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Bibliometric Analysis of the Application of Internet of Things (IoT) in Financial Services

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ABSTRACT

This study presents a comprehensive bibliometric analysis of the application of Internet of Things (IoT) in financial services. The analysis encompasses a systematic review and analysis of existing literature, identifying key research themes, trends, and patterns in the field. Through the utilization of bibliometric indicators such as co-citation analysis, keyword co-occurrence analysis, and citation network analysis, the intellectual structure of the domain is mapped, uncovering emerging research topics and areas of focus. The study also provides insights and recommendations for future research directions and practical implications. The findings contribute to advancing our understanding of IoT's role in reshaping financial services and offer guidance for researchers, policymakers, and industry stakeholders.

Keywords: *Application, IoT, Financial Sevices, Bibliometric Analysis*

1. INTRODUCTION

The rapid evolution of technology has revolutionized various industries, and the financial services sector is no exception [1]–[3]. One of the most transformative innovations in recent years is the Internet of Things (IoT), which refers to the network of interconnected devices capable of exchanging data over the internet without human intervention [4], [5]. In the realm of financial services, IoT offers unprecedented opportunities to enhance efficiency, security, and customer experience.

The integration of IoT devices in financial services encompasses a wide array of applications, including but not limited to smart payment systems, asset tracking, risk management, customer relationship management, and fraud detection [6]–[8]. These applications have the potential to streamline operations, reduce costs, mitigate risks, and create new revenue streams for financial institutions [3], [9]. However, despite its promise, the adoption of IoT in financial services is still in its nascent stage, with various challenges and opportunities yet to be fully explored and understood.

Despite the growing interest in the application of IoT in financial services, there is a lack of comprehensive analysis regarding the current state of research in this domain [10]. Existing studies often focus on specific applications or technologies, overlooking the broader landscape of IoT adoption in financial services [11], [12]. Furthermore, the rapidly expanding body of literature makes it challenging for researchers and practitioners to stay updated on the latest trends, developments, and gaps in knowledge.

This research aims to address these gaps by conducting a bibliometric analysis of the application of Internet of Things (IoT) in financial services. Specifically, the objectives of this study are as follows:

This research is significant for several reasons. Firstly, it contributes to the academic literature by providing a comprehensive overview and analysis of the existing research on IoT in financial services. Secondly, it offers valuable insights for policymakers, regulators, and industry stakeholders seeking to understand the potential impact of IoT on the financial services landscape. Finally, it serves as a roadmap for future research endeavors, guiding scholars towards promising avenues for further exploration and innovation in this rapidly evolving field.

2. LITERATURE REVIEW

2.1 Internet of Things (IoT)

The Internet of Things (IoT) refers to the network of physical devices, vehicles, home appliances, and other items embedded with electronics, software, sensors, and connectivity which enables these objects to connect and exchange data [13]. The IoT allows for the creation of smart environments, where devices can communicate with each other and with humans, leading to increased efficiency, accuracy, and convenience in various aspects of life such as transportation, healthcare, and home automation [14], [15].

Research on the Internet of Things (IoT) is a rapidly growing field that focuses on the development of interconnected devices and systems that can communicate with each other and with humans. This research involves the integration of various technologies such as sensors, cloud computing, and machine learning to create smart and efficient systems that can automate tasks, improve decision-making, and enhance the overall quality of life [16]. Some of the key areas of research in IoT include security and privacy [17], [18], data analytics, energy efficiency, and interoperability. As IoT continues to evolve, researchers are exploring new ways to leverage its potential to address a wide range of societal challenges and create new opportunities for innovation and growth [16], [19]. For example, IoT is being implemented in various areas of the modern economy, such as healthcare, quality control, logistics, energy, agriculture, and production. The Industrial Internet of Things (IoT) is also blazing the trail to a better understanding of the manufacturing process, thus enabling efficient and sustainable production. However, the widespread adoption of IoT technologies has drastically increased the breadth and depth of attack surfaces in networked systems, providing new mechanisms for intrusion. Therefore, research is also focused on the security of IoT systems as applied to smart-world critical infrastructures [20].

2.2. Internet of Things (IoT) and Financial Services

The integration of the Internet of Things (IoT) within the finance services industry offers significant potential for innovation and disruption. IoT devices generate vast amounts of data that can be analyzed to improve risk assessment, fraud detection, and personalized financial services [21], [22]. Additionally, IoT, when combined with blockchain technology, enables secure and transparent contract execution, reducing transactional friction and increasing trust among parties. Connected devices and smart homes with embedded IoT sensors enable novel insurance products, energy efficiency monitoring, and improved customer experiences [23]–[25]. Furthermore, IoT tracking

systems enhance transparency and security throughout the supply chain, benefitting logistics, trade financing, and inventory management. By automating routine tasks and optimizing resource allocation, IoT contributes to lower operating expenses and increased profit margins. However, implementing IoT in finance requires addressing concerns regarding cybersecurity, data protection, regulatory compliance, and scalable architecture. As IoT continues to mature, financial institutions will increasingly leverage its capabilities to drive competitive advantage and meet changing customer demands.

3. METHODS

This study will employ a bibliometric approach to analyze the literature on the application of Internet of Things (IoT) in financial services. A systematic search will be conducted across academic databases such as Web of Science, Scopus, and PubMed, using predefined search terms related to IoT and financial services. The search results will then be imported into bibliometric VOSviewer software. Various bibliometric indicators, such as co-citation analysis, keyword co-occurrence analysis, and citation network analysis, will be utilized to map the intellectual structure of the field, identify and uncover emerging research themes and trends. Additionally, statistical techniques such as descriptive statistics and trend analysis will be employed to quantify the growth and evolution of IoT research in financial services over time. Through this methodological approach, this study aims to provide a comprehensive understanding of the current state of research in this domain and offer valuable insights for future scholarship and practice.

4. RESULTS AND DISCUSSION

4.1 Research Data Matriks

Table 1. Research Data Metrics

Publication years	: 2001-2024
Citation years	: 23 (2001-2024)
Paper	: 980
Citations	: 152672
Cites/year	: 6637.91
Cites/paper	: 155.79
Cites/author	: 65862.11
Papers/author	: 441.65
Author/paper	: 2.94
h-index	: 157
g-index	: 376
hI,norm	: 112
hI,annual	: 4.87
hA-index	: 68
Papers with ACC	: 1,2,5,10,20:931,834,600,414,236

Source: Publish or Perish Output, 2024

Table 1 presents various metrics related to the research data analyzed in this study, covering publication years from 2001 to 2024 and citation years spanning 23 years (2001-2024). A total of 980 papers were included in the analysis, accumulating a substantial number of citations amounting to 152,672 over the citation period. On average, the research received approximately 6,637.91 citations per year, with each paper garnering an average of 155.79 citations. Remarkably, each author

associated with the research received an average of 65,862.11 citations, reflecting the collaborative nature of the scholarly work. Furthermore, the data indicate an average of 441.65 papers authored by each researcher, with an average of 2.94 authors per paper, suggesting moderate collaboration among researchers. The h-index, a widely used metric to evaluate research impact, stands at 157, indicating that 157 papers have each received at least 157 citations. Similarly, the g-index, another measure of research impact, is calculated at 376. The hI,norm and hI,annual values provide normalized and annualized h-indices, respectively, which are useful for comparing research impact across different fields and years. The hA-index, representing the number of papers an author has with at least h citations, is noted as 68. Finally, the table includes data on the number of papers with different levels of accumulated citations (ACC), demonstrating the distribution of research impact across varying thresholds. Overall, these metrics provide insights into the extent of scholarly activity, collaboration patterns, and research impact within the domain of Internet of Things (IoT) in financial services, offering valuable information for researchers, practitioners, and policymakers alike.

4.2 Network Visualization

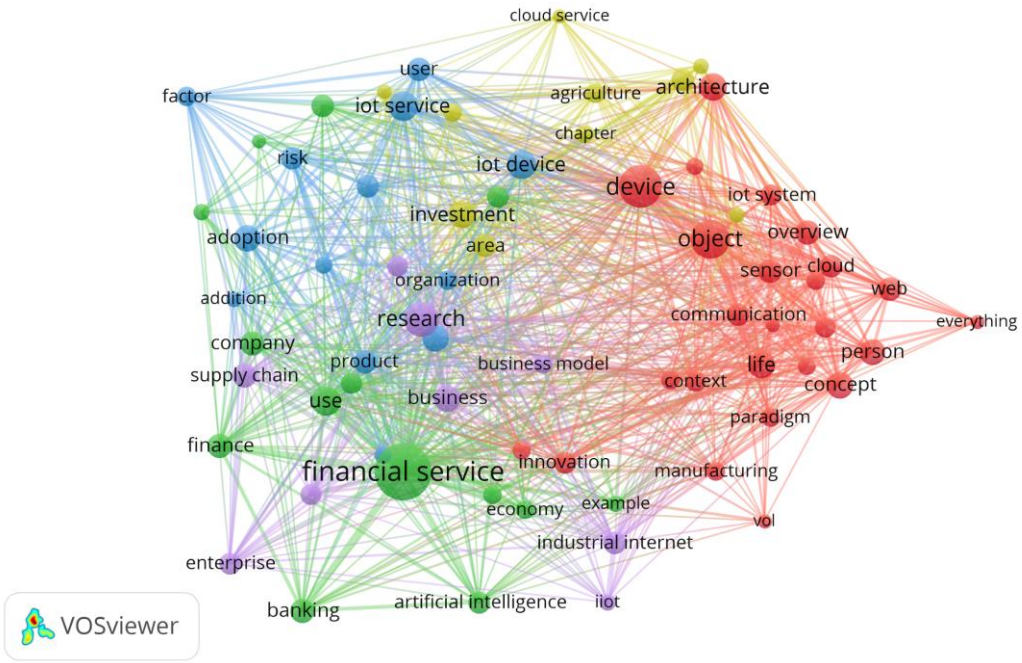

Figure 1. Network Visualization
Source: Data Analysis Result, 2024

From the image above, each color represents a different cluster of terms that are often found together in the literature. This indicates that these terms are related or used in similar contexts. The size of the nodes (the dots representing terms) often corresponds to the weight or the frequency of the term's occurrence within the data set. Larger nodes suggest terms that are more prevalent in the research. Meanwhile, the lines (or edges) indicate the strength of the relationship between terms. A thicker line suggests a stronger association or more frequent co-occurrence between the connected terms. Terms that are closer to each other are more strongly related, while those further apart are less so. Several clusters can be identified from the image as follows:

1. The red cluster seems to include terms related to technology and the Internet of Things (IoT), such as "device," "IoT system," "sensor," "cloud," "communication," and "web."

2. The yellow cluster might be focusing on the user aspect, including "user," "IoT service," and "agriculture," indicating perhaps a focus on IoT in agriculture.
3. The green cluster seems to relate to business and finance, with terms like "investment," "company," "supply chain," and "financial service."
4. The blue cluster could be associated with research and development, as it includes "research," "innovation," "product," and "use."
5. The purple cluster seems to pertain to the intersection of finance and technology, with "banking," "enterprise," "artificial intelligence," and "IoT" being prominent.

4.3 Overlay Visualization

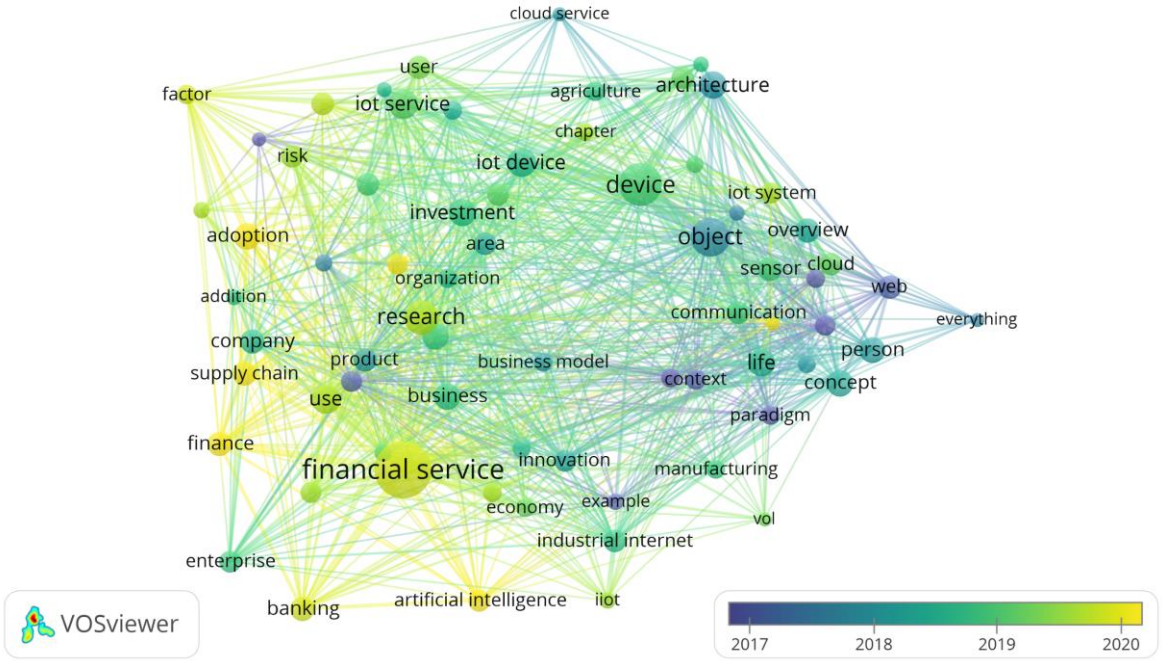

Figure 2. Overlay Visualization
Source: Data Analysis Result, 2024

The color gradient applied to the nodes (terms) and lines (connections) may indicate the time of occurrence or prominence of these terms. It looks like the scale progresses from yellow to blue, which suggests that yellow represents earlier years (2017) and blue represents more recent years (2020). Terms that are more yellowish would suggest topics that were more prominent or more frequently researched around 2017. Terms that are green or transitioning to blue represent the shift in research focus or emerging topics between 2018 and 2019. Terms that are distinctly blue would be those that are most relevant or represent the frontiers of research in 2020. It does seem that there is a mix of colors throughout the network, which could suggest that research topics evolved over the years but remained interconnected. The presence of blue in many areas might indicate a number of topics that have remained or become relevant in 2020.

4.4 Citation Analysis

Table 3. The Most Impactful Literatures

Citations	Authors and year	Title
15335	J Gubbi, R Buyya, S Marusic, M Palaniswami (2013)	Internet of Things (IoT): A vision architectural elements, and fututr directions

Citations	Authors and year	Title
7157	A Zanella, N Bui, A Castellani (2014)	Internet of things for smart cities
5848	L Da Xu, W He, S Li (2014)	Internet of things in industries: A survey
3598	I Lee, K Lee (2015)	The Internet of Things (IoT): Applications, Investments, and challenges for enterprises
3335	J Rifkin (2014)	The zero marginal cost society: The internet of things, the collaborative commons, and the eclipse of capitalism
3157	SMR Islam, D Kwak, MDH Kabir, M Hossain (2015)	The internet of things for health care: a comprehensive survey
2652	S Li, LD Xu, S Zhao (2015)	The internet of things: a survey
2494	JA Stankovic (2014)	Research directions for the internet of things
2122	A Whitmore, A Agarwal, L Da Xu (2015)	The Internet of Things-A survey of topics and trends
2114	D Bandyopadhyay, J Sen (2011)	Internet of things: Applications and challenges in technology and standardization

Source: Publish or Perish Output, 2024

Table 3 presents the most impactful literature in the field of Internet of Things (IoT), based on citation counts. The top-cited papers span from 2011 to 2015 and cover various aspects of IoT, including its architectural elements, applications in smart cities and industries, challenges, and potential impacts on different sectors such as healthcare. Notable works include Gubbi et al.'s seminal paper from 2013, which outlines the vision, architectural elements, and future directions of IoT, and Zanella et al.'s 2014 paper focusing on IoT applications for smart cities. Other significant contributions include surveys and research directions provided by authors such as Xu et al., Lee and Lee, Rifkin, and Stankovic, which offer insights into the diverse applications, investments, challenges, and research trends within the IoT domain. These highly cited works collectively contribute to shaping the discourse and advancing knowledge in the rapidly evolving field of IoT.

4.5 Density Visualization

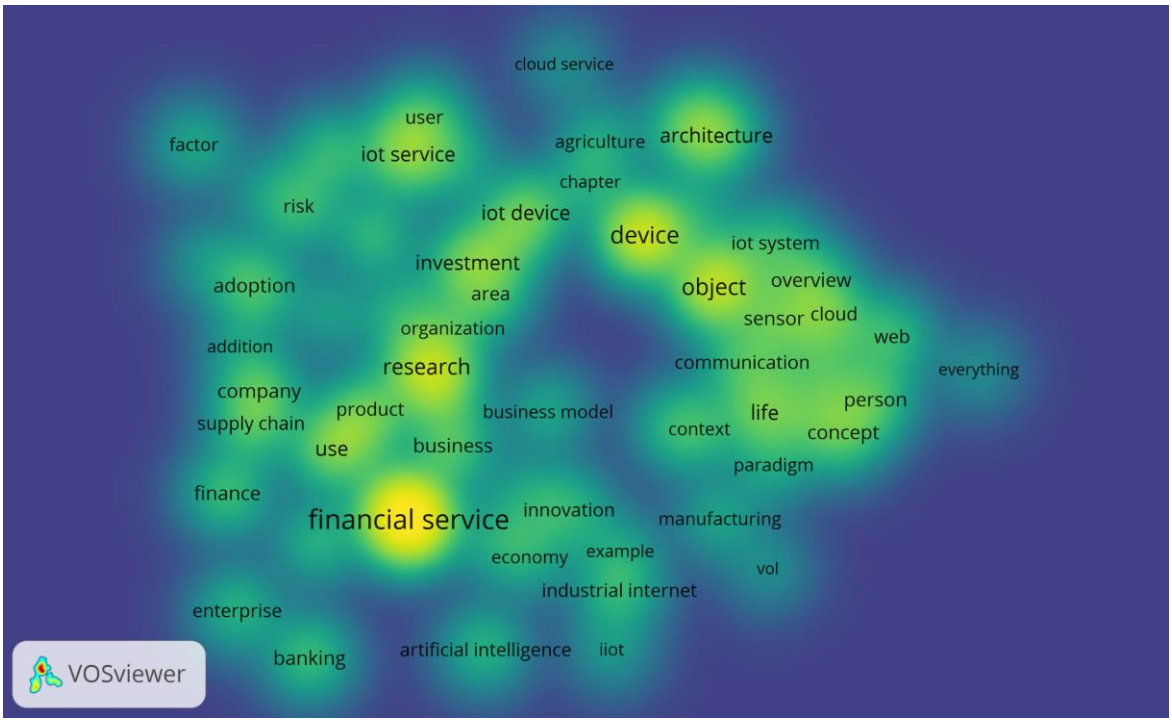

Figure 3. Density Visualization

Source: Data Analysis Result, 2024

Interpreting the potential research topics from this visualization involves looking at the most prominent terms and considering their interrelations, as well as their position in the density field:

1. IoT (Internet of Things) Related Terms: The terms "IoT service," "IoT device," "device," "IoT system," and "sensor cloud" are closely grouped, suggesting a strong research focus on IoT and its applications, architecture, and the cloud computing aspects related to it.
2. Financial Services and Technology: There is a significant focus on "financial service" adjacent to terms like "business," "business model," "enterprise," "banking," and "investment." This suggests that there is considerable research interest in the intersection of finance and technology, potentially in areas like FinTech, blockchain in banking, and digital transformation of financial services.
3. Artificial Intelligence: The term "artificial intelligence" is close to "IoT" and "industrial internet," which might indicate a convergence of research topics related to the application of AI in industrial IoT settings.
4. Communication Technologies: With "communication," "web," "cloud service," and "sensor cloud" in proximity, one can infer a research concentration on communication technologies as they relate to IoT and cloud computing.
5. Supply Chain and Business Operations: "Supply chain" and "company" are relatively close to each other, indicating a potential research topic around how IoT and digital innovations are impacting supply chains and business operations.
6. Emerging Concepts and Paradigms: The terms "concept," "paradigm," "life," "person," "everything," and "overview" suggest a broader and perhaps more theoretical or conceptual research interest that could involve the societal impact of technology, or the overarching paradigms of modern technological life.

CONCLUSION

Based on the results of the bibliometric analysis, it is evident that research on the application of Internet of Things (IoT) in financial services has experienced significant growth and diversification over the years. The analysis revealed a substantial body of literature spanning various topics, including IoT architecture, applications, challenges, and potential impacts on financial services. Key research themes identified include the integration of IoT with blockchain technology, risk assessment, fraud detection, personalized financial services, and supply chain management. Furthermore, the visualization of research networks highlighted the interconnectedness of different research clusters, emphasizing the multidisciplinary nature of IoT in financial services research. The citation analysis showcased the most impactful literature in the field, underscoring seminal works that have shaped the discourse and advanced knowledge in IoT applications within financial services. Notably, these influential papers have contributed to establishing foundational frameworks, identifying emerging trends, and addressing critical challenges in the domain. Additionally, the density visualization provided insights into prominent research topics, highlighting areas of focus such as IoT architecture, financial services, artificial intelligence, and supply chain management. In conclusion, the bibliometric analysis offers a comprehensive overview of the current state of research on IoT in financial services, providing valuable insights for academics, policymakers, and industry practitioners. The findings contribute to a deeper understanding of the opportunities, challenges, and implications of IoT adoption in the financial sector, guiding future research endeavors and informing strategic decision-making. As IoT continues to reshape financial services, this research serves as a valuable resource for navigating the complexities of this rapidly evolving landscape and unlocking the full potential of IoT-enabled innovations in the financial industry.

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