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Review

Research Trends of the Internet of Things in Relation to Business Model Innovation: Results from Co-Word and Content Analyses

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Abstract: In the era of the Internet of Things, innovative business model initiatives continue to deepen, and the trend of search domains continues to expand. This paper aims to scientifically analyze research trends of the Internet of Things in relation to Business Model Innovation through bibliometric studies. The data were collected using the Clarivate Web of Science (WoS) Core Collection (SSCI and SCI indexed) from 2005 to 2022 (November). However, the publications for the research domains started in 2015. The results show that scientific publications on the Internet of Things in relation to Business Model Innovation have increased gradually since 2019. The WoS database is utilized for analyses because it contains journals and conference proceedings deemed more relevant by the academic domain and highly reputable sources for bibliometric studies. The VOS viewer, R Language, and Microsoft Excel were also used to analyze and complete the study. Bibliometric and scientometric analyses were conducted to identify publication patterns, text analysis, most important keywords (co-word, word cloud, and co-occurrence), trends for the topicality, and content clustering for the publication periods. The visualization of the research trends of the Internet of Things in relation to Business Model Innovation resulted in four co-occurrence clusters leading to some of the topic areas mentioned as follows: (1) The Internet of Things, (2) Business model innovation, (3) Technology infrastructure, and (4) Digital transformation and capabilities. The results of this study will assist academics in identifying worldwide research trends related to the Internet of Things and Business Model Innovation as well as recommending future research areas.

Keywords: internet of things; IoT; business model innovation; bibliometric; co-word analysis; text mining/analysis; content analysis; scientometric; Web of Science

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1. Introduction

The Internet of Things designates how devices that are interconnected to each other and to the Internet can all be integrated at all times [1]. In other words, the Internet of Things (IoT) allows all devices to be connected "anytime, anyplace, with anything and anyone" [1] (p. 8). As such, the Internet of Things creates and enables enormous opportunities and threats. On the one hand, billions of devices allow for unprecedented applications to be utilized. In contrast, such a massive execution holds many potential dangers such as breaches of security and privacy, and other issues.

Companies need a clear vision and powerful tools to create and sustain a competitive advantage. Even though the possible opportunities available from the Internet of Things seem endless regarding improved levels of performance and higher innovativeness, companies and managers do not seem to be crystal clear when it comes to highlighting the particular ways in which they can take advantage of these features [2]. By utilizing and exploiting these potentials, the Internet of Things' promises may turn into realities.

In an attempt to address these issues, recently, there has been a surge in the number of studies attempting to shed light on how the Internet of Things allows new business models

to transform existing ones. "A business model is an overview of the manner in which a company does its business" [3] (p. 673). Even though some of these studies have considered a particular area within this field, a comprehensive approach is needed to provide more significant meaning on how these trends are being reshaped. Metallo et al. examined three firms—Intel, Solair, and Apio—in an exploratory study format using a multiple-case study method to understand how business models are affected by the Internet of Things [4]. Their findings suggest that the most significant building blocks for creating and capturing better value are the company's key activities, key resources, and value proposition. They also assert that the companies' unique competencies and the different competencies they develop are the main differentiating factors [4].

In addition to business models, the architecture and the ecosystem of the Internet of Things seem to be significant factors that will determine this industry's future [5,6]. By transforming how companies create and provide value through their products and services, the Internet of Things can revolutionize how businesses operate. Currently, how capabilities must be implemented in this new era depicts an incomplete picture [7].

This study aims to identify and discover the Internet of Things research trends in relation to Business Model Innovation in scholarly publications. The authors employed bibliometric co-word and content analyses. This research utilized the Web of Science Core Collection database to classify the research domains in order to investigate the interrelations and effects among them. Therefore, to understand and map the intellectual structure of the research domains, the research questions are formed as below:

(RQ1) What are the most influential keywords and word dynamics to show the trends in the research domain?

(RQ2) What main themes emerge in the current intellectual structure?

This paper is structured in the following way: The methodology is explained in Section 2, descriptive bibliometric results, co-word, thematic content analyses, implications, and suggestions for future research along with discussions are presented in Section 3, and Section 4 comprises the conclusion.

2. Materials and Methods

2.1. Research Design

The term "bibliometrics" is also used to describe a statistical strategy for analyzing bibliometric publishing data across various media, including peer-reviewed articles, books, conference proceedings, magazines, reviews, and related reports. Along with bibliometric instruments, there are numerous ways to conduct analysis for a literature review. This method enables a deeper, more comprehensive grasp of a particular subject and the trends in its publishing.

To perform the search strategy in the database, we conducted a six-step approach which is supported by the literature as follows: (1) select the database; (2) obtain the keywords (search strings) that are relevant to our research domains for the period of 2005 to 2022; (3) screen the initial findings of published materials by reviewing all articles in their titles, keywords, and abstracts, followed by the methodological aspects as well as conclusions; (4) remove the unnecessary or unrelated publications (exclusive criteria). (5) Having identified the most relevant keywords, titles, and abstracts for co-word analysis by using the text mining approach, (6) cluster the dataset for content analysis and discuss the findings of the clusters accordingly [8–10]. This paper's classification included the dimensions that researchers highlighted (deductive approach). The publications were categorized based on the research domain; namely, the Internet of Things in relation to Business Model Innovation. For the exclusion of irrelevant studies, the authors extracted the papers from the dataset. Further, the authors categorized the studies based on cluster and content analyses in line with the research method used.

2.2. Search Strategy and Data Collection

In this study, the Business Model Innovation in relation to the Internet of Things subject fields was explored using the Clarivate Web of Science Core Collection. This study analyzes all published documents indexed in the Web of Science Core Collection (Science Citation Index Expanded; SCI-EXP and Social Sciences Citation Index; SSCI) about Business Model Innovation in the Internet of Things. Only Web of Science (WoS) publications were considered, as it is regarded as the most reputable database for collecting and analyzing scientific papers [11].

We then constructed the search strings in the categories of ([TOPIC] "internet of things" OR "IoT") AND ([TOPIC] "innovation") AND ([TOPIC] "business model"). The findings were 78 publications in "ALL" categories, and the timespan was 2005–2022; however, the publications started from the year 2015. The exclusive language criterion, "English", was applied and resulted in 77 publications. Following step five above, the title, abstract, and keywords metadata were screened, six more publications were removed from the dataset, and the final documents resulted in 71 journal articles.

2.3. Procedure and Data Analysis

In order to address issues about research involving the Internet of Things and Business Model Innovation, we employed the bibliometric co-word and content analyses in the research domains; the publications started in the year 2015 since the Internet of Things is a new and emerging field that has recently become popular in academic journals. Co-word analysis was conducted with the help of the R language text mining and Bibliometric packages. A related dataset was extracted for further analysis in Microsoft Excel for descriptive results. Simultaneously, the final dataset was analyzed with the VOS viewer for data visualization and clustering of content analysis. The extensive literature review was also applied to discuss findings in regard to cluster topics in detail. Following prior research [12–17], co-word and social network analyses with clustering were used to map the conceptual structure of the research domains. Therefore, the authors reviewed all papers by title and abstract, followed by the introduction, findings, conclusions, and discussions. With the software's help, the content analysis results (topicality of clusters) were identified and selected for relevance to research domains.

3. Results and Discussion

3.1. Descriptive Findings

The research findings reported that the scientific production on the IoT in relation to Business Model Innovation subject domains had 71 publications in the WoS Core Collection database (SSCI- and SCI-indexed). All articles were written in the English language. The descriptive results of the publications depicted that the majority of them corresponded to peer-reviewed journal articles (66/71, 92.96%), followed by review articles (9/71, 12.68%), and editorial materials (2/71, 2.82%). The top five publishers among 13 were Elsevier (34), Emerald Group Publishing (12), MDPI (9), Springer Nature (6), and Taylor & Francis (4). Publication records started from 2015. Since the starting period, the production has increased steadily. From 2020 to 2021, publication count doubled, showing a dramatic increase in the published results. Further, (n = 8.88) indicates the mean number of published documents in each year, with a 110% rise in the publications recorded for the 2020–2021 period. The proportional rise in the average number of articles published each year throughout this period was (n = 16.5).

The WoS Core Collection topic category dataset was utilized to classify the associated research areas under the top five major themes out of a total of 34, containing themes with at least eight papers as follows: Business (n = 30), Management (n = 24), Engineering Electrical Electronic (n = 10), Environmental Sciences (n = 8), and Regional Urban Planning (n = 8). There were 50 publication sources in the dataset. The most productive journal sources with (n >= 3) are *Technological Forecasting and Social Change* (n = 6), *Journal of Business*

Research (*n* = 5), *Industrial Marketing Management* (*n* = 4), *Sustainability* (*n* = 4), *International Journal of Production Economics* (*n* = 3), and *Long Range Planning* (*n* = 3).

There were 242 authors/co-authors from 35 countries led by Germany, the People's R. China, Italy, Finland, England, and the remaining 30 countries. A total of 157 institutions worldwide contributed to the domain fields. The most productive organizations with (*n* >= 4) publication count are Linkoping University, Lulea University of Technology, Parthenope University Naples, University of Erlangen Nuremberg, University of Padua, University of St. Gallen, and University of Vaasa. The citation records of the 71 publications derived from the WoS database statistics between 2015 and 2022 (until November) showed that the average number of citations per item was 28.95 equating to 257 per year (2015 to 2022). The total number of cited papers in that period was 2056. The top 10 publications' citation count was 1221 (average *n* = 122.1 per item).

3.2. Co-Word Analysis

Callon et al. were the first to propose a co-word analysis approach [18]. Researchers have since utilized the co-word analysis to discover the patterns of the bibliometric data of various fields [8,10,15], so the co-word analysis is accepted as a successful approach for text mining as well as thematic content analysis [13]. A high frequency of keywords (co-occurrence) that appear together suggests that the articles are more closely related and have a stronger association [19–21].

The occurrence of the keywords in scholarly publications is revealed via keyword (co-word) analysis. "Author Keywords" and "Keywords Plus" are the main two types of keywords for bibliometric research. "Author Keywords" are phrases that researchers choose to apply in their works, and "Keyword Plus" also contains key terms from the pre-set list of linked research fields that was developed by the journals' editors and WoS specialists.

Table 1 displays the top 10 most pertinent terms found in the publication records related to the Internet of Things with Business Model Innovation domains. The keyword distribution is found as Keyword Plus (ID) (*n* = 258) and Author's Keywords (DE) (*n* = 293). The most frequent Author's Keywords included "internet of things (IoT)", "business model/models", "industry 4.0", "business model innovation", "digital transformation", and "digitalization". The most frequent Keyword Plus terms included "innovation", "internet", "technology", "challenges", "management", and "value creation".

Table 1. Top 10 keywords.

	Author Keywords (DE)	Article Counts	Keywords Plus (ID)	Article Counts
1	internet of things	39	innovation	30
2	business model/models	26	internet	12
3	industry 4.0	24	technology	12
4	business model innovation	15	challenges	11
5	digital transformation	8	management	11
6	digitalization	8	value creation	10
7	value creation	5	future	8
8	artificial intelligence	4	smart	8
9	circular economy	4	transformation	8
10	industrial internet of things	4	business model innovation	7

A "word cloud", commonly referred to as a "tag cloud," is a graphic representation of textual data [22] derived from different keywords or from any given text corpus [23]. The Web of Science database structure states four essential elements when analyzing a word cloud: the abstract, the paper's title, the Author's Keywords (DE), and Keyword

Plus (ID). The significant terms and phrases are emphasized; typically, words or phrases that are given specific font sizes and colors based on their relevance and depending on the frequency of the text data relating to the primary categories. Bold and larger-sized words denote a word's greater significance and rising level of interest among researchers in the topic they belong to [8]. In order to apply a co-word analysis and create a word cloud to depict the influence of key terms based on their frequency in research domains, it is common that both keywords among the dataset should be gathered from the articles to complete the clear picture of the science mapping according to the search strategies [15,24].

Figure 1 demonstrates the most frequent words in each of the categories. The term "innovation" has the highest use among the corpus text in Keyword Plus, followed by "internet", "technology", "management", "challenges", and "value creation". Similarly, the term "business model innovation" has significantly higher use than others, followed by "business model/models", "digitalization", and "digital transformation". The terms "internet of things" and "industry 4.0" have various text forms in the corpus (Figure 2) such as "internet of things", "iot", "internet of things (iot)" and "industry 4", "0", and "industry 4.0". Therefore, those need to be combined for clarification. In Table 1, the combined values of those two terms are corrected in single terms. In the abstracts and titles, the dominant terms can be seen as "business", "internet", "model", "industry", "innovation", and "digital".

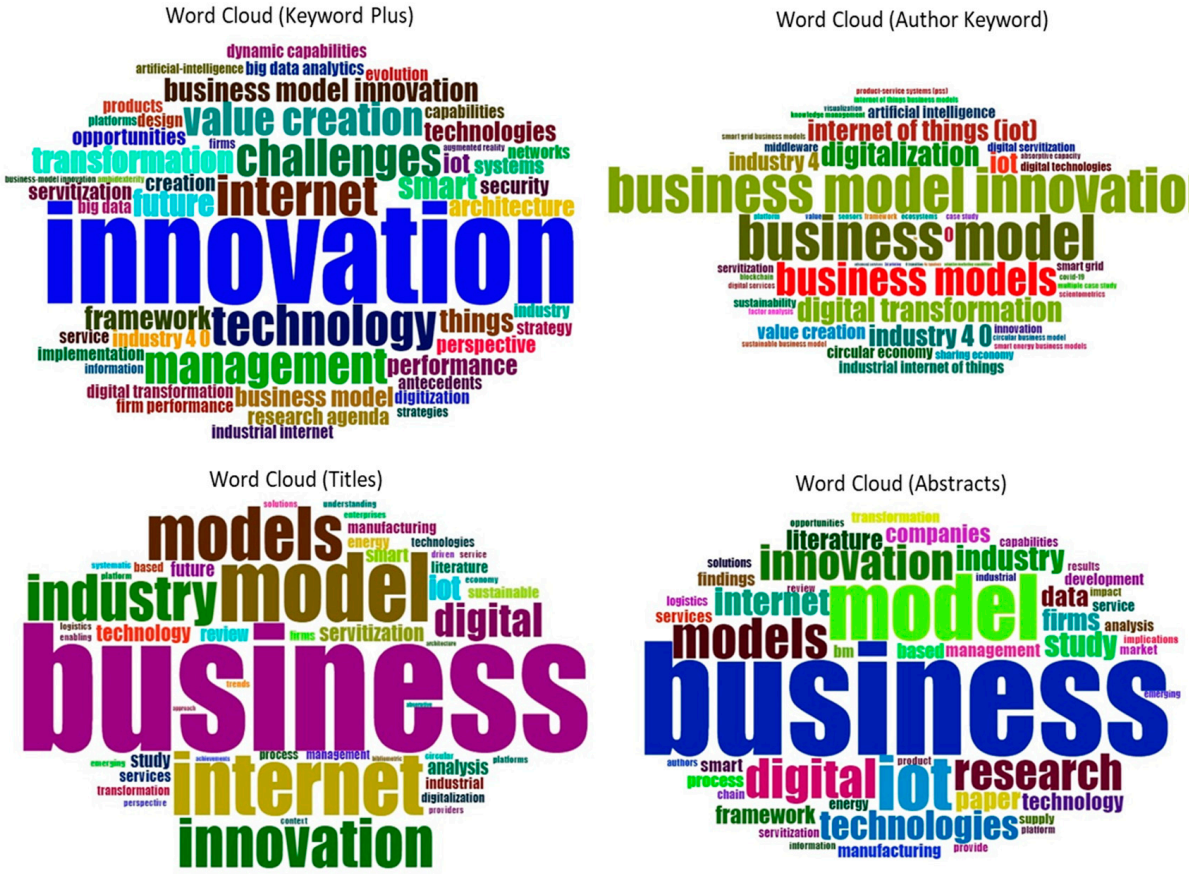

Figure 1. Word clouds.

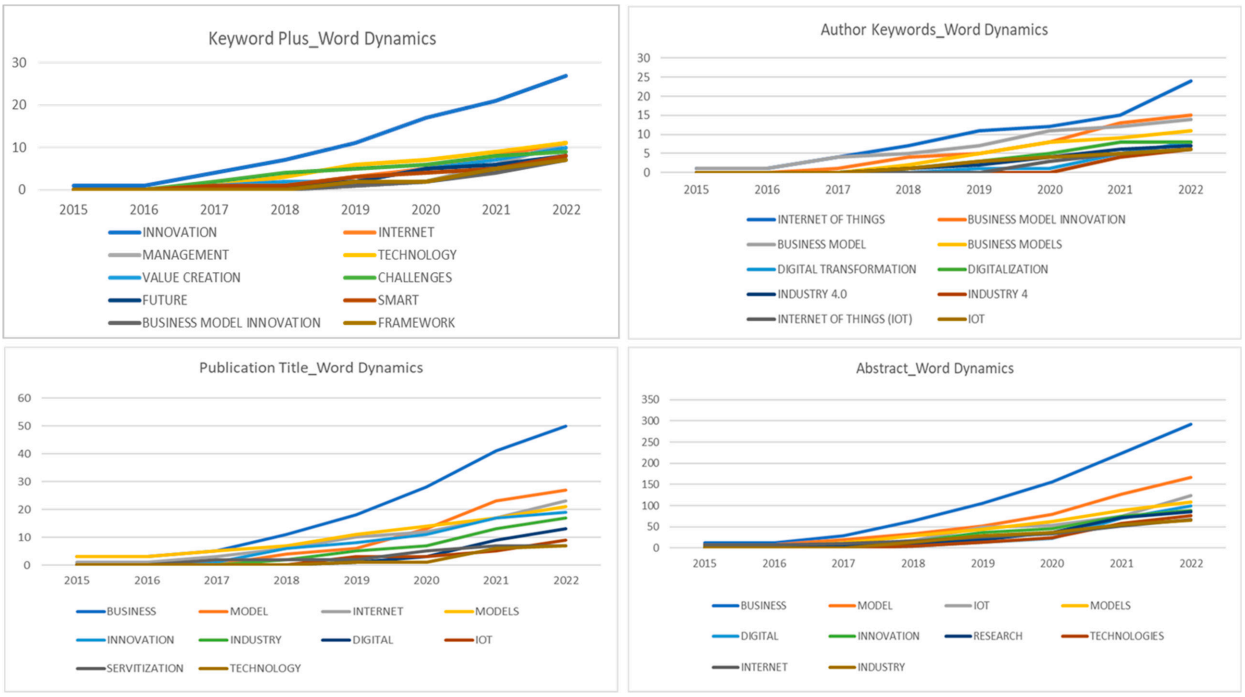

Figure 2. Word dynamics-growth.

To assess the keyword and term dynamics across the study periods, the top key terms were used to create a word dynamic-growth graph in Figure 2. Each word's repetition trend, or the frequency of occurrences in the dataset throughout the course of the search, demonstrates the occurrences. According to the annual distribution of keywords, the graph also displays the trend components for analyzing upward or downward movements throughout the trend line. To assess patterns in subject domain interest and significance in the study field, the most common terms could be observed over the course of the period. Finding themes with increasing interest allows academics to focus on recent subject areas, and can also produce important findings that advance the research fields [15].

Figure 2 illustrates the top 10 word dynamics-growth of the Internet of Things in relation to Business Model Innovation domains. Although the dataset represents similar patterns for each dimension, Author Keyword distribution and word dynamics show a similar frequency level in the terms. The "Internet of Things" and "Business Model Innovation" show higher values in the Author's Keywords, whereas "Innovation" is the highest among others in the Keywords Plus word dynamics. The following terms are close to each other and show similar trends in the same category: The term "Business" is the highest in both the Titles and Abstracts categories, followed by "Model". The common pattern for those graphs is that the publications start from 2015, and interest in the topics becomes visible from 2016 and mainly increases from 2018 to 2022 (Figure 2). Each category's word dynamics support the word cloud findings (Figure 1) and the top 10 keyword list (Table 1), accordingly. The graphs also demonstrate similar trend lines for content topicality growth. It could be stated that further studies will continue with the same patterns, whereas some combination of the studies would extend the themes in a more detailed manner.

3.3. Content Analysis

To ensure a stronger link and relationship among publications, the frequency of keyword co-occurrence is a generally accepted reliable indicator [19,25]. Mohammed et al. assert that content analysis provides an effective medium for collecting valuable themes according to the research domains [26]. Similarly, Andrianto et al. argue that keyword analysis alone is not sufficient to understand the current intellectual structure and its

relations in detail [17]. Therefore, the thematic content analysis is required to thoroughly clarify the connections between each sub-topic [15]. We employed the thematic content analysis to address the second research question regarding "the main themes–topics and clusters which emerge in the current intellectual structure". This method is appropriate for analyzing the categorization of the selected articles during the review process [24,27,28].

To detect the intellectual structure in the publication dataset, we conducted a thematic cluster analysis using the VOS viewer software [16]. As depicted in Figure 3, there are four main thematic clusters from 71 articles. According to its algorithm, the software automatically generates tag names (nodes) from Keyword Plus, Author's Keywords, Publication Titles, and Abstracts. The co-occurrences of these nodes are as follows: 258 single occurrences of 524 frequent Keyword Plus; 293 single occurrences of 446 frequent Author's Keywords; 328 single occurrences of 667 frequent Publication Titles; and 2439 single occurrences of 8898 frequent Abstracts. The illustration of the main thematic clusters is sorted by relevance and different colors in the diagram for the Internet of Things in relation to Business Model Innovation. The visualization of the research trends of the Internet of Things in relation to Business Model Innovation resulted in four co-occurrence clusters leading to some of the topic areas mentioned as follows: (1) The Internet of Things, (2) Business Model Innovation, (3) Technology infrastructure, and (4) Digital transformation and capabilities.

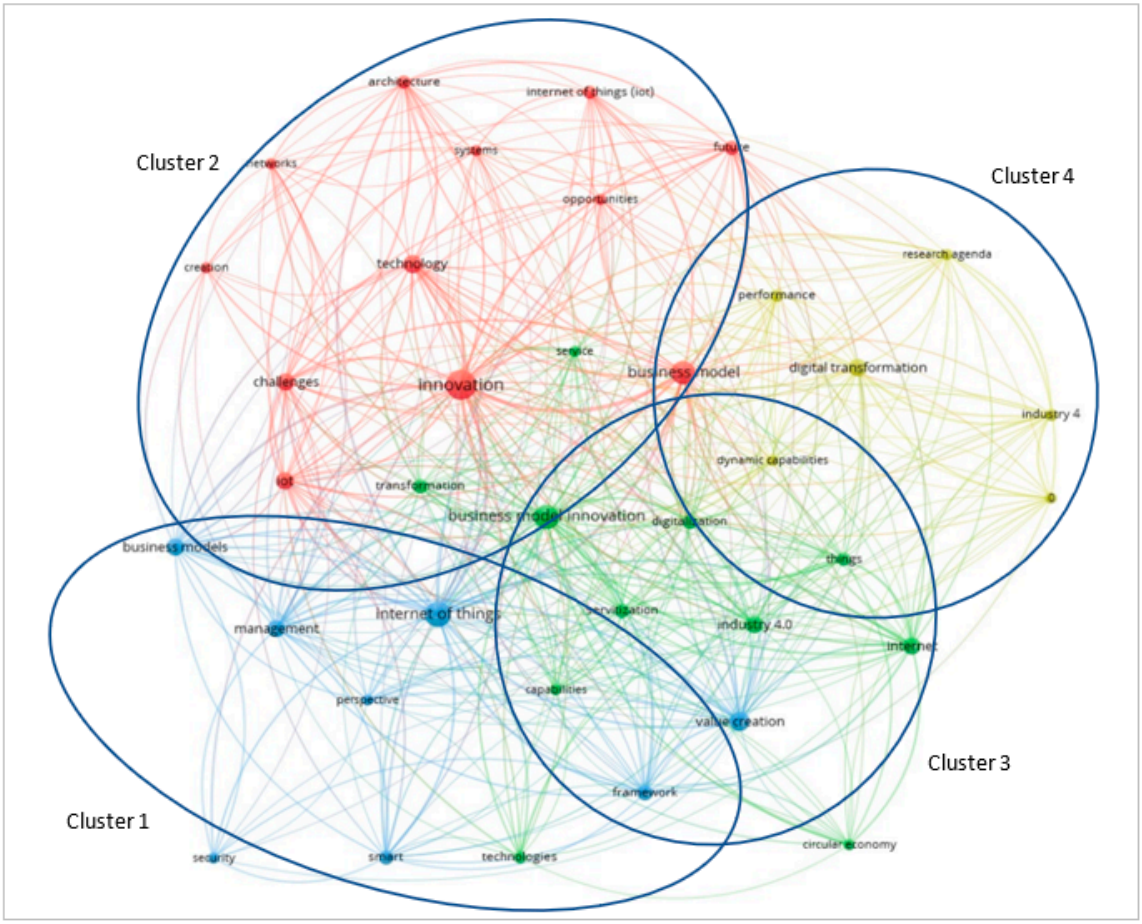

Figure 3. Thematic Clusters.

3.3.1. Cluster 1: The Internet of Things (IoT)

The Internet of Things has been defined in various ways since its inception [29]. Generally, the common perception is that the Internet of Things refers to the digital interconnectivity of different objects. These interconnected objects collect data through sensors, process the gathered data, and make them available for further use [30]. Furthermore,

such interconnectedness can take various forms, such as between people, between people and machines, and among devices [31]. Balaji and Roy emphasize that the Internet of Things is the basis of Industry 4.0 [32]. Turber et al. assert that the Internet of Things may significantly affect the features of products and services [33]. They argue that these will also potentially influence the entities involved within the ecosystem in which the Internet of Things survives and helps co-create. Abdmeziem and Tandjaoui claim that partnerships and cooperation among these involved actors are necessary across different businesses and industries [34]. Therefore, a perspective that integrates an ecosystem approach is expected to be more beneficial and comprehensive when these relationships and actors are required to be in a holistic network. Vargo and Lusch highlight the need for such a structure in the ecosystem of interconnected businesses [35]. Such interdependencies will inevitably determine the effectiveness and efficiency of the Internet of Things and all its services.

Mazhelis et al. argue that the Internet of Things naturally creates a competitive and co-operative environment [36]. In this ecosystem of intertwined networks, the involved actors engage in direct competition and cooperation due to the fact that the assets associated with the products and services are shared. Following this line of thought, Lai et al. assert that analysis of such a dynamic ecosystem is particularly challenging [37]. This interdependent nature of the Internet of Things creates an environment that is not conducive to typical business situations where the relationships between the company and the suppliers and the relationships between the company and the customers are the primary focus. On the contrary, the Internet of Things reshapes and redefines the business environment so that all the involved actors generate new ways of creating value, delivering value, and offering value co-dependently [38].

Mahdad et al. argue that the Internet of Things imposes a radical change in the ecosystem, especially the agri-food industry [39]. They claim that the interdependencies among industry actors may cause friction, so, in order to provide a smooth collaboration, an effective and innovative business model incorporating these relationships and interdependencies is highly sought after [39].

The Internet of Things has already started to affect the manufacturing world. In this respect, we can also talk about the Industrial Internet of Things [40]. The Industrial Internet of Things has an apparent and direct impact on business models [41] while the Internet of Things seems to suffer from well-established, clear, and compelling business models [42,43]. There have already been several significant attempts to combine business models with the Internet of Things. Gassmann et al. studied more than 300 companies citing 55 commonly occurring business models [44]. Building upon this great effort, Fleisch et al. point to 20 of these 55 business models as having high potential, especially in the Internet of Things applications [45]. In a further analysis, Weinberger et al. point to six critical attributes common within these 20 major business models [46]. These are "(1) Digital Add-On, (2) Digital Lock-In, (3) Product as a Point of Sales, (4) Physical Freemium, (5) Object Self Service, and (6) Remote Usage and Condition Monitoring". "Digital Add-On" refers to after-sales services offered to augment the user experience. "Digital Lock-In" refers to the exclusive use of original parts, equipment, and software. All other substitutes will be redeemed as incompatible. "Product as a Point of Sales" refers to using physical products as a sales platform. "Physical Freemium" refers to bundling the physical product together with free digital services. "Object Self Service" refers to machines re-ordering instead of human beings. "Remote Usage and Condition Monitoring" refers to smart solutions reporting real-time data to companies [46].

3.3.2. Cluster 2: Business Model Innovation

"Business model innovation describes the efforts made by the business in finding new business logic or new ways of value creation" [47] (p. 1175). In this regard, Business Model Innovation is integral to new product development activities [48]. To create value in the Internet of Things era, companies must be innovating in their business models while taking technology into careful consideration [49]. This is due to the fact that almost

every industry is expected to be affected significantly by the applications associated with the Internet of Things [50]. Tesch et al. claim that the two major generic approaches to business model innovation occur as either the technology push perspective or the market pull perspective [51]. Companies try to impose newly generated innovation into the market in the technology push. In contrast, in the market pull approach, the market expectations and demand dynamics play significant roles in determining how the company allocates its resources to address these potential opportunity areas. In this regard, Chesbrough and Rosenbloom argue that technological changes constitute critical factors in determining business model innovations in this new era [52]. Markides suggests that Business Model Innovation is a comprehensive construct on its own in that it includes different aspects [53]. One of these aspects is extending the current business model. Here, the company is tapping into the previously untapped territory through more extensive use of technology. There are also reconfiguration and modification efforts that try to utilize a practical application or a version of the existing business model. Then, there is the disruptive approach whereby companies turn their strategy into a game changer.

Del Sarto et al. provide an alternative interpretation of the business model Canvas framework in their study [54]. They assert that ad-hoc business models are required and that companies need to concentrate on different dimensions to succeed in this new paradigm. Their point of view seems to emphasize that the original and unique architecture of the Internet of Things enables companies to take advantage of opportunities [54].

Russo et al. suggest that the Internet of Things can activate innovation processes across all sectors. In that regard, the potential of the Internet of Things is quite real and ever-changing in its nature [55]. They claim that not all regions have this potential in the same way. They assert that the various competencies needed to provide effective solutions through the Internet of Things are provided by many distinct companies [55]. Thus, a truly effective business model that exploits the Internet of Things must be based on a company's unique resources. Foltean et al. argue that a significant success factor for technology companies is their Business Model Innovation. Their study shows that the strategic aspects of Business Model Innovation are "proactive market orientation, technology orientation, entrepreneurial orientation, and adaptive marketing capabilities" [56]. All these factors share one common theme—strong adaptation. To achieve competitive advantage and customer satisfaction, companies need to show a robust adaptive nature in their business model.

Shammar et al. emphasize that the Internet of Things will be very different in nature compared to the Internet that we use now, even though it will utilize similar systems, RFID, internet protocols, and WSN [57]. The reason for this is that the Internet of Things will greatly impact how human beings and objects interact at any time [57]. Wang focuses on how distance education will be affected by the Internet of Things. The author suggests that, with an effective business model, the Internet of Things may significantly affect distance education [58]. Furthermore, the author claims that resources can be saved, advances in business systems can be promoted, and more widespread resources in the education industry can be maintained in this way [58]. On the other hand, in the energy industry, smart energy products can have significant positive effects on human lives by providing better value to customers [59].

3.3.3. Cluster 3: Technology Infrastructure

Chauhan et al. suggest that the circular economy bears the true potential of exploiting emerging technologies such as artificial intelligence, the Internet of Things, Big Data, etc. [60]. Dijkman et al. claim that the Internet of Things is crucial in the future of energy, healthcare, and manufacturing, and emphasize the eminent need to create new business models [3]. In other words, Business Model Innovation and improved ways of doing business seem to be the critical factors in capitalizing on this particular transition era [61]. Figueredo et al. assert that the true potential of the Internet of Things can be realized when deploying a marketplace framework instead of concentrating on single-purpose

uses. They emphasize how such applications may be effectively used in smart cities and transport systems [62].

Paiola et al. emphasize servitization and its impact on the effective use of these new emerging technologies. Their multiple-case study addresses the interaction between servitization and sustainability [63]. Paiola et al. suggest three levels of servitization in the digital era. These are progressive levels; namely, product-oriented, process-oriented, and outcome-oriented levels [64]. Having studied 32 case studies of major international corporations which are true business model innovators, Weking et al. conceptualize three super-patterns [65]. These super-patterns, which are the overriding business model frameworks in the Industry 4.0, are (1) integration, (2) servitization, and (3) expertization [65]. Integration brings together more parts of the value chain. This pattern is more process-focused and aims to create synergies rather than new products. In servitization, a more product-focused business model, new products, and service offerings are aimed for based on the data gathered. In expertization, which is a hybrid business model, companies utilize their in-house expertise and offer it as a consulting service or a new viable platform.

Han et al. propose a product-as-service model by asserting that new methods in the business models will be essential in the fourth industrial revolution. They claim that servitization can be effective in the circular economy era as more smart connected products make more meaningful everyday use of the Internet of Things. They suggest that, in this new era, cost and convenience will be differentiating factors in the effectiveness of the new business models [66].

Bujari et al. set out four structural layers that constitute the architecture of the Internet of Things. The first layer is the "objects" level [66]. The objects are sensors that measure, check, or perceive external inputs through actuators that effectuate electrical, hydraulic, pneumatic, or mechanical movements. These objects connect and communicate at the second layer through data link protocols such as WiFi, Ethernet, "Near Field Communication (NFC) technology", or "Radio-Frequency Identification (RFID)" [66]. The third layer is the Platform layer of the IoT. For example, the platform layer connects the hardware of the IoT device to the cloud by using multi-layer technology and broad data-processing powers. The fourth layer, the performance layer, is where connected devices manage traffic, control health, manage waste, monitor water, or enable smart payment.

In other words, even though the Internet of Things has so much potential to offer to both consumers and companies at large, the architecture alone does not guarantee the rightful and ethical utilization of data. On the one hand, for example, it may be wonderful to know that, through the Internet of Things, your alarm clock will communicate with your traffic data, traffic lights, and other features regarding your regular morning commute and do the "needful" to adjust the exact time that the alarm will start beeping. On the other hand, all these smart devices possess a very high degree of pervasive presence throughout our lives.

Atif et al. argue, in their systematic literature review of 139 studies, that "adopting Industry 4.0 technologies to the business and manufacturing model enables sustainability, energy, and resource efficiency while enhancing performance and offering innovative products through smart services" [67] (p. 1). Therefore, they suggest that companies should systematically adopt Industry 4.0 technologies to support the circular economy. In this way, companies may create value through servitization [67].

3.3.4. Cluster 4: Digital Transformation and Capabilities

Agostini and Nosella, in their study, classified the current literature on digital technologies and business models into four main research streams [68]. These main research streams are "digital technologies and business model innovation, digital strategy and business models, digital platforms and business models, and the Internet of Things, servitization and business models" [68] (p. 1633).

Some studies tried to propose methods to integrate the existing literature. For example, Chang et al. considered digital finance innovation based on 296 studies. They classify

different types of digital innovation through the perspective of value creation [69]. Green et al. reviewed the literature on servitization [70]. They find divergence in the literature, some focusing on goods-dominant logic and the rest on service-dominant logic. Their two-tiered thematic analysis identifies five main areas of departure within the current literature; these are the "value-in-use, design of the servitized offering, value co-production and value co-creation, contextual variety and complexity, and business model of solutions and outcomes" [70] (p. 40). Coskun-Setirek and Tanrikulu propose a "process model for digital innovations-driven business model regeneration" [71]. Niemimaa et al. assert that business models are "vulnerable to various contingencies in the business environment that may unexpectedly render their business logic ineffective" [72] (p. 208). So, to have a robust and reliable model, they suggest an approach "which consists of two parts: (1) sustaining the continuity of the company business model (value preservation) and (2) evaluating and modifying the business model (value creation)" [72] (p. 208).

In their study of 76 German manufacturing firms, Kiel et al. show that offers drive business model changes [73]. The company mainly reflects these offers through product and process optimizations based on customer input. In that way, any update or modification is an outcome of an iterative and dynamic process [73]. Muller et al. studied 221 German companies [74]. Their research reveals that knowledge management directly impacts how companies can take advantage of innovation strategies. Their findings show that absorptive capacity affects the redesigning of business models [74].

In an industry-specific study, Athanasopoulou et al. argue that, in the automotive industry, four major factors seem to have the most significant effect on business models [75]. These are "(1) personalized services, (2) generic mobility services (3) shared mobility, and (4) connected cars" [75]. They suggest that possible blueprints for future strategies need to rely on considering such critical factors [75]. In their study of 500 global Information and Communication Technology companies, Naveed et al. assert that capabilities such as transforming from a software focus to a more network focus, merging network competencies with those associated with brick- and mortar-type businesses, and moving from a commodity focus to a more culture focus helps to transform strategies and provide more value [76]. In another industry-specific study, Guijarro et al. suggest that subsidizing users' subscriptions or the developers' registrations in the mobile app platforms may help improve the value that the business models on such platforms offer [77]. Simsek et al. assert that digital innovations and transformations in business models are mandatory to be successful in digital platforms. Their research on a real-life business case at a global-tech company reveals the importance of not only technical aspects but also the role of transformational leadership in making such shifts in how business is carried out a true success [78]. Another industry-specific study shows that the supply chain logistics industry has experienced new and essential changes [79]. Operational efficiency in this particular industry is expected to be heavily and positively affected by integrating these new emerging technologies. Therefore, this study argues that the Internet of Things is not just a significant factor but also an inevitable requirement for developing smart logistics.

3.3.5. Final Remarks: Implications, Limitations, and Future Research Directions

This study depended on the VOS viewer software results in a co-occurrence network outcome. Based on the four major clusters which emerged as a consequence of this research and the depictions of the co-occurrence network in Figure 4, specific themes mark the important highlights of the future research trends of the Internet of Things [80]. Co-occurrence networks also signify the relationships and associations between the articles in the same research domain [19,20]. Moreover, co-occurrences emphasize and highlight the key terms in the text corpus to show the graphic visualization of the importance of relations in the dataset [21]. In this particular study, the co-occurrence network provides extra insightful outcomes by pairing data related to the article collection and by analyzing the text. More significant relations are displayed visually which enabled further analyses and discussions.

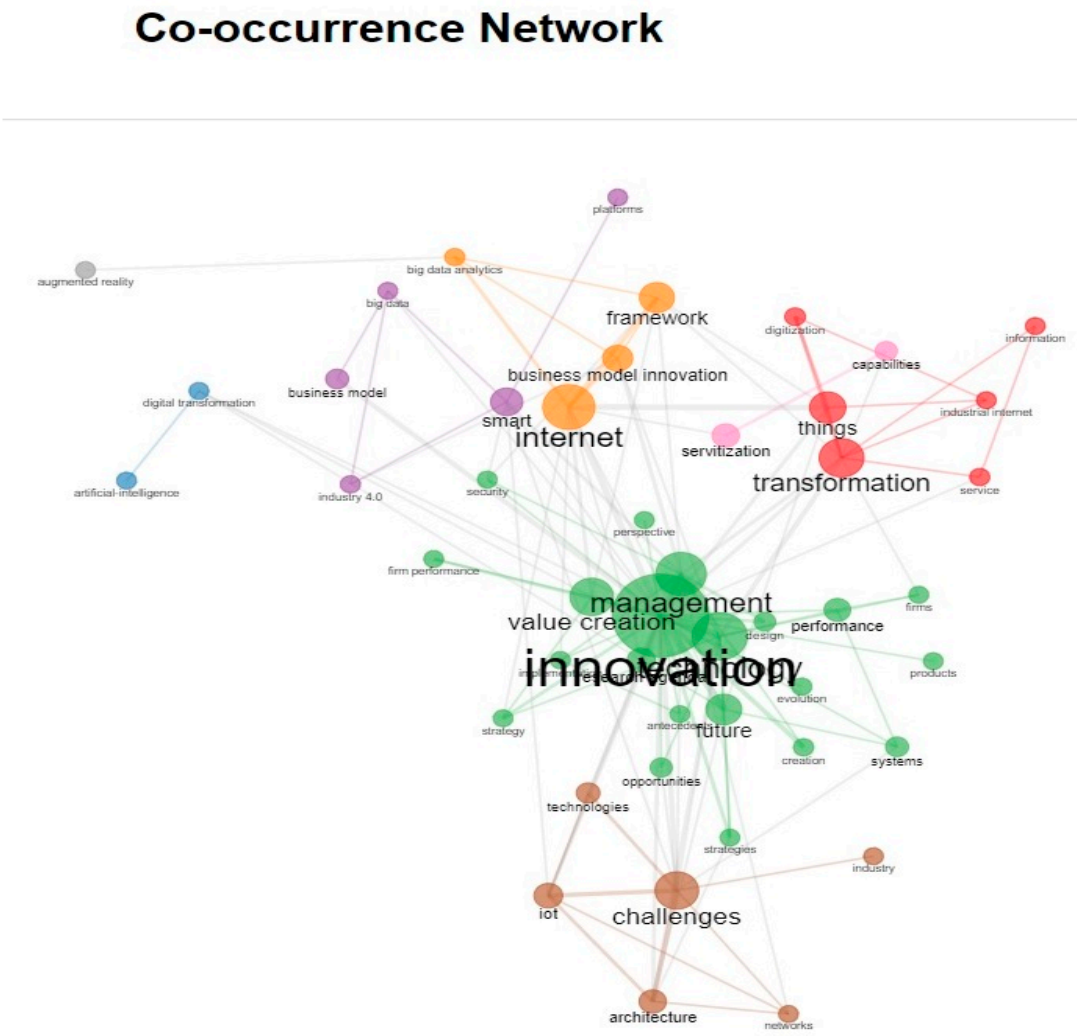

Figure 4. Co-occurrence network.

As depicted by Figure 4 above, several factors emerge. First, the Internet of Things appears to have a direct and significant impact on Business Model Innovation, technology utilization, and digital transformations and capabilities [81]. The Internet of Things enables new realms in each change cluster, accelerates change, and provides new directions for cutting-edge applications. Second, there seems to be an immense amount of co-creations from the fact that the Internet of Things allows instant access to information and interactions based on its real-time nature. This makes real-time data usage a top priority in future products and services like servitization [66]. Another vital point in this regard is value creation, which appears to be a major critical success factor in future businesses and business models [82]. Third, the architecture of the Internet of Things emerges as a major point of interest that integrates value creation, value design, and value proposal. With a more effective system architecture, the companies of the future may create a more distinct, exquisite, and sustainable edge over their competitors [83]. Firm performance can be enhanced by the effectiveness of the business model and its innovative capability. Fourth, digital transformation possesses relentless opportunities in and of itself since it is a never-ending paradigm reshaping itself as it advances [84]. Services in this new smart era are to be direct products of Big Data analyses, and this is expected to reshape industries as each industry will be affected by a varying degree of change in this evolution.

Furthermore, an inevitable perspective is the inherent challenges that these clusters entail regarding all that they offer [85]. At each step, human interaction and effective design capabilities will play crucial roles in shaping strategies for better use and fit [82]. Also,

each challenge will carry with itself further opportunities (untapped otherwise) if exploited well and effectively. An undeniable challenge for all new changes will undoubtedly be the increased ease in imitability in this new era. Imitating methods, products, services, business models, and innovations will naturally be more accessible than ever, given that the competitors have matching capabilities in conjunction with the pioneering companies [69]. A sure way to overcome such a robust challenge naturally lies in the continuous pursuit of new forms of delivering better value [86]. Only a non-stop innovating entity will be safe from imitating competitors in this new era of everything being connected to everything else in a real-time fashion [87]. Thus, digital transformation and deploying better ways of utilizing the Internet of Things may indeed be sources of competitiveness if they offer more enduring values of great distinction in light of all possible opportunities [88].

Analyses show that the Internet of Things has several strengths and opportunities for businesses and society at large. Endless applications and practices are revealed as a result of connecting all the devices of a network in real time. This also provides benefits in terms of cost reduction, efficiency, and effectiveness in business processes. With the help of the technological advancements in all devices and analytical capabilities, the Internet of Things reshapes and redefines the business environment by providing best-value propositions to the stakeholders.

Despite the contributions to the Internet of Things research field in relation to Business Model Innovation, several limitations could be found in the nature of research work. The Internet of Things and Business Model Innovation domains are relatively recent subjects for the combined research area; most articles have been published since 2015. In addition, there is a lack of empirical evidence and a systematic review of the current knowledge domain from a state-of-the-art perspective. First, the bibliometric approach supports the minimization of subjectivity in the review process. We focused on conducting a non-biased review. However, this would not be completely free of limitations to keep out of subjectivity to some degree. Second, although our study is comprehensive, we utilized the WoS Core Collection database to search relevant keywords and conducted the analyses based on Co-word (keyword co-occurrences) and Thematic Content Analysis (clustering the publication dataset). Therefore, we depended on the software results in a co-occurrence network. Third, the paper concentrates on discovering the topics' relations and trends rather than the bibliometrics' descriptive style. Further studies would focus more on the country's performance, author, institutions, citation/co-citation patterns, and other perspectives. Fourth, articles in languages other than English were not included. Finally, the bibliometric study does not present and test the significant statistical relevance. In addition, some constraints could be found that would impact any quantitative studies.

The research domains are prominent, and since 2016, there has been an upward trend in publication records, suggesting that interest in them is expanding. As previously discussed, the word dynamics shows the trends and potential research areas to be continued in further studies. The main themes, as illustrated in Table 1, and Figures 1 and 2, are the popular research themes "internet of things (IoT)", "innovation", "model/models" "business model innovation", "industry 4.0", and "digitalization". The new research directions could focus more on content-specific themes with various research approaches such as reviews (state-of-the-art, systematic literature review), empirical studies, industry-related cases, and comparison studies. Since technology advances in more of a digital context, the opportunities available for scholarly publications are within those themes.

4. Conclusions

This study aimed to discover the scientific trends and performances of research domains—namely, The Internet of Things regarding of Business Model Innovation—in scholarly publications. The study has two main research questions: "the most influential keywords and word dynamics to show the trends in the knowledge domains" and "the main themes–topics and clusters which emerge in the current intellectual structure". Although the number of papers on "The Internet of Things regarding Business Model

Innovation" was relatively low and the publication record started in 2015, there has been an overall increase in this research domain in recent years. The analysis included 71 articles published between 2015 and 2022.

First, we conducted a co-word (text and keyword) analysis of the literature, which displayed the primary keywords of the Internet of Things regarding Business Model Innovation. The results showed that word clouds highlight the essential keywords (Keyword Plus and Author's Keywords) along with word dynamics to show the trends in the frequently used terms in the corpus of the dataset search. Co-word (text) analysis showed that the most common vital terms overall were Keyword Plus (ID) (n = 258) and Author's Keywords (DE) (n = 293). The most frequent Author's Keywords included "internet of things (IoT)", "business model/models", "industry 4.0", "business model innovation", "digital transformation", and "digitalization". In addition, the most frequent Keyword Plus terms included "innovation", "internet", "technology", "challenges", "management", and "value creation".

Second, we conducted cluster analysis for thematic content recognition. Four main clusters were identified with the help of the VOS viewer software to diagnose the co-occurrence network. Those clusters are titled "the Internet of things (IoT)", "business model innovation", "technology infrastructure", and "digital transformation and capabilities" after carefully reading all publication sets. Sub-terms under each primary cluster node were discussed in detail to highlight the themes and topics. This helped to map scientific relations and patterns of domains.

With this study, we aimed to explore publishing trends to give insights and research paths for academics, practitioners, and readers who aspire to work in these fields in the future. The data highlight the significance of further explorations to improve understanding and relations.

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