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Confluence of Factors that Influence Business Model by Digitalisation and Industry 4.0 Technologies

Confluencia de Factores que Influyen en El Modelo de Negocio por la Digitalisación y las Tecnologías de la Industria 4.0

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ABSTRACT

The emergence of digital technologies and the expansion of their use has significantly transformed organisations and their Business Models (BM), modifying their traditional structures, redefining the client's meaning and positioning, as well as retally adjusting the way individuals live and interact with each other in the Fourth Industrial Revolution, also known as Industry 4.0 (I4.0). This research aims to reflect on the confluence of factors influencing BM through digitalisation and I4.0 disruptive technologies. Firstly, a Systematic Literature Review was conducted to map the top articles and most persuasive authors in the area, journals, institutions, and countries with the most publications within this theme. Secondly, five thematic clusters were pointed out and analysed through the co-occurrence of keywords. Finally, an in-depth analysis was run to identify influencing aspects of BM in the digitalisation era, relating them to specific I4.0 technologies. The research revealed that digital technologies enable improvements in distribution strategy and traceability, facilitate the relationship between buyers and suppliers, improve customer segmentation and product demand forecasting, enable cost reduction, and assist in implementing circular economy practices. In the context of the pandemic/COVID-19, BM has changed significantly, making it necessary to deepen knowledge about digitalisation and adopt I4.0 technologies.

Keywords: Industry 4.0, Digitalisation, Business Models, Factors, Technologies, Innovation.

R E S U M E N

El surgimiento de las tecnologías digitales y la expansión de su uso ha transformado significativamente las organizaciones y sus Modelos de Negocio (MN), modificando sus estructuras tradicionales, redefiniendo el significado del cliente y su posicionamiento, así como ajustando la forma como los individuos viven e interactúan con ellos en la Cuarta Revolución Industrial, también conocida como Industria 4.0 (I4.0). Esta investigación tiene como objetivo reflexionar sobre la confluencia de factores que influyen en los MN por la digitalización y las tecnologías disruptivas de la I4.0. Primer, se realizó una Revisión Sistemática de la Literatura para mapear los artículos más destacados y los autores más persuasivos en el área, así como las revistas, instituciones y países con mayor número de publicaciones dentro de esta temática. Después, mediante la coexistencia de palabras clave, se señalaron y analizaron cinco grupos temáticos. Finalmente, se realizó análisis en profundidad para identificar aspectos influyentes del MN en la era de la digitalización relacionándolos con tecnologías específicas de la I4.0. La investigación reveló que las tecnologías digitales permiten mejoras en la estrategia de distribución y la trazabilidad, pueden facilitar la relación entre compradores y proveedores, permitir una mejor segmentación de clientes y previsión de la demanda de productos, además de permitir la reducción de costes y ayudar en la implementación de prácticas de la economía circular. En el contexto de la pandemia/COVID-19, los MN ha cambiado significativamente, siendo necesario profundizar en el conocimiento de la digitalización y la adopción de tecnologías de la I4.0.

Palabras clave: Industria 4.0, Digitalización, Modelos de Negocio, Factores, Tecnologías, Innovación.

1. INTRODUCTION

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

This research aims to reflect on the confluence of factors influencing BM through digitalisation and I4.0 disruptive technologies. It is impressive how I4.0 technologies (e.g., Internet of Things (IoT), Industrial Internet of Things (IIoT), Cyber-Physical Systems (CPS), Smart Manufacture, Smart Factories, Cloud Computing, Cognitive Computing, Artificial Intelligence) have significantly affected production processes and how companies, independently of their type, create value through their BM (Paiola *et al.*, 2021). For, the underlying characteristic of I4.0 is the connectivity between machines, supply chain, procurement and stakeholders, 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). In order to succeed in the digital economy, businesses need to be both digitalised and digital. Despite the similarity of the words, there are differences in their meanings. For Ross *et al.* (2022) digitalisation is an operational necessity involving the standardisation of business processes, i.e., it consists of using digital technologies to transform production, product development and/or BM processes, aiming at process optimisation and efficiency. It is also considered an internal process executed by companies to transform the existing BM into a digital-based BM, where information and communication technologies are located at the centre of daily operational life, involving customers and suppliers for business activity (Gartner, 2020). For a company to become digital (digitalisation), leaders must articulate a visionary digital value proposition for customers and deliver it in digital offerings. It can be considered the procurement process through which companies acquire new equipment that converts part of the analog process into a digital one (Gartner, 2020).

The result is more efficient companies, which includes optimised costs and time processes and reduced waste and errors. Notably, technological adaptation is not a choice for businesses, being nearly standard, especially in today's world. Companies must innovate technologically to enable better stakeholder engagement, leverage their competitive advantage, and remain customer-centric (Faridi & Malik, 2019). Rosa *et al.* (2020) stated that I4.0 mechanisms enable significant business improvements, increasing customer experience and optimising operations or even creating BM. However, many factors influence companies' results in changing BM in the context of I4.0 technologies. 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). Nevertheless, transforming from a traditional BM to a digital BM is accelerating to deliver new values to all stakeholders and compete more effectively in a digital economy.

In the face of a particularly new scenario, it becomes necessary to investigate the confluence of factors that influence BM through digitalisation and I4.0 disruptive technologies. It is observed that there is a research gap in the importance of interconnecting themes in this study. No comprehensive studies discuss and present a bibliographic review on this specific theme, except for the systematic literature review by Caputo *et al.* (2021), which addresses the relationship between digitalisation and innovation of BM and the progress that occurred during the last decade. Despite increasing research on I4.0, digitalisation and BM, the investigations are distinct. In recent decades, scientific literature has paid increasing attention to digitalisation and its effects on organisations, economies, and societies. While some are focused on debating the impacts that I4.0 and digitalisation can have on BM, others address the effects of digitalisation on BM of SMEs and/or large companies and analyse Circular Economy BM. Several studies present concepts and frameworks to help companies achieve market leadership, implement technology solutions, and give guidance on and during the decision-making process.

This research addresses the lack of understanding about the growing research field of factors that influence BM through digitalisation and I4.0 disruptive technologies and conducts a systematic literature review and bibliometric analysis to contribute to the field. Moreover, through the co-occurrence of keywords, five thematic clusters were pointed out and analysed, namely: (1) Technology Innovation, (2) Innovation in Business Models, (3) Digital Transformation, (4) Digital Technologies and (5) Circular Economy & Sustainability.

Motivated by digitalisation, this research explores the existing state of the art on the theme and the dimensions that organisations adopt I4.O technologies. Firstly, the theoretical reference framework is presented, followed by the research method and the results of the bibliometric analysis. Afterwards, there is a discussion about clusters and factors found, as well as suggestions for future research and main conclusions.

2. INDUSTRY 4.0 AND BUSINESS MODEL: AN OVERVIEW

In this section, the main concepts found in the researched literature on I4.0 and BM are presented to allow a theoretical basis to support the objective of this investigation, seeking a better understanding of the phenomenon to be explored.

2.1. Industry 4.0

In recent decades, the scientific literature has paid increasing attention to digitalisation and its effects on organisations, economies, and societies. Nonetheless, the industry has been renewing itself over the last centuries, bringing technological innovations with an ever-increasing speed. The First Industrial Revolution used water and steam power to mechanise production. The second industrial revolution used electricity to create mass production. The third Industrial Revolution used electronics and computer technology to automate production. Currently, the Fourth Industrial Revolution is growing on the foundation of the third revolution, the digital revolution that has been taking place since the middle of the last century and is characterised by the merging of technologies that draw their lines between the physical, digital and biological worlds. According to Halvorsen *et al.* (2017),

I4.0 is a new term for combining industry and the Internet of Things (IoT).

The concept of I4.0 represents the current production paradigm being driven by the advancement of some base technologies (e.g., The internet of things (IoT), The industrial internet of things (IIoT), Cyber-physical systems (CPS), Smart manufacture, Smart factories, Cloud computing, Cognitive computing, Artificial intelligence, Big Data (BD)) that enable companies to renew their BM by integrating digital technologies into business processes (Trivelli *et al.*, 2019). I4.0 disruptive technologies have transformed the traditional systems of many companies, offering new strategic opportunities to increase competitiveness by optimising costs and improving quality, service levels, and flexibility (Ferdows, 2018).

The underlying characteristic of I4.0 is connectivity between machines, purchasing and logistics sectors, employees, suppliers, and customers. I4.0 technologies enable smart manufacturing by 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 optimised processes in both cost and time and reduced waste and errors. However, according to Rahman *et al.* (2019), the business organisation is moving towards Industry 5.0 (Internet of Thought) along with the GIG economy (a labour market characterised by flexible, temporary or freelance jobs, as opposed to permanent, full-time work) where the traditional way of entirely relying on full-time workers is no longer as relevant (Silva & Moreira, 2022). From an organisational perspective, the leap in strategy with technological advancement is significant in achieving a competitive advantage to ensure business continuity.

2.2. Business Model

In general, the BM concept can be described as a complex system that allows the core value proposition to be transferred to the customer as a benefit (Seelos & Mair, 2007) as well as the application of digital technologies in BM can also help create value, generate revenue, and reduce costs (Alkaraan *et al.*, 2022). According to Rosa *et al.* (2020), I4.0 mechanisms enable significant business improvements, enhancing customer experience and optimising operations or even creating BM. However, many factors influence companies outcomes in ways that change BM, such as customers and the market, competitors and suppliers, employees and location, costs and prices, products and services offered and similar and/or substitute products, government, and the economy, as well as when a company decides to adopt one or more I4.0 technologies.

Although conceptualisations about BM differ in the number and specification of components, in general, four main areas are highlighted: (1) target customers, (2) the value proposition offered by an organisation to its customers, (3) value creation and delivery, through where the value proposition is produced and brought to the customer, and (4) value capture activities related to revenues and costs to create and deliver a value proposition (e.g., Dentchev *et al.*, 2018). While the "value creation" component of BM is used in the context of the products and/or services offered to customers, the "value delivery" component of BM aims to implement activities and processes capable of delivering the promised value and the "value capture" component concerns to company revenue issues and cost structure. The case study by Chen *et al.* (2021) argues that digital technologies are crucial to making viable changes between expanding the value proposition into personalised and intelligent solutions, opening up the value delivery system to the supply chain beside the ecosystem, and introducing various value capture mechanisms. The interaction between BM change and digital technology adoption occurs within and across these three distinct phases.

3. METHOD: SYSTEMATIC LITERATURE REVIEW

3.1. 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 whole period (2003-2021) covered by the database was contemplated; (d) using the topics: title, abstract, author keywords, and keywords plus, with the following terms: "business model" AND "industry 4.0" OR "digitalisation". The research results, shown in Figure 1, 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 publishing area criteria (b), and 18 articles were 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 than 6 articles that were outside of this research scope, such as articles focused on academics and not companies. Therefore, 322 articles were analysed for this research.

3.2. Bibliometric Analysis

To map the articles that address topics related to I4.0 and digitalisation in the BM, 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.

Five indicators (articles, authors, journals, countries, and academia), the software citation (Cit), the co-citation, and 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: the relationship between scientific elements, and (ii) performance: citations, keywords frequency, and publication (Caputo *et al.*, 2021; Ferreira, 2018). The number of citations is a measure of influence, and documents must reach a minimum inclusion limit. 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. Keywords 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, offering a comprehensive examination of the scientific domain (Ferreira, 2018) and increasing the veracity of the data.

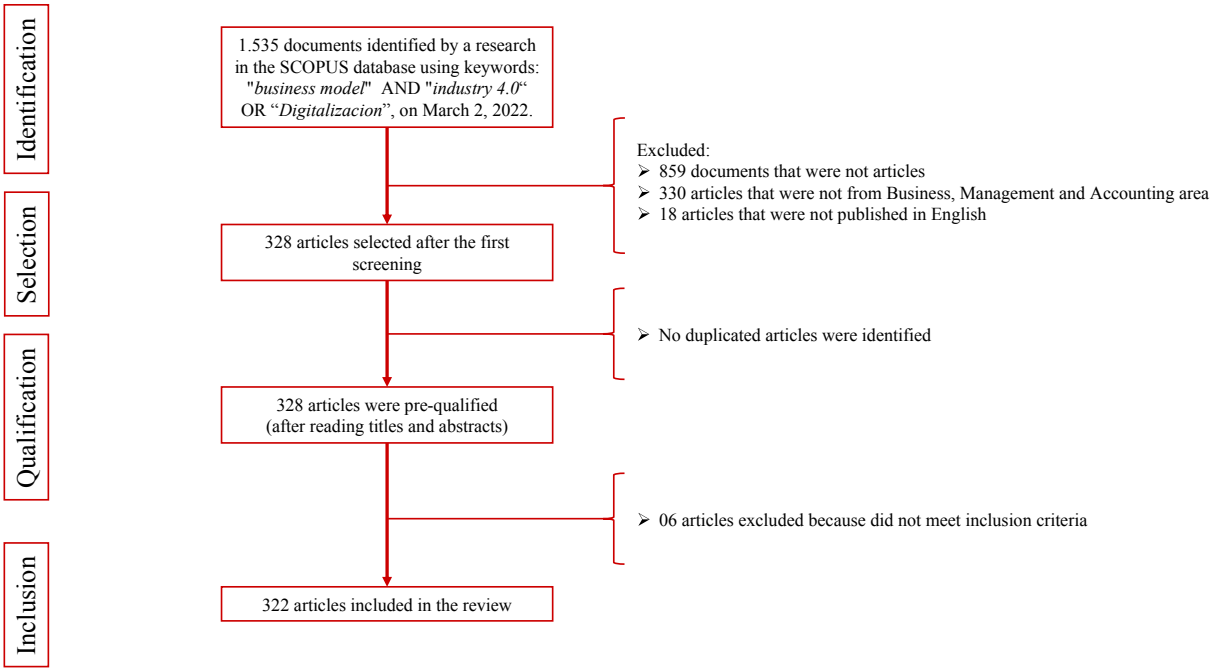

Figure 1
Research Protocol
Source: Own elaboration.

4. RESULTS OF DATA ANALYSIS

Before doing the comparative analysis, it was written a *thesaurus file* (Van Eck & Waltman, 2010) to unite the names of authors, Journals, and Institutions, written in a different format but which are the same and to unite words that were synonymous and/or abbreviated (e.g., authors: "Baines, t." was replaced by "Baines, t.s." / Journals: "acad. manag. j." was replaced by "Academy of Management Journal' / institutions: "Free University of Bozen-Bolzano" was replaced by "Free University of Bolzano-Bozen" / words: 'business model" was replaced by "business models").

4.1. Analysis Of Authors

A comparison of authors' citations, co-citation, and bibliographic coupling was run to analyse the most cited authors in the area. Co-citation analyses were performed using *fractional counting,* maintaining the VOSviewer analysis pattern. Of the 23,450 authors, they 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 of the key authors in this area. The author Vanit Parida appears at the top of the three analyses, as shown in Table 1.

Table 1
Author impact. Comparison of authors citations, co-citation, and bibliographic coupling

Citation				Co-Citation			Bibliographic Coupling	
Author	**Doc**	**Cit**	**TLS**	**Author**	**Cit**	**TLS**	**Author**	**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.
Source: Own elaboration.

4.2. Analysis of Articles

Regardless of whether there is much research in the digitalisation 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 the COVID-19 pandemic. Of the 322 articles, 213 were published between 2020 and 2022, i.e., 66% 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 (Tables 2, 3 and 4), in terms of citation and bibliographic coupling, a minimum of 20 citations was established for the 322 documents; 72 meet the threshold. On the co-citation analysis, with a minimum of 10 citations, of the 18,628 cited references, 13 meet the threshold.

Table 2
Analysis of Articles: Top three articles

Rank	Authors	Year	Title	Main Contributions
1	Moeuf, A., Pellerin, R., Lamouri, S., Tamayo-Giraldo, S., & Barbaray, R.	2018	The industrial management of SMEs in the era of Industry 4.0	— New changes brought to the production planning and control functions in SMEs in the era of I4.0; — Describes technologies under-exploited or ignored by SMEs as well as the most exploited; — Presents a framework for analysing papers associated with the I4.0 concept.
2	Müller, J. M., Buliga, O., & Voigt, K. I.	2018	Fortune favours the prepared: How SMEs approach business model innovations in Industry 4.0	— How I4.0 impacts manufacturing SMEs' business models; — Implementation motives and implications are shown for I4.0 users and providers; — Presents four implementation stages of I4.0 within SMEs.
3	Warner, K. S., & Wäger, M.	2019	Building dynamic capabilities for digital transformation: An ongoing process of strategic renewal	— What digital transformation means for incumbent firms; — Analysis of the ongoing digital transformation; — Provides a perspective where digitalisation drives changes to digitally transform an incumbent's BM, organisational structures, and processes.

Source: Own elaboration.

Table 3
Analysis of Articles: three most impacting articles in terms of Total Link Strength (TLS)

Rank	Authors	Year	Title	Main Contribution
1	Müller, J. M., Buliga, O., & Voigt, K. I.	2018	Fortune favours the prepared: How SMEs approach business model innovations in Industry 4.0	Refer to table 2
2	Warner, K. S., & Wäger, M.	2019	Building dynamic capabilities for digital transformation: An ongoing process of strategic renewal	Refer to table 2
3	Kamalaldin, A., Linde, L., Sjödin, D., & Parida, V.	2020	Transforming provider-customer relationships in digital servitisation: A relational view on digitalisation	— Guides on how companies can facilitate both customisation and operational efficiency by leveraging the value of digital technologies; — Development of a relational transformation framework for digital servitisation to guide B2B relations.

Source: Own elaboration.

Table 4
Comparison of articles citations, co-citation, and bibliographic coupling

Citation			Co-Citation			Bibliographic Coupling	
Author	Cit	links	Author	Cit	TLS	Author	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.* (2018)	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.

Source: Own elaboration.

4.3. Analysis of Journals

The Journal with the highest number of publications in the I4.0 and digitalisation area associated with BM is Technological Forecasting and Social Change, with 17 publications and the highest number of citations (1,041). The Journal of Cleaner Production has the highest number of co-citations (405), with 10 articles published. 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 citations; only 96 of the 7,560 Journals meet the selection criteria. Table 5 displays the top ten Journals that contributed more with publications about the theme I4.0 and digitalisation associated with BM.

Table 5
Comparison of journals' citations, co-citation, and bibliographic coupling

Citation				Co-Citation			Bibliographic Coupling	
Journal	Article	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 Business Research	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.

Source: Own elaboration.

Table 6
Comparison of countries citations, 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: Doc – documents; Cit – citation; TLS –Total Link Strength.

Source: Own elaboration.

4.4. Analysis of Country Collaboration

Germany was the country that contributed most to the 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 6 displays the top ten countries with the highest number of articles published, their citation and TLS of the 100 countries analysed; only 24 published more than five articles.

4.5. Analysis of Institutional Collaboration

Regarding collaboration of institutions, approximately 554 institutions, at least 17 published 4 articles or more. The two universities with the most publications were: Luleå University of Technology (Sweden) and the University of Vassa (Finland), with 15 articles each. Table 7 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 num-

ber of citations 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 a chair professor of Entrepreneurship and Innovation at one of the universities with the largest number of published articles at Luleå University of Technology, during the period of this research.

Table 7
Comparison of institutions' citations, 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.
Source: Own elaboration.

4.6. Analysis of Keywords

A full counting method was used to identify and group the clusters with at least five occurrences; of 1,607 keywords, 71 met the threshold. As the three keywords, part of the research themes, were influencing the results, these were excluded: "industry 4.0", "digitalisation" and "business model". Using a three-item minimum cluster size, the analysis by association provided five clusters with 805 links and 1,194 total link strength (TLS). Table 8 presents the complete list of keywords and their clusters, and this number of links demonstrates that there are topic overlaps between the clusters (Figure 2).

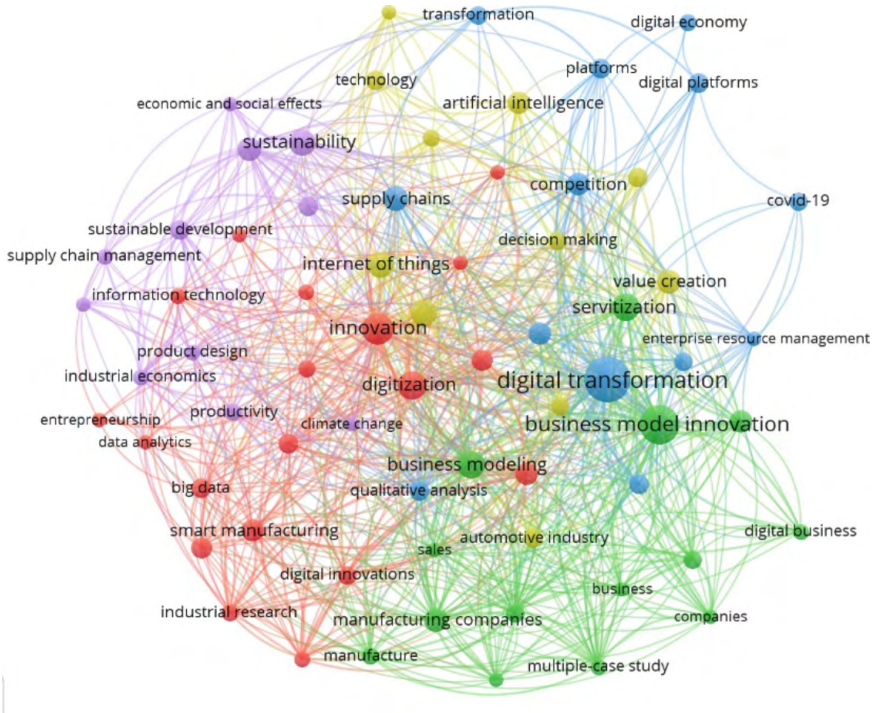

Figure 2
Network Visualisation by VOSviewer 1.6.18
Source: Own elaboration.

Table 8
All keywords co-occurrence analysis by VOSviewer 1.6.18

	Keyword	Occurrence	TLS Cluster
Cluster 1: Technology Innovation	Innovation	23	80
	digitalisation	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
	strategic approach	5	26
Cluster 2: Business Model Innovation	business model innovation	36	106
	servitisation	19	51
	business modelling	18	82
	manufacturing companies	13	62
	digital servitisation	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
	climate change	5	20
	3d printing	5	15

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

Along with the clusters (Table 8), the co-occurrence analysis offers network (Figure 2), overlay (Figure 3) and density visualisation (Figure 4). The links present the articles' stronger and more prominent words (Figure 4). The five colours in Figure 2 represent each of the 5 clusters (Table 9) 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 (see Table 9).

In addition to this generic analysis, the clusters will be addressed individually in Section 5 - Discussion of clusters results.

Visualising the overlay of words (Figure 3) presents the temporal distribution of keywords and thematic evolution over the years using non-normalised scores; this means that researchers currently focus on digital technology analysis, digital transformation, technology innovation, digital platforms, and innovation in digital BM. Previous studies have focused on I4.0 manufacturing, smart manufacturing, and technologies like Big Data. These less dense themes indicate themes for future research. At the same time, the denser themes point to themes that may be saturated in research.

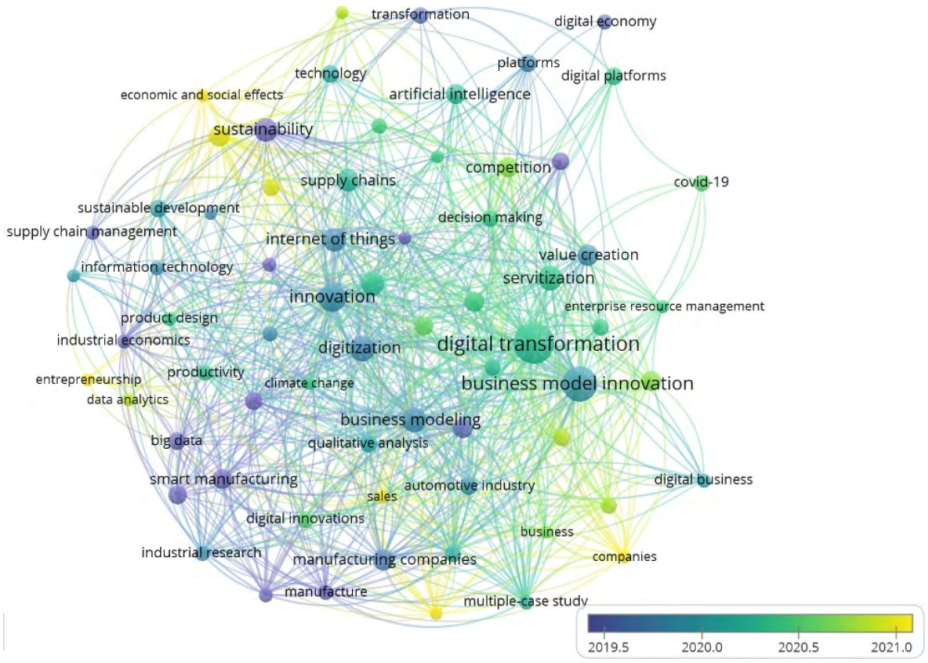

Figure 3
Overlay Preview through by VOSviewer 1.6.18
Source: Own elaboration.

The word density visualisation (Figure 4) continues, showing the connections between keywords. The colours 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, digital transformation and innovation in BM are denser than digital economy and digital business. These less dense themes indicate topics for future research. In comparison, denser themes point to themes that may be saturated in research.

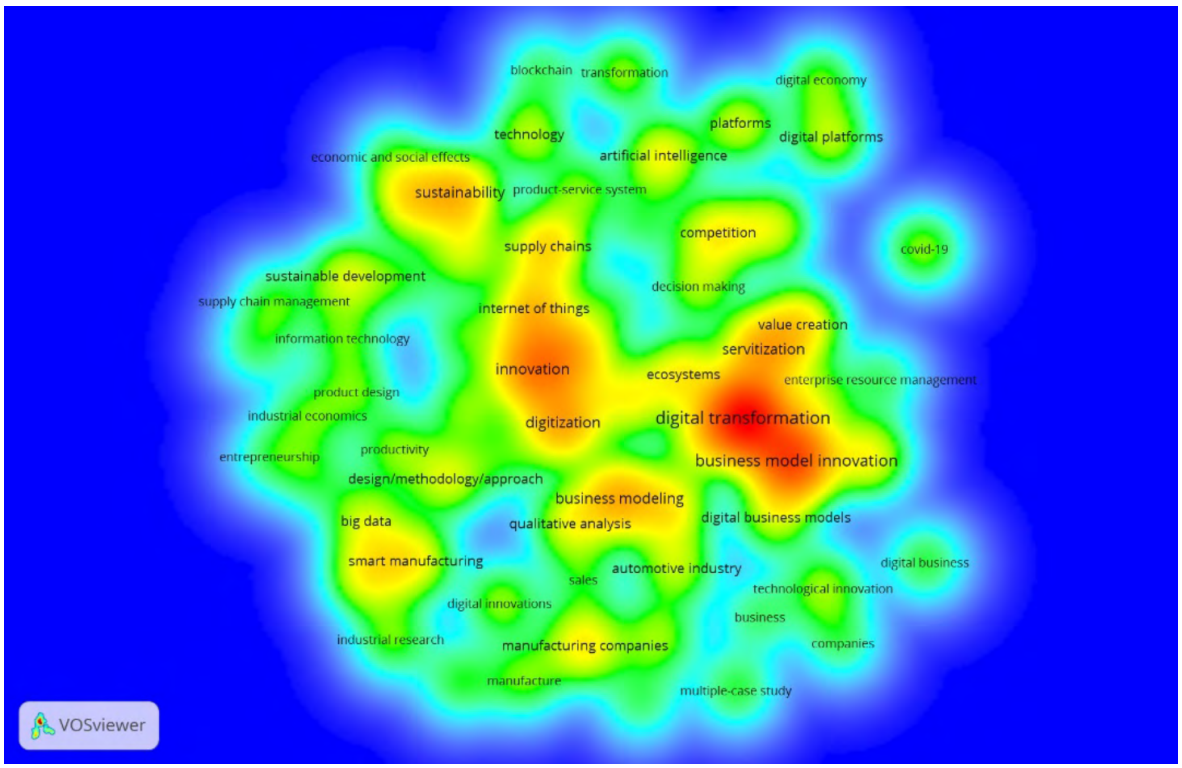

Figure 4
Density Display by VOSviewer 1.6.18
Source: Own elaboration.

5. DISCUSSION

Firstly, as mentioned previously, the clusters were grouped through the VOSviewer software that analysed the keywords and the links' total strength; nevertheless, it was necessary to read the articles to identify which cluster each article belonged. Table 9 displays the number of articles grouped in each cluster and their colours. 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) clusters have the most powerful keywords in the link: "business model innovation" (TLS = 106) and "digital transformation" (TLS 132) respectively.

Table 9
Number of articles per cluster and their respective colours

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

Source: Own elaboration.

5.1. Technology Innovation

The first cluster was named Technology Innovation, as this tends to offer opportunities to develop innovative BM. Research has been into the effectiveness of transformative BM and disruptive I4.0 technologies (Kovaitė & Stankevičienė, 2021) that are revolutionising the market for products and services, disrupting global markets (Hannibal, 2020). Among several factors, it was observed that I4.0 technologies could support open innovation initiatives (Strazzullo *et al.*, 2022), promising a future of discontinuities and disruptive innovations, replacing the deployment of digital technologies initially enabled by Industry 3.0 (Wofford *et al.*, 2020), with for example, industrial robots can help improve product quality and offer better working conditions to limit the use of resources, resulting in cost savings (Vido *et al.*, 2020); Information and Communication Technologies and BM innovation can enhance the traditional advantages of physical markets by transforming and upgrading the traditional system into an enterprise ecosystem (Song *et al.*, 2022). Therefore, the digital revolution has substantially changed the business environment, transforming various sectors, such as the banking sector, which has recognised the importance of investing in innovative technologies due to analytical capabilities to attain competition and sustainability (Gul & Ellahi, 2021) as well as improve the performance and satisfaction of its customers.

5.2. Cluster 2 - Innovation in Business Models

Since "Business Model" is one of the research keywords, it was challenging to classify the articles of this cluster, as it was identified through the perception of the difference in the focus of each article when relating to BM, I4.0, and digitalisation. Thus, the Innovation cluster in the BM grouped the themes related to business management, people, and how a company's previous knowledge affects its strategies in implementing digital services. Publications in this cluster also discuss the barriers to digitalisation, decision-making guidance, strategies for implementing digital technologies, and innovation in BM to deliver digital products and services through technology innovation and intelligent solutions. For Bouncken & Kraus (2022), organisations must not only compete among themselves through well-developed autonomous strategies to gain advantages over their competitors, solely relying on their resources and capabilities, but also base their BM on shared resources, knowledge dissemination, local resources, and government support. For Müller *et al.* (2021), firms that acquire, assimilate, transform and exploit external knowledge are better prepared to engage in exploratory and experimental innovation strategies, allowing such firms to redesign their BM towards efficiency and novelty. According to Paiola *et al.* (2021), prior knowledge has been considered crucial to properly conceptualise and classify the digital service models and designs to be adopted before even beginning the digitalising services. Companies without sufficient prior knowledge are forced to close their knowledge gaps by learning to manage various new and specific aspects of digital technologies. Support from external sources and knowledge is also crucial to upgrading the internal capabilities of family businesses to adopt I4.0 disruptive technologies (Cucculelli *et al.*, 2022).

In addition to these factors, people management practices are strongly correlated with the productivity and innovation of the BM (Llinas & Abad, 2019). Top management and leadership guidelines, employee motivation, collective wisdom, creativity, and innovations are critical factors influencing BM in a smart factory (Jerman *et al.*, 2019), as well as the continuous and orderly management of organisational leadership is also considered to be one of the critical success factors of I4.0 implementations (Pozzi *et al.*, 2021). Digital technologies have had a tremendous impact on the world and have forced companies to adapt their BM, their strategies and, especially, their management practices (Fernandez-Vidal *et al.*, 2022). Suppliers and customers move from the product-centric transactional model to service-oriented relational engagement to profit from digitalisation. The interaction between digitalisation and high-service delivery has become positive and significant, which can improve company's financial performance (Kohtamäki *et al.*, 2020).

5.3. Cluster 3 - Digital Transformation

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

tions in modern business is the shift from traditional to digital BM to achieve a higher level of competitiveness (Jovanović *et al.*, 2018); consequently, digital transformation has been one of the main challenges faced by contemporary businesses (Saarikko *et al.*, 2020). The case study carried out by Rubio *et al.* (2021), which presents a new algorithm to maximise the use of AGVs (Autonomous Guided Vehicles) efficiently and reliably, presents evidence of increased productivity, reduction in energy consumption, improvement in production time and decrease in labour costs, which has an impact on the factory's revenue and consequently on the decision-making process and BM.

Regarding the adoption of I4.0 technologies, inter- and intra-organizational factors that influence BM were also identified. For Zeng *et al.* (2021), inter-organisational factors such as regulatory pressure, pressure from business stakeholders, and the influence of large organisations and market leaders influence adoption decisions to different degrees. The intra-organizational factors are related to top management support, which directly influences the organisation's adoption decisions and the technology compatibility within each organisation. For Menchini *et al.* (2021), enterprise architecture can be useful in the digitalisation of BM; however, for this to happen, support from top management is essential, especially since it requires much work in the transition to a digital BM, where collaborations with external partners could be beneficial (Palmié *et al.*, 2022). Finally, the COVID-19 pandemic has led to a shift in BM towards socially responsible business and adherence to sustainable development goals. According to Miethlich *et al.* (2021), digital transformation is a necessary and important process for developing a company in COVID-19, aiming to maintain its integrity and survival, driving the extensive use of digital technologies in everyday life. In pandemic scenarios, digital enterprise management is focused on survival, self-learning and cooperation without intermediaries through innovation and transformation of business processes.

5.4. Cluster 4 - Digital Technologies

Publications in the digital technology cluster share a common denominator: value creation influenced by digitalisation. Digital technologies influence organisations' creation, proposition, and capture of value and how they deal with the challenges of increased digitalisation (Acciarini *et al.*, 2021; Rachinger *et al.*, 2018). Other investigations seek to clarify the impacts of one of the specific digital technologies in BM, e.g., Cyber-Physical Systems, IoT, Blockchain, cloud computing, Big Data, and Artificial Intelligence, among others. Dynamic capacity is another theme that has caught the attention of researchers, whether in building dynamic management capabilities to drive digital transformation (Warner & Wäger, 2019), using new digital technologies, or using them to generate changes in operational capabilities and business activities (Oyebanjo & Tengeh, 2021). In terms of digital technologies, IoT has created many kinds of extraordinary business opportunities for e-commerce, and with the use of the internet on mobile devices, new forms of BM have emerged (Bhullar & Gill, 2018). IoT can change not only BM but also how individuals and organisations create value (Langley *et al.*, 2021), as its use can aid in real-time data capture and, when integrated with Blockchain, allows business intelligence to improve resource management agility (Rane & Narvel, 2021). Another factor that influences BM is the development of new biclustering algorithms that can help designers, managers, innovators, and others to identify who the customers are in general, their desirable and undesirable characteristics or combinations through IoT devices, and thus corroborate the process of developing new products (Garbuio & Gheno, 2021). According to Srivastava *et al.* (2019), Blockchain helps manage the integrity of finished products, the collection of medicines, safety announcements, traceability, and security of your supply chain from raw material to manufacturing and final distribution to customers. Augmented Reality (AR) can also be a potential solution for improving business processes, operational efficiency, and overall competitiveness (Rejeb *et al.*, 2021).

5.5. 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 contribute to understanding how I4.0 and digitalisation associated with BM innovation are related to practices, principles and objectives, strategies, and the transformation of the circular economy. There is much research on circular BM, whether BM innovation or BM related to sustainability. According to Beier *et al.* (2020), I4.0 technologies offer 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 implementing I4.0 technologies. According to Alkaraan *et al.* (2022), the circular economy is an industrial system that uses renewable energy to help eliminate waste through materials, products, systems, and BM. Digital transformation, defined through new digital technologies, enables significant business improvements, enhances the customer experience, streamlines operations and supports the creation of BM. The consolidation of I4.0 as a new innovative ecosystem has generated great expectations about its economic and environmental effects (Díaz-Chao *et al.*, 2021). For example, lean design combined with eco-design and I4.0 represents an innovative model that includes sustainability throughout the product life cycle (Dahmani *et al.*, 2021). Using I4.0 technologies, such as in green energy platforms, can contribute significantly to the energy sectors' decarbonisation, digitalisation and decentralisation and, consequently, to the slowdown of climate change (Menzel & Teubner, 2020). Implementing technologies such as Blockchain can help improve circular economy practices and companies' environmental and financial performance (Khan *et al.*, 2021). In conclusion, these digital technologies influence BM innovation, being considered to provide solutions to numerous problems in the world, including those related to the transformation of the circular economy.

6. CONCLUSIONS, FUTURE RESEARCH AGENDA AND LIMITATIONS

This paper investigates the confluence of factors influencing BM by digitalisation and I4.0 disruptive technologies. Firstly, bibliometric analysis was conducted to detect the most cited authors and the most impactful articles, Journals with the highest number of publications within this theme, and institutional and country collaboration. Through the co-occurrence of keywords, five clusters were pointed out and analysed: (1) Technology Innovation, (2) Innovation in BM, (3) Digital Transformation, (4) Digital

Technologies, and (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 digitalisation, (b) the impacts that digital technologies have caused on BM, (c) servitisation and digitalisation, which is present in an expressive number of articles, and (d) the digitalisation and adoption of technologies in the context of the COVID-19 pandemic, that has changed BM significantly. After that, an in-depth analysis was conducted to investigate explicitly the factors that influence BM through digitalisation and I4.0 disruptive technologies.

The research revealed that some technologies, such as BD & BD Analytics, IoT, and AI, have been explored more than others. Nevertheless, all technologies have several factors, some of which are similar; for example, these three mentioned technologies can be useful in developing concepts and/or products and/or services and can help the process of customer segmentation and top management orientation. IoT and Blockchain can be valuable in implementing a circular economy, while cloud computing and AI are very effective for data collection, analysis, and sharing. However, technological innovation can impact the BM positively and/or negatively (Patrucco *et al.*, 2021). While digitalisation can bring new opportunities, the process conveys risks that may be difficult to mitigate or for which it is difficult to prepare (Amankwah-Amoah *et al.*, 2021). In the case of SMEs, which need to rely on the support of universities, government, and/or advanced technology centres, the adoption of some advanced technologies may be in short supply due to the low scale of operation, which makes such technologies inaccessible to SMEs (Benitez *et al.*, 2020).

Another example is the case of augmented reality, where despite helping improve training and working conditions, there are some challenges to implementation as employees may have restrictions on the training type (Dalmarco *et al.*, 2019). Furthermore, before adopting any technology, it is necessary to carefully analyse the internal and external consequences, seeking to understand what creates, delivers and captures value within BM according to each organisation's profile. These and other factors directly influence the BM of organisations in the digitalisation era.

The results of this study offer valuable contributions regarding knowledge about dimensions that influence BM in the digitalisation and I4.0 era, where the main findings and contributions concern the identification of themes and factors that have been further explored to drive future research to other areas less studied. It also offers a new approach to scientific mapping in digitalisation and BM. The analyses carried out in Journals, authors, and articles provide comprehensive and vital knowledge that systematises the body of knowledge and is based on the research of the academic panorama (Caputo *et al.*, 2021).

Despite the well-established research methodology, which is 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 characterise the results obtained: using 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. To comply with the standards, we present only the main bibliographic references.

The findings of this study provide suggestions for policymakers, academics, and researchers to understand better the factors that influence BM through digitalisation and I4.0 disruptive technologies and can guide future research in this field (see Table 10).

Table 10
Proposal of a Research Agenda

Theme	Future Research Proposed
Technology Innovation	— Technologies implemented in the specific phase of the open innovation process and the intensity of the adoption of I4.0 technologies; — Effects of digitalisation-driven innovation connected to the BM reshaping; — Digitalisation activities of SMEs and family businesses during their business successions; — Strategies to implement I4.0 technologies identifying new opportunities in BM.
Innovation in Business Models	— Innovation in BM resulting from different levels of servitisation and the digitalisation process; — Innovative BM that are more appropriate to capacities, internal resources and the external environment; — Differences and/or similarities between countries in the digital BM innovation procedure.
Digital Transformation	— Connection between BM settings and the revenue/profit model through digital transformation — Relationship of strategic competencies that contribute to the transformation of digital BM; — Effects of digital transformation that can lead to business failure when the transformation process occurs slowly.
Digital Technologies	— Benefits versus costs for the adoption of digital technologies; — Study whether management, for BM innovation, differs between industries by adopting digital technologies; — What partnerships between companies and other organisational actors, such as startups which develop digital solutions, universities, and public and private R&D centres, could contribute to implementing digital technologies; — Better understanding of the relationship between sustainability and the adoption of digital technologies, focusing on sustainable entrepreneurship and BM.
Circular Economy and Sustainability	— New strategies and address the adverse effects of unemployment caused by innovation and technological progress; — Which sectors and/or companies have had an advantage through digitalisation and Circular Economy; — How circular BM affect the delivery of value during the adoption of various digital technologies; — Influence of digitalisation on various product and/or service sustainability aspects.

It was carefully identified and revealed the most relevant areas in terms of research, journals, and authors and, in doing so, it highlighted significant issues that offer future research directions. Policymakers aiming to increase the implementation of digitalisation and I4.0 disruptive technologies can provide training programs or tax incentives to incite firms to invest in developing new business models. Focusing on adopting new business models in companies will promote implementing practices aligned with sustainability goals and a circular economy.

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