Exploring the Internet of Things adoption in the Fourth Industrial Revolution: a comprehensive scientometric analysis

Journal of Innovative Digital Transformation

Diana Teresa Parra-Sánchez
Centro de Innovación y Productividad InnovaCTIon, Río de Oro, Colombia

Received 7 July 2024
Revised 23 September 2024
Accepted 17 October 2024

Abstract

Purpose – This study examines the adoption of the Internet of Things (IoT) within the Fourth Industrial Revolution (4IR) context, using a comprehensive scientometric analysis to map the evolution of IoT adoption.

Design/methodology/approach – Utilising data sourced from Scopus and analysed through CiteSpace, this research encompasses documents from 2018 to early 2024. It employs a two-phase analysis methodology, starting with a descriptive exploration of publication trends that provides an overview of the IoT adoption field by presenting yearly publication statistics. The second phase of the study encompasses a detailed scientometric analysis, including co-citation and burst analysis.

Findings – The research underscores significant growth in IoT adoption studies and their broadening impact across various sectors. Key advancements include addressing security challenges, integrating IoT with emerging technologies like blockchain and artificial intelligence (AI) and applying these in critical areas such as agriculture and healthcare.

Practical implications – This article is a valuable resource for stakeholders in the digital ecosystem – including policymakers, educational institutions and industry leaders – engaged with IoT adoption in the context of the 4IR .

Originality/value – This article contributes to the literature by providing a scientometric analysis that charts the development of IoT adoption research within the framework of the fourth industrial revolution, presenting a unique perspective on its integration with other cutting-edge technologies.

Keywords IoT adoption, Technology adoption, Industry 4.0, Digital transformation

Paper type Literature review

1. Introduction

Adopting the Internet of Things represents a qualitative leap in how societies relate to technology, marking a milestone in the fourth industrial revolution (Hoosain *et al.*, 2020). This phenomenon is characterised by the creation of networks of physical objects integrated with technology capable of communicating and interacting with their internal state and the external environment (Atzori *et al.*, 2010). The expansion of IoT has been remarkable, showcasing an expenditure that exceeded 268 billion dollars across various sectors in 2022, with a projected compound annual growth rate of 15% from 2021 to 2025 (Gartner, 2023). This growth underscores the increasing massification and deployment of IoT, transforming

Declaration of generative AI and AI-assisted technologies in the writing process: During the preparation of this work, the author used ChatGPT to review the grammar of the text. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the publication.

Journal of Innovative Digital Transformation
Emerald Publishing Limited
e-ISSN: 2976-906X
p-ISSN: 2976-9051
DOI 10.1108/JIDT-06-2024-0013

it into a fundamental platform for developing new business models and reconfiguring existing ones.

Integrating IoT with other technologies is crucial for its adoption and expansion (Allioui and Mourdi, 2023). IoT complements artificial intelligence, big data, and cloud computing, enhancing efficiency and innovation across various industrial sectors (International Telecommunication Union, 2018). This technological symbiosis facilitates the analysis and management of large volumes of data generated by connected devices, paving the way towards process optimisation, the creation of personalised services, and improvement in decision-making.

Globally, the adoption of IoT has been uneven, reflecting significant variability among different industries and regions (McKinsey and Company, 2021). However, its penetration into large and small businesses has demonstrated the potential to transform operations, business models, and consumer interactions (Masood and Sonntag, 2020). Various theoretical references support the organisational adoption of IoT by analysing the benefits and challenges inherent in its implementation. Models such as the Technology Acceptance Model (TAM), the Technology-Organisation-Environment Model (TOE), and Rogers' Diffusion of Innovations model provide conceptual frameworks for understanding IoT adoption, highlighting factors such as perceived usefulness, ease of use, and social influence.

Specifically, for small and medium enterprises (SMEs), adopting IoT presents an opportunity to compete in increasingly globalised and technologically advanced markets (Parra-Sánchez, 2022). Applying specific theories, practices, and standards for IoT allows SMEs to overcome entry barriers and adapt to the dynamics of an ever-evolving business environment (Ahmetoglu *et al.*, 2022). The implementation of interoperability standards, the adoption of cybersecurity practices, and investment in training and technological development are key aspects that can facilitate the effective integration of IoT into SME operations, thereby allowing them to improve their efficiency, innovation, and competitiveness in the market (Gartner, 2017).

This article aims to explore the adoption of IoT within the context of the fourth industrial revolution, analysing its impact, the dynamics of integration with other technologies, and its global adoption, with a particular focus on the organisational realm, encompassing both large corporations and SMEs. Through this literature review, we seek to understand the theories underpinning IoT adoption and how these can be applied to maximise its potential in the business sphere. This leads us to address the following research question: How has the field of IoT adoption evolved within the context of the fourth industrial revolution? To answer this, we conducted a descriptive and scientometric analysis using CiteSpace v. 6.3.R1 (64-bit) Basic, considering 710 documents indexed in Scopus regarding IoT adoption. Our study reveals an increasing trend in publications on IoT adoption, indicating a burgeoning interest among researchers in this evolving area of study. This literature review aims to synthesise and report the key findings that have surfaced, shedding light on how the study of IoT adoption has advanced and expanded over time.

The paper is structured as follows. Section 2 presents the literature review. Section 3 describes the materials and methods used for data collection and analysis. Section 4 presents the results, including an overview of the IoT adoption field and the scientometric analysis. Section 5 discusses these findings, and Section 6 concludes the paper.

2. Literature review

The adoption of the Internet of Things has been a research topic of growing interest within the fourth industrial revolution, with numerous studies exploring its benefits, risks, and applications across various sectors. Brous *et al.* (2020) conducted a systematic review to analyse IoT adoption by organisations, focusing on associated benefits and risks. Using a

Big, Open, Linked Data (BOLD) categorisation, the authors explored the dual nature of technology, showing how IoT benefits in asset management can lead to unexpected social changes and organisational transformations. Ghosh *et al.* (2020) explored the opportunities IoT offers for the construction industry, employing scientometric techniques and a systematic review of 417 articles to identify and classify the main research areas associated with IoT in construction. The research highlights the need for more holistic and integrated approaches and outlines key drivers for successful IoT and digitisation technology adoption.

Maroli *et al.* (2021) conducted a systematic review to understand the IoT scenario in the agricultural sector. The authors reviewed 82 articles, highlighting that research efforts have evolved from conceptual stages to implementation phases, with extensive use of machine learning algorithms. Al-rawashdeh *et al.* (2022) synthesised knowledge on the factors influencing healthcare professionals' adoption of IoT applications through a systematic review. The authors analysed 22 articles, identifying the most used adoption theories and key adoption factors at individual and technological levels, providing deep insights into the barriers and opportunities for effective IoT implementation in healthcare.

Ahmetoglu *et al.* (2022) reviewed the literature on IoT adoption in organisations to develop a coherent taxonomy that can serve as a framework for future research. It highlights the essential features, benefits, and challenges of IoT in organisations and identifies six critical factors influencing IoT adoption, providing a comprehensive overview to understand this research field further. Kumar *et al.* (2023) focused on IoT adoption in Industry 4.0, synthesising existing knowledge using a systematic literature review with the SPAR-4-SLR framework. The authors developed an integrative conceptual framework, categorising antecedents based on the Technology-Organization-Environment framework and identifying significant research gaps for further investigation.

This article advances the existing body of research by offering a comprehensive and integrated perspective on the evolution of IoT adoption from 2018 to early 2024. Unlike studies that narrowly focus on specific economic sectors or applications, this research adopts a holistic view, capturing the dynamic shifts in focus, methodologies, and outcomes within the fourth industrial revolution. This extensive temporal analysis elucidates how the role and impact of IoT adoption have evolved in recent years. Additionally, this study conducts a descriptive analysis followed by a comprehensive scientometric analysis that uses CiteSpace to visualise and analyse citation networks while integrating findings across various sectors. This dual approach enriches the analysis by providing depth and breadth, distinguishing it from studies that employ these methods separately. Moreover, the research examines how IoT intersects with emerging technologies like blockchain and AI, highlighting the interdisciplinary nature of IoT research and its practical applications in sectors such as agriculture and healthcare. This exploration demonstrates how these technologies shape and influence IoT's development.

3. Materials and methods

The scientometric analysis was selected to study advancements in the adoption of the Internet of Things due to its unique capability to objectively map out the scientific knowledge published on this emerging topic. This analytical methodology is noted for its effectiveness in quantifying and evaluating scientific and academic research's production, distribution, and impact, allowing for identifying emerging trends, critical research paths, and significant contributions to IoT adoption. By adopting a scientometric approach, we aim to gain a comprehensive and detailed understanding of how IoT adoption and development have expanded and transformed over time, highlighting its dynamism and growing significance as a research area.

CiteSpace, a visual analytic tool for visualising landmarks, critical paths, and emerging trends in research fields based on relevant scholarly publications, plays a crucial role in this analysis (Chen, 2023). Designed to facilitate a deep understanding of structures and evolutions within a specific study domain, CiteSpace enables researchers to generate complex visualisations, such as co-citation maps and collaboration networks (Chen, 2022). These visualisations assist in pinpointing key areas of focus and evolution within the IoT adoption field, demonstrating how interactions between researchers, institutions, and technologies have shaped the development of this burgeoning area.

As an emergent research topic, applying scientometric analysis to the study of IoT adoption aims to unravel the adoption patterns, technological innovations, and practical applications that characterise this field. This approach highlights the exponential growth of interest and investment in IoT and reveals how this technology intersects with other fields to forge innovative solutions.

IoT's rapid expansion and transformative potential across various sectors, from agriculture to healthcare, demonstrate its emergent nature. This characteristic positions it as a research area of critical importance whose study can provide crucial insights into the future of technology and its societal impact.

The findings from the scientometric analysis are essential for various stakeholders, including policymakers, educational institutions, and industry leaders. These findings shed light on rapidly developing areas, emerging opportunities within the IoT adoption field, and current challenges and limitations. This scientometric analysis provides a comprehensive and updated view of the state of research on IoT adoption, serves as an invaluable guide for future investigations, encourages strategic collaborations, and informs policies that support the effective development and adoption of IoT technologies.

3.1 Data collection

For the data collection of this study, the Scopus database was selected as the primary source of information. Scopus was chosen for its recognised breadth and neutrality as an abstract and citation database that indexes a vast number of journals, conference proceedings, and other sources covering multiple disciplines and fields of knowledge (Elsevier B.V, 2024). This feature is particularly beneficial for analysing a topic as interdisciplinary and far-reaching as the adoption of IoT. The database enables a comprehensive analysis that addresses the complexity and diversity inherent in IoT adoption, facilitating a holistic approach that captures the various perspectives and approaches applied in this emerging field of study.

During the data collection phase, a specific search string was used: ("IoT adoption" OR "Internet of Things adoption" OR "adoption of IoT" OR "adoption of Internet of Things"). This search strategy was designed after conducting several preliminary tests, where initially only the term "IoT adoption" was used. Including abbreviations and full terms in the search string was a strategic decision to maximise the retrieval of relevant documents, reflecting a thorough approach that ensures broad coverage of the existing literature on the topic.

The selection of documents for analysis started in 2018 and extended through March 5, 2024. This period was chosen based on preliminary tests in CiteSpace, where the basic version's node limit of 300 necessitated a reduction in the number of years under consideration to manage the data effectively within the tool's constraints. For this study, only articles and conference proceedings published in English were considered, without additional inclusion or exclusion criteria. The search yielded 710 publications, demonstrating the relevance and growing interest in IoT adoption. Data retrieval was conducted by searching the descriptors in the article title, abstract, and keywords, with a data retrieval time recorded at 6:29 a.m. on March 5, 2024.

3.2 Data analysis

Our analysis of the data from the Scopus database involved two main phases, each with specific objectives that significantly contribute to the knowledge area concerning IoT adoption. These phases allow for an understanding of the current state of research in this field and the identification of emerging trends and areas of increasing interest. Below, we detail the phases and their contributions to the knowledge area:

3.2.1 Phase 1: descriptive analysis. The first phase concentrated on analysing publication trends in IoT adoption from 2018 to early 2024. This study segment detailed the number of documents published annually, revealing an upward trend in research interest and output.

3.2.2 Phase 2: co-citation analysis and burst analysis. The second phase of the analysis used CiteSpace v. 6.3.R1 (64-bit) Basic to extract co-citation analysis for co-cited references and conduct burst analysis. Co-citation analysis is crucial for identifying the most influential publications or authors in IoT adoption. Examining how documents cite each other helps uncover the foundational works that have defined and directed research in this area, facilitating an understanding of knowledge networks and collaboration. Burst analysis, on the other hand, focuses on identifying the most rapidly growing research areas in IoT adoption and those that have received less attention over time. This technique identifies emerging themes and turning points in research, indicating new developments and approaches that capture the academic community's interest.

We utilised a dataset exported from Scopus in.csv format containing 710 documents. This dataset was converted into the Web of Science (WoS) format using CiteSpace. This conversion is essential as CiteSpace typically requires data in WoS format to analyse and visualise citation networks properly. The configuration of CiteSpace was set to analyse the dataset from January 2018 to 2024, focusing on the most recent trends and developments in the field. This timeframe allows for a more detailed examination of current patterns without overwhelming the system's capacity.

We did a detailed analysis of clusters using Latent Semantic Indexing (LSI), Log-Likelihood Ratio (LLR), and Mutual Information (MI) in the scientometric analysis during this phase.

Latent Semantic Indexing is a natural language processing technique to discern patterns in the relationships between terms and concepts across large data sets. In our scientometric analysis, LSI was instrumental in deriving labels for each cluster by analysing the abstracts and titles of the included documents. It deciphers the underlying semantics or meanings of words, facilitating the identification of central themes or topics within each cluster.

The Log-Likelihood Ratio is another method to pinpoint significant words or phrases tied to each cluster. It involves comparing the likelihood of a particular term's frequency within a specific cluster against its frequency across the entire dataset. A term's higher LLR value suggests a more unique association with that cluster, thereby effectively representing the cluster's focus. LLR is pivotal in identifying the distinctive terms that set one cluster apart, thus illuminating the specific research frontiers within the IoT adoption field.

Mutual Information quantifies the information gained about one random variable through another. In our study, MI identified terms strongly associated with the clusters, measuring the dependency between a term's occurrence and the presence of documents in a particular cluster. High MI values indicate that the presence of certain terms significantly informs the cluster's content, making them suitable labels.

By integrating these three methodologies—LSI, LLR, and MI—we compiled a comprehensive set of labels for each cluster. These labels mirror each cluster's core topics and themes and underscore the unique research focuses within the broader domain of IoT adoption. This layered analytical approach provided a deep understanding of the IoT adoption research landscape, identifying overarching themes and subtle distinctions across clusters.

4. Results and analyses

4.1 Overview of the field of IoT adoption

The publication trend on IoT adoption from 2018 to early 2024 demonstrates a positive trajectory with significant annual fluctuations. In 2018, 55 documents were published. The following year saw a notable increase, with 85 documents published, marking a 54.55% increase over the previous year. This upward trend continued with subsequent increases of 16.47% in 2020 (99 documents published), 11.11% in 2021 (110 documents published), 29.09% in 2022 (142 documents published), and a significant 33.1% increase in 2023 (189 documents published), reflecting robust and sustained interest in IoT adoption across various research areas. It is important to note that the data for 2024 only covers up to March 5th, with 30 documents published to date.

These statistics demonstrate the variability in interest and research in IoT adoption over the years, highlighting a dynamic and evolving field of study. The observed decline in 2024 warrants careful consideration due to the partial nature of the data; however, the overall trend underscores the increasing significance of IoT and its transformative impact on various industrial and academic sectors.

4.2 Scientometric analysis

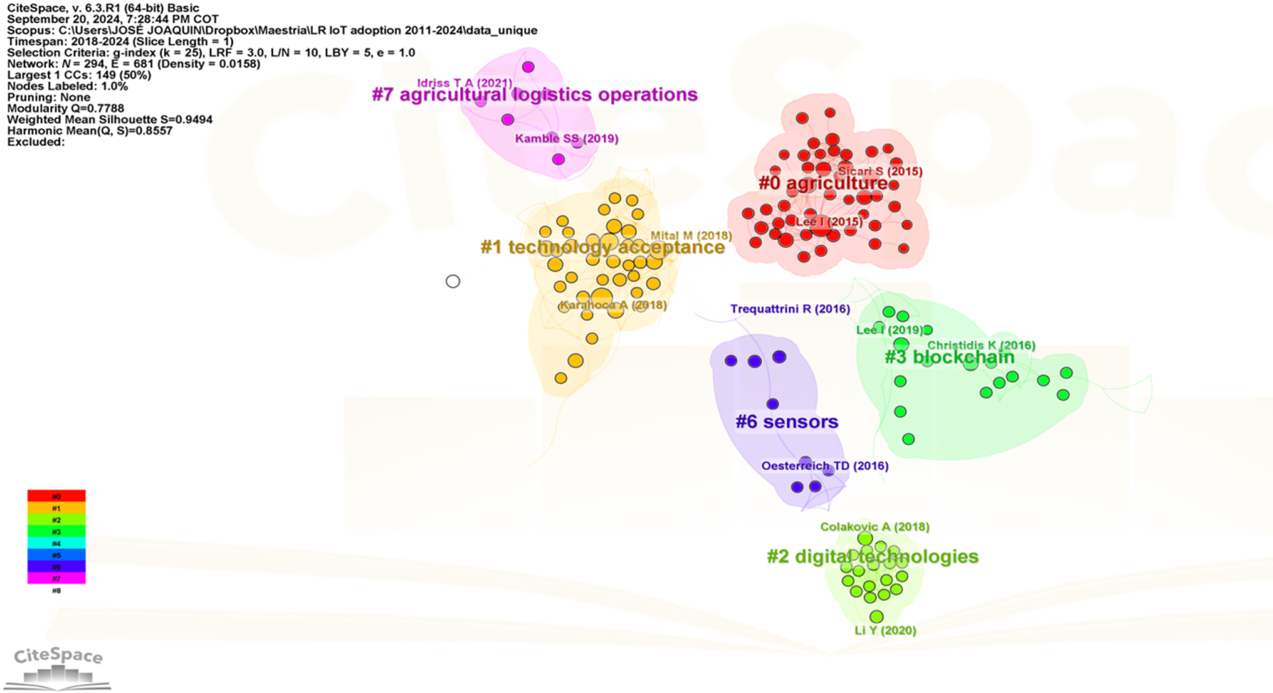
4.2.1 The co-cited reference network. The co-cited reference network analysis illustrates the evolving research trends, clusters, and focal points within the literature on IoT adoption. This analysis, visualised through a network comprising 294 nodes and 681 links, showcases a moderate level of interconnectivity with an overall density of 0.0158. Although far from the maximum density of 1.00, indicative of a highly centralised and interconnected network, this density value still underscores the network's clarity and influence (see Figure 1). The network's weighted mean silhouette score of 0.9494 and modularity score of 0.7788 also show that the clustering results on the network map are very reliable, pointing to clear and important research clusters.

Table 1 details the six clusters, each with a size of at least eight and indicating a minimum number of citing articles per cluster. A cluster's size represents its breadth regarding the number of articles it encompasses. In contrast, each cluster's mean number of articles indicates the recency of research activities. Additionally, these clusters' log-likelihood ratios labels highlight the cutting-edge research frontiers within this domain.

The co-cited reference network analysis shows IoT adoption is a dynamically emerging research area. The segmentation into distinct clusters reflects a multifaceted exploration of IoT adoption across various dimensions, including technological, organisational, and societal implications. IoT adoption is at the forefront of academic inquiry, as indicated by the mean year of clusters and the active citation dynamics. Based on this literature review, IoT adoption is a complex, rapidly evolving topic that spans technical advancements, strategic implementations in organisations, and broader societal impacts, underscoring its significance and potential for profound influence in current and future technological landscapes.

The following section details the six clusters and explains the labels obtained through Latent Semantic Indexing, Log-Likelihood Ratio, and Mutual Information.

The largest cluster (#0), labelled "Agriculture," encapsulates a focal area of research within the domain of IoT adoption. This cluster, comprising 47 documents with a high silhouette score of 0.938, underscores the cohesiveness and thematic consistency of the works within it. The average publication year of 2015 suggests that the research topics encapsulated within this cluster gained prominence in the mid-2010s, reflecting the evolving nature of IoT adoption discussions.



Source(s): Citespace

Figure 1.
References co-occurrence network

The labels obtained through LSI reveal a concentration on "digitalisation," "connectivity," "embedded systems," "innovation," and "technologies," alongside direct references to "IoT adoption." This suggests a broad exploration of IoT's technological foundations and innovative aspects (Lee and Lee, 2015), as well as its practical implications in fields such as agriculture (Jayashankar *et al.*, 2018) and healthcare (Xu *et al.*, 2018), as indicated by the LLR labels. Including "behavioural reasoning theory" and "wireless sensor networks" among the LSI labels indicates an interest in understanding the motivations behind IoT adoption (Sicari *et al.*, 2015) and the technical challenges involved (Haddud *et al.*, 2017), respectively.

The cluster spans significant sectors like agriculture and healthcare, indicating a focused interest in how IoT technologies can revolutionise these fields through enhanced digital transformation (Tripathi, 2019), RFID technology, and the application of "Micmac" analysis (a method for systemic and strategic planning) (Janssen *et al.*, 2019). The specificity of sectors such as agriculture and healthcare in the LLR labels underscores IoT solutions' applicability and transformative potential in addressing sector-specific challenges and opportunities.

Lastly, the MI label "behavioural reasoning theory" hints at a theoretical underpinning for dissecting the decision-making processes behind IoT adoption (Pillai and Sivathanu, 2020). The reference to "control and automation" in the MI labels suggests a particular interest in how IoT adoption can enhance control mechanisms and automation within these sectors.

The second largest cluster (#1), "Technology acceptance," encompasses 39 documents and showcases a notable silhouette score of 0.939, indicating strong internal coherence and thematic alignment among its constituent research papers. The cluster's average publication year, 2019, serves as a reference point highlighting significant developments within a relatively short span, underlining ongoing and emergent trends in IoT adoption.

The cluster's thematic focus, as revealed through LSI, centres on "digital transformation," "technology adoption," "elderly patients," "specific factors," and "virtual reality." This indicates a nuanced exploration of how various demographic groups (Chohan and Hu, 2020), including the elderly (Jo *et al.*, 2021), shape and impact digital transformation and technology adoption processes, and how these processes integrate specific technological solutions like virtual reality. The mention of "smart campus" alongside "end-user specific factors," "environmental-specific factors," and "organisational-specific factors" underlines a multidimensional approach to understanding IoT adoption, emphasising the importance of context-specific factors in shaping technology integration and acceptance (Ali *et al.*, 2023; Sneesl *et al.*, 2022).

The LLR labels further refine the cluster's focus, highlighting "technology acceptance" and "smart campus" as significant themes, along with "IoT," "adoption," and "agriculture." These labels suggest a broad spectrum of interest within the cluster, from theoretical frameworks for technology acceptance to practical applications of IoT in educational settings (smart campuses) (Sneesl *et al.*, 2022) and agriculture (Vadivelu *et al.*, 2023). This

Table 1.
Clusters information

Cluster-ID	Size	Silhouette	Mean (Year)	LLR
0	47	0.938	2015	Agriculture
1	39	0.939	2019	Technology acceptance
2	19	0.99	2019	Digital technologies
3	18	0.918	2017	Blockchain
6	8	0.955	2017	Sensors
7	8	0.982	2020	Agricultural logistics operations

Source(s): Table created by authors

indicates an interdisciplinary approach to IoT adoption, linking theoretical models with real-world implementations.

The MI labels provide additional insights, identifying "elderly patients" (Malarvizhi *et al.*, 2023) and "education" (Masadeh and El-Haggar, 2023) as key areas of focus. These mentions align with the cluster's emphasis on demographic-specific and sector-specific studies, exploring how IoT technologies can benefit elderly populations and educational environments.

The third largest cluster (#2), labelled "Digital technologies," consists of 19 documents and boasts a remarkably high silhouette score of 0.99, indicating an exceptionally cohesive and well-defined research grouping within the field. The average publication year 2019 highlights the cluster's focus on contemporary issues and advancements. The predominant themes, as depicted through various labelling techniques (LSI, LLR, MI), converge on "operations management," "digital technologies," "artificial intelligence," and "digital transformation," reflecting a convergence of management practices and cutting-edge technologies within the scope of IoT adoption.

The labels derived from LSI and LLR consistently emphasise the integration of digital technologies and artificial intelligence into operations management as a critical facet of digital transformation (Rocha and Kissimoto, 2022). This indicates a significant interest in how IoT, as part of a broader digital technology toolkit, reshapes operations management. The strong alignment between LSI and LLR labels on these themes suggests a focused and in-depth exploration of these areas within the cluster.

The LLR scores particularly underscore the importance of "digital technologies" and "artificial intelligence," reaffirming their central role in the ongoing transformation within operations management practices.

While more concise, MI labelling reinforces the cluster's strong focus on "digital technologies" and "artificial intelligence." Despite the relatively low MI value, it highlights the cluster's thematic concentration, emphasising these areas as key contributors to the discourse on operations management in digital transformation.

The fourth largest cluster (#3), labelled "Blockchain," comprises 18 documents and demonstrates a high silhouette score of 0.918, indicating a well-defined and coherent set of research works. The average publication year of 2017 suggests that the research within this cluster primarily focuses on earlier stages of the developments in IoT adoption that are still influencing current trends. The themes identified through LSI, LLR, and MI labelling techniques highlight a blend of technological and organisational aspects of IoT adoption, particularly within medium enterprises.

The LSI labels such as "IoT adoption," "medium enterprises," "TOE (Technology-Organisation-Environment) framework," "digital transformation," and "logit model" suggest a focus on the factors influencing IoT adoption in medium-sized businesses. Including specific methodologies and frameworks indicates a rigorous approach to understanding the multifaceted nature of technology adoption processes.

The LLR labels reveal a broader technological scope, mentioning "blockchain," "fog computing," "smart home," "smart contract," and "distributed systems." These labels suggest that the cluster's research goes beyond IoT adoption in enterprises to explore the integration of emerging technologies that can enhance or influence the adoption process (Parra-Sánchez and Guerrero, 2020). The emphasis on blockchain and smart contracts points to an interest in security, privacy, and efficiency in IoT implementations (Andrea *et al.*, 2015; Qashlan *et al.*, 2021).

The MI labels underscore the importance of "fog computing" and "smart home" in the cluster, emphasising specific domains actively pursuing IoT adoption (Mayer *et al.*, 2021). The mention of "fog computing" aligns with a growing interest in decentralised computing architectures that can support IoT devices by providing localised processing and storage capabilities. Similarly, “smart home” technology represents a practical application area for IoT, emphasising user-centric considerations in adoption studies.

The fifth largest cluster (#6), “Sensors,” comprises eight documents with an impressive silhouette score of 0.955, suggesting a highly cohesive and focused group of research within the domain. The cluster’s average publication year of 2017 focuses on concepts and methodologies that have been pivotal during this period in understanding IoT adoption. The cluster engages with theoretical frameworks and analytical tools to dissect the intricacies of adopting IoT technologies.

The LSI labels—“technology acceptance model,” “gratifications theory,” “IoT adoption,” “information systems success model,” and “scientometric analysis”—indicate a strong emphasis on established models and theories to evaluate and understand the factors influencing IoT adoption (Kim and Wang, 2021). This indicates a scholarly endeavour to apply and possibly extend these models within the context of IoT, providing insights into user acceptance and the success of information systems incorporating IoT technologies.

The LLR labels enrich this narrative by pinpointing “scientometric analysis,” “strategic roadmap,” “information systems success model,” “computerised system,” and “technology acceptance model” as key themes. This suggests an analytical approach to studying IoT adoption, employing scientometric analysis to map the research landscape and identify emerging trends and gaps. The focus on strategic roadmaps and the information systems success model further indicates a strategic and evaluative perspective on implementing IoT solutions effectively.

MI labels such as “sensors,” “actuators,” “computerised systems,” and “industry 4.0” highlight the technological components and industrial context of IoT adoption. These terms underscore the physical infrastructure and the paradigm of the fourth industrial revolution, where IoT adoption is a critical component. This technological emphasis complements the theoretical focus, suggesting a comprehensive approach encompassing both the abstract models of technology acceptance and the tangible aspects of IoT systems.

The sixth largest cluster (#7), labelled “Agricultural logistics operations,” comprises eight documents and showcases an exceptionally high silhouette score of 0.982. This indicates a highly cohesive cluster with strong internal consistency and focus. The average publication year of 2020 suggests that this cluster represents some of the most recent research within the IoT adoption domain, focusing on innovative methodologies and their application to specific sectors like agriculture and food supply chains.

The labels that come from LSI and LLR show that there is a specific interest in using grey theory methods like “grey Delphi” and “grey DEMATEL,” along with “systematic literature review” and “meta-synthesis method.” These methodologies are renowned for handling uncertainty and limited data, which are common challenges in emerging research areas. The focus on “agricultural logistics operations” (Rajabzadeh and Fatorachian, 2023) and “the food supply chain” (Singh *et al.*, 2023) shows that these methods are being used specifically to address key success factors and operational efficiency in these areas.

This focus is strengthened by the LLR, which gives “agricultural logistics operations,” “food supply chain,” “grey Delphi,” “systematic literature review,” and “meta-synthesis method”, all high relevance scores. This uniformity in relevance scores across diverse yet interrelated themes suggest a comprehensive approach to tackling the complexities and challenges within agricultural logistics and food supply chains through advanced analytical techniques.

The MI label further supports the cluster’s thematic concentration on “agricultural logistics operations” and “food supply chain,” albeit with a relatively low MI score (0.08). While the cluster focuses on these areas, the interconnections between the specific themes may not be as tightly integrated as within other clusters, suggesting that the field is still evolving.

Switching to a timeline view of the co-occurrence network allows us to delve deeper into the temporal dynamics of IoT adoption research (see Figure 2). This perspective reveals how the focus areas within IoT adoption have evolved and highlights the temporal coverage of each identified cluster. Cluster 0, which spans from 2013 to 2019, represents one of the longest-running clusters over seven years, indicating sustained research interest in themes related to digitalisation, connectivity, and embedded systems within the IoT domain during these years. Similarly, Cluster 1 and Cluster 3, each extending over six years from 2017 to 2022 and from 2015 to 2020, respectively, signify ongoing research efforts in areas such as digital transformation, technology adoption, and the integration of IoT in specific contexts like smart campuses and healthcare.

Cluster 2, from 2017 to 2021, reflects 5 years of concentrated research into the interplay between operations management, digital technologies, artificial intelligence, and digital transformation in the context of IoT. Cluster 6, also spanning five years from 2016 to 2020, delves into theoretical frameworks such as the technology acceptance model and the information systems success model, suggesting a focus on understanding the drivers behind IoT adoption. Cluster 7, the most recent cluster running from 2019 to 2022 over 4 years, explores the application of grey theory methods to food supply chains and agricultural logistics, highlighting the latest methodological approaches to studying IoT adoption.

The timeline view highlights that the clusters capture the most recent research up to 2022, with no clusters actively continuing into 2023 or the current year, 2024. This observation indicates that, while the scientometric analysis has provided a comprehensive overview of the evolution of IoT adoption research until 2022, further updates and analyses would be necessary to capture the latest trends and clusters emerging in 2023 and beyond. The absence of clusters for these years may reflect the data collection cut-off or an emerging gap in the literature that future research could address, marking an opportunity for scholars to contribute new insights into the continuously evolving field of IoT adoption.

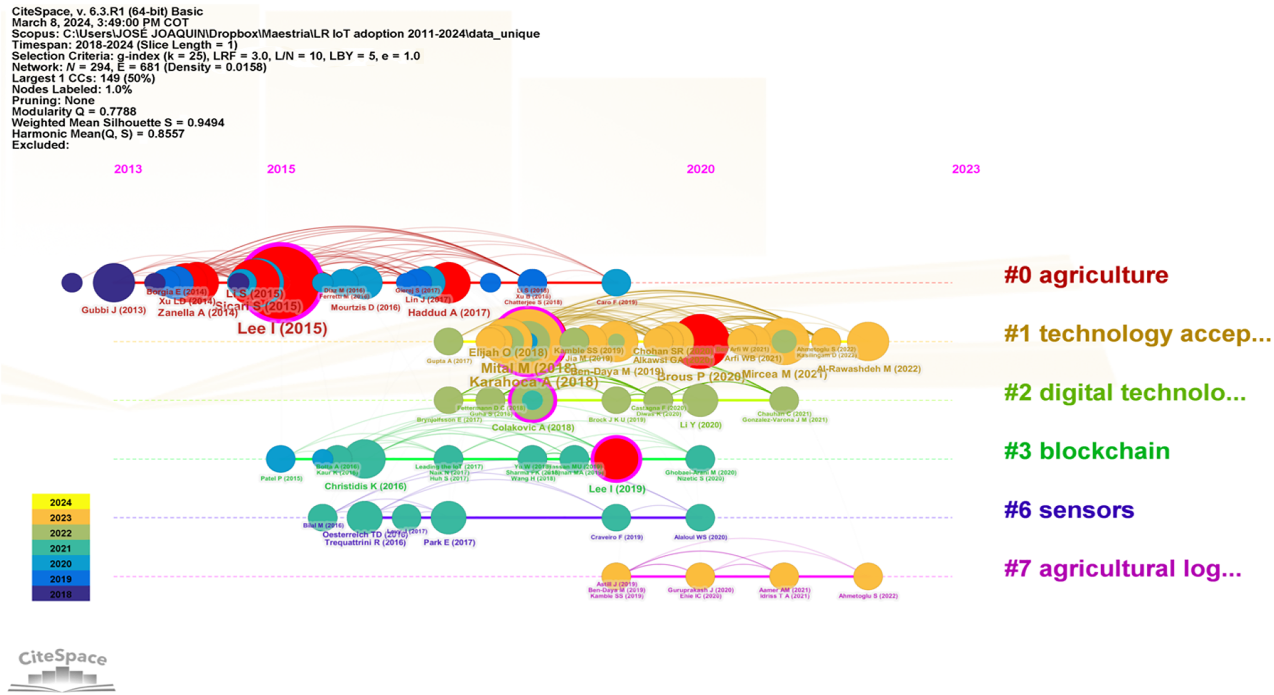
4.2.2 Burst references analysis. Identifying the most active research areas in IoT adoption is crucial for understanding the evolution of topics and trends within this field. Since the emergence of publications in 2011, the literature on IoT adoption has consistently expanded. A pivotal method for pinpointing these dynamic research areas is the analysis of citation bursts, which indicate a sudden and significant increase in citations for specific works over a brief period. This surge reflects a growing interest and recognition by the academic community, marking the works as influential within the domain of IoT adoption. Such analyses offer a window into the developmental trajectory of research focal points.

Table 2, derived from a citation burst analysis in CiteSpace, showcases references with the most pronounced citation bursts. It sheds light on the vibrant topics of interest within the IoT adoption landscape and reveals several key publications that have notably impacted the discourse on IoT adoption.

Lee and Lee (2015) focused on the applications, investments, and challenges for enterprises regarding IoT, which is at the forefront of these influential works. The authors introduced five crucial IoT technologies for implementing effective IoT-based products and services. They also examined three specific IoT categories for enterprise applications aimed at improving customer value. Its citation burst of 5.31 illustrates its critical role in shaping enterprise engagement with IoT technologies. Following closely, Karahoca *et al.* (2018), exploring the critical factors influencing individuals' intention to adopt IoT in healthcare technology products, exhibit a burst of 3.21, highlighting the growing intersection of IoT and healthcare.

Zanella *et al.* (2014) surveyed the enabling technologies, protocols, and architecture for an urban IoT. The paper has a burst of 2.54, which signals the significance of IoT in urban development and smart city initiatives. Li *et al.* (2015) investigated the definitions, architecture, basic technologies, and applications of IoT. Xu *et al.* (2014) explored the

Figure 2.
Timeline view



Source(s): Citespace

Begin	End	Span	Strength	Year	Citation	Cluster-ID
2018	2020	3	5.31	2015	Lee and Lee (2015)	0
2018	2019	2	2.54	2014	Zanella *et al.* (2014)	0
2018	2020	3	2.08	2015	Li *et al.* (2015)	0
2018	2019	2	2.03	2014	Xu *et al.* (2014)	0
2020	2021	2	1.81	2019	Lee (2019)	3
2020	2021	2	1.81	2017	Haddud *et al.* (2017)	0
2022	2024	3	3.21	2018	Karahoca *et al.* (2018)	1
2022	2024	3	1.79	2020	Brous *et al.* (2020)	1

Source(s): Table created by authors

Table 2. Top 8 burst references

enabling technologies, IoT applications in industry, and research trends and challenges. Both papers showed much interest in IoT applications and industrial integration, with 2.08 and 2.03 bursts, respectively.

Further contributions include Haddud *et al.* (2017) examination of IoT integration's potential benefits and challenges in supply chains and Lee (2019) exploration of IoT ecosystems for enterprises, featuring bursts of 1.81. Brous (2020) systematic review on the dual effects of IoT adoption by organisations, with a burst of 1.79, underscores the nuanced benefits and risks associated with IoT implementation.

These findings from the citation burst analysis elucidates the dynamic and evolving nature of IoT adoption research. From enhancing enterprise operations and fostering smart city development to revolutionising healthcare and addressing supply chain integration challenges, the highlighted publications reflect the multifaceted impact of IoT across various sectors. The analysis underscores the pivotal role of IoT in driving innovation and transformation in the era of the fourth industrial revolution, signalling ongoing areas of interest and emerging directions for future research.

5. Discussion

The scientometric analysis unveils a dynamic and multifaceted evolution of the IoT adoption field within the context of the fourth industrial revolution. From the early stages, which focused on understanding the potential and challenges of interconnecting electronic devices, to current discussions addressing the integration of advanced technologies and their applications across various sectors, research on IoT adoption has undergone several significant phases.

Research initially focused on the fundamentals of IoT and its revolutionary potential for device interactions (Lee and Lee, 2015). Security, interoperability, and privacy emerged as key concerns, reflecting the need for a solid foundation for effective IoT deployment (Sicari *et al.*, 2015). Security issues were highlighted due to the vulnerability of interconnected devices to breaches and cyber-attacks, which could potentially compromise personal and organisational data. Concerns about interoperability were crucial to ensuring that devices from different manufacturers could work together without compatibility issues, facilitating broader adoption and functionality of IoT systems. Privacy concerns were intensified by the extensive data collection involved in IoT operations, raising significant questions about data handling, user consent, and data rights. These concerns underscored the essential need for robust technical standards and frameworks to ensure the secure, efficient, and ethical deployment of IoT technologies, thus establishing a solid foundation for their widespread adoption and effectiveness in various applications (Andrea *et al.*, 2015).

As the years progressed, the field expanded significantly, exploring IoT's application in specific contexts such as health and agriculture. In healthcare, IoT technologies have been explored for their potential to revolutionise patient care through enhanced data collection and monitoring, telemedicine, and personalised treatment plans that leverage real-time health data (Al-rawashdeh *et al.*, 2022). Meanwhile, IoT adoption has been examined in the agricultural sector for its ability to improve efficiency and sustainability through precision farming techniques that optimise resource use and crop management, thus contributing to food security (Maroli *et al.*, 2021).

Studies began to address how IoT could serve as a critical enabler for the 4IR, driving automation and operational efficiency (Hoosain *et al.*, 2020). This period of exploration and expansion was followed by consolidation and integration, focusing on the integration of IoT with other emerging technologies like artificial intelligence, big data, and cloud computing (Rocha and Kissimoto, 2022). A notable shift towards integrating IoT with cutting-edge technologies like blockchain emerged, reflecting a broader understanding of the complex security, privacy, and operational demands of IoT applications (Qashlan *et al.*, 2021). Research has concentrated on the organisational adoption of IoT, analysing determinants, barriers, and strategies for successful integration (Masadeh and El-Haggar, 2023). The most recent phase has shown a trend towards specialisation, with studies employing advanced methodologies like the grey Delphi and DEMATEL analysis and exploring IoT in sectors with high innovation demands, such as food supply chains and agricultural logistics (Singh *et al.*, 2023).

The evolution of the IoT adoption field has fostered interdisciplinary collaboration, bringing together researchers from technology, business management, and applied disciplines to address the complex challenges of effectively implementing IoT technologies. The analysis highlights IoT's transformative potential in key sectors for the 4IR, emphasising how strategic adoption of these technologies can lead to significant advancements in efficiency, sustainability, and competitiveness. We observe a clear evolution towards deeper technological integration, underscoring the importance of technological convergence to maximise the 4IR's impact.

From a theoretical perspective, the diversity and evolution of themes identified in the scientometric analysis underscore the importance of enriching the theoretical corpus for IoT adoption. This implies delving deeper into technology adoption theories, such as the Technology Acceptance Model, the Technology-Organisation-Environment Model, and Rogers' Diffusion of Innovations model, specifically in the IoT context. The integration of IoT across different sectors (healthcare and agriculture) suggests a need for interdisciplinary research approaches. Studying IoT adoption from multiple perspectives can reveal how interactions between technologies, individuals, and organisational processes facilitate or inhibit adoption. Finding research areas and themes that change quickly through burst and cluster analyses shows that IoT adoption is a dynamic process that requires ongoing consideration of how technological changes, user expectations, and regulations impact adoption theories.

On the practical side, organisations must develop clear policies and robust protection measures that ensure the security and privacy of IoT systems while maintaining interoperability between different IoT devices and systems. This involves creating standardised security protocols and privacy guidelines that can be universally applied to protect user data and ensure seamless device integration. Likewise, the increasing deployment of IoT technologies across various sectors should inform and guide policy-making. Governments are key in setting industry standards, facilitating cross-sector collaboration, and providing incentives such as tax breaks or funding for IoT projects. Such policies can help overcome barriers to adoption and stimulate innovation.

As IoT technologies evolve rapidly, there is a significant need for continuous learning and skill development. The insights suggest developing educational programmes to equip current and future professionals to manage and work with advanced IoT systems. This includes interdisciplinary training covering IoT's technical, managerial, and ethical aspects. In addition, educational institutions and industry leaders should work together to develop curricula that address the multifaceted challenges of IoT, from technical setup and maintenance to ethical management and policy implications. This collaboration can help ensure educational offerings keep pace with technological advancements and industry needs.

To harness the full potential of IoT and ensure its successful integration into various domains, there is a need for open innovation and collaboration among policymakers, educational institutions, and industry leaders. Such collaborations can facilitate sharing of knowledge, resources, and best practices, leading to more innovative solutions and the effective implementation of IoT. The insights emphasise creating ecosystems where stakeholders from different sectors can collaborate on IoT projects. This could involve partnerships for research, development, and deployment of IoT solutions that address specific societal or business needs. The creation of such collaborative ecosystems is crucial, as it can help accelerate the adoption of IoT by pooling expertise, reducing costs, and creating more tailored and effective solutions.

6. Conclusion and future work

Our comprehensive scientometric analysis has charted the evolution of the adoption of the Internet of Things within the fourth industrial revolution from 2011 to early 2024, providing a detailed map of the growth and transformation of this field. By employing CiteSpace to visualise and analyse the connections within the body of literature, we have identified several distinct clusters that highlight the interdisciplinary nature and dynamic development of IoT adoption research.

The cluster analysis revealed diverse research areas, each reflecting a unique aspect of IoT development. For instance, the largest cluster focused on IoT adoption in agriculture, suggesting a robust interest in applying IoT to enhance efficiency and sustainability in farming practices. Another significant cluster revolved around technology acceptance, pointing to ongoing research into how businesses and consumers embrace IoT technologies. Emerging technologies such as blockchain and AI have been pinpointed in separate clusters, indicating their growing importance in enhancing the security and efficiency of IoT systems. These clusters answer the primary question of how IoT adoption has evolved and highlight the critical areas of technological integration, security concerns, and sector-specific applications.

Our analysis shows that the field has moved from basic discussions of IoT connectivity to more complex integrations with advanced technologies. The focus has broadened from technical implementations to include significant considerations of privacy, security, and cross-sectoral applications, particularly in agriculture and healthcare. This evolution reflects a maturing field that increasingly addresses the practicalities and challenges of IoT in a digitally transformed world.

Security and privacy concerns have gained prominence as IoT becomes more entrenched in critical infrastructure and everyday devices. The analysis of influential papers and citation bursts within our scientometric review has highlighted that addressing these concerns is a recurring and growing area of focus, necessitating ongoing research and innovative solutions to protect data and ensure user privacy in IoT networks.

Overall, our analysis suggests that future research should continue to explore the technological and theoretical aspects of IoT adoption and address the socio-economic and educational challenges that limit IoT's potential in less developed regions. This balanced approach will ensure that IoT can contribute to global development goals, reduce the digital divide, and foster sustainable development across the globe.

References

Ahmetoglu, S., Che Cob, Z. and Ali, N. (2022), "A systematic review of Internet of Things adoption in organizations: taxonomy, benefits, challenges and critical factors", *Applied Sciences*, Vol. 12 No. 9, 4117, doi: 10.3390/app12094117.

Al-rawashdeh, M., Keikhosrokiani, P., Belaton, B., Alawida, M. and Zwiri, A. (2022), "IoT adoption and application for smart healthcare: a systematic review", *Sensors*, Vol. 22 No. 14, 5377, doi: 10.3390/s22145377.

Ali, I., Aboelmaged, M., Govindan, K. and Malik, M. (2023), "Understanding the key determinants of IoT adoption for the digital transformation of the food and beverage industry", *Industrial Management and Data Systems*, Vol. 123 No. 7, pp. 1887-1910, doi: 10.1108/IMDS-02-2022-0082.

Allioui, H. and Mourdi, Y. (2023), "Exploring the full potentials of IoT for better financial growth and stability: a comprehensive survey", *Sensors*, Vol. 23 No. 19, 8015, doi: 10.3390/s23198015.

Andrea, I., Chrysostomou, C. and Hadjichristofi, G. (2015), "Internet of Things: security vulnerabilities and challenges", *2015 IEEE Symposium on Computers and Communication (ISCC)*, IEEE, pp. 180-187, doi: 10.1109/ISCC.2015.7405513.

Atzori, L., Iera, A. and Morabito, G. (2010), "The Internet of Things: a survey", *Computer Networks*, Vol. 54 No. 15, pp. 2787-2805, doi: 10.1016/j.comnet.2010.05.010.

Brous, P., Janssen, M. and Herder, P. (2020), "The dual effects of the Internet of Things (IoT): a systematic review of the benefits and risks of IoT adoption by organizations", *International Journal of Information Management*, Vol. 51, 101952, doi: 10.1016/j.ijinfomgt.2019.05.008.

Chen, C. (2022), "How to use CiteSpace", available at: https://citespace.podia.com/citespace-standard

Chen, C. (2023), "CiteSpace", available at: https://citespace.podia.com/ (accessed 11 April 2023).

Chohan, S.R. and Hu, G. (2020), "Success factors influencing citizens' adoption of IoT service orchestration for public value creation in smart government", *IEEE Access*, Vol. 8, pp. 208427-208448, doi: 10.1109/ACCESS.2020.3036054.

Elsevier B.V. (2024), "Scopus", available at: https://www.scopus.com/

Gartner (2017), *Business Benefits of the Internet of Things: A Gartner Trend Insight Report*, USA.

Gartner (2023), "Cross-industry insight: IoT market opportunities and top spend use cases", available at: https://www.gartner.com/en/documents/4432199

Ghosh, A., Edwards, D.J. and Hosseini, M.R. (2020), "Patterns and trends in Internet of Things (IoT) research: future applications in the construction industry", *Engineering Construction and Architectural Management*, Vol. 28 No. 2, pp. 457-481, doi: 10.1108/ECAM-04-2020-0271.

Haddud, A., DeSouza, A., Khare, A. and Lee, H. (2017), "Examining potential benefits and challenges associated with the Internet of Things integration in supply chains", *Journal of Manufacturing Technology Management*, Vol. 28 No. 8, pp. 1055-1085, doi: 10.1108/JMTM-05-2017-0094.

Hoosain, M.S., Paul, B.S. and Ramakrishna, S. (2020), "The impact of 4IR digital technologies and circular thinking on the United Nations sustainable development goals", *Sustainability*, Vol. 12 No. 23, 10143, doi: 10.3390/su122310143.

International Telecommunication Union (2018), *Measuring the Information Society Report 2018*, Geneva.

Janssen, M., Luthra, S., Mangla, S., Rana, N.P. and Dwivedi, Y.K. (2019), "Challenges for adopting and implementing IoT in smart cities: an integrated MICMAC-ISM approach", *Internet Research*, Vol. 29 No. 6, pp. 1589-1616, doi: 10.1108/INTR-06-2018-0252.

Jayashankar, P., Nilakanta, S., Johnston, W.J., Gill, P. and Burres, R. (2018), "IoT adoption in agriculture: the role of trust, perceived value and risk", *Journal of Business and Industrial Marketing*, Vol. 33 No. 6, pp. 804-821, doi: 10.1108/JBIM-01-2018-0023.

Jo, T.H., Ma, J.H. and Cha, S.H. (2021), "Elderly perception on the Internet of Things-based integrated smart-home system", *Sensors*, Vol. 21 No. 4, 1284, doi: 10.3390/s21041284.

Karahoca, A., Karahoca, D. and Aksöz, M. (2018), "Examining intention to adopt to internet of things in healthcare technology products", *Kybernetes*, Vol. 47 No. 4, pp. 742-770, doi: 10.1108/K-02-2017-0045.

Kim, K.J. and Wang, S. (2021), "Understanding the acceptance of the Internet of Things: an integrative theoretical approach", *Aslib Journal of Information Management*, Vol. 73 No. 5, pp. 754-771, doi: 10.1108/AJIM-03-2021-0073.

Kumar, A., Dhingra, S. and Falwadiya, H. (2023), "Adoption of Internet of Things: a systematic literature review and future research agenda", *International Journal of Consumer Studies*, Vol. 47 No. 6, pp. 2553-2582, doi: 10.1111/ijcs.12964.

Lee, I. (2019), "The Internet of Things for enterprises: an ecosystem, architecture, and IoT service business model", *Internet of Things*, Vol. 7, 100078, doi: 10.1016/j.iot.2019.100078.

Lee, I. and Lee, K. (2015), "The Internet of Things (IoT): applications, investments, and challenges for enterprises", *Business Horizons*, Vol. 58 No. 4, pp. 431-440, doi: 10.1016/j.bushor.2015.03.008.

Li, S., Xu, L.D. and Zhao, S. (2015), "The internet of things: a survey", *Information Systems Frontiers*, Vol. 17 No. 2, pp. 243-259, doi: 10.1007/s10796-014-9492-7.

Malarvizhi, C., Sree Subramaniam, S. and Jayashree, S. (2023), "Exploring the impact of IoT adoption on elderly non-communicable disease patients: attitudes, subjective norms, and perceived behavioral control in Malaysia", *2023 Second International Conference On Smart Technologies For Smart Nation (SmartTechCon)*, IEEE, pp. 189-194, doi: 10.1109/SmartTechCon57526.2023.10391307.

Maroli, A., Narwane, V.S. and Gardas, B.B. (2021), "Applications of IoT for achieving sustainability in agricultural sector: a comprehensive review", *Journal of Environmental Management*, Vol. 298, 113488, doi: 10.1016/j.jenvman.2021.113488.

Masadeh, S.A. and El-Haggar, N. (2023), "Analyzing factors influencing IoT adoption in higher educational institutions in Saudi Arabia using a modified TAM model", *Education and Information Technologies*, Vol. 29 No. 5, pp. 6407-6441, doi: 10.1007/s10639-023-12039-2.

Masood, T. and Sonntag, P. (2020), "Industry 4.0: adoption challenges and benefits for SMEs", *Computers in Industry*, Vol. 121, 103261, doi: 10.1016/j.compind.2020.103261.

Mayer, A.H., Rodrigues, V.F., Costa, C.A.D., Righi, R.D.R., Roehrs, A. and Antunes, R.S. (2021), "FogChain: a fog computing architecture integrating blockchain and Internet of Things for personal health records", *IEEE Access*, Vol. 9, pp. 122723-122737, doi: 10.1109/ACCESS.2021.3109822.

McKinsey & Company (2021), "The Internet of Things: catching up to an accelerating opportunity".

Parra-Sánchez, D.T. (2022), "A framework for IoT adoption in small and medium enterprises", Doctoral Thesis, Universidad Autónoma de Bucaramanga, Bucaramanga, available at: https://www.mckinsey.com/~/media/mckinsey/business%20functions/mckinsey%20digital/our%20insights/iot%20value%20set%20to%20accelerate%20through%202030%20where%20and%20how%20to%20capture%20it/the-internet-of-things-catching-up-to-an-accelerating-opportunity-final.pdf

Parra-Sánchez, D.T. and Guerrero, C.D. (2020), "Decision-making IoT adoption in SMEs from a technological perspective", *2020 15th Iberian Conference on Information Systems and Technologies (CISTI)*, IEEE, pp. 1-6, doi: 10.23919/CISTI49556.2020.9141045.

Pillai, R. and Sivathanu, B. (2020), "Adoption of internet of things (IoT) in the agriculture industry deploying the BRT framework", *Benchmarking: An International Journal*, Vol. 27 No. 4, pp. 1341-1368, doi: 10.1108/BIJ-08-2019-0361.

Qashlan, A., Nanda, P., He, X. and Mohanty, M. (2021), "Privacy-preserving mechanism in smart home using blockchain", *IEEE Access*, Vol. 9, pp. 103651-103669, doi: 10.1109/ACCESS.2021.3098795.

Rajabzadeh, M. and Fatorachian, H. (2023), "Modelling factors influencing IoT adoption: with a focus on agricultural logistics operations", *Smart Cities*, Vol. 6 No. 6, pp. 3266-3296, doi: 10.3390/smartcities6060145.

Rocha, I.F. and Kissimoto, K.O. (2022), "Artificial intelligence and internet of things adoption in operations management: barriers and benefits", *RAM. Revista de Administração Mackenzie*, Vol. 23 No. 4, doi: 10.1590/1678-6971/eramr220119.en.

Sicari, S., Rizzardi, A., Grieco, L.A. and Coen-Porisini, A. (2015), "Security, privacy and trust in Internet of Things: the road ahead", *Computer Networks*, Vol. 76, pp. 146-164, doi: 10.1016/j.comnet.2014.11.008.

Singh, R., Khan, S., Dsilva, J. and Centobelli, P. (2023), "Blockchain integrated IoT for food supply chain: a grey based delphi-DEMATEL approach", *Applied Sciences*, Vol. 13 No. 2, p. 1079, doi: 10.3390/app13021079.

Sneesl, R., Jusoh, Y.Y., Jabar, M.A., Abdullah, S. and Bukar, U.A. (2022), "Factors affecting the adoption of IoT-based smart campus: an investigation using analytical hierarchical process (AHP)", *Sustainability*, Vol. 14 No. 14, p. 8359, doi: 10.3390/su14148359.

Tripathi, S. (2019), "System dynamics perspective for adoption of Internet of Things: a conceptual framework", *2019 10th International Conference on Computing, Communication and Networking Technologies (ICCCNT)*, IEEE, pp. 1-10, doi: 10.1109/ICCCNT45670.2019.8944664.

Vadivelu, V., Nachimuthu, P., Ravi, A. and Thatchanamurthy, A.K. (2023), "An IoT adoption in agriculture: challenges and futuristic directions", *AIP Conference Proceedings*, Vol. 2984, 020025, doi: 10.1063/5.0164985.

Xu, L.D., He, W. and Li, S. (2014), "Internet of Things in industries: a survey", *IEEE Transactions on Industrial Informatics*, Vol. 10 No. 4, pp. 2233-2243, doi: 10.1109/TII.2014.2300753.

Xu, B., Li, L., Hu, D., Wu, B., Ye, C. and Cai, H. (2018), "Healthcare data analysis system for regional medical union in smart city", *Journal of Management Analytics*, Vol. 5 No. 4, pp. 334-349, doi: 10.1080/23270012.2018.1490211.

Zanella, A., Bui, N., Castellani, A., Vangelista, L. and Zorzi, M. (2014), "Internet of Things for smart cities", *IEEE Internet of Things Journal*, Vol. 1 No. 1, pp. 22-32, doi: 10.1109/JIOT.2014.2306328.

Corresponding author
Diana Teresa Parra-Sánchez can be contacted at: dianadelavalliere@gmail.com