future internet

Review

Internet of Things and Distributed Computing Systems in Business Models

Albérico Travassos Rosário [1,*] and Ricardo Raimundo [2,3]

[1] The Research Unit on Governance, Competitiveness and Public Policies (GOVCOPP), Universidade Europeia, 1200-649 Lisbon, Portugal
[2] ISEC Lisboa, Instituto Superior de Educação e Ciências (Superior Lisbon Institute of Education and Sciences), 1750-142 Lisbon, Portugal; ricardo.raimundo@iseclisboa.pt
[3] IADE-Faculdade de Design, Tecnologia e Comunicação, Universidade Europeia, 1200-649 Lisbon, Portugal
* Correspondence: alberico@ua.pt

Abstract: The integration of the Internet of Things (IoT) and Distributed Computing Systems (DCS) is transforming business models across industries. IoT devices allow immediate monitoring of equipment and processes, mitigating lost time and enhancing efficiency. In this case, manufacturing companies use IoT sensors to monitor machinery, predict failures, and schedule maintenance. Also, automation via IoT reduces manual intervention, resulting in boosted productivity in smart factories and automated supply chains. IoT devices generate this vast amount of data, which businesses analyze to gain insights into customer behavior, operational inefficiencies, and market trends. In turn, Distributed Computing Systems process this data, providing actionable insights and enabling advanced analytics and machine learning for future trend predictions. While, IoT facilitates personalized products and services by collecting data on customer preferences and usage patterns, enhancing satisfaction and loyalty, IoT devices support new customer interactions, like wearable health devices, and enable subscription-based and pay-per-use models in transportation and utilities. Conversely, real-time monitoring enhances security, as distributed systems quickly respond to threats, ensuring operational safety. It also aids regulatory compliance by providing accurate operational data. In this way, this study, through a Bibliometric Literature Review (LRSB) of 91 screened pieces of literature, aims at ascertaining to what extent the aforementioned capacities, overall, enhance business models, in terms of efficiency and effectiveness. The study concludes that those systems altogether leverage businesses, promoting competitive edge, continuous innovation, and adaptability to market dynamics. In particular, overall, the integration of both IoT and Distributed Systems in business models augments its numerous advantages: it develops smart infrastructures e.g., smart grids; edge computing that allows data processing closer to the data source e.g., autonomous vehicles; predictive analytics, by helping businesses anticipate issues e.g., to foresee equipment failures; personalized services e.g., through e-commerce platforms of personalized recommendations to users; enhanced security, while reducing the risk of centralized attacks e.g., blockchain technology, in how IoT and Distributed Computing Systems altogether impact business models. Future research avenues are suggested.

Keywords: internet of things; distributed computer systems; business

check for updates

Citation: Rosário, A.T.; Raimundo, R. Internet of Things and Distributed Computing Systems in Business Models. *Future Internet* **2024**, *16*, 384. https://doi.org/10.3390/fi16100384

Academic Editor: Luis Javier Garcia Villalba

Received: 1 September 2024
Revised: 17 October 2024
Accepted: 18 October 2024
Published: 21 October 2024

1. Introduction

The advent of the Internet of Things (IoT) and Distributed Computing Systems has ushered in a transformative era in business models across various industries. These innovations have redefined the technological environment and fundamentally altered how businesses operate, compete, and deliver customer value [1]. The convergence of IoT and Distributed Computing Systems catalyzes a shift from traditional, centralized business frameworks to more agile, decentralized, and data-driven models. This transformation is driven by the need for enhanced efficiency, real-time decision-making, and a greater emphasis on customer-centric approaches. Dijkman et al. [2] define IoT as the interconnected network of physical devices embedded with sensors, software, and other technologies. This innovation enables these devices to collect and exchange data. In addition, the vast network of connected devices generates an unprecedented volume of data, providing businesses with valuable insights into consumer behavior, operational efficiency, and market trends. The ability to monitor, analyze, and act upon real-time data has become a crucial part of modern business strategies. It enables companies to optimize processes, reduce costs, and enhance customer experience.

Simultaneously, Distributed Computing Systems have further revolutionized business operations. According to Ageed et al. [3], these innovations encompass a range of technologies, including cloud computing, edge computing, and blockchain. These systems distribute computing resources across multiple locations rather than relying on a single centralized server [4]. This decentralization enhances system resilience, reduces latency, and facilitates more efficient resource utilization. Cloud computing, in particular, has democratized access to powerful computing resources, enabling businesses of all sizes to leverage advanced technologies without significant upfront investments.

The integration of IoT and Distributed Computing Systems has significantly impacted business models. Traditional businesses, which often relied on hierarchical and linear processes, are now evolving into more dynamic and interconnected entities. The ability to leverage real-time data through IoT devices allows businesses to monitor operations continuously, making adjustments on the fly to optimize performance [5]. Predictive analytics, powered by data from IoT sensors, enable companies to anticipate issues before they occur, reducing downtime and increasing efficiency. Moreover, Distributed Computing Systems facilitate greater flexibility and scalability in business operations. Alamouti et al. [4] explain that decentralized computing resources ensure companies to quickly adapt to changing demands and scale their operations efficiently. Blockchain technology enhances security and transparency, fostering trust and enabling new collaboration and transactions without traditional intermediaries [6]. These technological advancements also support the creation of personalized customer experiences. Analyzing data from various perspectives allows businesses to gain deeper insights into customer preferences and behavior, allowing for more targeted marketing and tailored product offerings. This customer-centric approach enhances satisfaction, builds loyalty, and drives growth.

IoT and DCS have been subject to various criticisms, ranging from technical limitations to economic and social concerns, such as increasing vulnerabilities to cyber attacks, compatibility and interoperability challenges between devices, overwhelming data volume that poses challenges in data processing and storing, high costs of maintenance, and job displacement in sectors like manufacturing [1]. Despite this criticism, the advantages of those systems for business models are overwhelming. To what extent do the Internet of Things and other Distributed Computing Systems enhance business models? This research question guides this piece of literature over the intended literature review.

This literature review begins with an introductory section that outlines the key concepts, the central problem, and the research question driving the investigation. The next section presents the methodology used to guide and support the review. This is followed by a theoretical framework that underpins the knowledge base for the study. A discussion section then explores how the integration of IoT and Distributed Computing Systems (DCS) influences business operations. Finally, the review concludes with a summary of findings and suggestions for future research directions.

2. Materials and Methods

This research employs the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 framework to conduct a systematic bibliometric literature review (LRSB) on the impact of the Internet of Things (IoT) and Distributed Computing Systems on business models. The PRISMA framework is a widely recognized methodology that ensures transparency, thoroughness, and reproducibility in systematic reviews. While the PRISMA methodology has been subject to some criticism in terms of emphasizing the reporting rigor of quantitative data syntheses rather than the conduct of research throughout the nuances of qualitative synthesis, we tried to mitigate this sort of strictness formulaic reporting by extending new methods, in particular the LRSB. It thus allows providing flexible and deeper insight and reducing the bias, whilst maintaining transparency, quality, and standardization of this systematic review [7]. Furthermore, methods, data sources, and selection criteria are clearly stated to understand the path towards conclusion. Finally, this study in its uniformity and robustness, from initial identification to final inclusion, could also be available for others to replicate the findings over time [7,8].

The researchers utilized the LRSB methodology to spot important fonts and make new insights, contrasting with conventional literature review methods. By resorting to LRSB it allows to enhance a scientific and also scalable and crystal-clear method built to mitigate partiality by unveiling relevant literature to the issue [9–11]. The authors also manage to ensure a coherent narrative aiming at tracing the stream of studies the article is based upon, as well as the ensuing methodologies. The LRSB method relies upon a path of both showing and collecting data sources to ensure the consistency and exactness of data. This methodology is separated into three stages and is made up of six steps overall [9–11] (Table 1).

Table 1. Steps of LRSB.

Fase	Step	Explanation
Exploration	Step 1	Stating the research problem
	Step 2	Directing a search for pertinent literature
	Step 3	Critically assessing the selected studies
	Step 4	Synthesizing data from individual sources
Interpretation	Step 5	Reporting findings and ensuing recommendations
Communication	Step 6	LRSB reporting

Source: Adapted from Rosário and Dias [9,11].

The authors therefore used the Scopus database to ascertain reliable fonts that are well-regarded in the scientific and academic communities. However, the restricted reliance on Scopus ends up hindering the study, due to some likelihood of omitting important databases. The literature search should, therefore, aim at an exhaustive inclusion and comprehend peer-reviewed publications up to August 2024.

The search starts thus with the key choice of the Scopus database. The initial examination process (Table 2) was carried out through Scopus, acknowledged for its wide reporting of peer-reviewed literature. The procedure then advanced through several stages. First, a broad search identified 206,901 documents based on the keywords “internet of thing”. This was refined by including the exact keyword “distributed computer systems”, which reduced the results to 2926 documents. Finally, limiting the search to the subject area “Business” narrowed the results to 91 documents. The titles and abstracts of these 91 documents were reviewed for relevance to the research topic.

The full-text articles were obtained and evaluated according to the well-known inclusion and exclusion criteria. The inclusion criteria required articles to address the impact of IoT and Distributed Computing Systems on business models, be peer-reviewed, and be published in the subject area “Business”. Articles not written in English, inaccessible through the Scopus database, or identified as duplicates were excluded from the review. This thorough screening process resulted in a final selection of 91 documents that met all criteria and were included in the systematic review (n = 91).

Table 2. Screening methodology.

Scopus Database	Screening	Publications
Initial Query	Keywords: internet of thing	206,901
First Screening	Keywords: internet of thing Add the exact keyword: distributed computer systems	2926
Eligibility criteria	Keywords: internet of thing Add the exact keyword: distributed computer systems Limited: Business	91
Final screening	Keywords: internet of thing Add the exact keyword: distributed computer systems Limited: only publications up to August 2024	

Source: Adapted from Rosário and Dias [9,11].

In order to explore, analyze, and report the identified studies and ensuing findings, the authors resorted to a method of content thematic analysis which consists of, according to Rosário and Dias, gaining conceptual meaning from data by spotting general and repetitive patterns or themes within the context of emerging studies. Correspondingly, Rosário et al. [11] posit that a review based upon themes from past research feeds the current research problem by emphasizing the studied paradigm and research problem. This method turns out assembling the research insights around major themes.

As recommended by Rosário and Dias [9,10], the aforementioned methodology was strictly followed to process the ensuing pieces of literature. The analysis included 91 documents indexed in Scopus, directly related to the research question, which embrace the aimed content analysis, allowing to over enhance and isolate common themes (Figure 1).

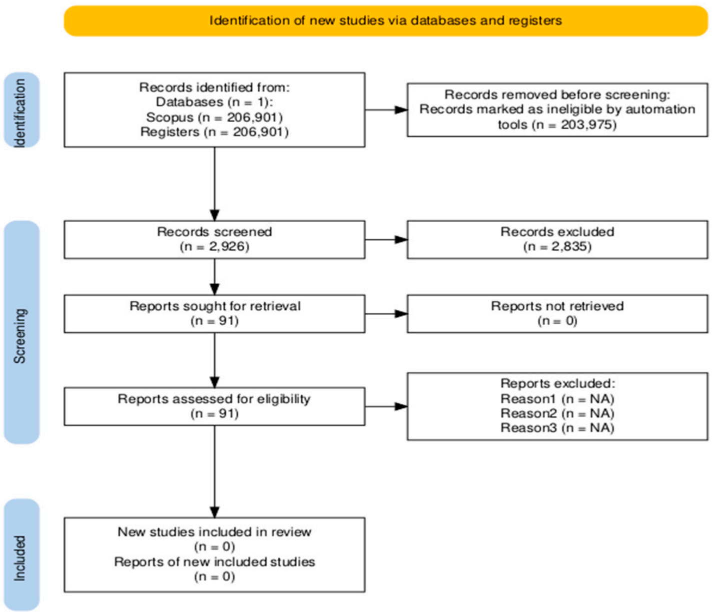

Figure 1. PRISMA 2020 flow diagram of the literature search and screening process [7,8].

The PRISMA 2020 guidelines ensure the reliability and robustness of systematic reviews. These guidelines provide specifications and a path to assist researchers in reporting their systematic reviews clearly and comprehensively. This effort is essential to ensure that scientific evidence is strong, thus promoting further scientific research [7,8].

In the vein of Rosário and Dias [9,11], analysis was performed through the already mentioned content analysis methods to categorize the various documents [9,11]. The 91 documents were addressed by both narrative and bibliometric approaches to delve into the recurrent themes that emerged from the research question [9–11]. Among the elected documents, 53 were conference papers, 34 were articles, two were books, and two were book chapters.

3. Publication Distribution

Internet of Things and Distributed Computing Systems in Business Models were addressed up to August 2024. 2018 topped the number of publications reviewed by peers with as many as 24 publications. As seen below (Figure 2), the relevant literature up to August 2024 is displayed.

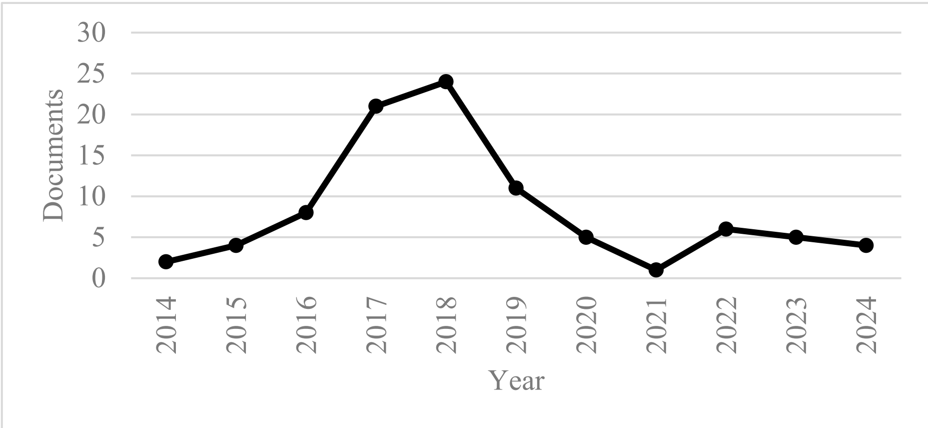

Figure 2. Documents by year. Source: Scopus platform output.

The papers were ordered in the following manner: Proceedings from the 19th IEEE International Conference On Computational Science And Engineering 14th IEEE International Conference On Embedded And Ubiquitous Computing And 15th International Symposium On Distributed Computing And Applications To Business Engineering And Science Cse Euc Dcabes 2016 8 (6); Lecture Notes In Business Information Processing (5); IEEE Transactions On Engineering Management (4); the Proceedings 2018 IEEE from the 27th International Conference on Enabling Technologies Infrastructure For Collaborative Enterprises Wetice 2018 (2); Proceedings 2017 5th International Conference On Enterprise Systems Industrial Digitalization By Enterprise Systems Es 2017; Proceedings 14th International Symposium On Distributed Computing And Applications For Business Engineering And Science Dcabes 2015; Knowledge Based Systems; Journal Of Network And Systems Management; Journal Of Cleaner Production; International Journal Of Production Research; International Journal Of Information Management; IEEE Potentials; IEEE International Conference On Industrial Engineering And Engineering Management; and Benchcouncil Transactions On Benchmarks Standards And Evaluations). The last publication presents the residual outcome of one document.

Similarly, Figure 3 shows the geographical representation of the literature on the subject. China, the United States, Indian subcontinent, and Germany topped with regard to significant literature in the area, compared with other regions.

On the other hand, Table 3 together with Figure 3 gathers the key scientific contributors in terms of countries for the theme. Note that the figure below displays the publications by geographic region, irrespective of their varying co-authors' nationalities, which implies that the number of citations by authors might mismatch the number of ensuing regional publications. This study intends to identify geographies that underline technology in terms of IoT, for instance with respect to tourism.

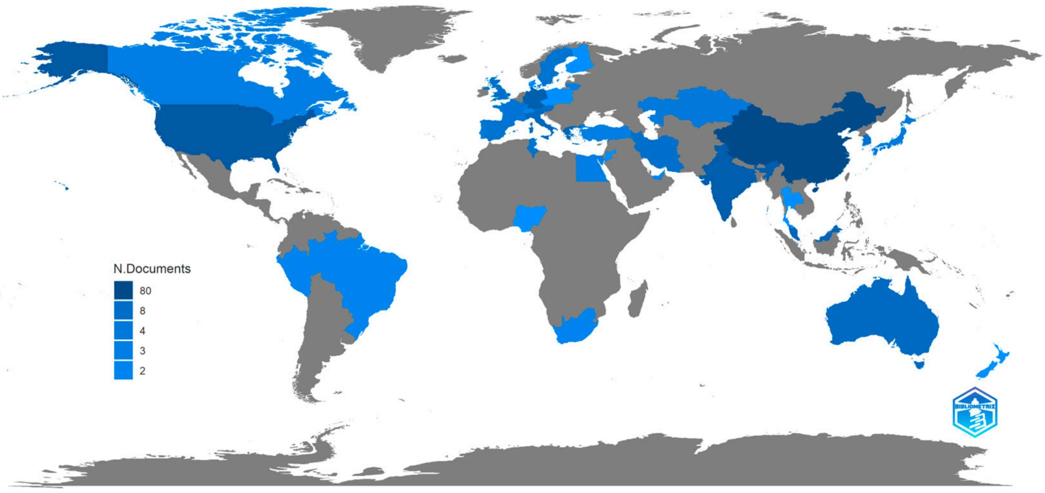

Figure 3. Literature by Geography.

Table 3. Countries that present more publications.

Country	Number of Publications
China	80
USA	35
India	24
Germany	22
Greece	15
Malaysia	14
Italy	12
Australia	10
Austria	8
Iran	7

Source: Own elaboration upon Scopus display.

In Table 4, we examine the Scimago Journal & Country Rank (SJR), best quartile, and H-index for the journal* Technological Forecasting and Social Change*, which has an SJR of 5.780, a Q1 quartile ranking, and an H-index of 177. Among the 68 publication titles, 13 fall into Q1, seven into Q2, one into Q3, and three into Q4. Publications in the top quartile, Q1, represent 19% of the total, while Q2 accounts for 10%, Q3 for 1%, and Q4 for 4%. Additionally, 44 publications, or 65% of the total, do not have indexing data. As shown in Table 4, most publications are categorized in the Q1 quartile.

Table 4. Process of systematic LRSB.

Title	SJR	Best Quartile	H-Index
International Journal of Information Management	5.780	Q1	177
IEEE Communications Standards Magazine	2.740	Q1	36
International Journal of Production Research	2.670	Q1	186
Knowledge-Based Systems	2.220	Q1	169
Transportation Research Part A Policy and Practice	2.180	Q1	167
Journal of Cleaner Production	2.060	Q1	309
Electronic Commerce Research and Applications	1.340	Q1	101
Industrial Management and Data Systems	1.210	Q1	125
IEEE Transactions on Engineering Management	1.200	Q1	112

Table 4. *Cont.*

Title	SJR	Best Quartile	H-Index
Journal of Network and Systems Management	1.040	Q1	40
TQM Journal	0.940	Q1	79
Engineering Construction and Architectural Management	0.900	Q1	73
Big Data and Cognitive Computing	0.820	Q2	33
Journal of High Technology Management Research	0.720	Q2	55
Electricity Journal	0.710	Q1	58
Service-Oriented Computing and Applications	0.560	Q2	31
Journal of Organizational and End User Computing	0.490	Q2	46
International Journal of Crowd Science	0.380	Q2	15
Engineering Management in Production and Services	0.380	Q2	21
ZWF Zeitschrift Fuer Wirtschaftlichen Fabrikbetrieb	0.350	Q2	18
Lecture Notes in Business Information Processing	0.340	Q3	63
IEEE Potentials	0.170	Q4	39
International Journal of Product Development	0.120	Q4	30
Paper Asia	0.110	Q4	6
Proceedings 19th IEEE International Conference on Computational Science and Engineering 14th IEEE International Conference on Embedded and Ubiquitous Computing and 15th International Symposium on Distributed Computing and Applications to Business Engineering and Science Cse Euc Dcabes 2016	0	- *	11
Proceedings 2018 IEEE 27th International Conference on Enabling Technologies Infrastructure for Collaborative Enterprises Wetice 2018	0	- *	6
Proceedings 2017 5th International Conference on Enterprise Systems Industrial Digitalization by Enterprise Systems Es 2017	0	- *	8
Proceedings 14th International Symposium on Distributed Computing and Applications For Business Engineering and Science Dcabes 2015	0	- *	8
IEEE International Conference on Industrial Engineering and Engineering Management	0	- *	27
Wit Transactions on Information and Communications Technologies	0	- *	14
Rtsi 2017 IEEE 3rd International Forum on Research and Technologies for Society and Industry Conference Proceedings	0	- *	13
Proceedings of The European Conference on E-Government Eceg	0	- *	16
Proceedings of the 2016 IEEE 20th International Conference on Computer Supported Cooperative Work in Design Cscwd 2016	0	- *	12
Proceedings of the 2015 IEEE 19th International Enterprise Distributed Object Computing Conference Workshops and Demonstrations Edocw 2015	0	- *	8
Proceedings 2021 International Conference on Management Science and Software Engineering Icmsse 2021	0	- *	6
Proceedings 2019 IEEE International Conference on Services Computing Scc 2019 Part of the 2019 IEEE World Congress on Services	0	- *	16
Proceedings 2019 4th International Conference on Internet of Things Smart Innovation and Usages Iot Siu 2019	0	- *	13
Proceedings 2018 Crypto Valley Conference on Blockchain Technology Cvcbt 2018	0	- *	13
Proceedings 2018 17th International Symposium on Distributed Computing and Applications for Business Engineering and Science Dcabes 2018	0	- *	6
Proceedings 2017 IEEE 19th Conference on Business Informatics CBI 2017	0	- *	17
Proceedings 2017 2nd International Workshop on Science of Smart City Operations and Platforms Engineering in Partnership with Global City Teams Challenge Scope 2017	0	- *	7
Proceedings 2016 IEEE 9th International Conference on Service-Oriented Computing and Applications Soca 2016	0	- *	5
Picmet 2019 Portland International Conference on Management of Engineering and Technology Management in The World of Intelligent Systems Proceedings	0	- *	12
International Conference on Logistics Engineering Management and Computer Science Lemcs 2014	0	- *	5

Table 4. *Cont.*

Title	SJR	Best Quartile	H-Index
Ictc 2019 10th International Conference on ICT Convergence Leading the Autonomous Future	0	- *	12
Conference Proceedings of the 6th International Symposium on Project Management Ispm 2018	0	- *	2
Annual Conference on Innovation and Technology in Computer Science Education Iticse	0	- *	37
2018 IEEE International Conference on Engineering Technology and Innovation ICE Itmc 2018 Proceedings	0	- *	16
2017 IEEE Technology and Engineering Management Society Conference Temscon 2017	0	- *	9
2017 26th International Conference on Computer Communications and Networks ICCCN 2017	0	- *	22
2016 Management and Innovation Technology International Conference Miticon 2016	0	- *	6
10th IEEE Int Conf on Service Operations and Logistics and Informatics Soli 2015 in Conjunction with Ict4all 2015	0	- *	7
Benchcouncil Transactions on Benchmarks Standards and Evaluations	- *	- *	- *
Proceedings of the 32nd International Business Information Management Association Conference Ibima 2018 Vision 2020 Sustainable Economic Development and Application of Innovation Management from Regional Expansion to Global Growth	- *	- *	- *
Proceedings of the 2020 IEEE International Conference Quality Management Transport and Information Security Information Technologies IT and Qm and Is 2020	- *	- *	- *
Proceedings 2020 2nd International Conference on Applied Machine Learning Icaml 2020	- *	- *	- *
Proceedings 2017 IEEE 3rd International Conference on Collaboration and Internet Computing Cic 2017	- *	- *	- *
Joint 13th Ctte and 10th Cmi Conference on Internet of Things Business Models Users and Networks	- *	- *	- *
Fog Computing Concepts Frameworks and Technologies	- *	- *	- *
Crowdsourcing of Sensor Cloud Services	- *	- *	- *
6g Connectivity Systems Technologies and Applications Digitalization of New Technologies 6g And Evolution	- *	- *	- *
2024 2nd International Conference on Disruptive Technologies Icdt 2024	- *	- *	- *
2023 9th International Conference on Web Research Icwr 2023	- *	- *	- *
2022 International Conference on Data Analytics for Business and Industry Icdabi 2022	- *	- *	- *
2020 International Conference on Technology and Entrepreneurship Virtual Icte V 2020	- *	- *	- *
2018 7th International Conference on Industrial Technology and Management Icitm 2018	- *	- *	- *
18th Asia Pacific Network Operations and Management Symposium Apnoms 2016 Management of Softwarized Infrastructure Proceedings	- *	- *	- *
Proceedings of the 11th International Conference on Strategic Management and Its Support by Information Systems 2015 Smsis 2015	- *	- *	- *

* data not available. Source: Own elaboration.

The themes embraced by the 91 scientific and/or academic documents were as follows: Business, Management, and Accounting (91); Computer Science (65); Engineering (46); Decision Sciences (39); Mathematics (17); Social Sciences (12); Environmental Science (4); Energy (4); Economics, Econometrics, and Finance (4); Physics and Astronomy (2); Medicine (1); and lastly the reviews on Materials Science (1).

Leading the number of citations was the paper "Smart manufacturing", with 883 published Smart manufacturing 2670 (SJR), the best quartile (Q1), and H-index (186), while exploring the concepts of cyber-physical systems, driven by advancements in the IoT, AI, data science, and cloud service-oriented computing. Figure 4 demonstrates the changes in citations in terms of overall works available up to August 2024. The period from 2014 to 2024 displays a mounting increase in terms of citations, with an R^2 value of 66%, closing in 5249 citations by August 2024.

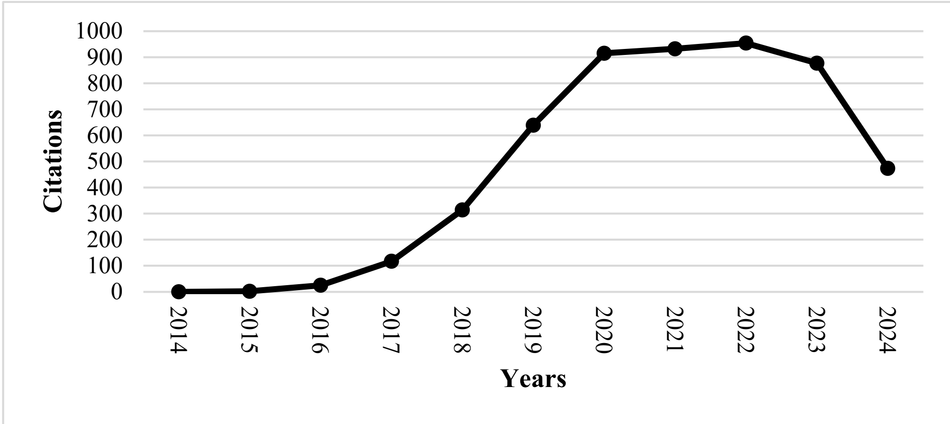

Figure 4. Trend in citations ranging from 2014 to 2024.

This study favored the h-index, which is a metric employed to ponder the effectiveness and soundness of publications by comparing the quantity of cited articles against the value of the index. Among the documents analyzed for the h-index, 28 were subject to ensuing 28 citations, as a minimum. From 2014 to August 2024, the total number of citations topped 5222. Out of the 91 documents, 15 remained uncited. By May 2024, self-citations accounted for 276 of the total citations (Appendix A). On the other hand, the chosen bibliometric method intends to emphasize patterns in terms of literature content over the review, particularly on key terms (Figure 5).

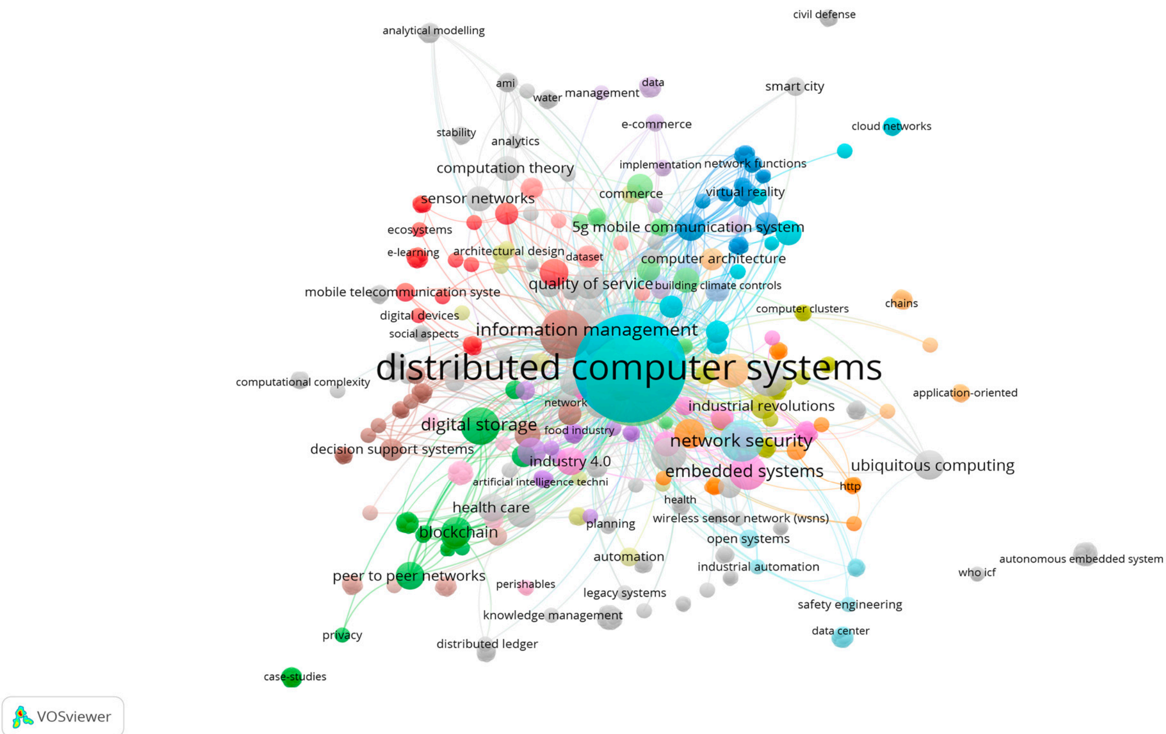

Figure 5. A web of keywords.

This visualization over enhances the majority of network nodules, in which its volume equals the ensuing occurrence of linked keywords, demonstrating its incidence. As well, the linkages between bulks correspond to keyword interplays and displays which keywords came up together, interrelated. The width of such linkages made up the repetitive occurrence of these interactions between keywords altogether.

In the depicted picture above, the distinct bulge size represents the weight of the ensuing keyword, intertwined with ensuing knots of different importance of correspondent keyword, whereas the boldness of the crossing net relates with the intensity of keyword co-occurrence. Likewise, different colors equal distinct thematic clusters, as well. The denser the network, the greater the number of topics in a theme.

This outcome was achieved by VOSviewer, which is an application tool employed to deliver a big picture with regard to varying issues interplay such as the aim of the study of "Internet of Things" and "Distributed Computing Systems in Business Models". Figure 6 illustrates the process, in which further avenues for research are ascertained.

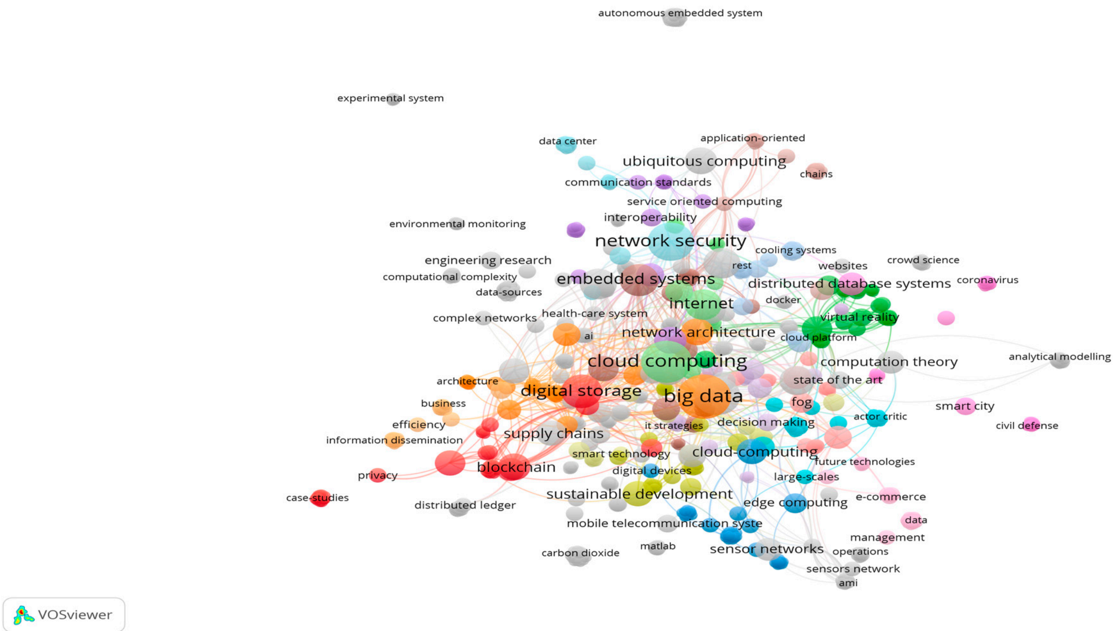

Figure 6. A Web of Related Keywords.

Finally, Figure 7, with regard to a bibliographic linkage, built upon the document scrutiny and gave rise to an overall examination of the intertwined co-citation process. This feature lets the readers ascertain trends inside the subjects of "Internet of Things" and "Distributed Computing Systems in Business Models" transversely to multiple papers.

Figure 7. A snapshot of co-citations.

In conclusion, the chosen methodology guaranteed accuracy and robustness for further research. Coherence, validity, and reliability of the new insights are thus guaranteed and discussed in greater detail below.

4. Theoretical Framework

The integration of the IoT and Distributed Computing Systems has catalyzed significant changes in contemporary business models. These technological advancements have introduced new levels of connectivity, efficiency, and capability in data analysis with regard to decision-making [12]. IoT enables immediate data collection and analysis, whereas Distributed Computing Systems enhance flexibility, scalability, and security. Together, these innovations facilitate the development of dynamic and customer-centric business strategies, transforming traditional operational frameworks and opening up new avenues for competitive advantage [13]. This literature review delves into the intersection of IoT and distributed computing within business models.

4.1. Internet of Things

IoT is about linking devices that interplay one to another mainly through the internet. The history of this innovation dates back to 1999 and was due to Kevin Ashton. He deemed it as "uniquely identifiable interoperable connected objects with radio-frequency identification (RFID) technology" [14] (p. 243). Nevertheless, this classification has continued to change as researchers and scientists strive to understand the concept and the innovations involved. For example, Rose et al. [15] (p. 7) depict it as "scenarios in which Internet connectivity and computing capability extend to a variety of objects, devices, sensors, and everyday items". Li et al. [14] (p. 243–244) found that it is also defined as a "dynamic global network infrastructure with self-configuring capabilities based on standards and interoperable communication protocols; physical and virtual 'things' in an IoT have identities and attributes and are capable of using intelligent interfaces and being integrated as an information network". Despite the different wording, these definitions all converge on the core idea that IoT encompasses a huge system of linked devices that interplay both with one another and with the environment, driven by advanced technologies and protocols to enhance automation, efficiency, and data exchange. Figure 8 shows the significant evolution of IoT and enabling technologies.

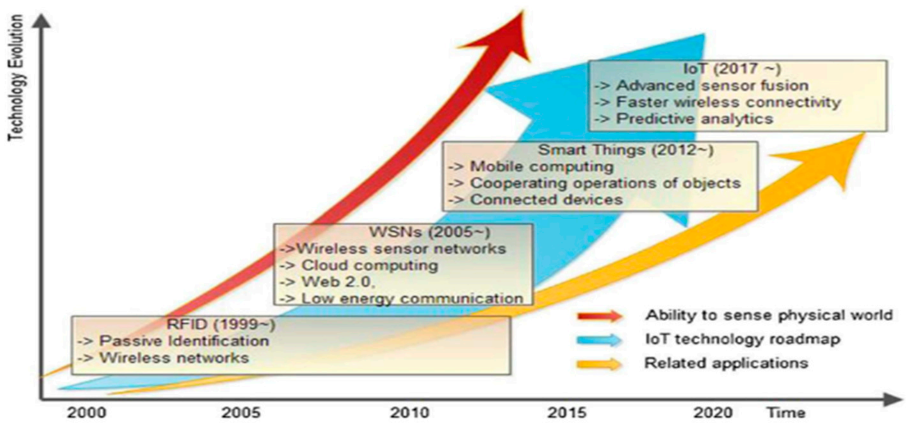

Figure 8. IoT evolution since 1999 [14].

IoT devices are often equipped with technology (e.g., sensors) that allows connecting to other devices and systems. The primary objective of IoT is to enable seamless connectivity and data exchange between objects, creating a smart environment where devices can autonomously make decisions or provide insights based on the data collected [16,17]. IoT comprehends varying devices, from daily products like smart thermostats and wearable fitness trackers to complex industrial systems such as smart manufacturing equipment and automated supply chains [18]. Each IoT device typically includes sensors that monitor environmental conditions or user interactions, processors that handle data processing, and communication nodes that allow data broadcast. The data gathered by these machines can include information on temperature, humidity, location, motion, and other variables relevant to their function.

The core of IoT lies in its ability to create a connected ecosystem where devices can work together to enhance functionality and efficiency. For example, IoT gadgets such as smart lighting machines, thermostats, and protection cameras may be interconnected in a smart home environment to provide a cohesive user experience [19]. These devices can be programmed to operate based on user preferences or environmental conditions, such as adjusting the thermostat when a user leaves the house or turning on lights as dusk approaches. In industrial settings, IoT enables advanced monitoring and automation by integrating sensors and devices within machinery and infrastructure [20,21]. This can significantly improve operational efficiency, predictive maintenance, and real-time analytics. For instance, sensors incorporated into manufacturing devices could keep up with performance data whilst identifying errors, enabling on-time rectification and mitigating the risk of failures [22]. This wide application of IoT innovations in multiple settings is projected to contribute significantly to global economic growth. For example, Rose et al. [15] posit that the global economic impact of IoT will reach USD 11 trillion by 2025, with more than 100 billion connected IoT gadgets. This shows the innovation's massive potential and continued growth. Furthermore, its integration with DCS combines the power of those interconnected smart devices with scalable computing resources, enabling effective data processing in terms of replication, real-time processing, and efficiency, sustaining advanced applications across varying industries [17], as developed in Section 4.3.

4.2. Distributed Computer Systems

Distributed computing systems are a computing architecture where multiple interconnected computers, or nodes, work together to perform tasks and process data as a unified system. Unlike centralized computing systems where a single server or mainframe handles all processing, distributed systems distribute computational workload across multiple machines, often spread over different geographical locations [23]. This architecture leverages the power of multiple processors or computers to achieve greater performance, reliability, and scalability. In a distributed computer system, nodes communicate and coordinate with each other through a network, or even the internet [24,25]. Each node in the system can be an individual computer, server, or device contributing to the overall computational power. The nodes collaborate to achieve common objectives, such as processing large volumes of data and running complex algorithms.

Among the advantages of Distributed Computing Systems is their capacity to replicate horizontally. In order to deal with the augmenting workload of computing assets, extra nodes can be included in the system, therefore adding scalability and flexibility [26]. This approach contrasts with vertical scaling, where increasing the capacity of a single machine is often limited by hardware constraints. Distributed systems can also enhance fault tolerance and reliability by replicating data and functions across multiple nodes [27,28]. In case one node collapses, others could take its place mitigating the impact on the system altogether, allowing further service level. Distributed systems also facilitate resource sharing and load balancing [29]. Resources (e.g., storage) are thus distributed across nodes, optimizing their utilization and balancing the workload to prevent bottlenecks [30]. This distributed approach allows for efficient management of resources and improved performance, as tasks can be allocated dynamically based on current system demands and node capabilities.

Distributed computing systems can support various types of distributed architectures and models, including client-server, peer-to-peer (P2P), and cloud computing models. In a client-server model, clients demand services from a central machine that delivers the ensuing reply [31,32]. In contrast, P2P networks involve a decentralized approach where each knot could perform at once as client and supplier, whilst exchanging information with each other. Cloud computing is a prominent example of a distributed system [33]. It allows on-time entrance, by internet, to a common platform of information technology assets (e.g., servers) [34]. Distributed service providers manage and operate distributed infrastructure, offering user scalability, flexibility, and cost-efficiency. This model allows businesses and individuals to leverage powerful computational resources without investing in and maintaining their hardware. To sum up, the integration of DCS with IoT combines the power of distributed resources with a vast network of interconnected devices, which enhances the effectiveness of IoT deployments, in terms for instance of generating a huge number of information, enhancing cloud, edge, and cloud computing, irrespective of the geographical location, whilst enabling opportune decisions and facilitating the deployment of AI models for large datasets [33]. It offers therefore new possibilities in automation and intelligence as developed below.

4.3. Business Models

A business model can be deemed in terms of the way a firm relates with its market in terms of adding value. It is a comprehensive framework that outlines the paramount factors of a business, detailing how it generates revenue, provides products or services, and maintains competitive advantage [5,35]. In addition, business models are often used as tools for initiating organizational changes to enhance performance and productivity. They guide a company's strategic direction, making it an essential element for achieving long-term success and sustainability [36]. A business model consists of nine major building blocks, as displayed in Figure 9.

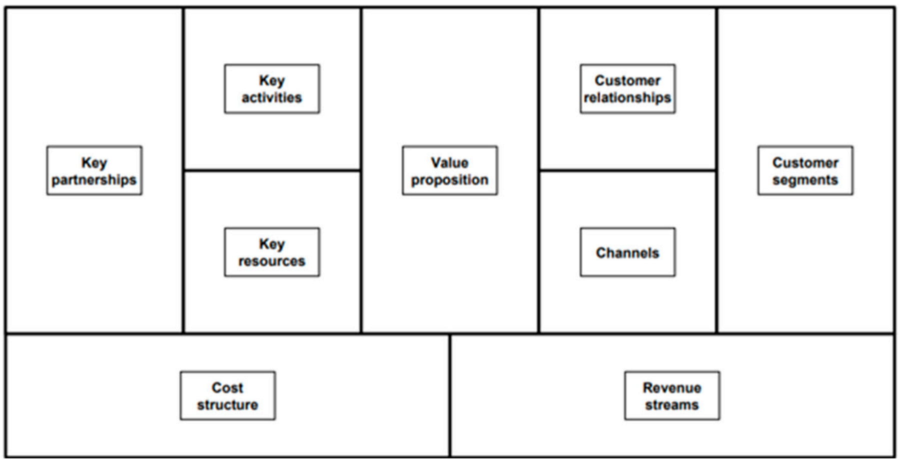

Figure 9. Business model canvas [5].

4.3.1. Value Proposition

Value proposition is the fundamental component of one's business. It articulates the distinct benefits and ensuing value delivered to clients. This could include solving specific problems, fulfilling unmet needs, or delivering superior distinctive features [5]. For instance, a company offering a revolutionary technology that enhances productivity or a service that simplifies a complex process can attract customers by demonstrating clear value.

4.3.2. Revenue Streams

Revenue streams consist of the varying options a firm presents to get profit from its clients (e.g., transaction-based charges). Different business models may utilize multiple revenue streams to diversify income sources and mitigate financial risks.

4.3.3. Customer Segments

Market segments identify the distinct sets of entities a business aims to serve. Each segment may have specific needs, preferences, and behaviors, influencing how the company tailors its products or services. Understanding customer segments helps businesses to design targeted marketing strategies and develop solutions that resonate with different audiences.

4.3.4. Channels

Channels describe the various methods and pathways a company uses to reach and communicate with its customers. According to Kiel et al. [5], this can include for instance physical stores among others which effectively guarantee the provision of products/services to customers in the most convenient and efficient manner.

4.3.5. Customer Relationships

Customer relationships encompass the types of interactions and engagements a company maintains with its customers. This includes customer service, support, loyalty programs, and personalized experiences [37]. Building strong customer relationships is essential for retaining customers and encouraging repeat business. Companies may adopt various strategies, such as offering exceptional customer service, creating loyalty rewards, or implementing personalized marketing.

4.3.6. Key Concepts

Key activities consist of key actions a firm carries out to add effectively the corresponding value. These activities range from product development to marketing and sales, supply chain management, and customer support. Identifying and optimizing key activities helps businesses streamline operations and enhance overall efficiency [37].

4.3.7. Key Resources

Key resources are considered the set of resources needed to support the firm's operations and achieve its objectives. These resources can be physical, intellectual, human, or financial. For example, a technology company may rely on its intellectual property (patents, software), skilled engineers, and funding to develop and market innovative products [37].

4.3.8. Key Partnerships

Key partnerships involve collaborating with other businesses or organizations to achieve mutual benefits. Partnerships can include strategic alliances, joint ventures, supplier relationships, and distribution agreements. Leveraging the strengths and resources of partners allows companies to expand their reach, access new markets, and enhance their offerings [37].

4.3.9. Cost Structure

The cost structure underlines the credit and debit obligations related to the business operation. It comprehends both fixed costs (e.g., salaries) and variable costs (e.g., production). Analyzing the cost structure helps businesses manage their budget, optimize spending, and ensure profitability [37].

The use of IoT and Distributed Computing Systems results in businesses adjusting their processes and operations to include novelty. Consequently, these changes have resulted in various impacts on business models. This section synthesizes data to show how IoT and Distributed Computing Systems influence the adopted business models.

4.4. IoT and CDS Impact on Business Models

4.4.1. Improved Data and Workflow Management

Integrating IoT and Distributed Computing Systems significantly enhances business data and workflow management. IoT devices are equipped with various sensors and connectivity capabilities, continuously collecting vast amounts of data from different aspects of operations [38]. This on-time collection of information eases the monitoring processes, tracks performance, and identifies inefficiencies that might go unnoticed. For instance, in a manufacturing setting, IoT instruments can check the status of machinery, track production output, and detect deviations from standard operating conditions [39]. This immediate visibility into operations enables proactive maintenance, reducing downtime and improving overall productivity. Distributed computing systems further improve data and workflow management by providing the necessary infrastructure to work out the large volumes of information built by IoT computing [40,41]. The decentralized approach minimizes latency and ensures that data can be processed close to its source, which is crucial for opportune analytics and decision-making. Businesses can thus leverage distributed systems to handle complex datasets, perform advanced analytics, and derive actionable insights quickly.

Moreover, the synergy between IoT and distributed systems facilitates seamless integration and coordination across different departments and processes within an organization. Workflow management systems powered by these technologies can automate routine procedures, such as reporting and scheduling that enable employees to focus on more strategic tasks [42,43]. For instance, IoT devices can automatically update inventory levels in a warehouse management system, triggering reorders when stock runs low [44]. Distributed systems ensure this information is immediately available across the supply chain, enabling timely and efficient responses. In addition, integrating IoT and distributed systems supports advanced data management strategies, such as edge computing and real-time data streaming, in which information is constantly shared with the data center [45]. This approach is key with regard to just-in-time operations, for instance when it comes to robotics [46]. Real-time data streaming, facilitated by distributed systems, allows businesses to analyze data as it arrives, providing up-to-the-minute insights and enabling rapid responses to changing conditions.

4.4.2. Automation and Task Scheduling

IoT and Distributed Computing Systems facilitate automation and task scheduling in business operations, driving efficiency, reducing manual effort, and enhancing productivity. IoT devices are equipped with instruments and connectors that allow businesses to automate routine and repetitive tasks traditionally performed manually [47]. This capability is particularly impactful in sectors like manufacturing, logistics, and healthcare, where precision and timely execution of tasks are crucial. For instance, manufacturing plants use IoT-enabled instruments to check operations performance and ensuing flaws, while automatically adjusting settings to optimize production processes [48,49]. These sensors can trigger automated maintenance schedules based on real-time data, preventing equipment failures and reducing downtime. Hossain et al. [50] explain that the capacity to gather and respond on time ensures that machines operate at peak efficiency, minimizing waste and maximizing output. Distributed computing systems are key in this automation by processing the huge number of data created by IoT machines, running complex algorithms to predict maintenance needs, and scheduling tasks accordingly.

IoT and distributed systems allow businesses to implement advanced task scheduling algorithms considering multiple variables, such as resource availability, task priority, and real-time data inputs. According to Pham and Huh [51], these algorithms can dynamically allocate tasks to the most appropriate resources, ensuring optimal use of personnel, equipment, and time. IoT devices, for instance in a plant, can check the status of different production lines and automatically assign tasks to the lines that are best equipped to handle them [52]. It helps balance workloads and prevents bottlenecks. Furthermore, automating administrative and back-office tasks through IoT and distributed systems frees manpower to focus on more strategic work [53,54]. Routine tasks like data entry and report creation can be automated, reducing the risk of human setbacks and increasing overall productivity. Distributed computing ensures that these automated systems are robust, scalable, and capable of handling the demands of a growing business.

4.4.3. Enhanced Operational Efficiency

IoT and Distributed Computing Systems enhance operational efficiency across various business functions. For instance, businesses utilize IoT devices to continuously monitor and report on various operational parameters [55]. This provides them unprecedented visibility into their processes. In addition, Xiong et al. [56] indicate that this real-time monitoring allows organizations to identify and address inefficiencies promptly, ensuring smoother operations and reducing wastage. Distributed computing systems complement IoT by providing the computational power needed to process the huge number of information created by IoT machines [57,58]. These systems can distribute the computational load across multiple nodes, ensuring efficient data processing without bottlenecks. For instance, a large manufacturing plant can use distributed systems to aggregate data from hundreds of IoT sensors, analyze it to spot regularities, and provide actionable data to operators and decision-makers [59]. This decentralized approach to information sorting guarantees rapid responses to operational issues.

4.4.4. Improved Decision-Making

IoT and Distributed Computing Systems transform business decision-making processes from reactive to proactive data-driven approaches. IoT devices continuously generate a huge amount of information from varying fonts (e.g., machinery) and operator interactions [60]. This data provides an intertwined perspective of business operations, client behavior, and market trends, forming the basis for informed and timely decisions. Distributed computing systems facilitate the organization of the massive volumes of information created by IoT machines [61]. These systems distribute the computational load across multiple nodes, allowing efficient and scalable data processing. This decentralized approach ensures data can be analyzed close to its source, reducing latency and enabling real-time analytics [62]. For instance, IoT sensors can monitor traffic patterns, air quality, and energy usage in a smart city. Distributed systems can process this data on time to ease its stream, reduce pollution, and manage energy distribution, supporting quick and effective decision-making by city planners and administrators.

The combination of IoT and distributed systems facilitates the use of advanced analytics and machine learning algorithms. These systems could unveil regularities, forecast tendencies, and advance in knowledge [63]. In the financial sector, IoT devices can monitor market conditions, track asset performance, and gather economic indicators. Distributed systems can analyze this data using prospective heuristics to predict business tendencies, assess risks, and develop investment strategies [64,65]. This level of predictive capability enables financial institutions to make proactive decisions, minimize threats, and capitalize on rising prospects. Furthermore, IoT and Distributed Computing Systems provide an integrated perspective of the organization's operations and market environment [66]. These systems allow executives to make more informed decisions aligned with business objectives. For example, real-time data on production efficiency, customer feedback, and market trends can inform key, long-term decisions (e.g., market expansion) [67,68]. Distributed systems ensure that decision-makers have access to up-to-date and accurate information, enabling them to respond swiftly to changes in the business landscape.

4.4.5. New Revenue Streams

IoT and Distributed Computing Systems enable innovative business models and services that generate additional income. Granados et al. [69] found that IoT devices can transform traditional products into smart, connected products that offer additional value to customers. For example, a manufacturer of home appliances can integrate IoT sensors into their products, allowing customers to monitor and control them remotely through a mobile app [70]. This can lead to the introduction of subscription-based services for remote monitoring and maintenance, generating recurring revenue [71,72]. Distributed systems facilitate these new business models by providing the infrastructure to support large-scale IoT deployments and data processing [73]. They enable businesses to offer services such as predictive maintenance, where customers pay for monitoring and maintenance services based on real-time data from their equipment. In addition, the data collected by IoT devices can be monetized through data analytics services, where businesses analyze and sell insights derived from the data to other companies or stakeholders.

4.4.6. Enhanced Customer Experiences

IoT and Distributed Computing Systems enable personalized and responsive interactions, thereby enhancing customer experiences. IoT machines could collect detailed data, for instance on client preferences, which allows product tailoring [74]. Distributed systems support these personalized experiences by processing and analyzing the information collected by IoT machines. They enable on-time personalization, where services and recommendations are dynamically adjusted based on current data [75]. For instance, a store can check client itineraries through IoT sensors. At the same time, distributed systems can analyze this data to provide personalized offers and product recommendations [76]. This level of personalization enhances customer satisfaction and loyalty by making interactions more relevant and engaging.

4.4.7. Supply Chain Optimization

Businesses use IoT and Distributed Computing Systems to optimize supply chain operations. IoT devices provide real-time visibility into varying features of the supply chain (e.g., inventory). This visibility allows businesses to check and act on their supply chains in real time, reducing delays and improving efficiency [77,78]. Distributed systems enable predictive analytics, where historical data and current trends are analyzed to forecast demand, optimize inventory levels, and identify potential disruptions. For example, IoT sensors in a warehouse can track inventory movements and send real-time data to a distributed system, which analyzes the data to predict stock outs and automatically reorder supplies [79]. This proactive approach minimizes inventory shortages and excesses, ensuring a smooth and efficient supply chain.

4.4.8. Enhanced Security and Compliance

IoT and Distributed Computing Systems enhance security and compliance by providing on-time checking and automated response capabilities. IoT machines can detect and report security threats, such as unauthorized access or anomalies in operational data, enabling businesses to respond promptly to potential risks [52]. For instance, IoT sensors in a data center can monitor for unusual temperature fluctuations or unauthorized entry, triggering alerts and initiating corrective actions. Distributed systems support the implementation of advanced security protocols (e.g., access control) to ensure confidential information [80,81]. In addition, distributed systems can ensure compliance with regulatory requirements by providing accurate and timely data on various aspects of operations. For instance, in the pharmaceutical industry [82], IoT devices can check the conditions under which drugs are stored and transported, while distributed systems analyze this data to ensure compliance with regulations and standards.

4.4.9. Cost Reduction

The integration of IoT and Distributed Computing Systems can lead to significant cost reductions across various business operations. IoT devices allow for on-time monitoring and organization of assets, reducing the need for manual inspections and maintenance [46]. For example, IoT sensors can detect equipment malfunctions and trigger automated maintenance processes, minimizing downtime and reducing repair costs [83]. Distributed systems contribute to cost reduction by optimizing resource allocation and improving operational efficiency. They enable businesses to analyze data and identify areas in which costs can be mitigated, such as energy consumption, inventory management, and labor [84,85]. For instance, distributed systems can analyze energy usage data from IoT sensors and identify patterns that lead to energy waste, allowing businesses to implement energy-saving measures. Additionally, the automation and task scheduling capabilities of distributed systems reduce the need for manual intervention and labor costs, further contributing to overall cost savings.

4.5. Discussion

Despite the multiple positive impacts of IoT and distributed computer systems on business models, there are several challenges to watch out for. For instance, the increased connectivity results in complex systems that can be hard to manage and subject to higher security threats. Such situations can undermine customer trust and confidence in the organization's capacity to manage their data, thereby affecting customer relationships, loyalty, and overall sales among businesses [86]. Therefore, businesses should implement appropriate strategies to address potential challenges associated with adopting and implementing IoT and distributed computer systems.

4.5.1. Data Security and Privacy

The rapid expansion of IoT and Distributed Computing Systems introduces significant challenges. For instance, IoT devices are interconnected and continuously collecting data, increasing the potential entry points for cyber attacks [44]. These devices often handle confidential data, such as health data, financial transactions, or proprietary business data. The sheer amount and variety of data created by IoT machines make it challenging to ensure robust security measures across all network points [87]. In DCS, data is processed across varying nodes, further complicating security management. Ensuring that data is protected in transit between nodes, as well as while stored at various locations requires sophisticated encryption methods and consistent security protocols [25,88]. The scattered organization of these systems implies that vulnerabilities in one part of the system can potentially jeopardize it overall, making it difficult to implement a unified security strategy for the business. Privacy concerns are also heightened with the extensive data collection capabilities of IoT devices [89]. The constant monitoring and collection of personal data can lead to unauthorized access or misuse if not properly managed. The risk of data breaches or leaks can undermine consumer trust and result in significant legal and financial repercussions for the company.

4.5.2. Complexity and Management

The match of IoT and DCS implies substantial complexity in terms of system management and coordination. IoT networks consist of numerous interconnected devices, each generating huge quantities of information that must be processed [90]. Managing such a large-scale, heterogeneous network requires advanced infrastructure and sophisticated software to ensure seamless operation and interoperability. Distributed computer systems, which operate by dividing computational tasks across multiple nodes, add another layer of complexity. The complexity of these innovations is illustrated in Gao et al. [91], which indicates that a simple IoT application consisting of 95% status-reporting queries and 5% user queries, and serving 10 billion machines requires 1000 to 100,000 nodes functioning at a 50ms response rate. Coordinating these nodes, managing their interactions, and ensuring data consistency across the network can be challenging for most managers.

4.5.3. Requires Extensive Resources

Implementing and maintaining IoT and Distributed Computing Systems often require extensive resources, both in terms of financial investment and technical expertise. The deployment of IoT devices involves significant upfront costs for purchasing and installing sensors, communication modules, and other hardware [92]. Additionally, the infrastructure needed to support data collection, storage, and processing, including servers, networking equipment, and cloud services, represents a substantial financial commitment. The operational costs associated with these technologies also add to the resource requirements for management [93]. Managing, maintaining, and updating IoT devices and distributed systems involves ongoing expenses for system administration, cyber security measures, and technical support. As these systems generate large volumes of data, businesses need to invest in scalable data storage solutions and high-performance computing resources to handle data processing and analytics effectively, which could be problematic for Small and Medium Enterprises that fall short of resources.

4.5.4. Software Quality Issues

The improvement and deployment of applications for IoT and DCS are fraught with challenges related to software quality. The complexity of these systems requires that software solutions be robust, reliable, and capable of handling diverse and dynamic conditions [33]. However, ensuring high software quality can be difficult due to the numerous interactions and dependencies involved. IoT devices and distributed systems often operate with real-time data and require high levels of accuracy and reliability [94,95]. Software bugs or performance issues in any component of the system can lead to cascading failures, impacting the overall functionality and reliability of the system [96,97]. Ensuring that software can handle edge cases, unforeseen scenarios, and varying operational conditions adds to the complexity of development and testing, in particular with regard to strategic decision-making.

4.5.5. Data Consistency and Synchronization

Maintaining data consistency and synchronization across IoT and Distributed Computing Systems presents a significant challenge. In DCS, information is often distributed over varying nodes, each of which may process and update data independently [98]. Ensuring all nodes have a consistent view of the data and that changes are accurately reflected across the entire system is complex. For IoT networks, where devices generate data continuously and in real-time, achieving data consistency becomes even more challenging [99,100]. Information gathered from varied IoT devices has to be integrated and synchronized to provide a unified view. Discrepancies or delays in data synchronization can lead to inconsistent or outdated information, affecting both decision-making and operational efficiency with regard to management [101,102]. The challenge is further compounded by issues such as network latency, device failures, and data transmission errors that might impact business in varying ways.

5. Conclusions

IoT and Distributed Computing Systems are significantly transforming business models by allowing on-time information gathering, advanced analytics, and automated processes. IoT devices encompass sensors, wearables, and smart appliances. They provide on-time checking of operations, predictive upholding, and robotics, enhancing efficiency and reducing costs. On the other hand, Distributed Computing Systems distribute data processing tasks across multiple nodes, providing the necessary computational power and scalability to cope with multiple amounts of information created by IoT machines. IoT and distributed frameworks enable ameliorated decisions in terms of on-time information, which help businesses optimize operations, personalize customer experiences, and create new revenue streams. Furthermore, these technologies improve the supply chain overall by allowing on-time monitoring, ensuring smoother operations with ensuing cost reduction and augmented efficiency. The combined impact of these innovations is driving businesses toward more efficient, innovative, and competitive operations.

Nonetheless, the incorporation of IoT and distributed frameworks also implies major hurdles that businesses must address to fully realize their benefits. Data safety and privacy are central issues since interconnected frameworks increase the risk of cyber attacks and data breaches. Managing extensive IoT networks and distributed systems requires substantial resources and specialized expertise, adding to the complexity of implementation and maintenance. Software quality issues, data consistency, and synchronization further complicate the deployment and operation of these systems. To guarantee the consistency and synchronization of data across all knots of a distributed system is key for maintaining the integrity and trustworthiness of business processes. Businesses must deal with these issues to guarantee the reliability, safety, and efficiency of their IoT and distributed systems implementations. In order to attain competitiveness, organizations need to tackle these issues proactively, whilst promoting these technologies towards operational and strategic gains. Addressing these challenges is crucial for operational success and maintaining customer trust and compliance with regulatory standards, thereby safeguarding business sustainability and growth in the long run.

Theories related to the IoT and Distributed computing systems have significantly impacted business models across various industries. These contributions can be categorized into several key areas. In particular, integration of IoT and Distributed Systems in Business Models does the following: (a) Smart Infrastructure (combining IoT with distributed systems enables the creation of smart cities and infrastructure, enhancing urban living and efficiency (e.g., smart grids use IoT sensors and distributed computing to manage energy distribution and consumption more effectively; (b) Edge Computing (integrating IoT with edge computing, a form of DCS, enables information processing by its font, reducing delays and bandwidth usage (e.g., autonomous vehicles); (c) Predictive Analytics and upholding (IoT data blended with distributed computing powers predict analytics, helping businesses anticipate issues before they arise (e.g., manufacturing companies use predictive maintenance to foresee equipment breakdown, mitigating delays and repair expenses); (d) Personalized Services (the incorporation of IoT and distributed framework supports the delivery of personalized services at scale (e.g., e-commerce platforms use data from IoT devices and distributed systems to offer personalized recommendations to users); and (e) Enhanced Security (distributed systems emphasize the safety of IoT networks by fostering decentralized data storage and processing, reducing the risk of centralized attacks (e.g., blockchain can secure IoT transactions and data exchanges).

These contributions illustrate how IoT and Distributed Computing Systems are reshaping business models, driving innovation, and creating new opportunities across industries.

Exploring future lines of investigation in IoT and Distributed Computing Systems within business models involves examining emerging trends, challenges, and opportunities that these technologies bring. Particularly, with respect to advanced data analytics and AI integration, they investigate the integration of advanced analytics and artificial intelligence to ascertain deeper knowledge from IoT information, enabling forecasting and prescriptive data, as well as develop AI models that can autonomously interpret IoT information for opportune decisions and automated responses. Regarding distributed computing systems, future studies might be based upon the evolution of decentralized architectures, such as blockchain and distributed ledgers, in enhancing trust and transparency in business models.

Another line of investigation consists of applying decentralized systems in supply chain management, finance, and digital identity verification, and integration of IoT and Distributed Systems in Business models to explore the creation of fully autonomous systems that leverage IoT data and distributed computing to operate without human intervention.

By exploring these future lines of investigation, businesses can better understand the potential of IoT and Distributed Computing Systems to innovate, optimize, and transform their operations and strategies.

Author Contributions: Conceptualization, A.T.R. and R.R.; methodology, A.T.R. and R.R.; software, A.T.R. and R.R.; validation, A.T.R. and R.R.; formal analysis, A.T.R. and R.R.; investigation, A.T.R. and R.R.; resources, A.T.R. and R.R.; data curation A.T.R. and R.R.; writing—original draft preparation, A.T.R. and R.R.; writing—review and editing, A.T.R. and R.R.; visualization, A.T.R. and R.R.; supervision, R.R. and A.T.R.; project administration, R.R. and A.T.R.; funding acquisition, R.R. and A.T.R. All authors have read and agreed to the published version of the manuscript.

Funding: The first author received financial support from the Research Unit on Governance, Competitiveness and Public Policies (UIDB/04058/2020) + (UIDP/04058/2020), funded by national funds through FCT—Fundação para a Ciência e a Tecnologia, and the second author received financial support from ISEC Lisboa. Both entities provided invaluable support.

Data Availability Statement: Not applicable.

Acknowledgments: We would like to express our gratitude to the Editor and the Referees. They offered valuable suggestions or improvements. The authors were supported by the GOVCOPP Research Center of the University of Aveiro, and ISEC Lisboa provided invaluable support.

Conflicts of Interest: The authors declare no conflicts of interest.

Appendix A

Table A1. Overview of document citations period ≤2014 to 2024.

References		≤2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	Total
	Total	-	3	25	118	313	638	906	928	953	867	471	**5222**
[1]	2014	-	1	-	1	1	-	-	-	2	-	-	5
[2]	2020	-	-	-	-	-	-	3	1	4	4	1	13
[4]	2018	-	-	-	-	3	2	1	-	-	1	-	7
[5]	2017	-	-	-	-	4	2	6	7	2	4	-	25
[6]	2018	-	-	-	-	-	1	3	7	11	12	6	40
[10]	2017	-	-	-	-	5	11	9	10	6	8	2	51
[12]	2017	-	-	-	-	4	15	16	19	18	19	9	100
[13]	2019	-	-	-	-	-	-	4	6	9	5	7	31
[16]	2016	-	-	1	5	6	11	14	13	12	19	3	84
[17]	2019	-	-	-	-	-	-	4	6	4	2	-	16
[18]	2019	-	-	-	-	-	-	-	1	1	-	-	2
[19]	2023	-	-	-	-	-	-	-	1	3	6	7	17
[20]	2017	-	-	-	-	2	3	3	3	2	-	2	15
[21]	2015	-	-	2	2	1	1	1	2	-	-	-	9
[22]	2017	-	-	-	-	-	1	-	-	-	-	-	1
[23]	2018	-	-	-	-	-	-	1	-	-	1	-	2
[24]	2022	-	-	-	-	-	-	-	-	6	18	12	36
[25]	2018	-	-	-	-	-	1	3	4	6	4	-	18
[26]	2017	-	-	-	-	1	1	-	-	-	-	-	2
[27]	2018	-	-	-	-	-	2	1	2	2	-	-	7
[29]	2018	-	-	-	-	-	-	2	2	2	-	-	6
[31]	2019	-	-	-	-	-	-	2	1	1	1	-	5
[32]	2020	-	-	-	-	-	-	-	-	-	2	-	2
[33]	2016	-	-	-	3	1	7	3	7	3	2	2	28
[34]	2017	-	-	2	1	2	1	-	-	1	-	-	7
[35]	2017	-	-	-	-	-	4	3	5	2	2	-	16
[38]	2019	-	-	-	-	-	-	-	1	1	-	-	2
[39]	2017	-	-	-	-	2	1	1	6	3	1	1	15
[40]	2018	-	-	-	-	-	1	2	2	-	1	-	6
[42]	2018	-	-	-	-	-	1	4	9	8	5	6	33
[44]	2018	-	-	-	-	6	26	59	69	62	54	33	309
[46]	2019	-	-	-	-	-	-	-	1	-	-	-	1

Table A1. *Cont.*

References		≤2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	Total
[47]	2018	-	-	-	-	-	4	16	16	27	23	16	102
[49]	2018	-	-	-	-	5	13	15	19	19	13	6	90
[50]	2019	-	-	-	-	-	-	1	-	1	3	-	5
[51]	2016	-	-	-	8	18	33	40	41	25	25	12	202
[52]	2018	-	-	-	1	3	9	3	-	3	-	1	20
[53]	2017	-	-	-	1	1	4	5	4	4	3	-	22
[54]	2018	-	-	-	-	1	1	5	1	8	1	2	19
[55]	2018	-	-	-	-	9	45	74	66	51	55	34	334
[56]	2015	-	-	2	2	3	2	2	2	2	1	-	16
[57]	2019	-	-	-	-	-	-	-	1	-	-	-	1
[58]	2019	-	-	-	-	-	-	-	-	2	-	-	2
[59]	2016	-	-	-	9	19	12	6	11	15	8	4	84
[61]	2017	-	-	-	1	4	17	18	14	9	13	6	82
[63]	2018	-	-	-	-	-	1	2	5	4	1	-	13
[64]	2017	-	-	-	-	4	4	8	2	1	2	-	21
[65]	2018	-	-	-	-	1	4	8	9	12	5	2	41
[67]	2017	-	-	-	-	1	-	2	-	-	-	-	3
[68]	2016	-	-	6	34	86	122	155	150	112	78	51	794
[69]	2020	-	-	-	-	-	-	2	13	23	22	13	73
[70]	2017	-	-	-	-	-	1	1	4	1	1	1	9
[71]	2015	-	-	1	3	-	-	-	-	-	-	-	4
[72]	2016	-	-	-	20	31	41	55	42	55	41	20	305
[73]	2022	-	-	-	-	-	-	-	-	-	1	-	1
[74]	2014	-	1	-	1	1	-	-	-	2	-	-	5
[76]	2019	-	-	-	-	-	-	-	-	-	1	-	1
[77]	2024	-	-	-	-	-	-	-	-	-	4	5	9
[78]	2017	-	-	-	-	4	10	11	19	18	28	15	105
[80]	2023	-	-	-	-	-	-	-	-	-	1	-	1
[81]	2020	-	-	-	-	-	-	6	7	6	11	5	35
[82]	2018	-	-	-	-	-	-	1	-	-	-	1	2
[83]	2018	-	-	-	-	19	76	157	152	197	180	102	883
[84]	2018	-	-	-	-	-	1	1	1	1	2	4	10
[85]	2016	-	-	3	8	16	10	13	4	6	11	3	74
[86]	2015	-	1	8	10	13	20	14	19	11	9	1	106
[88]	2017	-	-	-	-	-	1	-	-	-	-	-	1
[90]	2022	-	-	-	-	-	-	-	-	-	3	-	3
[92]	2016	-	-	-	8	14	34	32	31	22	14	4	159
[93]	2017	-	-	-	-	-	-	1	1	1	-	-	3

Table A1. *Cont.*

References		≤2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	Total
[94]	2018	-	-	-	-	-	1	3	3	-	-	1	8
[96]	2019	-	-	-	-	-	-	-	-	-	-	3	3
[97]	2017	-	-	-	-	2	16	22	24	27	23	21	135
[98]	2017	-	-	-	-	-	4	1	1	1	1	-	8
[99]	2017	-	-	-	0	13	48	72	62	102	99	40	436
[101]	2018	-	-	-	-	7	12	9	19	14	12	6	79
[102]	2023	-	-	-	-	-	-	-	-	-	1	1	2

References

1. Westerlund, M.; Leminen, S.; Rajahonka, M. Designing Business Models for the Internet of Things. *Technol. Innov. Manag. Rev.* **2014**, *4*, 5–14. [CrossRef]
2. Dijkman, R.M.; Sprenkels, B.; Peeters, T.; Janssen, A. Business models for the Internet of Things. *Int. J. Inf. Manag.* **2015**, *35*, 672–678. [CrossRef]
3. Ageed, Z.S.; Ibrahim, R.K.; Sadeeq, M.A. Unified ontology implementation of cloud computing for distributed systems. *Curr. J. Appl. Sci. Technol.* **2020**, *39*, 82–97. [CrossRef]
4. Alamouti, S.M.; Arjomandi, F.; Burger, M. Hybrid edge cloud: A pragmatic approach for decentralized cloud computing. *IEEE Commun. Mag.* **2022**, *60*, 16–29. [CrossRef]
5. Kiel, D.; Arnold, C.; Collisi, M.; Voigt, K.I. The impact of the industrial internet of things on established business models. In Proceedings of the 25th International Association for Management of Technology (IAMOT) Conference, Orlando, FL, USA, 15–19 May 2016; pp. 673–695.
6. Hbib, G.; Sharma, S.; Ibrahim, S.; Ahmad, I.; Qureshi, S.; Ishfaq, M. Blockchain technology: Benefits, challenges, applications, and integration of blockchain technology with cloud computing. *Future Internet* **2022**, *14*, 341. [CrossRef]
7. Page, M.J.; McKenzie, J.E.; Bossuyt, P.M.; Boutron, I.; Hoffmann, T.C.; Mulrow, C.D.; Shamseer, L.; Tetzlaff, J.M.; Akl, E.A.; Brennan, S.E.; et al. The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *BMJ* **2021**, *372*, n71. [CrossRef]
8. Haddaway, N.R.; Page, M.J.; Pritchard, C.C.; McGuinness, L.A. PRISMA 2020: An R package and Shiny app for producing PRISMA 2020-compliant flow diagrams, with interactivity for optimized digital transparency and Open Synthesis. *Campbell Syst. Rev.* **2022**, *18*, e1230. [CrossRef]
9. Rosário, A.T.; Dias, J.C. The New Digital Economy and Sustainability: Challenges and Opportunities. *Sustainability* **2023**, *15*, 10902. [CrossRef]
10. Rosário, A.; Moreira, A.; Macedo, P. Dinámica competitiva de los grupos estratégicos en la industria bancaria portuguesa. *Cuad. Gest.* **2021**, *21*, 119–133. [CrossRef]
11. Rosário, A.T.; Lopes, P.R.; Rosário, F.S. Metaverse in Marketing: Challenges and Opportunities. In *Handbook of Research on AI-Based Technologies and Applications in the Era of the Metaverse*; Khang, A., Shah, V., Eds.; IGI Global: Hershey, PA, USA, 2023; pp. 204–227. [CrossRef]
12. Gill, S.S.; Buyya, R.; Chana, I. IoT based agriculture as a cloud and big data service: The beginning of digital India. *J. Organ. End User Comput.* **2017**, *29*, 1–23. [CrossRef]
13. Subbarao, V.; Srinivas, K.; Pavithr, R.S. A survey on internet of things based smart, digital green and intelligent campus. In Proceedings of the 2019 4th International Conference on Internet of Things: Smart Innovation and Usages, IoT-SIU, Ghaziabad, India, 18–19 April 2019. [CrossRef]
14. Li, S.; Xu, L.D.; Zhao, S. The internet of things: A survey. *Inf. Syst. Front.* **2015**, *17*, 243–259. [CrossRef]
15. Rose, K.; Eldridge, S.; Chapin, L. The internet of things: An overview. *Internet Soc.* **2015**, *80*, 1–53.
16. Zhong, C.L.; Zhu, Z.; Huang, R.G. Study on the IOT architecture and gateway technology. In Proceedings of the 14th International Symposium on Distributed Computing and Applications for Business, Engineering and Science, DCABES, Guiyang, China, 18–24 August 2015. [CrossRef]
17. Casadei, R.; Tsigkanos, C.; Viroli, M.; Dustdar, S. Engineering resilient collaborative edge-enabled IoT. In Proceedings of the 2019 IEEE International Conference on Services Computing, SCC 2019—Part of the 2019 IEEE World Congress on Services, Milan, Italy, 8–13 July 2019. [CrossRef]
18. Gabbrielli, M.; Giallorenzo, S.; Lanese, I.; Zingaro, S.P. Linguistic abstractions for interoperability of IoT platforms. In *Towards Integrated Web, Mobile, and IoT Technology: Selected and Revised Papers from the Web Technologies Track at SAC 2017 and SAC 2018, and the Software Development for Mobile Devices, Wearables, and the IoT Minitrack at HICSS 2018*; Springer International Publishing: Berlin/Heidelberg, Germany, 2019; pp. 83–114. [CrossRef]

19. Akkaoui, R. Blockchain for the Management of Internet of Things Devices in the Medical Industry. *IEEE Trans. Eng. Manag.* **2023**, *70*, 2707–2718. [CrossRef]
20. Breivold, H.P. Internet-of-Things and Cloud Computing for Smart Industry: A Systematic Mapping Study. In Proceedings of the 2017 5th International Conference on Enterprise Systems: Industrial Digitalization by Enterprise Systems, Beijing, China, 22–24 September 2017. [CrossRef]
21. Eigner, M.; Faißt, K.G.; Apostolov, H.; Schäfer, P. Short description and benefits of system lifecycle management in context of industrial internet including industry 4.0 and internet of thinks and services. *ZWF Z. Wirtsch. Fabr.* **2015**, *110*, 475–478. [CrossRef]
22. Kim-Hung, L.; Datta, S.K.; Bonnet, C.; Hamon, F.; Boudonne, A. An industrial IoT framework to simplify connection process using system-generated connector. In Proceedings of the RTSI 2017—IEEE 3rd International Forum on Research and Technologies for Society and Industry, Conference Proceedings, Modena, Italy, 11–13 September 2017. [CrossRef]
23. Guerra, J.G.; Armando Fermin Perez, F. Inclusion of blockchain in course of distributed systems at the school of computer science. In Proceedings of the 23rd Annual ACM Conference on Innovation and Technology in Computer Science Education, ITiCSE, Larnaca, Cyprus, 2–4 July 2018. [CrossRef]
24. Wu, Q.; Wu, J.; Shen, J.; Du, B.; Telikani, A.; Fahmideh, M.; Liang, C. Distributed agent-based deep reinforcement learning for large scale traffic signal control. *Knowl.-Based Syst.* **2022**, *241*, 108304. [CrossRef]
25. Beer, M.I.; Hassan, M.F. Adaptive security architecture for protecting RESTful web services in enterprise computing environment. *Serv. Oriented Comput. Appl.* **2018**, *12*, 111–121. [CrossRef]
26. Brondolin, R.; Ferroni, M.; Santambrogio, M.D. FFWD: Latency-Aware Event Stream Processing via Domain-Specific Load-Shedding Policies. In Proceedings of the 19th IEEE International Conference on Computational Science and Engineering, 14th IEEE International Conference on Embedded and Ubiquitous Computing and 15th International Symposium on Distributed Computing and Applications to Business, Engineering and Science, CSE-EUC-DCABES, Paris, France, 24–26 August 2016.
27. Chamekh, M.; Hamdi, M.; El Asmi, S.; Kim, T.H. Secured distributed IoT based supply chain architecture. In Proceedings of the 2018 IEEE 27th International Conference on Enabling Technologies: Infrastructure for Collaborative Enterprises, Paris, France, 27–29 June 2018.
28. Christoforidis, J.; Dasygenis, M. An Efficient Scalable Parallelized Version of the Mondrian Algorithm. In Proceedings of the 19th IEEE International Conference on Computational Science and Engineering, 14th IEEE International Conference on Embedded and Ubiquitous Computing and 15th International Symposium on Distributed Computing and Applications to Business, Engineering and Science, CSE-EUC-DCABES, Paris, France, 24–26 August 2016. [CrossRef]
29. He, A.; Shen, J.; Wang, Y.; Liu, L. Research on the Fusion Model Reference Architecture of Sensed Information of Human Body for Medical and Healthcare IoT. In Proceedings of the 2018 17th International Symposium on Distributed Computing and Applications for Business Engineering and Science, (DCABES), Wuxi, China, 19–23 October 2018. [CrossRef]
30. Huang, J. Study on the mechanism of collaborative business customized logistics distribution based on large data under the background of "Internet plus". *Pap. Asia* **2018**, *1*, 49–51.
31. Jacobson, D.; Dickerman, L. Distributed intelligence: A critical piece of the microgrid puzzle. *Electr. J.* **2019**, *32*, 10–13. [CrossRef]
32. Saksonov, E.A.; Leokhin, Y.L.; Azarov, V.N. Information interaction in distributed systems. In Proceedings of the 2020 IEEE International Conference "Quality Management, Transport and Information Security, Information Technologies", Yaroslavl, Russia, 7–11 September 2020. [CrossRef]
33. Kiruthika, J.; Khaddaj, S. Software quality issues and challenges of internet of things. In Proceedings of the 14th International Symposium on Distributed Computing and Applications for Business, Engineering and Science, DCABES, Guiyang, China, 18–24 August 2015. [CrossRef]
34. Resner, D.; Fröhlich, A.A. TSTP MAC: A Foundation for the Trustful Space-Time Protocol. In Proceedings of the 19th IEEE International Conference on Computational Science and Engineering, 14th IEEE International Conference on Embedded and Ubiquitous Computing and 15th International Symposium on Distributed Computing and Applications to Business, Engineering and Science, CSE-EUC-DCABES, Paris, France, 24–26 August 2016. [CrossRef]
35. Lewandowski, M. Designing the business models for circular economy—Towards the conceptual framework. *Sustainability* **2016**, *8*, 43. [CrossRef]
36. Wirtz, B.W.; Pistoia, A.; Ullrich, S.; Göttel, V. Business models: Origin, development and future research perspectives. *Long Range Plan.* **2016**, *49*, 36–54. [CrossRef]
37. Massa, L.; Tucci, C.L.; Afuah, A. A critical assessment of business model research. *Acad. Manag. Ann.* **2017**, *11*, 73–104. [CrossRef]
38. Seiger, R.; Heisig, P.; Aßmann, U. *Retrofitting of Workflow Management Systems with Self-X Capabilities for Internet of Things*; Lecture Notes in Business Information Processing; Springer: Berlin/Heidelberg, Germany, 2019. [CrossRef]
39. Petrasch, R.; Hentschke, R. Cloud storage hub: Data management for IoT and industry 4.0 applications: Towards a consistent enterprise information management system. In Proceedings of the 2016 Management and Innovation Technology International Conference, Bang-San, Thailand, 12–14 October 2016. [CrossRef]
40. Riad, M.; Elgammal, A.; Elzanfaly, D. Efficient Management of Perishable Inventory by Utilizing IoT. In Proceedings of the 2018 IEEE International Conference on Engineering, Technology and Innovation, ICE/ITMC 2018—Proceedings, Stuttgart, Germany, 17–20 June 2018. [CrossRef]
41. Wang, Y.; Bi, X.; Zhang, M. The effect of cloud computing and the internet of things on traditional IT outsourcing. In *WIT Transactions on Information and Communication Technologies*; WIT Press: Southampton, UK, 2014. [CrossRef]

42. Shi, Z.; Wang, G. Integration of big-data ERP and business analytics (BA). *J. High Technol. Manag. Res.* **2018**, *29*, 141–150. [CrossRef]
43. Tyagi, R.; Kathuria, K.; Sharma, P.; Sharma, P.K. Optimizing Water Management and Conservation Through IoT. In Proceedings of the 2024 2nd International Conference on Disruptive Technologies, ICDT, Greater Noida, India, 15–16 March 2024.
44. Ahmad, I.; Kumar, T.; Liyanage, M.; Okwuibe, J.; Ylianttila, M.; Gurtov, A. Overview of 5G Security Challenges and Solutions. *IEEE Commun. Stand. Mag.* **2018**, *2*, 36–43. [CrossRef]
45. Routray, S.K.; Mohanty, S. Information and communications technology for a sustainable world. *IEEE Potentials* **2024**, 2–8. [CrossRef]
46. Watanabe, S.; Komatsu, Y.; Ono, M.; Katayama, K. Distributed healthcare and medicine: Technological feasibility and future scope for redirecting the current centralized model to benefit remote areas. In Proceedings of the PICMET 2019—Portland International Conference on Management of Engineering and Technology: Technology Management in the World of Intelligent Systems, Proceedings, Portland, OR, USA, 25–29 August 2019. [CrossRef]
47. Gružauskas, V.; Baskutis, S.; Navickas, V. Minimizing the trade-off between sustainability and cost-effective performance by using autonomous vehicles. *J. Clean. Prod.* **2018**, *184*, 709–717. [CrossRef]
48. Hao, T.; Gao, W.; Lan, C.; Tang, F.; Jiang, Z.; Zhan, J. Edge AIBench 2.0: A scalable autonomous vehicle benchmark for IoT–Edge–Cloud systems. *BenchCouncil Trans. Benchmarks Stand. Eval.* **2022**, *2*, 100086. [CrossRef]
49. Siderska, J.; Jadaan, K.S. Cloud manufacturing: A service-oriented manufacturing paradigm. A review paper. *Eng. Manag. Prod. Serv.* **2018**, *10*, 22–31. [CrossRef]
50. Hossain, M.S.; Ramli, M.R.; Lee, J.M.; Kim, D.S. Fog Radio Access Networks in Internet of Battlefield Things (IoBT) and Load Balancing Technology. In Proceedings of the ICTC 2019—10th International Conference on ICT Convergence: ICT Convergence Leading the Autonomous Future, Jeju, Republic of Korea, 16–18 October 2019. [CrossRef]
51. Pham, X.Q.; Huh, E.N. Towards task scheduling in a cloud-fog computing system. In Proceedings of the 18th Asia-Pacific Network Operations and Management Symposium, APNOMS 2016: Management of Softwarized Infrastructure—Proceedings, Kanazawa, Japan, 5–7 October 2016. [CrossRef]
52. Al-Turjman, F. Optimized Hexagon-Based Deployment for Large-Scale Ubiquitous Sensor Networks. *J. Netw. Syst. Manag.* **2018**, *26*, 255–283. [CrossRef]
53. Dalmazo, B.L.; Vilela, J.P.; Curado, M. Performance Analysis of Network Traffic Predictors in the Cloud. *J. Netw. Syst. Manag.* **2017**, *25*, 290–320. [CrossRef]
54. Kaur, J.; Kaur, P.D. CE-GMS: A cloud IoT-enabled grocery management system. *Electron. Commer. Res. Appl.* **2018**, *28*, 63–72. [CrossRef]
55. Catlett, C.E.; Beckman, P.H.; Sankaran, R.; Galvin, K.K. Array of things: A scientific research instrument in the public way. In Proceedings of the 2017 2nd International Workshop on Science of Smart City Operations and Platforms Engineering, in partnership with Global City Teams Challenge, SCOPE, Pittsburgh, PA, USA, 18–21 April 2017. [CrossRef]
56. Xiong, G.; Ji, T.; Zhang, X.; Zhu, F.; Liu, W. Cloud operating system for industrial application. In Proceedings of the 10th IEEE International Conference on Service Operations and Logistics, and Informatics, SOLI, Yasmine Hammamet, Tunisia, 15–17 November 2015. [CrossRef]
57. Tsoutsa, P.; Fitsilis, P.; Ragos, O. *Enhancing Teamwork Behavior of Services*; Lecture Notes in Business Information Processing; Springer: Berlin/Heidelberg, Germany, 2019. [CrossRef]
58. Wolf, S.; Cooley, R.; Borowczak, M. S-CHIRP: Securing communications in lightweight peer-to-peer networks in the IoT. *IEEE Potentials* **2019**, *38*, 14–19. [CrossRef]
59. Yang, C.; Shen, W.; Wang, X. Applications of Internet of Things in manufacturing. In Proceedings of the 2016 IEEE 20th International Conference on Computer Supported Cooperative Work in Design, Nanchang, China, 4–6 May 2016. [CrossRef]
60. Tien, J.M. Internet of things, real-time decision making, and artificial intelligence. *Ann. Data Sci.* **2017**, *4*, 149–178. [CrossRef]
61. El-Sayed, H.; Sankar, S.; Prasad, M.; Puthal, D.; Gupta, A.; Mohanty, M.; Lin, C.T. Edge of things: The big picture on the integration of edge, IoT and the cloud in a distributed computing environment. *IEEE Access* **2017**, *6*, 1706–1717. [CrossRef]
62. Abdel-Basset, M.; Manogaran, G.; Gamal, A.; Chang, V. A novel intelligent medical decision support model based on soft computing and IoT. *IEEE Internet Things J.* **2019**, *7*, 4160–4170. [CrossRef]
63. Uslu, B.; Eren, T.; Gür, Ş.; Özcan, E. Evaluation of the difficulties in the internet of things (IoT) with multi-criteria decision-making. *Processes* **2019**, *7*, 164. [CrossRef]
64. Kalatzis, N.; Routis, G.; Marinellis, Y.; Avgeris, M.; Roussaki, I.; Papavassiliou, S.; Anagnostou, M. Semantic interoperability for iot platforms in support of decision making: An experiment on early wildfire detection. *Sensors* **2019**, *19*, 528. [CrossRef]
65. Mahmood, Z. *Fog Computing: Concepts, Frameworks and Technologies*; Springer International Publishing: Berlin/Heidelberg, Germany, 2018. [CrossRef]
66. Zhang, Z.; Guo, C.; Martínez, L. Managing multigranular linguistic distribution assessments in large-scale multiattribute group decision making. *IEEE Trans. Syst. Man Cybern. Syst.* **2016**, *47*, 3063–3076. [CrossRef]
67. Zimmermann, A.; Schmidt, R.; Sandkuhl, K.; Jugel, D.; Bogner, J.; Möhring, M. *Multi-Perspective Digitization Architecture for the Internet of Things*; Lecture Notes in Business Information Processing; Springer: Berlin/Heidelberg, Germany, 2017; Volume 263, pp. 289–298. [CrossRef]
68. Hashem, I.A.T.; Chang, V.; Anuar, N.B.; Adewole, K.; Yaqoob, I.; Gani, A.; Chiroma, H. The role of big data in smart city. *Int. J. Inf. Manag.* **2016**, *36*, 748–758. [CrossRef]

69. Granados, J.; Westerlund, T.; Zheng, L.; Zou, Z. *IoT Platform for Real-Time Multichannel ECG Monitoring and Classification with Neural Networks*; Lecture Notes in Business Information Processing; Springer: Cham, Germany, 2018. [CrossRef]
70. Chhabra, A.; Arora, S. An Elliptic Curve Cryptography Based Encryption Scheme for Securing the Cloud against Eavesdropping Attacks. In Proceedings of the 2017 IEEE 3rd International Conference on Collaboration and Internet Computing (CIC), San Jose, CA, USA, 15–17 October 2017; pp. 243–246. [CrossRef]
71. Singh, S.; Singh, N. Internet of Things (IoT): Security challenges, business opportunities & reference architecture for E-commerce. In Proceedings of the 2015 International Conference on Green Computing and Internet of Things (ICGCIoT), Greater Noida, India, 8–10 October 2015; pp. 1577–1581. [CrossRef]
72. Del Rio, A.; Conti, G.; Castano-Solis, S.; Serrano, J.; Jimenez, D.; Fraile-Ardanuy, J. A Guide to Data Collection for Computation and Monitoring of Node Energy Consumption. *Big Data Cogn. Comput.* **2023**, *7*, 130. [CrossRef]
73. Luong, N.C.; Hoang, D.T.; Wang, P.; Niyato, D.; Kim, D.I.; Han, Z. Data collection and wireless communication in Internet of Things (IoT) using economic analysis and pricing models: A survey. *IEEE Commun. Surv. Tutor.* **2016**, *18*, 2546–2590. [CrossRef]
74. Aripin, Z.; Paramarta, V. Utilizing Internet of Things (IOT)-based Design for Consumer Loyalty: A Digital System Integration. *J. Penelit. Pendidik. IPA* **2023**, *9*, 8650–8655. [CrossRef]
75. Hoyer, W.D.; Kroschke, M.; Schmitt, B.; Kraume, K.; Shankar, V. Transforming the customer experience through new technologies. *J. Interact. Mark.* **2020**, *51*, 57–71. [CrossRef]
76. Kirsal, Y.; Caglar, E. Analytical modelling and QoS evaluation of IoT applications in E-government. In Proceedings of the 19th European Conference on Digital Government (ECDG 2019), Nicosia, Cyprus, 24–25 October 2019. [CrossRef]
77. Sahoo, S.; Kumar, A.; Mishra, R.; Tripathi, P. Strengthening Supply Chain Visibility with Blockchain: A PRISMA-Based Review. *IEEE Trans. Eng. Manag.* **2024**, *71*, 1787–1803. [CrossRef]
78. Yu, Y.; Wang, X.; Zhong, R.Y.; Huang, G.Q. E-commerce logistics in supply chain management Implementations and future perspective in furniture industry. *Ind. Manag. Data Syst.* **2017**, *117*, 2263–2286. [CrossRef]
79. Wang, Y.; Chao, J.; Li, Y. Real-time information sharing model of product supply chain based on Internet of Things. *Int. J. Prod. Dev.* **2022**, *26*, 89–101. [CrossRef]
80. Fathi, M.; Marufuzzaman, M.; Buchanan, R.K.; Rinaudo, C.H.; Houte, K.M.; Bian, L. An Integrated Pricing, QoS-Aware Sensor Location Model for Security Protection in Society 5.0. *IEEE Trans. Eng. Manag.* **2023**, *70*, 3863–3875. [CrossRef]
81. Singh, A.; Garg, S.; Kaur, R.; Batra, S.; Kumar, N.; Zomaya, A.Y. Probabilistic data structures for big data analytics: A comprehensive review. *Knowl.-Based Syst.* **2020**, *188*, 104987. [CrossRef]
82. Fuchao, L. Research on the innovation of Liaoning public safety and security emergency management system from the perspective of smart city. In Proceedings of the 2018 7th International Conference on Industrial Technology and Management (ICITM), Oxford, UK, 7–9 March 2018. [CrossRef]
83. Kusiak, A. Smart manufacturing. *Int. J. Prod. Res.* **2018**, *56*, 508–517. [CrossRef]
84. Mantri, D.S.; Pawar, P.M.; Kulkani, N.P.; Prasad, N.R.; Prasad, R. Industry 5.0 and 6G: Human-centric approach. In *6G Connectivity-Systems, Technologies, and Applications: Digitalization of New Technologies, 6G and Evolution*; River Publishers: Aalborg, Denmark, 2024; pp. 21–41, ISBN 9781003515920.
85. Mourtzis, D.; Vlachou, E. Cloud-based cyber-physical systems and quality of services. *TQM J.* **2016**, *28*, 704–733. [CrossRef]
86. Pochyla, M. Internet of things: Big challenge for enterprises. In Proceedings of the 11th International Conference on Strategic Management and Its Support by Information Systems 2015, SMSIS, Uherske Hradiste, Czech Republic, 21–22 May 2015.
87. Alfaw, A.H.; Al-Omary, A. 5G Security Threats. In Proceedings of the 2022 International Conference on Data Analytics for Business and Industry, ICDABI, Sakhir, Bahrain, 25–26 October 2022. [CrossRef]
88. Rufus, R.; Esterline, A. Concatenating unprotected internet of things network event-driven data to obtain end-user information. In Proceedings of the 2017 26th International Conference on Computer Communications and Networks, ICCCN, Vancouver, BC, Canada, 31 July–3 August 2017.
89. Khomami, M.M.D.; Saghiri, A.M.; Rezvanian, A.; Meybodi, M.R. A Framework for Scalable Object Storage and Retrieval Considering Privacy Concerns: A Case Study on the Signature Detection. In Proceedings of the 2023 9th International Conference on Web Research, ICWR, Tehran, Iran, 3–4 May 2023. [CrossRef]
90. Mahlaba, J.; Mishra, A.K.; Puthal, D.; Sharma, P.K. Blockchain-Based Sensitive Document Storage to Mitigate Corruptions. *IEEE Trans. Eng. Manag.* **2022**, *71*, 12635–12647. [CrossRef]
91. Gao, W.; Wang, L.; Chen, M.; Xiong, J.; Luo, C.; Zhang, W.; Huang, Y.; Li, W.; Kang, G.; Zheng, C.; et al. High fusion computers: The IoTs, edges, data centers, and humans-in-the-loop as a computer. *BenchCouncil Trans. Benchmarks Stand. Eval.* **2022**, *2*, 100075. [CrossRef]
92. Skarlat, O.; Schulte, S.; Borkowski, M.; Leitner, P. Resource provisioning for IoT services in the fog. In Proceedings of the 2016 IEEE 9th International Conference on Service-Oriented Computing and Applications, SOCA, Macau, China, 4–6 November 2016. [CrossRef]
93. Tsourma, M.; Dasygenis, M. Development of a Hybrid Defensive Embedded System with Face Recognition. In Proceedings of the 19th IEEE International Conference on Computational Science and Engineering, 14th IEEE International Conference on Embedded and Ubiquitous Computing and 15th International Symposium on Distributed Computing and Applications to Business, Engineering and Science, CSE-EUC-DCABES, Paris, France, 24–26 August 2016. [CrossRef]

94. Yahyaoui, A.; Abdellatif, T.; Attia, R. READ: Reliable event and anomaly detection system in wireless sensor networks. In Proceedings of the 2018 IEEE 27th International Conference on Enabling Technologies: Infrastructure for Collaborative Enterprises, WETICE, Paris, France, 27–29 June 2018. [CrossRef]
95. Yang, K.C.; Huang, C.H.; Chianglin, C.Y. Combining IOT and Android APP System for Upper Limb Stroke Rehabilitation. In Proceedings of the 2018 IEEE International Conference on Industrial Engineering and Engineering Management (IEEM), Bangkok, Thailand, 16–19 December 2018. [CrossRef]
96. Yang, L.; Ye, M. The design and development of intelligent warehouse management system: Based on.NET and internet of things. In *International Conference on Logistics, Engineering, Management and Computer Science LEMCS*; Atlantis Press: Amsterdam, Netherlands, 2014. [CrossRef]
97. Yao, X.; Zhou, J.; Zhang, J.; Boer, C.R. From Intelligent Manufacturing to Smart Manufacturing for Industry 4.0 Driven by Next Generation Artificial Intelligence and Further on. In Proceedings of the 2017 5th International Conference on Enterprise Systems (ES), Beijing, China, 22–24 September 2017. [CrossRef]
98. Yaqoob, I.; Hashem, I.A.T.; Gani, A.; Mokhtar, S.; Ahmed, E.; Anuar, N.B.; Vasilakos, A.V. Big data: From beginning to future. *Int. J. Inf. Manag.* **2016**, *36*, 1231–1247. [CrossRef]
99. Ahram, T.; Sargolzaei, A.; Sargolzaei, S.; Daniels, J.; Amaba, B. Blockchain technology innovations. In Proceedings of the 2017 IEEE Technology & Engineering Management Conference (TEMSCON), Santa Clara, CA, USA, 8–10 June 2017. [CrossRef]
100. Chai, Y.; Miao, C.; Sun, B.; Zheng, Y.; Li, Q. Crowd science and engineering: Concept and research framework. *Int. J. Crowd Sci.* **2017**, *1*, 2–8. [CrossRef]
101. Deakin, M.; Reid, A. Smart cities: Under-gridding the sustainability of city-districts as energy efficient-low carbon zones. *J. Clean. Prod.* **2018**, *173*, 39–48. [CrossRef]
102. Zhou, X.; Wang, Y. Understanding competency requirements in the context of AEC industry informatization: Policy insights from China. *Eng. Constr. Archit. Manag.* **2023**. [CrossRef]