BPM in the Era of Industry 4.0: A Bibliometric Analysis

Hadjer Khider[1,2][a], Slimane Hammoudi[3], Abdelkrim Meziane[1] and Alfredo Cuzzocrea[4]
[1]*Information Systems and Multimedia Systems Department, CERIST, Algiers, Algeria*
[2]*Computer Science Department, Faculty of Exact Sciences,University of Bejaia, Bejaia 06000, Algeria*
[3]*ERIS Team, Computer Science Department – ESEO, Angers, France*
[4]*iDEA Lab, University of Calabria, Rende, Italy*

Keywords: Industry 4.0, Digital Transformation, BPM, Bibliometric Analysis.

Abstracts: In the age of today's technological development, with the advancement of the digitization of organizations, Industry 4.0 (I4.0) has evolved as a consequence of the fourth industrial revolution, leading industry to face a digital transformation (DT). This transformation is based on the use of cyber-physical systems (CPS) and information and communication technologies (ICT), in particular artificial intelligence (AI) and the Internet of Things (IoT). This new paradigm has brought changes in various areas of the functioning of the organization through a DT that holistically affects business processes, products, relationships and competencies which is a major challenge for organizations. This paper is dedicated to analyze the literature on BPM in the digital industry era through a bibliometric analysis, in order to analyze the impact of the I4.0 concepts and their associated technologies on the BPM, which will allow to determine the main BPM issues.

1 INTRODUCTION

Business Process Management (BPM) is at present one of the most often implemented methods of management within organizations (Szelagowski et al., 2020). According to Gartner in (Gartner, 2018), BPM software is a technology solution that enables organizations to design, analyze, execute, monitor and optimize important processes. It aims at providing techniques and software to design, enact, control, and analyze business processes involving humans, organizations, papers and other sources of information (Di Ciccio et al., 2015) . BPM presents a valuable and an advantageous tool through cost reduction, process excellence, and continuous process improvement. This important revolution has been stirred-up by recent advancements in the big data research area (Leung et al., 2018; Leung, Braun, et al., 2019; Leung, Chen, Hoi, Shang, & Cuzzocrea, 2020; Leung, Chen, Hoi, Shang, Wen, et al., 2020; Leung, Cuzzocrea, et al., 2019). In the age of today's technological development, with the advancement of the digitization of organizations, Industry 4.0 (I4.0) has evolved as a consequence of the fourth industrial revolution (Mohanta et al., 2020). The Fourth Industrial Revolution is being realized through the combination of various technologies, such as artificial intelligence, cloud computing, adaptive robotics, augmented reality, additive manufacturing and the Internet of Things (IoT) (Queiroz et al., 2022). This new paradigm has brought changes in various areas of the functioning of the organization through a digital transformation (DT) that holistically affects business models, processes, products, relationships and competencies, which is a major challenge for organizations (Flechsig et al., 2022), and which requires a fail fast culture due to the current business environment and competitive factors (Szelągowski et al., 2022). In line with the aforementioned concepts, this paper presents a bibliometric analysis on BPM in the era of I4.0 and DT. This study has three main objectives: (i) to analyze the nature and evolution of the literature related to BPM in the era of digital industry and (ii) to identify the thematic areas related to I4.0 and its impact on BPM, and (iii) to identify the challenges of BPM in the era of DT. To achieve this, a bibliometric analysis of 231 papers listed in the Scopus was conducted.

Structurally, this paper is organized as follows: Section 2 shows a summarized background on I4.0

[a] https://orcid.org/0000-0002-0566-923

Khider, H., Hammoudi, S., Meziane, A. and Cuzzocrea, A.
BPM in the Era of Industry 4.0: A Bibliometric Analysis.
DOI: 10.5220/0011995200003467
In *Proceedings of the 25th International Conference on Enterprise Information Systems (ICEIS 2023) - Volume 2*, pages 651-659
ISBN: 978-989-758-648-4; ISSN: 2184-4992

and DT, Section 3 presents a bibliometric analysis on the BPM in the era of I4.0 and DT, Section 4 discusses the results and findings on the Knowledge base of BPM in the digital Age. Section 5 presents discussion, synthesis and positioning. Finally, in Section 6, we conclude with a summary of the findings, limitations of the study, and some directions of the future research.

2 BACKGROUNDS

In this Section, we provide an overview of backgrounds that are relevant to our research: Industry 4.0 and Digital Transformation. These will represent the relevant scientific humus for the remaining part of the paper.

2.1 Industry 4.0

The term Industry 4.0 refers to a new model of organization and control of the value chain through the product life cycle supported by information technologies that is, it is the application to the model industry (Okano, 2017). Various technologies or techniques can be used for implementing Industry 4.0. These technologies include Cyber Physical Systems, IoT, cloud computing, blockchain, industrial information integration and other related technologies (Xu et al., 2018).

2.2 Digital Transformation

The ongoing worldwide digital transformation, triggered by the Industry 4.0 initiative, has brought new concepts and emerging technologies to the surface (Pires et al., 2019). This new paradigm has historically been defined as the use of technology to profoundly and rapidly transform business activities, processes, competencies, and models to fully leverage the changes and opportunities brought by digital technologies and their impact across society in a strategic and prioritized way, to meet changing business and market requirements, and to lead an organization into the digital future (Albert, 2020). The digital transformation of an organization is much more than just digitalization, as defined by (Schwab, 2016), it is the result of an organizational change where people, processes and the entire business model understand technology as a tool to generate value among its consumers and collaborators.

3 BIBLIOMETRIC ANALYSIS: A TECHNIQUE OF SYSTEMATIC LITERATURE REVIEW

One of the most important methods of discovering knowledge is by synthesizing the results of previous studies. We conduct a bibliometric analytic approach to investigate the knowledge base on BPM and analyzing the impact of the I4.0 concepts and their associated technologies in the management of organizations and their business processes (BPs). Recourse to bibliometric analysis has become increasingly popular. It facilitates the identification of frequently referenced authors and related publications, and the keywords most commonly used in a given study field (Zehra et al., 2022). It also facilitates the review of the literature by bringing the researcher to influential research works or publications, in a given study field (Zupic et al., 2015). (Donthu et al., 2021) discussed in detail the methodology to conduct bibliometric analysis.

3.1 Evaluative Techniques

Evaluation techniques are used to analyze the relative influence and academic impact of a topic. These include various measures of productivity, such as evaluation of the historical evolution of the number of publications, the distribution of papers by field, journal and author, and the analysis of the most cited papers (Hall, 2011). These analyses have been carried out by means of the VOSviewer (van Eck et al., 2010) software, as well as by means of the information that Scopus itself has generated.

3.2 Visualization Software

The use of bibliometric analysis often involves using network visualization software (Donthu et al., 2021), ranging from software based entirely on graphical user interfaces, such as VOSviewer (van Eck et al., 2010), to software based on commands, such as the Bibliometrix package in R (Aria et al., 2017). For our bibliometric analysis we used the VOSviewer software.

3.3 Study Design: Methodology

The goal of this study was to achieve two purposes. The first was the analysis of the BPM literature in the era of I4.0 and DT. This, will help BPM researchers determine BPM issues, and the second was to determine research trends over time. To achieve our

goals, we combined both bibliometric methodologies; performance analysis and science mapping. The techniques for bibliometric analysis manifest across two categories: (1) performance analysis and (2) science mapping. (Donthu et al., 2021). As mentioned in (Donthu et al., 2021), performance analysis examines the contributions of research constituents to a given field (Cobo et al., 2011), while science mapping focuses(Baker et al., 2021) on the relationships between research constituents.

Table 1: Data Collection.

Features	Values
Database	Scopus
Search Criterion	Topic
Kind of Paper	Article, conference book chapter (published or early access)
Time Range	2016-2023
Keywords	("business process management" OR "BPM") AND (“Industry 4.0” OR “Digital transformation”)
Number of Initial Papers	231
Filter Criterion	Duplicated papers. Paper not in English, Papers not related with the topic
Number of final Papers	222

In accordance with the general guidelines for the conduct of a bibliometric analysis presented in(Baker et al., 2021), the next five key steps have been followed:

- **Research Design**: Various types of methodologies have been developed to construct a bibliometric analysis, we have considered citation and co-citation analysis (by author and journal) (Appio et al., 2014), co-word analysis, and network analysis .
- **Bibliometric Data Collection**: we have browsed the Scopus database accessed via our SNDL[2]portal, which gives us access to rich and diverse international electronic documentation. which has offered a total of 231 papers for examination. The search terms ("business process management" OR "BPM") AND (“Industry 4.0” OR “Digital transformation”) were used to extract bibliometric data as mentioned in Table 1.
- **Inclusion Criteria**: There were three inclusion rules that were followed: Journal articles, conference papers, and book chapters in which one of the keywords appears in the article title, abstract, or keywords. The publication date ranges from 2016 to 2023. If they met all inclusion criteria, English language abstracts were included in the bibliometric review.
- **Exclusion Criteria**: All papers with a core subject of industry 4.0 or DT but not relevant to the field of BPM were left out of the analysis. After filtering the data based on the inclusion and exclusion criteria, a total of 231 papers were gathered (see Table 1). We have excluded the paper that are not in English. which has limited to a total of 222.
- **Methodology and Software**: We have used the Scopus data set in the analysis and the approaches listed above, in addition to the VOSviewer [3] (van Eck et al., 2010) as a software for visual and quantitative analysis.

4 KNOWLEDGE BASE OF BPM IN THE DIGITAL AGE: RESULTS AND FINDINGS

4.1 Productivity Assessment

Figure 1 presents the annual scientific production in I4.0 and DT fields related to BPM. A fundamental jump in the number of works occurred in 2017 and 2018, while the number of works extremely increased in 2022. Table 2 shows the top productive nations.

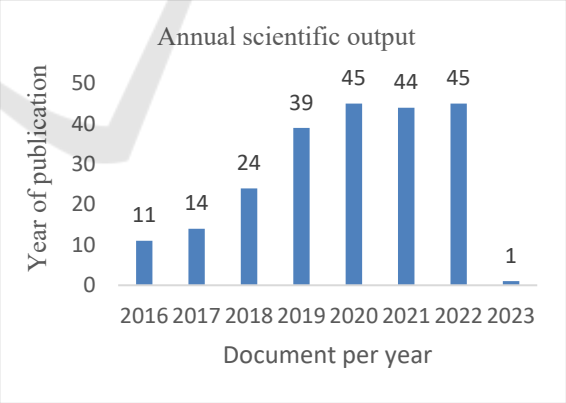

Figure 1: Annual scientific output on BPM and industry 4.0: A Scopus database analysis (2016–2023).

As shown in Figure 2, Germany is one of the countries that has played an important and crucial role in the ongoing progress of the field, followed by Russian Federation. Austria, Portugal and Italy.

[2]https://www.sndl.cerist.dz/index.php?p=9

[3] https://www.vosviewer.com/

Table 2: Distribution of papers per country.

Country	Num. of Papers	Country	Num. of Papers
Germany	45	Australia	3
Russian Federation	21	Liechtenstein	3
Austria	18	Denmark	2
Portugal	17	Hungary	2
Italy	**17**	Japan	2
United States	14	Latvia	2
Brazil	11	Sweden	2
Belgium	9	Turkey	2
India	7	Azerbaijan	2
U. Kingdom	7	Finland	2
South Africa	6	Slovenia	1
France	6	Tunisia	1
South Africa	6	Colombia	1
Czech	5	Cyprus	1
Netherlands	5	Ecuador	1
Switzerland	5	Greece	1
Croatia	4	Ireland	1
Lithuania	4	Mexico	1
Peru	2	Namibia	1
Romania	2	Norway	1
South Korea	2	Saudi A.	1
Thailand	3	Bangladesh	1
Ukraine	3	Argentina	1
Cambodia	2	U.A.E.	1
Canada	2	Slovakia	1
China	2		

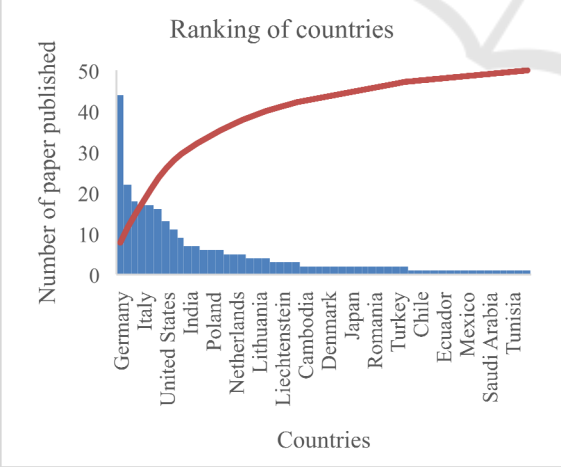

Figure 2: Ranking of countries based on scientific output on BPM in the era of industry 4.0 and digital transformation (2016-2023).

4.1.1 Most Productive Authors

The most productive authors working on the topic of I4.0 and the DT in relation to BPM are shown in Figure 3. As we can see in Figure 3, German researchers such as Flechsig and Schmidt W. are the most active contributors (see Figure 3), Schmidt W., which emphasizes the agility required by business processes to support process execution for the digital transformation of organizations (Fleischmann et al., 2021), followed by Imgrund, F. (Marcus Fischer et al., 2020; Rehse et al., 2021), and Fischer, M. followed by Janiesch C. in (M Fischer et al., 2019; Marcus Fischer et al., 2020, 2021; Imgrund et al., 2018, 2019) and Fettke, P. (Niesen et al., 2016; Rehse et al., 2021) who focused on the great potential of BPM techniques to meet I4.0 challenges.

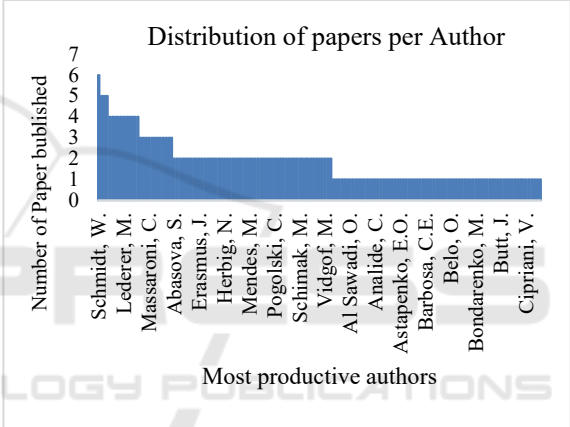

Figure 3: An overview of the most productive authors.

4.1.2 Most Influential Publications

Table 3: Most cited authors.

Author	Paper per Author	Citations
Fettke P.	4	91
Imgrund F.	5	85
Janiesch C.	5	85
Fischer M.	4	82
Winkelmann A.	4	82
Lederer M.	4	53
Van looy A.	4	44
Santoro F.M.	4	34
Kirchmer M.	4	28
Stary C.	5	24
Telukdarie A.	4	24
Teixeira L.	4	18
Schmidt W.	6	17
Barata J.	4	8

Table 3 shows the most cited among the 222 papers, for example, the most cited paper is *Industry 4.0: State of the art and future trends,* by (Xu et al., 2018) with 1428 local citations and 2398 global citations, followed by the paper, Blockchain based business process management framework for service composition in industry 4.0 by (Viriyasitavat et al., 2020) with 115 and 264 local and global citations, respectively.

Intriguingly, although (Baiyere et al., 2020) receives 89 local citations, this work has 209 global citations followed by Imgrund F. et al. (2020). *Strategy archetypes for digital transformation: Defining meta objectives using business process management,* with 58 local citations and 179 global citations. It examines how the large companies use BPM to implement digital transformation.

Table 4: Distribution of paper by type of publication.

Publication type	Papers	Frequency (%)
Conference Paper	132	59.45
Article	63	28.37
Conference Review	14	6.30
Book Chapter	6	2.70
Review	4	1.80
Book	2	0.90
Editorial	1	0.45

Table 4 shows that the 222 selected papers were included in 2752 publications. Specifically, the distribution according to the type of publication is as follows: 132 (59,45%) were published in conference papers, 63 (28,37%) in journals, 14 in conference reviews (6.30%), 6 (2.70%) in book chapters, 4 (1.80%) in reviews, 2 (0.90%) in books and 1 paper in editorial (0,45%). The distribution of papers by type of publication is shown in Figure 4.

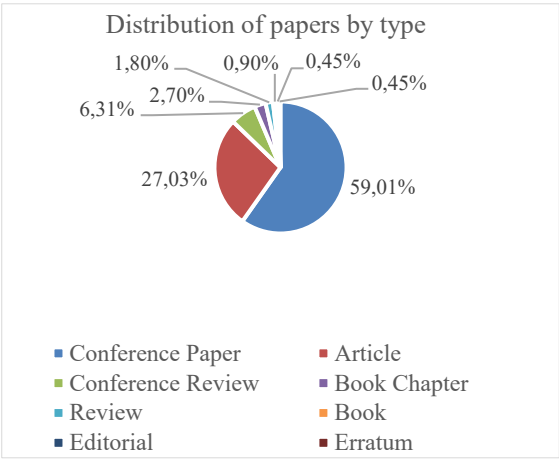

Figure 4: Distribution of papers by type of publication.

Figure 5 presents the distribution of papers according to the source. Of the 222 selected papers, 63 are published in journals. It can be seen from Table 5, that the Business Process Management Journal has the highest number of publications on the subject of I4.0 and DT related to BPM in the Scopus index, followed by Sustainability Switzerland , Applied Sciences Switzerland, Business And Information Systems Engineering, Business And Information , Business And Information Systems Engineering Systems Engineering, IEEE Access, Information And Management, Information Systems, International Journal of Engineering And Advanced Technology and Journal On Data Semantics.

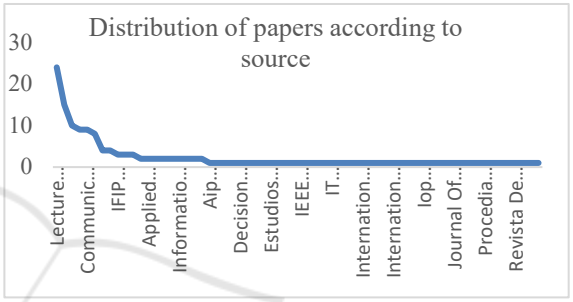

Figure 5: Most Relevant Papers Sources.

Table 5: Most Relevant Journal Sources. (Total of 63).

Journal Name	Nub. of publications	Assigned quartile
Business Process Management Journal	10	Q1
Sustainability Switzerland	4	Q2
Applied Sciences Switzerland	2	Q2
Business And Information Systems Engineering	2	Q1
IEEE Access	2	Q1
Information And Management	2	Q1
Information Systems	2	Q1
International Journal of Engineering and Advanced Technology	2	No yet assigned quartile
Journal On Data Semantics	2	Q3

As Table 6 reflects, most of the papers of this selection (31.9%) have been published in the computer science area, followed by Some other relevant areas as Engineering (17,0%), Business, Management and Accounting (14,5%), Decision Sciences (11,2%), Mathematics (11,0%), and Other Science Technology Topics. Thus, there appear to be four perspectives from which to approach I4.0 and DT: Technology, Engineering, Management and

Science. The distribution of papers by research area is presented in the Figure 6 below.

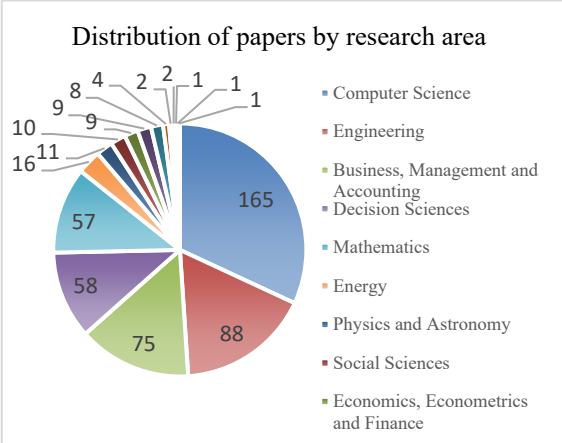

Figure 6: Distribution of papers by research area.

Table 6: Distribution of papers by research area.

Research areas	Papers (N)	Percentage (N/222)
Computer Science	165	31,9
Engineering	88	17,0
Business, Management and Accounting	75	14,5
Decision Sciences	58	11,2
Mathematics	57	11,0
Energy	16	3,1
Physics and Astronomy	11	2,1
Social Sciences	10	1,9
Economics, Econometrics and Finance	9	1,7

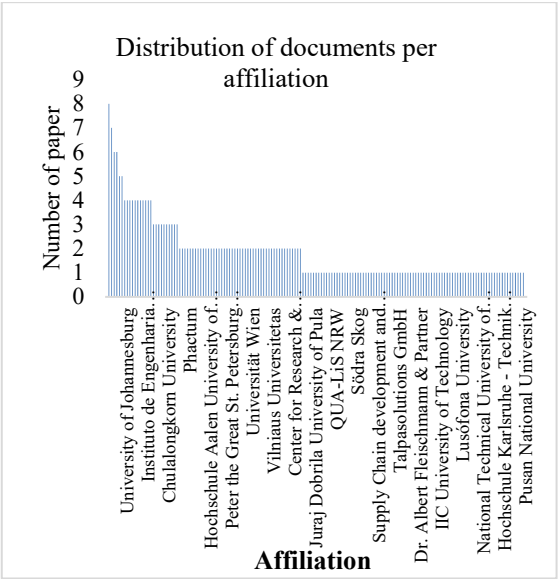

Figure 7: Distribution of papers by affiliation.

4.2 Network Analysis

The use of bibliometric analysis often involves using network visualization software (Donthu et al., 2021), ranging from fully graphical user interface-based software such as VOSviewer (van Eck & Waltman, 2010) to command-based software such as the Bibliometrix package in R (Aria et al., 2017). We have used the VOSviewer software to carry out our bibliometric analysis. Each node in a network represents an entity (e.g. article, author, country, institution, keyword, journal). The nodes and links in this cluster can be used to explain the coverage of the theme (cluster) by the topics (nodes) and the relationships (links) between the topics (nodes) manifested under this theme (cluster).

4.2.1 Collaboration Network Analysis

Figure 8 shows the collaboration matrix. Among the total of 57 countries in the original dataset, the collaboration of the researchers by country showed that the authors have collaborated with researchers from the same country as well as with researchers from other countries. As shown in Figure 8, the sizes of most nodes in the yellow cluster (Germany node), the green cluster (Russian Federation), the sea green cluster (Austria and Portugal nodes), and the orange cluster (Italy node) are larger than in other clusters. This visualization indicates that most of the selected researchers in these clusters have published more articles than other researchers (as we can see in Figure 8, Germany is the country with more publications). The distance between the nodes shows the partnerships between the yellow, green, sea green and the orange clusters. Of all these clusters, the dark orange cluster is in the center.

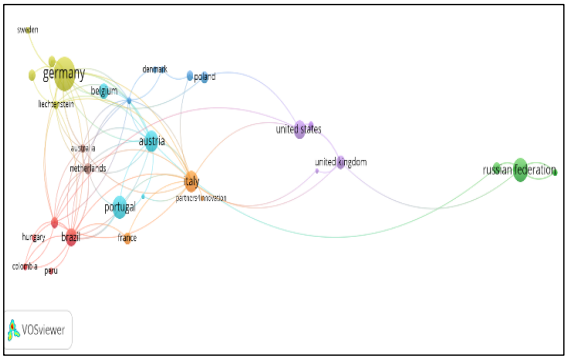

Figure 8: Collaboration among researchers from different countries (visualized by VOSviewer).

4.2.2 Keyword Co-Occurrence Network Analysis

Figure 9. shows the co-occurrence matrix. Each node in a network represents a *keyword*, in which: The size of the node is an indication of the occurrence of the keyword (i.e. the number of occurrences of the keyword), The link between nodes represents keyword co-occurrence (i.e. keywords that occur together), The thickness of the link signals the occurrence of keyword co-occurrences (i.e. the number of times the keywords occur together), Larger nodes indicate more occurrences of the keyword, The thicker the link between the nodes, the greater the number of co-occurrences between keywords. Each *color* represents a *thematic cluster.* As seen in Figure 9, the main keywords in the research topic are: "business process management (117 occurrences and 554 total link strength), "enterprise resource management" (116 occurrences and 634 total link strength), "digital transformation" (84 occurrences and 395 total link strength), "industry 4.0" (76 occurrences and 317 total link strength), "business process" (46 occurrences and 266 total link strength), "Internet Of Things "(17 occurrences and 101 total link strength) and "digitalization" (13 occurrences and 79 total link strength).

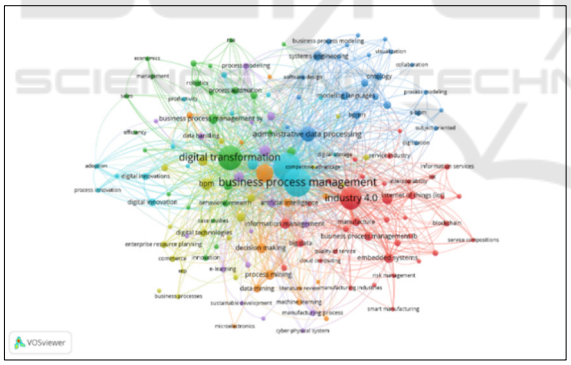

Figure 9: Keyword co-occurrence network using VOSviewer.

Research trends and hot topics emerge from the co-word analysis of the most frequent keywords (Li et al., 2016), As can be seen in Figure 10, in our sample of 222 papers, we detected 1,501 keywords. We only considered the 19 keywords that appear in at least 12 publications. The nodes illustrate the occurrence of the keywords, while the links between the nodes represent the number of times that the words appear together.

Selected	Keyword	Occurrences	Total link strength
☑	enterprise resource management	116	634
☑	business process management	117	554
☑	digital transformation	84	395
☑	industry 4.0	76	317
☑	business process	46	266
☑	administrative data processing	33	208
☑	process management	19	119
☑	bpm	19	103
☑	information management	16	102
☑	internet of things	17	101
☑	information systems	15	94
☑	metadata	13	92
☑	embedded systems	14	89
☑	systems engineering	13	88
☑	decision making	14	87
☑	life cycle	12	86
☑	business process management systems	13	81
☑	digitalization	13	79
☑	industrial revolutions	9	76

Figure 10: The main keywords in the research topic of BPM and I4.0 and DT.

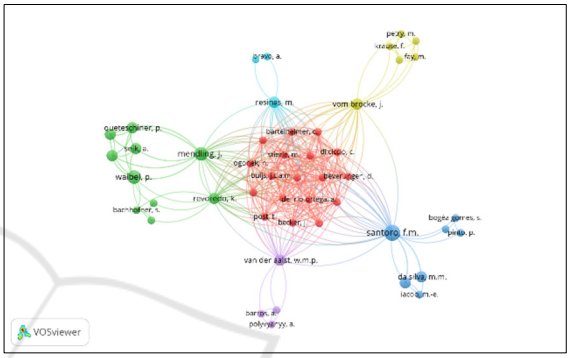

Figure 11: Co-authorship network in the I4.0 and DT related to BPM field.

The co-authorship analysis included researchers with at least one publication (fractional counting) regarding I4.0 and DT related to BPM. 603 researchers met this threshold and were selected for network analysis. The co-authorship network in I4.0 and DT related to BPM is mapped in Figure 11, and this map can be used to focus on research areas that are shared by many currently active authors. As can be seen in Figure 11, the co-authorship network can be divided into seven groups. Of all these clusters, the red cluster is at the center. 603 met this threshold and were selected for network analysis. Among these 603 researchers, only 48 of them collaborated directly or indirectly. The authors separated these 48 researchers into seven clusters to form a network of co-authorship. As shown in Figure 11, the sizes of most nodes in the red cluster yellow cluster and green cluster are bigger than in other clusters. This visualization indicates that most of the selected researchers in these clusters have published more articles than other researchers. The distance between the nodes shows partnerships among the red, yellow, green blue, orange light blue and purple clusters. Of all these clusters, the red cluster is at the center. This represents the frequent collaboration between authors who are interested in the same research area.

5 SYNTHESIS, DISCUSSION AND POSITIONING

This paper presents a bibliometric analysis study on BPM in the I4.0 era. In this study, we analyzed a total of 231 papers published in 63 journals, 8 books, and 132 conference titles from 2016 to 2023. We have explored some interesting results concerning the BPM-related publications. The results of this study confirm the important role of BPM in the success of the I4.0 and DT. The growing number of publications shows that many research centers and universities are starting to explore this topic. Many countries, such as Germany, followed by the Russian Federation, Austria, Portugal and Italy, have played a crucial role in the ongoing progress of the field which proves the importance of this discipline. However, the number of papers is still very low compared to the importance and novelty of Industry 4.0, and most of the papers do not propose technologies and methods for BPM implementation that can support the implementation of the I4.0 concept. New research opportunities and challenges arise from the concept of I4.0. One of these key challenges is the future of the BPM and how it can be implemented for the I4.0 and the DT.

6 CONCLUSIONS

The aim of the bibliographic analysis was to investigate the current research trends and challenges in the field of BPM in the era of the new digital industry and the challenges it faces. According to the study's findings, the research on the topic of I4.0 and DT is growing at a rapid pace. Researchers have published their findings in different types of publications: research papers, books, book chapters and conference papers, increasingly collaborating to improve their quality. Germany, followed by the Russian Federation, Austria, Portugal and Italy, are among the countries that have played an important and decisive role in the ongoing progress of the field. The keywords most frequently used by researchers (e.g. Industry 4.0, BPM, Digital Transformation, Digitalization and Internet of Things) indicate the hotspots in BPM research. The main purpose of adopting different bibliometric analysis methods was to reveal research trends and published papers. The bibliometric analysis we have presented is limited as we have only used Scopus as a knowledge base. In the future we intend to extend the bibliometric analysis to another knowledge base such as Web of Science.

REFERENCES

Albert, M. (2020). *Digitalization and Digital transformation in Finance Operations*. *December*. doi: 10.3389/fpsyg.2022.1081595

Appio, F. P., Cesaroni, F., & Di Minin, A. (2014). Visualizing the structure and bridges of the intellectual property management and strategy literature: a document co-citation analysis. *Scientometrics*, *101*(1), 623–661. doi: 10.1007/s11192-014-1329-0

Aria, M., & Cuccurullo, C. (2017). bibliometrix : An R-tool for comprehensive science mapping analysis. *Journal of Informetrics*, *11*(4), 959–975. doi: 10.1016/j.joi.2017.08.007

Baiyere, A., Salmela, H., & Tapanainen, T. (2020). Digital transformation and the new logics of business process management. *European Journal of Information Systems*, *29*(3), 238–259. doi: 10.1080/0960085X.2020.1718007

Baker, H. K., Kumar, S., & Pandey, N. (2021). Forty years of the Journal of Futures Markets : A bibliometric overview. *Journal of Futures Markets*, *41*(7), 1027–1054. doi: 10.1002/fut.22211

Cobo, M. J., López-Herrera, A. G., Herrera-Viedma, E., & Herrera, F. (2011). An approach for detecting, quantifying, and visualizing the evolution of a research field: A practical application to the Fuzzy Sets Theory field. *Journal of Informetrics*, *5*(1), 146–166. doi: 10.1016/j.joi.2010.10.002

Di Ciccio, C., Marrella, A., & Russo, A. (2015). Knowledge-Intensive Processes: Characteristics, Requirements and Analysis of Contemporary Approaches. *Journal on Data Semantics*, *4*(1), 29–57. doi: 10.1007/s13740-014-0038-4

Donthu, N., Kumar, S., Mukherjee, D., Pandey, N., & Lim, W. M. (2021). How to conduct a bibliometric analysis: An overview and guidelines. *Journal of Business Research*, *133*(March), 285–296. doi: 10.1016/j.jbusres.2021.04.070

Fischer, M, Imgrund, F., Janiesch, C., & Winkelmann, A. (2019). Directions for future research on the integration of SOA, BPM, and BRM. *Business Process Management Journal*, *25*(7), 1491–1519. doi: 10.1108/BPMJ-05-2018-0130

Fischer, Marcus, Hofmann, A., Imgrund, F., Janiesch, C., & Winkelmann, A. (2021). On the composition of the long tail of business processes: Implications from a process mining study. *Information Systems*, *97*, 101689. doi: 10.1016/j.is.2020.101689

Fischer, Marcus, Imgrund, F., Janiesch, C., & Winkelmann, A. (2020). Strategy archetypes for digital transformation: Defining meta objectives using business process management. *Information & Management*, *57*(5), 103262. doi: 10.1016/j.im.2019.103262

Flechsig, C., Lohmer, J., Voß, R., & Lasch, R. (2022). Business Process Maturity Model for Digital Transformation: An Action Design Research Study on The Integration of Information Technology.

International Journal of Innovation Management, *26*(03). doi: 10.1142/S1363919622400126

Fleischmann, A., Friedl, A., Großmann, D., & Schmidt, W. (2021). Modeling and Implementing of Industrie 4.0 Scenarios. In Communications in Computer and Information Science: Vol. 1401 CCIS (pp. 90–112). doi: 10.1007/978-3-030-72696-6_4

Gartner. (2018). *Gartner Says BPM is Critical for Business Transformation Success*. Retrieved from https://solutionsreview.com/business-process-management/gartner-says-bpm-is-critical-for-business-transformation-success/

Hall, M. (2011). Publish and perish? Bibliometric analysis, journal ranking and the assessment of research quality in tourism. *Tourism Management*, *32*(1), 16–27. doi: 10.1016/j.tourman.2010.07.001

Imgrund, F., Fischer, M., Janiesch, C., & Winkelmann, A. (2018). Approaching digitalization with business process management. *MKWI 2018 - Multikonferenz Wirtschaftsinformatik*, *2018-March*, 1725–1736.

Imgrund, F., & Janiesch, C. (2019). Understanding the Need for New Perspectives on BPM in the Digital Age: An Empirical Analysis. *Lecture Notes in Business Information Processing*, *362 LNBIP*, 288–300. doi: 10.1007/978-3-030-37453-2_24

Leung, C. K., Braun, P., Hoi, C. S. H., Souza, J., & Cuzzocrea, A. (2019). Urban Analytics of Big Transportation Data for Supporting Smart Cities. In Lecture Notes in Computer Science: Vol. 11708 LNCS (pp. 24–33). Springer International Publishing. doi: 10.1007/978-3-030-27520-4_3

Leung, C. K., Chen, Y., Hoi, C. S. H., Shang, S., & Cuzzocrea, A. (2020). Machine Learning and OLAP on Big COVID-19 Data. *2020 IEEE International Conference on Big Data (Big Data)*, 5118–5127. doi: 10.1109/BigData50022.2020.9378407

Leung, C. K., Chen, Y., Hoi, C. S. H., Shang, S., Wen, Y., & Cuzzocrea, A. (2020). Big Data Visualization and Visual Analytics of COVID-19 Data. *2020 24th International Conference Information Visualisation (IV)*, *2020-Septe*(Iv), 415–420. doi: 10.1109/IV51561.2020.00073

Leung, C. K., Cuzzocrea, A., Mai, J. J., Deng, D., & Jiang, F. (2019). Personalized DeepInf: Enhanced Social Influence Prediction with Deep Learning and Transfer Learning. *Proceedings - 2019 IEEE International Conference on Big Data, Big Data 2019*, 2871–2880. doi: 10.1109/BigData47090.2019.9005969

Leung, C. K., Hoi, C. S. H., Pazdor, A. G. M., Wodi, B. H., & Cuzzocrea, A. (2018). Privacy-Preserving Frequent Pattern Mining from Big Uncertain Data. *2018 IEEE International Conference on Big Data*, 5101–5110. doi: 10.1109/BigData.2018.8622260

Li, H., An, H., Wang, Y., Huang, J., & Gao, X. (2016). Evolutionary features of academic articles co-keyword network and keywords co-occurrence network: Based on two-mode affiliation network. *Physica A: Statistical Mechanics and Its Applications*, *450*, 657–669. doi: 10.1016/j.physa.2016.01.017

Mohanta, B., Nanda, P., & Patnaik, S. (2020). Management of V.U.C.A. Using Machine Learning Techniques in Industry 4.0 Paradigm. In New Paradigm of Industry 4.0 Internet (Vol. 64, pp. 1–24). doi: 10.1007/978-3-030-25778-1_1

Niesen, T., Houy, C., Fettke, P., & Loos, P. (2016). Towards an integrative big data analysis framework for data-driven risk management in industry 4.0. *Proceedings of the Annual Hawaii International Conference on System Sciences*, *2016-March*, 5065–5074. doi: 10.1109/HICSS.2016.627

Okano, M. T. (2017). IOT and Industry 4 . 0 : The Industrial New Revolution. *International Conference on Management and Information Systems*, 26.

Pires, F., Cachada, A., Barbosa, J., Moreira, A. P., & Leitao, P. (2019). Digital Twin in Industry 4.0: Technologies, Applications and Challenges. *2019 IEEE 17th International Conference on Industrial Informatics (INDIN)*, *2019-July*, 721–726. doi: 10.1109/INDIN41052.2019.8972134

Queiroz, M. M., & Wamba, S. F. (2022). Managing the Digital Transformation. In Managing the Digital Transformation. Boca Raton: CRC Press. doi: 10.1201/9781003226468

Rehse, J.-R., Dadashnia, S., & Fettke, P. (2021). Business process management for Industry 4.0-Three application cases in the DFKI-Smart-Lego-Factory. *IT - Information Technology*, *60*(3), 133–141. doi: 10.1515/itit-2018-0006

Schwab, K. (2016). The Fourth Industrial Revolution: what it means and how to respond. *World Economic Forum*, 1–7.

Szelagowski, M., & Lupeikiene, A. (2020). Business Process Management Systems: Evolution and Development Trends. *Informatica (Netherlands)*, *31*(3), 579–595. doi: 10.15388/20-INFOR429

van Eck, N. J., & Waltman, L. (2010). Software survey: VOSviewer, a computer program for bibliometric mapping. *Scientometrics*, *84*(2), 523–538. doi: 10.1007/s11192-009-0146-3

Viriyasitavat, W., Da Xu, L., Bi, Z., & Sapsomboon, A. (2020). Blockchain-based business process management (BPM) framework for service composition in industry 4.0. *Journal of Intelligent Manufacturing*, *31*(7), 1737–1748. doi: 10.1007/s10845-018-1422-y

Xu, L. Da, Xu, E. L., & Li, L. (2018). Industry 4.0: state of the art and future trends. *International Journal of Production Research*, *56*(8), 2941–2962. doi: 10.1080/00207543.2018.1444806

Zehra, A., & Urooj, A. (2022). A Bibliometric Analysis of the Developments and Research Frontiers of Agent-Based Modelling in Economics. *Economies*, *10*(7), 171. doi: 10.3390/economies10070171

Zupic, I., & Čater, T. (2015). Bibliometric Methods in Management and Organization. *Organizational Research Methods*, *18*(3), 429–472. doi: 10.1177/1094428114562629