

MAPPING THE INTERSECTION OF CYBERSECURITY AND INDUSTRY 5.0: A BIBLIOMETRIC ANALYSIS

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Abstract

Industry 5.0 is a human-centric strategy that emphasizes the collaboration between humans and advanced technologies. On the other hand, cybersecurity is fundamentally oriented towards protecting people and their interactions with these technologies, especially within the framework of Industry 5.0. The increasing digitization and reliance on technology emerge in the development and implementation of cybersecurity concepts, measures, and implementations. This paper includes the intersection of Industry 5.0 and cybersecurity, focusing on their integration and the resulting research. It identifies the most influential authors and key areas of research, highlights essential keywords, and examines the most productive countries in the field of cybersecurity within Industry 5.0.

Key words: cybersecurity, Industry 5.0, cyber threats, digital transformation, bibliometric analysis

1. Introduction

In 2015 the term Industry 5.0 was introduced as a new strategy that relies on three main concepts: human-centricity, sustainability, and resilience (Rada & Schaller, 2024; Slavic, 2023). The concept of Industry 5.0 can be understood from multiple perspectives and defined in various ways, depending on the source. Leng et al. (Leng et al., 2022) distinguish between EU proposal-based, human-machine collaboration-based, and intelligent cutting-edge technology-based definitions. At its core, Industry 5.0 places humans at the center, focusing on their role in utilizing and interacting with advanced technologies such as artificial intelligence (AI),

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digitalization, blockchain, and IoT in different industries such as automotive (Crnobrnja et al., 2023; Rakic et al., 2023; Slavic et al., 2024).

The use of AI in human-oriented industries broadens the range of cutting-edge technologies available, making the implementation of cybersecurity essential. With a variety of cybersecurity threats, using AI to support cybersecurity can reduce the risks of damage scenarios by implementing the most innovative cybersecurity solutions. (Komosar et al., 2024).

To investigate current trends in the field of cybersecurity in Industry 5.0 this research covers a bibliometric analysis approach. Currently, there is a lack of bibliometric analysis that can address this research field. The aim of this paper is to synthesize current research in a bibliometric manner as a direction for further investigations. To conduct precise research, the authors declared research questions as follows:

1. RQ1: Which authors have contributed the most in this field?
2. RQ2: Which journals have the most published papers in this field?
3. RQ3: Which countries have the biggest production of papers in this field?
4. RQ4: Which keywords were the most used in the papers?

The paper is defined as follows: after the introduction the methodology is presented, followed by the results and discussion. At the end of the paper, the conclusion is provided with future direction and the limitations of the study.

2. Methodology

In this paper standard research framework for bibliometric analysis is provided. The authors selected Scopus as one of the most relevant databases for research. The initial step involved conducting a research query. After various combinations, the final query was: TITLE-ABS-KEY (cyber security OR cybersecurity OR cyber-sec*) AND TITLE-ABS-KEY (industry 5.0 OR industry 5* OR 5th industrial revolution OR fifth industrial revolution) AND PUBYEAR > 2018 AND PUBYEAR < 2025. The total number of 94 is taken for analysis.

Software R studio (rstudio-2024-04.2-764) including biblio shiny() is used to run analysis and obtain results. Additionally, VOSViewer is used to visualize the results.

3. Results and Discussion

To systematically present the results, the research questions and their corresponding answers will be addressed separately in sub-sections.

3.1 The authors who contributed the most

To answer RQ1, three aspects are taken into consideration: the number of published papers, the number of citations, and production over time. Table 1 presents an overview of the authors that contributed the most. All the authors have

an equal number of published papers – 2. In 2022, a total of 10 papers were published, increasing to 35 in 2023 and surpassing 40 in 2024. This significant growth highlights the rising importance of cybersecurity in Industry 5.0 as a critical area for development. On the other hand, considering the duration of productivity, Das AK has the longest active period in this field, followed by Mikolajewski. Bakkar, Nelufule, and Pal each have a one-year production period.

Table 1: Number of published papers per author

Number	Author	Number of published papers	Production period
1	Bakkar MN.	2	2023
2	Das AK.	2	2022-2024
3	Mikolajewski D.	2	2023-2024
4	Nelufule N.	2	2024
5	Pal S.	2	2024

Furthermore, Table 2 presents authors with the highest cite score per paper on a global level. The paper (Javed et al., 2022) has the highest score of citations – 268. One of the most popular topics in the most cited papers is blockchain, cryptography incorporated into operations, and supply chain management. For example, in the (Raja Santhi & Muthuswamy, 2022) Blockchain and cryptography are integrated and investigated in supply chain management with a total number of 132 citations. Additionally, in (Kumar & Mallipeddi, 2022) investigates the same topic expanding it with operations management with a score of 45 citations. Furthermore, in (Mourtzis et al., 2023) also focus on integrating blockchain in the era of the industrial metaverse with a 62-citation score.

While on the other hand Wang et al. (Wang et al., 2022) focus on data security storage mechanisms based on blockchain in IoT with 44 citations. Dhirani et al. (Dhirani et al., 2023) investigate ethical dilemmas and privacy issues in emerging technologies with 64 citations.

Table 2: Highest citation score by paper

Number	Author	Number of citations
1	Javed AR.	268
2	Raja Santhi A.	132
3	Dhirani LL.	64
4	Mourtzis D.	62
5	Kumar S.	45

3.2 The most relevant journals

To answer RQ2, the number of published papers in specific journals is taken into consideration. Table 3 presents the most relevant journals. In the first place, there is IEEE Transactions on Consumer Electronics with 5 published papers. On the other hand, the rest of the journals – Electronics, IEEE Access, IEEE Open Journal of the Communications Society, and Sensors have the same number of published papers – 3.

Table 3: Number of published papers per journal

Number	Journal	Number of published papers
1	IEEE Transactions on Consumer Electronics	5
2	Electronics (Switzerland)	3
3	IEEE Access	3
4	IEEE Open Journal of the Communications Society	3
5	Sensors	3

On the other hand, it is also H-index taken into consideration. The full overview is presented in Table 4. The highest H-index is IEEE Transactions on Consumer Electronics followed by Sensors with H-index 3. The IEEE Open Journal of the Communications Society has a value of 2 for the H-index, and the Electronics (Switzerland) and IEEE Access have an H-index of 1.

Additionally, the G-index is also the highest in the case of IEEE Transactions on Consumer Electronics with a score of 5 followed by a score of 3 for Electronics (Switzerland) and Sensors. Furthermore, the highest M-index is obligated for IEEE Transactions on Consumer Electronics and IEEE Open Journal of the Communications Society.

Table 4: Different indexes by journals with the highest number of published papers

Number	Journal	H-index	G-index	M-index
1	IEEE Transactions on Consumer Electronics	4	5	2
2	Electronics (Switzerland)	1	3	0.5
3	IEEE Access	1	1	0.5
4	IEEE Open Journal of the Communications Society	2	2	2
5	Sensors	3	3	1.5

3.3 Countries with the highest score of production

To address RQ3, Figure 1 illustrates the countries that have contributed publications in this field. India leads, followed by the USA. In third place is the UK, while Ukraine ranks fourth. Spain rounds out the top five.

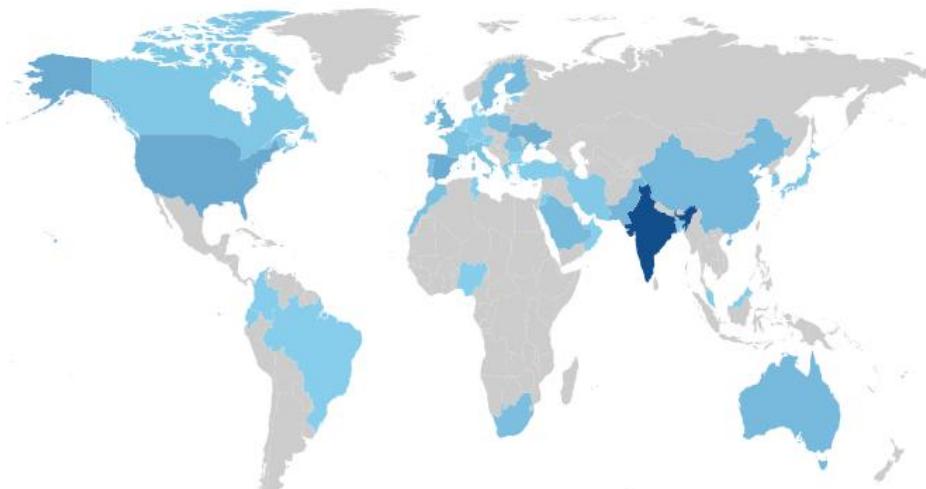


Figure 1. Overview of published papers per country

To take other factors into account, Table 5 provides an overview of the papers published in these countries over the past period. This result demonstrates the growing popularity of this topic in recent years. In relation to RQ3 and RQ1, there is a clear trend of expanding research in this area, particularly with the integration of cybersecurity into Industry 5.0.

Table 5: Overview of production per country over the years

Year	India	UK	USA	Spain	Ukraine
2022	9	1	2	-	-
2023	44	13	9	3	9
2024	76	16	21	20	17

Furthermore, one of the main factors that can be considered for contribution is the cite score. Table 6 presents the citation scores for the five most cited countries. Australia ranks first with 290 citations, followed by India with 186. Ireland has 72 citations, Greece 62, and the USA completes the top five with 49 citations.

Table 6: Overview of most cited countries

Number	Country	Number of citations	Average citations
1	Australia	290	96.7
2	India	186	15.5
3	Ireland	72	36
4	Greece	62	62
5	USA	49	16.3

3.4 The most used keywords

To identify the answer to RQ4, Figure 2 illustrates the most used keywords and the correlation between them. The most frequently used keyword is 'cybersecurity,' appearing 37 times. The second most common keyword is 'Industry 5.0,' with 27 occurrences. Additionally, the term 'Internet of Things' appears in 24 papers, followed closely by 'cyber security,' which occurs 22 times. Furthermore, the term 'network security' represents another cluster in Figure 2, with 18 occurrences, followed by 'Industry 4.0,' which appears 16 times.

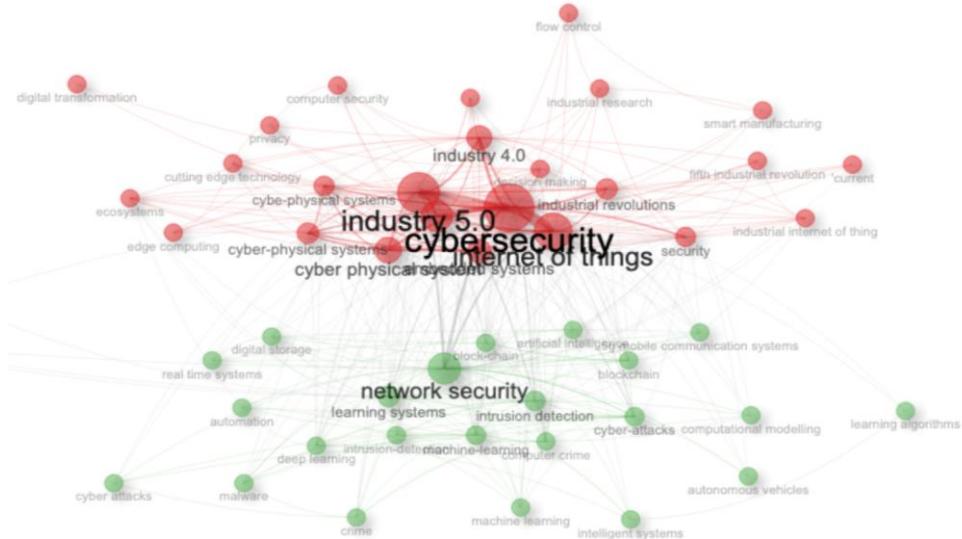


Figure 2. Correlation between keywords

3. Conclusion

This paper presents a bibliometric analysis of the development of cybersecurity within the framework of Industry 5.0. Through its approach, Industry 5.0 enhances the possibility of human interaction with the latest technologies, creating ideal conditions for the development of cybersecurity, not only for individuals but for entire industries (e.g., the automotive sector). Four research questions were proposed, and the analysis enabled the synthesis of the obtained results. Based on the results and discussion, the following conclusions were drawn:

- Interest in the development of this field has grown over the years. Regarding this trend, it can be expected to expand this field.
- The authors with the highest number of publications and citations focus on the use of blockchain and cryptographic concepts, integrating them into operations and supply chain management.

- The most frequently used keywords relate to cybersecurity and Industry 5.0, where a challenge is observed in the unification of different terms.
- The journal with the highest number of papers in relation to the number of citations is IEEE Transactions on Consumer Electronics.
- The country with the most success in this field is India, based on both the number of published papers and the number of citations.

Future research directions are expected to develop in this area, particularly in specific branches of cybersecurity (e.g., network security). The limitation of this study lies in the database used; future research offers the opportunity to expand the scope of scientific databases.

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