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Business Models in the Digitalization and Industry 4.0 era – A bibliometric Review and Future Research

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1. Introduction

The emergence of digital technologies has significantly transformed organizations by forcing them to adapt their Business Models (BM), management strategies and practices (Latos *et al*., 2018; Fernandez-Vidal *et al*., 2022), modifying traditional business structures, as well as redefining the client´s meaning, and how individuals live and interact with each other in the Fourth Industrial Revolution, also known as Industry 4.0 (I4.0) (Berman *et al*., 2016).

It is impressive how I4.0 technologies have had a significant effect not only on production processes, but also on how companies in any sector create value through their BM (Paiola, *et al*., 2021). For, the underlying characteristic of I4.0 is the connectivity between machines, purchasing and logistics sectors, workers, suppliers and customers, enabling the intelligent manufacturing process, providing high performance associated with product design, production and logistics systems through communication between machines and digital devices (Alkaraan *et al*., 2022). The result is more efficient companies, with optimized processes in both cost and time, as well as reduced waste and errors. It is remarkable that technology adaptation is not a choice for companies, especially nowadays, since organizations in general have to adopt new technologies to be more competitive (Faridi & Malik, 2019).

Rosa *et al*. (2020) stated that I4.0's mechanisms enable significant business improvements, which can increase customer experience and optimize operations or even create BM. However, there are many factors that influence the results of companies in order to change BMs in the context of I4.0 technologies. This research aims to identify the dimensions that influence BM in the digitalization and I4.0 era. Therefore, BM can be described as a simplified representation of the elements of the business system and its interrelations, aiming to reveal the business strategy through the creation, delivery and capture of value (Richardson, 2008). However, the transformation from traditional BM to a digital BM is happening in an accelerated way to deliver new values to both employees and customers besides having the ability to compete more effectively in a digital economy.

In recent decades, scientific literature has paid increasing attention to digitalization and its effects on organizations, economies, and societies. While some are focused on debating the impacts that I4.0 and digitalization can have on BMs, others address the effects of digitalization on BMs of SMEs and/or large companies, as well as analyze Circular Economy BM. There are also several studies with the objective of presenting concepts and frameworks to help companies achieve market leadership, implement technology solutions, and give guidance on and during the decision-making process.

Although there is an increasing number of investigations on I4.0, digitalization, and BM, in the existing literature there are no comprehensive studies that discuss and present a bibliographic review on the dimensions that influence BM in the digitalization and I4.0 era, except for the systematic bibliometric review of the literature, by Caputo *et al*., (2021), which addresses the relationship between digitalization and innovation of BMs, and its progresses occurred during the last decade. Therefore, it is observed that there is a research gap and the importance of interconnecting the themes object of this study.

Motivated by the phenomenon of digitalization, this systematic review of the literature seeks to explore the existing state of the art on the theme and the dimensions that organizations adopt I4.O technologies, in addition to presenting suggestions for future research. Considering the above, the main research question of this study is: "*What dimensions are adopted by companies that influence Business Models in the digitalization and industry 4.0 era*"?

The article is structured as follows: Section 2 present the research method and section 3 perform the results of the bibliometric analysis, derived from the systematic literature review. Section 4 discusses the results of each cluster and in the section 5 are the conclusions. Finally, the last section contains main bibliographic references.

2. Method: Systematic Literature Review

2.1. Research Protocol

The research was conducted in the Scopus database on March 2, 2022, using the following pre-established research protocol (Liberati *et al.*, 2009) to conduct the Systematic Literature Review: (a) Only articles in the area of Business, Management and Accounting were included; (b) English language articles only; and although no filter was established per year of publication (c) the full period (2003-2021) covered by the database was contemplated; (d) using the topics: title, abstract, author's keywords, and keywords plus, with the following terms: "business model" AND "industry 4.0" OR "digitalization". The research results are shown in Figure 1.
The survey resulted in 1,535 documents. However, 859 documents were excluded based on the publication criteria, as they were not classified as articles (a), 330 articles were not from business, management and accounting, according to the criteria of the publishing area (b), and 18 articles not published in English (c), remaining 328 articles. After an objective screening, with the reading of the titles and abstracts, to evaluate whether the results addressed the theme of interest, it was removed more 06 articles that was outside of this research scope, such as articles directed to the Academy and not companies, for example: Cron & Baldauf (2021), which aims to facilitate future research on links identified in specific articles; Schlegelmilch (2020), which investigates BM studied in traditional management schools. Therefore, it was analyzed 322 articles for this research.

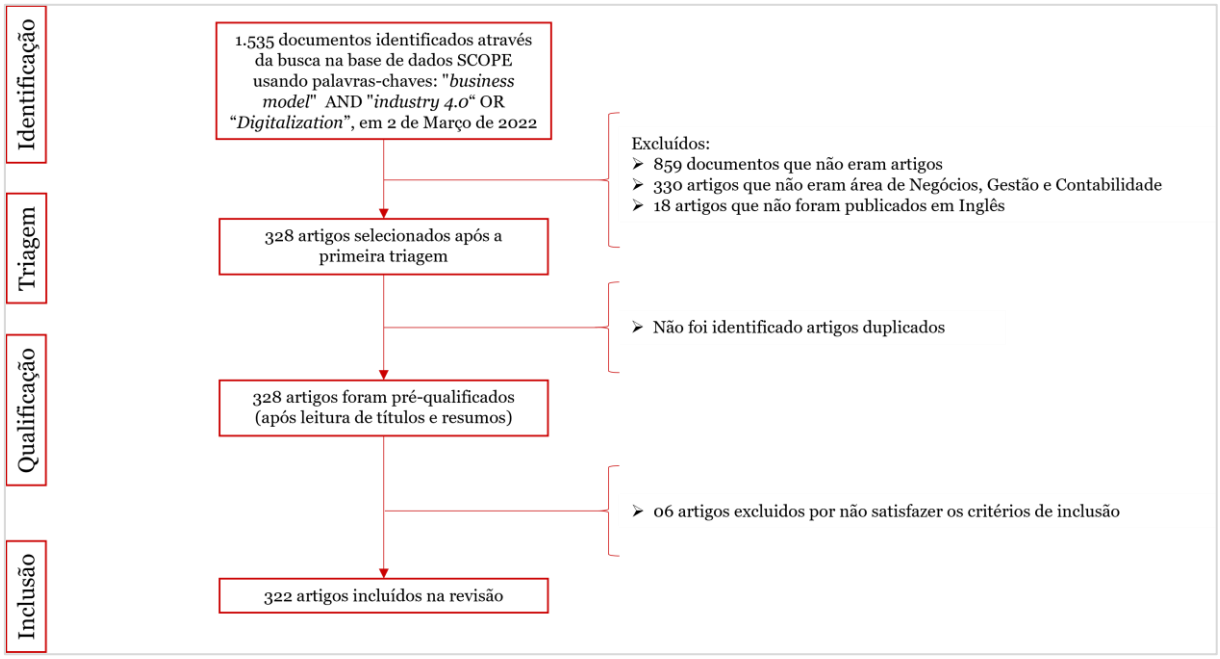

***Figure* 1 –Research Protocol**
Source: Own elaboration

2.2. Bibliometric Analysis

In order to map the articles that address topics related to I4.0 and digitalization in the BMs, a bibliometric analysis was made, in a comprehensive way, using the software VOSviewer

version 1.6.18 (van Eck & Waltman, 2010) to understand the scientific activity related to this theme.

Using five indicators (articles, authors, Journals, countries and academia), the software citation (Cit), the co-citation and the analysis of the bibliographic coupling analysis (Total Link Strength/TLS) were presented. To complement, a co-occurrence analysis of all keywords was performed to group the results by theme. Hence, the evaluation combines (i) scientific mapping: relationship between scientific elements, and (ii) performance: citation, keywords frequency, and publication (Caputo *et al*., 2021; Ferreira, 2018).

Following are the VOSviewer results for the units of analysis: authors, articles, Journals, countries, academies and co-occurrence of keywords. The citations, co-citations and results of the analysis of the bibliographic coupling between publications, co-authorship between researchers and co-occurrence between the terms, is in the next section and its six subsections. The number of citations is a measure of influence and documents needed to reach a minimum limit for inclusion. The co-citation evaluates the documents cited in the results and the bibliographic coupling assesses how much a particular document is connected to the rest of the included documents, that is, if the coupling force is too low, the document is disconnected from the rest of the investigation and is not part of a large flow of research. Keyword co-occurrence analysis provides a thematic cluster, a set of items included in a map that guides the discussion. This comparative analysis overcomes the biased restrictions of using only one of them, offering a comprehensive examination of the scientific domain (Ferreira, 2018), increasing the veracity of the data.

3. Analysis of the Results

3.1. Authors' Analysis

It was written a *thesaurus* file (Van Eck & Waltman, 2010) to unite the authors' names written in different format (e.g., 'baines, t.' and 'baines, t.s.'), but which are the same author. Next, co-citation analyses were performed using *fractional counting* maintaining the VOSviewer analysis pattern. Of the 23,450 authors, meet a minimum of 20 citations threshold.

Concerning citations and bibliographic coupling, the features were a minimum of 4 articles per author, without minimum citations; of 889 authors, 11 meet the threshold. Table 1 provides the list with the key authors in this area.

Table 1 - Comparison of authors' citation, co-citation, and bibliographic coupling.

Citation				***Co- Citation***			***Bibliographic Coupling***	
Autor	**Doc**	**Cit**	**TLS**	**Autor**	**Cit**	**TLS**	**Autor**	**TLS**
Parida V.	15	406	28	Parida, V.	190	174.96	Parida V.	2.763
Kraus S.	6	261	0	Zott, C.	175	162.80	Kraus S.	306
Gebauer H.	5	289	16	Amit, R.	171	160.67	Gebauer H.	1.356
Sjödin D.	5	75	24	Teece, D.J.	137	129.94	Sjödin D.	1.100
Elidjen	4	23	0	Gebauer, H.	131	123.80	Elidjen	543
Kohtamäki M.	4	296	14	Kohtamäki, M.	121	112.90	Kohtamäki M.	1.260
Mihardjo L.W.W.	4	36	0	Sjödin, D.	111	104.24	Mihardjo L.W.W.	388
Müller J.M.	4	486	1	Porter, M.E.	109	103.73	Müller J.M.	637
Sasmoko, Alamsjah F.	4	23	0	Kowalkowski, C.	98	93.82	Sasmoko, Alamsjah F.	543
Voigt K.-I.	4	413	1	Baines, T.S.	93	89.96	Voigt k.-I.	637
Wincent J.	4	57	10	Eisenhardt, K.M.	93	90.34	Wincent J.	1.079

Note: Doc – documents; Cit – citation; TLS –Total Link Strength

3.2. Análise dos Artigos

Regardless of whether there is much research in the digitalization and I4.0 area, which is still a relatively recent topic, the number of investigations on BM associated with I4.0 has increased significantly, especially after the onset of pandemic/COVID-19. Of the 322 articles 213 were published between 2020 and 2022, i.e., 66% of the articles were published from 2020 to the time of this research, 79 in 2020, 111 in 2021 and 23 in 2022.

Regarding the analysis of the articles (Table 2), in terms of citation and bibliographic coupling, a minimum of 20 citation was established, of the 322 documents; 72 meet the threshold. On the co-citation analysis, with 10 citations minimum, of the 18,628 cited references, 13 meet the threshold. The top three articles are:

- Moeuf, A., Pellerin, R., Lamouri, S., Tamayo-Giraldo, S., & Barbaray, R. (2018). The industrial management of SMEs in the era of Industry 4.0. *International Journal of Production Research*, 56 (3), 1118-1136.
- Müller, J. M., Buliga, O., & Voigt, K. I. (2018). Fortune favors the prepared: How SMEs approach business model innovations in Industry 4.0. *Technological Forecasting and Social Change*, 132, 2-17.
- Warner, K. S., & Wäger, M. (2019). Building dynamic capabilities for digital transformation: An ongoing process of strategic renewal. *Long Range Planning*, 52(3), 326-349.

In terms of Total Link Strength (TLS), the most impacting articles of the area are:

- Müller, J. M., Buliga, O., & Voigt, K. I. (2018). Fortune favors the prepared: How SMEs approach business model innovations in Industry 4.0. *Technological Forecasting and Social Change*, 132, 2-17.
- Warner, K. S., & Wäger, M. (2019). Building dynamic capabilities for digital transformation: An ongoing process of strategic renewal. *Long Range Planning*, 52(3), 326-349.
- Kamalaldin, A., Linde, L., Sjödin, D., & Parida, V. (2020). Transforming provider-customer relationships in digital servitization: A relational view on digitalization. *Industrial Marketing Management*, 89, 306-325.

Table 2 - Comparison of articles' citation, co-citation, and bibliographic coupling.

Citation			***Co- Citation***			***Bibliographic Coupling***	
Autor	Cit	links	Autor	Cit	TLS	Autor	TLS
Moeuf *et al*. (2018)	385	1	Zott C. (2011)	23	58	Müller *et al*. (2018)	195
Müller *et al*. (2018)	365	0	Teece D. (2010)	20	62	Warner & Wäger (2019)	188
Warner & Wäger (2019)	247	2	Porter & Heppelmann (2014)	16	28	Kamalaldin *et al*. (2020)	149
Frank *et al*. (2019)	224	2	Eisenhardt K. (1989)	15	52	Zhao y. (2020)	144
Verhoef *et al*. (2021)	212	0	Eisenhardt & Graebner (2007)	15	43	Verhoef *et al*. (2021)	136
Sung T. (2018)	203	1	Foss & Saebi (2017)	15	42	Kohtamäki *et al*. (2019)	129
Ślusarczyk B. (2018)	169	0	Amit & Zott (2001)	14	44	Frank *et al*. (2019)	129
Kraus *et al*. (2020)	166	1	Chesbrough H. (2010)	12	31	Moeuf *et al*. (2019)	114
Rachinger *et al*. (2019)	158	0	Gioia *et al*. (2013)	12	37	Kohtamäki *et al*. (2020)	113
Kohtamäki *et al*. (2019)	151	1	Vandermerwe & Rada (1988)	11	26	Parida & Wincent (2019)	108

Note: Doc – documents; Cit – citation; TLS –Total Link Strength

3.3. Journals analysis

As happen in the authors' analysis, a *thesaurus* file was first written (Van Eck & Waltman, 2010) to unite the names of journals written in different formats (e.g.: acad. manag. j. was replaced by Academy of Management Journal). The most relevant Journals in the I4.0 and digitalization area, associated to BM, are the *Technological Forecasting and Social Change* with the highest number of citations (1,041), and publications (17) respectively, and *the Journal of Cleaner Production* with the highest number of co-citation (405). Concerning the citation and bibliographic coupling, with a minimum of 4 articles per journal of 183 Journals, 14 meet the thresholds.

Regarding the co-citation, the default features specify 20 citation; only 96 of the 7,560 journals meet the selection criteria. Table 3 displays the top ten Journals that contribute more I4.0 and digitalization associated to BM.

Table 3 - Comparison of journals' citation, co-citation, and bibliographic coupling.

Citation				***Co- Citation***			***Bibliographic Coupling***	
Journal	Artigo	Cit	TLS	Journal	Cit	TLS	Journal	TLS
Technological Forecasting and Social Change	17	1041	10	Journal of Cleaner Production	405	12994	Journal of Business Research	948
Journal of Business Research	12	510	11	Industrial Marketing Management	376	15851	Technological Forecasting and Social Change	839
International Journal of Production Research	4	500	2	Long Range Planning	364	14151	Industrial Marketing Management	667
Journal of Manufacturing Technology Management	5	278	4	Strategic Management Journal	333	12800	Journal of Manufacturing Technology Management	340
Industrial Marketing Management	8	224	7	Journal of BusinessResearch	286	12726	Review of Managerial Science	335
Journal of Cleaner Production	10	159	2	Technological Forecasting and Social Change	273	9328	Journal of Cleaner Production	287
Business Horizons	4	84	3	Harvard Business Review	264	9570	Technology Innovation Management Review	219
Review of Managerial Science	5	79	0	International Journal of Production Research	210	7653	Business Horizons	204
Production Planning and Control	4	47	3	International Journal of Production Economics	195	7882	Production Planning and Control	184
Technology Innovation Management Review	5	28	3	Mis Quarterly	185	7948	International Journal of Innovation and Technology Management	151

Note: Doc – documents; Cit – citation; TLS – Total Link Strength.

3.4. Colaboração dos Países

Germany was the country that most contributed with research agenda with 66 articles published, followed by Finland (35), Italy (35), Sweden (35) and the United Kingdom (34). Brazil (14) and Portugal (09) are in 10th and 19th place respectively. Table 4 displays the top ten countries with the highest number of published articles, their citation and TLS, and Figure 2 presents the connection between the 24 countries analyzed through citation; of the 100 countries analyzed, only 24 published more than five articles.

Table 4 - Comparison of countries' citation, co-citation, and bibliographic coupling.

Country	*Article*	*Cit*	*TLS*
Germany	66	1607	90
Finland	35	1083	103
Italy	35	953	80
Sweden	35	827	109
United Kingdom	34	1177	63
United States of America	25	583	44
France	23	1183	60
Spain	21	378	21
Russian Federation	16	40	5
Brazil	14	385	45

Note: Cit – citation; TLS –Total Link Strength

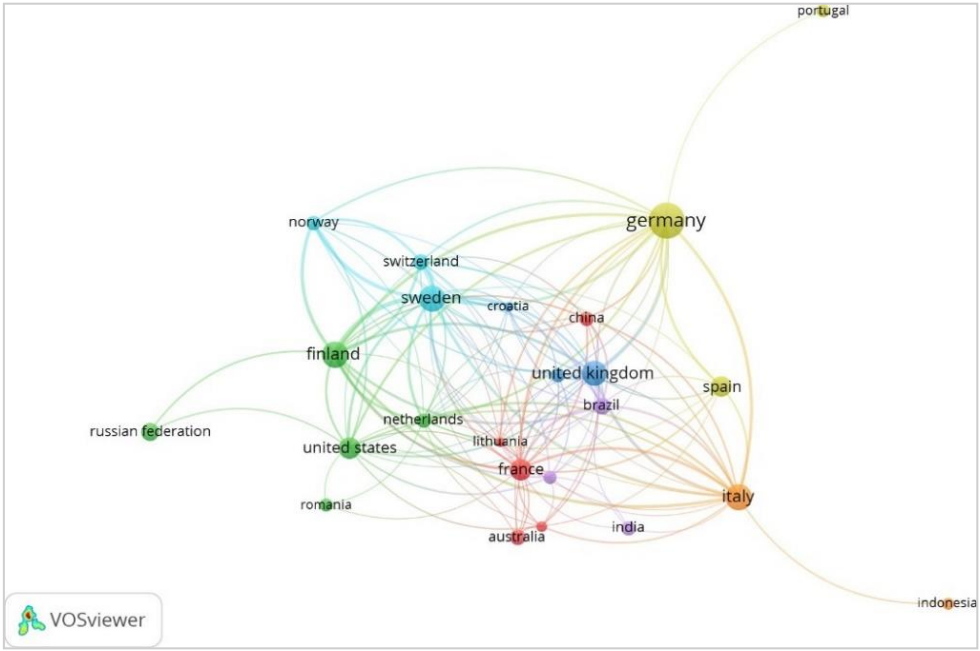

***Figure* 2: Connection and collaboration between countries by VOSviewer 1.6.18**
Source: Own elaboration

3.5. Institutional Collaboration

Before doing the comparative analysis, to verify the collaboration of the institutions, a *thesaurus* file was written (Van Eck & Waltman, 2010) to unite the names of institutions written in different formats (e.g.: Free University of Bozen-Bolzano was replaced by Free University of Bolzano-Bozen). Regarding collaboration of institutions, of approximately 554 institutions, at least 17 published 04 articles or more. The two universities with the highest number of publications were: Luleâ University of Technology (Sweden) and University of Vassa (Finland) with 15 articles each. Table 5 displays the list of the 13 universities that have published four or more articles related to the theme of this research, in addition to a comparison between the number of citation and TLS. It was observed that the author Vanit Parida, who has the highest number of citations, co-citation and TLS, in the bibliographic calculation, is Chaired Professor of Entrepreneurship and Innovation at one of the universities with the largest number of published articles Luleå University of Technology.

Table **5** - Comparison of Institutions' citation, co-citation, and bibliographic coupling.

Institution	*Country*	*Article*	*Cit*	*TLS*
Luleå University of Technology	Sweden	15	425	36
University of Vaasa	Finland	15	467	38
Bina Nusantara University	Finland	7	40	0
Linkoping University	Sweden	7	464	23
University of Bayreuth	Germany	7	96	6
Friedrich-Alexander University Erlangen-Nürnberg (FAU)	Germany	6	423	3
Hanken School of Economic	Finland	6	132	18
University of St. Gallen	Switzerland	6	96	22
Free University of Bolzano-Bozen	Italia	5	83	2
University of Lincoln	United Kingdom	5	102	4
University of South Eastern Norway	Norway	5	179	30
Durham University	United Kingdom	4	252	6

Note: Doc – documents; Cit – citation; TLS – Total Link Strength.

3.6. Co-occurrence of Keywords

To identify the clusters, a co-occurrence analysis of keywords was run. Table 6 presents the full list of keywords and their clusters. Before starting the analysis, it was written a *thesaurus* file (Van Eck & Waltman, 2010) to unite words that were synonymous, as well as abbreviations (e.g: business model was replaced by business models; start-ups was replaced by startup). It was used *full counting* method, designating at least five occurrences; of 1,607 keywords, 71 meet the threshold. As the three keywords, part of research themes, were influencing the results, these were excluded: "industry 4.0", "digitalization" and "business model". The analysis by association using a three items minimum cluster size provided five clusters with 805 links and 1,194 of total link strength (TLS). This number of links demonstrates that there are topic overlaps between the clusters (Figure 3).

Table 6 – All keywords co-occurrence analysis by VOSviewer 1.6.18

	Keyword	**Occurrence**	**Total Link Strength**	**Cluster**
Cluster 1: Technology Innovation	Innovation	23	80	
	digitalization	20	67	
	smart manufacturing	12	39	
	sme	12	39	
	business development	11	51	
	new business models	11	30	
	design/methodology/approach	10	39	
	Big Data	9	25	
	digital innovations	8	26	
	industrial performance	7	39	
	industrial research	7	39	
	information technology	6	17	
	small and medium sized enterprise	6	35	
	technological change	6	20	
	data analytics	5	18	
	entrepreneurship	5	9	
	industrial development	5	18	
	networks	5	11	

	Keyword	Occurrence	Total Link Strength Cluster
	strategic approach	5	26
Cluster 2: Business Model Innovation	business model innovation	36	106
	servitization	19	51
	business modeling	18	82
	manufacturing companies	13	62
	digital servitization	12	39
	manufacturing	8	52
	technological innovation	8	38
	manufacture	7	47
	digital business	6	20
	multiple-case study	6	48
	business	5	32
	companies	5	34
	sales	5	31
	service industry	5	35
Cluster 3: Digital Transformation	digital transformation	50	132
	supply chains	15	31
	ecosystems	12	35
	competition	12	46
	platforms	10	21
	qualitative analysis	10	53
	digital platforms	9	13
	digital business models	9	26
	covid-19	8	6
	transformation	8	16
	competitive advantages	8	24
	digital economy	7	4
	enterprise resource management	5	25
Cluster 4: Digital Technologies	digital technology	16	65
	internet of things	16	54
	value creation	13	31
	artificial intelligence	12	28
	strategy	10	16
	automotive industry	9	30
	technology	9	17
	decision making	8	31
	dynamic capabilities	8	43
	product-service system	7	23
	blockchain	5	16
Cluster 5: Circular Economy and Sustainability	sustainability	17	41
	circular economy	13	51
	sustainable development	10	33
	systematic literature review	9	23
	productivity	7	21
	industrial economics	6	37
	product design	6	23
	supply chain management	6	12
	economic and social effects	5	21

Keyword	Occurrence	Total Link Strength Cluster
climate change	5	20
3d printing	5	15

Along with the clusters (Table 6), the co-occurrence analysis offers network (Figure 3), the overlay (Figure 4) and density visualization. The links presents the words that are stronger and more present in the articles (Figure 5). The five colors displayed in Figure 3 represent each of the 05 clusters and the network to which they belong. The link strength is visible in the size of the word. In this way the clusters were named using the themes with the highest total strength of the link:

I. Cluster 1 - Technology Innovation (red)
II. Cluster 2 - Innovation in Business Models (Green)
III. Cluster 3 - Digital Transformation (blue)
IV. Cluster 4 - Digital Technologies (yellow)
V. Cluster 5 - Circular Economy and Sustainability (violet)

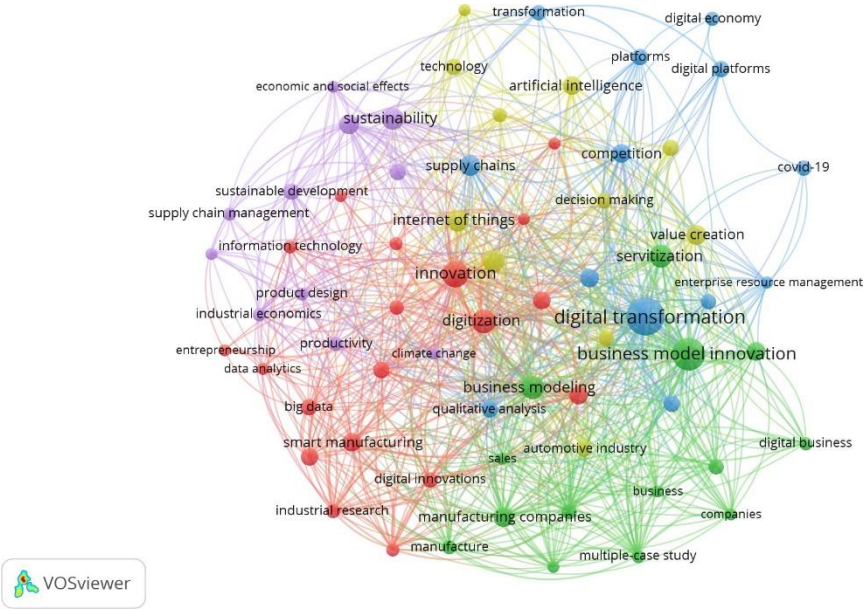

Figure 3: Network Visualization by VOSviewer 1.6.18
Source: Own elaboration

In addition to this generic analysis, the clusters will be addressed individually, in section 4 - Discussion of cluster results.

The visualization of the overlay of words (Figure 4) presents the temporal distribution of keywords and thematic evolution over the years using non-normalized scores. This means that researchers currently focus on digital technology analysis, digital transformation, technology innovation, digital platforms, innovation in digital BM and BM. Previous studies have paid more attention to I4.0 manufacturing, smart manufacturing and technologies, such as Big Data. These less dense themes indicate themes for future research. While the denser themes point to themes that may be saturated in research.

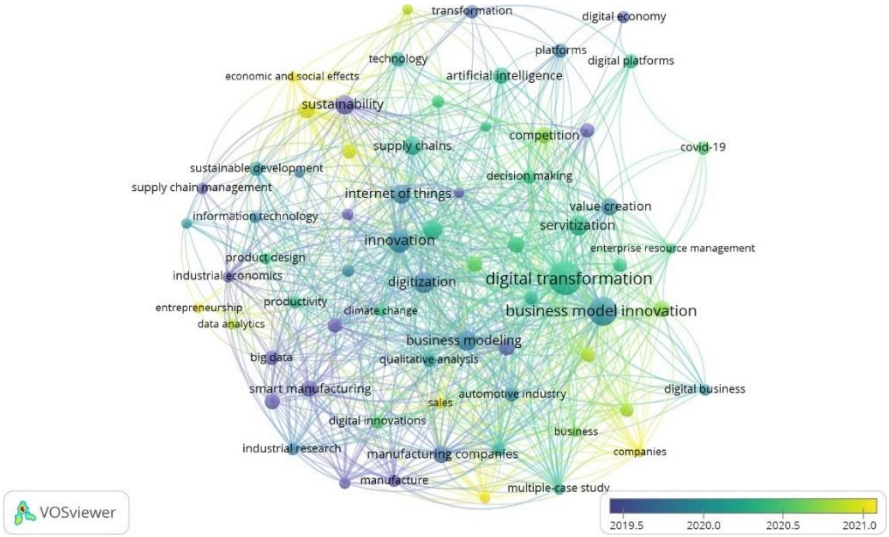

Figure 4: Overlay Preview through by VOSviewer 1.6.18
Source: Own elaboration

The word density visualization (Figure 5) continues to show the connections between the keywords. The colors yellow and red and the size of the word indicate a more robust presence and the strength of the link between them, while light blue indicates the opposite. For example, topics such as digital transformation and innovation in BM are denser than digital economy and digital business. These less dense themes indicate topics for future research. While denser themes point to themes that may be saturated in research.

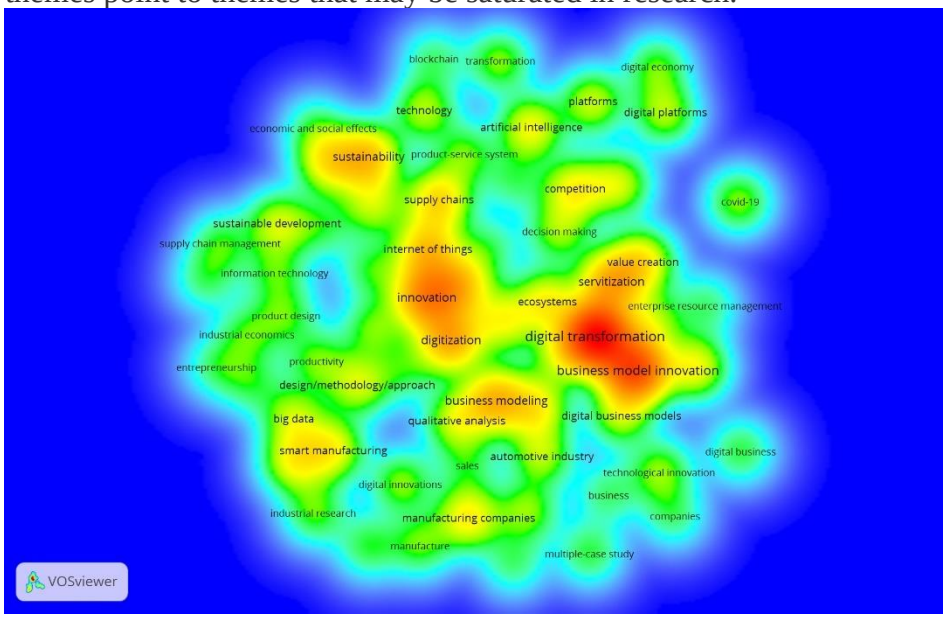

Figure 5 - Density Display by VOSviewer 1.6.18
Source: Own elaboration

4. Discussion of Cluster Results

As mentioned previously, the clusters were grouped through the VOSviewer software that performed the analysis of the keywords and the total strength of the link between them, but it was necessary to read the articles to identify which cluster each article belonged to. Table 7 displays the number of items grouped in each cluster and their respective colors. Although the first cluster (Technology Innovation) has the largest number of keywords (n=19) it does not include the largest number of articles, which may have occurred because the second (Innovation in business models) and third (Digital Transformation) cluster have the most powerful

keywords in the link: "business model innovation" (TLS = 106) and "digital transformation" (TLS 132) respectively.

Table **7 – Number of articles per cluster and their respective colors**

No.	*Cluster*	*No. of Articles*	*Figure Color*
1	Technology Innovation	68	red
2	Innovation in Business Models	103	green
3	Digital Transformation	84	blue
4	Digital Technologies	43	yellow
5	Circular Economy and Sustainability	24	violet

4.1. Cluster 1 - Technology Innovation

The first cluster (in red) was named Technology Innovation, as technology innovation tends to offer opportunities to develop innovative BMs. The efficiency of I4.0's transformative and disruptive BM has been investigated, revolutionizing the market for products and services, leading to the collapse of global markets (Hannibal, 2020). The digital revolution has substantially changed the business environment that is transforming the lives of various sectors, such as banking sector, which has recognized the importance of investing in innovative technologies that have analytical capabilities in order to remain competitive and sustainable (Gul & Ellahi, 2021), as well as improving the performance and satisfaction of its customers. The research in this cluster also includes research on The BMs of SMEs and Startups, where the challenges, capacity of knowledge absorption, risks, opportunities and critical success factors of I4.0 in SMEs have been analyzed for the creation of new BMs through digitalization, which are affected by new I4.0 technologies, but which can play a relevant role in the transition to a more sustainable BM, leading to a better integration of circular economy practices (Pizzi *et al*., 2021).

For future research it has been suggested to investigate which technologies could be implemented in the specific phase of the open innovation process and the intensity of the adoption of various I4.0 technologies; what are the effects of digitalization-driven innovation connected to the BM reshaping; studying the digitalization activities of SMEs and family businesses during their business successions, besides suggesting strategies to implement I4.0 technologies identifying new opportunities in BMs.

4.2. Cluster 2 - Innovation in Business Models

Since “Business Model” is one of the keywords of the research, it was challenging to classify the articles of this cluster, being identified through the perception of the difference in focus of each article when relating the BM, I4.0 and digitalization. Thus, the Innovation cluster in the BM (second largest, in green) grouped the themes related to business management, people and how the previous knowledge of a company affects its strategies in the implementation of digital services. Publications in this cluster also discuss the barriers to digitalization, decision-making guidance and strategies for implementing digital technologies, as well as innovation in BMs to deliver digital products and services through technology innovation and intelligent solutions. The publications also identify various types of BM, assess the risks to implement digital BM, and feature BM creations, such as Das *et al*. (2020) that presented a mapping of the transformation of companies in I4.0 and Kans & Ingwald (2021) that describe new business opportunities within the industry to meet the needs and requirements of I4.0.

As an opportunity for future studies, it is suggested to analyze innovation in BMs resulting from different levels of servitization and the digitalization process; look for innovative BM that are more appropriate to capacities, internal resources and the external environmental; analyze the differences and/or similarities in the digital BM innovation procedure between different countries, as well as identify factors that influence BM in the digitalization age.

4.3. Cluster 3 - Digital Transformation

Publications in the digital transformation cluster (in blue) focus on the development of the BM of digital platforms, the transition of traditional BM to digital BM that are influenced by digitalization, the challenges and stages of digital transformation and the digital transformation caused by the COVID-19 pandemic. Digital platforms are influencing BMs in a diverse of organizations as well as business relations (Veile *et al*., 2022), besides activities not related to the products and equipment manufacturing or even supply and logistics chain, such as insurance sector, travel sector, media/newspaper sector, among others, which has had its business and services completely affected by digital transformation. For Mariani & Nambisan (2021) digital platforms can deliver value through innovation analysis and serve as a powerful tool for experimenting digital innovation, enabling companies to innovate more effectively and transform their BM to adapt to rapidly changing market conditions.

In this area there are also several opportunities for new research, such as analyzing the connection between BM settings and the revenue/profit model through digital transformation; identifying the relationship of strategic competencies that contribute to the transformation of digital BM and what are the effects of digital transformation that can lead to business failure when the transformation process occurs slowly.

4.4. Cluster 4 - Digital Technologies

Publications in the digital technology cluster (in yellow) share a common denominator: value creation influenced by digitalization. Digital technologies are influencing the creation, proposition, and capture value of organizations and how they deal with the challenges posed by increased digitalization (Rachinger *et al*., 2019; Acciarini *et al*., 2021;). Other investigations seek to clarify in detail the impacts of one of the specific digital technologies in BM, e.g.: Cyber-Physical Systems, IoT, Blockchain, cloud computing, Big Data, Artificial Intelligence, among others. Dynamic capacity is also another theme that has caught the attention of researchers, whether in building dynamic management capabilities to drive digital transformation, using new digital technologies, or using them to generate changes in operational capabilities and business activities. Mihardjo *et al*. (2021) discuss the transformation of business and organizational capabilities to address I4.0 through co-creation strategies and BM Innovation.

Future research, within this topic, could analyze the benefits versus costs for the adoption of digital technologies; study whether management, for BM innovation, differs between industries by adopting digital technologies; investigate what partnerships between companies and other organizational actors, such as startups, which develop digital solutions, universities, and public and private R&D centers, could contribute to implement digital technologies; better understanding the relationship between sustainability and adoption of digital technologies, focusing on sustainable entrepreneurship and BM.

4.5. Cluster 5 - Circular Economy and Sustainability

In the last cluster, the articles have their roots in the circular economy and sustainability. Publications in the fifth cluster (in violet) contribute to the understanding of how I4.0 and digitalization associated with BM innovation are related to practices, principles and objectives, strategies, and the transformation of the circular economy. There are several research on the circular BM, whether BM innovation or BM related to sustainability. According to Beier *et al*. (2020) I4.0 offers a greater chance of aligning sustainability goals with digital transformation in the context of current industrial development, which can also become a threat if sustainability goals are not considered in the implementation of I4.0 technologies. To Alkaraan *et al*. (2022) the circular economy is an industrial system that allows the use of renewable energy to help eliminate waste through materials, products, systems and BM. Digital transformation, defined

through the use of new digital technologies, enables significant business improvements, enhances the customer experience, streamlines operations and supports creation of BM.
This area has also a room for research, such as analyzing new strategies and enables to address the negative effects of unemployment caused by innovation and technology progress; which sectors and/or companies have had advantage through digitalization and Circular Economy; how circular BMs affect the delivery of value during adoption of various digital technologies; and finally investigate the influence of digitalization on various aspects of the sustainability of the product or service offered.

5. Conclusions

This study aimed to identify the dimensions that influence BM in the digitalization and I4.0 era through a systematic literature review to answer the research question: "*What dimensions are adopted by companies that influence Business Models in the digitalization and industry 4.0 era*". Therefore, the work revealed that research in this area is fragmented in interdisciplinary sectors and publications are dispersed by a multitude of Journals, methodologies and topics. Through the co-occurrence of keywords, five clusters were pointed out and analyzed: (1) Technology Innovation, (2) Innovation in BMs, (3) Digital Transformation, (4) Digital Technologies, (5) Circular Economy and Sustainability. In addition to clusters, other key themes have also been identified that complement this analysis, such as: (a) SMEs in the context of digitalization, (b) the impacts that digital technologies have caused on BMs, (c) servitization and digitization, which is present in an expressive number of articles, and (d) the digitalization and adoption of technologies in the context of the pandemic/COVID-19, that has changed BMs significantly.
The results of this study offer useful contributions regarding knowledge about dimensions that influence BM in the digitalization and I4.0 era, where the main findings and contributions concern the identification of themes and companies/sectors that have been further explored in order to drive future research to other areas less studied. It also offers a new approach to scientific mapping in the digitalization and BM area. The analyses carried out in Journals, authors and articles provide comprehensive and vital knowledge that systematizes the body of knowledge and is based on the research of the academic panorama (Caputo *et al*., 2021).
Despite the well-established research methodology, capable of ensuring the clarity and reproduction of the study, the limitations related to systematic literature reviews shall be underlined. These derive from the research keywords and the chosen database, which affect and characterize the results obtained: the use of another set of keywords (and their appropriate combinations) and other databases (such as Google Scholar or ISI Web of Science) could have led to a different analysis sample. In this article, to comply with the standards, we present only the main bibliographic references.

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