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Evolving from Industry 4.0 to Industry 5.0: Evaluating the conceptual structure and prospects of an emerging field

Evolução da Indústria 4.0 para a Indústria 5.0: Avaliação da estrutura concetual e perspectivas de um campo emergente

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Abstract

The world is experiencing unprecedented transformation brought about by the Fourth Industrial Revolution, also known as Industry 4.0, and the pandemic caused by COVID-19. Industry 4.0 seeks to transcend from the physical production processes to the digital environment, strengthening the link between the production agents. However, the pandemic evidenced the need to transform the industry and how it fosters global development. The Fifth Industrial Revolution or Industry 5.0 arises at this point and it sets a new paradigm of development and seeks to foster an industrial activity transcending the technical or economic goals, such as productivity and efficiency. Industry 5.0 fosters essential purposes for the future, which its predecessor did not state clearly. Nevertheless, as it is a new concept based on another relatively new, it is complicated to identify the components distinguishing it and boosting its development, as well as the most relevant agents in its consolidation. In this sense, by using bibliometric techniques and tools, this piece of research analyzes the conceptual structure of Industry 5.0, pursuant to its productivity, impact and contents according to the literature available in Scopus. To this end, we have retrieved and analyzed 343 publications from 2018 to 2022, using SciMAT, which has allowed us to establish a detailed frame of reference about the main lines of research, development and innovation related to Industry 5.0 and the agents vitalizing it.

Keywords: Competitive intelligence. Smart Industry. Smart Factory. Advanced Manufacturing. Regional Competitiveness.

Resumo

O mundo está passando por um processo de transformação sem precedentes provocado pela Quarta Revolução Industrial, também conhecida como Indústria 4.0, e pela pandemia causada principalmente pela COVID-19. A Indústria 4.0 procura transcender dos processos físicos de

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produção ao ambiente digital, fortalecendo a ligação entre os agentes de produção. Entretanto, a pandemia evidenciou a necessidade de transformar tanto a indústria quanto a forma como ela fomenta o desenvolvimento global. A Quinta Revolução Industrial ou Indústria 5.0 surge neste ponto e estabelece um novo paradigma de desenvolvimento e procura fomentar uma atividade industrial que transcenda os objetivos técnicos ou econômicos, como produtividade e eficiência. A indústria 5.0 fomenta propósitos essenciais para o futuro, que seu predecessor não afirmava claramente. Entretanto, por ser um conceito novo baseado em outro relativamente novo, é complicado identificar os componentes que o distinguem e impulsionam seu desenvolvimento, assim como os agentes mais relevantes em sua consolidação. Neste sentido, ao utilizar técnicas e ferramentas bibliométricas, esta pesquisa analisa a estrutura conceitual da Indústria 5.0, de acordo com sua produtividade, impacto e conteúdo de acordo com a literatura disponível no Scopus. Para isso, recuperamos e analisamos 343 publicações de 2018 a 2022, utilizando SciMAT, o que nos permitiu estabelecer um quadro detalhado de referência sobre as principais linhas de pesquisa, desenvolvimento e inovação relacionadas à Indústria 5.0 e os agentes que a vitalizam.

Palavras-chave: *Inteligência competitiva. Indústria inteligente. Fábrica Inteligente. Manufatura Avançada. Competitividade regional.*

Introduction

The world is immersed in a process of transformation favored mainly by the impact of the Fourth Industrial Revolution, also known as Industry 4.0, on the organizations, their production models and relations in their chains of value, and the prioritization of disruptive, smart technologies. Besides, because of the changes of paradigms brought about by the pandemic COVID-.19 and oriented mainly towards seeking resilient, sustainable models, that they should include persons in their main considerations, thus fostering the construction of a more stable environment with more capacity to reaction to complex situation situation (Furstenau *et al.*, 2020; Madhavan *et al.*, 2022; Reymond, 2021; Zizic *et al.*, 2022).

Industry 4.0 has sought to maximize the efficacy and efficiency of the organizations by optimally organizing their production capacities. Achieving sustainable, continuous optimization of the different processes makes it possible to increase the satisfaction of all organizational stakeholders in the organization. Another goal of Industry 4.0 is to put an end to the inefficiencies of factories and, to that end, it seeks to improve the profitability of the business, improving control and reducing business risks by implementing principles such as analytic, real-time interconnection, advanced automation, virtualization, decentralization and orientation towards the target client (Ghobakhloo, 2020; Masood; Sonntag, 2020).

It is important to understand that the potential of this fourth industrial revolution lies in the evolution of the production processes. However, its scope is much wider and it even considers aspects related both to sustainability and to making good use of existing resources. In this sense, Industry 4.0 has changed the paradigm of how things should be done, questioning the way of interacting in the chain of value and with the target client as well as the roles and capabilities persons should have now and in the future in physical and virtual environments (Machado *et al.*, 2019; Papadopoulos *et al.*, 2022).

Besides, Industry 4.0-related technologies can also be considered elements catalyzing the development of new services and products, taking into account the intensive use of smart and/or mobile devices, sensors, techniques for data analysis and robotics, among others. These technologies enable improvements in products and services in several ways ranging from developing prototypes to incorporating new functionalities (i.e. connectivity, multiplatform, virtual and augmented reality, advanced automation and artificial intelligence, among others), passing by testing and validating them. All this also translates into changes in the supply chain and consequently into the

relationship with the client, which ends up coming back to the beginning of the cycle, where design and manufacture play a more relevant role (Bag *et al.*, 2018; Hahn, 2020).

In turn, all this has been influenced by the pandemic that, in addition to being a milestone in history, has also evidenced the need to make structural changes in the way society and the organizations interact among themselves and manage, regardless of their nature. Therefore, the need arises to build a society from a holistic approach fully incorporating business-related, social, political, scientific, academic and technological strategies giving rise firstly to sustainable, resilient organizations targeted at persons, with capabilities to develop accordant products and services (Acioli; Scavarda; Reis, 2021; Rinker *et al.*, 2021).

This situation has accounted for the emergence of the Fifth Industrial Revolution or Industry 5.0. This new approach fosters industrial development towards a production model focused on technological innovation and economic growth and commitment with environment-friendly practices. It also fosters the consolidation of resilient strategies strengthening the sector against sudden disruptions such as the one derived from the pandemic (Akundi *et al.*, 2022; Huang *et al.*, 2022).

Though its origin is not completely clear, one of its main driving forces is the European Commission that, as a result of many meetings in 2020, proposed this concept, emphasizing that Industry 5.0 is neither an evolution of Industry 4.0 nor an alternative paradigm designed to replace it. Somehow, it draws attention to the course the fourth industrial revolution has taken and how it has focused mostly on process digitizing and the use of artificial intelligence to increase productivity and efficiency, its priorities relegating the role of the persons participating in the production tissue or the transition to more sustainable and resilient development models (Alexa; Pîslaru; Avasilcăi, 2022; Cillo *et al.*, 2021).

Therefore, in Industry 5.0 the human factor gets back prominence and stands again at the core of the process of design, production, testing and validation. According to this premise, technology should be at the human service and not the other way around, so the aspiration is to move forward towards a scenario of full collaboration between men and machines (Ghobakhloo *et al.*, 2022; Madsen; Berg, 2021; Saniuk; Grabowska; Straka, 2022).

In this sense, the model of growth and development promoted by Industry 5.0 will become an indispensable part of any strategy worldwide, so it is necessary to understand which are the main subjects related to it in terms of research, development and innovation as well as the related sub-subjects in order to be able to have a frame of reference allowing transition.

To this end, analyzing performance and bibliometric networks is an adequate framework to foster a comprehensive, comparative, objective analysis of the main Industry 5.0-related research themes (research lines) and assess their evolution. Besides, it will make it possible to include prospective support to the identification of opportunities for and gaps in research, development and innovation for the future decisions made by agents interested in this issue (Furstenau *et al.*, 2020; López-Robles *et al.*, 2019).

Considering the above, the goals of this piece of research are to visualize and understand the conceptual structure of Industry 5.0, using *SciMAT* bibliometric software, by evaluating the main indicators related to bibliometric performance (publications, citations received, authors, geographic distribution, among others) and science maps (Silva Júnior; Dutra, 2021; Gamboa-Rosales *et al.*, 2020; Gontijo; Hamanaka; Araujo, 2021; Sott *et al.*, 2021).

Methodology

In order to achieve the goals of this piece of research, we used a complete bibliometric approach based on the analysis of the scientific map and the indicators of performance so as to find out the condition of research about Industry 5.0 in literature.

To evaluate research on Industry 5.0 in literature, we carried out a bibliometric analysis based on indicators of performance and the analysis of scientific maps. Firstly, the analysis of performance is based on bibliometric indicators measuring the output of several authors and the impact achieved by the publications in *Scopus* database (Gutiérrez-Salcedo *et al.*, 2018; Moed *et al.*, 1985; Moed; De Bruin; Van Leeuwen, 1995).

Secondly, we carried out an analysis of conceptual scientific mapping based on the network of co-words, using *SciMAT*, which is based on an approach focused on two stages: (1) detection of research themes, and (2) visualization of themes and their relation as a thematic network (Cobo, 2012; Cobo *et al.*, 2011).

To this end, the identified research subjects have been represented in a strategic diagram. It is a map of two dimensions separated into four different areas according to their relevance, where research themes are shown as a sphere. Their volume is equivalent to the total of publications related to that theme: (Q1) Motor themes (upper right quadrant) the subjects in this quadrant are relevant to structure and develop the field of research; (Q2) Very developed and isolated themes (upper left quadrant) the subjects in this area are significant but lack importance enough to be considered something more than a very specialized or peripheral activity for research on the smart industry field, (Q3) Emerging or declining themes (lower left quadrant) the lines of research in this quadrant are weak. Still, this weakness may be understood as emerging or declining subjects, (Q4) Basic and transversal themes (lower right quadrant) the subjects included in this quadrant are not sufficiently developed but could be relevant to the area of knowledge.

Finally, we analyzed the themes making up each of them to understand the lines of research, development and innovation identified in the literature that boost new knowledge and their applications. This methodological procedure is a first approach since, in accordance with the results and as a next interaction, an analysis by periods of time can be carried out, as well as the identification of research areas (Herrera-Viedma *et al.*, 2020; Sott *et al.*, 2021).

So as to carry out the analysis of performance and scientific mapping, we have compiled and processed the publications related to the Industry 5.0 in *Scopus* database: *TITLE-ABS-KEY-AUTH("industry 5.0" OR ""industry-5.0" OR "industrie 5.0" OR "industrie-5.0") AND (EXCLUDE(PUBYEAR, 2016) OR EXCLUDE(PUBYEAR, 2010) OR EXCLUDE(PUBYEAR, 2005)) AND (LIMIT-TO(DOCTYPE, "ar") OR LIMIT-TO(DOCTYPE, "cp") OR LIMIT-TO(DOCTYPE, "re") OR LIMIT-TO(DOCTYPE, "ch")) AND (EXCLUDE(PUBYEAR, 2023))*.

The advanced query search used in this piece of research retrieved 343 documents from 2018 to 2022. The publications and their gross data were retrieved from *Scopus* as plain text and processed in *SciMAT* to establish the knowledge foundation for the analysis of performance and scientific mapping. For the purpose of improving data quality, a process of elimination of both duplicities was carried out (for instance, "INTERNET-OF-THINGS", "IOT" and "INTERNET-OF-THINGS-(IOT)" were merged as "INTERNET-OF-THINGS") and senseless words (for instance, "EFFICIENCY", "SOFTWARE" or "APPLICATION" were excluded from the analysis).

Results

The concept of Industry 5.0, like that of Industry 4.0, is an area of knowledge of interest to all kinds of agents ranging from scientific, academic and technological to political, social and entrepreneurial due to its cross-sectional and currently important nature. In this line, we analyzed the evolution of the concept of Industry 5.0 in the literature in terms of performance and impact, considering the bibliometric indicators most used for that purpose (most prolific authors, most cited authors, countries, organizations, sources, areas of knowledge, among others). Furthermore, we resorted to the h-index to be able to complement the above, identifying those agents and publications relevant to the development of the area.

In terms of number of publications and citations obtained since the publication of the first document where the concept of Industry 5.0 is mentioned to date, a positive and considerable evolution ranging from only one publication in 2018 to over 200 in 2022 can be observed and verified, rises of at least 200% having been recorded from year to year in relation to the previous period. In turn, the citations recorded go beyond the barrier of 2,000 citations in 2022, this situation shows the interest of entrepreneurial, academic, scientific, technological, political and social communities in this subject, an interest that in principle seems to remain at least in the next years.

Besides, it is important to stress that the distribution of said publications, according to their typology, is distributed mainly in articles (56%), publications in congresses (31%), reviews of the state of the art (8%) and book chapters (5%), which shows an orientation towards the generation of new knowledge but also its dissemination, thus providing a certainly balanced theoretical and practical sense. In this context, Figure 1 shows the distribution of publications and their Industry 5.0-related citations recorded in Scopus from 2018 to 2022.

Figure 1 – Distribution of publications and Industry 5.0-related citations from 2018 to 2022.
Source: Own elaboration (2023).

The trend in both cases is positive and sustained over time, an aspect reinforced by the fact that in 2022, despite being an active year in terms of possibilities of publication, the values of the previous years have already been exceeded and there are already publications related to the subject, accepted to be published in 2023, as per the data consulted in Scopus.

In this sense, Table 1 shows performance from the perspective of several bibliometric indicators, starting with the most prolific and cited authors, followed by the organizations, countries and sources, and ending with the main areas of knowledge that currently address the concept of Industry 5.0.

Table 1 – Productivity and impact for the concept of Industry 5.0 from 2018 to 2022 as per Scopus.

Description	(Publications or Cites) Description [Publications or Cites]
Most productive authors (n=343)	(7) Carayannis, E.G. [74] (4) Abonyi, J. [0]; Kopacek, P. [25] (3) Aguayo-González, F. [8]; Ávila-Gutiérrez, M.J. [8]; Campbell, D.F.J. [33]; Chang, V. [91]; Demir, K.A. [123]; Dev, K. [114]; Doyle-Kent, M. [17]; Franceschini, F. [0]; Gervasi, R. [0]; Grabowska, S. [9]; Haleem, A. [105]; Javaid, M. [105]; Li, X.; Margherita, E.G. [11]; Mastrogiacomo, L. [0]; Mourtzis, D. [7]; Saniuk, S. [9]; Wang, L. [92] (>=2) 1.154 authors
Most cited authors (n=2.083)	(210) Nahavandi, S. [2] (164) Hekim, N. [2]; Özdemir, V. [2] (123) Demir, K.A. [2] (>=118) 1.177 authors
Most productive organizations (n=343)	(7) The George Washington University (5) King Saud University; Technická Univerzita v Košiciach; (4) Silesian University of Technology; Högskolan i Skövde; Technische Universität Wien; Jamia Millia Islamia; Universidade do Minho; Samara State Technical University; Pannon Egyetem; Universidad de Sevilla; Taif University; University of Petroleum and Energy Studies; Chandigarh University; South East Technological University (>=3) 832 Organizations
Most productive countries (n=343)	(61) India (41) China (31) United States (>=18) 77 Countries
Most productive sources (n=343)	(20) IEEE Transactions on Industrial Informatics (14) Sustainability Switzerland (9) Ceur Workshop Proceedings; IFIP Advances in Information and Communication Technology (>=8) 115 Sources
Most productive subjects (n=343)	(196) Computer Science (193) Engineering (61) Business, Management and Accounting (>=53) 19 Subjects

Source: Own elaboration (2023).

Among the most prolific authors stands out Carayannis, E.G., a science, technology, innovation and entrepreneurial spirit professor at the Business School in George Washington University in Washington, who has seven publications, as well as Abonyi, J. and Kopacek, P, with four publications each one respectively. This fact slightly contrasts with the most prolific authors who mostly do not come to be among the most cited, Nahavandi, S. being the most cited author with 210 citations, followed by Hekim, N. and Özdemir, V. with 164 each one respectively. Demir, K.A., with 123 citations, is the only author included in both references.

The previous condition shows two scenarios, on the one hand, the scenario of productivity, where the first advances can be considered to occur, followed by the scenario of citations, where the references supporting the area of knowledge are generated.

In terms of countries, India, China and the United States are the most prolific countries, with 61, 41 and 31 publications, respectively. This fact supports the reference that the origin of the

concept of Industry 5.0 is not exclusive to Europe and is reinforced by the most cited organizations: The George Washington University, King Saud University and Technická Univerzita v Košiciach, which keeps said behavior.

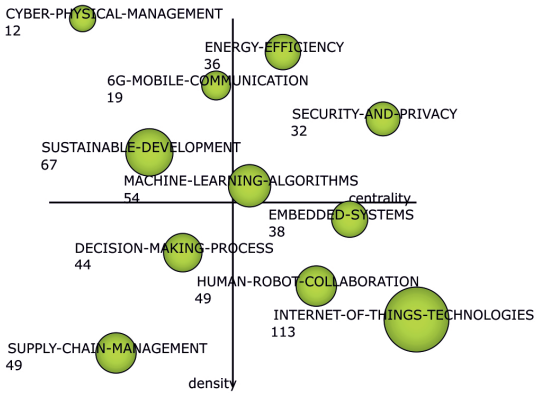
Finally, the sources are representative too, since they can be considered references in their fields, which coincide with the main areas of knowledge wherefrom the concept of Industry 5.0 is being boosted: Information Technology, Engineering and Business, Management and Accounting.

Considering the above and envisaging that there is a relation among the indicators, where productivity and impact in this stage of evolution bear a relation, we resorted to the h-index to complete the above, before carrying out the analysis of the main subjects about the concept of Industry 5.0 or Fifth Industrial Revolution. The h-index, or Hirsch index, is a metric for evaluating the cumulative impact of an author's academic output and performance; measures quantity with quality by comparing publications to citations. The h-index corrects for the disproportionate weight of highly cited publications or publications that have not yet been cited.

In this sense, the number of publications considered relevant to the development of Industry 5.0 amounts to 20 so far. These publications are distributed mainly in 2020 (8 publications), followed by 2019 and 2021 (4 publications each year respectively), which coincides with the stance of the European Commission. Moreover, these 20 publications concentrate 1,334 citations (64%) out of the total citations accumulated by all publications, which confirms their specific weight. Regarding relevant publications according to h-index, patterns and performance indicators were not founded to confirm a clear reference, as the indicators of productivity and reference remain the same. This shows that the area is growing, so waiting for its consolidation to extract more information through the literature analysis based on the h-index is prudent.

Though Industry 5.0 shows positive evolution in terms of productivity and its impact has a similar situation according to the h-index, it is appropriate to recognize the research, development and innovation subjects participating in said evolution. To this end, in line with the methodology described above, Figure 2 shows the main subjects arranged in four different quadrants according to their role in the development of the area of knowledge.

From 2018 to 2022, 11 main themes have been identified, which are distributed, in a balanced order, in the four quadrants, those included in quadrants 1 and 4 being the



Theme	Documents	h-index	Average Citations	Citations
INTERNET-OF-THINGS-TECHNOLOGIES	113	13	9.32	1053
SUSTAINABLE-DEVELOPMENT	67	8	2.88	193
MACHINE-LEARNING-ALGORITHMS	54	6	4.24	229
HUMAN-ROBOT-COLLABORATION	49	9	7.51	368
SUPPLY-CHAIN-MANAGEMENT	49	7	5.22	256
DECISION-MAKING-PROCESS	44	6	6.36	280
EMBEDDED-SYSTEMS	38	4	4.26	162
ENERGY-EFFICIENCY	36	5	2.53	91
SECURITY-AND-PRIVACY	32	6	4.50	144
6G-MOBILE-COMMUNICATION	19	3	7.47	142

Figure 2 – Strategic map and conceptual structure of Industry 5.0 from 2018 to 2022.
Source: Own elaboration (2023).

ones accumulating more publications. This shows that it is a growing area of knowledge, since quadrants 1 and 4 are even considered to be those marking the growth and development of an area, an aspect that coincides with the above. Thus, the themes are: SECURITY-AND-PRIVACY, ENERGY-EFFICIENCY, EMBEDDED-SYSTEMS, HUMAN-ROBOT-COLLABORATION, INTERNET-OF-THINGS-TECHNOLOGIES, SUSTAINABLE-DEVELOPMENT, SUPPLY-CHAIN-MANAGEMENT, DECISION-MAKING-PROCESS, MACHINE-LEARNING-ALGORITHMS, 6G-MOBILE-COMMUNICATION and CYBER-PHYSICAL-MANAGEMENT.

As regards the subjects identified as motor themes: MACHINE-LEARNING-ALGORITHMS, ENERGY-EFFICIENCY and SECURITY-AND-PRIVACY, which have a relation with intelligence applied to production systems, energy efficiency and the need to make the virtual world a safe environment in every sense. Figure 3 shows the thematic networks for each motor theme and it is convenient to remark that, in terms of MACHINE-LEARNING-ALGORITHMS, the most relevant relations include subjects such as DEEP-LEARNING, EDGE-COMPUTING, INTELLIGENT-SYSTEMS and SENTIMENT-ANALYSIS, mainly. In turn, as regards ENERGY-EFFICIENCY, the most relevant subjects, according to their relation, are 5G-MOBILE-COMMUNICATION-SYSTEMS, OPTIMIZATION-TECHNIQUES, SWARM-INTELLIGENCE and OPEN-SOURCE-SOFTWARE-AND-HARDWARE, while in the theme SECURITY-AND-PRIVACY the most relevant themes are BLOCKCHAIN-TECHNOLOGIES, NETWORK-SECURITY and ELECTRONIC-DATA-INTERCHANGE.

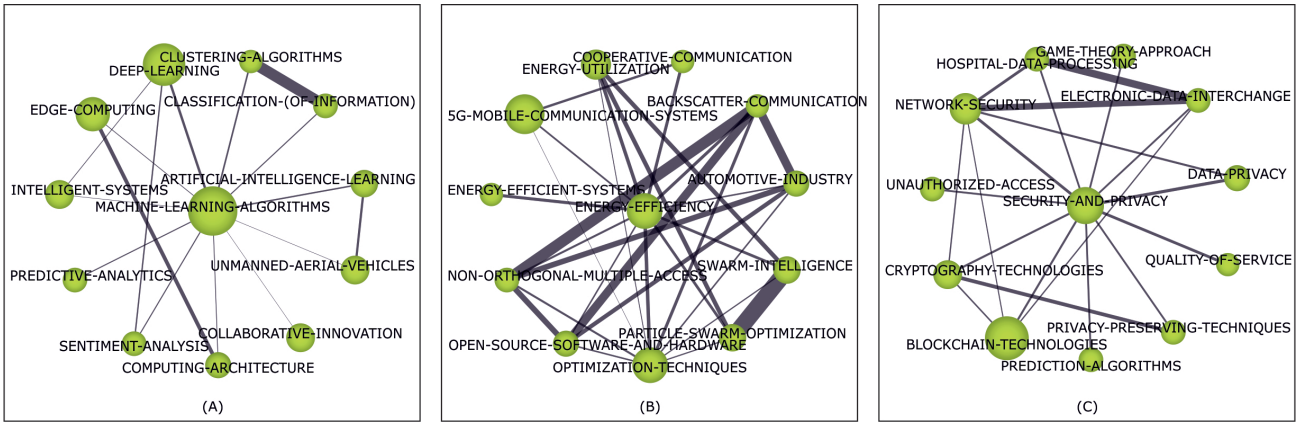


Figure 3 – Conceptual networks of motor themes (Quadrant 1): (A) MACHINE-LEARNING-ALGORITHMS, (B) ENERGY-EFFICIENCY and (C) SECURITY-AND-PRIVACY.
Source: Own elaboration (2023).

In the same line, Figure 4 shows those themes related to quadrant 2 that covers the very developed and isolated themes, they are: SUSTAINABLE-DEVELOPMENT, CYBER-PHYSICAL-MANAGEMENT and 6G-MOBILE-COMMUNICATIONS, where the former is the one including the most significant themes like SOCIAL-SUSTAINABILITY, HUMAN-CENTRIC-APPROACH, DIGITALIZATION-APPLICATIONS and RESILIENCE-MANAGEMENT, while the others are themes proper to the new technologies of the fifth industrial revolution and therefore are currently isolated.

Figure 5 shows the conceptual networks of the emerging or declining themes, they are: SUPPLY-CHAIN-MANAGEMENT and DECISION-MAKING-PROCESS. Both subjects are extensively developed in literature but they are also intensely linked to the nature of the fourth and fifth industrial revolutions, the most outstanding elements being

those related to KEY-ENABLING-TECHNOLOGIES, MANUFACTURING-INDUSTRIES, COST-EFFECTIVE-METHODS, VIRTUAL-AND-AUGMENTED-REALITY, WORKER-WELL-BEING and HUMAN-MACHINE-INTERACTION.

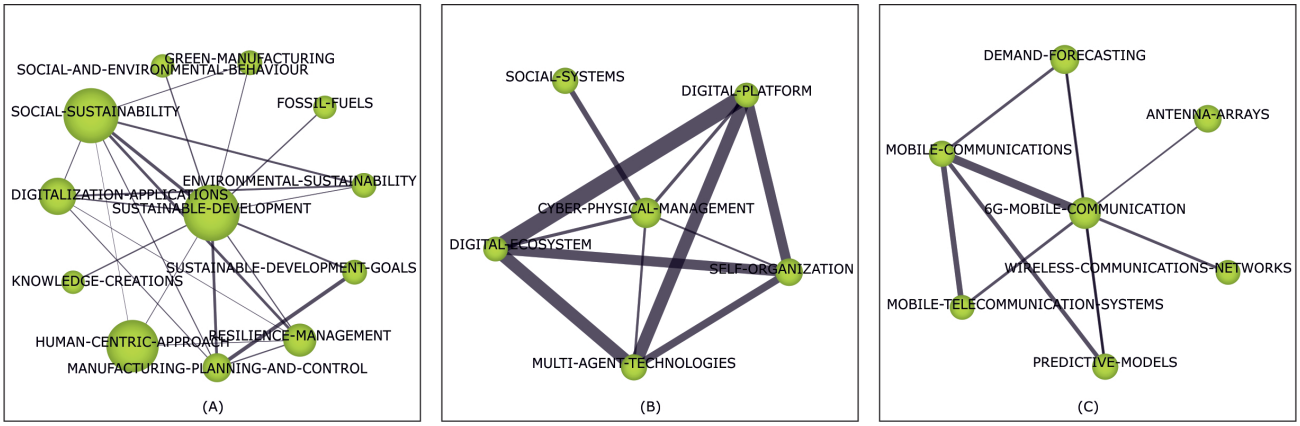


Figure 4 – Conceptual networks of the very developed and isolated themes (Quadrant 2): (A) SUSTAINABLE-DEVELOPMENT, (B) CYBER-PHYSICAL-MANAGEMENT and (C) 6G-MOBILE-COMMUNICATIONS.
Source: Own elaboration (2023).

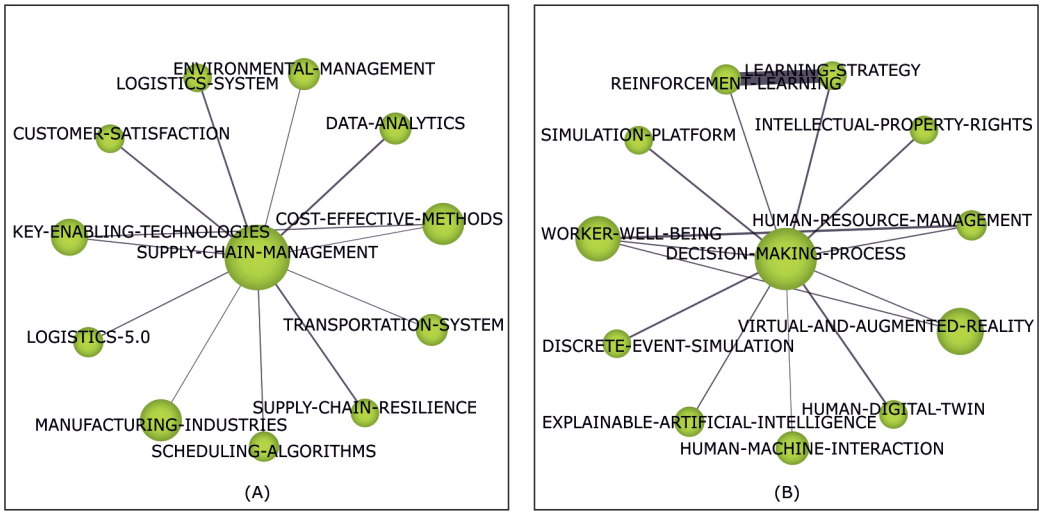


Figure 5 – Conceptual networks of the emerging or declining themes (Quadrant 3): (A) SUPPLY-CHAIN-MANAGEMENT and (B) DECISION-MAKING-PROCESS.
Source: Own elaboration (2023).

Synergically to the themes included in the first quadrant, INTERNET-OF-THINGS-TECHNOLOGIES, HUMAN-ROBOT-COLLABORATION and EMBEDDED-SYSTEMS can be identified as basic and transversal themes in the fourth quadrant, as can be seen in Figure 6. These quadrants stand out as they include themes and relations between some of them such as ARTIFICIAL-INTELLIGENCE-TECHNOLOGIES, INDUSTRIAL-INTERNET-OF-THINGS-TECHNOLOGIES, BIG-DATA-ANALYTICS, ROBOTIC-TECHNOLOGIES, HUMAN-ROBOT-INTERACTION, HUMAN-MACHINE-SYSTEMS, COLLABORATIVE-ROBOTS, CYBER-PHYSICAL-SYSTEMS, INDUSTRIAL-CYBER-PHYSICAL-SYSTEMS and WEARABLE-TECHNOLOGIES. They are all linked to the technological avant-garde and

disruption but are oriented towards persons and sustainability, pillars clearly defined within Industry 5.0 or fifth industrial revolution.

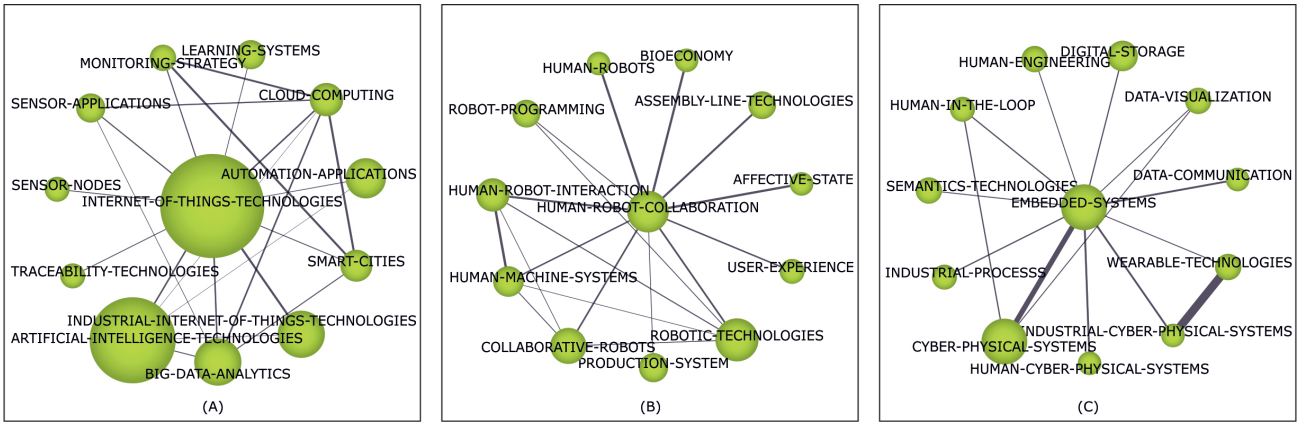


Figure 6 – Conceptual networks of the basic and cross-sectional subjects (Quadrant 4): (A) INTERNET-OF-THINGS-TECHNOLOGIES, (B) HUMAN-ROBOT-COLLABORATION and (C) EMBEDDED-SYSTEMS.
Source: Own elaboration (2023).

Finally, can be observed that the themes developed in literature and their structures are coherent with the recently in-progress approach to what regards the fifth industrial revolution or Industry 5.0, said approach being supported by disruptive technologies with clear applications to sustainability, resilience and focused on persons, according to their interaction.

Discussion and Conclusions

In light of the above, it could be possible to say that Industry 5.0 or fifth industrial revolution seeks to restructure the concept defined in Industry 4.0; it adds characteristics that are key to the organizations, after the pandemic, taking into account that the latter has resulted in a change in all paradigms defined in the world. Among the aspects Industry 5.0 seeks to restructure, can be highlighted the creation of customized or customizable products that can be adapted to the needs of both the user and the environment, taking into account the materials, production processes, technologies and the products themselves.

So as to make the above true, Industry 5.0 emphasizes the relation between persons and machines and the use of smart technologies and collaborative robotics. This will result in the mechanical, dangerous, routine tasks being passed on to the machines that will integrate capabilities around artificial intelligence. This way, the human being can have more time to bring these tasks to a satisfactory conclusion that only reason can carry out, creating balanced work environments.

Likewise, all the above will promote changes in the chains of value and the way they are revitalized. Industrial production chains will be much faster thanks to the collaboration between robots and humans. Besides, any product created in this environment will have more quality without sacrificing the human touch but, above all, mechanisms and systems connecting every link of the chain will be established, thus improving communication among them, strengthening the capacity of response to any possible contingencies.

In the same way, Industry 5.0 fosters the economic performance of industries, thus guaranteeing environmental sustainability above all. The data on power consumption of industries, which have notably increased due to the rise in the use of new technologies, require that increasingly more efficient and environment-friendly levels be shown, an aspect that is paid special attention.

In brief, we can say that the advances in Industry 5.0 will be constant and steady, in increasingly shorter periods of time, despite the fact that the organizations themselves will be the ones that will gradually adapt according to their needs and the requirements of their respective sectors, laying the foundation of the latest industrial revolution on sustainability, resilience and the persons.

In terms of bibliometric evolution, can be confirmed that all agents have taken an interest in developing Industry 5.0-related knowledge, as well as the relation of this concept to the smart and advanced technologies, the chains of value, the sustainability and competitiveness of organizations. Though the number of publications recorded in Scopus database is significantly striking, the citations achieved are an indicator better describing the interest above.

In the first instance, the themes included in the strategic map stand out: SECURITY-AND-PRIVACY, ENERGY-EFFICIENCY, EMBEDDED-SYSTEMS, HUMAN-ROBOT-COLLABORATION, INTERNET-OF-THINGS-TECHNOLOGIES, SUSTAINABLE-DEVELOPMENT, SUPPLY-CHAIN-MANAGEMENT, DECISION-MAKING-PROCESS, MACHINE-LEARNING-ALGORITHMS, 6G-MOBILE-COMMUNICATION and CYBER-PHYSICAL-MANAGEMENT. In turn, these themes represent areas of interest related to other fields, so the growth of Industry 5.0 can be expected to remain over time, in a direct way to the concept, as well as indirectly by these subjects.

The most relevant themes because of their contribution to the consolidation of Industry 5.0 are MACHINE-LEARNING-ALGORITHMS, ENERGY-EFFICIENCY, SECURITY-AND-PRIVACY, INTERNET-OF-THINGS-TECHNOLOGIES, HUMAN-ROBOT-COLLABORATION and EMBEDDED-SYSTEMS, which adequately align themselves with both the main components identified in this piece of research and the goals of this latest industrial revolution. It is important to stress that the evolution of these components likewise responds to changes of paradigms brought about by the pandemic, where the use of digital technologies and the evolution of systems have marked the beginning of the new organizational models.

Finally, the Fifth Industrial Revolution or Industry 5.0 is a growing research area, both individually and together with other themes such as sustainability, resilience and smart technologies. In this sense, the opportunities for growth and continuity will have to do with applications in specific sectors, successful cases and the acceptance of a concept initially born for Europe but likely to be transferred to other regions. The following are examples of these opportunities: adopting a human-centric approach for digital technologies including artificial intelligence; up-skilling and re-skilling workers, particularly digital skills; modern, resource-efficient and sustainable industries and transition to a circular economy; and a globally competitive, speeding up investment in research and innovation.

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