning technological progress with social and ecological values (Mourtzis, Angelopoulos & Panopoulos, 2022).

In this research, we explore the main global industrial policy initiatives, choosing those corresponding to the biggest economies measured in GDP (World Bank, 2023), with the aim of defining their scope from an academic perspective and relating them to each other and to Industry 4.0 as a common reference.

Moreover, with the growing interest in Industry 5.0 and its potential to redefine industrial priorities, there is an urgent need to map the current academic discourse around these concepts to clarify their evolution and identify emerging trends. Particularly, in terms of their academic conceptualization and their emphasis on sustainable and human-centered development. This study contributes to that need by providing a comprehensive bibliometric analysis of the major industrial initiatives shaping contemporary discourse, thereby providing scholars and policy makers with an integrated view of how these paradigms are constructed, interpreted, and connected within the academic literature. To this end, Section 2 presents the Theoretical Framework, where we define Industry 4.0 alongside the key initiatives that form the focus of this analysis. Section 3 details the research methodology, Section 4 discusses the results, and finally, Section 5 presents the main conclusions of the research.

2. Theoretical Framework: Industry 4.0 and Related Industrial Policies

This article focuses on Industry 4.0, Industry 5.0, Society 5.0, Made in China 2025, and the Advanced Manufacturing Partnership (AMP), as they represent industrial policies of major industrial powers worldwide. These approaches reflect distinct visions and priorities in digital and green transformation.

Industry 4.0 emerged in Germany in 2011 (Raja-Santhi & Muthuswamy, 2023; Xu, Lu, Vogel-Heuser, & Wang, 2021), aiming to integrate traditional production with digitization, leading to the creation of "smart factories". These smart factories collect and store large volumes of data through sensors that monitor business processes, enabled by technologies such as the Internet of Things (IoT) and cloud computing (Abdirad & Krishnan, 2020). In addition, these factories require advanced software applications, such as Artificial Intelligence (AI) and Big Data, for efficient data analysis (Raja-Santhi & Muthuswamy, 2023). On the other hand, the digital transformation driven by Industry 4.0 enables a wide array of possibilities, including the integration of augmented reality (AR) and virtual reality (VR) technologies in industrial processes. For instance, these technologies can be employed in training programs to enhance worker performance and improve task efficiency (Eswaran & Bahubalendruni, 2022).

Industry 4.0 promotes the transformation of traditional production models, elevating them to new levels of automation, efficiency, and optimization, leveraging emerging technologies to facilitate digital transformation. Digital transformation, particularly through the framework of Industry 4.0, is increasingly recognized as a strategic opportunity to promote sustainable development. Industry 4.0 offers innovative solutions to optimize resource efficiency, reduce environmental impact, and accelerate the transition toward a low-carbon, circular economy (Ghobakhloo,2020; Kamble, Gunasekaran & Gawankar, 2018; Stock & Seliger, 2016). Some authors even consider Industry 4.0 as the next industrial revolution, as reflected in how other industrial policies have adopted its technologies (Xu et al., 2021; Abdirad & Krishnan, 2020).

In 2011, alongside the development of Industry 4.0, the U.S. President's Council of Advisors on Science and Technology (2011) presented the "Report to the President on Ensuring American Leadership in Advanced Manufacturing." In response, President Obama launched the Advanced Manufacturing Partnership (AMP) initiative, aimed at fostering strategic collaboration between government, industry, and academia to integrate new technologies into manufacturing processes and products (Hemphill, 2014). Since then, the initiative has been assessed and updated periodically, in 2018 and in 2022. The 2022 report depicts a vision aimed at achieving a number of benefits, such as: economic growth, employment and strengthened supply chains; as well as national security, environmental sustainability, climate change mitigation and improved healthcare. That vision is articulated through three interrelated goals: develop and implement advanced manufacturing technologies; grow the advanced manufacturing workforce; and build resilience into manufacturing supply chains (National Science and Technology Council, 2022).

In 2015, China introduced the "Made in China 2025" initiative, aiming to ascend the global value chain and reestablish itself as an industrial leader. This strategy emphasizes enhancing the quality of Chinese-manufactured products and cultivating national brands, transitioning from a "Made in China" to a "Designed in China" model. By advancing cutting-edge technologies and researching new materials and products, China aspires to become a key competitor in the evolving global industrial landscape (Li, 2018). Notably, China designated 30 cities to implement and test this industrial policy, selecting Ningbo as a pilot city in 2016. Recent evaluations of the "Made in China 2025" plan indicate positive outcomes, particularly in environmental aspects (Yuan & Liu, 2024).

In 2016, the Japanese government introduced the concept of Society 5.0, grounded in ethical principles and a human-centered approach (López-Aranguren, 2023). This initiative emerged in response to concerns about various social challenges in Japan, including an aging population, low birth rate, and the potential negative impact of new technologies —such as robotics and artificial intelligence— on job availability (Huang, Wang, Li, Zheng, Mourtzis, & Wang, 2022). Society 5.0 envisions a sustainable and inclusive future, where digitalization not only enhances industrial efficiency but also promotes social welfare and environmental sustainability (Narváez-Rojas, Alomia-Peñafiel, Loaiza-Buitrago, & Tavera-Romero, 2021; Ruiz-de-la-Torre, Guevara, Rio-Belver, & Borregan-Alvarado, 2023). To achieve these objectives, Society 5.0 emphasizes the importance of social capital as a core asset and advocates for globally oriented open innovation grounded in human-centric values (Carayannis & Morawska-Jancelewicz, 2022).

The concept of Industry 5.0 emerged around 2020, sparking significant debate in both academic and political spheres (Grosse, Sgarbossa, Berlin & Neumann, 2023). It represents an evolution of Industry 4.0 (Lv, 2023), with aspects in common with Society 5.0, as it emphasizes the synergy between humans and machines, promoting collaboration to achieve a true symbiosis (Leng, Zhong, Lin, Xu, Mourtzis, Zhou et al., 2023; Ivanov, 2023). Industry 5.0 aims to tap the potential of emerging digital technologies through increased interaction between people and machines in intelligent industrial environments. This has led to the emergence of the human-centered approach, a concept that prioritizes the well-being, skills and autonomy of workers. Therefore, Industry 5.0, instead of focusing solely on objectives such as efficiency and cost reduction, places the human being at the center of industrial processes, promoting a more balanced production model (Alves, Lima & Gaspar, 2023; Zhang, Wang, Zhou, Chang, Ma, Jing et al., 2023). It also highlights the importance of human creativity, intuition, and emotional intelligence, as opposed to the predominantly automated and technological focus of Industry 4.0 (Frederico, 2021; Xu et al., 2021).

The other two fundamental pillars of Industry 5.0 are sustainability and supply chain resilience (Huang et al., 2022; Ivanov, 2023). The European Commission (2021) in its report "Industry 5.0: A transformational vision for Europe" analyzes how Industry 4.0 prioritizes efficiency and digitization over sustainability and concludes that the new concept of Industry 5.0 adapts better to European targets in the envisioned ecological transition by 2030. There is an ongoing discussion whether Industry 4.0, which is largely technology-driven, could evolve to integrate the new challenges generally related to sustainability or instead, Industry 5.0 should become the new paradigm to really integrate those new goals. In this context, some experts contend that the differences between the two paradigms may not be substantial enough to warrant a formal distinction (Huang et al., 2022).

3. Methodology

In this article, we employed a bibliometric analysis (BA) methodology to identify the most relevant scientific contributions related to the industrial initiatives discussed in the introduction. This integrative method supports the construction of new conceptual models, uncovers inconsistencies within the literature, and enables the synthesis of findings across a broad range of studies. BA ensure a structured process to collect, evaluate, and synthesize existing research on a specific topic (Cobo, Martínez, Gutiérrez-Salcedo, Fujita & Herrera-Viedma, 2015). Bibliometric techniques are generally categorized into two main approaches: performance analysis and science mapping. Performance analysis evaluates the productivity and impact of various research constituents, such as authors or countries, providing insight into the structure and development of a given field. In contrast, science mapping examines the conceptual relationships between these constituents, offering a more dynamic view of how knowledge evolves. Among the methods used for science mapping, co-word analysis stands out by shifting the focus from publication-based metrics to the actual content within the publications. Co-word analysis investigates the frequency and co-occurrence of terms, typically derived from author-provided keywords. This technique enables the identification of emerging themes, research trends, and conceptual structures within a domain by mapping how specific terms cluster together and evolve over time (Palmatier, Houston & Hulland, 2018).

On the other hand, the increasing accessibility of comprehensive scientific databases like Scopus and Web of Science has further enhanced the capacity for such reviews by enabling the collection of extensive bibliometric datasets. Tools such as Gephi, Leximancer, and VOSviewer have proven instrumental in analyzing and visualizing these data (Donthu, Kumar, Mukherjee, Pandey & Lim, 2021; Hassan & Duarte, 2024).

Additionally, the BA records each step of the review process in detail, providing full traceability of decisions and conclusions, which facilitates replicability by other researchers. For the development of the BA we followed the general stages proposed by Zupic and Čater (2015): (1) research design, (2) compilation of bibliometric data, (3) analysis, (4) visualization and (5) interpretation. In the first stage, we planned the review and conducted a preliminary study to assess the relevance and scope of the existing literature. In the second stage, we carried out the review using objective data extraction criteria, including title, author, and publication details. In the third stage, we filtered and refined the author keywords to ensure consistency and analytical accuracy. On the other hand, for steps four and five, we deviated from the process proposed by Zupic and Čater. Instead, we analyzed the author keywords from a semantic perspective, manually grouping them into clusters rather than relying on an algorithm. This approach allowed for a more accurate result interpretation.

3.1. Research Design

The objective of this research is to analyze the patterns and trends of major industrial initiatives worldwide from an academic perspective. By examining their definitions and the results presented in the scientific literature, we aim to identify relationships between these initiatives and their potential connections to Industry 4.0, which serves as a common reference.

In this initial phase, we conducted a preliminary study of the Industry 4.0 paradigm and related industrial policies, as outlined in the Theoretical Framework. We formulated three research questions to define the study's scope and guide the bibliometric analysis (BA), ensuring a systematic and objective approach. The five main subjects of this research —Industry 4.0, Industry 5.0, AMP, Made in China 2025, and Society 5.0— are hereafter generically referred to as "themes".

RQ1: What is the relevance of each theme in the academic world, and how has this relevance evolved?

RQ2: What are the most frequent topics within each theme? What are the similarities and differences among these sets of topics?

RQ3: For each theme, does the identified set of topics align with the theoretical definitions provided in the Theoretical Framework?

3.2. Compilation of Bibliometric Data

For the search, we used two of the most important academic databases: Web of Science and Scopus. For RQ1, we compared the results from both databases to verify the robustness of observed trends. For RQ2 and RQ3, we used Scopus due to its larger collection of articles.

For RQ1, we conducted 10 searches —five in Web of Science and five in Scopus— up to December 2023, obtaining the number of articles shown in Table 1. These are arranged chronologically based on the emergence of each concept, as outlined in the Theoretical Framework. Each search identified all articles that included the corresponding theme in the title, abstract, or keywords.

Theme	Year	Web of Science	Scopus
Industry 4.0	2011	20,343	32,820
Advanced Manufacturing Partnership	2011	8	26
Made in China 2025	2015	186	331
Society 5.0	2016	328	726
Industry 5.0	2020	752	1,131

Table 1. Number of articles published by theme and database

RQ2 and RQ3 involve identifying the most frequent topics within each theme. Given the small number of articles on the Advanced Manufacturing Partnership in both databases, we decided to exclude it from the topic analysis. Therefore, RQ2 and RQ3 focus on the themes of Industry 4.0, Made in China 2025, Society 5.0, and Industry 5.0. In each case, we aim to identify the most frequent topics unique to that theme. We first selected the articles that exclusively address a single theme, excluding those that mention any of the others to subsequently extract the set of articles from Scopus. For example, for Industry 4.0, we searched in Scopus using the query: "Industry 4.0" AND NOT "Industry 5.0" AND NOT "Society 5.0" AND NOT "Made in China 2025" within the fields Title, Abstract, and Keywords. Unlike the RQ1 search, where using full years was more representative, these searches included all articles published up to September 2024 to capture the maximum number of articles.

3.3. Analysis

In order to investigate the relevant topics within each theme, we assumed that the author keywords provide a valid representation of the topics covered in each article. We used VOSviewer software to easily determine the number of occurrences of the most frequent keywords within each theme's article set.

Table 2 summarizes the keyword filtering process we performed using VOSviewer for the four sets of articles previously exported from Scopus. To establish the number of keywords that VOSviewer outputs, the user must define the minimum number of occurrences required for a keyword to be included in the list. For Industry 4.0 and Industry 5.0, the themes with the highest number of articles, we set the Minimum Occurrences parameter by dividing the total number of keywords by 250, keeping the parameter proportional to the total number of keywords. This criterion produced a list of 48 different keywords for Industry 4.0 and 31 for Industry 5.0. In the cases of Society 5.0 and Made in China 2025, due to the smaller number of articles, dividing by 250 would yield an unrepresentative Minimum Occurrences value; therefore, we set the Minimum Occurrences parameter to a value that provided 10 keywords (the minimum number that would allow for a meaningful keyword analysis).

Theme	Articles (Total)	Keywords (Total)	Minimum Occurrences	Keyword Threshold
Industry 4.0	35,990	51,823	207	48
Industry 5.0	1,367	3,574	14	31
Society 5.0	639	1,668	10	10
Made in China 2025	266	920	5	10

Table 2. Number of articles, total keywords, minimum occurrences, and keyword thresholds per theme

4. Results and Discussion

In addressing RQ1 —"What is the relevance in the academic world, and how does this relevance evolve for each of the themes?"— Figure 1 presents the number of articles published per year in Web of Science and Scopus for the themes under study.

Based on Table 1 and Figure 1, we can draw some conclusions regarding RQ1. Firstly, as noted earlier, the Advanced Manufacturing Partnership holds minimal relevance in the scientific literature, with only 8 articles in Web of Science and 26 in Scopus. Among the remaining four themes, all receive attention in the academic literature; however, Industry 4.0 is by far the most established, while Made in China 2025 is the least prominent, with a difference of more than two orders of magnitude between them.

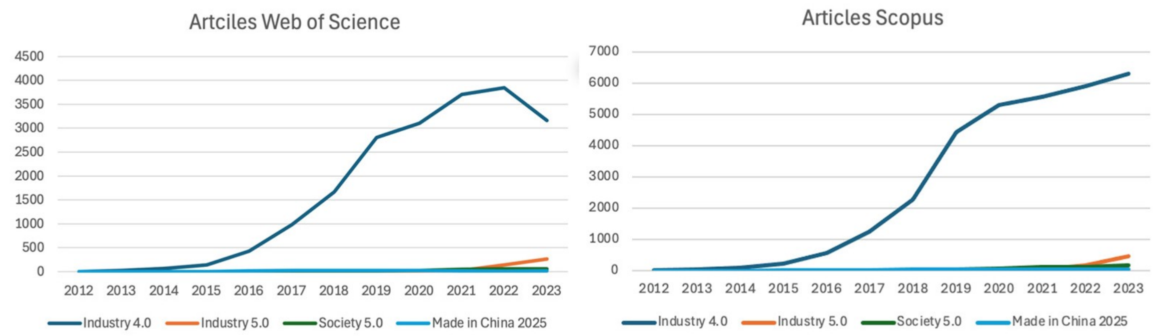

Figure 1. Number of articles published per year in Web of Science and Scopus

In the Web of Science database, publications related to Industry 4.0 increased from just 2 articles in its early years to a peak of 3,848 in 2022. The subsequent decline observed in 2023 may suggest a stabilization of the trend; however, it is still too early to draw definitive conclusions. In contrast, Industry 5.0 shows a more recent and growing interest, ranging from 0 to a maximum of 262 articles in 2023. Society 5.0 recorded up to 58 articles, with its peak in 2022, while Made in China 2025 reached a maximum of 26 articles in 2019. In Scopus database, Industry 4.0 increased from 2 articles to 6,319 in 2023, Industry 5.0 from 0 to a peak of 455 articles in 2023, Society 5.0 from 0 to 175 articles in 2023 and Made in China 2025 from 0 to a peak of 47 in 2020.

On the other hand, Figure 2 groups the articles published per year in Web of Science and Scopus, dividing the results by the total number of articles in each category to facilitate a comparison of the temporal evolution of each theme.

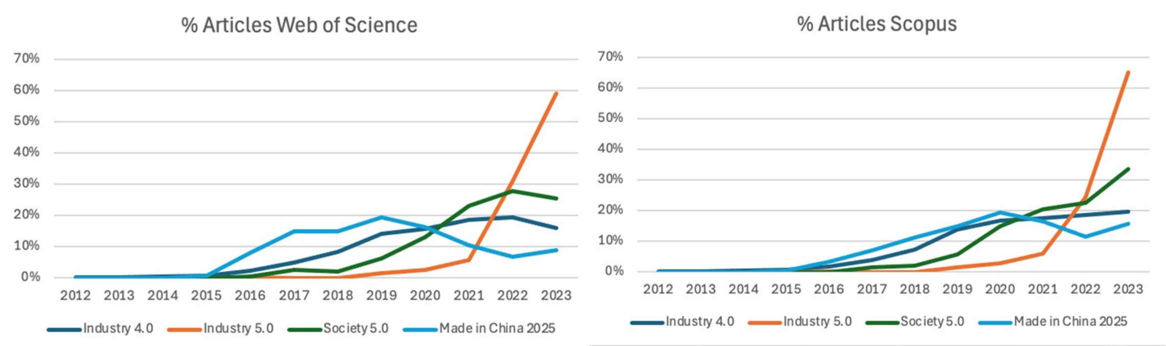

Figure 2. Percentage of articles published per year in Web of Science and Scopus

Regarding the evolution of each theme's relevance over time, Figure 2 shows that the emergence of the four themes in the academic literature aligns with the institutional and political momentum outlined in the theoretical framework. In terms of trends, while Industry 4.0 has remained stable and consistent since 2019 and Society 5.0

shows a moderate upward trend, Industry 5.0 has experienced strong growth since its emergence around 2020. Conversely, Made in China 2025 has shown a downward trend since 2019.

To assess the generalization of Industry 4.0, we analyzed the articles by country, specifically recording the location of the authors' institutions. Figure 3 presents the 10 countries with the highest number of publications on Industry 4.0. As expected, Germany ranks first, being the origin of Industry 4.0. However, the USA and China also hold prominent positions, ranking 4th and 5th, respectively. When these results are viewed alongside Figure 2 and Table 1, it becomes clear that the academic communities in the USA and China have embraced Industry 4.0, underscoring the dominance of this theme over other national industrial policy initiatives. Among the top 10 countries, European nations such as Germany, Italy, Spain, France, and Russia are represented, alongside Asian countries like India and China, and American nations such as the USA and Brazil. This shows that although Industry 4.0 originated in Germany, it has spread globally.

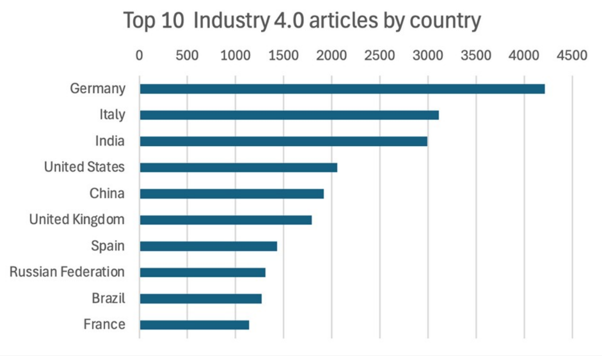

Figure 3. Top 10 countries publishing articles on Industry 4.0

RQ2 and RQ3 both involve analyzing the characteristic topics of each theme. As previously stated, we use author keywords as representatives of the topics covered in the articles, basing our analysis on these keywords. For each theme, we followed the same procedure. First, we refined the lists of keyword occurrences obtained with VOSviewer (summarized in Table 2) by removing the keyword corresponding to the theme itself—for instance, removing "Industry 4.0" from the list of Industry 4.0 keywords. We also consolidated equivalent keywords into a single term, such as merging "Machine learning" and "Machine-learning" or "Internet of Things" and "IoT." To facilitate analysis, we classified the keywords into four clusters:

- **Industry 4.0 Used Technology**: Keywords related to technologies that are either specific to or intensively used within Industry 4.0.
- **Tactics Related**: Keywords related to the uses or applications of the technologies.
- **Strategy Related**: Keywords representing objectives or goals to be achieved.
- **General**: Keywords that are generic or not specific to any theme.

The resulting classifications for Industry 4.0, Industry 5.0, Society 5.0, and Made in China 2025 are presented in Figures 4, 7, 8, and 9, respectively. In those figures Each keyword comes with the number of occurrences in the corresponding set of articles.

Regarding RQ2 —"What are the most frequent topics in each of the themes? What are the similarities and differences between these sets of topics?"— Figure 4 reveals a significant concentration of keywords related to new technologies characteristic of Industry 4.0. These keywords account for 70% of the total weight, with "Internet of Things" standing out, appearing 2.5 times more frequently than the next most common topic, "smart manufacturing." The Tactics Related and the Strategic Related clusters have a similar weigh of 12% each. Within the Tactics Related cluster, "supply chain" emerges as the most repeated keyword. In the Strategy Related cluster, it is particularly noteworthy the combined weight of "sustainability" and "circular economy", representing almost half of the cluster's total weight. Finally, the General cluster comprises 6% of the total weight, grouping keywords that hold less significance concerning our research question.

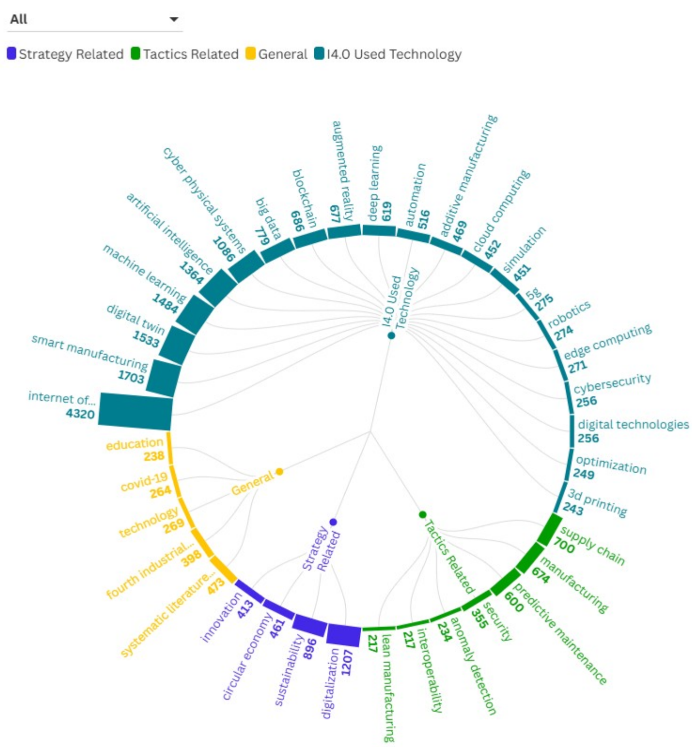

Figure 4. Classification of keywords for Industry 4.0

Regarding RQ3 —"For each theme, does the set of topics identified correspond to the theoretical definition given in the Theoretical Framework?"— the set of keywords found closely aligns with the commonly accepted definition of Industry 4.0, as outlined in the Theoretical Framework. Industry 4.0 is strongly associated with new technologies such as the "Internet of Things," "big data," "artificial intelligence," "cloud computing", "augmented reality" and "digital technologies." This alignment is also consistent with the premise that Industry 4.0 aims to integrate "digitalization" with traditional production, leading to "smart manufacturing."

Since Industry 4.0 is the most prominent trend among those studied and emerged earlier, in 2011, we performed a complementary analysis to assess its topic evolution over time. We divided the timeline into two periods: 2011 to 2019 and 2020 to 2024, with 2019 chosen as the inflection point when Industry 4.0 publications stabilized, as shown in Figure 2. Table 3 presents the same analysis and methodology used in Table 2, applied to these two time frames.

Industry 4.0	Articles (Total)	Keywords (Total)	Minimum Occurrences	Keyword Threshold
2011-2019	8,889	15,669	63	34
2020-2024	27,101	42,645	170	52

Table 3. Number of articles, total keywords, minimum keyword occurrences, and keyword thresholds for Industry 4.0 across two time frames

In each period, we set the Minimum Occurrences parameter by dividing the total number of keywords by 250, keeping the parameter proportional to the total number of keywords.

After refining and clustering the keywords, we obtained the results shown in Figures 5 and 6.

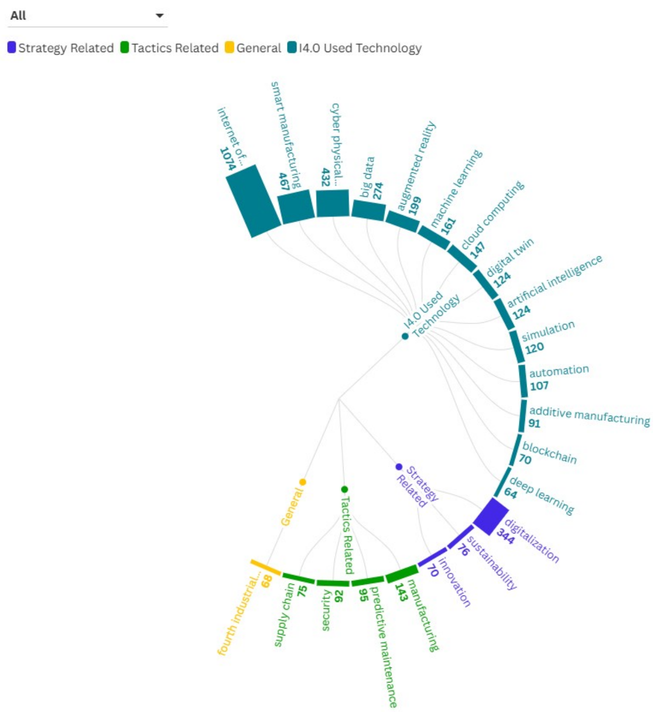

Figure 5. Classification of keywords for Industry 4.0 from 2011 to 2019

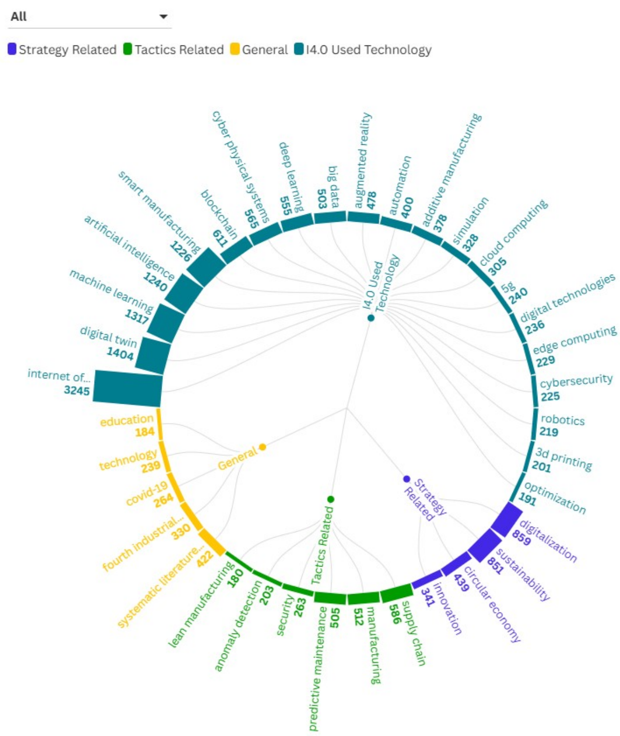

Figure 6. Classification of keywords for Industry 4.0 from 2020 to 2024

Figure 5 shows similar category percentages to those of Industry 4.0, though the number of keywords obtained is smaller due to the limited number of articles in this first time frame.

Figure 6 more closely resembles Figure 4, as articles from 2020 to 2024 represent 75% of the total number of Industry 4.0 articles. Comparing with the 2011 to 2019 period, "internet of things" remains the most frequent keyword in the Industry 4.0 Used Technology cluster. It is followed by "digital twin", "machine learning" and "artificial intelligence", which emerge as important topics coming from much more discrete positions in the previous period. There are as well new additions such as "5G," "cybersecurity," and "3D printing". The Strategy Related cluster shows a marked change in the prominence of "sustainability", together with the emergence of "circular economy". This trend can be interpreted as an indicator of how Industry 4.0 has adapted to new social and technological trends while maintaining its core principles as outlined in the Theoretical Framework.

For Industry 5.0, Figure 7 shows the three keyword clusters obtained.

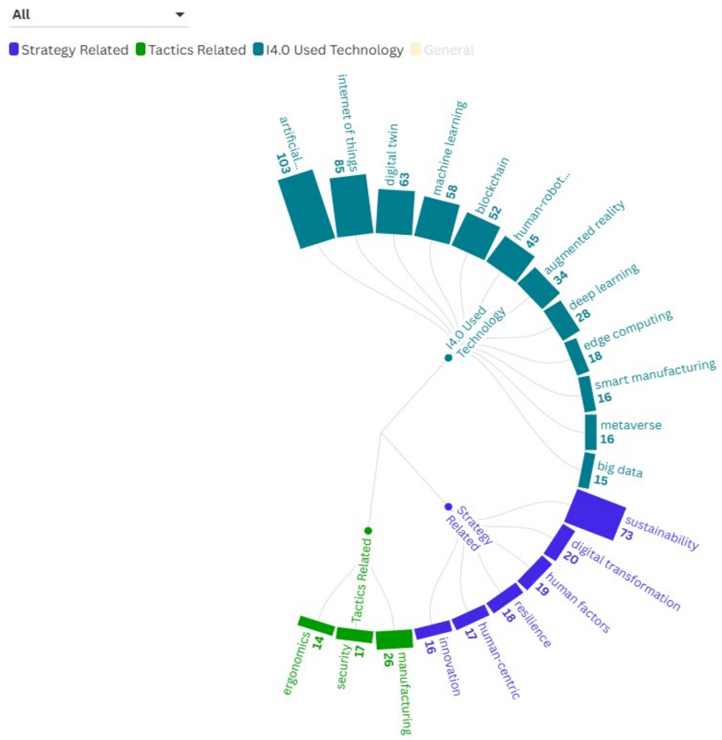

Figure 7. Classification of keywords for Industry 5.0

Similar to Industry 4.0, the most prominent cluster is Industry 4.0 Used Technology, comprising 71% of the total weight. However, for Industry 5.0, "artificial intelligence" is the most frequent keyword in this cluster, surpassing "Internet of Things", which contrasts with Industry 4.0. This difference may be attributed to Industry 5.0's recent emergence in 2020, compared to Industry 4.0's inception in 2011. The second most relevant cluster is Strategy Related, with a total weight of 22%, where "sustainability" is the most significant keyword, representing nearly half of the cluster's weight. Unlike Industry 4.0, many keywords in both the Tactics and Strategy clusters are related to the human aspect, such as "human-robot collaboration," "ergonomics," "human factors," and "human-centric."

Regarding RQ3, the Theoretical Framework describes how Industry 5.0 aims to advance beyond Industry 4.0, particularly in sustainability, human-centered approaches and supply chain resilience. This focus is clearly reflected in the keyword set. Furthermore, the shift of Industry 5.0 toward human values, as suggested by Xu et al. (2021), is supported by these data, with the Strategy Related cluster showing a 10% higher weight in Industry 5.0 compared to Industry 4.0. On the other hand, it is interesting to note that the word "digitalization", which is very relevant in Industry 4.0, is not directly represented.

As explained in Section 3, the limited number of unique keywords found for Society 5.0 resulted in a smaller set, as shown in Figure 8.

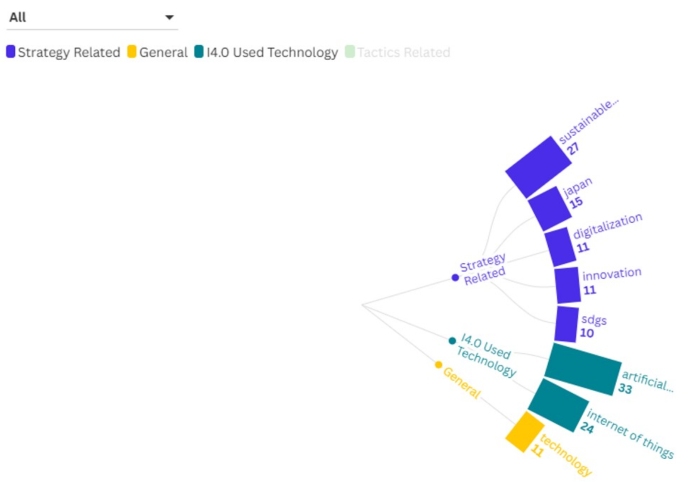

Figure 8. Classification of keywords for Society 5.0

Regarding RQ2, the most significant cluster in this case is Strategy Related, comprising 52% of the total weight. Similar to Industry 5.0, half of this cluster's weight is related to sustainability, reflected in the combined weight of "sustainable development" and "SDGs." The second most important cluster is Industry 4.0 Used Technology, with 40% of the total weight. As with Industry 5.0, the most frequent keywords are "artificial intelligence" and "Internet of Things." This similarity may again be attributed to the timeline.

Regarding RQ3, we observe that certain characteristics relevant to Society 5.0, as described in the theoretical framework—such as the aging population, low birth rate, or the potential for new technologies to reduce job positions—do not explicitly appear in the keyword set. However, it is important to consider two points. First, the sample of Society 5.0 articles in Scopus is relatively small, with only 639 articles. Second, it is possible that keywords categorized as Industry 4.0 Used Technology, such as "artificial intelligence" and "Internet of Things," may refer in the corresponding articles to the relationship of these technologies with potential job loss and social impacts.

Finally, Figure 9 presents the keyword set obtained for Made in China 2025. In this case, the most prominent cluster by far is Strategy Related, comprising 78% of the total weight. Keywords such as "China," "industrial policy," and "Belt and Road Initiative" suggest topics focused purely on industrial policy. The second cluster is the Tactics related with a 12% of total. The remaining 10% of the weight corresponds to the I4.0 Used technology cluster. This indicates that Made in China 2025 is a purely "industrial policy" initiative, centered more on political considerations than on new technologies or industrial applications.

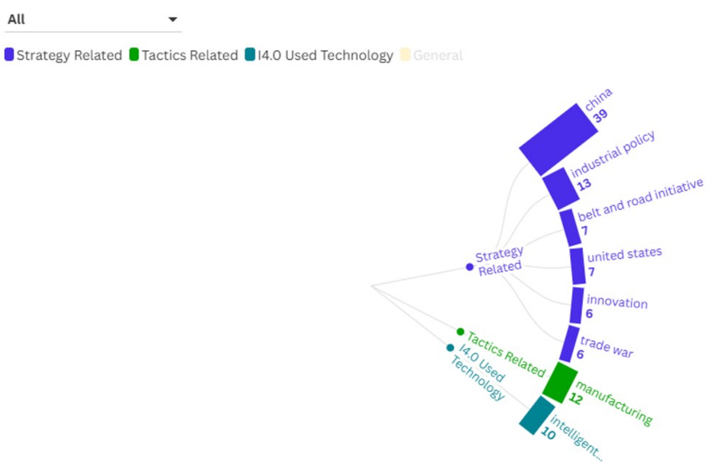

Figure 9. Classification of keywords for Made in China 2025

Regarding RQ3, the topics identified align with those in the theoretical framework, as Made in China 2025 is a movement primarily focused on empowering Chinese industry and transitioning toward "intelligent manufacturing." However, it is important to note that the low number of articles found limits the possibilities for analysis.

5. Conclusions

This paper presents an analysis of the academic importance and characteristics of Industry 4.0 and several major related industrial policies. To achieve this, we performed a bibliometric analysis over several sets of articles, using two key databases: Web of Science and Scopus. The primary conclusion from this analysis is the vast difference in article volume, with Industry 4.0 dominating the field. The number of Industry 4.0-related articles is nearly 30 times that of Industry 5.0. Following in descending order are Society 5.0, Made in China 2025, and AMP. In terms of trends, Industry 4.0 remains steady, while Industry 5.0 has shown significant growth in the past two years. The coming years may reveal whether Industry 5.0 has the potential to replace Industry 4.0 as the new paradigm; however, it is too early to draw conclusions. Conversely, Society 5.0, Made in China 2025, and AMP appear to have a very limited impact in the academic literature.

To enrich the analysis and investigate the specific topics characteristic of each theme, we developed and tested a procedure for bibliometric analysis and clustering of author keywords. To our knowledge, this type of analysis is novel, as all papers we found using VOSviewer limit their keyword analysis to the graphs automatically generated by the software. The keyword analysis enabled a meaningful characterization of each theme, allowing for comparisons between themes and alignment with their theoretical definitions. For the most prominent themes, Industry 4.0 and Industry 5.0, the analysis revealed that both share a strong technological foundation, though Industry 5.0 is more strategy-oriented than Industry 4.0. The trend analysis for Industry 4.0 indicates that it has successfully incorporated sustainability as a key focus, further prompting the question of whether a distinct concept like Industry 5.0 is necessary.

This research provides a foundation for further exploration in different directions. First our keyword-based bibliometric method offers an efficient and reproducible way to analyze large volumes of literature, a logical next step would involve complementing this approach with qualitative methods, such as systematic literature reviews or content analysis, to deepen the understanding of the thematic evolution and contextual nuances behind keyword trends. Furthermore, since Industry 5.0 and Society 5.0 are at an early-stage of development, it is necessary to follow the evolution of these paradigms over time, both in the academic literature and in the industrial practice.

The keyword clustering-based analysis developed, is replicable in any other area of interest and provides a very efficient, structured and unbiased process to perform a first exploration of a large scientific area, as is the case of Industry 4.0, with almost 40,000 articles.

Declaration of Conflicting Interests

The authors declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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