

SCHOOL OF ENGINEERING DEPARTMENT OF INFORMATION AND ELECTRONIC ENGINEERING

MASTER IN WEB INTELLIGENCE

BIBLIOMETRIC ANALYSIS AND SYSTEMATIC LITERATURE REVIEW OF INDUSTRY 5.0: A RESILIENT, SUSTAINABLE, AND HUMAN-CENTRIC APPROACH



MASTER THESIS

by

KONSTANTINOS MOURATIDIS

Thesis supervisor: Prof. Periklis Chatzimisios

Thessaloniki, September 2023

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Abstract

The current M.Sc. thesis determines research trends and scopes for Industry 5.0 through an exploratory analysis of the emerging literature upon Industry 5.0. As Industry 5.0 is a novel concept, this study first attempts to understand the landscape, scope and agenda of Industry 5.0 literature. Secondly, identifies the progress and development trends of Industry 5.0. Furthermore, it investigates if human-centricity, sustainability, and resiliency are stressed in Industry 5.0 literature or if it is only seen as an extension of the Industry 4.0 paradigm with no mention of societal objectives. Lastly, considering that Industry 5.0 is a concept that the European Commission introduced, determines if there is a larger emphasis on human-centricity, sustainability, and resilience in the EU region than there is in the rest of the world. The scientific databases Scopus and Web of Science were utilized together with and the bibliometric tools Bibliometrix/Biblioshiny, VOSviewer, and ATLAS.ti. The result of the performed study concluded that Industry 5.0 mainly emerged due to limitations in the implementation of Industry 4.0 that is technology oriented. Small and Medium Enterprises (SMEs), which are significant factors in the development of the global economy and the creation of jobs, could not participate in Industry 4.0 due to their well-known resource limitations in terms of personnel, technology, and budget. Major Political, Social and Environmental crises emphasized the importance of workers and generated attention for the environmental and social impact of Industry. Furthermore, young generation of workers, Millennials and Zoomers, are among the most passionate supporters of worker welfare and stress the importance of human aspects in the working environment of the coming years. The bibliometric analysis demonstrates the shift towards a societally focused industry, a more resilient and sustainable industry that is enhancing humanization and protecting the environment.

Keywords: Industry 5.0; Industry 4.0; bibliometrics; Scopus; Web of Science, Bibliometrix; Biblioshiny; VOSviewer; ATLAS.ti; trajectory; human-centricity, sustainability, resiliency

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Acronyms

5G/6G	5 th and 6 th Generation of Communication Technologies
AHCI	Arts and Humanities Citation Index
AI	Artificial Intelligence
AR	Augmented Reality
Cobots	Collaborative Robots
CPS	Cyber Physical System
EC	European Commission
EU	European Union
FA	Factorial Analysis
HMI	Human Machine Interaction/Interface
HRC	Human-Robot Collaboration
HRI	Human-Robot Interaction
I4.0	Industry 4.0
I5.0	Industry 5.0
ICT	Information and Communication Technology
IEEE	Institute of Electrical and Electronics Engineers
IIoT	Industrial Internet of Things
IoT	Internet of Things
ISI	Institute for Scientific Information
LC	Local Citations
MCA	Multiple Correspondence Analysis
MCP	Multiple Countries Publication
NCS	Normalized Citation Score
NLP	Natural Language Processing
NP	Number of Publications
OECD	Organization for Economic Co-operation and Development
PICOTS	Populations, Interventions, Comparators, Outcomes, Timing, and Setting
PRISMA	Preferred Reporting Items Around Systematic Reviews and Meta-Analyzes

PY	Publication Year Start
QDA	Qualitative Data Analysis
QoS	Quality of Service
RQ	Research Question
SDGs	Sustainable Development Goals
SCI	Science Citation Index
SCP	Single Country Publication
SLR	Systematic Literature Review
SMEs	Small and Medium-Sized Enterprises
SSCI	Social Sciences Citation Index
TC	Total Citations - Global Citations
UN	United Nations
VOS	Visualization of Similarities
VR	Virtual Reality
WoS	Web Of Science

1

Introduction

Over the past years, profound changes have occurred in production systems, largely driven by the wave of digitalization. This integration of Information and Communication Technologies (ICT) into all phases of production has brought about intricate challenges in technological, logistical, organizational, and environmental domains. The effective management of this transformative process is of paramount importance. The influence of novel technologies extends beyond operations to impact the workforce and daily life. Both employees and customers play pivotal roles in acclimating to emerging circumstances and embracing continuous learning. This era witnesses the prominence of decentralization within contemporary organizational structures, utilizing technology and data to expedite decisionmaking processes.

In Britannica dictionary, industry is defined as "a group of productive enterprises or organizations that produce or supply goods, services, or sources of income" [1]. The term Industry 5.0 (I5.0), also known as the Fifth Industrial Revolution, is a new industrial paradigm, which emphasizes the human factor, develops as a complementary paradigm to Industry 4.0. Actually, Industry 5.0 that advocates a holistic strategy that takes into account both the human factor and technological improvements for sustainable and effective manufacturing processes, marks a significant change in industrial practices.

Different authors have varied perspectives on the definition of Industry 5.0 and what it involves. While Industry 4.0 was still developing, the idea of Industry 5.0 was slowly formed, especially after the drawbacks of Industry 4.0 were pointed during COVID-19 pandemic.

1.1 Industry transformation

Industry 4.0 (Industrie 4.0 - 14.0), started in 2011 as a German government initiative. It promotes digital manufacturing by expanding digitization and the connectivity of products, value chains, and business models. It also makes an effort to advance research, networking among industry collaborators, and standards. The usage of digital technologies in the workplace results in numerous novel production techniques, business models, and products. Industry 4.0 mixes modern ICT with traditional industrial techniques [2].

Industry 4.0 marked a significant advancement in human-machine interaction; however, it necessitates a thoughtful consideration of the central role humans play. This paradigm hinges on the concept of smart factories, where intelligent products, machines, storage systems, and data converge within the realm of cyber-physical production systems [3].

Industry 4.0 does have some limitations, though. For example, it prioritizes encouraging industry innovation and productivity over sustainable development and employee welfare. As these limitations were pointed out, the concept of Industry 5.0 emerged.

Major Political, Social and Environmental crises have occurred in recent years, such as the COVID-19 pandemic, climate change, Brexit and the Russia Ukraine war, that had led to change the value focus from economic to societal value and the goal is to build a sustainable, inclusive economy that benefits everyone in society [4].

The COVID-19 pandemic emphasized the value of employees and caused the Industry 4.0 paradigm to be reexamined. Thus, Industry 4.0 had to be extended to include social and environmental aspects and as a result Industry 5.0 emerged. Industry 5.0 emphasizes workers' capacity to effectively collaborate with machines and robots by focusing on their skills, knowledge, and collaboration abilities. Additionally, it emphasizes production process flexibility and takes the environment's effects into account [3].

Industry 5.0 was based on ideas such as the Sustainable Development Goals (SDGs), established by the United Nations in 2015 as a historic global endeavor to address a wide range of social, economic, and environmental concerns confronting the world [5]. Additionally, the vision of Japan for society, the Society 5.0 in 2016, which is a focused-on humans' society that balances economic advancement with the eradication of societal issues [6]. Furthermore, the Economy of Well-being, by the Organization for Economic Cooperation and Development in 2019, that reflects a change in the economic paradigm toward a more thorough and human-centered approach to development, acknowledging that economic success does not ensure a good standard of living for everyone [7].

The above actually led EC in 2021 to define Industry 5.0, as an industry that builds on and complements Industry 4.0. It emphasizes elements that determine variables for the position of

industry in the future European society, not merely economic or technological ones. These elements also have aspects related to the environment and society [8].

According to the European Commission stated in 2021: "It moves focus from shareholder to stakeholder value, with benefits for all concerned. Industry 5.0 attempts to capture the value of new technologies, providing prosperity beyond jobs and growth, while respecting planetary boundaries, and placing the wellbeing of the industry worker at the center of the production process" [8].

Industry 5.0, also refers to the use of technologies like Artificial Intelligence (AI) and robotics to improve the overall customer experience. Eliminating the gap between humans and technology to enable seamless integration and interaction between the two, is one of the guiding principles of Industry 5.0 [9].

While Industry 4.0 is essentially about connecting devices together and is based on the concept of typical centrally managed manufacturing processes, Industry 5.0 is about collaboration between workers and machines on the factory floors having decentralized control of processes and giving a central role to skilled workers [10]. Industry 5.0 implies a creative human touch on the production instead of a standard robotic production. Workers' skill development is a priority of Industry 5.0. New skill sets and even professions are emerging. Skilled workers will assume better roles on the factory floor. Industry 5.0 is the return of the human touch on the factory floors [11] [12].

Thus, Industry 5.0 marks the transition from Industry 4.0's technology-centric philosophy to a more human-centric one. It acknowledges the value of resilience, sustainability, and the role of humans in the context of industry. Industry 5.0, as it began to be recognized, has broadened the scope of research beyond technology-driven developments to concentrate on supporting a smart and prosperous socio-economic transition that combines both humans and technology. The significance of how people influence technical advancement is emphasized [3].

While the existing literature extensively addresses resilience, sustainability, and humancentricity in isolation or pairs, Industry 5.0 introduces a distinctive framework that harmonizes these dimensions in a novel context.

This study examines Industry 5.0 concepts, approaches, and challenges using bibliometric analysis and Systematic Literature Review (SLR). Through an analysis of authorship, publication venues, research locations, and keywords, the study seeks to comprehend the widespread adoption and advancement of Industry 5.0 [13].



Figure 1 - The 3 pillars of Industry 5.0 according to the EC – human-centric, resilient and sustainable [14]

1.2 Scope of Thesis

This study seeks to explore the research trends and scopes for Industry 5.0 through an exploratory analysis of the emerging literature upon Industry 5.0. There are several reviews that performed systematic literature reviews on Industry 5.0 that formulated a basis to start this research. Among those the closest to this work are [15], [16] yet they were based on a small number of articles. Moreover, they were based only on Scopus articles and used only VOSviewer to comment their research. In [17], both Scopus and Web Of Science articles were used although not clearly stated if and how they used them altogether through Bibliometrix to output results. All these three works luck from volume of data that their based on, even [15] that is published in 2023 has articles published until July 2022.

As our review was under development, an article was published on 22 March 2023 [18], which had a similar scope with this work and follow a similar methodology and analysis stage. The difference is that their work is based only on Scopus articles for the period 2019-2022, although they use both VOSviewer and Bibliometrix/Biblioshiny, besides MS Excel software; our work also uses the aforementioned tools, but there are certain differences. The first difference is that the utilized keywords in [18] are not only oriented to Industry 5.0 as in

our work. The aim of our work is to gather as much as possible, but documents relevant to this research area and, therefore, any document in the collection of this study contains the term Industry 5.0. The reasoning for this, is that an article about Industry 5.0 certainly uses this term in order to get the attention. Other than that, this work analyses documents from both databases, Scopus and Web of Science, and through R-Studio merges the two datasets. Although the merged dataset has several drawbacks (that will be analyzed later), it provides certain useful information based upon a relatively big dataset.

Moreover, our work focuses on the Human-Centric, Sustainable and Resilient dimensions of Industry 5.0 based on the definition that European Commission gave for Industry 5.0 and extends [19] and examines (not only human-centricity) all 3 pillars. Furthermore, it is also inspired from [20] where the 3 dimensions of Industry 5.0 are explored from the perspectives only of operations and supply chain management. Our work provides a broader view. Additionally, our work uses ATLAS.ti as proposed for Industry 4.0 in [21] that gives extra features such as conceptualization and Natural Language Processing (NLP) features in this work.



Figure 2 - Scope of Thesis [22]

1.2.1 Contributions of the thesis

A total of four Research Questions (RQ) were formulated in the present study as follows:

- 1. What is the landscape, scope and agenda of Industry 5.0 literature?
- 2. What is the progress of Industry 5.0 and what are Industry 5.0's development trends?
- 3. Is human-centricity, sustainability and resiliency a priority in Industry 5.0 literature or is Industry 5.0 regarded just as an evolution of the Industry 4.0 paradigm with no societal goals promoted?
- 4. Is there a greater emphasis on human-centricity, sustainability, and resilience of Industry 5.0 in the EU region compared to the rest of the world, given that Industry 5.0 is a concept that the European Commission introduced?

1.3 Structure of the Thesis

The current Thesis is comprised of seven chapters, with the first chapter serving as an introduction to the main aspects of the research presented throughout the Thesis. This introductory chapter helps readers to better understand the subject matter of the Thesis. The remaining chapters are structured in the following manner:

Chapter 2 presents the Methodology of the bibliometric analysis carried out.

Chapter 3 presents an overview of Industry 5.0's literature.

Chapter 4 explores literature findings on Industry 5.0. Furthermore, its distinguishing features in relation to past industrial revolutions by drawing on sources from the literature.

The direction of the literature related to Industry 5.0 is examined in Chapter 5. Moreover, the Thesis studies if the literature is human-centered and not just a technological evolution of Industry 4.0.

In Chapter 6 the interest in the EU region compared to the rest of the world is studied.

Finally, Chapter 7 concludes the Thesis by summarizing the main points. Extended research related bibliography is included in the current Thesis.

2

Methodology

Bibliometrics is a method based on quantitative analysis of scientific literature [23]. Scientific research is increasingly being visualized using cutting-edge scientometric methods called "science mapping". Making maps based on thorough research on a subject gives one a comprehensive view of the subject that enables one to connect various fields of knowledge. Science maps can help scholars from a variety of fields cross disciplinary barriers and collaborate to increase knowledge while creating value [24].

The enormous multidisciplinary database Scopus contains references and abstracts from peerreviewed journal articles, business publications, books, patent records, and conference proceedings. It offers resources for monitoring, evaluating, and displaying search results. Launched in November 2004, Scopus. The most thorough summary of scientific findings in the humanities, social sciences, science and technology is provided by Scopus.

It is common practice to employ bibliometric techniques to track the evolution of management notions and theories [16]. On the other hand, in order to address an issue or collection of questions, systematic reviews use scientific procedures that specifically try to reduce unintentional mistakes or bias by locating, evaluating, and combining all pertinent research.

Using cutting-edge scientific mapping software, which makes use of co-citation analysis to visualize the relationships amongst scientometric indicators, the mapping and cutting-edge reviews are carried out. Information such as the author, the document, the organization, the keywords, the sources, and the countries of publication might all be identified by combining sophisticated thematic analysis techniques were possible by the extraction of frequently occurring noun phrases. This technique clusters all of the collected data's content literature on Industry 5.0 [24].

For evaluating intellectual output in certain fields, bibliometric techniques have grown in popularity as a research methodology in business and management studies. Bibliometric techniques offer insights on the trajectories and development of management theories and concepts by using statistical analysis of scholarly publications. By counting and classifying publications on a particular topic, researchers frequently use bibliometric studies to chart the evolution of interest in management concepts [25].

Despite some detractors' claims to the contrary, bibliometric methods, through statistical analysis of scientific literature, do offer useful information regarding the macro-level evolution of these concepts. They do not, however, provide profound insights into the practical application of management principles in organizations. In the context of the current study, which seeks to gain an extensive understanding about the conception as well as the rise of the Industry 5.0 paradigm as a field of study using bibliometric methods rather than examining its adoption in specific organizations or even industries, is thought as a reasonable approach [26].

The Scientific bibliography databases used were the Scopus (www.scopus.com, last accessed 1st of July 2023) and the Web of Science (WoS - www.webofscience.com, last accessed 1st of July 2023), in order to gather the bibliometric data for the current study. Both databases offer benefits and drawbacks. Scopus has a number of benefits, including greater source coverage than Web of Science. On the other hand, Web of Science contains two fields - Keywords Plus and Subject Category - that can aid in the development of this study. An issue that in other cases may exist is the older coverage, however, since Industry 5.0 only recently began, it should be highlighted that current analysis does not need to take this into account. Furthermore, since early articles about a new concept often appear outside of a discipline's primary or leading publications, wide coverage is essential in the context of Industry 5.0. According to [27], "broader coverage is useful for mapping smaller research areas" [16]. Despite heterogeneity difficulties between these two databases - which are later explained - data from each of Scopus and the Web of Science databases were gathered with a merging procedure in order to provide the study a broader scope.

The 397 documents that were identified as duplicates, they have been removed from the merged dataset. The analysis was performed on the merged database, but whenever the data were inadequate the analysis was performed separately for each database.

The bibliometric study identifies Industry 5.0's inception and development as a research area. The search keyword has a major effect on the research's findings. The reason for this is that, as stated in [28], some important questions that define the review's parameters and provide details regarding the Populations, Interventions, Comparators, Outcomes, Timing, and Setting

(known as PICOTS), as well as sporadically the study designs or other interesting examine features, are prone to bias and inconsistencies.

That is why the analysis conducted for the present research focuses on how the term "Industry 5.0" is used, using double quotations in order to get an accurate match when using phrase search, in titles, abstracts and keywords. Furthermore, it covers publications published from 2018 to June 2023. In order to avoid missing any possibly relevant works, we chose to look for anything having "Industry 5.0" within their title/abstract/keywords fields. It is crucial to take this into account since Industry 5.0 is an emerging concept so there is not much literature on it.

Although past Industry 4.0 reviews, enhanced the variety of keyword searches they used, by having related to Industry 4.0 terms, like "smart manufacturing" or "smart factories", it could have led to a significant number of articles that did not specifically address Industry 5.0. It is also unknown what other words or synonyms have been used, because Industry 5.0 is yet a new and developing concept [16]. Therefore, in regard to this, it was assumed that it is probably used in every document that refers to it, excluding for instance in the search string an abbreviation such as "I5.0" or a similar concept "Society 5.0" (with the Boolean operator OR). Although Society 5.0 has similar objectives with Industry 5.0, it has dissimilarities that distinguish it from Industry 5.0. As pointed by [30], for the forthcoming industrial and societal landscape, these coexisting conceptions (Industry 5.0 and Society 5.0) can be seen as two parallel ideas. This can also be seen illustrated in Figure 1, the fundamental shares and the differences between them. Instead of focusing on production, the goal of Society 5.0 is to cope with societal issues [31]. Moreover, Industry 5.0 can be seen as a subset of Society 5.0



Figure 3 - Pillars of Industry 5.0 and Society 5.0 [29]

The Systematic Literature Review (SLR) approach adopted for the current study serves to provide a thorough and intelligible summary of the analysis of literature, as opposed to a descriptive literature review. According to [10], finding fresh research opportunities in a subject of study can be done effectively using systematic literature, by evaluating and synthesizing previously published papers. The SLR performed for this study intends to collect, verify, evaluate, and describe scientific evidence on the principles, frameworks, difficulties, and constraints of Industry 5.0. A five-step process is used as suggested in [18], [32], [33], [34]. The five stages of the suggested science mapping workflow are outlined as follows:

- (1) developing the research questions,
- (2) finding relevant studies,
- (3) choosing and assessing the research findings,
- (4) investigating and combining findings, and
- (5) summarizing and applying what was found.

The systematic review methodology provides a comprehensive overview and framework for future investigations [19].



Figure 4 - SLR Five-step process

By utilizing the meta-analysis, which occurs after the qualitative assessment of the chosen articles, qualitative as well as quantitative methods can be advantageous for an SLR and neutralize the effects of selection bias with regard to a traditional (narrative) literature review [35]. Thus, after collecting the articles from the databases and in order to avoid a risk of bias, before using the studies in the review, a four-phase flow diagram and the PRISMA (preferred reporting items around systematic reviews and meta-analyzes) framework's principles were applied. Through PRISMA established guidelines for inclusion and exclusion is utilized and the worth of chosen publications is rigorously evaluated before they are either included or excluded [36].



Figure 5 - The PRISMA Flow Diagram – Presenting findings derived from the systematic research.

Evaluation regarding the authors, the publication venues, the research locations, the publication year and the keywords are all included in the descriptive analysis of the gathered papers. This analysis explains how Industry 5.0 has become more widely accepted and how its trends have evolved over time. To get insights into the topic's evolution and trends, areas like journals, authorship distribution across time, geography, and keyword analysis are investigated [37].

(1) Formation of the Research questions (RQs)

- •What is the landscape, scope and agenda of Industry 5.0 literature?
- What is the progress of Industry 5.0 and what are Industry 5.0's development trends?
 Is human-centricity, sustainability and resiliency a priority in Industry 5.0 literature or is Industry 5.0 regarded just as an evolution of the Industry 4.0 paradigm with no societal goals promoted?
- •Is there a greater emphasis on human-centricity, sustainability, and resilience of Industry 5.0 in the EU region compared to the rest of the world, given that Industry 5.0 is a concept that the European Commission introduced?

(2) Finding the studies using the Scopus and Wos Databases

•The TITLE-ABS-KEY keyword that was applied was "Industry 5.0" but also searches made through Boolean operators for specific keyword searches to answer RQs as: ("Industry 5.0" and "Human*"), ("Industry 5.0" and "Sustain*"), ("Industry 5.0" and "Resilien*"), ("Industry 5.0" and "Resilien*"), ("Industry 5.0" and "Resilien*"), ("Industry 5.0" and not ("Human*" or "Sustain*" or "Resilien*")), ("Industry 5.0" and not ("Human*" or "Sustain*")), ("Industry 5.0" and not ("Human*")).

(3) Study preference and evaluation

- •To select only appropriate studies to include in the review studies that truly address the study questions filtering criteria were provided using the PRISMA framework in this stage.
- •To avoid Publication bias after a review, documents prior to 2018 were excluded as they were irrelevant. In addition, letters and conference reviews (no abstract present) were excluded from the Scopus database and for the WoS database, after reviewing the sources the Editorial documents (no abstract present) and one letter were also excluded.
- •Seeking to expand the research's focus and not exclude potentially essential data, the exclusion criteria were minimized. After reviewing the retrieved Scopus documents, the books and editorial documents were included, to get a broader view of the field studied. Thus, in order to avoid missing any minor collection of publications that are possibly less mentioned but yet significant, as many documents as possible were kept.
- •Moreover, no language restrictions were applied as the TITLE-ABS-KEY fields are in English.

(4) Investigation and combination

•Each paper's content was examined to determine the major concerns and then data synthesis was applied through the use of bibliometric software tools (VOSViewer, Biblometrix/Biblioshiny and ATLAS.ti) and Excel.

(5) Reporting and using the results

•This step involves the Interpretation of the findings. Therefore, the data in the papers was condensed, then the results were produced with related categories, such as study methodology and other main discoveries.

Figure 6 - Constructing the SLR

A thorough knowledge of Industry 5.0 as a human-center paradigm is provided utilizing bibliometric analysis in conjunction with rigorous literature study. The study examines the concepts and techniques of Industry 5.0, as well as the difficulties that come with putting them into practice. The results add to our understanding of Industry 5.0 and offer a framework for further study and investigation in this field of study.

2.1 Utilized software tools

The extra benefit of using software tools to conduct a SLR using quantitative analysis of a considerably larger body of literature than is often included in traditional systematic reviews, allows researchers draw conclusions while offering policy and procedure suggestions [38].

Data and graphical information, in this study, were obtained from the Scopus and the WoS databases, but to further analyze the bibliometric data the software tools that were used are: Microsoft Excel, for tables and graphs, Microsoft Word, for Shapes and SmartArt, R studio, for the merging process and to run Biblimetrix/Biblioshiny and three bibliometric software tools, Bibliometrix/Biblioshiny, VOSviewer and ATLAS.ti.

Regarding the bibliometric software tools, we have used the following ones:

1) For in-depth science mapping study, the open-source R-package bibliometrix is useful. Bibliometrix, designed and developed by Massimo Aria and Corrado Cuccurullo, comprises an entire package for Science Mapping Workflow, i.e., provides the resources needed for carrying out a comprehensive bibliometric analysis while adhering to the Science Mapping Workflow. There is a wide range of tools available, through the R-package bibliometric analysis. It is written in the open-source, ecosystem-rich R language. The availability of reliable, effective statistical algorithms, the availability of exceptional numerical routines, along with integrated data visualization capabilities are perhaps the major factors that make R superior over other programming languages for scientific computation. A web-interface for bibliometrix is provided by the Shiny application biblioshiny, that provides an interactive web-based environment from which it is easy to use the bibliometrix functions.

Data collected by the six major bibliographic databases can be used by Bibliometrix: Scopus (in 'BibTeX' and 'CSV export' format), Web of Science (in BibTeX', 'plaintext' and 'EndNote Desktop' format), Dimensions (in 'Bibliometric mapping' and 'Excel' format), The Lens (in 'CSV export file' format) PubMed (in 'PubMed export file' format) and Cochrane Library (in 'plaintext' format).



Figure 7 - Implementing the recommended science mapping workflow through Bibliometrix [34]

For Data Acquisition the Web of Science (WoS) or the Scopus databases can be queried to retrieve bibliographic information using a variety of search criteria, including topic, author, journal, time period, and more.

Figure 7, shows how the Bibliometrix workflow supports the second through the fourth of the 5 steps of the suggested scientific mapping workflow.

The discovery of pertinent studies is the second step and Bibliometrix supports the following sub-stage for the data gathering stage:

• Data import and R data frame conversion.

For the third step, that is the choosing and assessing of the research findings, the Data Analysis in short, it is broken down into three sub-stages:

- Examining a Bibliographic Data Frame Descriptively;
- Network synthesis of Bibliographic Coupling, Co-Citation, Collaboration, and Co-Occurrence analysis; and
- Normalization.

For the fourth step, that is investigating and combining findings, the Data visualization stage in short:

- Conceptual structure mapping;
- Network mapping [39].
- 2) Another software application for creating and visualizing bibliometric networks is VOSviewer. It was released in 2010 by Nees Jan van Eck and Ludo Waltman from the Leiden University in the Netherlands. Such networks may include journals, researchers, or papers and can be created by citation, bibliographic coupling, cocitation, or co-authorship links. Data can be used from Web of Science, Scopus, Dimensions, Lens, and PubMed, but also from Crossref, Europe PMC, and OpenAlex and moreover from Semantic Scholar, OpenCitations, and WikiData. VOSviewer also
has text mining capabilities that enable the creation and visualization of cooccurrence networks of relevant phrases extracted from a body of academic literature. The visual depiction of bibliometric maps is a focus of VOSviewer. When presenting extensive bibliometric maps, VOSviewer's features make it easy to comprehend.

The tool is accessible to bibliometric researchers for free at www.VOSviewer.com. In particular, maps of authors, journals, or keywords can be created with VOSviewer using input from co-citations and co-occurrences. A viewer provided by the application enables in-depth examination of bibliometric maps. Using VOSviewer, a map can be displayed in several of methods, all stressing a different aspect of the map. It contains functions for scrolling and zooming, but also provides searching features, that make it simpler to view a map in depth. For maps with at least a reasonably significant number of items (such at least 100 items), VOSviewer's viewing features are extremely helpful. The majority of bibliometric mapping software does not display such maps in an acceptable manner.

VOSviewer use the Visualization Of Similarity (VOS) mapping technique introduced in [40], to create maps. It may display maps which were created via any suitable mapping method. As such, in addition to the VOS mapping approach, the program can also be used to display maps made using other methodologies, such as multidimensional scaling. VOSviewer supports a variety of hardware and operating system platforms and may even be started web (@ via the https://app.VOSviewer.com/).

Using any appropriate mapping approach, VOSviewer may display maps that have been created. As a result, the program can be used to display maps created using other approaches as well, including multidimensional scaling, in addition to the VOS mapping methodology. VOSviewer may be launched immediately from the internet and is compatible with a wide range of hardware and operating system platforms [41].

3) ATLAS.ti, is Qualitative Data Analysis (QDA) software tool with a full range of innovative features and tools helping to organize data and discover valuable insights. It can be used as a literature review tool to empower researchers to perform powerful and collaborative analysis and to help them make sense of the most important insights in their research field.

Data analysis was promoted by the usage of coding software in a cyclical and iterative manner that would not have been possible with note cards, word processing, or spreadsheet programs. Instead of encouraging a linear progression of activities, ATLAS' design and functionality, as proposed in [42], encourages a flowing and developing method for qualitative research. The coding method used by ATLAS.ti is

inductive rather than hierarchical. The software follows the suggestions of [42] and allows for the expression of techniques to design relationships between codes, concepts, and themes that are frequently unable to be described in a hierarchical list. ATLAS.ti leverages spaCy, a free open-source Python library written in Cython, as its natural language processing engine for Sentiment Analysis with AI [43].

2.2 Data collection process

Three separate stages make up the data collection process. Data retrieval comes first. Many online bibliographic databases are potential resources for bibliographical data, such as Clarivate Analytics Web of Science (WoS formerly known as Web of Knowledge @ www.webofscience.com), owned by Clarivate Analytics, which was established by Eugene Garfield, one of the bibliometrics founders, and Elsevier's Scopus a database of abstracts and citations, released in 2004 (@ www.scopus.com), which will be both used in this study. These databases store metadata about scientific works. There are certain consistency difficulties to take into account later in the subsequent stage, which is loading of data and conversion to suitable for the bibliometric tools format, because they do not provide the same coverage of scientific subjects and journals in the same way.

WoS and Scopus, are the most well-known academic literature databases, that are frequently used for literature searches, on various scientific subjects [44]. For many years, WoS was the only publication and citation database that included all study fields. Nevertheless, Scopus was launched in 2004 by Elsevier Science, and has already made a name for itself as a good competitor [45]. The introduction of Scopus presented a challenge to WoS, and resulting competition has improved the services they both provide [46].

New techniques for indexing and sharing the world's scientific and academic research material were invented by Eugene Garfield and by the Institute for Scientific Information (ISI) that Garfield was its founder. The idea of citation indexing for the sciences was initially proposed by Garfield in 1955, and the first Science Citation Index (SCI) was created by ISI in 1964. Information retrieval has been transformed via citation indexing. The SCI served as an index of associations of ideas, by indexing and linking together the references that authors mentioned in their publications.

In 1973, the Social Sciences Citation Index (SSCI) and in 1978, the Arts and Humanities Citation Index (AHCI), respectively were found. Several items, including Index Chemicus, the ISI's debut release in 1960, were devoted to the chemical sciences. The Journal Citation Reports, which were first published in 1976, compiled journal-to-journal citations to assist publishers and libraries in understanding the communication structure of the literature in the

social sciences and sciences, as well as the standing and influence of certain works. The Journal Impact Factor was most well-liked among the product's other indicators.

Quantitative studies in science's sociology and history were also built on SCI data, which eventually gave rise to the area of scientometrics. In 1997, The Web of Science makes its online debut.

While the Thomson Corporation obtained ISI in 1992, Thomson and Reuters joined to establish Thomson Reuters in 2008. In 2016, Clarivate purchased Thomson Reuters' scientific and academic information division [47].

Scopus is a large multidisciplinary database, which is regularly updated and enlarged. It contains references and abstracts from peer-reviewed journal articles, business publications, books, patent records, and conference proceedings. It offers resources for monitoring, evaluating, and displaying search results. It is regarded as having the largest citation and abstract database. [48]. The Scopus Cited References Expansion project, launched in March 2014, added content from before 1996 (extending back to even 1823). The results of the expansion have impact on the metrics of the documents published as the total citation count increases and the widely used metric h-index is impacted [49]. Scopus database, provides the most thorough summary of the world's studies in the humanities, social sciences, technology, and science [46] [50] [51].

The assumption made for the current study is that merging these data sources may improve the quality of the bibliometric study as it can produce outcomes that are broader in terms of the literature fields [52].

The documents collected should have had Industry 5.0 in the central theme or Industry 5.0 was one of the several topics addressed within the articles. Thus, to collect related to Industry 5.0 documents, initially the keyword used for searching the database was "Industry 5.0" for TITLE, ABS and KEY fields. That made a search of academic papers having the term "Industry 5.0" either within the title, abstract, or keywords by the author fields and no any constriction.

The search in Scopus returned 776 documents.

To avoid Publication bias after reviewing the Scopus dataset 3 papers from 2005, 2010 and 2016 were excluded as they were irrelevant. In addition, the 2 letters and the 14 conference reviews retrieved founded with little significance, thus were excluded. In order to avoid missing any minor collection of publications that are possibly less mentioned but yet significant, as many documents as possible were kept. Therefore, after examination, the books and editorials documents were included, to get a broader view of the field studied.



Figure 8 - Search String used for WoS

Thus, the keyword search term posed was:

TITLE-ABS-KEY ("Industry 5.0") AND (EXCLUDE (PUBYEAR, 2010)) AND (EXCLUDE (PUBYEAR, 2005)) AND (EXCLUDE (PUBYEAR, 2016)) AND (EXCLUDE (DOCTYPE, "cr")) AND (EXCLUDE (DOCTYPE, "le"))

Giving 757 document results, which were exported in a csv format file to be used for bibliometric analysis.

For the WoS dataset the search string and the exclusion criteria was made similarly (Figure 3).

And after reviewing the retrieved documents, 2 documents were excluded from 2005 and 2016, one letter and 10 Editorial Material (of minor significance) yielding in a dataset of 457 documents, which were exported in a text format file for bibliometric analysis.

The two datasets exported from Scopus and WoS bibliographic Databases hereafter in this review will be named as the Scopus dataset and the WoS dataset respectively.

The integrity of the Scopus data when inserted in the Bibliometrix/Biblioshiny tool, is shown in the below table (Table 1).

Metadata	Description	Missing Counts	Missing %	Status
AB	Abstract	0	0,00	Excellent
AU	Author	0	0,00	Excellent
DT	Document Type	0	0,00	Excellent
SO	Journal	0	0,00	Excellent
LA	Language	0	0,00	Excellent
PY	Publication Year	0	0,00	Excellent
TI	Title	0	0,00	Excellent
TC	Total Citation	0	0,00	Excellent
C1	Affiliation	1	0,13	Good
CR	Cited References	23	3,04	Good
DI	DOI	39	5,15	Good
DE	Keywords	72	9,51	Good
	Corresponding			
RP	Author	154	20,34	Poor
ID	Keywords Plus	272	35,93	Poor
WC	Science Categories	757	100,00	Completely missing

Table 1 - Completeness of Scopus's bibliographic metadata

Metadata	Description	Missing Counts	Missing %	Status
C1	Affiliation	0	0,00	Excellent
AU	Author	0	0,00	Excellent
DT	Document Type	0	0,00	Excellent
SO	Journal	0	0,00	Excellent
LA	Language	0	0,00	Excellent
PY	Publication Year	0	0,00	Excellent
WC	Science Categories	0	0,00	Excellent
ТІ	Title	0	0,00	Excellent
ТС	Total Citation	0	0,00	Excellent
CR	Cited References	1	0,22	Good
DD	Corresponding	1	0.22	Cood
KP	Author	1	0,22	Good
AB	Abstract	3	0,66	Good
DI	DOI	18	3,94	Good
DE	Keywords	23	5,03	Good
ID	Keywords Plus	123	26,91	Poor

Table 2 - Completeness of WoS's bibliographic metadata

Respectively for the WoS data the integrity of the data when inserted in the Bibliometrix/Biblioschiny tool is shown in the above table (Table 2). The integrity of the data in WoS is better than Scopus data.

The overview of the bibliometric analyses via Bibliometrix/Biblioshiny for the Scopus and WoS datasets respectively are shown in Figure 9 and in Figure 10.



Figure 9 - Overview of Scopus dataset by Bibliometrix/Biblioshiny



Figure 10 - Overview of WoS dataset by Bibliometrix/Biblioshiny

Following the initial examination of the datasets, the merging of the two datasets through the Bibliometrix library in R-Studio was attempted. The procedure of the merging through R-Studio was:

- 1) Loading Bibliometrix/Biblioshiny
 - > *library(bibliometrix)*
- 2) Scopus dataset to a bibliographic dataframe conversion
 - > S = convert2df("R/biblioanalysis/scopus.bib", dbsource = "scopus", format = "bibtex")
- 3) WoS dataset to a bibliographic dataframe conversion (the conversion from the text format dataset worked better than the BibTeX format for WoS)
 - > W = convert2df("R/biblioanalysis/ Wos1stJuly.txt", dbsource = "wos", format = "plaintext")
- 4) Merging the two dataframes
 - > Merged_df = mergeDbSources(S, W, remove.duplicated = TRUE)

Yielding in 388 duplicated documents removed

- 5) Export the merged dataframe
 - > library(openxlsx)
 - > write.xlsx(*Merged_df*, file = "R/biblioanalysis/Database.xlsx") [53]

Thus, the merging was done but had some issues that will be discussed later on. The Venn diagram in Figure 11, presents the number of documents contained in each collection.



Figure 11 - The 3 datasets: Scopus, WoS and the merged

Metadata	Description	Missing Counts	Missing %	Status
AU	Author	0	0,00	Excellent
DT	Document Type	0	0,00	Excellent
SO	Journal	0	0,00	Excellent
LA	Language	0	0,00	Excellent
PY	Publication Year	0	0,00	Excellent
ті	Title	0	0,00	Excellent
тс	Total Citation	0	0,00	Excellent
C1	Affiliation	5	0,59	Good
AB	Abstract	14	1,65	Good
CR	Cited References	26	3,06	Good
DI	DOI	45	5,30	Good
DE	Keywords	91	10,72	Acceptable
	Corresponding			
RP	Author	158	18,61	Acceptable
ID	Keywords Plus	314	36,98	Poor

Table 3 - Completeness of the merged dataset Bibliographic metadata





Some of the issues derived from the merging process will be described. WoS has a field named Science Categories, not found in the Scopus database, that in the merging procedure was neglected and thus it is empty.

Also, there are two types of keywords as viewed within Bibliometrix/Biblioshiny. The Author's keywords named as Keywords, that are chosen by the author to best reflect the content of the document and the Keywords Plus, as referenced in Bibliometrix/Biblioshiny that is different in the two databases. The Scopus keyword field that fills the Keywords Plus field in Bibliometrix/Biblioshiny are the indexed keywords by Scopus. The Indexed keywords are chosen by Scopus, a team of professional indexers assigns them, and are standardized to thesauri-derived vocabulary that Elsevier owns. For instance, the Ei Thesaurus is used in engineering, technology and physical sciences. The Indexed keywords, as opposed to Author keywords, takes into consideration synonyms, alternative spellings, and plurals. The Index keyword field for some recently added articles, as it is not done automatically, may take a period to appear. Thus, there are documents that this field is empty in our selected dataset from Scopus and consequently in the merged dataset.

The WoS discovered KeyWords Plus field in WoS contains the data for Keyword Plus in Bibliometrix/Biblioshiny. These are phrases or terms that are frequently used in references yet not in the title of an article. By searching across disciplines for all the publications that have cited references in common, KeyWords Plus expands the functionality of cited-reference searching. The foundation of KeyWords Plus is a proprietary algorithm unique to Clarivate datasets. KeyWords Plus are extracted from cited titles and cannot be altered. KeyWords Plus are phrases that are formed from the names of publications mentioned by the author of the piece being indexed, therefore papers without references or papers whose references are not linked to source items will not have them. KeyWords Plus can additionally be included in publications that don't have any author keywords or with publications that merely contain significant terms not included in the author keywords [54] [55].

When comparing WoS Keywords Plus terms and the Author's Keywords terms, Garfield, that as previously noted, introduced the concept of citation indexing for the sciences in 1955, suggested that Keywords Plus terms can more effectively and diversely capture an article's substance [56]. In terms of bibliometric analysis, which looks at the knowledge structure of scientific subjects, the Keywords Plus field is just as useful as the Author Keywords field, although it is less thorough in describing the content of an article [57].

All types of keywords mentioned above, was used in this research, but the keyword plus field in the merged dataset, although filled in during the merging procedure, cannot be used due to its data inconsistency, as it is derived from either index keywords in Scopus or the keyword plus in WoS and these two fields are different. Therefore, the keyword plus field is only used separately either on Scopus or WoS datasets.

Moreover, from the merging process, besides the keyword plus and the subject category fields issues mentioned already, there are also other issues to report. The Corresponding Author field has incomplete data which is an issue that the merging report did not initially indicate. But, while reviewing the overview of the merged dataset and trying to produce graphs by the Bibliometrix/Biblioshiny tool, it came out that the International Co-Authorship percentage is false and thus the Corresponding Author's plot cannot be derived from the merged dataset.

Furthermore, another issue is due to the variation in citation counts between each of these databases. That happens because each database stores independently the citation information and any information regarding Total Citations and metrics derived from it cannot be used when merging records from them. Finally, minor metadata used in the analysis was missing by the merging process not affecting though the analysis procedure.

Some general information derived from the data, either, when possible, from the merged dataset or from the Scopus or the Wos datasets. Besides the heterogeneity issues mentioned for the two databases the merged dataset can be used only from the Biblimetrix/Biblioshiny tool as the format of the data is not recognized both from the VOSviewer and ATLAS.ti tools. Thus, it cannot be used by the VOSviewer tool, so the two datasets have to be analyzed separately by the VOSviewer tool. For the ATLAS.ti tool, the merging of the datasets is done differently, and the merged dataset, after being transformed to pdf format, was used to produce Word Clouds and Concept Clouds. In order to use ATLAS.ti for Opinion Mining, a Sentiment mining method, after importing separately, the Scopus and WoS datasets in BibTeX format, the duplicate records were deleted manually. Hereafter, if not mentioned, the data used in a Bibliometrix/Biblioshiny graph are from the merged dataset, otherwise it is noted from which dataset the information (either some kind of graph or table) is derived.

3

Overview of Industry 5.0's literature

The First Industrial Revolution, which emerged in the 18th century, driven from the development of mechanical power, included textiles, steam power, iron, cement, chemicals, gas, lighting, transportation and other things, and it promoted growth in industries like agriculture, transportation, and employment; however, it also brought about problems like pollution and slow implementation, while using mathematical tools like linear programming.

The Second Industrial Revolution, which emerged in the 19th century, electrical energy prevails, a focus was placed also on steel, machine tools, petroleum, chemical, trains, cars, engines, turbines, telecommunications and contemporary business management, which helped to advance telephone systems, electrical grids, and internal combustion engines, but was hampered by high power prices and a reliance on differential equations.



Figure 13 - The five industrial revolutions - The advances in technology that drove them were agents of changes and emerged as revolutions in business, economy and manufacturing [58]

The Third Industrial Revolution, which emerged in the 20th century, was using electronics and information technologies. Industry 3.0 was centered on semiconductors, digital circuits, programmable integrated circuits, automation, and renewable energy, ushering in the telecommunication, robots and automated industries but encountering complexity issues in the implementation of its Flexible Manufacturing Systems, utilizing differential equations and logical controllers.

Industry 4.0, which emerged in the 21st century, uses technologies such as IoT and Cloud Computing. The fourth Industrial Revolution involves intelligent systems across industries, introduces full automation, AI and machine learning, but there are also problems introduced such as cloud data security concerns. Industry 4.0 employs network theory and optimization approaches as mathematical tools [26] [10].

The European Commission (EC) outlined its vision of Industry 5.0 in 2021, which aims to promote inclusive workplaces, strong supply networks that are resilient to disruptions, and the use of sustainable production techniques. Industry 5.0 provides a unique paradigm that harmonizes resilience, sustainability, and human-centricity in a novel context, whereas the existing literature extensively discusses these topics in isolation or pairs [20].

In order to answer the first RQ to get an overview of Industry 5.0 and understand the spread of the topic and its acceptance globally, the following features through the analysis will be obtained:

- 1. Research volume and growth trend for Industry 5.0
- 2. Types of publications
- 3. Languages of publications
- 4. Distribution across different Subject Areas
- 5. Top cited Publications
- 6. Most relevant and most influential Authors
- 7. Most relevant and most influential Affiliations
- 8. Most relevant ana most influential Sources
- 9. Major Sponsors
- 10. Most relevant and most influential Countries

3.1 Annual Scientific Production

The first feature to observe is the annual number of Industry 5.0 documents published in either of the two bibliographic databases until 1st of July 2023. More documents are published every year and in 2023 it seems that the number of documents will continue to rise.



Figure 14 - Industry 5.0's Annual Scientific Production

3.2 Types of Publications

As already noted, the search in Scopus returned 776 documents. Before applying any filter, the document types are presented below.



Figure 15 - 15.0's Types of Publications in Scopus



Figure 16 - 15.0's Types of Publications in WoS

Similarly, the search in WoS returned 470 documents, of which their document types can be seen in Figure 16.

3.3 Languages of Publications

Industry 5.0 has an international interest from all over the world, therefore English, as expected, is the dominant language in both databases, Scopus and WoS, as only 11 out of 776 and 1 out of 470 respectively, were non-English documents. Moreover, it is found that the documents referring to this research field in a language other than English are very few. Although there could be excluded, however, after reviewing them, it was found that those documents not in English but written in another language, have the Title/Abstract/Keywords fields written in English, thus these documents can be used for the current research and were included in the datasets used.



Figure 17 - Languages of Industry 5.0 documents in Scopus



Figure 18 - Languages of Industry 5.0 documents in WoS

3.4 Area of Knowledge

As Scopus dataset does not contain the field provided by WoS named "Subject Category", the Subject Areas information has to be retrieved separately from the two datasets. From the Scopus dataset, it can be obtained by the number of documents categorized by the subject area that they are published. The heterogeneity of the classification by the two scientific databases results in non-unified results.

A wide distribution can be seen from the below pie chart, across different areas. Half of the documents (one quarter each) belong to Engineering and Computer Science, and the other half, belongs to many different subject areas.



Figure 19 - 15.0's Scopus Documents by subject area (graph provided by Scopus)



Figure 20 - I5.0's WoS Documents by Subject Category (through Bibliometrix/Biblioshiny)

As WoS offers a field called Subject Category that was used to get the Subject Area information. Thus, from the WoS dataset based on the Web of Science Subject category through Bibliometrix/Biblioshiny derives the above scatter graph. The Subject Categories reported are mostly various engineering and computer science categories.

3.5 Top cited publications

The most Globally and most Locally cited documents are investigated. Global Citations (TC -Total Citations) is used to describe the overall quantity of references from sources contained in a bibliographic database (such as WoS, Scopus, etc.) that a document found within a collection has received, whereas, Local Citations (LC) quantify the number of times an author (or a document) in a collection has been cited by other authors who are authors in the collection themselves. Thus, from the nature of the TC field, the merging dataset cannot be used for anything that involves the TC field. Instead, the analysis must be done separately with the two datasets from Scopus and WoS.



Figure 21 - Bibliometrix figure for Documents, References and Cited Documents of a collection [59]

Paper	Total Citations	TC per Year	Normalized TC
NAHAVANDI S, 2019, SUSTAINABILITY	372	74.40	7.91
MADDIKUNTA PKR, 2022, J IND INFOR INTEGR	298	149.00	45.38
XU X, 2021, J MANUF SYST	286	95.33	21.33
ÖZDEMIR V, 2018, OMICS J INTEGR BIOL	228	38.00	1.00
DEMIR KA, 2019, PROCEDIA COMPUT SCI	199	39.80	4.23
LONGO F, 2020, APPL SCI	146	36.50	6.12
ABDEL-BASSET M, 2020, IEEE INTERNET THINGS J	109	27.25	4.57
PILLAI SG, 2021, INT J HOSP MANAGE	108	36.00	8.05
BEDNAR PM, 2020, INF SYST FRONT	103	25.75	4.32
CHOI T-M, 2022, PROD OPER MANAGE	96	48.00	14.62

Table 4 - Industry 5.0 10 Most Global Cited Documents in Scopus

To determine the normalized citation score for documents, authors, and sources considering both global and local citations, bibliometrics uses the normalized TC measure. It is possible to calculate a document's Normalized Citation Score (NCS) by dividing the actual number of citing items by the anticipated citation rate for works published in the same year.

The Most Globally Cited Documents are shown in Table 4 and Figure 22.



Figure 22 - 15.0's 10 Most Global Cited Documents in Scopus (through Bibliometrix/Biblioshiny)

Document	Year	Local Citations	Global Citations	LC/GC Ratio (%)	Normalized Local Citations	Normalized Global Citations
NAHAVANDI S, 2019, SUSTAINABILITY	2019	143	372	38.44	8.00	7.91
XU X, 2021, J MANUF SYST	2021	115	286	40.21	25.62	21.33
DEMIR KA, 2019, PROCEDIA COMPUT SCI	2019	92	199	46.23	5.14	4.23
LONGO F, 2020, APPL SCI	2020	86	146	58.90	10.75	6.12
MADDIKUNTA PKR, 2022, J IND INFOR INTEGR	2022	66	298	22.15	36.46	45.38
ÖZDEMIR V, 2018, OMICS J INTEGR BIOL	2018	64	228	28.07	1.00	1.00
ASLAM F, 2020, INFORMATION	2020	45	80	56.25	5.63	3.35
LU Y, 2022, J MANUF SYST	2022	44	74	59.46	24.31	11.27
JAVAID M, 2020, J IND INTEGR MANAG-a	2020	41	84	48.81	5.13	3.52
LENG J, 2022, J MANUF SYST	2022	31	49	63.27	17.12	7.46

Table 5 - Industry 5.0 10 Most Local Cited Documents in Scopus

The Most Locally Cited Documents in Scopus are shown in Table 5 and Figure 23.



Figure 23 - 15.0's 10 Most Local Cited Documents in Scopus (through Bibliometrix/Biblioshiny)

Paper	Total Citations	TC per Year	Normalized TC
NAHAVANDI S, 2019, SUSTAINABILITY-BASEL	280	56.00	6.61
MADDIKUNTA PKR, 2022, J IND INF INTEGR	239	119.50	26.65
XU X, 2021, J MANUF SYST	223	74.33	13.49
OZDEMIR V, 2018, OMICS	171	28.50	2.00
ZAMBON I, 2019, PROCESSES	131	26.20	3.09
LONGO F, 2020, APPL SCI-BASEL	115	28.75	3.91
CHOI TM, 2022, PROD OPER MANAG	96	48.00	10.70
PILLAI SG, 2021, INT J HOSP MANAG	93	31.00	5.63
BEDNAR PM, 2020, INFORM SYST FRONT	80	20.00	2.72
JAVAID M, 2020, J IND INTEGR MANAG	71	17.75	2.41

Table 6 - Industry 5.0 10 Most Global Cited Documents in WoS

WoS's Most Globally Cited Documents are presented in Table 6 and in Figure 24.



Figure 24 - I5.0's 10 Most Global Cited Documents in WoS (through Bibliometrix/Biblioshiny)

Table 7 - Industry 5.0 10 Most Local Cited Documents	in	WoS
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Document	Year	Local Citations	Global Citations	LC/GC Ratio (%)	Normalized Local Citations	Normalized Global Citations
NAHAVANDI S, 2019, SUSTAINABILITY-BASEL	2019	140	280	50.00	10.55	6.61
XU X, 2021, J MANUF SYST	2021	100	223	44.84	16.28	13.49
MADDIKUNTA PKR, 2022, J IND INF INTEGR	2022	91	239	38.08	32.54	26.65
OZDEMIR V, 2018, OMICS	2018	64	171	37.43	2.00	2.00
LONGO F, 2020, APPL SCI-BASEL	2020	64	115	55.65	5.93	3.91
ASLAM F, 2020, INFORMATION	2020	36	69	52.17	3.34	2.35
LU YQ, 2022, J MANUF SYST	2022	33	59	55.93	11.80	6.58
JAVAID M, 2020, J IND INTEGR MANAG-a	2020	30	56	53.57	2.78	1.90
JAVAID M, 2020, J IND INTEGR MANAG	2020	27	71	38.03	2.50	2.41
ELFAR OA, 2021, ENERG CONVERS MAN-X	2021	27	54	50.00	4.40	3.27

The Most Locally Cited Documents in WoS are illustrated in Table 7 and in Figure 25.



Figure 25 - 15.0's 10 Most Local Cited Documents in WoS (through Bibliometrix/Biblioshiny)

3.6 Most relevant and most influential authors

In order to first get a hint upon the productivity per author through Bibliometrix/Biblioshiny, the Lotka's law shows useful information regarding the author's productivity. The authors that are productive and influencing this research field are those belonging to the "core" authors publishing at least 3 related documents.



Figure 26 - I5.0's Lotka's Law (through Bibliometrix/Biblioshiny)



Figure 27 - 15.0's Most Relevant Authors (through Bibliometrix/Biblioshiny)

Next, by the scatter graph presented in Figure 27, containing the number of publications, the aim is to obtain important for the research field Authors.

The productivity of the authors over time is estimated in the following plot, in terms of publications and total citations annually. The color intensity is proportional to the annual sum of citations, while the bubble size is proportional to the number of papers.



Figure 28 - I5.0's Authors' Production over Time (through Bibliometrix/Biblioshiny)



Figure 29 - 15.0's Authors' Local Impact in Scopus (through Bibliometrix/Biblioshiny)

For the above and below plots, the local impact by the h-index is calculated. As h-index is calculated differently by the two databases, it will be presented separately by the two datasets.



Figure 30 - I5.0's Authors' Local Impact in WoS (through Bibliometrix/Biblioshiny)

Element	h-index	g-index	m-index	тс	NP	PY_start
CARAYANNIS EG	6	8	2.000	195	8	2021
WANG L	6	6	2.000	467	6	2021
LI X	5	7	2.500	109	7	2022
MOURTZIS D	5	8	2.500	153	8	2022
LENG J	4	5	2.000	72	5	2022
MASSARO A	4	5	1.000	46	5	2020
WANG X	4	4	2.000	34	4	2022
ZHENG P	4	5	2.000	103	5	2022
ABONYI J	3	4	1.500	23	9	2022
AGUAYO- GONZÁLEZ F	3	3	1.000	25	3	2021

Table 8 - Various Scientometric indicators to evaluate an author's impact on Scopus dataset (through Bibliometrix/Biblioshiny)

Furthermore, there are other indicators (h-index generalizations) to evaluate an author's impact. Above are various scientometric indicators from the Scopus dataset and below from the WoS.

TC means the Total Citations; NP means number of Publications and PY the Publication Year Start (i.e., the year it was first published). A measure of a scientist's or scholar's production and the significance of their published work is the h-index. For instance, h-index = 6 means that 6 documents from this set have been cited at least 6 times, but the 7th document has been cited less than 7 times.

The m-index is calculated as (h-index)/n, where n is the period of time since a scientist's first article was published (PY_start). The g-index is an enhancement of the h-index for gauging an article set's overall citation performance. The g-index is the unique highest number in which the top g articles received (collectively) at least g^2 citations if this set is ranked in decreasing order of the total amount of citations they got.

Element	h-index	g-index	m-index	тс	NP	PY_start
CARAYANNIS EG	5	7	1.667	176	7	2021
WANG LH	5	6	1.667	373	6	2021
KUMAR S	4	5	2.000	118	5	2022
LENG JW	4	6	2.000	89	6	2022
MOURTZIS D	4	6	2.000	125	6	2022
AGUAYO- GONZALEZ F	3	3	1.000	16	3	2021
ANGELOPOULOS J	3	4	1.500	46	4	2022
AVILA-GUTIERREZ MJ	3	3	1.000	16	3	2021
CHEN X	3	4	1.000	54	4	2021
FORTUNA B	3	3	1.000	13	3	2021

Table 9 - Various Scientometric indicators to evaluate an author's impact on WoS dataset (through Bibliometrix/Biblioshiny)

Thus, for Carayannis m-index = 2 (because it derives from the fraction 6 / 3, where the numerator is the h-index that equals to 6 and the denominator is 3 as it comes from the calculation n = 2023 - 2021 + 1 = 3) and g-index = 8 (as NP²=8²=64, TC=195 and NP²<=TC) [60].

3.7 Most relevant affiliations

As stated on the Scopus website, the automatic method of identifying name variants and linking them into one profile can never be accurate due to the wide range in how affiliations are represented by writers and publishers. Some variations might be left out, while others might be improperly included [61].

Thus, to get this information, from the merged dataset gave results that were misleading. Therefore, the two datasets from Scopus and WoS were used separately. From the ten most relevant affiliations in the research field examined in the Scopus dataset the most are from Europe. In precise, six are from Europe, three are from Asia and just one is from the USA.



Figure 31 - 15.0's Most Relevant Affiliations in Scopus (Data provided by Scopus)



Figure 32 - I5.0's Most Relevant Affiliations in WoS (through Bibliometrix/Biblioshiny)

From the ten most relevant Affiliations in the research field examined, the WoS dataset contains documents by more worldwide distributed Affiliations. Four of them are from Asia, four from Europe, one from the USA and one is from Africa.

3.8 Most relevant and influential sources

In this section the sources are presented based on their production of articles, their impact through various indexes and their classification in zones by the Bradford's law. A journal, book, conference proceeding series, etc. that published one or more documents that are a part of our bibliographic collection is regarded as a source. As the names used by the two databases for the sources are different, for instance a source is named as APPLIED SCIENCES-BASEL in WoS whereas in Scopus is named APPLIED SCIENCES (SWITZERLAND), thus, errors are found in the merged dataset information and therefore the information is been taken separately from the two datasets. The journals derived from both datasets in the top 10, are almost the same (7 out of the 10), although the ordering of the top 2 journals is vice versa in the two datasets.



Figure 33 - 15.0's Top 10 Most Relevant Sources in Scopus (through Bibliometrix/Biblioshiny)

Scopus top sources on Industry 5.0 can be found in Figure 33 and in Figure 34.



Figure 34 - 15.0's Top 7 Sources' Production over Time/Document per year by source in Scopus (graph provided by Scopus)



Figure 35 - 15.0's Top 10 Most Relevant Sources in WoS (through Bibliometrix/Biblioshiny)

WoS's top sources on Industry 5.0 can be found in Figure 35 and in Figure 36.



Figure 36 – I5.0's Top 7 Sources' Production over Time in WoS (through Bibliometrix/Biblioshiny)



Figure 37 - 15.0's Bradford's Law in Scopus (through Bibliometrix/Biblioshiny)

Subsequently sources were clustered using the Bradford's Law. According to Bradford's Law, the geometric series 1: ns: ns²: ns³ is created if journals are arranged in descending order of the number of articles, they include on a given topic, with each zone holding an equal number of articles. Bradford referred to the first zone as the nucleus of journals that were especially focused on the specific subject [62].

Core Zone in Scopus is composed of 19 journals out of 377. More analytically (Figure 38):

- Core Zone (Zone 1): 19 journals, 254 articles,
- Middle Zone (Zone 2): 109 journals, 254 articles,
- Minor Zone (Zone 3): 249 journals, 249 articles.



Figure 38 - 15.0's Source Clustering through Bradford's Law with Scopus



Figure 39 - 15.0's Bradford's Law in WoS (through Bibliometrix/Biblioshiny)

Core Zone in WoS is composed of 10 journals out of 226. More analytically (Figure 40):

- Core Zone (Zone 1): 10 journals, 157 articles,
- Middle Zone (Zone 2): 66 journals, 150 articles,
- Minor Zone (Zone 3): 150 journals, 150 articles.

Bibliometrix/Biblioshiny offers an option to focus only on the first zone's sources, but it was not selected to have as many sources for the current research.



Figure 40 - 15.0's Source Clustering through Bradford's Law with WoS



Figure 41 - 15.0's Top 10 Sources' Local Impact in Scopus (through Bibliometrix/Biblioshiny)

The top Industry 5.0 sources according to their local impact in Scopus are shown in Figure 41 and in Table 10.

Table 10	-Top	10 Sources'	Local Impact	in Scopus
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Element	h-index	g-index	m-index	тс	NP	PY_start
IEEE TRANSACTIONS ON INDUSTRIAL INFORMATICS	9	14	3.000	244	28	2021
SUSTAINABILITY (SWITZERLAND)	8	22	1.600	510	26	2019
JOURNAL OF MANUFACTURING SYSTEMS	7	13	2.333	502	13	2021
APPLIED SCIENCES (SWITZERLAND)	6	14	1.500	217	23	2020
JOURNAL OF THE KNOWLEDGE ECONOMY	6	8	2.000	193	8	2021
ENERGIES	5	9	1.667	107	9	2021
LECTURE NOTES IN MECHANICAL ENGINEERING	5	9	1.250	85	13	2020
SENSORS	5	10	1.667	114	21	2021
COMPUTERS AND INDUSTRIAL ENGINEERING	4	8	1.333	71	10	2021
IEEE ACCESS	4	6	1.333	45	8	2021



Figure 42 - 15.0's Top 10 Sources' Local Impact in WoS (through Bibliometrix/Biblioshiny)

The top Industry 5.0 sources according to their local impact in WoS are shown in Figure 42 and in Table 11.

Table 11 - Top 10 Sources' Local Impact in WoS

Element	h-index	g-index	m-index	ТС	NP	PY_start
IEEE TRANSACTIONS ON INDUSTRIAL INFORMATICS	8	13	2.667	191	23	2021
SUSTAINABILITY	8	20	1.600	418	28	2019
JOURNAL OF MANUFACTURING SYSTEMS	6	10	2.000	405	10	2021
APPLIED SCIENCES- BASEL	5	13	1.250	181	22	2020
INTERNATIONAL JOURNAL OF PRODUCTION RESEARCH	5	9	2.500	98	16	2022
JOURNAL OF THE KNOWLEDGE ECONOMY	5	7	1.667	173	7	2021
SENSORS	5	10	1.250	108	20	2020
COMPUTERS & INDUSTRIAL ENGINEERING	4	7	1.333	60	8	2021
ENERGIES	4	7	1.333	88	7	2021
IEEE ACCESS	4	6	1.333	40	9	2021



Figure 43 - I5.0's 10 Most Local Cited Sources in Scopus (through Bibliometrix/Biblioshiny)

Any publication, such as a journal, a book, or a collection of conference proceedings that is listed minimum in one of the references lists or bibliographies of the documents set is considered to be a cited source. Above (Figure 43) and below (Figure 44), are presented the top 10 Local Cited sources in the two datasets. From the two scatter graphs presented, it can be seen that in the first 5 places the 4 sources are in both datasets although not in the same place except Sustainability which is in the second place in both datasets.



Figure 44 - 15.0's 10 Most Local Cited Sources in WoS (through Bibliometrix/Biblioshiny)

3.9 Funding Sponsors

It should be noted that the sponsor field is typically left blank in documents but from those that have it, the sponsors are primarily from Europe and more specifically these are mostly EC fundings but also fundings from several European countries such as Portugal, Spain, Hungary, Italy, Slovakia, Slovenia, Ireland and UK. The origin of top sponsors is as well China, South Korea, Saudi Arabia, Australia and few more countries.



Figure 45 - Industry 5.0 Funding Sponsorship in Scopus (graph from Scopus data)



Figure 46 - Industry 5.0 Funding Sponsorship in WoS (graph from WoS data)

3.10Country Scientific Production

Author appearances by country of association are counted as a component of country scientific production. This implies that if an article features three authors, each of whom originate from a different country, the appearances counter for each of those three countries will be raised by one. In other words, each article will be counted as many times as there are writers because it is assigned to the nations of all of its co-authors. In the aforementioned case, it occurs three times. It follows that, the sum of the production indicator must be more than the number of articles, except if all of the articles are written by one author.

The country scientific production is visualized in Figure 47, and the darkest the blue color mean more production per country, as it measures a total of authors who appear according to their country affiliations. The graph had to be run separately for each dataset as the merged dataset due to missing references produced wrong output.

	Region	Frequency
	INDIA	403
	CHINA	281
	ITALY	220
A A A C	UK	106
	GERMANY	104
	PORTUGAL	101
	USA	94
R AND	SPAIN	92
	IRELAND	73
	PAKISTAN	72
	FRANCE	68
	AUSTRALIA	63
	POLAND	60
	SWEDEN	60
	BRAZIL	55
	CANADA	51
	GREECE	51

Figure 47 - Country Scientific Production in Scopus (through Bibliometrix/Biblioshiny)

From India are the most document produced for Industry 5.0 in Scopus. From 2020 India was in the 1st place but the amount of research produced raises more compared to other countries. China and Italy are in the second and third place.



Figure 48 - Country Production over Time in Scopus – top 5 countries (through Bibliometrix/Biblioshiny)



Figure 49 - Most Cited Countries in Scopus (through Bibliometrix/Biblioshiny)

Although India is more productive, China is the most cited country in Scopus regarding the Industry 5.0 field, followed by Italy, Australia, New Zealand, India, USA, S. Korea and Canada.

Table 12 - Most Cited Countries in Scopus (through Bibliometrix/Biblioshiny)

Country	TC	Average Article
CHINA	646	12.20
AUSTRALIA	479	43.50
NEW ZEALAND	379	94.80
INDIA	336	5.30
ITALY	330	7.50
KOREA	315	26.20
USA	305	20.30
CANADA	253	19.50
TURKEY	202	50.50
UNITED KINGDOM	174	7.60
POLAND	159	8.80
LITHUANIA	121	13.40
SPAIN	115	5.00
EGYPT	109	109.00
MALAYSIA	109	18.20
IRELAND	88	8.00
MEXICO	75	25.00
GREECE	72	7.20
GERMANY	62	3.30
PAKISTAN	61	10.20
PANAMA	56	56.00
NORWAY	51	5.70
JAPAN	48	9.60
-	Region	Frequency
---	-----------	-----------
	CHINA	159
	INDIA	129
	ITALY	100
	USA	60
	UK	56
	PORTUGAL	55
	GERMANY	46
	SPAIN	42
	FRANCE	39
	PAKISTAN	38
	AUSTRALIA	30
	GREECE	30
	IRELAND	28
	RUSSIA	28
	POLAND	27
	SAUDI	27
	ARABIA	

Figure 50 - Country Scientific Production in WoS (through Bibliometrix/Biblioshiny)

China, India and Italy are in the top 3 places in the WoS database. Italy was in the 1st place until 2021 but the last two years is in the third place.



Figure 51 - Country Production over Time in WoS - top 5 countries (through Bibliometrix/Biblioshiny)



Figure 52 - Most Cited Countries in WoS (through Bibliometrix/Biblioshiny)

China is the most cited country in WoS regarding the Industry 5.0 field, followed by USA, Italy, Australia, New Zealand, India, S. Korea and Canada. The top 8 countries are the same in both databases, just a few are in different places.

Table 13 - Most Cited Countries in WoS (through Bibliometrix/Biblioshiny)

Country	TC	Average Article Citations
CHINA	621	11.90
USA	476	25.10
ITALY	419	9.10
AUSTRALIA	373	28.70
NEW ZEALAND	300	75.00
INDIA	294	8.40
KOREA	252	22.90
CANADA	189	27.00
UNITED KINGDOM	154	6.70
POLAND	112	8.00
SPAIN	99	5.80
MALAYSIA	98	19.60
GERMANY	96	5.10
LITHUANIA	83	13.80
PAKISTAN	63	10.50
GREECE	56	7.00
FRANCE	51	4.60
IRELAND	46	3.10
NORWAY	43	5.40
BRAZIL	39	6.50
U ARAB EMIRATES	33	11.00
ISRAEL	31	15.50
JAPAN	31	7.80

The "Corresponding Author's Country", is an alternative analysis of a country's dimension, suggested by Bibliometrix/Biblioshiny. It assigns each article to a single country according to the corresponding author's affiliation. The person who, when working on a paper with several authors, assumes primary responsibility for corresponding with the journal to be published in is known as the corresponding author. In this instance, the overall number of articles and the frequency per country are equivalent.

MCP stands for Multiple Countries Publication and SCP for Single Country Publication. The number of documents with at least one co-author from a nation other than the corresponding author's is shown by MCP for each country. The number of documents with at least one co-author from a nation other than the corresponding author's is shown by MCP for each country.

MCP as a result measures the degree to which a nation collaborates internationally. As noted before the merging process yields an issue regarding this information and the results of this graph are misleading. Therefore, separate runs made with the Scopus and the WoS datasets yielding:

• The Corresponding Author's Countries from Scopus: A remarkable difference between China and India or Italy, the three first in publications countries, where for China around 60% are international collaborations whereas for India it is about one third and for Italy a quarter of total country's publications.



Figure 53 - Corresponding Author's Countries in Scopus (through Bibliometrix/Biblioshiny)



Figure 54 - Corresponding Author's Countries in WoS (through Bibliometrix/Biblioshiny)

• The Corresponding Author's Countries from WoS: The results, as can be seen in Figure 54, were similar to the Scopus dataset, at least for the top in publications countries.

As VOSviewer cannot use the merged dataset, the Scopus and the WoS datasets were used separately, to examine any underlying relationships between countries via the VOSviewer tool through the Bibliographic coupling analysis by country, citations by country and co-authorship by countries.

Typically, with VOSviewer, a network is first constructed using the data made accessible to VOSviewer when a map is to be developed via bibliographic or text data. The next step is the creation of a map by using the network. A network of relationships involving co-authorship, co-occurrence, citation, bibliographic coupling, or co-citation can be created using bibliographic data. VOSviewer is a distance-based method to visualize bibliometric networks, where the distance between two items indicates how strongly they are related to one another. In a bibliometric network, the number of edges that individual nodes have with other nodes can vary significantly. One typically does a normalization for these large differences between nodes in the analysis of bibliometric networks. The association strength normalization is used by default, as a normalization mechanism, in VOSviewer. After creating a normalized network, the next step in creating a network graph is the process of locating the network's nodes in a two-dimensional space so that strongly associated nodes are close to one another and weakly related nodes are far apart. As we previously stated, VOSviewer implements the "Visualization Of Similarities" (VOS) mapping approach. [41] [63].

A cluster is a collection of nodes that are closely related to one another. By default, VOSviewer assigns the network nodes to clusters. Each node in a network receives a cluster. A resolution parameter determines the number of clusters. With a higher value for this parameter, there are more clusters. In this research, the default value of 1.00 was used, and the default value of 1 was also used for the minimum size of the cluster. The cluster that a node has been assigned is denoted by an alternative color in the graphic representation of a bibliometric network by VOSviewer. The clustering method used by VOSviewer is discussed in [64]. An algorithm must be used in the technique to solve an optimization problem. VOSviewer uses the clever local movement technique described in [65] for this purpose.

Researchers have usually utilized the full counting method to build bibliometric networks. A more realistic viewpoint than full counting is provided by fractional counting. Many argue that full counting results could rather easily cause inaccuracies whereas by employing fractional counting, this can be prevented. [66].

Before running the tool, the parameters used are analyzed. As noted above, Association strength normalization is employed by VOSviewer to adjust for variations in the number of edges that each node has when compared with other nodes. Since VOSviewer considers all networks as undirected, it is necessary to normalize the co-occurrence matrix, or correct the matrix for variations in the total number of either occurrences or co-occurrences of items, in order to ensure that the weight of the edge between any two nodes is the same. The cosine and the Jaccard index are the most widely used similarity measures for normalizing co-occurrence data. However, none of these similarity metrics are applied by VOSviewer. Instead, it makes use of a probabilistic similarity metric known as the association strength. Observed cooccurrence frequencies are measured against expected cooccurrence frequencies under the assumption of independence, can be understood as probabilistic similarity normalization measures [41]. Curiously, despite their popularity, the cosine and Jaccard indexes have proven inadequate for normalization in certain contexts. It is argued that a more suitable normalization measure for co-occurrence data is the association strength, also known as the proximity index or the probabilistic affinity index. While less known, this measure possesses the necessary theoretical properties for normalizing co-occurrence data effectively [67].

In scientometric research, similarity measures often serve for normalization. It is contended that, especially in this context, probabilistic similarity measures like the association strength outweigh set-theoretic alternatives. Therefore, for most applications of direct similarity measures in scientometric research, the use of set-theoretic similarity measures is discouraged, and instead, the adoption of probabilistic similarity measures is recommended.

Regarding Network visualization, items are represented in the network representation by their label and by default, a circle as well. The weight of an object determines the size of the circle

and label for that item. In terms of network visualization, each object in the network representation gets a circle by default and is also represented by its label. The size of the circle and label for an item are dependent on its weight. An object's label and circle enlarge in proportion to its weight. Labels in VOSviewer are only displayed for a subset of all nodes to prevent labels from overlapping with one another. In order to present as many labels as feasible, the selection prioritizes labels of more significant nodes, the nodes that have more edges, above labels of less significant nodes [63]. An item's color is determined by the cluster to which it belongs. Links are denoted by lines between items.

In the Visualization Network graph, the approximate distance between two nodes shows how closely associated the nodes are in terms of co-citation relationships. In general, the more geographically closer two nodes are to one another, the more closely they are related. Additionally, lines show the strongest journal-to-journal co-citation connections.

Additional differences in the context of citation relationships can be drawn between direct citation relationships, both co-citation relationships, and bibliographic coupling ties. Weighted networks are typical of bibliometric networks. Therefore, edges show the strength of the relationship as well as whether there is a relationship between two nodes.

The next network graph is the Bibliographic coupling analysis. Two articles are considered to be bibliographically coupled if at least one mentioned source can be found in the citations of both. The relationship among multiple documents that cite a third document is known as bibliographic coupling. Bibliographic coupling can be thought of as the mirror image of co-citation. Bibliographic coupling is predicated on the idea that two papers can be highly connected even if they do not directly cite one another since they share at least one bibliographic reference. On the other side, co-citation analysis is mostly based on finding pairs of frequently referenced works. These show to be reliable indicators of the appearance of fresh subjects. While co-citation mostly has a forward-looking perspective, bibliographic coupling is retrospective [68] [69].



Figure 55 - Bibliographic coupling vs co-citation [69]

As a result, Bibliographic coupling analysis can offer a picture of the state of the research field presently [70]. Bibliographic coupling analysis with VOSviewer by country follows (using: fractional counting, association strength as normalization method and min occurrences = 5).

As significant countries have been already identified, and can be seen in the following networks by the size of the circle, the goal is to find the connections between the countries. This can be found by the clustering procedure, the placement on the network map and by the lines that connect the countries. The closest two nodes are on the map, the more related to each other. Additionally, the thickness of a line conveys the volume of collaboration among two countries.

The Scopus Clusters are: the Yellow Cluster containing China, Taiwan, Hong Kong, Sweden etc., the Green Cluster containing Italy, USA, Poland, Austria, etc., the Orange Cluster containing India and Russia, the Purple Cluster containing UK, Portugal, Greece, Ireland, etc., the Red Cluster containing Australia, Pakistan, Saudi Arabia, Canada, S. Korea, Turkey, Malaysia, U.A.E. etc., and the Azzurro Cluster containing Germany, Brazil, Norway, Netherlands, Iran, etc.



Figure 56 - I5.0's Bibliographic coupling by countries in Scopus (through VOSviewer)

The WoS Clusters are slightly different. England is in the China's Yellow Cluster, as is Scotland and Sweden. USA and Lithuania form a small Cluster as they are highly related (as the thickest line of the network connects them). Portugal, Greece and Ireland are again together in a Cluster the Blue one, with many European countries such as Spain, France, Croatia, Finland, Slovenia and Austria. The Red Cluster is mainly made by European countries such as Italy, Germany, Poland, Netherlands, Norway, Hungary but also Brazil, Iran and Japan. The Green Cluster looks like the Scopus Red Cluster containing Australia, Pakistan, Saudi Arabia, Canada, S.Korea, Turkey, Malaysia, U.A.E. but also containing India. There is also a small Purple Cluster with Russia and Taiwan.



Figure 57 - I5.0's Bibliographic coupling by countries in WoS (through VOSviewer)

The next Network graph is the Citation by countries made with VOSviewer (using: fractional counting, association strength as normalization method, weighted by Documents and min occurrences = 5). The relatedness of articles is more clearly demonstrated through direct citations, also known as cross citations.

Some observations from the Network maps are: India, Italy, Saudi Arabia and Brazil in both Network graphs belong to the same cluster, same with China and Pakistan, USA and Spain, Greece and Canada, Poland, Sweden, Hungary and Slovakia, Austria, Ireland and Iran. Also, although not in the same cluster in both graphs, Germany is related with Portugal and France (when selecting Germany in the graph in the Scopus Network they are connected with very thick edges).



Figure 58 - I5.0's citations between countries in Scopus (through VOSviewer)



Figure 59 - 15.0's citations between countries in WoS (through VOSviewer)

Co-authorship by countries are the next two network graphs, made from both datasets (Figure 60 and Figure 61 respectively) via the VOSviewer tool. Co-authorship is the process of writing a study with another author. It is among the most well-known and transparent forms of scientific cooperation. By looking at co-authorship networks and applying bibliometric approaches, nearly every characteristic of scientific collaboration networks may be precisely recorded [71].



Figure 60 - I5.0's Co-authorship by countries in Scopus (through VOSviewer)

From the Networks can be obtained the international co-authorship information of each country. Co-authorships occur between authors from: Greece and for instance UK (or England in WoS), UK (or England in WoS) and China, China and USA, Germany and Hungary, China and Australia, India and Saudi Arabia, India and USA, China and Sweden, Portugal and Spain, Italy and France, China and Sweden, Poland and Lithuania, Poland and Slovakia, Italy and Germany, Germany and France etc.



Figure 61 - 15.0's Co-authorship by countries in WoS (through VOSviewer)

The last in this category graph is a Collaboration Network of the Countries on the merged dataset with Bibliometrix/Biblioshiny. The Network layout is Sphere because it avoids overlaps and visualizes better the connections between the countries displayed, the Clustering algorithm is Walktrap and the Normalization method is association. The Walktrap algorithm, proposed by Pon & Latapy, is a hierarchical clustering method based on the tendency of short-distance random walks to stay within the same community, iteratively merging adjacent communities to update distances [72].

To analyze the mapping of Countries' collaboration network, the emphasis is placed on the size of each circle as well as the width of the lines that connect them. The bigger the circle, then the country is of greater significance in the network, thus, wider the countries' collaboration network; and when the lines' association is thicker, the more collaboration occurs between the countries connected. India is the most significant county in the network, followed by Italy and China. India and USA have the most synergies followed by India-Portugal, India-China and China-USA collaborative couples. Two are the most significant clusters. India, China, USA, Portugal, Russia, Germany and Malaysia form the one Cluster. The other significant cluster is with Italy, Spain, France, Croatia, Greece, South Africa, Turkey, Saudi Arabia, Norway, Slovenia and Austria.



Figure 62 - Collaboration Network of the Countries (through Bibliometrix/Biblioshiny)

4

Literature findings on Industry 5.0

After revealing the Environment in which Industry 5.0 evolves, the current research directions in the area of Industry 5.0 have to be identified. They will be determined with the aid of a Bibliometric analysis. Bibliometric analysis, which has its roots in library science, is essentially a taxonomy of literature, and might be an effective technique for revealing complex networks of connections among an extensive collection of literature. And for this study, being done for Industry 5.0, it can help to reveal the current status of the research for Industry 5.0 and its progress through out these few years. Due to the recent rapid growth of the body of academic literature, in general but certainly for Industry 5.0, such a research strategy is especially important nowadays, as the manual review procedure for content analysis is time-consuming [73].

Using various tools science mapping will be performed. By taking a statistical perspective, Science Mapping reveals concealed patterns and facilitates insights into the overarching themes and trends that underpin scientific discourse while empowering statistical analysis of scientific information. Knowledge synthesis of what is written in academic literature research about Industry 5.0, gives its Conceptual structure. Science mapping, in this study, represents relations among concepts or words in the set of Industry 5.0's publications, revealing the main themes and trends of Industry 5.0 [74].

In order to determine the co-occurrence counts of chosen terms in literature and to characterize the interconnections that exist between various phases of the invention processes, co-word analysis, a type of bibliometric method, was developed. A co-word network analysis may offer supplementary perspectives for examining the conceptual organization of research keywords [75].

Therefore, to identify the development trends of research about Industry 5.0, this study conducted a series of co-word network analysis of the related literature. A co-word network

analysis looks at the structure of keyword co-occurrence. A comprehensive representation of the central themes addressed in the literature can be achieved through a co-word analysis, depicting the extent and intensity of keyword collaboration. This network visualization elucidates the keyword structure by highlighting co-occurrence connections [73].

Moreover, bibliometric data can be used to create sophisticated "Word Clouds" and frequency charts of the most popular terms. In the generated visual, word size grows proportionally with the frequency of its occurrence in the analyzed text, making word clouds increasingly popular for swiftly grasping the primary concept conveyed within written content [76].

In addition to mapping, clustering can help to the analysis of the research field. Clustering and mapping are complementary techniques. Mapping bibliometric networks provides an accurate image of their structure, yet due to practical constraints, this visualization is usually confined to two dimensions, obscuring relationships in higher dimensions; in contrast, clustering remains unaffected by dimensionality but is constrained to binary dimensions rather than continuous ones, offering only a general glimpse into the structure of bibliometric networks [64].

Moreover, as Bibliometrix/Biblioshiny offers a different approach to perform a conceptual analysis using Factorial Analysis (FA). FA is a data reduction technique and is a well-known approach in Text Mining domain but it is still little used in science mapping. The main goal of FA, is to make data less dimensional and represent it in a low-dimensional space. The proximity between words corresponds to the shared-substance principle. When two terms are used together frequently in articles, they are close to one another on the map, however when they are used rarely together in articles, they are far apart. The origin of the map represents the average position of all column profiles, representing the heart of the research field, or the common and widely discussed topics of the research field [39] [74].

The last method used was a sentiment mining tool. ATLAS.ti opinion mining carries out a sentiment analysis on the collection's abstract fields evaluating key points as positive or negative. The outcome of this process helps to get a bird's eye review of the relevant literature and gather key insights about Industry 5.0.

Furthermore, as a variety of analysis methods were used, to get sufficient answers, the data given as inputs to these methods used, are an important parameter. Thus, for each method the selection of data for the particular method was seen as significant and adequate attention was paid, as content validity is considered to be the key to a good measure [77].

Therefore, in order to answer the second Research Question, this study aims to identify research trends in the field of Industry 5.0. To this end, co-occurrence analysis of 4 periods (years: 2019-2020, 2021, 2022 and 2023) and co-word analysis was conducted to examine the selected articles published in the Scopus and Web of Science's Scientific bibliographic

databases. Furthermore, trend topics were identified and even the spread of the interest for trend topics through the connectivity of terms and the countries of origin of the Authors, using a three-field plot was examined. Moreover, the word's frequency over time to help identifying the developing trends in the context of Industry 5.0 over the years. Lastly, from the most frequent words used, various word clouds and concept clouds were made and analyzed to understand whether the outcome of the research for Industry 5.0 signifies a transition from emphasizing economic value to prioritizing societal value. Before conducting the Bibliometric analysis, it is important to understand the current state of Industry 5.0 and the technologies involved, in order to more effectively examine and combine the information from the literature.

4.1 Literature review on Industry 5.0

Production systems have seen significant changes over the last ten years, largely as a result of the wave of digitization. Complex issues have been created in the technological, logistical, organizational, and environmental domains as a result of the ICT integration into every stage of production. It is crucial to handle this transformational process well. Innovative technologies have an impact on daily living and the workforce in addition to operations. In order to adapt to changing circumstances and embrace continual learning, workers and consumers play critical roles. Decentralization is increasingly prevalent in modern organizational structures, which use data and technology to speed up decision-making [20] [3].



Figure 63 - Industrial revolutions - The advances in technology that drove them were agents of changes and emerged as revolutions in business, economy and manufacturing [78]

Industry 4.0 resulted in a major improvement in human-machine interaction, but it also necessitates careful consideration of the crucial role that people play. This paradigm is based on the idea of "smart factories," which are areas of cyber-physical production systems where intelligent equipment, products, storage systems, and data combine. The pandemic highlighted the importance of the workforce, leading to a review of Industry 4.0 and the creation of Industry 5.0, which adds elements of societal and environmental impact [20] [3].

Several countries are promoting initiatives to advance technologies, systems, and services centered around human needs, termed as Industry 5.0, with a consequential impact on societal transformation culminating in the emergence of a new society. This shift will prioritize the human and social facets of tools and technologies introduced under the ambit of Industry 4.0, placing sustainability and human well-being at the forefront of the forthcoming Industry 5.0, which forms an integral part of the new improved society, Society 5.0. Industry 5.0 shifts toward embracing resilience, sustainability, and human-centricity as essential parts of value generation, assisted by enhanced technological capabilities, in contrast to Industry 4.0, which was primarily focused on technology-driven breakthroughs [20] [30].

Personalized products and the difficulties faced by SMEs were two elements that fueled a reevaluation of the barriers encountered in implementing Industry 4.0. Although these businesses are essential to economies, the technology requirements of Industry 4.0 present significant obstacles. The assessment of change readiness and the careful selection of suitable technology become crucial factors. The idea of placing people at the core of manufacturing emerges during these discussions. Industry 5.0's fundamental goal is to use new technologies to generate wealth, not just to create jobs and economic progress. Moreover, Industry 5.0 goes beyond these goals by respecting ecological restrictions and putting the welfare of industrial employees first [20] [3].



Figure 64 - UN's SDGs [79]

Presently, a number of countries including the EU, Japan, and the USA, are steering toward the realization of the human-centric epoch of Industry 5.0. The Industry 5.0 concept extends to Society 5.0, that cares for each and any human and the environment, and equips people with the tools they need to lead active, satisfying lives. These intertwined notions represent two parallel frameworks for the imminent industrial and societal horizons to lead humanity in a society that can both promote economic development and find solutions to social problems [30] [31].

We now present certain key facts that led to the EC definition of Industry 5.0. With the adoption of the "2030 Agenda for Sustainable Development" in 2015, the United Nations General Assembly made an important step towards protecting Earth. The agenda, which were adopted by all UN Member States, outlined a 15-year plan for achieving 17 Sustainable Development Goals (SDG). The importance of science, technology, and innovation as a key force behind sustainability has been publicly acknowledged for the first time at this level. The ability of states to integrate science into the core of their national development programs will determine how well they are able to address difficulties, some of which are still unidentified. A vision for a systemic shift toward an economy that is more sustainable and beneficial to both people and the environment [62] [63].



Figure 65 - Society5.0 and Industry 5.0 comparison [29]

In an article titled "Industry 5.0 from virtual to physical" that was published in 2015, Michael Rada presented a method he called "industrial upcycling" and began putting it into practice in the actual commercial and industrial environment of Czechia. He emphasized the value of real tools and environments and treated virtual tools and environments equally to other tools that are present in the physical world, allowing them to work with humans as tools. He also stressed-out concerns for the environment [80].

The concept of a new improved society known as "super-smart society" or Society 5.0 was proposed in Japan in 2016 by the Japanese government. The proposed Society 5.0, which is not aimed at productivity, but is intended to achieve UN's SDGs. The idea is to help deal with social issues and improve many aspects of society [31]. The Society 5.0 concept thus, seeks to use the most recent technological advancements, including digital systems, AI, cloud computing, IoT, and automation, to address larger social and environmental concerns [81].



Figure 66 - Society 5.0 [31]

In 2018, in a paper published by Özdemir and Hekim, it was announced the emergence of Industry 5.0. They stated that Industry 4.0 was a high-tech approach to automate manufacturing utilizing the Internet of Things to create smart factories, but that this level of extreme automation still had numerous flaws. As a result, they suggest Industry 5.0, which uses new ideas from symmetric innovation to democratize the knowledge co-production of large data. Although the Internet of Things is used in their proposed Industry 5.0, as their perspective of Industry 5.0 builds on the ideas and methods of Industry 4.0, it tries to fix the existing asymmetries and limitations of Industry 4.0. Thus, they are proposing Industry 5.0 as an evolutionary, crucially important advancement to them of Industry 4.0 for the design of a resilient, responsible, and sustainable innovation ecosystem in the digital era [82].

The Organization for Economic Co-operation and Development (OECD) defined the economy of well-being in 2019, stating that there is now a strong and well-established case for looking "beyond GDP", using well-being metrics in the policy process, and evaluating economic growth in terms of its impact on people's well-being and on societies' standard of living [83].

In 2021, the EC unveiled the concept of Industry 5.0, envisioning workplaces marked by inclusivity, the establishment of resilient supply chains capable of withstanding disruptions, and the adoption of sustainable production methods. The EC emphasizes that the significance of Industry 5.0 transcends mere employment generation and economic advancement. It requires manufacturing to operate within planetary boundaries and to prioritize the well-being of industry workers, thus positioning human-centricity and sustainability at the heart of the production process.

More precisely for Human-Centricity, addressing education, training, and skills is crucial for digital transition. Retraining won't be feasible for everyone. As for Sustainability, embracing the principle "Better with less", that means optimizing output and resources. This includes end-of-life considerations and a circular economy shift. Finally, for Resiliency, basically adapting to change. Global value chains face geopolitical shifts (such as the Ukraine war, Brexit, trade disputes, protectionism) and natural threats (like pandemics and climate change consequences). Industries must swiftly adjust for long-term prosperity. Resilience spans factory, supply, and system levels. Focus on cost-efficiency might lead to fragility [84].

The United Nations' Agenda 2030 and specifically its 9th and 12th SDGs for "Industry, Innovation and Infrastructure" and "Responsible Consumption and Production" are directly tied to the EC's adoption of innovative resource efficiency serves as the model for a new economy, in 2021 [84].

In contrast to Industry 4.0, which was primarily focused on technology-driven advancements, Industry 5.0 pivots towards embracing resilience, sustainability, and human-centricity as intrinsic elements of value creation, facilitated by advanced technological capabilities.

At its core, Industry 5.0 strives to utilize emerging technologies not merely for generating employment and economic growth, but to transcend these objectives, honoring ecological constraints, and prioritizing the well-being of industrial workers.

The obstacles encountered in implementing Industry 4.0 spurred a reassessment, fueled by factors like personalized products and the challenges faced by SMEs. These enterprises are fundamental to economies; however, the technological requisites of Industry 4.0 pose substantial barriers.

Being known for their constraints in human, technical, and financial resources, SMEs struggle in the transition phase during introducing industry 4.0. SMEs do not only struggle with the resources, but also with the expertise and the management support in terms of difficulties concerning new technologies [85].

The evaluation of preparedness for change and the judicious selection of appropriate technologies become pivotal considerations. Amid these deliberations, the notion of putting humans at the center of production gains prominence.

Industry 5.0 fits three of the priorities set forward by the EC for the five years between 2019 and 2024, namely: "An economy that works for people", "European Green Deal" and "Europe fit for the digital age" [86].

With the help of a new generation of technology, the "Europe fit for the digital age" digital plan will give people more control. People's lives are altering due to digital technology. By making this shift beneficial to both individuals and companies, the EU hopes also to meet its goal of having a climate-neutral Europe by 2050.

The EC has created the European Green Deal, a package of policy initiatives with the overarching goal of achieving the European Union (EU) climate neutral by the year 2050. In order to reduce net greenhouse gas emissions by no less than 55% by 2030 in comparison with 1990 levels, it is planned to evaluate each existing policy according to how well it addresses climate change. Additionally, new legislation regarding the circular economy, energy-efficient building renovation, biodiversity, farming, and clean technological innovation will be introduced.

European Commissi	on
Priorities	2 titer 3 antal Arrow 6 antal 7 antal 8 antal Arrow 9 antal Arrow 6 antal 7 an
European Green Deal	
Economy that works for people	1 Nummer 3 Beneficient 4 Balling 5 Beneficient 8 Beneficient 9 Beneficient 10 Beneficient 1 Nummer
Europe fit for the digital age	4 BOLTAN DECISION DEC
European way of life	3 senaran → M → 10 secara ↓ 10 secara ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓
Stronger Europe in the world	
European Democracy	

Figure 67 - EC Priorities 2019-2024 [86]

The European Green Deal aims at improving the health and well-being of its citizens and future generations by providing, among other things:

- clean air and water,
- healthy soil,
- resilient goods that can be repaired, recycled, and repurposed,
- nutritious food at affordable prices,
- a more sustainable use of plant and soil natural resources,
- transition-proof jobs, training for new skills, and
- a worldwide competitive and resilient industry [69].

SMEs serve as the core of the EU's economy; hence it is vital that the EC take efforts to support them. That is one of the objectives of the EC's action plan for the social economy, "An economy that works for people." The EU needs to improve the environment for investments and promote quality job creation, particularly for young people and small firms. Additionally, steps should be taken to mitigate inequality and poverty [69].

Finding an approach that would assist SMEs in the transition to automated and semiautomated systems was one of the most crucial elements of Industry 5.0. The emphasis will be on reorganizing the work while maximizing the human factor to comply with the strategic values of the business. Therefore, it is essential to guarantee that human demands are given equal priority to the adopted technology in order for this new system to succeed. These human demands must be a major consideration in the design of the system if the work involved is to be regarded beneficial [87].



Figure 68 - Factory of the future in Industry 5.0 [58]

The Covid-19 outbreak highlighted the important role of employees, and the pandemic itself led to a reconsideration of the Industry 4.0 concept. As a result, the concept of Industry 5.0 emerged bringing social and environmental dimensions to Industry 4.0. The workforce has to continually change, from the economic value and profitability perspective of Industry 4.0 to the value to society and human well-being perspective in Industry 5.0. The need of putting employee well-being first is only increasing, and it won't go away anytime soon [3].

Younger generations, notably Millennials and Zoomers, are some of the most passionate advocates of worker welfare and they emphasize the value of human factors in the workplace of the future.

Industry 5.0, also refers to the use of technologies like artificial intelligence (AI) and robotics to improve the overall customer experience. Eliminating the gap between humans and technology to enable seamless integration and interaction between the two is one of the guiding principles of Industry 5.0 [9].

Therefore, Industry 5.0 is divided into two main areas: the one is the Human-Centric approach, that it acknowledges the value of human employees and focus on their skills, knowledge, and capacities to cooperate and collaborate with machines and robots, and the second is flexibility, innovation and quality in the production process and the impact it has on the environment.

4.2 Exploring the Industry 5.0 related terms

The terms identified from the datasets, can help in investigating the Industry 5.0 paradigm to better understand which particular terms the researchers had been concentrating on. In this part of the analysis the ATLAS.ti tool was used. The datasets from Scopus, WoS and the merged dataset had to be transformed to a format that is acceptable by the tool.

As already noted, there are different types of keywords used. Basically, each database has an alternative keyword field to the author- defined keyword field. The Author keywords are filled in by the Author to best reflect the content of the document. Scopus uses an index keyword field, which contains keywords chosen by Scopus and are standardized to vocabularies derived from an Elsevier owned thesaurus. Unlike Author keywords, Indexed keywords take into account synonyms, various spellings, and plurals. For some recently added articles, as it is not filled in automatically, may take a period to appear. Thus, there are documents that this field is empty in the Scopus dataset used. WoS uses the keyword plus field that are words or phrases that are frequently found in the titles of an article's references, yet are absent from the article's title [54] [55].

The combination of keyword terms not only broadens the perspective offered by a particular term, but it may also draw the attention to elements or perspectives that might have otherwise been missed [88].

The first analysis was made by the Author's keywords. For the Author's keywords the corresponding column from the merged Excel file was saved in a pdf format and consequently it was imported.

Since Kelly back in 1927 defined the concept of validity, as the degree to which a test measures the things that it claims to assess, using author-specified keywords to denote a selected article's major subject is valid in the current analysis [89]. Furthermore, particular value is placed on the authors' selection of keywords since they provide crucial cues for understanding how the research topic was defined [90].

The Word Cloud derived from Author's keywords is shown in Figure 69 (using Threshold=37, approximately the 1/20 of maximum occurrences of top used term, numbers were included and the infer to base forms was selected).



Figure 69 - Word Cloud by Author's keywords through ATLAS.ti

In order to briefly describe the Word Cloud, Industry 5.0 has a human perspective. Digitalization, artificial intelligence, smart manufacturing, technology, internet and machine learning are among the most used terms. Sustainability and sustainable are highly used, society and centric are also terms that often occur. Other used terms are innovation, transformation, IoT, robot, supply chain etc.

The tool includes an algorithm that generates a concept cloud, which is created when the data is split into various categories in order to be classified. The significant noun phrases are initially identified in order to identify the most prevalent concepts in the data. In the second stage of processing, all files are combined to compile the concepts and their frequency. The depth of language can be shaped by machine learning, which can analyze text and determine which words go together. Because of ATLAS.ti's dynamic concept filtering, only the concepts that are the most important are given in the findings.

The creation of a Concepts Cloud using the Author's keywords, is given in Figure 70.



Figure 70 - Concepts by Author's keywords through ATLAS.ti

While for the Word Cloud a selection is available whether or not to ignore case in letters the Concepts analysis does not offer such an option. Thus, terms can be found twice, in lower and upper case, as separate terms. Despite that, the Concepts Cloud is helpful in order to identify what is the Authors focus on their research.

Human is a major term, center, centric, centricity, human centric, human factors, relative terms to human can be found. Sustainability (twice in lower and upper case), sustainable, resilience, social is another group of relative terms.

Thus, the EC definition can be produced by the terms contained in the concept cloud.

Next for the index by Scopus keywords, the corresponding column from the Scopus dataset csv file was saved in a pdf format and imported first. Then, the Word Cloud derived from the index keyword field is shown in Figure 71 (using Threshold=30, numbers were included and the infer to base forms was selected).



Figure 71 - Word Cloud by keywords index by Scopus through ATLAS.ti

By its nature the terms that appear from the index by Scopus keywords, indicate how the proposed research will be achieved rather than what is the purpose of the research that reflect the Author's keywords. A short description can be that it is similar in content but richer in terms compared with the previous Word Cloud made by Author's keywords. Various Industry 4.0 technologies appear, upon which Industry 5.0 will be based, to achieve the transition from Industry 4.0 to Industry 5.0. The human/social/environmental factors are slightly less present from the previous Word Cloud made by the Author's keywords.

The same can be said, for the Concepts Cloud derived in Figure 72.



Figure 72 - Concepts by keywords index by Scopus through ATLAS.ti

For the Keywords plus field provided by WoS, the corresponding column from the Excel WoS dataset file was saved in a pdf format first before given as input to the ATLAS.ti tool. The Word Cloud derived from Keywords plus can be found in Figure 73 (using Threshold=5, numbers were included and the infer to base forms was selected).

As the keywords plus field consists of terms that come from the titles of the references from which the article was made and should not be in the title of the article, they reflect the theoretical background on which their work is based on. As the words selected are not common to their title, and must appear more than once in the article's bibliography, an additional and, in a sense, broader and with more general terms description of the research fields is achieved. Basically, the keyword plus list of words substantially augments the list of words from the title and from the author-selected keywords [88].

Except from general kind of terms that are most used such as systems, management, framework, model, design, challenges and future, many technology-related terms appear. Among them, artificial intelligence, big (data), internet, cyber physical, digital twin, technology, IoT, things, robot, blockchain, cloud, edge, network, wireless etc. There are also present Industry 5.0's pillars, human, sustainability, resilience but also close to them terms such as collaboration, personalization, cooperation, circular economy, social, energy, satisfaction.



Figure 73 - Word Cloud by keywords plus by WoS through ATLAS.ti



Figure 74 - Concepts by keywords plus by WoS through ATLAS.ti

The respective Concepts Cloud derived is in Figure 74. The description of the above concepts is similar to the Word Cloud made by the keyword plus field.

For the Title field because during the merging process made with the bibliometrix R-function, the merged dataset's title field were changed by NLP (in a tokenized form), it was preferred to avoid using the column from the merged dataset and instead create a better data source for the titles. Thus, manually in an Excel file, first the titles from the Scopus dataset and next the titles from the WoS dataset were copied and through a review the duplicates were deleted. Afterwards, the file was saved in a pdf format.

The Word Cloud derived from the Title field is shown in Figure 75 (using Threshold=25, numbers were included and the infer to base forms was selected).

The description given for the Word Cloud based on Author's keywords fits to this Word Cloud as well. Same applies for the Concepts Cloud made from the titles (Figure 76).

<pre></pre>

Figure 75 - Word Cloud by titles through ATLAS.ti



Figure 76 - Concepts by titles through ATLAS.ti

Finally, the Abstract field was used. The procedure to import the Abstract data was to copy the column from the merged Excel dataset file and saved it in pdf format to be then recognized by the tool.

The Word Cloud derived from Abstract word frequencies created, shown in Figure 77 (using Threshold=179, numbers were included and the infer to base forms was selected). Again, the Word Cloud is similar to the Word cloud made by the Author's keywords and the Title fields respectively. The creation of similar diagrams increases their usefulness and aids in determining the analysis's conclusion.



Figure 77 - Word Cloud by abstracts through ATLAS.ti



Figure 78 - Concepts by abstracts through ATLAS.ti

The corresponding Concepts Cloud from Abstract words can be seen in Figure 78, gave also similar to the Word Cloud results.

4.3 Co-occurrence of keywords

To be able to depict the network structure of the keywords' co-occurrence associations, a series of co-word network analysis was used in this study. Applying respectively the Scopus and the WoS datasets, VOSviewer co-occurrence of keywords Network Visualization were created, by using thesaurus, fractional counting and for Normalization the LinLog layout technique and the modularity clustering (as the nodes are not displayed the one on the other).

Based on Garfield's idea that more terms bring more detail, the "All keywords" option was used, that is, both Author's keywords and the Indexed by Scopus keywords for the Scopus dataset giving the following graph [88].



Figure 79 - VOSviewer co-occurrence of keywords Network Visualization using the Scopus dataset

From the above co-occurrence of keywords Network in Figure 79, the below clusters were formed:

- The Industry 5.0 (green colored) cluster containing amongst other topics the Industry 4.0, human-centricity, AI, sustainability, personalization, Society 5.0, green, supply chain, resilience, Covid-19, circular economy, SMEs, digitalization and industrial revolution;
- The IoT (red colored) cluster containing the blockchain, energy efficiency, big data, automation, Industrial IoT, 5G/6G, cloud computing, edge computing, machine learning, deep learning, security;
- The manufacturing (blue colored) cluster containing worker, operator 4.0, smart manufacturing, industrial research, robot, industrial robots, cobots, robotics, intelligent robots, behavioral robots, and various human and robot related topics such as human-robot collaboration and human-machine interaction;
- The cyber physical systems (yellow colored) cluster containing the topics like digital twin, VR, AR, decision making, data mining, metaverse, embedded systems, cybersecurity.

• The small multi agent systems (purple colored) cluster containing the resource management and self-organization, thus containing only 3 topics.

The Knowledge that yields from the relationships in the graph, helps to understand Industry 5.0. For instance, the interest upon human-center issues such as the operator safety. By interpreting the connectivity between nodes in the graph, when the operator safety was selected, the operator safety is an issue related to human-centricity, to worker and sustainability in the Industry 5.0 and Industry 4.0 context. Also, it is related to Human-robot collaboration, as well to accident prevention and to decision support systems.



Figure 80 - Operator safety in Scopus VOSviewer co-occurrence of keywords Network Visualization



Figure 81 - VOSviewer co-occurrence of keywords Network Visualization using WoS dataset

For the next graph in Figure 81, the "All keywords" option was used, that is, both Author's keywords and the keyword plus by WoS, built from the WoS dataset.

The WoS data's clustering derives the below clusters:

- The Industry 5.0 (green colored) cluster, which is containing amongst other topics the Industry 4.0, AI, sustainability, human-centricity, technologies, Society 5.0, environmental sustainability, resilience, decision making, circular economy, digitalization, SMEs, personalization, metaverse, worker, operator 4.0, human factors, human-machine interaction, future and innovation;
- The IoT (red colored) cluster, which contains the internet, industry, blockchain, security, authentication, privacy, challenges, big data, automation, supply chain, Industrial IoT, 5G/6G, cyber physical systems, smart city, cloud and edge computing;
- The Human-robot collaboration (blue colored) cluster, that contains smart manufacturing, framework, design, machine learning, deep learning, digital twin, VR, AR, robotics, robots, human-robot collaboration, cobots, reliability, optimization;
- The systems (yellow colored) cluster, that contains the topics like management, operator safety, healthcare, lean manufacturing, logistics, automation, green, energy efficiency, performance, transportation.



Figure 82 - Operator safety in WoS VOSviewer co-occurrence of keywords Network Visualization

Again, when the operator safety was selected, it's connections illustrate that the operator safety is an issue related to human-robot collaboration, Industry 5.0, Industry 4.0, digital twin, security and through a broader view to systems, management, performance, framework and design.

When selecting personalization, it is found that personalization is an issue related to Industry 5.0, Industry 4.0, AI, technologies, human-centricity, Society 5.0, metaverse and privacy.



Figure 83 - Personalization in WoS VOSviewer co-occurrence of keywords Network Visualization



Figure 84 - VOSvViewer co-occurrence of keywords plus Network Visualization using WoS dataset

The next graph in Figure 84, is a Keyword-plus derived co-occurrence graph using the WoS dataset. Frames instead of circles were used and the association strength method for normalization. The terms and clusters derived are easily viewed. As already mentioned, due to the nature of the keyword-plus field, the terms are from the references used by the authors of the documents, so these terms reflect the conceptual basis upon which the Authors work was based on.

The absence of the term human is worth to be noted. 6 clusters were formed. One is the system, management, model cluster that contains the resilience term. Also contained in this cluster are terms such as optimization, algorithm, networks, resource allocation and machine. The AI, CPS, Big data, Internet, supply chain, digital twin, blockchain, things, IoT, security is the largest cluster. The technologies cluster with Industry 4.0, integration, service and robots. The framework, future cluster, with terms such as performance, decision making, impact, implementation, collaboration and more. And finally, the sustainability cluster containing circular economy, VR, digitalization and innovation.
4.4 Trends – Topics

The below Trend Topics Bibliometrix/Biblioshiny graph that uses the Author's keywords field, shows the trend topics as they evolve.

Resilience is found as a promising topic in 2023, as Human-Centricity was found in 2022 and SMEs in 2021.



Figure 85 - Trend Topics by Bibliometrix/Biblioshiny

4.5 Three-field plot

Another overview through the Three-Field Plot, where Title, Countries and Author's keywords were selected having 13 items on each category, showing the connection between the countries of the Authors, and the titles and keywords that they use.

The relationship among Top Keywords, Top Countries and Top Title's words summarized by a Sankey Plot can gives information on the status of Industry 5.0. For instance, sustainable is a term that appears in the title of all countries displayed for at least one document except for Germany. Sustainability as an Author's keyword appears in at least one document from all countries appeared in the graph except Turkey and Pakistan, whereas resilience appears in at least one document from China, Italy, UK, Portugal, USA, Spain, Germany and Australia. Furthermore, Society 5.0 does not appear in the keywords list to any document retrieved from USA, Germany and Poland.



Figure 86 - Three-Field Plot, where Title, Countries and Author's keywords by Bibliometrix/Biblioshiny



Figure 87 - Most Relevant Words by Bibliometrix/Biblioshiny

4.6 Most Frequent Words

Most Frequent Words, is a graph made by the Bibliometrix/Biblioshiny tool, based on Author's keywords generated by the merged dataset and after applying a thesaurus. As can be seen in Figure 87, Industry 5.0 as expected is the top frequent used word, followed by Industry 4.0, human-centricity, AI and sustainability. IoT, digitalization, Society 5.0, IIoT and Human-Robot collaboration complete the top 10.

Below, is a Word cloud from the merged dataset was made with the Bibliometrix/Biblioshiny tool using the Abstract's bigrams. Artificial Intelligence has the most occurrences, followed by industrial revolution, supply chain, machine learning, sustainable development, digital transformation and digital twins.



Figure 88 - Word cloud using Abstract's bigrams by Bibliometrx/Biblioshiny



Figure 89 - The Abstract's bigrams Word frequency over time by Bibliometrix/Biblioshiny

And for the most frequently used bigrams from the Abstract field, their frequency over time is presented in Figure 89.

4.7 Thematic Evolution

4.7.1 Co-occurrence analysis in different periods

Analyzing counts of co-occurring entities within a collection of units is the main goal of cooccurrence analysis. The co-occurrence matrix is a common type of data used in cooccurrence analysis; the intersection of the row and column represents the co-occurrence. The items constitute the row and column headers. Co-occurrence analysis in bibliometrics is used to investigate the possible association between two bibliographic entries that are present in the same study. Over the past two decades, bibliometrics' co-occurrence analysis techniques have advanced [91].

The Industry 5.0 evolution was examined through the VOSviewer tool. Firstly, the Cooccurrence of keywords Network Visualization and Density Visualization with the Scopus dataset was made, where the type of analysis performed was with all keywords, fractional counting as counting method and association strength normalization to Normalized link strengths and then they are inputs for the VOS layout method and the VOS clustering method, respectively, for all examined periods.

As 2018 has only one paper, the first period was set to 2019-2020. From the graph made through VOSviewer with the Scopus dataset, the papers of this period mostly reflect technology values.

The minimum number of occurrences was set to 3 as the number of sources of the period was small.



Figure 90 - VOSviewer co-occurrence Network Visualization 2019-2020 using the Scopus dataset

	autonomous aerial vehicles
	big data
	decision making
	artificial intelligence
	industry 5.0dustry 4.0
internet of things internet of things (iot)	manufacturing technological innovation industrial revolutions robotics
and the second second	robots

Figure 91 - VOSviewer co-occurrence Density Visualization 2019-2020 using the Scopus dataset

Same co-occurrence graph was made with the WoS dataset having the same parameters as the previous graph with the Scopus dataset and the output was alike the Scopus one.



Figure 92 - VOSviewer co-occurrence Network Visualization 2019-2020 using the WoS dataset



Figure 93 - VOSviewer co-occurrence Density Visualization 2019-2020 using the WoS dataset

The next period was set to 2021. The first couple of graphs made with the Scopus dataset, having the same parameters of the first period. The only difference is that the minimum occurrences was set to 4. Interesting output as beside technology factors the new dimensions introduced with Industry 5.0 can be found in this graph: Sustainability, humans (workers, human-robot collaboration, Operator 4.0, human, humans) and Society 5.0.



Figure 94 - VOSviewer co-occurrence Network Visualization 2021 using the Scopus dataset



Figure 95 - VOSviewer co-occurrence Density Visualization 2021 using the Scopus dataset

The corresponding graphs with the WoS dataset are next. In these graphs beside technology factors the new dimensions introduced with Industry 5.0 can be found such as sustainability, human-centricity, operator safety, human-robot collaboration and society 5.0.



Figure 96 - VOSviewer co-occurrence Network Visualization 2021 using the WoS dataset



Figure 97 - VOSviewer co-occurrence Density Visualization 2021 using the WoS dataset

The following period was set to 2022. The VOSviewer parameters remain the same, only the minimum occurrences field was set to the default value that is 5. From the Scopus dataset, 2022 was richer in concepts than the previous year. In the new concept's list, included terms are such as, resilience, wellbeing, personnel etc.



Figure 98 - VOSviewer co-occurrence Network Visualization 2022 using the Scopus dataset

	.c	obots			
operator 4.0	covid-19	aborative robots			
competition	humans-robot intera	iction intelligent robots			
human resource management	human-robot collaboration maintenance	ot Interaction semantics			
digitalization workers' well being	performance robots				
supply cha	in management	forecasting	forecasting		
engineering education	manufacture mac	hine-learning			
ergonomicservalectory constant	supply chains machine l	earning deep learning	security		
personnel sustainable development	industry 5.0	learning systems	network security		
e-learning human-centric	robotics smart manufacturing automation	fuellon wongewent	g mobile communication system		
resilience sustainability virtual real	digital twin ity artificial intelligence	internet of things discons	6g		
digital transformation manufacturing	ision making		block-chain		
human centricities	manufacturing process	big data energy efficiency optimiz	ar, blockchain		
indus prodúction system prodúction process	itry interop human fourth industrial revolutio embedded systems	erability on			
cyb society 5.0	er physicals	smart city			
		iot			
	cyber physical system				
cybe-phy	rsical systems				

Figure 99 - VOSviewer co-occurrence Density Visualization 2022 using the Scopus dataset

The corresponding WoS graphs are next, and they can be seen as similar to the Scopus graphs of 2022.



Figure 100 - VOSviewer co-occurrence Network Visualization 2022 using the WoS dataset



Figure 101 - VOSviewer co-occurrence Density Visualization 2022 using the WoS dataset

Last period is 2023. For the Scopus dataset, the 2023 graph made was similar to 2022. A difference that can be seen is that the sustainability cluster has been expanded.



Figure 102 - VOSviewer co-occurrence Network Visualization 2023 using the Scopus dataset



Figure 103 - VOSviewer co-occurrence Network Visualization 2023 using the Scopus dataset

As for the 2023 WoS dataset the obtained graphs, again look alike the Scopus of this period.



Figure 104 - VOSviewer co-occurrence Network Visualization 2023 using the WoS dataset



Figure 105 - VOSviewer co-occurrence Density Visualization 2023 using the WoS dataset

4.7.2 Thematic Evolution

The thematic evolution from Bibliometrix/Biblioshiny shows the transition from Industry 4.0 concepts to Industry 5.0 concepts.

Below is the graph made with the merged dataset based on the keywords plus field (a mix of index by Scopus keywords and keyword plus terms). It shows a transition focus from a technology-based perspective to Humans (focus on workers) and Sustainability (plus energy efficiency) perspective. Sustainability was from the beginning in the research focus, as concerns about sustainability was in the focus from Industry 4.0 but human workers concerns raise in recent works.



Figure 106 - Bibliometrix/Biblioshiny Thematic Evolution

4.8 Co-word analysis

Co-word analysis is a method used to identify clusters of keywords in a given dataset. These clusters, known as themes, can be classified and visually represented on a two-dimensional thematic map. The position of each theme on the map provides information about its characteristics and significance within the research field. The thematic map is divided into four quadrants. The distribution, development, and importance of themes within Industry 5.0 can be revealed, aiding in the identification of key areas of focus, emerging trends, and potential research directions. The co-word analysis was made through Bibliometrix/Biblioshiny tool using the merged dataset and the Author's keywords. Based on centrality and density, the themes are divided into four groups.

The motor themes are those that have been extensively studied and are significant to the scientific community. Ideas that are equally important but less thoroughly explored make up the core themes. Niche themes are specialized topics with minimal application to the research field but connections to related topics. As a result of their lack of development and marginal significance, developing or declining subjects are grouped under emerging/declining themes. The distribution of these four groups can be seen along two axes: the X-axis represents the level of relevance of a topic, and the Y-axis represents the level of development [92].

The co-word analysis might offer an idea of what the research field can look like in the future [70].



The first period examined was 2018-2021 (Figure 107 and Figure 108).

Figure 107 - Industry 5.0's Thematic map 2018-2021 through Bibliometrix/Biblioshiny



Figure 108 - Industry 5.0's Thematic Map Network 2018-2021 through Bibliometrix/Biblioshiny

The second period was 2022-2023 (Figure 109 and Figure 110).



Figure 109 - Industry 5.0's Thematic map 2022-2023 through Bibliometrix/Biblioshiny



Figure 110 - Industry 5.0's Thematic Map Network 2022-2023 through Bibliometrix/Biblioshiny

In the early years 2018-2021 many clusters have been identified as Motor Themes. They primarily include technological factors. In the next period only one cluster (the IOT, AI, blockchain cluster) remains in the Motor Themes. The Industry 5.0 cluster in the last period while probably has changed its focus and is more human-centric, is placed in the Basic Themes.

It is expected that the relevance degree of the Industry 5.0 cluster will be high, that is why it can be found in both maps in the rightest position.

In the first period that the tool interprets the Industry 4.0 - Industry 5.0 cluster, the technology with human interaction cluster and blockchain cluster, the IoT and AI cluster, the cobots cluster and the manufacturing cluster were well developed, sustainability is emerging.

Whereas, in the second period Industry 5.0 cluster is decreasing its density degree as it has a human-centricity focus and resilient is a new topic in this cluster. Moreover, Sustainable development with AI and human form a cluster positioned in the map's center.

Human factors and cobots may not be extensively developed but are relevant across different research areas and sustainability in a different cluster is still emerging.

The Thematic map for the whole period of our research (2018-2023) through Bibliometrix/Biblioshiny using the Author's keywords was also made and can be found next in Figure 111.



Figure 111 - Industry 5.0's Thematic map through Bibliometrix/Biblioshiny

This map shows 5 clusters. The cluster with the highest centrality, that is the most relevant to the topic cluster, is the Industry 5.0 - Industry 4.0 - human-centricity cluster but with medium density, that is, it is not fully developed. That is why it is half in the Motor Themes quadrat and half to the Basic Themes quadrat. With less centrality but more density from the previous cluster is the IoT – blockchain - Industrial IoT cluster and it is placed in the Motor Themes quadrat. The next cluster based on the order of the centrality degree is the sustainability – supply chain – technologies – resilience cluster that half belongs to the basic and half to the Emerging or Declining Themes quadrat. The next cluster belonging as well to the Emerging or Declining Themes quadrat. Finally, the smaller cluster is the reliability cluster that has low centrality but high density and belongs to the Niche Themes quadrat.



Figure 112 - Industry 5.0's Thematic Map Network through Bibliometrix/Biblioshiny

4.9 Factorial Analysis

Factorial analysis was employed to construct a conceptual structure map utilizing Multiple Correspondence Analysis (MCA), which serves as a descriptive technique for assessing twodimensional and multiplexed tables of corresponding metrics between rows and columns. This method effectively groups indicator levels with shared traits, revealing their coherence within a two-dimensional plot forming clusters of points.

The proximity of keywords in the plot reflects their degree of relatedness, with closer keywords exhibiting greater association. Additionally, hierarchical clustering was applied to cluster keywords with the utmost similarity, yielding a tree graph that intricately delineates the interplay and divergence of keywords [74].

Thus, it can be identified in the generated graph that resilience and sustainable development are very close thus they are related. Also, human centricity is not far away from both resilience and sustainable development. Furthermore, Sustainability is close to human-robot interaction and supply chain. Industry 5.0 and Industry 4.0 are very close. Moreover, close are Human centric to human robot collaboration, and human robot collaboration to Operator 4.0 and digitalization. And again, it is noted that their closeness indicates a degree of relevance between the topics. Another, worth mentioned observation is that all terms belong to one cluster, meaning this type of analysis found a high degree of relevance in between the themes of the Industry 5.0 topic.



Figure 113 - Factorial Analysis - Conceptual Structure Map using MCA by Bibliometrix/Biblioshiny



Figure 114 - Factorial Analysis - Topic Dendrogram using MCA by Bibliometrix/Biblioshiny



Figure 115 - Factorial Analysis - Parts of the Dendrogram 1

Interpreting parts of the dendrogram, make logical sense, and helps to understand the relationships among terms. Therefore, follows an observation of certain parts of the dendrogram. The above left part of the dendrogram may be explained as for supply chains sustainability is an important aspect and human robot interaction can help on this as well the robotics may help. For the above right part, sustainable development and resilience are close related and together are strong related to human centricity. Also, manufacturing may rely on them.

For the below left part, three different ways to express Industrial IoT were identified and connected. Industries and Security are obviously related and both are connected to Industrial IoT.

For the right part, Augmented Reality is a key factor for digital transformation, and Robots and Virtual Reality are close together. These terms are then connected with the pair CPS and Industrial Revolution. And to all these terms automation is a related term.



Figure 116 - Factorial Analysis - Parts of the Dendrogram 2



Figure 117 - Factorial Analysis - Parts of the Dendrogram 3

A connection exists between digitalization and Operator 4.0 that then they are connected to human robot collaboration. Human centric and human robot collaboration (different instance) are also connected and then they have a relationship connection with the previous block. Manufacturing and technology forming a relationship and after they are connected with the previous human-related block of terms.

Industry 4.0 and cobots have a connection and help to accomplish Industry 5.0. The Covid-19 and Society 5.0 connection may be interpreted as Society 5.0 cares about society, thus for its citizens and their Health Care. And then Industry 5.0 and Society 5.0 are together related.

The two big blocks of terms, described, are then connected and all together are related to User experience.

4.10 Opinion Mining

The last analysis method for the second research question to discover emerging fields and research trends, conducted using the ATLAS.ti tool, was Opinion Mining. It is an AI technology that can find sentiments in concepts. It is sentiment mining, also known as opinion mining, which involves creating a way to find authors' ideas provided in documents. Its purpose is to ascertain an author's attitude about a particular subject.

It is possible to extract insights from data by using natural language processing to find feelings that are embedded in text. Text analysis can reveal the sentiments that underlie words

and sentences, in addition to their meaning. Opinion mining is a Sentiment analysis of the papers in the collection to determine whether a context is favorable or unfavorable. The Opinion Mining program can recognize frequently occurring words in key phrases, display descriptive statistics of the words connected to each term, and suggest sentiment and opinion codes for every relevant quotation. This makes it simple to comprehend both what is being discussed in the literature data and how individuals feel about that particular item. Therefore, it might be interpreted as the author making an optimistic or pessimistic declaration about a subject.

Opinion mining therefore, can be regarded as a sentiment analysis of citations in research articles to spot trends and suggest novel directions for future research. The goal of the sentiment analysis approach, which is part of the machine learning family, is to find relevant patterns contained in a database. The primary objective of sentiment analysis is, by using text analysis tools, to determine the polarity of citations (positive, negative, and neutral) made in various research articles.

In general, sentiment classification is to assign either a positive or negative polarity to the review materials. It doesn't look into the preferences of the reviewer or opinion container. If someone has a favorable impression of a document, it does not always follow that they feel the same way about every part of the document. An unfavorable opinion of a product does not necessarily imply that the person disapproves of all aspects of it. Although in general opinions may be positive or negative, the opinion container in an analysis document writes both the positive and negative essence of the item [43] [93].

The Scopus and WoS datasets that were collected were exported to BibTeX format and imported in the ATLAS.ti tool and the duplicate records were deleted manually through a search procedure provided by the tool. This format helps to have a detailed record of the document where a positive or a negative opinion occurs. In advance, it helps to make quick reviews on large collections of papers identifying spots on these papers that contain particular terms. The opinion mining process performed a sentiment analysis that it can help to reveal the author's optimism or pessimism (skepticism maybe is a better term to express the negative sentiment of an author regarding a field in the present use of Sentiment Analysis) upon the issues addressed in their works. Thus, by using the aforementioned different approach, the directions of the research on Industry 5.0 should be clearer.

The positive quotes produced by ATLAS.ti Opinion Mining are more than the negative in our collection. More specifically, the positive quotations in Scopus are 1042, whereas the negatives are 904. In WoS respectively 258 versus 111. In the merged dataset (Scopus and WoS) there are 1094 positive compared to 928 negatives quotations. As positive sentiment may imply something new, that will bring changes with positive impact whereas negative

sentiments may imply the obstacles to achieve the transition from Industry 4.0 to Industry 5.0, by reading these quotes either positive or negative, helps any researcher to develop his/her understanding on the evolution of Industry 5.0.

Studying the output of the Opinion Mining process helped to have an in depth understanding and gather key insights of the research field, because it may disclose numerous unknown or hidden facts. Through the tool's interactive environment, it is possible to quickly and thoroughly overview the scientific area and support knowledge that has already been obtained using other techniques.

In the Appendix A, a collection of screenshots from the output of the Opinion Mining process is included. Both positive or negative quotes are presented. Reading them, aim for the qualified analysis of the academic articles collection, substantiated the findings of this research regarding Industry 5.0.

5

From Industry 4.0 to Industry 5.0

Industry 5.0 is a novel paradigm and as so it is evolving. Regarding what the Industry 5.0 concept should be about, several authors have varied perspectives as what it is [16]. Based on the definition coined by EC a definition in [20], identifies it as a set of organizational principles and technological tools for designing and running supply chains and operations as resilient, sustainable, and human-centric systems. As Industry 5.0 has many definitions, the directions pointed by the researchers can also vary. In order to identify the direction Industry 5.0 is heading, the analysis will focus on identifying the portion of Industry 5.0 articles in the two databases that contains at least one of the three pillars of Industry 5.0 and compare the impact of the articles containing one of the three pillars to those not containing. Further, the direct and indirect presence of the three pillars in the research literature is to be examined.

5.1 The 3 pillars in Scopus for Industry 5.0

The below table present the percentage of Articles in Scopus databases containing the keyword "Industry 5.0" and some subqueries using logical operators to discover the portion of documents covering the concepts of Human-centricity, Sustainability and Resiliency. As it can be seen there is an increasing interest for the 3 Industry 5.0 pillars. The majority of articles, more than three quarters of articles, that are published discuss a concept regarding the 3 Industry 5.0 pillars.

Table 14 - Industry 5.0 Articles in Scopus

Articles in Scopus							
Industry 5.0							
Year	2018	2019	2020	2021	2022	2023 (until 1 st of	
						July 2023)	
Doc	1	17	36	90	369	244	
		Industr	y 5.0 And H	uman-centr	·ic		
Doc	1	6	12	47	221	158	
%	100	35,29	33,33	52,22	59 <i>,</i> 89	64,75	
		Indust	ry 5.0 And S	Sustainabilit	y		
Doc	0	1	5	23	129	84	
%	0	5,88	13,89	25,56	34,96	38,11	
Industry 5.0 And Resiliency							
Doc	0	0	0	7	55	43	
%	0	0	0	7,78	14,91	18,03	
Industry 5.0 And (Human or sustainability or resiliency)							
Doc	1	7	17	62	270	184	
%	100	41,18	47,22	68,89	73,17	75,41	

In order to have a better view on the Industry 5.0 documents stored in the Scopus database, a Venn chart has been created. The data comes from relative keyword searches on Scopus.



Figure 118 - Venn chart of Scopus various datasets formed after applying relative keyword searches



Figure 119 - Industry 5.0 articles per year in Scopus

From the Scopus dataset, several graphs were produced showing the growth of interest for the 3 Industry 5.0 pillars.



Figure 120 - Industry 5.0 articles in Scopus covering any of the 3 pillars



Figure 121 - Percentage of Industry 5.0 articles in Scopus covering any of the 3 pillars



Figure 122 - Overview of Industry 5.0 articles in Scopus



Figure 123 - Area Graph presented the percentage of Industry 5.0 articles in Scopus covering any of the 3 pillars

5.2 The 3 pillars in WoS for Industry 5.0

The below table presents the percentage of Articles in WoS database containing the keyword "Industry 5.0" and some subqueries using Logical operators to discover the portion of documents covering the concepts of Human-centricity, Sustainability and Resiliency. As it can be seen there is an increasing interest for the 3 Industry 5.0 pillars. The majority of articles, more than three quarters of articles, that are published discuss a concept regarding the 3 Industry 5.0 pillars.

Articles in Web of Science						
	Industry 5.0					
Year	2018	2019	2020	2021	2022	2023 (until 1 st
						of July 2023)
Doc	2	11	20	59	233	132
		Industry	5.0 And Hur	nan-centric		
Doc	2	3	5	39	142	85
%	100	27,27	25,00	66,10	60,94	64,39
	Industry 5.0 And Sustainability					
Doc	0	2	6	22	87	51
%	0	18,18	30,00	37,29	37,34	38,64
Industry 5.0 And Resiliency						
Doc	0	0	0	7	45	28
%	0	0	0	11,86	19,31	21,21
Industry 5.0 And (Human or sustainability or resiliency)						
Doc	2	4	10	49	177	109
%	100	36,36	50,00	83,05	75,97	82,58

Table 15 - Industry 5.0 articles in WoS



Figure 124 - Venn chart of WoS various datasets formed after applying relative keyword searches

In order to have a better view on the Industry 5.0 documents stored in the WoS database, a Venn chart has been created. The data come from relative keyword searches on WoS. Similarly, with the Scopus dataset, the below graphs are produced from the WoS dataset, showing the growth of interest for the 3 Industry 5.0 pillars.



Figure 125 - Industry 5.0 articles in WoS



Figure 126 - Industry 5.0 articles in WoS covering any of the 3 pillars



Figure 127 - Percentage of Industry 5.0 articles in WoS covering any of the 3 pillars



Figure 128 - Overview of Industry 5.0 articles in WoS



Figure 129 - Area Graph presented the percentage of Industry 5.0 articles in WoS covering any of the 3 pillars

5.3 Comparing the Impact of the papers



Figure 130 - Overview of Scopus Industry 5.0 dataset containing any of the 3 pillars (Human, Sustainable, Resilience)

The impact of the Industry 5.0 documents with interest on any of the 3 pillars will be compared with those not containing any of the 3 pillars.

Two datasets were obtained from Scopus. One using the search string: "Industry 5.0" AND ("Human*" OR "Resilien*" OR "Sustain*") and the second using the search string: "Industry 5.0" AND NOT ("Human*" OR "Resilien*" OR "Sustain*")

The Citation Overview on the Scopus dataset shows by comparing the two sets of documents that the documents that contain Human-centricity, Sustainability and Resiliency are used on average more as references from the researchers than the other set of documents.

The overview of the dataset follows. First observation is that the set containing any of the 3 pillars in the title, abstract or keywords fields has the h-index = 32 while the second set that does not contain any of the 3 pillar terms has the h-index = 16. Moreover, the first set has an annual growth of 184% whereas the second has 57%. Furthermore, although the first set has as document average age 0.89 less than 1.17 that the second, so documents of the second are published less time on average, the first dataset has as average citations per document a score of 8.59 bigger than 5.52 of the second one.



Figure 131 - Overview of Scopus Industry 5.0 dataset not containing any of the 3 pillars (Human, Sustainable, Resilience)



Figure 132 - Overview of WoS Industry 5.0 dataset containing any of the 3 pillars (Human, Sustainable, Resilience)

Similar results are obtained from the WoS database. The dataset was obtained by using the search string in WoS: "Industry 5.0" AND ("Human*" OR "Resilien*" OR "Sustain*"). The dataset not containing any of the 3 Pillar terms was obtained by using the search string Search string in WoS: "Industry 5.0" NOT ("Human*" OR "Resilien*" OR "Sustain*").

If the two WoS datasets are compared, it can be easily observed the differences between them, more annual growth 128% vs 39%, more average citation per document (9.65 vs 8.54) even though the average age of the documents are lower (0.87 vs 1.23) and lastly the h-index of the first set is more than double (= 30) than the h-index of the second set (= 13).



Figure 133 - Overview of WoS Industry 5.0 dataset not containing any of the 3 pillars (Human, Sustainable, Resilience)

5.4 Industry 4.0 and Industry 5.0 coexist.

Industry 4.0 and Industry 5.0 coexist, since they are complementary to one another. As Industry 4.0 is more technological oriented, Industry 5.0 is not an integration of Industry 4.0 but rather is regarded as a new paradigm bringing new societal dimensions to Industry. Thus, Industry 5.0 relies on Industry 4.0's technological improvements but at the same time is oriented towards the 3 pillars as pointed out by EC: Human-Centricity, Sustainability and Resiliency. It helps to assess both their direct and indirect presence in the research literature.

5.4.1 Industry 4.0 and Industry 5.0 complement one another through Co-

Occurrence by keyword Network graph

Co-Occurrence by keyword Network graphs will be used to show that Industry 4.0 and Industry 5.0 are complement one another. Several topics are to be selected from the Co-Occurrence Network graphs described in Chapter 4 (paragraph 4.3). Scopus and WoS Industry 5.0 papers, through the VOSviewer co-occurrence by keyword Network graph, were used to reveal the impact of selected topics. As the option "All keywords" was used, both Author's keywords and Index by Scopus or Keyword Plus for Scopus and WoS datasets respectively, were used. The first two images are taken from the Scopus and WoS made graphs respectively when Human-Centricity was selected.

Human-centricity is a notable topic and is connected, in both graphs, with many other topics amongst them sustainability, resilience, European commission, personalization, society 5.0, human-robot collaboration, supply chain and more.



Figure 134 - Co-occurrence by keyword when Human-centricity is selected (Scopus and WoS)
Same as the previous one, to examine in the Industry 5.0 papers the impact of Sustainability the term sustainability was selected. The connections are very similar to Human-centricity mentioned above.



Figure 135 - Co-occurrence by keyword when Sustainability is selected (Scopus and WoS)

Next, the impact of Resiliency is to be examined.

Resilience is connected with just a few topics, such as sustainability, human-centricity, supply chain, uncertainty analysis, society 5.0, digitalization, industrial research, production system and data science in the Scopus graph whereas in the WoS graph resilience is connected to more terms. Sustainability, digitalization, human-centricity, AI, society 5.0, covid-19, supply chain, big data, IoT, challenges, digital twin, future, technologies, innovation and more.



Figure 136 - Co-occurrence by keyword when Resilience is selected (Scopus and WoS)

Not only from those 3 terms, but it can also be seen that Industry 5.0 is a new paradigm. Besides the technological oriented terms coming from Industry 4.0 which are present in the graphs, new dimensions were added and can be found, not only directly but also indirectly, within the Network co-occurrence graphs presented here. The selected terms were respectively, supply chain, supply chain resilience, human factors, social sustainability, human-robot collaboration and human-machine interaction in order to show the size of the new dimensions. The graphs are in pairs as they are taken from the Scopus Network graph the first and from the WoS Network graph the second.



Figure 137 - Co-occurrence by keyword when supply chain is selected (Scopus and WoS)



Figure 138 - Co-occurrence by keyword when supply chain resilience is selected (Scopus and WoS)



Figure 139 - Co-occurrence by keyword when Human factors is selected (Scopus and WoS)



Figure 140 - Co-occurrence by keyword when social sustainability is selected (Scopus and WoS)



Figure 141 - Co-occurrence by keyword when Human-robot collaboration is selected (Scopus and WoS)



Figure 142 - Co-occurrence by keyword when Human-machine interaction is selected (Scopus and WoS)

5.4.2 Industry 4.0 and Industry 5.0 complement one another through ATLAS.ti

concepts

ATLAS.ti was used to create, by selecting all contents of the collection of papers (title, abstract and keywords), the Word cloud and the Concept cloud respectively. The presence and the size of terms related to the 3 pillars are indications of their importance in these research works.

technological product social literature achieve require context performance enable method centric efficiency device collaboration datum network innovation factor environment chain paper machine abstract develop security
require context performance enable method need one intelligent improve device collaboration datum network innovation communication factor environment chain paper machine abstract develop security
device collaboration datum network innovation communication factor environment chain paper machine abstract develop security
device collaboration datum network innovation communication factor environment chain paper machine abstract develop security
factor environment ^{chain} paper machine abstract develop security
adstract develop security
real state approach development process Can will revolution field econom
show solution work design technology human well smart provide supply consider
business management
make analysis digital INCUSTRY at research society decision
increase analysis digital intervence inductrial we wait problem
value result time robot use root however industrial artificial and s
resource control application to role DIU system bace production 's focus sensor
indementation energy present
change concort manufacturing study
propose learning support impact and support
aution knowledge change information worker discuss
transformation numerous review physical high operator include quality
towards interaction took level operator
different issue service blockchain collaborative cyber

Figure 143 - Industry 5.0 Word cloud by ATLAS.ti



Figure 144 - Industry 5.0 Concept Cloud by ATLAS.ti

From the concept cloud various terms related to the 3 pillars were selected, to illustrate from which sentences they were derived from, that might help to understand the way these terms were used, and are presented in Appendix B.

The absence of the term Resilience should be noted, as the tool did not identify the term as important. Maybe this happened because the tool did not aggregate the different forms of expressing resilience as resiliency or resilient. In the contrary, Human centricity, sustainability and also other related to them terms concepts are highly present in the collection of papers examined.

6

Industry 5.0 in EU countries

As Industry 5.0 is a concept introduced by the European Commission, the European Union region shows a greater interest in human-centricity, sustainability, and resiliency than the rest of the world. From the dataset sources a study has been made, based on three different comparisons:

- 1. A metric to measure scientific production on a country level. The metric counts the number of times authors from a specific country appear in articles. If an article has multiple authors from different countries, each country represented by an author gets a count incremented by 1. However, due to this counting method, the total sum of the production indicator may exceed the total number of articles. This indicates collaborative efforts involving authors from multiple countries in various articles.
- 2. Following, the comparison between the number of sources, referring to at least one of the three pillars of Industry 5.0 i.e., containing any of the keywords Human-Centricity or Sustainability or Resiliency, from EU countries and non-EU countries.
- 3. Lastly, the Corresponding Author's Country analysis, which assigns each article to a country based on the corresponding author's affiliation. The frequency count for each country reflects the total number of articles from that country. Additionally, this method calculates the ratio of articles in which at least one author has an affiliation different from the corresponding author's country, called "Multiple Country Publications" (MCP).

From the 2 databases, Scopus and WoS, different datasets were acquired, either referring to at least one of the three pillars of Industry 5.0 i.e., containing the keywords Industry 5.0 AND (Human-Centricity OR Sustainability OR Resiliency) or Industry 5.0 documents not containing any of the three pillars.

Thus, a Scopus pillars and a Scopus non-pillars datasets and a WoS pillars and a WoS nonpillars datasets were made. A merging of the two pillars and the two non-pillars was made through R, but as has been already analyzed the merging process has some issues and some references were missed in the merging datasets resulting in numbers that were wrong for the Country Scientific Production and the Corresponding Author's Country. Therefore, the comparison was made separately for Scopus and WoS.

6.1 Countries Scientific production

First, from the two dataset sources made a comparison based on the countries scientific production. Authors from EU countries show a bigger interest regarding the new dimensions introduced by EC's Industry 5.0 definition.

region	I5.0 docs in	Containing at least one Billor	region	I5.0 docs in WoS	Containing at least one Billor				
INDIA	403	232	CHINA	159	106				
ITALY	220	193	ITALY	100	86				
CHINA	281	179	INDIA	129	79				
UK	106	87	UK	56	49				
SPAIN	92	87	PORTUGAL	55	44				
GERMANY					10				
	104	82	USA	60	43				
PORTUGAL	104 101	82 81	USA GERMANY	60 46	43				
PORTUGAL USA	104 101 94	82 81 65	USA GERMANY SPAIN	60 46 42	43 41 40				
PORTUGAL USA FRANCE	104 101 94 68	82 81 65 52	USA GERMANY SPAIN FRANCE	60 46 42 39	43 41 40 31				
PORTUGAL USA FRANCE IRELAND	104 101 94 68 73	82 81 65 52 48	USA GERMANY SPAIN FRANCE GREECE	60 46 42 39 30	43 41 40 31 29				
PORTUGAL USA FRANCE IRELAND SWEDEN	104 101 94 68 73 60	82 81 65 52 48 47	USA GERMANY SPAIN FRANCE GREECE PAKISTAN	60 46 42 39 30 38	43 41 40 31 29 26				
PORTUGAL USA FRANCE IRELAND SWEDEN AUSTRALIA	104 101 94 68 73 60 63	82 81 65 52 48 47 45	USA GERMANY SPAIN FRANCE GREECE PAKISTAN AUSTRALIA	60 46 42 39 30 38 30	43 41 40 31 29 26 25				
PORTUGAL USA FRANCE IRELAND SWEDEN AUSTRALIA PAKISTAN	104 101 94 68 73 60 63 72	82 81 65 52 48 47 45 43	USA GERMANY SPAIN FRANCE GREECE PAKISTAN AUSTRALIA IRELAND	60 46 42 39 30 38 30 28	43 41 40 31 29 26 25 24				

Figure 145 - Country Scientific production for Industry 5.0 documents containing at least one of the 3 pillars in Scopus (the first map) and WoS (the second map) respectively.

region	I5.0 docs in Scopus	Not Containing any of the 3 Pillars	region	I5.0 docs in WoS	Not Containing any of the 3 Pillars				
region	I5.0 docs in Scopus	Not Containing any of the 3 Pillars 171	region CHINA	15.0 docs in WoS 159	Not Containing any of the 3 Pillars 53				
region INDIA CHINA	15.0 docs in Scopus 403 281	Not Containing any of the 3 Pillars 171 102	region CHINA INDIA	I5.0 docs in WoS 159 129	Not Containing any of the 3 Pillars 53 50				
region INDIA CHINA USA	15.0 docs in Scopus 403 281 94	Not Containing any of the 3 Pillars 171 102 29	region CHINA INDIA USA	15.0 docs in WoS 159 129 60	Not Containing any of the 3 Pillars 53 50 17				
region INDIA CHINA USA PAKISTAN	15.0 docs in Scopus 403 281 94 72	Not Containing any of the 3 Pillars 171 102 29 29	region CHINA INDIA USA ITALY	15.0 docs in WoS 159 129 60 100	Not Containing any of the 3 Pillars 53 50 17 14				
region INDIA CHINA USA PAKISTAN ITALY	15.0 docs in Scopus 403 281 94 72 220	Not Containing any of the 3 Pillars 171 102 29 27	region CHINA INDIA USA ITALY PAKISTAN	15.0 docs in WoS 159 129 600 100 38	Not Containing any of the 3 Pillars 53 50 17 14 12				
region INDIA CHINA USA PAKISTAN ITALY SAUDI ARABIA	15.0 docs in Scopus 403 281 94 72 220 46	Not Containing any of the 3 Pillars 1711 1022 299 27 27	region CHINA INDIA USA ITALY PAKISTAN PORTUGAL	15.0 docs in WoS 159 129 60 100 38 55	Not Containing any of the 3 Pillars 53 50 17 14 12 11				
region INDIA CHINA USA PAKISTAN ITALY SAUDI ARABIA IRELAND	15.0 docs in Scopus 403 281 94 72 220 46 73	Not Containing any of the 3 Pillars 171 102 29 29 29 29 27 27 27 27	region CHINA INDIA USA ITALY PAKISTAN PORTUGAL RUSSIA SALINI	15.0 docs in WoS 159 129 60 100 38 55 28	Not Containing any of the 3 Pillars 53 50 17 14 12 11 10				
region INDIA CHINA USA PAKISTAN ITALY SAUDI ARABIA IRELAND GERMANY	15.0 docs in Scopus 403 281 94 72 220 46 73 104	Not Containing any of the 3 Pillars 1711 102 29 29 27 27 25 22	region CHINA INDIA USA ITALY PAKISTAN PORTUGAL RUSSIA SAUDI ARABIA	I5.0 docs in WoS 159 129 60 100 38 555 28 27	Not Containing any of the 3 Pillars 53 50 50 17 14 12 11 10 9				
region INDIA CHINA USA PAKISTAN ITALY SAUDI ARABIA IRELAND GERMANY POLAND	15.0 docs in Scopus 403 281 94 72 220 46 73 104 60	Not Containing any of the 3 Pillars 171 102 29 29 29 27 27 27 27 25 22 22	region CHINA INDIA USA ITALY PAKISTAN PORTUGAL RUSSIA SAUDI ARABIA FRANCE	15.0 docs in WoS 159 129 60 100 38 55 28 27 39	Not Containing any of the 3 Pillars 53 50 17 14 12 11 9 8				
region INDIA CHINA USA PAKISTAN ITALY SAUDI ARABIA IRELAND GERMANY POLAND PORTUGAL	15.0 docs in Scopus 403 281 94 72 220 46 73 104 60 101	Not Containing any of the 3 Pillars 1711 102 29 29 27 27 22 21 20	region CHINA INDIA USA ITALY PAKISTAN PORTUGAL RUSSIA SAUDI ARABIA FRANCE MALAYSIA	I5.0 docs in WoS 159 129 60 100 38 55 28 27 39 25	Not Containing any of the 3 Pillars 53 50 50 17 14 12 11 10 9 8 8				
region INDIA INDIA CHINA USA VSA PAKISTAN ITALY SAUDI ARABIA IRELAND GERMANY POLAND PORTUGAL UK	15.0 docs in Scopus 403 281 94 72 220 46 73 104 60 101 106	Not Containing any of the 3 Pillars 1711 102 299 299 297 270 270 270 270 270 270 270 270 270 27	region CHINA INDIA USA ITALY PAKISTAN PORTUGAL RUSSIA SAUDI ARABIA FRANCE MALAYSIA IRAN	I5.0 docs in WoS 159 129 60 100 38 55 28 27 39 25 11	Not Containing any of the 3 Pillars 53 50 17 14 12 111 10 9 8 8 8 8 8				
region INDIA CHINA USA PAKISTAN ITALY SAUDI ARABIA IRELAND GERMANY POLAND PORTUGAL UK AUSTRALIA	15.0 docs in Scopus 403 281 94 72 220 46 73 104 60 101 106 63	Not Containing any of the 3 Pillars 1711 102 29 29 27 27 22 21 20 19 18	region CHINA INDIA USA ITALY PAKISTAN PORTUGAL RUSSIA RUSSIA SAUDI ARABIA FRANCE MALAYSIA IRAN	15.0 docs in WoS 159 129 60 100 38 55 28 27 39 25 11 56	Not Containing any of the 3 Pillars 53 50 17 14 12 11 10 9 8 8 7				
region INDIA CHINA USA PAKISTAN ITALY SAUDI ARABIA IRELAND GERMANY POLAND PORTUGAL UK AUSTRALIA INDONESIA	15.0 docs in Scopus 403 281 94 72 220 46 73 104 60 101 106 63 28	Not Containing any of the 3 Pillars17111022929272725222120191818	region CHINA INDIA USA ITALY PAKISTAN PORTUGAL RUSSIA SAUDI ARABIA FRANCE MALAYSIA IRAN UK BRAZIL SOUTH	15.0 docs in WoS 159 129 60 100 38 55 28 27 39 25 111 56 17	Not Containing any of the 3 Pillars 53 50 17 14 12 111 10 9 8 8 7 7				

Figure 146 - Country Scientific production for Industry 5.0 documents not containing at least one of the 3 pillars in Scopus and WoS respectively.

The maps comparison shows that in European Union, authors are more interested in promoting the ideas of human-centricity, sustainability and resiliency, on average as a percentage compared to the rest of the world.

Secondly, using again the country scientific production, a comparison was made between sources referring to at least one of the three pillars of Industry 5.0, i.e., containing the keywords (Human-Centricity OR Sustainability OR Resiliency) AND Industry 5.0, from EU countries and non-EU countries.



Figure 147 - Percentage of I5.0 documents related to the 3 pillars based on the region

EU region countries show a higher interest in the three pillars. The 82% of the Industry 5.0 documents that originated from EU countries in the Scopus database and 85% in WoS database, are having an interest on human-centricity, sustainability or resiliency, compared to 66% and 71% respectively from the Industry 5.0 documents of non-EU countries. More analytically the data by countries gives in Scopus:



Figure 148 - Comparison of Scopus I5.0 documents in regard with the 3 pillars based on the region



The same, as with Scopus, can be observed with the WoS dataset:

Figure 149 - Comparison of WoS I5.0 documents in regard with the 3 pillars based on the region

6.2 Corresponding Author's Country.

Thirdly, the Corresponding Author's Country graph in Scopus, derived from Industry 5.0 documents, through Bibliometrix/Biblioshiny. The first graph, from the dataset that contains at least one of the 3 pillars, without containing any of the three pillars the second graph. It can easily be seen that the EU region countries are less present in the second than in the first graph.



Figure 150 - Corresponding Author's Country in Scopus; the first graph is made from the dataset that contains any of the 3 pillars of 15.0 whereas the second graph is made from the dataset that does not contain any.

Similar results can easily be seen and by the WoS datasets. The EU countries are less present in the second graph than in the first graph, meaning that authors from EU region are more interested in promoting ideas that incorporate with the new dimensions of Industy 5.0.



Figure 151 - Corresponding Author's Country in WoS; the first graph is made from the dataset that contains any of the 3 pillars of 15.0 whereas the second graph is made from the dataset that does not contain any.

7

Conclusions and Future Research

The bibliometric analysis performed on this work was held to answer research questions that were aiming in understanding the status of Industry 5.0.

7.1 Results and discussion

7.1.1 Results for the first RQ

Through the first RQ an overview of Industry 5.0 and the social structure of Industry 5.0 was revealed. In order to understand the spread of the topic and its acceptance globally, the following features through the analysis had been obtained:

1. Research volume and growth trend for Industry 5.0.

From 2018, more documents are published every year and from the 2023 it seems that the number of documents will continue to raise indicating an increased interest upon Industry 5.0.

2. Types of publications.

The types of publications are mostly articles and conference papers.

- Languages of publications.
 The vast majority of publications are written in English.
- 4. Distribution across different Subject Areas.Engineering and Computer Science are the main Subject areas of the researchers.
- 5. Top cited Publications.

Top cited publication in both databases is an article by Saeid Nahavandi, "Industry 5.0—A Human-Centric Solution," published in Sustainability- BASEL, in August 2019.

Other top cited publications are:

An article by Maddikunta, Praveen Kumar Reddy et al., "Industry 5.0: A survey on enabling technologies and potential applications.", published in Journal of Industrial Information Integration, in 2021.

An article by Xun Xu et al., "Industry 4.0 and Industry 5.0—Inception, conception and perception", published in Journal of Manufacturing Systems, in 2021.

The article that announced the emergence of the Industry 5.0 by Özdemir V, Hekim N., "Birth of Industry 5.0: Making Sense of Big Data with Artificial Intelligence, "The Internet of Things" and Next-Generation Technology Policy", published in OMICS, in 2018.

6. Most relevant and most influential Authors.

Through Lotka's law it was found that core authors published at least 3 documents. Most productive authors are:

Abonyi János 11, Elias G. Carayannis 9, Mary Doyle-Kent 8, Dimitris Mourtzis 8, Tamás Ruppert 8.

Authors with most local impact based on the h-index on both databases are:

Elias G. Carayannis and Lihui Wang.

7. Most relevant and most influential Affiliations.

In Scopus top affiliations, with 12 publications are: the Hong Kong Polytechnic University and the South East Technological University of Ireland.

From the ten most relevant affiliations in the research field examined in the Scopus dataset the most are from Europe. In precise, six are from Europe, three are from Asia and just one is from the USA.

In WoS top affiliations with 8 publications are: the University of Pannonia of Hungary and the South East Technological University of Ireland.

From the ten most relevant affiliations in the research field examined in the WoS dataset contains documents from more worldwide distributed affiliations. Four of them are from Asia, four from Europe, one from the USA and one is from Africa.

8. Most relevant and most influential Sources.

Most publications were published in below Sources:

In Scopus:

- IEEE Transactions on Industrial Informatics 28,
- Sustainability (Switzerland) 26,
- Applied Sciences (Switzerland) 23,
- Sensors 21

In WoS:

- Sustainability (Switzerland) 28,
- IEEE Transactions on Industrial Informatics 23,
- Applied Sciences-Basel (Switzerland) 22,
- Sensors 20

In Scopus to identify the most influential Sources, according to Bradford's Law the Core Zone consists of 19 journals (out of 377) that contain 254 relevant articles.

In WoS to identify most influential Sources, according to Bradford's Law the Core Zone consists of 10 journals (out of 226) that contain 157 relevant articles.

IEEE Transactions on Industrial Informatics and Sustainability are the top 2 sources with local impact based on h-index on both databases.

9. Major Sponsors.

It should be noted that while documents usually do not include a sponsor field, from those that have sponsors, they are primarily from Europe, specifically from the European Union and using EC funds but also from several other European countries including Portugal, Spain, Hungary, Italy, Slovakia, Slovenia, Ireland, and the United Kingdom. Leading sponsors have come from a number of other countries, including China, South Korea, Saudi Arabia, and Australia.

10. Most relevant and most influential Countries.

India has shown remarkable productivity in producing documents related to Industry 5.0 within the Scopus database. Since 2020, India has consistently held the first place, demonstrating a significant surge in research output compared to other countries. China and Italy secure the second and third positions, respectively. Notably, although India leads in productivity, China garners the highest number of citations in the Industry 5.0 field within Scopus, closely followed by Italy, Australia, New Zealand, India, the USA, South Korea, and Canada.

In the Web of Science (WoS) database, China, India, and Italy hold the top three spots in terms of both publications and citations. Until 2021, Italy held the top spot but has since moved to the third place in the last two years. Similarly, China retains its prominence as the most cited country in WoS for Industry 5.0, followed by the USA, Italy, Australia, New Zealand, India, South Korea, and Canada.

Notably, the top eight countries remain consistent across both databases, with a few variations in their rankings. A unique perspective can be gained by analyzing a country's dimension based on the corresponding author's affiliation. Here, a significant contrast emerges between China, India, and Italy, the leading countries in terms of publication. For China, approximately 60% of publications involve

international collaborations, while for India, this stands at around one-third, and for Italy, it's about a quarter of the total publications within the country.

The Bibliographic coupling analysis, the Citation by countries and Co-authorship by countries, were used with VOSviewer and the Collaboration Network of the Countries with Bibliometrix/Biblioshiny to show connections between the countries. By these network graphs the collaboration between authors of different countries can be revealed, of how authors relate to others in the field of Industry 5.0, helping to understand the social structure of the Industry 5.0's research academic community.

The bibliographic coupling analysis is a sign that there is likelihood that the two works cover the same topic of study. Bibliographic coupling analysis, offer a picture of the state of the research field presently [70], shows a connection between many European countries. Brazil and Iran share a connection with Germany, Norway and Netherlands. Sweden is connected with China. Also, a connection exists between Australia, Pakistan, Saudi Arabia, Canada, S.Korea, Turkey, Malaysia and U.A.E.

In the Citation by countries Network graph, the relatedness of articles is more clearly demonstrated through direct citations. Discoveries made include India, Italy, Saudi Arabia and Brazil belong to the same cluster, same with China and Pakistan, USA and Spain, Greece and Canada. Poland, Sweden, Hungary and Slovakia, Austria, Ireland and Iran also construct a cluster. Moreover, although not in the same cluster, Germany is related with Portugal and France.

Co-authorship by countries is the next network graph. Writing a study in collaboration with another author is known as co-authorship. Information about any country's international co-authorship can be gathered via this Network. Co-authorships occur between authors from: Greece and for instance UK (or England in WoS), UK (or England in WoS) and China, China and USA, Germany and Hungary, China and Australia, India and Saudi Arabia, India and USA, China and Sweden, Portugal and Spain, Italy and France, China and Sweden, Poland and Lithuania, Poland and Slovakia, Italy and Germany, Germany and France etc

The last graph is a Collaboration Network of the Countries with Bibliometrix/Biblioshiny. India is the most significant county in the network, followed by Italy and China. India and USA have the most synergies followed by India-Portugal, India-China and China-USA collaborative couples. Two are the most significant clusters. India, China, USA, Portugal, Russia, Germany and Malaysia form the one Cluster. The other significant cluster is with Italy, Spain, France, Croatia, Greece, South Africa, Turkey, Saudi Arabia, Norway, Slovenia and Austria.

7.1.2 Results for the second RQ

For the second RQ the current research directions in the area of Industry 5.0 has been identified and the conceptual structure of Industry 5.0 has been revealed.

- 1. Based on the Word cloud and Concept cloud generated by the ATLAS.ti program with different fields: the Author's keywords, the titles and the Abstract using the merged dataset, the Scopus keywords using the Scopus dataset or the keyword plus field using the WoS dataset, it can be observed that Industry 5.0 has a human/social/environmental perspective. Various Industry 4.0 technologies appear, upon which Industry 5.0 will be based, to achieve the transition from Industry 4.0 to Industry 5.0. Digitalization, artificial intelligence, smart manufacturing, technology, internet and machine learning are among the most used terms in the Word cloud. The human/social/environmental factors to achieve the Industry 5.0's pillars (human, sustainability and resilience) Sustainability and sustainable are highly used, society and centric are also terms that often occur. Other used terms are innovation, transformation, IoT, robot, supply chain etc. In the concept cloud Human is a major term, were center, centric, centricity, human centric, human factors, that are relative terms to human can be found. Sustainability, sustainable, resilience, social is another group of relative terms. Thus, the EC definition can be produced by the terms contained in the concept cloud.
- 2. For the second analysis a *co-word network analysis* was used. The VOSviewer co-occurrence of keywords Network Visualization helps by various means to identify useful knowledge, first by the formed clusters. Industry 5.0 forms the largest cluster that contains Industry 4.0, human-centricity, sustainability, personalization, Society 5.0, green, supply chain, resilience, circular economy, SMEs, etc. IoT is the second largest cluster that includes blockchain, energy efficiency, big data, automation, Industrial IoT, 5G/6G, cloud computing, edge computing, machine learning, deep learning, security. A third notable cluster is the Human-robot collaboration cluster, that contains smart manufacturing, robotics, robots, human-robot collaboration, cobots and human-machine interaction.

The relationships in the graph can be studied to learn helpful details. For instance, the operator safety is an issue related to human-centricity, to worker and sustainability in the Industry 5.0 and Industry 4.0 context. Also, it is related to Human-robot collaboration, as well to accident prevention and to decision support systems. Or it can be seen that personalization is an issue related to Industry 5.0, Industry 4.0, AI, technologies, human-centricity, Society 5.0, metaverse and privacy.

The keyword plus WoS field produced a graph that reveals the conceptual basis upon which the Authors work was based on. The absence of the term human is worth to be noted. 6 clusters were formed; One is the system, management, model cluster that contains the resilience term. Also contained in this cluster are terms such as optimization, algorithm, networks, resource allocation and machine. The AI, CPS, Big data, Internet, supply chain, digital twin, blockchain, things, IoT, security is the largest cluster. The technologies cluster with Industry 4.0, integration, service and robots. The framework, future cluster, with terms such as performance, decision making, impact, implementation, collaboration and more. And finally, the sustainability cluster containing circular economy, VR, digitalization and innovation.

- 3. On the *Trend Topics* derived from the Bibliometrix/Biblioshiny graph, Resilience is found as a promising topic in 2023, as Human-Centricity was found in 2022 and SMEs in 2021.
- 4. Another overview through the *Three-Field Plot*, by Title, Countries and Author's keywords, shows the connection between the countries of the Authors, and the titles and keywords that they use. Sustainable is a term that appears in the title of all countries displayed for at least one document except for Germany. Sustainability as an Author's keyword appears in at least one document from all countries appeared in the graph except Turkey and Pakistan, whereas resilience appears in at least one document from China, Italy, UK, Portugal, USA, Spain, Germany and Australia. Furthermore, Society 5.0 does not appear in the keywords list to any document retrieved from USA, Germany and Poland.
- 5. *Most Frequent Words*, is a graph made by Bibliometrix/Biblioshiny, based on Author's keywords top 5 words are Industry 5.0, Industry 4.0, human-centricity, AI and sustainability. The Word cloud from the Bibliometrix/Biblioshiny using the Abstract's bigrams gave as top terms: Artificial Intelligence, industrial revolution, supply chain, machine learning, sustainable development, digital transformation and digital twins.
- 6. The Industry 5.0 evolution was examined through the VOSviewer tool by the *Cooccurrence of keywords* Network Visualization and Density Visualization. While for the first period, 2019-2020 the papers of this period mostly reflect technology values, in the 2021 papers beside technology factors the new dimensions introduced with Industry 5.0 can be found such as sustainability, human-centricity (workers, human-robot collaboration, Operator 4.0, human, humans) and Society 5.0. The 2022 graph was richer in concepts than the previous year. In the new concept's list, terms included, are resilience, wellbeing and personnel amongst others. Finally, the 2023

graph made was similar to 2022 with the only difference that the sustainability cluster has been expanded.

- 7. *The thematic evolution* from Bibliometrix/Biblioshiny shows the transition from Industry 4.0 concepts to Industry 5.0 concepts. It shows a transition focus from a technology-based perspective to Human and Sustainability perspective. Sustainability was from the beginning in the research focus, as concerns about sustainability was in the focus from Industry 4.0 but human workers concerns raise in recent works.
- 8. *Co-word analysis* was the next method used through Bibliometrix/Biblioshiny, in order to identify clusters of keywords, known as themes, that visually represented on a two-dimensional thematic map. The position of each theme on the map provides information about its characteristics and significance within the research field.

In the early years 2018-2021 many clusters have been identified as Motor Themes. They primarily include technological factors. In the next period only one cluster (the IOT, AI, blockchain cluster) remains in the Motor Themes. The Industry 5.0 cluster in the last period while probably has changed its focus and is more human-centric, is placed in the Basic Themes. It is expected that the relevance degree of the Industry 5.0 cluster will be high, that is why it can be found in both maps on the rightest position. In the first period that the tool interprets the Industry 4.0 - Industry 5.0 cluster, the technology with human interaction cluster and blockchain cluster, the IoT and AI cluster, the cobots cluster and the manufacturing cluster were well developed, sustainability is emerging.

Whereas, in the second period Industry 5.0 cluster is decreasing its density degree as it has a human-centricity focus and resilient is a new topic in this cluster. Moreover, Sustainable development with AI and human form a cluster positioned in the map's center. Human factor and cobots may not be extensively developed but are relevant across different research areas and sustainability in a different cluster is still emerging.

The Thematic map for the whole period of our research (2018-2023) through Bibliometrix/Biblioshiny shows 5 clusters. The cluster with the highest centrality, that is the most relevant to the topic cluster, is the Industry 5.0 – Industry 4.0 – human-centricity cluster but with medium density, that is, it is not fully developed. That is why it is half in the Motor Themes quadrat and half to the Basic Themes quadrat. With less centrality but more density from the previous cluster is the IoT – blockchain - Industrial IoT cluster and it is placed in the Motor Themes quadrat. The next cluster based on the order of the centrality degree is the sustainability – supply chain – technologies – resilience cluster that half belongs to the basic and half to the

Emerging or Declining Themes quadrat. The next cluster with less centrality than the previous one but with little more density of it is the Energy efficiency cluster belonging as well to the Emerging or Declining Themes quadrat. Finally, the smaller cluster is the reliability cluster that has low centrality but high density and belongs to the Niche Themes quadrant.

- 9. Using *factorial analysis*, a conceptual structure map was created. Thus, it can be identified in the generated graph that resilience and sustainable development are related. Also, human centricity is closely related to resilience and sustainable development. Furthermore, Sustainability is close to human-robot interaction and supply chain. Industry 5.0 and Industry 4.0 are very close related terms. Moreover, close are Human centric to human robot collaboration, and human robot collaboration to Operator 4.0 and digitalization.
- 10. The last analysis method for the second research question to discover emerging fields and research trends, conducted using the ATLAS.ti tool, was *Opinion Mining* a sentiment mining method. The positive quotes produced are more than the negative in our collection. More specifically, the positive quotations in Scopus are 1042, whereas the negatives are 904. In WoS respectively 258 versus 111. In the merged dataset (Scopus and WoS) there are 1094 positive compared to 928 negatives quotations. As positive sentiment may imply something new, that will bring changes with positive impact whereas negative sentiments may imply the obstacles to achieve the transition from Industry 4.0 to Industry 5.0, by reading these quotes either positive or negative, helps any researcher to develop his/her understanding on the evolution of Industry 5.0.

The tool's interactive interface, helps to have a quick and detailed overview of the scientific field and support previous discoveries made using other methods. The findings of this research regarding Industry 5.0 have been substantiated.

7.1.3 Results for the third RQ

For the third RQ, to determine what trajectory Industry 5.0 is taking, the analysis began on finding the percentage of Industry 5.0 articles in the two databases that contain at least one of the three pillars of Industry 5.0 and consequently comparing the influence of the articles containing one of the three pillars to those not containing.

Firstly, the findings in the Scopus database were:

• in 2019 35% of the Industry 5.0 involved Human-centricity whereas 60% of the Industry 5.0 articles involve it 2023;

- in 2019 6% of the Industry 5.0 involved Sustainability whereas 35% of the Industry 5.0 articles involve it 2023;
- in 2019 0% of the Industry 5.0 involved Resiliency whereas 18% of the Industry 5.0 articles involve in 2023;
- in 2019 41% of the Industry 5.0 involved any of the 3 pillars whereas 75% of the Industry 5.0 articles involve any in 2023.

Respectively the WoS findings were:

- in 2019 27% of the Industry 5.0 involved Human-centricity whereas 64% of the Industry 5.0 articles involve it 2023;
- in 2019 18% of the Industry 5.0 involved Sustainability whereas 39% of the Industry 5.0 articles involve it 2023;
- in 2019 0% of the Industry 5.0 involved Resiliency whereas 21% of the Industry 5.0 articles involve in 2023;
- in 2019 36% of the Industry 5.0 involved any of the 3 pillars whereas 83% of the Industry 5.0 articles involve any in 2023.

The analysis continued, with acquiring two datasets from each of the scientific databases, with one encompassing any of the three pillars and the other devoid of all three.

The documents that contain Human-centricity, Sustainability, and Resilience was found that are used on average more frequently as references from the researchers than the other set of documents, according to the Citation Overview via Bibliometrix/Biblioshiny.

For the Scopus database, the h-index for the set including any of the three pillar terms in the title, abstract, or keywords fields is 32, while the h-index for the second set devoid of any of the three pillar terms is 16. Furthermore, the first set's yearly growth rate is 184%, compared to the second set's 57%. Furthermore, despite the fact that the first dataset's documents are on average 1.17 years older than the second's, meaning that the second's documents have been published for longer on average, the first dataset has an average of 8.59 citations per document, which is higher than the second dataset's average of 5.52.

The results from the WoS database are comparable to those from Scopus because the set containing any of the three pillars has a higher annual growth rate (128% vs 39%), more average citations per document (9.65 vs 8.54) despite a lower average document age (0.87 vs 1.23), and a higher h-index of the first set (= 30 that is more than double) than the h-index of the second set (= 13).

Furthermore, as Industry 4.0 and Industry 5.0 coexist in a complementary manner, where Industry 5.0 introduces new societal dimensions without being a mere integration of Industry

4.0; Industry 5.0 relies on the technological advancements of Industry 4.0 while emphasizing the three pillars of Human-Centricity, Sustainability, and Resiliency as highlighted by the EC. The examination of their presence in research literature involves two approaches: 1) Utilizing the VOSviewer Co-Occurrence keyword network graphs to showcase their mutual reinforcement, and 2) Utilizing ATLAS.ti to create Word Clouds and Concept Clouds from the entire paper collection (titles, abstracts, and keywords), where the presence and size of terms related to the three pillars serve as indicators of their significance in the research works.

The presence of Human/Sustainable/Resilient oriented terms shows the size of the new dimensions introduced by the new paradigm. Human-centricity and Sustainability are notable topics and are connected, with many other topics amongst them sustainability, resilience, European commission, personalization, society 5.0, human-robot collaboration, supply chain and more. Moreover, Resilience relates to just a few topics, such as sustainability, human-centricity, supply chain, uncertainty analysis, society 5.0, digitalization, industrial research, production system and data science in the Scopus graph whereas in the WoS graph resilience is connected to more terms. Sustainability, digitalization, human-centricity, AI, society 5.0, covid-19, supply chain, big data, IoT, challenges, digital twin, future, technologies, innovation and more.

Using the title, abstract, and keywords from each paper in the collection, ATLAS.ti was used to build the Word cloud and the Concept cloud. The presence and prominence of terms connected to the three pillars in these research papers serve as indicators of their significance. Furthermore, different terms relating to the three pillars were chosen from the concept cloud to demonstrate the phrases they were generated from, which helps to clarify how these concepts were employed. It is essential to note that the phrase "resilience" is missing maybe because the tool did not consider it to be significant. This might have occurred because the tool did not combine the many ways to express resilience as resiliency or resilient. On the other hand, the collection of articles under consideration heavily incorporates the concepts of human centricity, sustainability, and other terminology linked to them.

The overall findings show that the 3 new dimensions, human-centricity, sustainability and resiliency, are getting more prevalent in the research literature.

7.1.4 Results for the fourth RQ

For the fourth RQ, the higher interest in human-centricity, sustainability, and resiliency of Industry 5.0 in EU region compared to the rest of the world was examined.

First, from the two dataset sources made a comparison based on the countries scientific production. The maps comparison shows that in European Union, authors are more interested

in promoting the ideas of human-centricity, sustainability and resiliency, on average as a percentage compared to the rest of the world.

Secondly, using again the country scientific production, the comparison between sources referring to at least one of the three pillars of Industry 5.0 from EU region countries and non-EU countries. EU region countries show a higher interest in the three pillars. The 82% of the Industry 5.0 documents that originated from EU countries in the Scopus database and 85% in WoS database, are having an interest on human-centricity, sustainability or resiliency, compared to 66% and 71% respectively from the Industry 5.0 documents of non-EU countries.

Thirdly, the Corresponding Author's Country graph in Scopus, derived from Industry 5.0 documents, through Bibliometrix/Biblioshiny. Two graphs, were made by each database, one from the dataset that contains at least one of the 3 pillars, without containing any of the three pillars the second graph. EU region countries are less present in the second than in the first graph, meaning that authors from EU region are more interested in promoting ideas that incorporate with the new dimensions of Industy 5.0.

7.2 Summary and conclusions

Industry 5.0 is a novel concept, currently evolving. As different definitions are given for Industry 5.0, different approaches, have been proposed, on the way it should be implemented. Thus, different ideas on what it involves and how to get there. As the most prominent definition of Industry 5.0 was given by the EC, inspired by that, the majority of Industry 5.0's researchers from EU region countries are emphasizing on the human, environmental and social dimensions of Industry 5.0.

Although the majority of researchers, who are influenced by the EC definition more and more every year as the new dimensions introduced gain popularity, envision Industry 5.0 to represent a fresh phase of industrialization centered around humans, resilience, and sustainability, there are still many researchers, mainly from non-EU region countries, for which Industry 5.0 reflects a new revolution having a technological focus.

The science mapping performed, using structures of Knowledge, through statistical analysis of scientific information, facilitate insights into the overarching themes and trends of Industry 5.0. The COVID-19 pandemic underscored the significance of employees and prompted a reevaluation of the Industry 4.0 concept, culminating in the emergence of Industry 5.0, which integrates social and environmental dimensions into the framework of Industry 4.0. Industry 4.0 is technology-driven, emphasizing efficiency and productivity, while Industry 5.0 prioritizes worker well-being and sustainability, ensuring long-term business viability.

Resource limitations (technological, human resources, financial, knowledge), put barriers in a large percentage of mainly SMEs to adopt the principles of the 4th industrial revolution creating a technological gap between large robust enterprises and small and medium ones. The reevaluation of barriers in Industry 4.0 implementation was prompted by factors such as personalized products and challenges encountered by SMEs, crucial economic contributors facing technology-related hurdles. Readiness assessment and technology selection are pivotal, with emphasis on a human-centric manufacturing approach.

Industry 5.0's overarching objective is not just job creation and economic progress, but wealth generation through technology, respecting ecological limits, and prioritizing the well-being of industrial workers. Human-Centricity necessitates addressing education, training, and skills for the digital shift, acknowledging retraining limitations. Sustainability involves optimizing output and resources with the principle "Better with less", considering circular economy principles. Resiliency involves adapting to global shifts, both geopolitical (e.g., conflicts, trade issues) and natural (e.g., pandemics, climate change), while maintaining resilience across factory, supply, and system levels, despite potential cost-efficiency fragility.

Nevertheless, Industry 4.0 and Industry 5.0 coexist. While Industry 4.0 has already transformed economies and business operations through connected technology, Industry 5.0, seeks to empower humans with advanced technologies like AI and robotics for safer and more meaningful work. Industry 5.0 builds upon Industry 4.0's foundation by emphasizing collaboration between humans and technology, fostering efficiency and productivity. It shifts focus from what workers do with technology to what technology can do for workers, promoting a more cooperative approach. Having a central theme of placing human well-being and creativity at the core, Industry 5.0 expands Industry 4.0.

7.3 The challenges and projected future of Human-Centered

Industry

Because of the rapid pace at which technology is developing and the difficulties that lie ahead, industry must adopt more and more cutting-edge and modern technologies but must adopt a human-center perspective. Skilled workers should be in the center of production, with concerns on the Environmental impact. Sustainability and Resiliency are key factors to get to a better society and prioritize human values.

Industry 5.0 emerged due to limitations in the implementation of Industry 4.0. SMEs are significant factors in the development of the global economy and the creation of jobs, could not participate in industry 4.0 due to their well-known resource limitations in terms of personnel, technology, and budget. Major Political, Social and Environmental crises

emphasized the importance of workers and generated attention for the environmental and social impact of Industry. Furthermore, young generation of workers, Millennials and Zoomers, are among the most passionate supporters of worker welfare and stress the importance of human aspects in the working environment of the coming years. The bibliometric analysis demonstrates the shift towards a societally focused industry, a more resilient and sustainable industry that is enhancing humanization and protect the environment. Although the business industry is gradually coming to recognize bibliometric analysis as a valuable tool, not just for academic bibliometricians [94], and the research interest in Industry 5.0 is high while is still evolving, indicating a prominence future for Industry 5.0, the prediction made from the bibliometric analysis of Industry 5.0 cannot be long-term. Any bibliometric analyses are only able to provide short-term predictions for the research sector thus, the direction industry 5.0 appears to be taking may change [70]. Hence, the analysis should be performed again to determine how industry 5.0's will evolve in the future.



Figure 152 - Industry 5.0 definition by EC – human-centric, resilient and sustainable approach [14]

8

Appendices

8.1 Appendix A – Opinion Mining

The Scopus and WoS datasets that were collected for the purpose of this study, were exported to BibTeX format and imported in the ATLAS.ti tool. The duplicates were removed, and then the opinion mining method was done. From the outcome of this procedure, a number of screenshots were taken, some of which are given below and feature either positive or negative matches of terms in order to address the concept of Industry 5.0.

8.1.1 Opinion Mining for Revolution

The Positives matches for the term revolution are presented first:

revolution		45 Matches							
0	. Indust	ad and a second	All (45) fou next (2) nex industrial and s	rth industria kt industrial ocietal (1)	I (11) fiftI (2) contir more hum industrial (1)	h industrial (7) huous (1) di an centered (1)	industrial (7 igital (1) fir new (1)) fourth (2) st industrial (1) new technolog technical (1)	new industrial (2) ical and industrial (1) technological (1)
	9	19 1 5 in <i>Marić (2023)</i> - oretical frameworks, summarized respective adoption and governa resources; innovation; analyzed, and research Industry 5.0, future of 1	Innovation mand and future resear ly as: industrial re- nce; performance and sustainability predictions are p governance and 3 20 The Anotae	gement of ch trends. I evolution; s ; risk and u / and circul provided wi DP adoptic	three-dimen Major resear strategy; tecl incertainty; I ar economy th regards to on, operation	nsional printin ch themes, hnology human r, are closely o the topics of ns performa	g (3DP) t > + Opinio Sentin	on Mining: revo nent: Positive	No Co lution
		sty 5.0 focuses on so sustainability, and resil industrial and societal is the	poiety and the environment ience should become revolutions One of	vironment. ome a mor of the enab	Human cen e integral pa ler technolo	tricity, art of both gies for both	+ Opinia Sentin	on Mining: revo nent: Positive	lution
		122 fl 5 in <i>Pizoń (2023)</i> s and what technolog relationship are illustra changes in manufactu occurred in line	- Human–Machir gy was available a ted by <mark>successive</mark> ring paradigms. T	ne Relation: It the time, Industrial The change	ship—Persp Changes wi revolutions in the relation	ective and Fut thin this as well as onship	t ure Road 7	on Mining: revo nent: Positive	No Co lution
		171 11 5 in <i>Mahmood (2</i> The continuous revolu significant role in the co Industry 5.0, autonome autonomous and intel	023) - A Neural Co tion in Artificial Ir levelopment of kr ous decision-mak ligent robots a	omputing-l ntelligence ey consum ing, fault d	based Acces (Al) has play er applicatio liagnosis, etc	s Control Proto yed a ons, including c. In practice,	ocol for Al ⊅ + ○ Opinio ◇ Sentin	on Mining: revo nent: Positive	No Co lution
	9	175 11 5 in <i>Xian (2023)</i> - A revolution in advance technology in the four and has resulted in a si paradigm of Industry 5	Advanced Manu ed manufacturing th industrial revol ubstantial increase .0, advanced mar	facturing i g has been lution, also e in profits nu	n Industry 5. driven by di known as Ir for the indu	0: A Survey of igital ndustry 4.0, istry, In a new	Key Ena ⊅ + ○ Opinio ◇ Sentin	on Mining: revo nent: Positive	No Co lution
	9	235 11 5 in <i>Chandel (20</i> In today's time, with th both customers and or information than ever challenging, Industrial	23) - Technology , e digital revolutio ganizations are g before, making o Revolution 4.0 leo	Aspects of an and the etting expo rganization d to the em	Artificial Inte advent of te osed to a lare al decision i nergence o	elligence: Indu echnologies ger amount of making	stry 5.0 f 7 + Opinio Sentin	on Mining: revo nent: Positive	No Co lution
	3	241 11 5 in Akinsolu (20 I technologies are co implications of its app engineering managers manufacturing and ind revolution and more re	23) - Applied Artij ntinuously being lications have rela who are key play Justrial productio ecently, the fifth i	ficial Intelli harnessed. atively rema ers in the g n toward th ndustrial re	gence in Ma Consequen ained a gray gravitation of he fourth ind volution, ge	nufacturing a tly, Al and the area for many f dustrial merally	nd Indus ? + Opinio Sentin	on Mining: revo nent: Positive	No Co lution

Figure 153 - Opinion Mining for Revolution - Positive quotes

The Revolution negative matches identified are:

revolutior	ı	8 Matches			
2 0 International Contention	retinder	And and a second s			
		All (8) fifth industrial (2) fourth industrial (2) new	kt industrial (2) industrial	(1) technological (1)	
	9	37:1 11 5 in Nayeri (2023) - Designing an IoT-enabled supply chain network con The rapid growth of technology, environmental concerns, and disruptions	nsiderin ↗	No Coc	
		caused by the COVID-19 pandemic have led researchers to pay more attention to an emerging concept called the fifth industrial revolution (I5.0). Despite the high importance of the I5.0, the lit	 Sentiment: Negative 		
			durature of the	No Cor	
		the fifth industrial revolution or Industry 5.0. Hence, the first half of the	Opinion Mining: revolution		
		paper outlines the enabling technologies of Industry 4.0 and conceptualizes	♦ Sentiment: Negative		
		socio-economic challenges of the technologie			
		83:2 1 5 in Raja Santhi (2023) - Industry 5.0 or industry 4.0S? Introduction to in	dustry 4 🤊	No Coc	
		hey can overcome the challenges of Industry 4.0. The definition of	Opinion Mining: rev	olution	
		sustainability thermina 'a new term coined by the authors, and the reasoning for calling the next industrial revolution "Industry 4.05" (another new term) rather than Industry 5.0 are also presented. © 2023, The Author(s), under exclusive licence t	○ Sentiment: Negative		
		426:1 🛚 5 in Shahbakhsh (2022) - Industrial revolutions and transition of the m	aritime 🕫	Νο Coc	
		e in the expected current industrial revolution. As a result, there is a	Opinion Mining: rev	olution	
		generation of industrial revolution, namely Industry 5.0. This paper suggests that the impact of this revo	◇ Sentiment: Negative		
		544:1 🛚 5 in Olaizola (2022) - Artificial Intelligence from Industry 5.0 perspective	e: ls the ↗	No Coc	
		Industry 5.0 has been defined on the basis of principles of Human Centrality, Sustainability, and Resiliency by considering that the fourth industrial	Opinion Mining: rev	olution	
		revolution does not pursue these goals. This new vision, fostered by the European Commis	Sentiment: Negative		
	9	680:1 11 5 in Margherita (2021) - Socio-technical perspectives in the Fourth Indu	ıstrial R 🤊	Νο Ϲοϲ	
		perspective of the Fourth Industrial Revolution. The fourth industrial revolution refers to the novel wave of advanced technologies – like Robotics, the Internet of Things, Big Data – that are adopted in manufacturing organisations. Scholars and practitioners have forecasted the f	 Opinion Mining: rev Sentiment: Negative 	plution	
		683:1 11 5 in Doyle-Kent (2021) - Adoption of collaborative robotics in industry	5.0. An I ㅋ	No Coc	
		and robotics in their manufacturing industries. Looking forward, Industry	◇ Opinion Mining: revolution		
		Collaborative Robotics will play a significant r	Sentiment: Negative		

Figure 154 - Opinion Mining for Revolution - Negative quotes

Positive quotes for the term Centric:

centric	32 Matches						
27 0	and the set of the set						
		All (32)	human (27)	sustainable human	(3) m	nore human (1)	more patient (1)
	32 11 5 in Pang (2 for manual assi experimental rest can detect poten information after human centric in	023) - A verification stance in human-o ilt shows that the p ial part errors and manual assembly telligent manufact	n-oriented and centric assemb proposed mor track assembl work, which i turing system	<i>l part-focused as</i> ly. The ittoring system y process s significant for development	. ⊿ + ○ Opi ◇ Sen	No nion Mining: ce timent: Positive	Cod ntric
	 40 1 5 in Li (2023) 	- Proactive huma	n–robot collab	oration: Mutual-c.		No	Cod
	sical and psych to these realistic obvious trend, co technologies of P and research topi manufacturing ei	blogical load of hu needs, this paper p ncept, systematic roactive HRC, serv c for future work i a, Human–robot s	iman operator resents our ar architecture, a ring as a prosp n the <mark>human-</mark> symbiotic relat	s. In response guments on the ind enabling ective vision centric smart ion is evolvin	+ Opi Sen	nion Mining: ce timent: Positive	ntric
	9 44 11 5 in Hussain Purpose: With an hospitality indust anticipated, chara a human-centric ability a	(2023) - Next gene industry 5.0 revolu ry, a shift from ma icterized by greate approach. In this r	eration emploj ution taking pl anual to cogni er sustainabilitj egard, hospita	vability and caree. ace in the tive labor is 7, resilience and lity educators'	7 + Opi Osen	No inion Mining: ce timent: Positive	Cod ntric
	52 11 5 in Sucia (2 will change ma solution to dimin and prepare the s order to better in	023) - Core Compe ny jobs in most are ish these negative hift to a more hun plement this alter	etence—As a K eas of activity. effects is to ac nan-centric ap native so	ey Factor for a Su One alternative ccommodate proach. In	↗ + ○ Opi ○ Sen	No inion Mining: ce timent: Positive	Cod ntric
	85 fl 5 in Li (2023) With the emerger manufacturing p (robots, etc.) inte dynamic and cor human-robot int	- An AR-assisted nce of Industry 5.0, aradigm requires n ractively assist hur nplex production t eraction (HR	Deep Reinford , the human-c nanufacturing nan workers t iasks. To achie	ement Learning entric equipment o deal with ve symbiotic	. ⊅ + ◇ Opi ◇ Sen	No nion Mining: ce timent: Positive	Cod ntric
	112 1 5 in Shukla ology with com centric that prom coupled with resi technologies with pandemic has given	(2023) - Industry 5 nected value chain otes talents, divers lience leading to a prime focus on s en impetus to dig	.0 and digital across sector sity and empo gile and adapt ustainability. 7 it	innovations: Ante. s. It is human werment able he COVID-19	7 + Opi Sen	No nion Mining: ce timent: Positive	Cod ntric
	162 1 5 in Gomat s, and technolo discusses Healthe neuropoliced mark	hi (2023) - Industry gy in the manufac are 5.0's potential	v 5.0 for Health turing industr s and opportu	care 5.0: Opport y. The study nities, including	≯ + ○ Opi ◇ Sen	No nion Mining: ce timent: Positive	Cod ntric

Figure 155 - Opinion Mining for Centric - Positive quotes
Negative quotations with the term Centric:

centric 14 Matches	
11 11 5 in Tóth (2023) - The human-centric Industry 5.0 collaboration architecture at is more value-driven than technology-centric. The key objectives of the Industry 5.0 paradigm, which were not central to Industry 4.0, underscore that production should not only be digitalized but also resilient, sustainable, and human-centric This paper is focusing on the human-centric pill	a t + ○ Opinion Mining: centric ○ Sentiment: Negative
70 1 5 in Sitarević (2023) - The Psychosocial Model of Absenteeism: Transition from 4.0 to 5.0 ristics, and the mental health of the employees. The results support the premises of Industry 5.0 and offer a new human-centric approach to absenteeism through the promotion of mental health through long-term organizational strategies and a more inclusive approach to employees' preferences in relation to job characteristics. The study offers a new, double-sided model of ab	A Image: https://www.amage.com/imag
97 11 5 in <i>Luczak (2023) - Cloud Based Fault Diagnosis by Convolutional Neural Network as Time-Frequen</i> The human-centric and resilient European industry called Industry 5.0 requires a long lifetime of machines to reduce electronic waste. The appropriate way to handle this problem is to	ngy RGB I > + Opinion Mining: centric Opinion Sentiment: Negative
142 1 5 in Tu (2023) - TwinXR: Method for using digital twin descriptions in industrial eXtended reality ap Digital twins (DTs) and eXtended Reality (XR) are two core technological enablers for engineering in the Metaverse that can accelerate the human-centric Industry 5.0 transformation. The digital twin technology provides a digital r	p lications > 1 + Opinion Mining: centric Opinion Mining: Centric
240 1 5 in Wan (2023) - Human-centric zero-defect manufacturing: State-of-the-art review, perspectives s and resistance to changes in their work tasks. This paper can contribute to paving the roadmap of human-centric ZDM to bring defects to zero and reposition the manufacturing sector to become more resilient.	r, and cha ス ト + ○ Opinion Mining: centric ○ Sentiment: Negative
410 1 5 in Eriksson (2022) - Experiences in Running a Professional Course on Digitally-Enabled Production mplex challenges in industry 4.0 implementation. To conclude, the importance of lifelong learning in relation to the human-centric approach of industry 5.0 is emphasized as a future direction.	n in Colla > - Opinion Mining: centric Sentiment: Negative
540 11 5 in Kim (2022) - Human Digital Twin System for Operator Safety and Work Management shift in the approach towards worker well-being. However, the understanding of the effects on workers due to technological advancements of Industry 4.0, based on a human-centric approach, is limited. The reason for this limitation is that the tools	↗ ► + ○ Opinion Mining: centric ○ Sentiment: Negative

Figure 156 - Opinion Mining for Centric - Negative quotes

Centricity positive quotations, and for Centrality one positive quote:





Figure 158 - Opinion Mining for Worker - Positive quotes

For the worker positive quotes above and for Human wellbeing one positive quotation below:



Figure 159 - Opinion Mining for Wellbeing - Positive quote

Human Centricity positive quotations follow:

	centricity 10 Matches	
0	47 1 5 in Lehmann (2023) - The Anatomy of the Internet of Digital Twins: A Symbiosis of stry 5.0 focuses on society and the environment. Human centricity, sustainability, and resilience should become a more integral part of both industrial and societal revolutions. One of the enabler technologies for both is the	Agent a ス + Opinion Min Osentiment: P
	184 1 5 in Alimam (2023) - Intelligent Retrofitting Paradigm for Conventional Machines t	towards t ↗
	with digitalisation and intelligent activities. Whereas Industry 5.0 is the Age of Augmentation, striving to concentrate on human-centricity, sustainability, and resilience of the intelligent factories and synergetic industry. The crucial enhancer for the improvements accomp	+ Opinion Min
0	214 1 5 in Carayannis (2023) - From the Dark Side of Industry 4.0 to Society 5.0: Looking of e and innovation works for business and society. Humans and machines are expected to reconcile and work in symbiosis, supporting the emergence of Super Smart Societies (S5.0), the last ones based on human-centricity, sustainability, and resilience. Despite the mentioned, guidelines on how technoc	8¢#x201C; > + ○ Opinion Min ○ Sentiment: P
	291 11 5 in Fraga-Lamas (2022) - Mist and Edge Computing Cyber-Physical Human-Cen transition to Industry 5.0 is already underway. Under such a paradigm, Cyber- Physical Human-centered Systems (CPHSs) have emerged to leverage operator capabilities in order to meet the goals of complex manufacturing systems towards human-centricity, resilience and sustainability. This article first describes the essential conce	tered Sys ↗ + ○ Opinion Min ○ Sentiment: P
	349 1 5 in Ghobakhloo (2022) - Identifying industry 5.0 contributions to sustainable deve Scholars believe that the newly introduced Industry 5.0 has the potential to move beyond the profit-centered productivity of Industry 4.0 and to promote sustainable development goals such as human-centricity, socio-environmental sustainability, and resilience. However, little has been done to understand how	elopment: > + Opinion Min Sentiment: P
	389 1 5 in Jafari (2022) - Moving from Industry 4.0 to Industry 5.0: What Are the Implicat Background: Given the importance of human centricity, resilience, and sustainability, the emerging concept of Industry 5.0 has pushed forward the research frontier of the technology-focused Industry 4.0 to a smart and harmonious socio-economic transition driven by both humans and tech-nologies, where the role of the human in the technological transformation is predominantly focused on, Several studies discuss	ions for S ⊅ + ○ Opinion Min ○ Sentiment: P
	the impacts of disruptiv	

Figure 160 - Opinion Mining for Human Centricity - Positive quotes

Centric negative quotations:

	centric 14 0 _{visit} e	14 Matches		
11 fl 5 in Tóth at is more v 5.0 paradigm should not or paper is focu	(2023) - The human-centric Indu alue-driven than technology-ce which were not central to Indu ly be digitalized but also resilie sing on the human-centric pill	ustry 5.0 collaboration arc entric. The key objectives stry 4.0, underscore that j nt, sustainable, and huma	<i>hitecture</i> of the Industry + production an-centric This	ת ⊘ Opinion Mining ⊘ Sentiment: Neg:
70 1 5 in Sita. ristics, and Industry 5.0 a promotion of inclusive app study offers a	ević (2023) - The Psychosocial M the mental health of the employ nd offer a new human-centric mental health through long-te roach to employees' preference new, double-sided model of al	fodel of Absenteeism: Trai yees. The results support t upproach to absenteeism rm organizational strateg s in relation to job charac o	nsition from 4.0 to 5.0 the premises of + through the iies and a more teristics. The	> ٦ Opinion Mining Sentiment: Neg:
77 1 5 in Łucz The human-c lifetime of m problem is to	ak (2023) - Cloud Based Fault D entric and resilient European in achines to reduce electronic wa 	liagnosis by Convolutiona dustry called Industry 5.0 ste. The appropriate way t	al Neural Network as requires a long + to handle this	Time > Opinion Mining Sentiment: Nega
A 142 1 5 in Tu	(2022) Turin VD: Mathead for unit	an disital turin darasisting	no in industrial aVtan	dad en a
142 # 5 in 70 Digital twins engineering i transformatic	(2023) and eXtended Reality (XR) DTs) and eXtended Reality (XR) n the Metaverse that can accele n. The digital twin technology p	ng aigital twin description are two core technologic rate the <mark>human-centric</mark> Ir provides a digital r	al enablers for + ndustry 5.0	Copinion Mining
240 1 5 in W s and resist. the roadmap manufacturin	nn (2023) - Human-centric zero- Ince to changes in their work ta of human-centric ZDM to bring g sector to become more resilie	defect manufacturing: Sta sks. This paper can contri g defects to zero and repo ent.	ate-of-the-art review ibute to paving + sition the	, pers ↗ ◇ Opinion Mining ◇ Sentiment: Nega
410 II 5 in Erid mplex chall lifelong learn emphasized a	rsson (2022) - Experiences in Rur enges in industry 4.0 implemen ing in relation to the <mark>human-ce</mark> is a future direction.	nning a Professional Cour tation. To conclude, the in ntric approach of industry	rse on Digitally-Enab mportance of + y 5.0 is	led Pr > Opinion Mining Sentiment: Neg:
540 1 5 in Kir shift in the effects on wo	n (2022) - Human Digital Twin S approach towards worker well-t rkers due to technological adva	System for Operator Safety being. However, the unde ncements of Industry 4.0,	y and Work Manage. erstanding of the + , based on a	ment Opinion Mining Opinion Mining Sentiment: Nega

Figure 161 - Opinion Mining for Centric - Negative quotes

Positive for factor:

factor	29 Matches				
0	ver gede gedeler	All (29) human (11) hum complex social and human (1) dynamic (1) important (1) other influential (1) technolo	an and psychosocial (2) contextual (1) criti labour (1) main (1) gical and human (1)	key (2) center (1 cal (1) crucial (1) most important (1)) different technical (1) other (1)
	62 11 5 in Lo (2023) - y reduces the labo CRITIC results show sharing, and organiz factors affecting the The results show that	A data-driven decision support r and cost of supplier audits. In that digital transformation, rea zational culture transformation development of enterprises to at CTOPSIS can be used to qui	system for sustainab addition, the I-time information are the three main wards Industry 5.0.	He ↗ + ○ Opinion Mining ○ Sentiment: Posit	No Cod y: factor tive
	74 1 5 in Blandino (a tus and performar summarises the stre to contribute to a st intelligent manufac adopted to select st	2023) - How to Measure Stress in nce and companies' productivit ss indicators and other influent ress assessment of human work turing systems. The PRISMA me ud	n Smart and Intelliger y. This review ial factors in order kers in smart and kthodology is	nt > + Opinion Mining O Sentiment: Posit	No Cod p factor tive
6	126 1 5 in Salvadori, Industry 4.0 is movin of placing the huma in order to promote this, encouraging a	nho (2023) - Happy and Engagi ng towards Industry 5.0 and noi in factor at the center of techno sustainable human resource m happy and engaged employ	ed Workforce in Indus w has the challenge ological innovation, anagement. For	try > + Opinion Mining O Sentiment: Posit	No Cod p: factor tive
	141 11 5 in Mondal (2 ere explored throu research work ident have grouped them cohesive force, mot and functional force chain domain. Origi	023) - Reinforcing the significar Igh a cross-consistency matrix. Ified 20 critical dimensions of h under five important categorie ivating force, regulating force, that drive quality performance nality/value: In line with the rec	nce of human factor in Findings: This uman factor and s, namely, supporting force t in the supply unirements	n a ≯ + ○ Opinion Mining ○ Sentiment: Posit	No Cod y: factor tive
e	166 1 5 in Erro-Garc ource practices an implications: From a understand the role profitability, and it e strategies and techn Originality/value: Th	és (2023) - The role of human re d profitability were obtained. P a practical perspective, this artic of technological and human fa emphasises the relevance of hu loology to accomplish business of is study's findings reinfor	source management ractical ile helps to ctors in man resource putcomes.	pr > + Opinion Mining O Sentiment: Posit	No Cod p: factor tive
	167 1 5 in Loizaga (2 vide critical insigh physical, cognitive, efficiency, effectiver identifies six humar	2023) - A Comprehensive Study ts into workers' well-being. Hui and psychological states that c ness, and mental health of work factors that ar	of Human Factors, Se man factors refer to an impact the ærs. The article	ns ⊅ + ○ Opinion Mining ◇ Sentiment: Posit	No Cod j: factor tive
	167 1 5 in Loizaga (2 al, muscular, respi an overview of these	2023) - A Comprehensive Study ratory, and ocular reactions. Th e human factors and their speci	of Human Factors, Se is paper provides fic influence on	ns ↗ + ○ Opinion Mining ◇ Sentiment: Posit	No Cod y: factor tive

Figure 162 - Opinion Mining for factors - Positive quotes

Negative for factor:

factor 12 Matches	All (12) human (3) conceptual (1) dependent (1) dependent (1) dependent (1) influence (1) internal and external (1) set (1)	ent and independent (1) different (1 such (1)
39 11 5 in Gervasi (2023) cts related to the robo results investigating ho affects the user experies speed, task excution oc task in 12 di	 An experimental focus on learning effect and interaction quality in human-rot to but also human aspects. The focus of this paper is to expand on previous w the learning process (i.e., the experience gained through the interaction) nce in the HRC in conjunction with different configuration factors (i.e., robot ontrol, and proximity to robot workspace). Participants performed an assembly 	bot collabo > + Opinion Mining: factor Sentiment: Negative
6 54 1 5 in Gervasi (2023)	- Manual assembly and Human-Robot Collaboration in repetitive assembly pro	resses: a.s
uality and adaptability factors must be also tak	y of production processes. However, to fully exploit the benefits of HRC, human sen into account. A novel experimental setting involving a repetit	+ Opinion Mining: factor Sentiment: Negative
@ 259 1 5 in Asan (2022)	- The implication of Industry 50 to the marine environment: Protection against m	arine poll 7
data have been integ	rated on an internet basis. The chapter aims to present perspectives on how this ion provided by Industry 40 can feed the human factor for the prevention of the	+ Opinion Mining: factor
marine environment an management.	d, by this means, the role of Industry 5.0 in sustainable marine environment	Sentiment: Negative
351 1 5 in Hossain (202)	2) - DFC-D: A dynamic weight-based multiple features combination for real-time	e movina 7
e in a video with chall	enging background scenes. Numerous existing approaches used multiple	+ Opinion Mining: factor
features simultaneously factor to combine these	r to address the problem but did not consider any adaptive/dynamic weight e feature spaces. Being inspired by these observations, we propose	Sentiment: Negative
374 1 5 in Beiaizadeh (2)	2022) - A COMPREHENSIVE MODEL FOR DETERMINING TECHNOLOGICAL INNO	VATION L 7
echnological innovati	on in a green supply chain. Some preconceptions show that technological	+ Opinion Mining: factor
innovation in a busines correlations between <mark>su</mark> supply chain. Besides, p	s can be affected by internal and external factors, and therefore there must be ich factors to flourish the technological innovation and, subsequently, the greer redicting the technological innovation	Sentiment: Negative
374 1 5 in Beiaizadeh (2)	2022) - A COMPREHENSIVE MODEL FOR DETERMINING TECHNOLOGICAL INNO	VATION I A
Eco-friendly Design a	nd Customer Collaborations. In the 1st phase of the framework, dependent and	+ Opinion Mining: factor
independent factors co statistical data analysis, (dependent factor), will	nsidering the scope of the Research will be determined; and then, using the weight of factors, which reflects their impact on technological innovation be determined. Then, in the 2nd phase, a comprehensive model wi	 Sentiment: Negative
0 470 1 5 in Kovalenko (2	022) - Knowledge Driven Cyber-Convergent Systems Based on Situational Agent	ts 7
according to the situ	ation in the subject area. Conceptual factors of architectural components for	
constructing knowledg	e-driven cyber-convergent systems are discussed in the paper.	♦ Sentiment: Negative

Figure 163 - Opinion Mining for factor - Negative quotes

8.1.3 Opinion mining for Sustainability

Positive quotes for Sustainability:

sustaina	bility	11 Matches							
3 0 errirenner	great goi	a site contained							
			All (11)	environmental (3)	great (3)	social (2)	digital (1)	essential (1) Ion	g stand (1)
	(1)	14 1 5 in Hus: Purpose: With hospitality inc anticipated, c a human-cen ability a	sain (2023) - Nex a an industry 5.0 dustry, a shift fro haracterized by tric approach. In	t generation emp revolution taking m manual to cog greater sustainabil this regard, hosp	<i>loyability an</i> place in the nitive labor i lity, resilience itality educa	d caree + s e and tors'	א ⊘ Opinion I ⊘ Sentimen	No Coding Mining: sustainabi t: Positive	s lit
	100	81 11 5 in <i>Karn</i> and implem Industry 5.0 (I offering salier operations by there has been	naker (2023) - Ind entation of cutti 5.0) has gained i the features for the ensuring long-s n insufficient and	dustry 5.0 challeng ing-edge technolo ncreasing attentic e creation of resili tanding SC sustai alysis of	ges for post-p ogies. Recent on as a parad ent and inclu nability How	bande tly, + igm usive vever,	א ⊘ Opinion I ⊘ Sentimen	No Coding Mining: sustainabi t: Positive	s lit
	9 9 9 9	92 11 5 in <i>Espü</i> in addition showed: (1) ar paper publica areas such as industries infl well above ma	na-Romero (2023 to the Microsoft n exponential gr tions in 2022, all engineering and uenced by i5.0, v anufacturing, en	8) - Industry 5.0: To Excel application owth of article an indexed in journa computer science vhere the electron ergy and public so	racking Scier . The results d conference als of subject e; (2) four m nics sector le ervice; (3) se	ore ads ven	A Opinion I ♦ Sentiment	No Coding Mining: sustainabi t: Positive	s lit
	(1) 2	234 11 5 in <i>Ols</i> Organizing <mark>di</mark> crucial in orga sustainability apply the acco	en (2023) - Towo gital sustainabili anizations facing reporting requir ounting	ard a Digital Susta by reporting in ord the upcoming ts ements. The aim o	ainability Rej ganizations is unami of of this paper	s a +	A Opinion I ♦ Sentiment	No Coding Mining: sustainabi t: Positive	s lit
	(19) Z	237 1 5 in <i>Di I</i> According to should combi greater sustail processes. Ind	Marino (2023) - E the Industry 5.0 ine digitalization nability and hum leed, the optimiz	Enhancing Humar framework, the sr and prediction ac nan centrality with cation and improv	n-Robot Colla nart factory ctivities with nin working rement of the	aborati a e	א ⊘ Opinion I ⊘ Sentimen	No Coding Mining: sustainabi t: Positive	s lit
	(1)	849 1 5 in <i>Gh</i> Scholars belie potential to m Industry 4.0 ar as human-cer resilience. Ho	obakhloo (2022) we that the newl nove beyond the nd to promote si ntricity, socio-en wever, little has l	- Identifying indu y introduced Indu profit-centered p ustainable develop vironmental susta been done to und	<i>stry 5.0 conti</i> istry 5.0 has t iroductivity o pment goals ainability, an erstand how	ributio the + of such d	◄ Opinion I Sentimen	No Coding Mining: sustainabi t: Positive	s lit
	3	363 1 5 in <i>Gry</i> ture on the s this very relev ongoing trend 4.0, highlights for future rese	<i>rbauskas (2022)</i> social implicatio ant and fresh to ds on <mark>social sust</mark> s the existing gap earch.	- Social sustainab ns of Industry 4.0. pic, the study sum ainability consequ ps, and proposes e	ility in the ag Contributin marizes the Jences of Ind exciting aver	ge of di g to + lustry nues	⊼ ⊘ Opinion I ⊘ Sentimen	No Coding Mining: sustainabi t: Positive	s lit

Figure 164 - Opinion Mining for Sustainability - Positive quotes



Figure 165 - Opinion Mining for welfare - Positive quote

A Positive quote for welfare above and Negative quotes for Sustainability below:

	nability 5 Matches						
1 0	egeneric new new contraction						
		All (5)	digital (1)	economic (1)	environmental (1)	more notably (1)	social (1)
	234 11 5 in Olsen (2023) - Tow al sustainability reporting ir accounting perspective of di implementation of digital sus	ard a Digital Sustai the same fashion, jital financial report tainability reporting	inability Reporti The novelty of t ting to create a o g. The framewor	ng Framework in Org his paper is excelling conceptual framewo k for digital sustaina	anizations in the Industry upon the prior + k for the bility reporti	5.0 Er > Opinion Mining: sust Sentiment: Negative	No Codiı ainability
	276 11 5 in <i>Khan (2022) - Infor</i> ployed in sharing data digit	mation sharing in s ally across the SCs.	<i>upply chains — I</i> Drawing on the	nteroperability in an published research f	era of circular economy rom 2015 to 2021, +	ז ⊘ Opinion Mining: sust	No Codir ainability
	following the PRISMA framew SCs in terms of their standard sustainability Using the co-od	vork, this paper pre: ization, optimizatio currence metric, bi	sents the state o m, simulation, a bliometric ana	f research in the field utomation, security :	l of data sharing in and <mark>more notably</mark>	Sentiment: Negative	
	338 1 5 in Rowan (2022) - Dia	aital transformation	of peatland eco				
		filler in an offer marten		o-innovations ('Palud	'iculture'): Enabling a par	adigm 🛪	No Codir
	h the 'Industry 5.0 - a huma	n-centric solution'.	However, com	p-innovations ('Palud panies supporting pe	<i>iculture'): Enabling a pan</i> atland innovation + business model	adigm ㅋ 〇 Opinion Mining: sust	No Codir ainability
	h the 'Industry 5.0 - a huma may lack necessary standards propositions that can jeopard costs, increase pro	n-centric solution'. , data-sharing or ca ize <mark>economic, polit</mark>	However, comp apabilities that c ical and social s	<i>p-innovations ("Palud</i> panies supporting pe an also affect viable ustainability Digital s	iculture'): Enabling a par atland innovation + business model olutions may reduce	adigm > Opinion Mining: sust Sentiment: Negative	No Codir ainability
	h the 'Industry 5.0 - a huma may lack necessary standards propositions that can jeopare costs, increase pro 363 11 5 in <i>Grybauskas (2022)</i>	n-centric solution'. , data-sharing or ce ize economic, polit - Social sustainabil	However, comp apabilities that c ical and social s lity in the age of	- innovations ('Palud panies supporting pe an also affect viable ustainability Digital s i digitalization: A syst	iculture): Enabling a par atland innovation business model olutions may reduce ematic literature Review of	adigm > Opinion Mining: sust Sentiment: Negative	No Codir ainability No Codir
0	h the 'industry 5.0 - a huma may lack necessary standards propositions that can jeopare costs, increase pro 363 1 5 in <i>Grybauskas</i> (2022) edge research topic across	n-centric solution'. , data-sharing or ca ize economic, polit - Social sustainabil various disciplines.	However, comp pabilities that c ical and social s <i>ity in the age of</i> Similarly, sever	- innovations ('Palua panies supporting pe an also affect viable ustainability Digital s i digitalization: A syst al studies have addre	iculture): Enabling a par atland innovation business model olutions may reduce ematic literature Review ssed the	adigm > Opinion Mining: sust Sentiment: Negative on the > Opinion Mining: sust	No Codir ainability No Codir ainability
0	h the 'industry 5.0 - a huma may lack necessary standard: propositions that can jeopard costs, increase pro 363 1 5 in <i>Grybauskas (2022)</i> edge research topic across opportunities that industry 4. sustainability impli	n-centric solution', ;, data-sharing or cc ize economic, polit - Social sustainabil various disciplines. D might offer to env	However, comp pobilities that c ical and social s lity in the age of Similarly, sever vironmental sus	innovations ("Palua opanies supporting pe an also affect viable ustainability Digital s i digitalization: A systs al studies have addre tainability On the col	iculture's Enabling o para atland innovation + business model olutions may reduce ematic literature Review ssed the + htrany, the social	digm. > Opinion Mining: sust Sentiment: Negative on the > Opinion Mining: sust Opinion Mining: sust Sentiment: Negative	No Codir ainability No Codir ainability
	 h the 'Industry 5.0 - a huma may lack necessary standard: propositions that can jeopare costs, increase pro 363 1 5 in <i>Grybauskas (2022)</i> edge research topic across opportunities that Industry 4. sustainability impli 363 1 5 in <i>Grybauskas (2022)</i> 	n-centric solution, , data-sharing or ca lize economic, polit - Social sustainabil various disciplines. D might offer to em	However, comp pabilities that c ical and social s ity in the age of Similarly, sever vironmental sus	movations (Palua annies supporting pe an also affect viable ustainability Digital s i digitalization: A syst al studies have addre tainability On the co digitalization: A syst	iculture): Enabling a pan taland innovation + business model olutions may reduce ematic literature Review ssed the + thrary, the social ematic literature Review.	digm	No Codir ainability No Codir ainability
0	 h the 'Industry 5.0 - a huma may lack necessary standards propositions that can jeopare costs, increase pro 363 1 5 in <i>Grybauskas (2022)</i> edge research topic across opportunities that Industry 4: sustainability impli 363 1 5 in <i>Grybauskas (2022)</i> 4.0 might offer to environm 	n- centric solution , ; data-sharing or ca iize <u>economic</u> , pola - Social sustainabil various disciplines. O might offer to em - Social sustainability.	However, comp pabilities that c ical and social s <i>ity in the age of</i> Similarly, sever vironmental sus <i>ity in the age of</i> On the con <u>trar</u>	innovations (Palua annies supporting pe an also affect viable ustainability Digital s i digitalization: A syst al studies have addre tainability On the co i digitalization: A syst y, the social sustaina	iculture'): Enabling a par taland innovation + business model olutions may reduce ematic literature Review ssed the + trany, the social ematic literature Review bitry implications of +	digm	No Codir ainability No Codir ainability No Codir ainability

Figure 166 - Opinion Mining for Sustainability - Negative quotes

Positive quotes for development, many of which are related to sustainable development:

velopment	46 Matches				
		All (46) sustainable (13)	continuous (3) centric (2)	further (2)	late (2) professional (2
		sustainable and effective (2)	urban (2) concurrent (1)	continuous po	sitive and negative (1)
the jour	atic and late	dynamic (1) future (1)	incremental and iterative (1)	industrial (1)	integrate (1) intelligen
continue ce	, Inc	major (1) most current (1) new technological (1) or	rganizational (1)	past (1) previous (1)
		rapid (1) secondary (1)	technological (1) uncommo	only fast (1)	
19 1 5	in Marić (2023) - Inn	ovation management of th	nree-dimensional printing	(3DP) technol	ogy: >
oret	ical frameworks, and	future research trends. M	ajor research themes, sum	marized +	Opinion Mining: c
perfo and c	rmance; risk and unc ircular economy, are	evolution; strategy; techno ertainty; human resources, closely analyzed, and rese	; innovation; and sustainal arch predictions are provid	bility ded with	 Sentiment: Positive
opera	tions performance a	nd supply chain managem	ent, and sustainable devel	opme	
0 25 1 5	in Trivedi (2023) - Ti	he resurgence of augmente	ed reality and virtual realit	y in construct	ion: 🤊
e wl	here these technolog	ies are gaining traction. Th	e most current developme	ents +	Opinion Mining: d
allow	complete teams to p	lan a project meticulously	, from enhancing safety to erials for the job In additi		Sentiment: Positive
proje	t managers can accu	urately con	chais for the job. In built	511	
32 1 5	in Pang (2023) - A v	erification-oriented and p	art-focused assembly mon	itoring systen	i bas 🗵
for i	manual assistance in	human-centric assembly.	The experimental result sh	iows +	Opinion Mining: c
that t assen huma	ne proposed monitor ibly process informat n- <mark>centric intelligent</mark>	ring system can detect pot tion after manual assembl manufacturing system dev	ential part errors and track y work, which is significan relopment	t for	Sentiment: Positive
0 56 1 5	in Ghobakhloo (202	3) - Actions and approache	es for enabling Industry 5.0)-driven susta	inab 🛪
Altho	ugh Industry 4.0 was	believed to promote susta	<mark>inable development</mark> , it ha	s (+	Opinion Mining: d
ignor emer	ed or misunderstood gence of the Industry	many prevailing sustainat 5.0 agenda. While the des	oility concerns, which led t irable sustainability values	o the of Ind	Sentiment: Positive
00 132 T	5 in <i>Dwivedi (2023)</i> -	Studying the interactions	among Industry 5.0 and ci	rcular supply	chai >
nab	ility objectives via 15.	0 and CSC approaches. The	e proposed framework cou	uld also +	Opinion Mining: o
assist CSC a	the various governm nd <mark>sustainable devel</mark>	ient and industry association opment	ons in formulating policies	s for 15.0,	 Sentiment: Positive
00 160 T	5 in Reino-Cherrez (2	2023) - Model Production B	ased on Industry 5.0 Pillars	s for Textile SN	1Es 7
One c	f the most significan	t sectors in the global eco	nomy is the textile industr	y, which 🕂	Opinion Mining: c
has b globa of pr.	een influenced by ev I warming, and the re	ents such as globalization, ecent COVID-19, lt has cau	technological developme sed important changes in	nt, the way	◇ Sentiment: Positive
A 174 F	5 in Chun (2023) - Th	e Missing Link of Seconda	ry STEM Education in Hong	y Kong: Trans	disci 🛪
W 1/4 1					
ate	Hong Kong better tra	insiting to Industry 5.0. The	e objective is to examine th	ne +	Opinion Mining: d

Figure 167 - Opinion Mining for development - Positive quotes

Negative quotes for development:

development 22 Matches				
sofor we standard and the solution of an analysis of the solution of	apid (2)	asymmetric (1)	current (1) economic	(1)
encient and scalable (1) Tuture (1) Inter systematic (1) technical and connectivity (1)) unah	le (1)	so call (1) sustainable fu	iture (1)
63 1 5 in Marchenko (2023) - Ensuring Sustainable Development o of signals for the development of Industry 5.0. The main purpos	of the En. se +	🗷 🔿 Opinion Mi	No Codings ning: development	
of the article is to model the sustainable development of the enterprise in the context of the transition to Industry 5.0. To do thi the scientific task will be to selec	is,	◇ Sentiment: I	Negative	
63 1 5 in Marchenko (2023) - Ensuring Sustainable Development of	of the En.	א	No Codings	
using graphic language technologies was chosen. The obtained	- +	Opinion Mi	ning: development	
results of the study have elements of novelty through the present two directions for ensuring sustainable development for a really practicing enterprise. It is determined that the preparation of entrepr	ed	◇ Sentiment: I	Negative	
🐵 76 🛚 5 in Varriale (2023) - Industry 5.0 and Triple Bottom Line App	roach in.		No Codings	
osing scenarios of future research developments. For the latter, 1 article aims to identify opportunities for the implementation of digital technologies within own company to improve operations management and, at the same time, promote sustainable development. © 2023 by the authors.	the +	◇ Opinion Mi ◇ Sentiment: I	ning: development Negative	
00 101 1 5 in Pacher (2023) - The Role of Competence Profiles in Indus	try 5.0	. >	No Codings	
d vocational education and training initiatives. After elaborating	on +	Opinion Mi	ning: development	
development in adult education, an exemplary competence for industrial logistics engineering education is developed. Moreo this paper presents a preliminary inve	le ver,	◇ Sentiment: I	Negative	
142 1 5 in Tu (2023) - TwinXR: Method for using digital twin description	ptions i	. л	No Codings	
the use and indicate the validity of the method. We conclude the two TwinXB method is a promising way to advance the supervise	at +	Opinion Mi	ning: development	
between digital twins and eXtended reality: For eXtended reality, TwinXR enables efficient and scalable eXtended reality developme For digital twins, TwinXR unlocks and demonstrates the potential (digital twins for data interchange and system interoperation, Futu	nt; of ire	◇ Sentiment: I	Negative	
143 1 5 in Scapini (2023) - Future of biorefineries from a circular economic	onomy	л	No Codings	
d the consequent depletion of natural resources. For these reaso	ons, + ent	Opinion Mi	ning: development	
Goals 2030 (SDGs), which are guidelines designed to improve the socio-economic and environmental conditions through changes economic development, to reduce environmental pressure by mitigating greenhouse gas emissions and uncontrolled waste gen	in ier	◇ Sentiment: I	Negative	
ITT II 5 in Xu (2023) - Privacy-preserving Dynamic Multi-Keyword I With the provided set of a set o	Ranked		No Codings	
with the rapid development of consumer electronics in Industry 5 personalized service supplement based on th <u>e cloud infrastructur</u>	e -	Opinion Mi	ning: development	
for the Internet of Things (IoT) has been a promising requirement pushed to consumers, During the massive and frequent IoT data interac		⇔ Sentiment: I	vegative	

Figure 168 - Opinion Mining for development - Negative quotes

Positive quotes for solutions:

solution	33 Matches							
3								
		All (33) efficient (3)	effective (2)	exist (2)	ideal (2)	alternative (1)	artificial (1)	centric (1)
0		collaborative make (1)	current (1)	currently availa	able comn	nercial (1) custo	omize (1)	
thickent sective	eist ites matte	ecologically friendly (1)	friendly (1)	holistic and in	ntegrated	(1) inefficient (1	l) large (1)	layer (1)
¢ 6.	3HE.	modern (1) Most m	odern (1) 🛛 po	ssible (1) poi	tential (1)	propose (1)	scalable (1)	smart (1)
		smart more humane (1)	spatial (1)	such technolo	ogical (1)	very few sustain	able (1)	
	23 1 5 in Yadav (2023) - I-MEREC-T: Improv	ed MEREC-T	OPSIS schem	e for		No Codir	
	 ality of services and have developed a new 	the quality of experie v improved method b	ased on imp	rticle, we roved		Opinion Minin	g: solution	
	removal effects of cri	teria- technique for or	der performa	ince by		Sentiment: Pos	itive	
	similarity to ideal solu scheme. It is based or	i <mark>tion</mark> (I-MEREC-TOPSI) I the removal effect o	S) network se f alternative	lection				
) 24 1 5 in Rowan (202.	3) - The role of digital	technologies	in supporting	g an	л	No Codir	
	y, reducing waste, c	ontamination and foo	d fraud. The	focus on	+ 🗠	Opinion Minin	g: solution	
	digital technologies h robotics are coupled	as recently evolved to with the human mind	in order to a	where Al and dvance	d	Sentiment: Pos	itive	
	human- <mark>centric soluti</mark>	ons This viewpoint de	escribes the role of					
	Quadruple h							
	52 1 5 in Suciu (2023)	- Core Competence—	As a Key Fac	tor for a Sust	aina	л	No Codir	
	will change many jo	bs in most areas of a	most areas of activity. One alternative +			Opinion Minin	g: solution	
	solution to diminish t prepare the shift to a	hish these negative effects is to accommodate and to a more human-centric approach. In order to t this alternative so				Sentiment: Positi	itive	
	better implement this							
0	60 1 5 in Kernan Frei	e (2023) - The Human	Factors of A	-Empowered	l Kno	7	No Codir	
	requently reconfigu	re it for different prod	ucts. Consid	ering the		Opinion Mining: solution		
	solutionssolutions for	r sharing knowledge (e.g., word-of-mouth, issue reation, and decision support systems) are			e 🗠	Sentiment: Positive		
	reports, document cr							
	are an efficient	ource-intensive. Conv	ersational us	er interfaces				
0) 62 1 5 in <i>Lo (2023) - A</i>	data-driven decision	support syst	em for sustai	inabl	л	No Codir	
	weights of the core	criteria and their ranking. Finally, a modified				Opinion Minin	g: solution	
	solution (CTOPSIS) is	ique for order preference by similarity to ideal 5) is used to integrate the final performance values new alternative suppliers are added. The research			Sentiment: Pos	itive		
	of suppliers when new							
	concept is in line with	the concept						
0	78 1 5 in De Giovanni	(2023) - Sustainabilit	y of the Meta	verse: A Trai	nsitio	л	No Codir	
	nts required by artif	icial intelligence syste	ms. While <mark>ve</mark>	ry few	+ 0	Opinion Minin	g: solution	
	issues, similar effects	might materialize wh	en adopting	metaverse		Sentiment: Pos		
	technology. Therefor	erefore, this study provides tools to undertak		rtak				
0) 167 🛿 5 in <i>Loizaga (2</i> 0	23) - A Comprehensiv	e Study of H	uman Factor	s, Sen	7	No Codir	
	al, muscular, respire	tory, and ocular react	ions. This pa	per provides		Opinion Minin	g: solution	
	psycho-physiological	responses, along with	h suita <u>ble tec</u>	hnologies <u>to</u>		Sentiment: Pos	itive	
	measure them in wor	king environments an	g environments and the currently available					
	commercial solutions	to do so. By understa	inding the in	portance of				

Figure 169 - Opinion Mining for solution - Positive quotes

But there been found also many negative quotes for solutions:

solution	32 Matches				
3 0 	, use geot stronget	All (32)innovative (3)promising (3)base (2)complete (1)conventional (1)drive (1)efficientgood possible (1)industrial (1)missing (1)novpotential (1)prominent (1)propose (1)pythagstandardised (1)technological (1)transferable (1)	remot nt (1) /el (1) jorean fu:	e (2) appropriate emerge (1) enal novel assist (1) zzy combine (1)	e (1) collaborative (1) ole (1) optimum (1) real (1)
	13 1 5 in Suhail (20 ion and automat ML-based DTs sect of transparency of the decisions mad security challenge	223) - ENIGMA: An explainable digital twin security ion in the gamification approach. However, Al/ urity solutions are generally constrained by the lack Al operations, which results in less confidence in e by the Al models. To address the explainable s o	c + 0	⊅ Opinion Minir Sentiment: Ne	No Codi 1g: solution gative
	20 1 5 in Ullah (20 eavesdropper an efficient solution t algorithm that dec series of subproble optimal values, th hybrid precoding	23) - Hybrid precoding design for secure smart-grid d noise, on the secrecy capacity. To find an o the optimization problem, we propose an couples the original optimization problem into a ems and uses iterative techniques to find the ereby improving computational efficiency. The scheme is an effective tech	f en	⊅ Opinion Minin Sentiment: Ne	No Codi 1g: solution gative
	35 1 5 in Nauman g the lowest pos method based on to get the best pos problem so that w standard OMA fra	(2023) - Minimizing energy consumption for NOMA sible rate for wireless devices. We use a novel iterative sequential quadratic programming (SQP) sible solution to the non-convex optimization e may move on to the next step and solve it. The mework, the Karush-Kuhn-Tuck	4 <i>mu</i> + 0	⊅ Opinion Minir Sentiment: Ne	No Codi 1g: solution gative
0	45 11 5 in <i>Caiazzo</i> (cturing systems combines human based solutions w unified framework systems by enablin 2020, Bianca Caiaz	'2023) - An IoT-based and cloud-assisted AI-driven toward the Industry 5.0 concept. Indeed, it strengths, IoT technology on machines, cloud- th AI and zero detect manufacturing strategies in a s so to detect causalities in complex dynamic ng the possibility of products' waste avoidance. © zo, Teresa Murino, Alberto P	mon	⊅ Opinion Minin Sentiment: Ne	No Codi 1g: solution gative
	93 11 5 in Hoffman ed, and mundan study of a start-up Germany (Vay), th regulatory framew their legal and ecc solutions are com	n (2023) - On the Legal and Economic Implications e fields such as road traffic law. Based on a case developing remote operation solutions in is paper analyses and further develops the ork of remote operation solutions by highlighting nomic implications. Since remote operation prised o	of Te	⊅ Opinion Minir Sentiment: Ne	No Codi ng: solution gative
0	96 11 5 in <i>Redchuk</i> s considering the industrial enginee ensure that their d achieve better out	(2023) - Adoption Case of IIoT and Machine Learnin e role of people in the process. By empowering rs with data driven solutions, organizations can omain expertise can be applied to data insights to comes. © 2023 by the authors.	ng to	≯ Opinion Minir > Sentiment: Ne	No Codi 1g: solution gative
	115 11 5 in <i>Kimutai</i> in order to encor solutions, built on creating efficienci chapter draws on	(2023) - Digital financial transformation and legal urage innovation and e-business. Collaborative shared datasets, automate the financial services, es and accuracy in the financial systems. The the use of interdisciplinar	envi	⊿ > Opinion Minir > Sentiment: Nei	No Codi ıg: solution gative

Figure 170 - Opinion Mining for solution - Negative quotes

8.1.5 Opinion Mining for Intelligence

Positive quotes for Intelligence:

intelligence 26 Matches					
18 0 					
src sstore concer hu	All (26) artificial (18)	more (2) autonom	ous (1) conce	eived pervasive artificial (1)	human (1)
	human and artificial (1)	novel artificial (1) or	rganize (1)		
👳 27 🛿 5 in Pang (2023) - Toward	s a New Paradigm for Digital Healt	th Training and Educat	ion in Australia:	Explorin ㅋ	No Cc
als and students in the field o	f digital health. By leveraging Indu	stry 5.0-enabling techn	ologies, such	+ Opinion Mining: inte	lligence
as artificial intelligence, machin to be job-ready for the future of healthcare technologies. Ultim	re learning, blockchain, big data ar of work by providing them with har ately, this new training and educati	alytics, etc., we can cu ids-on experience in ac ion para	dvanced	◇ Sentiment: Positive	
107 1 5 in Naahdi (2023) - Mov	ina toward smart biomedical sensir	na			No Cc
ical/diagnostic sensing throu	gh eHealth systems. Herein, an ove	erview is provided to hi	ghlight the	+ Opinion Mining: inte	lligence
importance and necessity of an smart biomedical/diagnostic s Internet of Things (IoT), artifici bring together the different ty.	n inevitable transition in the era of c ensing and how to approach it via r al intelligence, IoT gateways (smart _j 	♦ Sentiment: Positive			
🔞 117 🛿 5 in Gürce (2023) - Artifici	al intelligence and collaborative rob	bots in healthcare: The	perspective of he	althcare ㅋ	No Cc
Industry 5.0 focuses on human	-machine collaboration and sustain	nability with collaborat	ive robots	+ Opinion Mining: inte	lligence
(Cobots) and artificial intellige devices have gained increasing	interest to	chnology-enabled devi	ices. Such	Sentiment: Positive	
🐵 123 🛚 5 in Taj (2023) - Towards	Machine Learning-Based FPGA Ba	ckend Flow: Challenge:	s and Opportunit	ties 7	No Cc
tant research spots requiring	significant focus. The potential of t	he new cloud-based an	rchitectures to	+ Opinion Mining: inte	lligence
discussed, together with visual platform, with the help of relat (CAOS). Altogether, this resear	izing the scenario of incorporating ively newer technologies such as C ch explores several resea	more intelligence in th AD as Adaptive OpenP	le cloud latform Service	♦ Sentiment: Positive	
🔞 198 🛚 5 in Leng (2023) - Manu(Chain II: Blockchained Smart Contra	ict System as the Digita	al Twin of Decent	ralized ㅋ	No Cc
's decentralized auto	nomous intelligence. Via incorpora	deep learning	+ Opinion Mining: inte	lligence	
algorithms into blockchained a intelligence of the manufactur	ycs, this study reveals a new way to ing system for enhancing resilience	realize the self-organiz toward Industry 5.0.	zing	Sentiment: Positive	
🐵 212 🛚 5 in Dash (2023) - Organ	izational Digital Transformations a	nd the Importance of A	ssessing Theoret	ical Fra 🤊	No Cc
crease profits, and improve c	onsumer engagement. To achieve t	their goals, all business	es undergo	+ Opinion Mining: inte	lligence
extensive digital transformatio computing, artificial intelligen costly journey, including strate	ns (UI) by implementing cutting-ec re (AI), the Internet of Things, and b gy, peop	dge technologies such blockchain, among oth	as cloud iers, DT is a	Sentiment: Positive	
(9) 241 1 5 in Akinsolu (2023) - Ap	olied Artificial Intelligence in Manu	facturing and Industria	l Production Syst	ems: PE >	No Cc
Presently, artificial intelligence applications. Despite its many	(Al) is playing a leading role in our advantages, analytical framewor	contemporary world v	ia numerous	+ Opinion Mining: inte	lligence

Figure 171 - Opinion Mining for intelligence - Positive quotes

Negative quotes for intelligence:

ntelligence 25 Matches	omputational (1) emotional (1) wearable	artificial (
59 1 in Al Mubarak (2023) - Sustainably Developing in a Digital World: harnessin	g artificial intelligence to meet 🤊	No Co
Sustainably Developing in a Digital World: harnessing artificial intelligence to meet work-based learning in Industry 5.0	the imperatives of + Opinion Mining: inte	lligence
🧝 65 115 in Tabaada (2022) - Artificial Intelligence Englied Project Management: A Su	etematic Literature Review 7	No Cr
65 # 5 in Tablada (2023) - Artificial Intelligence Enabled Project Management: A sy 	panagement would + Opinion Mining inte	lligance
benefit from artificial intelligence in order to achieve project goals by improving pr and consequently, reaching higher sustainable success. In this context, this paper e of	oject performance, examines the role	ingence
65 11 5 in Taboada (2023) - Artificial Intelligence Enabled Project Management: A Sy	rstematic Literature Review 🦻	No Cc
nsequently, reaching higher sustainable success. In this context, this paper exami	ines the role of + <> Opinion Mining: inte	
artificial intelligence in emerging project management through a systematic literat applications of AI techniques in the project management performance domains are results show that the number of influential	e presented. The	
65 1 5 in Taboada (2023) - Artificial Intelligence Enabled Project Management: A Sy	rstematic Literature Review 🦻	No Cc
as increased significantly over the last decade. The findings indicate that artificial	intelligence, + < Opinion Mining: inte	lligence
predominantly machine learning, can be considerably useful in the management o projects; it is notably encouraging for enhancing the planning, measurement, and performance domains by providing promising forecasting and decision-making ca the authors.	or construction and II uncertainty pabilities. © 2023 by	
69 1 5 in Asad (2023) - Human-Centric Digital Twins in Industry: A Comprehensive	Review of Enabling Technologi >	No Co
d using the VOSviewer keyword mapping technique. Current technologies such a	s motion sensors, + < Opinion Mining: inte	lligence
biological sensors, <u>computational intelligence</u> , simulation, and visualization tools a development of HCDTs in promising application areas; Domain-specific framework fo	re studied for the Sentiment: Negative s and guidelines are	
0 72 1 5 in Hozdić (2023) - Evolution of the Human Role in Manufacturing Systems: Or	n the Route from Digitalization 🦻	No Cc
Adaptive Cognitive Manufacturing Systems (ACMS). A fundamental building blo	ck of ACMS is the + Opinion Mining: inte	lligence
new generation of manufacturing systems called Cognitive Cyber-Physical Product CPPS), which are based on CPPS concepts and incorporate cognitive technologies intelligence This paper presents the revolutionary developmen	and artificial	
96 1 5 in Redchuk (2023) - Adoption Case of IloT and Machine Learning to Improve	Energy Consumption at a Proc >	No Cc
, the food industry, IIoT, and machine learning. The adoption case's relevancy is n	narked by how the + < Opinion Mining: inte	lligence
business model looks to democratize artificial intelligence in industrial firms. The p	roposed model	

Figure 172 - Opinion Mining for intelligence - Negative quotes

8.1.6 Opinion Mining for Robot and Robotics

Robot positive quotes:

robot 30 Matches		
12		
• •	All (30) human (12) collaborative (8)	autonomous (1) autonomous intelligent (1)
runer roat come more robote	base mobile (1) classic (1) edge comput	ing collaborative (1) especially engage (1)
CONER STOL STOL DEFE	future mobile (1) intelligent mobile (1) r	nore flexible and collaborative mobile (1)
	novel interactive intelligent able (1)	
🐵 57 🛚 5 in Gervasi (2023) - Applicati	ons of affective computing in human-robot interaction	: State-of-art and challe 🤊
uring sector with the emergence	of Industry 5.0. In order to take full advantage of the	uman-robot + Opinion Mining: robot
collaboration, the robotic system s the operator through different sen- physiological signals) and to adapt collabor	nouid be able to perceive the psycho-emotional and i sing modalities (e.g. facial expressions, body language its behavior accordingly, The development of socially	v voice, or v voice, or v intelligent
🤨 85 🛚 1 in Li (2023) - An AR-assisted	Deep Reinforcement Learning-based approach towa	rds mutual-cognitive saf ↗
An AR-assisted Deep Reinforcemer	nt Learning-based approach towards mutual-cognitiv	e safe human- + < Opinion Mining: robot
		Sentiment: Positive
90 115 in Lykov (2022) - Industry 5) and human capital	3
n the approach of a new paradig	m - Industry 5.0. This study briefly discusses the main	driving forces + Opinion Mining: robot
and means that contribute to the i it, as well as human responsibility :	ntroduction of this new paradigm, then examines the	role of man in cohots which
the new Industry is talking about. I	n conclusion, the main features and the problem	
🐵 117 🛿 5 in Gürce (2023) - Artificial ir	telligence and collaborative robots in healthcare: The	perspective of healthcare 🤊
Industry 5.0 focuses on human-ma (CoBots) and artificial intelligence	chine collaboration and sustainability with collaborat	ve robots + < Opinion Mining: robot
devices have gained increasing int	erest to	Sentiment: Positive
💿 128 🛛 5 in Dhirani (2023) - Ethical L	Dilemmas and Privacy Issues in Emerging Technologies	: A Review 7
Industry 5.0 is projected to be an ex customization and production effi	cemplary improvement in digital transformation allow	ring for mass + < Opinion Mining: robot
autonomous and self-driving robo	s, self-healing networks, cloud data analytics, etc., to	supersede the
limitations of Industry 4.0. To succe	essfully pave the way for acceptance of t	
175 1 5 in Xian (2023) - Advanced I	Manufacturing in Industry 5.0: A Survey of Key Engblin	a Technologies and Futu 🤉
ustomized products and a better	user experience. A number of key enabling technolog	ies are + Opinion Mining: robot
expected to play crucial roles in as and processing, communications.	sisting Industry 5.0 in meeting higher demands of data and collaborative robots in the advanced manufactur	acquisition ng process.
The aim of this survey is to provide	novel insig	
0.407.551.01.4.4.7		
197 II 5 in Ruiz-de-la-Torre (2023) - ty", "Triple Helix" and "Industrial	Industry 5.0 and Human-Centered Approach. Bibliom Revolution". Industry 5.0 links are also observed with "	etric review
factor", "Human robot collaboratio	on", "Smart manufacturing", "Human-centric", "Huma	an machine Sentiment: Positive
and approach	ar-organised-manufacturing . Finally, a new human-o	

Figure 173 - Opinion Mining for Robot - Positive quotes

Robot negative quotes:

robo	1 21 Matches		
9 0	Starten of the starten of the starten		
	د ^{وه} من All (21) human (9) collaborative (4) autonomous mobil	le (2) actual (1) industrial	(1)
	interactive (1) many (1) particularly (1) such (1)		
	121 1 5 in Geiß (2023) - Automatic Bounding Box Annotation with Small Training Datasets for Industrial M	lanufact ↗	
	In the past few years, object detection has attracted a lot of attention in the context of human-robot	+ Opinion Mining: robot	
	collaboration and Industry 5.0 due to enormous quality improvements in deep learning technologies. In	Sentiment: Negative	
	many applications, object detection models na		
	125 115 in Acad (2022) Piemachanical Madeling of Human Paket Accident Scongrigs & Computational	Accorcom 3	N
	12.5 III 5 in Asua (2025) - Biomechanical Modeling of Human-Robol Accident Scenarios: A Computational s and for designing a collaborative environment. In this study, quasi-static and dynamic analyses of	+ Opinion Mining robot	
	accidental scenarios during HRC are performed for medium- and low-payload-capacity robots	Continuet Mention	
	according to the conditions given in ISO TS 15066 to assess the threshold level of injury and pain, and is subsequently extended for high speeds and heavy payloads for collaborative robots. For this purpose, accidental scenarios are simul		
	188 11 5 in Ramachandran (2023) - Innovative Cyber Security Solutions Built on Block chain Technology for	Industri 7	
	been cited as contributing factors to the shift. The collaborative robots, trusted machine boundaries,	+ Opinion Mining: robot	
	and supply chains powered by artificial intelligence (Al). It is anticipated that this new trend, known as	Sentiment: Negative	
	196 🛚 5 in Yadav (2023) - A Study on Creation of Industry 5.0: New Innovations using big data through an	tificial in 🤊	
	are, cloud manufacturing, asset management, etc. Next, also discussed about Edge computing, digital twins, interactive robots, the Internet of Things, block chain, and 6G are just some of the	+ Opinion Mining: robot	
	technologies that can support this.	Sentiment: Negative	
	230 11 in Earnon (2023) - Dower solutions for autonomous mobile robots: A survey	7	N
	Power solutions for autonomous mobile robots: A survey	+ Opinion Mining: robot	
		Sentiment: Negative	
		Sentimenta Negative	
	239 II 5 In Faroog (2023) - Power solutions for autonomous mobile robots: A survey Autonomous mobile robots are a special class of robotic systems that can move a navioad from one		
	location to the other or perform a specific task. They allow efficient, precise, and streamlined w	Continuet Manatius	
		Sentiment, Negative	
	275 1 5 in Adel (2022) - Future of industry 5.0 in society: human-centric solutions, challenges and prospec	tive rese ㅋ	
	tion in manufacturing, cloud manufacturing, etc. The technologies discussed in this paper are big	+ Opinion Mining: robot	
	data analytics, Internet of Things, collaborative robots, Blockchain, digital twins and future 6G systems.	Sentiment: Negative	
	The study also included difficulties and issues		

Figure 174 - Opinion Mining for Robot - Negative quotes

Robotic Positive quotes:

	robotic ³ ₀ _{citebootic} _{strand} _{strand}	7 Matches			
	175 🛚 5 in Xian (2023) - Advanced Manufacturing in	Industry 5.0: A Su	irve	ק	No Codi
	ve robots in the advanced manufacturing process. survey is to provide novel insights into advanced ma Industry 5.0 by summarizing the latest progress of kr technologies such as Artificial Intelligence of Things 5G communications, and collaborative robotics Fina directions for future research to e	The aim of this anufacturing in ey enabling (AloT), beyond illy, key		Opinion Mining: Sentiment: Positi	robotic ve
9	282 1 5 in Babel (2022) - Industry 4.0, China 2025, Io	T: The hype arou	nd t	ע	No Codi
	ts and make them ready for automation standards history oft he modern robotics is shown for the auto In summery also is figured out the Industry 5.0	. In detail the motive industry.		Opinion Mining: Sentiment: Positi	robotic ve
9	521 Il 1 in Cen Cheng (2022) - A framework for safe	and intuitive hun	nan	ק	No Codi
	A framework for safe and intuitive human-robot into	eraction for		Opinion Mining:	robotic
				Sentiment: Positi	ve
9	606 1 5 in Feng (2022) - Intelligent Radio Resource A	llocation for Hum	nan	7	No Codi
	research is expediting a paradigm shift in today's co networks towards human-to-robot (H2R) centric tec support Industrial Internet of Things (IIoT) and Indus IIoT and Industry 5.0, human skills are	naptic devices mmunication hnologies that try 5.0. In both		Opinion Mining: Sentiment: Positi	robotic ve
	656 1 5 in Massaro (2021) - Electronics in Advanced	Research Industri	es: I	я	No Codi
	A one-of-a-kind examination of the latest developm	ients in machine		Opinion Mining:	robotic
	to Industry 5:0 Advances, accomplished electronics engineer Alessandro Massaro delivers a comprehens of the latest ways in which people have achieved ma including automated vision technologies, advanced	researcher and ive exploration achine control, electronic and		Sentiment: Positi	
	1144 11 5 in Proia (2022) - Control Techniques for Safe	, Ergonomic, and	Effi	ק	No Codi
	tantial influence on the manufacturing scenario. The key enabling technology that has made industry 4.0 a concrete reality is without			Opinion Mining: robotic	
	doubt collaborative robotics, which is also evolving pillar of the next revolution, the so-called Industry 5 improvement of employees' safety and well	as a fundamenta .0. The		Sentiment: Positi	ve
9	1191 1 5 in IEEE (2021) - A Literature Review on Contr	ol Techniques for	Coll	R	No Codi
	One of the key enabling technologies that has made concrete reality is without doubt collaborative robot	Industry 4.0 a ics, which is also		Opinion Mining:	robotic

Figure 175 - Opinion Mining for Robotics - Positive quotes

Robotic/Robotics/Robotization/Cobot negative quotes:



Figure 176 - Opinion Mining for Robotic/Robotics/Robotization/Cobot - Negative quotes

For collaboration and collaborations positive quotes:



Figure 177 - Opinion Mining for collaboration/collaborations - Positive quotes

Collaboration negative:

collaboration 5 Matches						
All (5) close (1) facilitated (1) human (1	I) increase (1)	more international (1)				
220 1 5 in Tlili (2023) - Metaverse for climbing the ladder toward 'Industry	y 5.0 🛪	No Codin				
arch adopted in education and health industries. Additionally, there is	+ Opinion Min	ing: collaboration				
industries, calling for more international collaboration in this regard to facilitate metaverse adoption worldwide. The findings have also revealed several concerns	◇ Sentiment: N	legative				
9 293 1 5 in Mincă (2022) - Digital Twin for a Multifunctional Technology of	f Fle 🤊	No Codini				
oring and real-time control of the whole system. The "Digital twin"	+ Opinion Min	ing: collaboration				
approach has been designed to meet all the requirements and	approach has been designed to meet all the requirements and attributes of Industry 4.0 and beyond towards Industry 5.0, the target					
attributes of Industry 4.0 and beyond towards Industry 5.0, the target						
production line, © 2022 by the authors.						
9 348 1 5 in Park (2022) - Sustainable Human–Machine Collaborations in L	Digit 🕫	No Codin				
t human-machine collaborations within factories. To this end, this	+ Opinion Min	ing: collaboration				
paper presents a research model between DX technologies and	Sentiment: N	legative				
abduction inference structures as an approach to resilient human-						
machine collaborations The purpose of this research is to analyze the						
d						
60 408 1 5 in Garcia Rivera (2022) - The Schematization of XR Technologies i	n th ↗	No Codin _i				
hcare, engineering, architecture, among others). Therefore, to set the	+ Opinion Min	ing: collaboratior				
dimensions that intervene in product and production design in regards	Sentiment: N	legative				
to XR facilitated collaboration With the ideas proposed in this paper,						
we want t						
A60 15 in Cassalin (2022) Pahat Companies on intelligent interactives	abot 7	No Codin				
To overcome the limitations of the so-called Industry 4.0 focusing on		iner collaboration				
mass production and full automation, a novel paradigm was recently	Opinion Min	ling: collaboration				
introduced, namely Industry 5.0, which aims at an increased	Sentiment: N	legative				
collaboration between humans and machines, and particularly robots,						
novel interactive intell						

Figure 178 - Opinion Mining for Collaboration - Negative quotes

Collaborations/Collaboration/Human-Robot Collaboration positive quotes:



Figure 179 - Opinion Mining for Collaboration/Collaborations/HRC - Positive quotes

Human-Robot Collaboration negative:



Figure 180 - Opinion Mining for HRC - Negative quotes

8.1.7 Opinion Mining for goal/challenge/change/value

For the goal term positive quotes:

goal	1	1 Matches							
2 0 profest galetty	adoreade proticolo	yesi	All (11) strategic (1	primary (2)) ultimate	societal (2) (1)	sustainable (2)	ambitious (1)	key (1)	large (1)
	235 ble hum orga orga the	¶ 5 in <i>Chanc</i> ed machines nan-machine mizations, as mizational de primary goal	lel (2023) - Te in organizatio collaboration well as the re cision makin © 2023, The J	chnology Asp onal decision n existing in r searchers, to g in industry Author(s), un	oects of Artific -making. Diffe research are al identify the n 5.0, where hu ider exclusive	ial Intelligence: I erent strategies r iso discussed to i nost suitable stra man-machine c license t	ndustry 5.0 for Or elated to = enable the ttegy for ollaboration is	ganiza ◇ Opinic ◇ Sentirr	
	② 247 e r sust resil conv	15 in <i>Leng (</i> mix-flow and ainable deve ient manufac ventional cer	2023) - Blocko frequently-d opment goal turing is envi tralised prod	hained smar isturbed envi and the inc sioned in Inc uct	t contract pyra ironment. Wit reasing indivi lustry 5.0 prop	amid-driven mul h the convergen dualised demano position. Concerr	ti-agent autonon ce of the Is in products, hing that	ous pr Opinic Sentir	
	253 Induachi cont procession	1 5 in <i>Ince (2</i> Istry 5.0 reco eve <mark>societal (</mark> forms to the cesses. Addin	022) - Socio-e gnizes the po goals beyond imits of natu g a personal f	ecological sus wer of indust employmen re and places couch to auto	tainability wit try to be a flex t and growth, s the well-beir omation incre	thin the scope of ible provider of v by ensuring that ig of employees ases	Industry 5.0 welfare to : production in all	◇ Opinic ◇ Sentin	
	296 by sign digit the	¶ 5 in <i>Charit</i> / last generat ificant collab tal tools that different mat	idis (2022) - F ion character orative actior allow for effe erials modelli	ostering rese ization techn is are needed ctive and effi ng and chara	arch and inno iiques. To achi I to develop c icient twinnin acterization do	wation in materi eve this <mark>ambitio</mark> ommon, usable, g of data and wo omains.	als manufacturin us goal, + and sharable ırkflows across	g for In ○ Opinic ○ Sentin	
	316 e t Soci emo mat relat	1 5 in <i>Kaklau</i> o address the ety 5.0, Indus vitional, affect ter and offers red fields. In t	skas (2022) - issues/challe try 5.0, and h ive, and phys tremendous his research,	A Review of enges in the t uman-cente iological stat growth of kr a review of A	AI Cloud and field. In efforts red design bet tes is progress nowledge and IFFECT recogn	Edge Sensors, Me s to achieve the tter, the recognit ively becoming a progress in thes ition	ethods, and Appl ey qoals of ion of an important e and other	ication Opinic	
	349 Scho beyo deve resil	1 5 in <i>Ghoba</i> plars believe pond the profi clopment go ience. Howe	khloo (2022) hat the newl c-centered pr ls such as hu rer, little has l	- <i>Identifying</i> y introduced oductivity of iman-centric been done to	industry 5.0 cd Industry 5.0 h Industry 4.0 a ity, socio-env understand h	ontributions to su as the potential nd to promote s ironmental susta iow	istainable develo to move ustainable iinability, and	p <i>ment:</i> Opinic Sentir	
	358 pa	1 5 in <i>Battin</i> te in measur	(2022) - Tow ng perceived	ards industry fatique and	/ 5.0: A multi-o	objective job rota primary goal of	tion model for an our model is	inclusi Opinic	

Figure 181 - Opinion Mining for goal - Positive quotes

Negative quotes for the goal term:



Figure 182 - Opinion Mining for goal - Negative quotes

Through the ATLAS.ti tool the NLP yield to positive opinion with 39 matches for the term challenge.

challenge	39 Matches						
4 0	e ^{ga} s ²⁵ s ⁴⁵	All (39) open (4) ke conventional (1) critica great (1) grow environ most common (1) ong relevant most relevant (1) upskilling and reskille (1)	ey (3) new (3) such (al (1) exist technological mental and geopolitical nov poing (1) other (1) pr relevant open (1) soc various critical (1) var	(3) c l (1) v wadays (otential cial and rious tec	complex (1) c foreseeable (1) 1) identify (1) (1) punish (1) economic (1) hnological (1)	onsiderable (1) frequently indicate immense (1) relate (1) societal (1) unic	: (1) modern (1) jue (1)
	20 1 5 in Ullah (2 ems in Industry approach providy wireless communum unique challenge	023) - Hybrid precoding 5.0 and smart qrid appl es an efficient method fo nication systems that can s posed by these critical	<i>design for secure smai</i> ications. The proposed or designing secure n effectively address th I infrastructure systems	rt-g I + ne s.	≯ ◇ Opinion Mi ◇ Sentiment:	No Coding ining: challenge Positive	
	30 1 5 in Pappas ponsible and su article discusses t transformation, e public organizati together in devel shared value whil	(2023) - Responsible Dig istainable practices is es he importance of respo mphasizing the need fo ons, civil society, and in oping digital business m e addressing societal ch	gital Transformation fo sential. This editorial nsible digital r academia, private an dividuals to work nodels that generate allenges The article hi.	or a + d	➤ Opinion Mi◇ Sentiment:	No Coding ining: challenge Positive	
	42 1 5 in Li (2023) ss connectivity Nonetheless, Indi such as large scal because of the pi challenges, we pi) - NOMA-based cogniti and human machine co ustry 5.0 will inevitably fi e connectivity and explo oliferation of IoT device opose a novel non	ive radio network with i Illaboration. ace the great challenge osive data traffic is, To meet these	hyb es +	ז ◇ Opinion Mi ◇ Sentiment:	No Coding ining: challenge Positive	
	47 1 5 in Lehman Due to the growin nowadays, which industry and soci complement and	n (2023) - The Anatomy ng environmental and g are causing supply cha ety are facing significan extension to the techno	of the Internet of Digit eopolitical challenges in complications, t new objections. As a ology	tal	⊅ ◇ Opinion Mi ◇ Sentiment:	No Coding ining: challenge Positive	
	93 1 5 in Hoffma d (in part) by th various technological also has many im impacting a wide torts performed, Based on a case s	nn (2023) - On the Lega e remote operation of v gical challenges, remote portant legal and econce area, including data pro and mundane fields suc tudy of a start-up devel	l and Economic Implica rehicles. Besides the eoperation of vehicles omic implications, otection, liability for h as road traffic law. oping r	ntio	≯ ◇ Opinion Mi ◇ Sentiment:	No Coding ining: challenge Positive	
	112 1 5 in Shukla technologies w pandemic has giv accelerated the fo with extended im concepts. This stu	(2023) - Industry 5.0 and ith prime focus on susta ven impetus to digital tri ocus on other challenge portance on people, pla ady shall attempt to exa	d digital innovations: A inability. The COVID-1 ansformation and s of present time and anet and societal mine the nature o	9 +	⊅ ◇ Opinion Mi ◇ Sentiment:	No Coding ining: challenge Positive	
	116 ¶ 5 in Dewası n of these techi performance, sec regulatory challei the challenges, b	ri (2023) - Fusion of artij nologies is still in its infa urity, privacy and trust, nges are the most comn anks should concern wi	ficial intelligence and b ncy. Employment, cost, ethical and non challenges To avoi 	id	➤ Opinion Mi ◇ Sentiment:	No Coding ining: challenge Positive	

Figure 183 - Opinion Mining for challenge - Positive quotes

Also, for change positive quotes:

change	15 Matches			
rapid cetair mpr	Be. Constant moglati.	All (15) rapid (2) certain (1) comprehensi	ive (1) constant (1)	demographical (1)
8	80	dynamic global (1) enormous (1) great (1)	halting (1) pandemie	and climate (1) predict (1)
		profound technological (1) revolutionary (1)	such (1)	
	📵 72 🛿 5 in Hozdić (20	23) - Evolution of the Human Role in Manufacturi	ing S ㅋ	No Coc
	Modern society is li areas of human life	ving at a time of revolutionary changes in all For example, the field of industrial manufacturi.	+ Opinion Minin	g: change
			" — 🔿 Sentiment: Pos	itive
	👳 113 🛿 5 in Saini (202	3) - Transformation for Sustainable Business and	Man 🦻	Νο Coc
	ng the negative et	hical and social consequences. Transformation	+ Opinion Minin	g: change
	for Sustainable Busi Spectrum of Industi foundations of thes started, evolved, an selection © 2023 Aa	ness and Management Practices: Exploring the ry 5.0 provides an understanding of the e predicted changes; how the transformation d accelerated over time. © Editorial matter and irti Sa	Sentiment: Pos	itive
	148 § 5 in Kehrbusc	h (2023) - Digital Transformation-Towards Flexibl	е Ни л	No Coc
	Our society is progr	essing from an industrial society to a knowledge	+ Opinion Minin	g: change
	unprecedented extension to improve qu	establishing constant changes with end of mankind end speed. This is due to the urge of mankind	○ Sentiment: Pos	itive
	186 1 5 in Awotund	e (2023) - The Influence of Industry 4.0 and 5.0 for	Dist 🛪	No Coc
	The emergence of supported by disrur	protound technological changes around us otive advances in both software and hardware has	+ Opinion Minin	g: change
	really helped mode technological conc	rn educational systems. The cross-fertilization of ept	Sentiment: Pos	itive
	💿 204 🛿 5 in Morandii	ni (2023) - THE IMPACT OF ARTIFICIAL INTELLIGE	NCE 🤊	No Coc
	ormed by humans	s or to reduce cognitive workload. While this can	+ Opinion Minin	g: change
	have significant imp also be perceived as this trans-formation	olucities for organisations and workers, as Al car leading to job losses. Successfully adapting to wi	n Sentiment: Pos	itive
	🐵 320 🛿 5 in Qahtan ((2022) - Integrated sustainable transportation mo	delli 🤊	Νο Coc
	Globally, governme this century, namely	nts are contributing to the four main concerns of	+ Opinion Minin	g: change
	change, ensuring er issues associated wi driven by the trans	rergy security and mitigating human health th air pollution. These concerns are primarily	◇ Sentiment: Pos	itive
	339 1 5 in Ma (2022)) - Human-centric Smart Manufacturing for Indu	stry 5 🛪	Νο Coc
	to the future hum	an-centric smart manufacturing. Such change in	+ Opinion Minin	g: change
	value indicates that	numan centric smart manufacturing will receive	Sentiment: Pos	

Figure 184- Opinion Mining for change - Positive quotes

Moreover, the positive value's quotes:

value	12 Matches
2 0 turnen reef	
	All (12) human (2) modify (2) sustainable (2) add (1) final (1) full (1)
	great economic (1) important (1) snare (1)
	(i) 30 11 5 in Pappas (2023) - Responsible Diaital Transformation for a Sustainable Society
	ponsible and sustainable practices is essential. This editorial article discusses the importance of responsible digital transformation, emphasizing the need for academia, private and public organizations, civil society, and individuals to work together in developing digital business models that generate shared value while addressing societal challenges. The article highlights the emergence of corporat
	8 56 1 5 in Ghobakhloo (2023) - Actions and approaches for enabling Industry 5.0-driven sustainab
	nd collaboration in Industry 5.0 transformation. Proactive governmental support is the most driving enabler of Industry 5.0, whereas eco-innovation and sustainable value network reformation are among the most complex and hard-to-develop enablers. Results offer several implications for policymak
	🔞 62 🛚 5 in Lo (2023) - A data-driven decision support system for sustainable supplier evaluation in
	weights of the core criteria and their ranking. Finally, a modified classifiable technique for order preference by similarity to ideal solution (CTOPSIS) is used to integrate the final performance values of suppliers when new alternative suppliers are added. The research concept is in line with the concept
	187 11 5 in Jiménez Rios (2023) - Bridge management through digital twin-based anomaly detecti
	Bridge infrastructure has great economic, social, and cultural value Nevertheless, many 🕂 Opinic of the infrastructural assets
	338 1 5 in Rowan (2022) - Digital transformation of peatland eco-innovations ('Paludiculture'): E
	rbon sequestration and environmental protection. This complex transition from 'brown to green' must be met in real time by enabling digital technologies across the full value chain. This will potentially necessitate creation of ne
	349 1 5 in Ghobakhloo (2022) - Identifying industry 5.0 contributions to sustainable development
	ustry 5.0 experts through expert panel meetings. Results revealed that Industry 5.0 delivers sustainable development values through 16 functions. Circular intelligent products, employee technica
	385 1 5 in Wang (2022) - BIM Information Integration Based VR Modeling in Digital Twins in Ind
	hen the time division factor (TDF) is increased. This study provides important, reference value for the intelligent development of the construction industry and the Sentin

Figure 185 - Opinion Mining for value - Positive quotes

8.2 Appendix B – Industry 4.0 and Industry 5.0 complement one another through ATLAS.ti concepts

Below are a number of concept cloud screenshots, where various terms related to the three pillars of Industry 5.0 have been selected, to show where they originated from and to assist in understanding how these concepts were employed.



Figure 186 - Industry 5.0 Concept cloud by ATLAS.ti – Selecting Sustainability



Figure 187 - Industry 5.0 Concept cloud by ATLAS.ti - Selecting Workers



Figure 188 - Industry 5.0 Concept cloud by ATLAS.ti - Selecting Humans







Figure 190 - Industry 5.0 Concept cloud by ATLAS.ti - Selecting operator







Figure 192 - Industry 5.0 Concept cloud by ATLAS.ti - Selecting society



Figure 193 - Industry 5.0 Concept cloud by ATLAS.ti - Selecting centric



Figure 194 - Industry 5.0 Concept cloud by ATLAS.ti - Selecting collaboration

9

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