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Research Article

Evolution of Consumer IoT: A Bibliometric Study of Research Trends and Knowledge Diffusion

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ABSTRACT

The Internet of Things (IoT) has transformed everyday life through the use of smart technologies and there is tremendous scope of such advancements in consumer product development. Hence it requires a structured understanding of research patterns, obstacles, and possibilities in the field of Consumer Internet of Things (CIoT). This research presents the first thorough bibliometric CIoT studies, assessing 589 articles indexed in Scopus (2000–2024) to illustrate the intellectual framework, pinpoint significant contributors, and shed light on emerging topics. Using R Studio (Biblioshiny) and Excel, the findings indicate an increase in publications after 2015, fueled by growing interest from both academic and industry sectors worldwide. While the United States, India, and the United Kingdom are at the forefront of publication output, East Asian countries demonstrate superior research impact. Prominent topics like automation and smart homes are contrasted with less explored areas like privacy, ethical AI, and sustainable IoT solutions. Journals like "Sustainability" have emerged as key players, although insufficient international collaboration highlights the necessity for partnerships beyond borders. The research identifies critical shortcomings in interdisciplinary studies, frameworks for consumer trust, and sustainable IoT solutions. By providing a foundational overview of the progression of CIoT, this study assists scholars in navigating future research pathways, advocating for improved collaboration, significant studies, and socio-technical innovations to serve as a fundamental resource for researchers and practitioners in aligning progress with societal demands and ethical considerations.

Keywords: Consumer Internet of Things (CIoT), Bibliometric Analysis, Smart Technologies, Privacy and Security, Sustainable IoT Solutions

INTRODUCTION

The world's increasing interconnectedness has greased the wheels for automation and advanced digital transformation, which has ushered in a new era of interconnectivity, with the Internet of Things (IoT) emerging as a transformative force that seamlessly integrates various electronic devices, sensors, and software to enhance the way we interact with our environment (Gubbi et al., 2013). IoT utilizes its underlying technologies-such as embedded devices, communication technologies, sensor networks, etc. to turn conventional objects into intelligent ones. It actually allows physical objects to "talk" to one another, exchange information, and make it possible for them to do tasks (Al-Fuqaha et al., 2015). Thus, the global network of machines and devices that has the potential to interact with one another is known as the Internet of Things (IoT), the Internet of Everything, or the Industrial Internet Lee & Lee, (2015);Pankaj et al., (2023). This interconnected web of devices has permeated numerous industries, including, healthcare (Gu et al., 2017; Ziwei et al., 2024), logistics (Minashkina & Happonen, 2023), agriculture (Pillai & Sivathanu, 2020), and transportation (Mitieka et al., 2023), and energy, revolutionizing traditional processes and paving the way for unprecedented efficiency and automation. Thus, the Internet of Things is a tremendous new resource that can improve and sustainably change processes in business, education, and industry for the betterment of present and forthcoming generations. Furthermore, the enormous impact of the Internet of Things on everyday activities has amazed many market analysts worldwide Sushma et al., (2025);Qadri et al., (2020). This scenario evolved as the IoT rendered more accessibility, encouraging businesses to reinforce better customer experience (Lo & Campos, 2018).

The pervasive integration of smart devices into the consumer landscape has fueled an explosion of research and development, attracting significant attention to the consumer IoT (CIoT) domain as it stands out as a particularly dynamic and rapidly evolving field, profoundly impacting our daily lives (Bhardwaj & Kole, 2016). This is because (firstly), the CIoT was deployed to target the specific needs of the consumers and, for the CIoT to thrive, its application must be tailored to the peculiar issues encountered by consumers in their everyday lives. Secondly, the changes introduced by the IoT were incremental and the impact of the IoT on social innovation is positive and encourages progress in the living standards of people (Kumar et al., 2023). The consumer Internet of Things has rapidly transitioned from a futuristic concept to an integral part of modern life. The CIoT landscape has experienced remarkable growth and evolution in recent years, reflecting the changes in people's lives with the development of smart technologies. This burgeoning field encompasses a diverse array of devices and applications designed to enhance consumer experiences, ranging from smart home technologies and wearable devices to connected cars and personalized entertainment systems (Malhan et al., 2021;Marikyan et al., 2018).

CIoT is a fledgling and rapidly evolving field that creates new opportunities for innovation involving devices and sensors that generate big data that yield valuable insights to organizations (Dwivedi et al., 2017). With connected devices, offering unprecedented capabilities for automation, control, and real-time monitoring, people face new security and privacy challenges in their private and business lives (Thapa et al., 2023;Kumar et al., 2024). As CIoT raises concerns about data security, confidentiality, and customer trust, the choice to embrace wearable devices entails a risk assessment that considers the balance between considerable advantages and perceived security risks, as utilizing them necessitates sharing personal health data (Almolhis et al., 2020). A framework for a consumer IoT ecosystem is being created that safeguards consumer privacy and supports predictive capabilities for future system enhancements. This proposed system develops a machine learning model that aids consumer IoT manufacturers in enhancing service quality and optimizing functionalities to ensure secure access.(Alghamdi et al., 2022)(Kumar et al., 2023). The privacy and security of users is a captivating and engaging subject that will instigate the researchers aiming to develop an intelligent IoT framework integrating blockchain technology with deep learning (DL) foster responsible use of Consumer IoT (CIoT), building trust among consumers (Narmatha et al., 2024).

1.1 Mapping the Intellectual Landscape

Even though studies are accessible on integrating the Consumer IoT in IoT space, a unified and clear perspective is lacking. Additionally, while the benefits of adopting IoT products are evident, they also bring about various new challenges in implementation. Numerous studies have evaluated and compiled information on CIoT and its applications across different areas, including smart homes, wearables, pet IoTs, smart health, connected vehicles, and more; however, the research fails to deliver a comprehensive overview of CIoT as a distinct domain. Given the exponential growth of the CIoT landscape, understanding the research trends, key players, and emerging themes within this domain is crucial for academics and industry practitioners to navigate the complexities of this transformative technology and harness its full potential for the benefit of society. Thus, bibliometric analysis is a popular tool in business research for scientific mapping (Donthu et al., 2021)(Kumar et al., 2023; Sushma et al., 2025). The academic disquisition assists scholars in grasping the significance and potential subsequent developments regarding a particular topic. It serves as a method that offers a well-informed and thorough evaluation of the extensive range of scientific literature in the domain (Van Nunen et al., 2018). Analyzing quantitative data can help illustrate the demographic details, promulgate patterns in publications, dominant investigations and growth of scientific production in the specific research field (Kumar et al., 2023; Pankaj et al., 2023;Leong et al., 2021).

In light of the significance of bibliometric studies, this paper strives for the development of keen acumen regarding the pertinent subject. As per our cognizance, there has not been a bibliometric study on this subject carried out thus far. Our efforts aim to highlight the scientific output and provide reflections on its future developments, particularly focusing on the initial research within the realm of consumer IoT. This paper will assist researchers in grasping emerging fields and identifying areas for future investigation while also illuminating the strengths of the literature in this domain.

1.2 Research Questions

RQ1: What is the volume of scholarly publications addressing Consumer IoT across relevant disciplines?

RQ2: Who are the 10 most prolific contributors (authors, journals, institutions, and countries) in the Consumer IoT domain?

RQ3: How have publication patterns and thematic focuses in Consumer IoT research evolved over time?

RQ4: What key terms and concepts are most frequently associated with Consumer IoT studies?

RQ5: What underexplored areas in Consumer IoT research necessitate further scholarly investigation?

2. RESEARCH METHODOLOGY

Bibliometric analysis offers a powerful quantitative approach to map the evolution and structure of research data, enabling researchers to identify patterns, trends, and dominant topics, most prolific authors, influential institutions, emerging areas, and impactful publications shaping the trajectory of the consumer IoT domain (Bovenizer & Chetthamrongchai, 2023). As the consumer IoT field continues to evolve, bibliometric analysis will play an increasingly important role in mapping the landscape, identifying key research areas, and informing future directions for innovation and development of the domain.

2.1 Statistical Analysis Software

The study was conducted using the R programming language, specifically the Bibliometric R package. R Studio serves as the integrated development environment (IDE) for working with R. it is designed for Quantitative analysis and graphic representation, making it highly extensible and facilitating the automation of various analyses (Aria & Cuccurullo, 2017). Spreadsheet methods tend to be straightforward since they typically do not demand programming abilities. For this reason, scientists and researchers across different fields favor the easily accessible and user-friendly Microsoft Excel (Kumar et al., 2023;Öksüz & Buzrul, 2024). The dataset was processed in R Studio and formatted for bibliometric analysis. Additionally, the evaluation was performed using Biblioshiny, an R Studio package designed for bibliometric evaluation.

2.2 Strategy for data collection and retrieval

The authors utilized the SCOPUS database to collect the foundational data required for the bibliometric analysis. SCOPUS was selected due to its extensive array of prime-quality abstracts and citations from scholarly publications(Choudhri et al., 2015;Kumar et al., 2024). Articles in all languages addressing consumer IoT were included in the study, as bibliometric analysis focuses solely on metadata rather than the full text of articles. This inclusive approach enhances the study's global scope, providing a broader perspective on the subject. Search string used to obtain relevant data is: (TITLE(("consumer" OR "customer") AND ("IoT" OR "Internet of Things")) OR TITLE("Smart wearables" OR "smart home" OR " smart healthcare")) AND (EXCLUDE (PUBYEAR,2025)) AND (LIMIT-TO (SUBJAREA,"SOCI") OR LIMIT-TO (SUBJAREA,"BUSI") OR LIMIT-TO (SUBJAREA,"ARTS")) AND (LIMIT-TO (DOCTYPE,"ar")) AND (LIMIT-TO (SRCTYPE,"j")).

3. BIBLIOMETRIC PROCEDURES EXECUTED

The metadata under analysis was reviewed to identify expository patterns and publication trends that encapsulate the bibliometric indicators and evaluate the impact of the dataset throughout the timeframe. Initially, publication trends for 589 articles were outlined through tables created in a Microsoft Excel spreadsheet. Subsequently, additional graphs were generated to display metrics illustrating the progression of research output, the most prolific authors, leading countries in publication volume, the most frequently cited journals, and, institutional affiliations of researchers. Biblioshiny is used as a tool to conduct was utilized to conduct bibliometric mapping. The process was launched to visualize co-authorship and citation patterns. Additionally, the method was employed to extract keywords and produce a visual representation of the co-occurrence of terms associated with the CIoT.

To facilitate bibliometric mapping, the software tool Biblioshiny was employed, enabling the envisioning of co-authorship and citation networks. This approach was also used to extract keywords and generate visual representations trend topics within the CIoT field.

The methodology undertaken for the review is delineated in Figure 1.

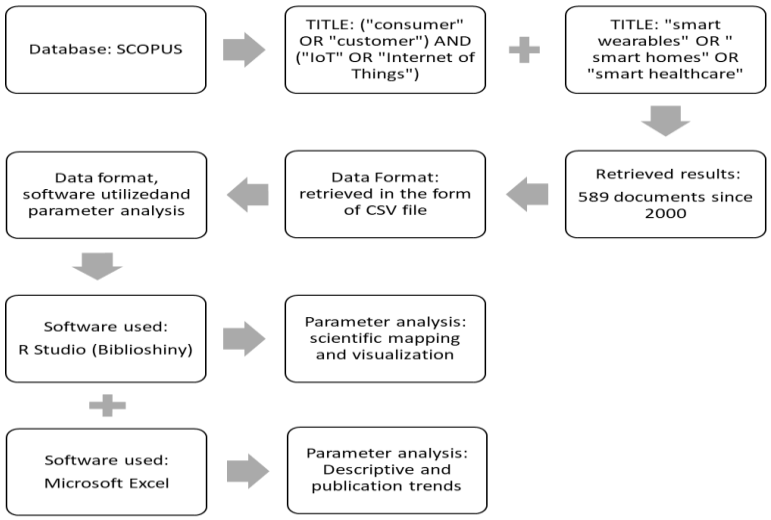

Figure 1: The schematic representation of data acquisition and retrieval

3.1 Trends and Metrics of Data

The research covers the time frame of 2000 to 2024 for collection and analysis of data from a comprehensive database, specifically "Scopus." The retrieved information was downloaded in CSV format from Scopus. For detailed analysis, tools such as Biblioshiny (via R Studio) and Microsoft Excel were employed. After evaluation of table 1, a total of 270 sources were identified, comprising 589 documents sourced from "Scopus." As detailed in the main information table, the annual growth rate in this field was 20.95, while the average number of citations per document was 28.61.in terms analysis total 1934 author keywords and 2566 Keyword Plus were utilized across various articles, reflecting an extensive array of research possibilities concerning the subject of Consumer IoT. Notably, there were only 47 single-authored articles, which is relatively low. Conversely, the average number of co-authors per document was 3.39, which is advantageous as co-authorship enhances research by integrating diverse strengths and expertise. Additionally, the collaboration among international authors was recorded at 23.43%, meaning that approximately one out of every four papers was authored by researchers from different countries.

Description	**Results**
Timespan	2000:2024
Sources (journals,Books,etc)	270
Documents	589
Annual Growth Rate%	20.95
Document Average Age	4.72
Average citations per doc	28.61
References	29731
DOCUMENT CONTENTS	
Keywords Plus (ID)	2566
Author's Keywords (DE)	1934
AUTHORS	
Authors	1743
Authors of single-authored docs	44
AUTHORS COLLABORATION	
Single-authored docs	47
Co-Authors per Doc	3.39
International co-authorships %	23.43
DOCUMENT TYPES	
Article	589

Table 1: Trends and Metrics of Data

3.2 Progression of Academic Publications

Tracking publishing trends on an annual basis is crucial for pinpointing plausible research topics for deeper exploration. Additionally, it aids current readers and future researchers in grasping the significance of a study's topic. Moreover, this can spark interest among upcoming scientists aiming to analyze the factors that affect the rise or fall in yearly publications. As demonstrated in Figure 2, the data shows that there have been limited numbers of articles published since 2000. Despite a slight decline in 2010, the publication numbers steadily rose from 2015 to 2019, culminating in an increase of 84 publications in 2022. The year 2024 saw the highest publication count, totaling 96 articles. Overall, 589 articles have been published between 2000 and 2024. The average number of articles released in the first 14 years stands at 2.7, while it significantly surged to 55.1 in the last decade, indicating that researchers began to focus more on this topic after 2015. For detailed information refer figure 2.

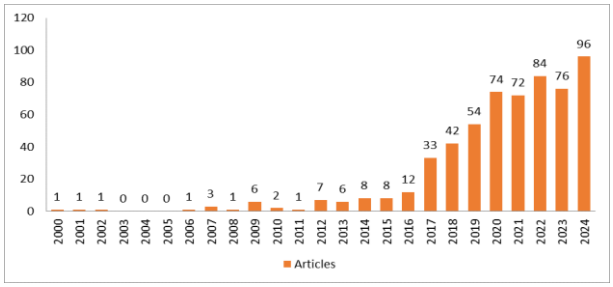

Figure 2: Progression of Academic Publications

3.3 Average Annual Citations per Article

Citation analysis constitutes a pivotal methodology in scientific mapping, predicated on the notion that citations signify intellectual linkages between scholarly works, manifesting when one publication acknowledges another (Saxena et al., 2024). The Citations directly reflect the extent of authorship and the collaborative efforts among researchers, institutions, and nations, highlighting the interconnectedness of scholarly contributions on a global scale (Tahamtan et al., 2016). The citation analysis in figure 3 indicates a notably shallow average annual citation per article between 2000 and 2010, surpassing the value of 2 on only two occasions. The period from 2014 to 2021 experienced improved citation rates. The peak average citation was recorded in 2011 at 11.33. However, the average citation per year has declined in recent years, which is quite concerning, especially considering the rise in publication quantity, which ideally should lead to an increase in citations.

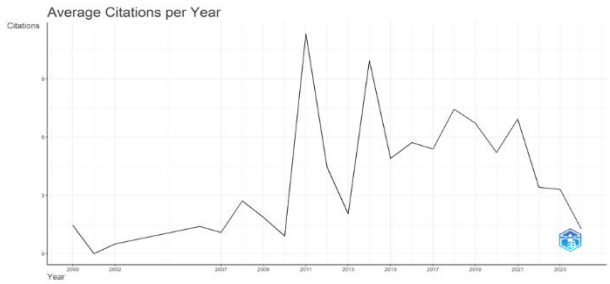

Figure 3: Average Annual Citations per article.

3.4 Journal Contributions

The author examined various sources and discovered that only one journal has published over 40 articles, specifically “Sustainability,” which has a total of 47 publications. Aside from “Sustainability,” there are just four journals that have published 15 or more articles, they are: “Internet of Things,” “Sustainable Cities and Societies,” “National Journal of Recent Technologies and Engineering,” and “Proceedings of ACM in Human-Computer Interaction,” which have 20, 17, 16, and 15 publications respectively. These figures are quite low, suggesting that journals should prioritize and encourage more publications in the field of consumer IoT. Figure 3 provides additional details about the top 10 journals ranked by the number of publications.

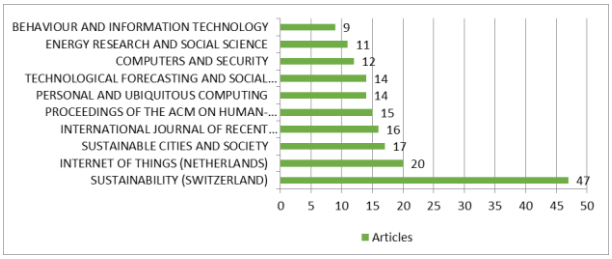

Figure 4: Journal Contributions

3.4.1 H-index

In 2005, J.E. Hirsch introduced the H-index. It is a system to evaluate the effectiveness of different authors and journals, which has been widely adopted by organizations and publications. “An author has an index h if h of their Np papers has at least h citations each and the remaining (Np - h) papers have no more than h citations each” (Hirsch, 2005). The index is particularly suitable for comparing authors or journals operating within the same field. Upon analyzing the H-index of the top 15 journals in the consumer IoT sector, as shown in Figure ---- and Table 2, it was found that “Sustainability (Switzerland)” possesses the highest H-index at 19. It was also noted that only four journals have an index above 10, with “Sustainable Cities and Society” and “Technological Forecasting and Social Change” following closely with H-indices of 16 and 12, respectively.

3.4.2 G-index

G-index is an improved version of H-index introduced in 2006 by Egghe. In the G-index evaluation, the journal “Sustainability (Switzerland)” holds the top position, boasting an index value of 27 and the highest H-index. Following closely are “Sustainable Cities and Society” and “Technological Forecasting and Social Change,” which have index values of 17 and 14, respectively. Details regarding the top 10 journals according to the G-index are presented in Table 2.

Element	h- index	g- index
Sustainability	19	27
Sustainable Cities and Society	16	17
Technological Forecasting and Social Change	12	14
Internet of Things (Netherlands)	11	20
Energy Research and Social Science	9	11
Computer and Security	8	12
Computers in human behaviour	8	8
IEEE Transactions on Human-Machine Systems	7	8
Personal and Ubiquitous Computing	7	14
Behaviour and Information Technology	6	9

Table 2: H-Index and G-Index

3.5 Author Contribution Analysis

In the author's analysis, the leading contributors to the topic have been identified. The researcher discovered that “Strengers Y” has made the most significant contributions in the area of Consumer IoT, having authored 8 documents. Only two scholars have written over five articles, with “Nicholls L” being the other one in addition to “Strengers Y.” This low number raises concerns, indicating that there is a limited interest among researchers in the field of consumer IoT. It might be attributed to the fact that more technical papers are written in the domain of Consumer IoT compared to those in social sciences, highlighting an area that requires improvement. More information regarding the articles published by the authors can be seen in Figure 5.

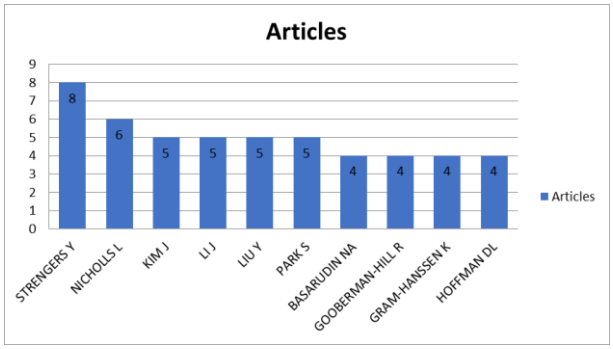

Figure 5: Author's Contribution Analysis

3.6 Affiliation Analysis

Figure 6 is in the form of bar chart illustrates the top 15 affiliations contributing to the chosen research area, as determined by bibliometric analysis. "Monash University" emerges as the top institution, having published the most articles i.e. 20. This suggests that Monash University possesses substantial expertise and resources committed to the domain. Followed by "Aalborg University", which has made a notable contribution with 15 articles, indicating its active participation in research and collaborations within the discipline. Both "Federal University of Lavras" and "Universiti Sains Malaysia" produced 14 articles each, demonstrating a steady involvement in research and further enhancing the variety of geographical and institutional contributions.

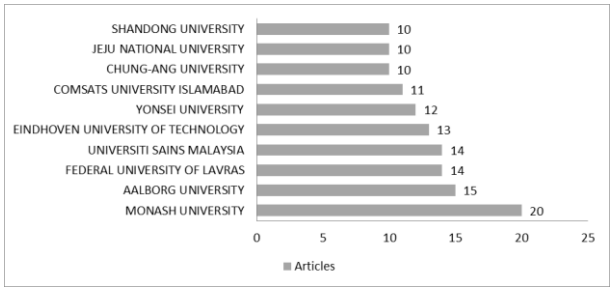

Figure 6: Affiliation Analysis

3.7 Country Analysis

For the analysis of countries, Microsoft Excel is utilized to create graphical representations of the Scopus data. Among the countries, the "USA" has the highest contribution with 84 documents, followed by India and the United Kingdom with 70 and 67 articles respectively. Additional details regarding the top 10 countries that have published the most articles can be found in Figure 7. This figure illustrates that research on the topic of Consumer IoT has been conducted globally.

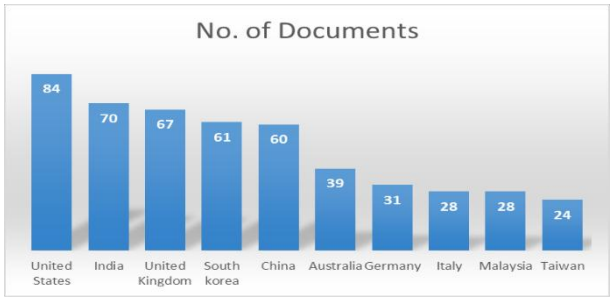

Figure 7: Total Document Production by Top 10 countries.

Examining the top 10 nations according to citations in Figure 8, it's evident that there is a significant disparity between the top five and the remaining five countries. This gap is substantial and requires enhancement, achievable only through consistent and quality efforts in the area of Consumer IoT. Therefore, nations must encourage research in this field to foster a deeper understanding among researchers. The impact of smaller nations such as Malaysia and Taiwan is significant in this area of research, which positions them among the top 10 countries, showcasing the extent of involvement in the concerned field. In contrast, the situation regarding citations received by countries varies, with

Korea leading the list at 1,535 citations, while China follows closely with 1,509, and the USA has 1,373 citations. Figure 7: Total Document Production by Top 10 countries.

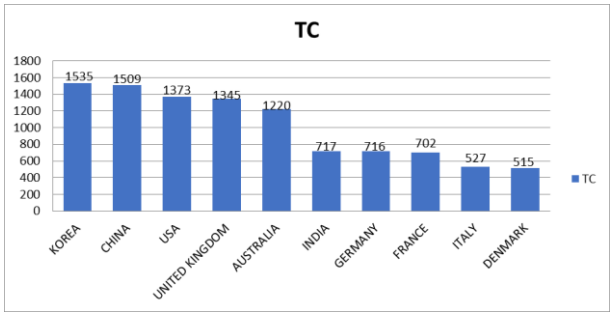

Figure 8: Total Citation Per Country

3.8 Most Relevant Corresponding Author's Countries

The figure 9: depicts the major nations contributing to the study field under consideration. China and the United States emerged as the leading contributors, each with 50 pieces. However, China has a higher share of Multiple country publications (MCP) "14" than the US "11", indicating greater international collaboration. South Korea follows closely with 47 articles, 41 of which are Single country publications (SCP), reflecting an emphasis on indigenous research activities. India ranks fourth, contributing 42 papers (35 SCP and 7 MCP), demonstrating a balanced approach with moderate international collaboration. The United Kingdom has 39 publications and a significant MCP count of 11. Brazil, Denmark, and France have contributed the fewest articles, with tallies ranging from 9 to 8. While Denmark has a balanced SCP and MCP (5 and 4, respectively), France's contributions are more focused in SCP, indicating a lack of international collaboration.

3.9 Frequently Occurred Words

The frequency of keywords may provide insights into the classification and sub-classification within the investigation region, as well as their acceptance among researchers (Kevork & Vrechopoulos, 2009). Examining keywords can offer an interesting perspective for understanding the themes "Codified" by writers, as they provide thematic overviews and can help in grasping the core of a scientific analysis (Wu et al., 2012). In Figure 10 the word "automation" is the most frequently used by researchers, followed by "smart homes", "intelligent buildings, "internet of things". The analysis revealed that there is a scarcity of research on subjects such as technology adoption, smart home technology, and smart cities, indicating that these fields represent significant research gaps. Potential research topics could encompass related concepts like privacy in smart homes and IoT sustainability to address these future gaps.

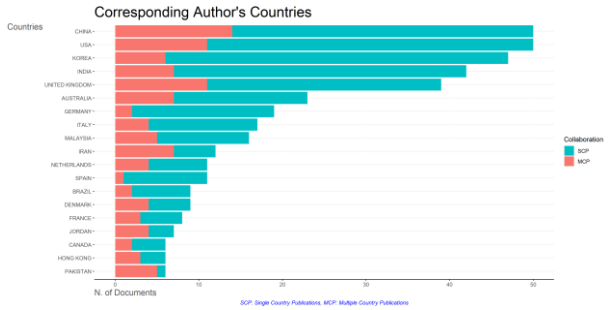

Figure 9: Most Relevant Corresponding Author's Contribution

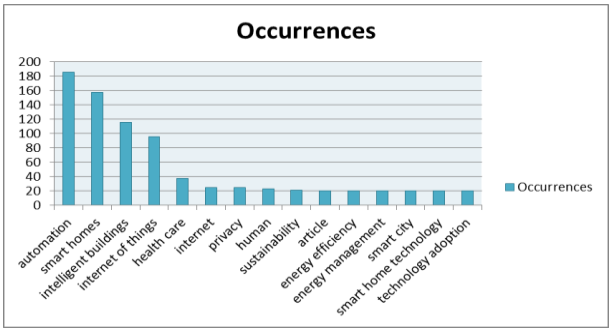

Figure 10: Frequently Occurred Words

3.10 Thematic Map

The thematic map in figure 11 divides research themes into two categories depending on their level of development (density) and relevance (centrality). Each quadrant indicates a distinct form of thematic focus. Niche Themes (Top-left quadrant): These themes, such as "human," "article," and "male," have high density but low centrality. Motor Themes (Top Right Quadrant): This quadrant often contains well-developed concepts inextricably linked to other topics. Basic Themes (Bottom-Right Quadrant): Themes such as "automation," "smart homes," and "intelligent buildings" appear here, indicating their high centrality but low density. Emerging or Declining Themes (Bottom-Left

Quadrant): Themes such as "internet," "sustainability," and "energy efficiency" are located here, indicating that they are either new and in development or are losing relevance in the area. Further inquiry is required to identify their current path.

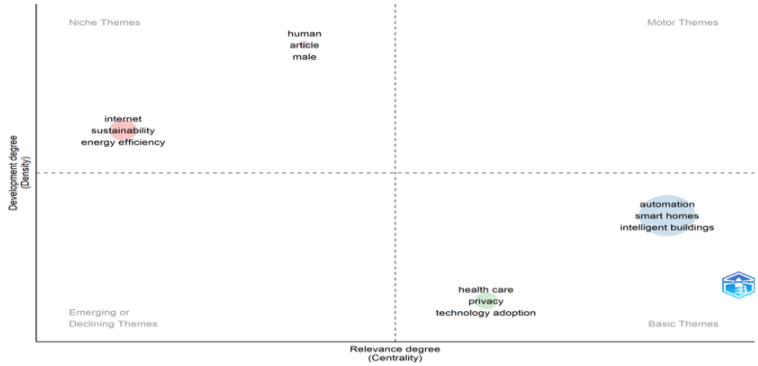

Figure 11: Thematic Map

3.11 Trending Topics

The image illustrates a bibliometric analysis of popular research topics from 2012 to 2024, showcasing their development and significance. The horizontal axis represents years, while the vertical axis features key terms like “IoT,” “healthcare,” “smart home,” and “energy.” The appearance and frequency of each term are shown by data points, with larger circles signifying greater usage. The analysis indicates that themes such as “IoT” and “smart home” gained traction after 2016, reflecting the growth of Internet of Things applications. In Figure 12 terms like “healthcare” and “energy” exhibit considerable growth after 2020, corresponding with an increased emphasis on sustainability and health technology. Additionally, the term “deep” sees a rise in frequency, indicating advancements in machine learning. This visualization depicts the shifting trends and research focuses, offering important insights into emerging domains.

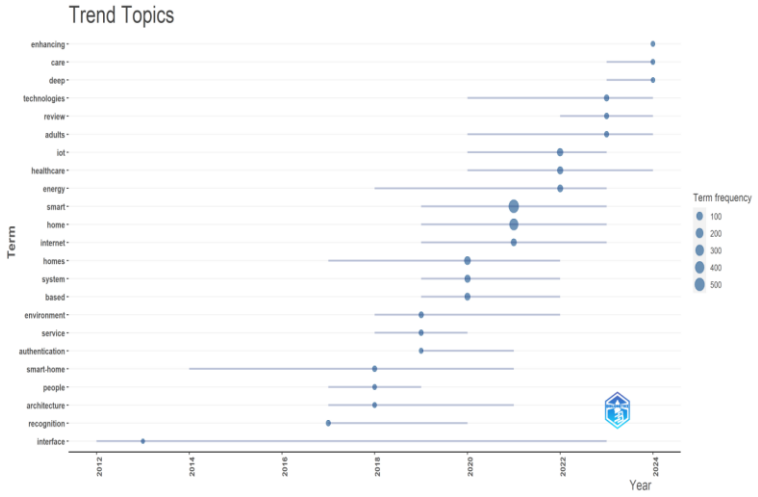

Figure 12: Trending Topics

CONCLUSIONS

The swift advancement of the Consumer Internet of Things (CIoT) has significantly altered contemporary life, integrating intelligent technologies into daily consumer interactions while also presenting vital challenges related to security, privacy, and trust. This research utilized bibliometric analysis to chart the intellectual terrain of CIoT studies, examining 589 articles from Scopus (2000–2024) that involved 1,743 authors, 270 journals, 466 institutions, and contributions from 71 countries linked to the chosen publications to pinpoint trends, key contributors, and emerging topics. The main findings indicate a notable increase in publications after 2015, with 96 articles released in 2024 alone, highlighting the rising interest from both academia and industry in CIoT. Nonetheless, the decrease in citation rates, despite an increase in publication output, suggests a requirement for more impactful research and enhanced interdisciplinary collaboration.

The USA, India, and the UK stood out as major contributors in terms of publication quantity, whereas South Korea and China excelled in citation performance. Our review of sources revealed that the journal centered on “sustainability” boasts the highest H and G-index, with respective scores of 19 and 27. Furthermore, it has produced the greatest number of articles in this field, accounting for 47, while all other journals have published 20 articles or fewer. It is important to note that international collaboration remains minimal (23.43%), indicating potential for global partnerships to tackle the intricate challenges of CIoT. Publications like “Sustainability” and “Sustainable Cities and Society” have played a crucial role in sharing research, yet the sector lacks specialized outlets, prompting journals to focus more on CIoT themes. An analysis of keywords revealed common themes like "automation" and "smart homes," while rising topics such as privacy, sustainability, and smart cities point out critical areas that need further exploration. The study shows a shift towards the Internet of Things (IoT), smart home innovations, healthcare, energy solutions, and deep learning, highlighting the evolving research interests and underscoring noteworthy growth in these fields over time.

As the inaugural bibliometric analysis of CIoT, this study lays the groundwork for comprehending the domain's development, highlighting its socio-technical intersections. It advocates for a greater emphasis on building consumer trust through effective frameworks (such as blockchain and federated learning) and tackles less explored areas like the integration of ethical AI and energy-efficient IoT solutions. Stakeholders need to promote global cooperation, motivate high-quality research, and ensure that innovations align with societal requirements to fully exploit CIoT's potential. By addressing these deficiencies, the CIoT ecosystem can grow sustainably, providing fair advantages for businesses, consumers, and future generations.

LIMITATIONS AND FUTURE DIRECTIONS

Several factors constrain the results of the study. Firstly, the exclusive reliance on the Scopus database may have resulted in the omission of relevant research found on platforms such as Web of Science or IEEE Xplore, thus potentially creating selection bias and restricting the breadth of the dataset. Moreover, even though the analysis incorporated articles in various languages, there might be a lack of representation for non-English publications due to Scopus's indexing tendencies, which could skew insights toward English-speaking academic environments. The bibliometric method primarily concentrated on metadata (e.g., titles, keywords) instead of the full text, which may lead to missing important interdisciplinary connections or the emergence of new sub-themes in CIoT research. In addition, keyword vagueness—such as general terms like "automation" that may intersect with non-CIoT areas—can diminish thematic clarity. Lastly, the incompleteness of 2024 data resulting from publication delays could influence the precision of contemporary trends, highlighting the necessity for careful consideration of timing when interpreting the findings.

To further CIoT research, there should be interdisciplinary collaborations that bridge socio-technical divides, such as the incorporation of ethical AI frameworks, the examination of consumer trust dynamics, and the development of governance policies specifically designed for IoT ecosystems. Tackling security and privacy concerns—especially in wearable technology and smart home devices—calls for innovative approaches like blockchain and federated learning systems. Sustainability should be a primary focus, with research investigating energy-efficient IoT designs, circular economy strategies for managing device lifecycles, and CIoT’s coherence with global sustainability objectives. On a geographical level, encouraging international collaborations could help alleviate regional disparities in research productivity while fostering culturally inclusive innovations. Urgent attention is needed for emerging topics such as privacy-preserving AI, the resilience of smart cities, and the creation of human-centric designs beneficial for underrepresented communities. Long-term studies that monitor the societal effects of CIoT—including changes in labor markets, shifts in consumer behavior, and issues of digital equity—will enrich our understanding of its long-term consequences. By emphasizing these areas, researchers can enhance the academic validity and practical significance of CIoT, ensuring its development keeps pace with ethical, technological, and societal progress.

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