IoT Research for Smart Retail: Global Mapping 2000–2025

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ABSTRACT

This study provides a comprehensive global mapping of IoT research in smart retail from 2000 to 2025, employing bibliometric and network analysis techniques. The research focuses on identifying key research trends, thematic clusters, geographical distributions, and technological milestones. Using data from Scopus and Web of Science, the study analyzes publication trends, citation patterns, author affiliations, and collaboration networks. The findings reveal the central role of IoT in smart retail, with significant contributions from artificial intelligence, blockchain, and energy efficiency. Additionally, the study highlights the evolving research priorities and geographic distribution, emphasizing the increasing involvement of emerging economies and regions in global research collaborations. The paper identifies critical research gaps and proposes future directions to enhance the development of smart retail systems.

Keywords: *IoT, Smart Retail, Bibliometric Analysis, Research Mapping, Artificial Intelligence*

1. INTRODUCTION

The rapid evolution of digital technologies over the past two decades has transformed how businesses operate, interact with consumers, and deliver value. Among these, the Internet of Things (IoT) has emerged as a foundational pillar of the Fourth Industrial Revolution, enabling physical objects to sense, communicate, and act in concert with digital systems [1]. In particular, retail sectors globally have embraced IoT as a mechanism to optimize processes, enhance customer experiences, and drive operational intelligence [2]. By connecting devices, products, environments, and consumer interfaces, IoT creates a data-rich ecosystem that empowers retailers to make real-time decisions and personalize services at a scale previously unattainable [3].

The application of IoT technologies in retail encompasses a wide spectrum of innovations, including smart shelves, RFID-based inventory systems, sensor-driven footfall analytics, and automated checkout processes [4]. These technologies enable retailers to reduce shrinkage, improve stock visibility, and fine-tune supply chain workflows, often resulting in measurable improvements in key performance indicators such as stock turnover and customer satisfaction [5]. Furthermore, IoT-enabled platforms facilitate seamless integration between online and physical retail channels, fostering an omnichannel retail experience that meets evolving consumer expectations.

From 2000 to 2010, the initial research on IoT in retail was largely exploratory, characterized by small-scale pilot studies and theoretical frameworks that examined potential applications [6], [7]. Technological constraints, such as limited sensor accuracy, interoperability issues, and high infrastructure costs, restricted widespread adoption. However, advancements in wireless connectivity, edge computing, and cost-effective sensor manufacturing throughout the 2010s catalyzed greater experimentation and deployment across markets. By the late 2010s, major retailers in North America, Europe, and Asia began investing heavily in IoT-driven solutions, indicating a shift from experimental deployments to strategic digital transformation initiatives.

The growth of consumer expectations has also driven the adoption of IoT in retail. Modern customers increasingly demand personalized experiences, frictionless transactions, and immediate fulfillment options, which traditional retail models struggle to provide [8]. IoT technologies enable such personalization through interactions like smart beacons that deliver context-aware promotions, automated checkout systems that eliminate queue time, and environment sensors that adjust in-store ambiance based on customer behavior patterns. These innovations not only elevate customer satisfaction but also generate rich datasets that retailers can leverage for predictive analytics, trend forecasting, and targeted campaign strategies.

In addition to enhancing customer engagement and operational efficiency, IoT in retail plays a significant role in sustainability and resource optimization. Smart energy management systems can reduce waste by intelligently controlling lighting, heating, and cooling based on real-time store usage data, while supply chain sensors track temperature-sensitive products to minimize spoilage [9], [10]. As environmental concerns and regulatory pressures mount globally, IoT-enabled sustainability solutions are becoming vital for retailers seeking not only economic resilience but also social responsibility credentials. Collectively, these trends illustrate the multifaceted impact of IoT technologies on retail from back-end logistics to front-end customer experiences thereby justifying a comprehensive mapping of research evolution from 2000 to 2025.

Despite the accelerated adoption of IoT-driven systems in smart retail and a proliferation of academic and industry research, there exists no unified global mapping that captures the evolution, key themes, geographic trends, and research gaps across the twenty-five-year period from 2000 to 2025. Available literature often focuses on isolated technological components (e.g., RFID, sensor networks) or region-specific case studies, limiting broader understanding of how research priorities and practical deployments have shifted over time [11]. Moreover, disparate research methodologies and terminologies across computer science, business analytics, and supply chain domains have resulted in fragmented findings that impede cumulative knowledge building. This fragmentation makes it difficult for scholars, practitioners, and policymakers to identify long-term patterns, benchmark innovations across regions, and anticipate emerging opportunities and challenges in smart retail IoT. Without such comprehensive mapping, stakeholders risk duplicating efforts, overlooking critical research lacunae, or misaligning investments with evolving technological trajectories. The objective of this study is to develop a comprehensive global mapping of IoT research for smart retail from 2000 to 2025, identifying key research trends, thematic clusters, geographic distributions, technological milestones, and emergent foci over time

2. METHODS

This study employs a systematic literature mapping and bibliometric analysis approach to examine the global development of IoT research in smart retail from 2000 to 2025. A structured review protocol was designed to ensure transparency, reproducibility, and comprehensive coverage of relevant scholarly works. Peer-reviewed journal articles, conference proceedings, and review papers were selected as primary sources to capture both theoretical and applied research contributions. Inclusion criteria focused on publications explicitly addressing IoT technologies within retail or smart retail contexts, while exclusion criteria removed studies unrelated to retail environments, non-English publications, and non-scholarly documents. This filtering process ensured that the dataset accurately reflected the academic evolution of IoT-driven smart retail research over the designated period.

Bibliometric techniques were applied to analyze publication trends, citation patterns, authorship networks, and geographic distribution of research outputs. Key metadata elements—including publication year, author affiliations, keywords, abstracts, and cited references—were extracted and standardized for analysis [12]. Visualization tools were utilized to map relationships among research topics, institutions, and countries, providing insights into global collaboration patterns and regional research priorities. To complement the quantitative bibliometric analysis, a qualitative thematic synthesis was conducted to interpret the conceptual evolution of IoT applications in smart retail. Selected high-impact and representative studies from each identified research phase were examined in depth to contextualize technological advancements, methodological approaches, and application domains.

3. RESULTS AND DISCUSSION

3.1 Network Visualization

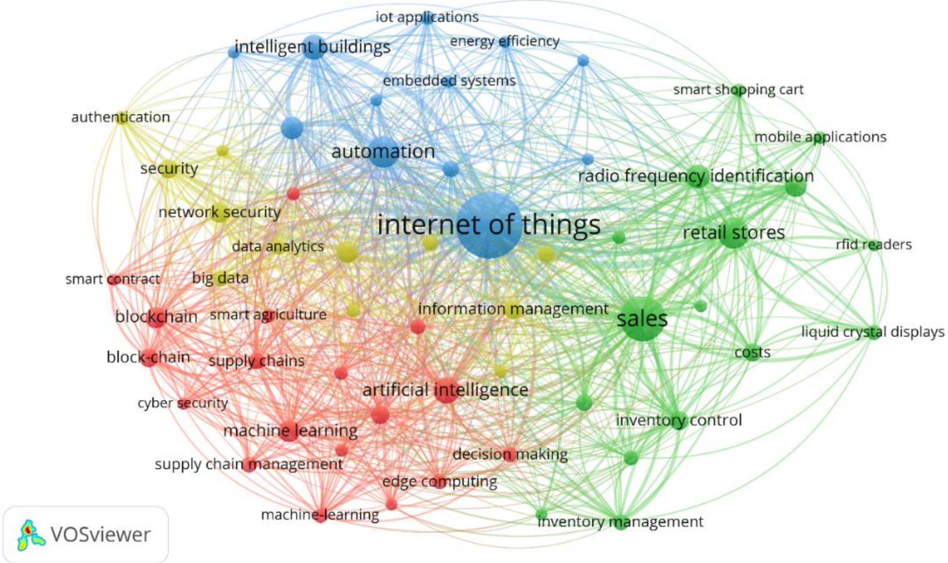

Figure 1. Network Visualization

Source: Data Analysis Result, 2026

Figure 1 above represents the relationship and frequency of key topics in IoT research within the context of smart retail, spanning across a range of concepts like automation, sales, security, artificial intelligence, and supply chains. The central node, labeled "Internet of Things," connects all other themes, emphasizing its central role in smart retail research. IoT serves as the backbone of modern retail systems, facilitating the integration of devices and systems to improve efficiency, automation, and customer experience. Key topics around IoT include automation, data analytics, radio frequency identification (RFID), and inventory control, reflecting its extensive application in inventory tracking, product management, and personalized customer services.

The red cluster surrounding IoT suggests strong connections between artificial intelligence (AI), machine learning, and blockchain. AI and machine learning are essential for decision-making processes, predictive analytics, and customer behavior analysis. They are heavily applied in areas like inventory management, costs, and sales optimization. On the other hand, blockchain technology, noted for its applications in smart contracts and supply chain management, facilitates secure and transparent transactions within retail environments, addressing concerns about authenticity and security. A green cluster forms around sales, retail stores, and inventory control, marking the significant impact of IoT on the retail sector. The presence of terms like smart shopping cart and rfid readers highlights the intersection of IoT with the retail customer experience. RFID technology, in particular, plays a critical role in enhancing the speed and accuracy of stocktaking, reducing human error, and streamlining supply chains, while smart shopping carts represent an effort to integrate customer interaction with inventory systems for better service.

Security, one of the primary concerns in IoT applications, is shown in the yellow and red clusters. Network security, authentication, and cybersecurity are fundamental to protecting the data flowing through IoT devices in retail environments. This is critical not only for preventing fraud but also for securing customer data and ensuring the integrity of transactions. The growing complexity of IoT systems increases the need for robust security measures to handle sensitive information, particularly in payment systems and smart contracts. In the blue cluster, there is a noticeable presence of terms like energy efficiency, intelligent buildings, and embedded systems. These represent an emerging focus on sustainability and environmental impact within the IoT ecosystem. Smart buildings and energy-efficient technologies in retail settings help reduce operational costs and minimize environmental footprints, aligning with global trends toward greener, more sustainable retail operations. This growing interest in energy-saving solutions is indicative of the increasing convergence of IoT with sustainability in future smart retail developments.

3.2 Overlay Visualization

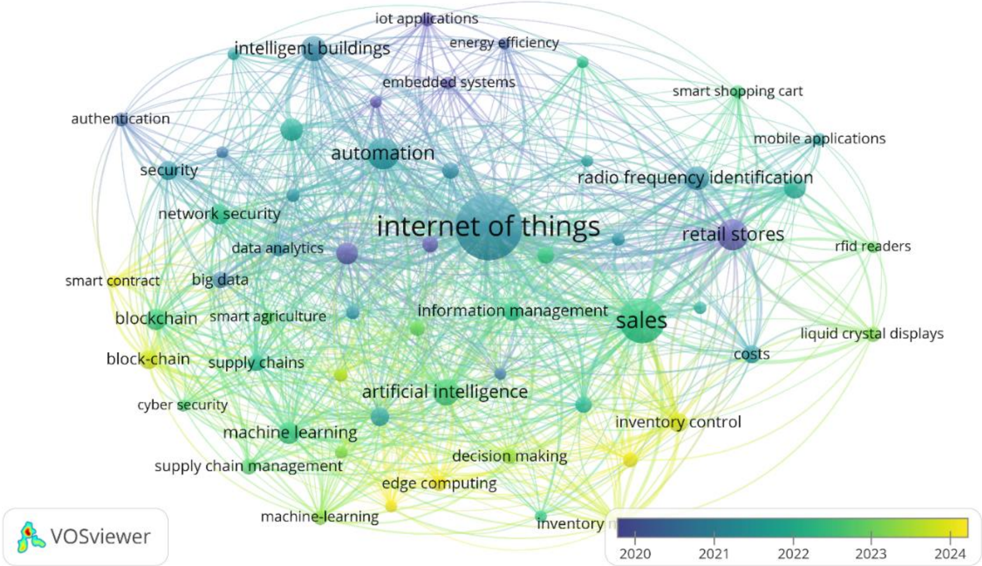

Figure 2. Overlay Visualization

Source: Data Analysis Result, 2026

Figure 2 displays the development of key research topics in the IoT and smart retail domains from 2020 to 2024. The map illustrates how various IoT-related technologies and themes evolve over time, with color coding indicating their emergence or increased relevance. The blue and green nodes dominate the central areas, marking the core topics such as Internet of Things (IoT), automation, sales, retail stores, and inventory control, which have maintained strong connections and consistent growth over the years. These topics are closely related to operational improvements in smart retail environments, especially concerning inventory and sales management.

As the visualization progresses towards 2021 and 2022, we see artificial intelligence (AI) and machine learning emerge as crucial elements, with their connections growing more pronounced (highlighted by the yellow-green clusters). These technologies, along with big data, are now being increasingly applied for decision-making, predictive analytics, and enhancing customer experiences in smart retail. AI and machine learning's influence extends to areas like security, network security, and information management, showcasing their cross-cutting impact on both operational and consumer-facing aspects of retail. Additionally, the purple and light blue areas, which represent topics like mobile applications, RFID readers, and smart shopping carts, illustrate the evolution of consumer-focused innovations, marking the integration of IoT with personalized retail solutions.

The recent period (2023–2024) shows an increased focus on energy efficiency, embedded systems, and intelligent buildings, reflecting growing interest in sustainable and smart building technologies. This shift, indicated by the light purple and blue areas, marks a move towards more integrated, eco-conscious solutions in retail environments. The connections between topics like IoT applications and energy efficiency suggest an increasing emphasis on reducing energy consumption in smart retail operations.

3.3 Citation Analysis

Table 1. The Most Impactful Literatures

Citations	Authors and year	Title
365	[13]	Design of Secure User Authenticated Key Management Protocol for Generic IoT Networks
303	[14]	Internet of things applications: From research and innovation to market deployment
278	[15]	Towards the internet-of-smart-clothing: A review on IoT wearables and garments for creating intelligent connected E-textiles
258	[6]	A Survey on Architecture, Protocols and Challenges in IoT
225	[16]	Influence of Blockchain Technology in Manufacturing Supply Chain and Logistics
189	[17]	Internet of Things for Industrial Automation-Challenges and Technical Solutions
188	[18]	Wireless Communication Technologies for IoT in 5G: Vision, Applications, and Challenges
165	[19]	Blockchain and smart contract for IoT enabled smart agriculture
147	[20]	The Fight against the COVID-19 Pandemic with 5G Technologies
145	[21]	A Fog-Based Internet of Energy Architecture for Transactive Energy Management Systems

Source: Scopus, 2025

3.4 Density Visualization

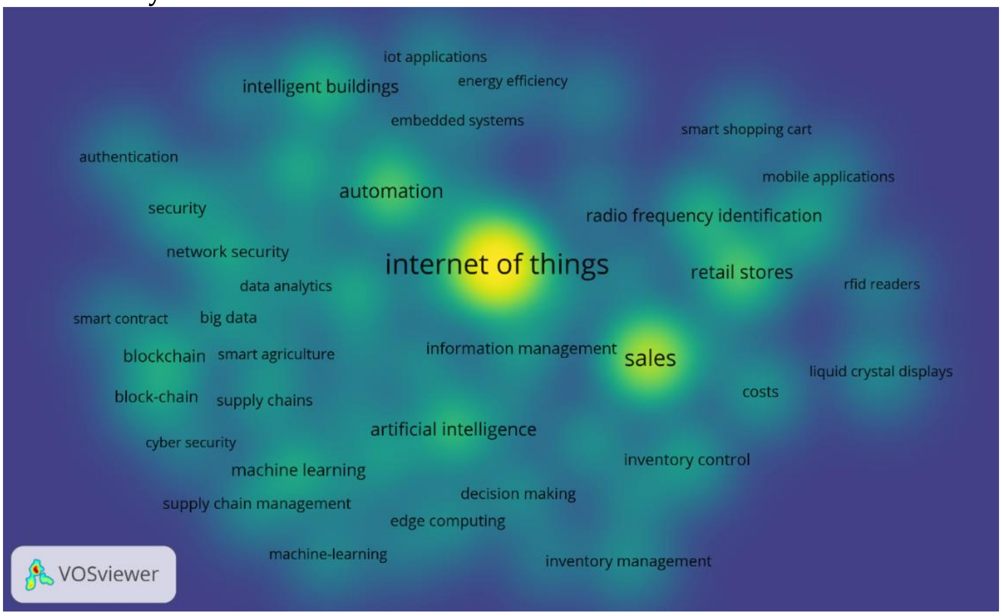

Figure 3. Density Visualization

Source: Data Analysis Result, 2026

illustrates the concentration of research topics within the field of IoT and smart retail. The central nodes like "Internet of Things" and "sales" exhibit the highest intensity, indicating that these are the primary focus areas in the literature. The central role of IoT is evident, as it links with various other topics like automation, inventory control, RFID readers, and retail stores, which are key for managing and optimizing retail operations. This suggests that IoT's application in automation and inventory management is a central theme, with an emphasis on improving operational efficiency and customer experiences. The heatmap also reveals emerging areas like artificial intelligence (AI), machine learning, and data analytics, which have substantial connections in the ecosystem. These topics, highlighted in green, are closely tied to decision making and information management, reflecting their role in enabling intelligent, data-driven retail systems. Topics such as blockchain, smart contracts, and network security are present, but their intensity is relatively lower, signaling that while they are part of the broader IoT landscape in retail, they might be considered secondary to core operational topics. The blue regions in the map, associated with energy efficiency and intelligent buildings, highlight a growing trend towards sustainability and smarter infrastructure in retail environments.

3.5 Co-Authorship Network

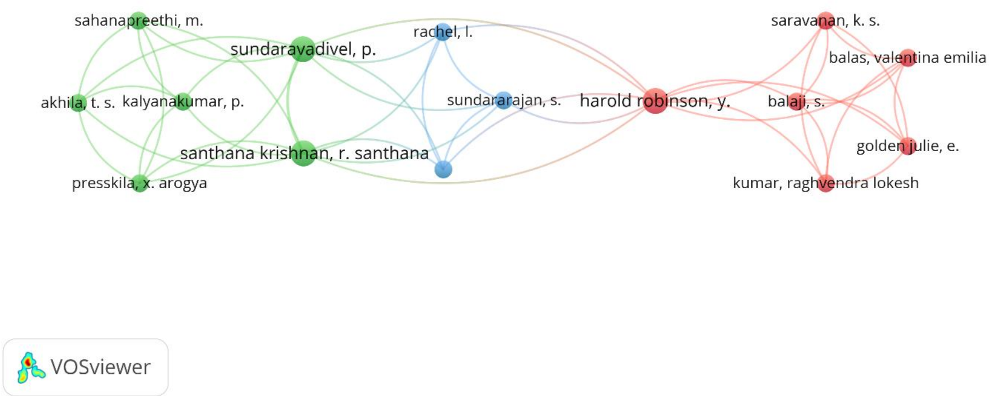

Figure 4. Author Visualization
Source: Data Analysis Result, 2026

Figure 4 represents the co-authorship relationships between several researchers, with color coding to indicate different clusters. The central node, Harold Robinson, Y., is highly connected, forming the core of the network, while other researchers are linked to him in varying degrees, as shown by their connections. The green cluster on the left (including Sundaravadivel, P., Santhana Krishnan, R., and others) suggests a group of authors who frequently collaborate with each other. The blue cluster in the middle, containing Rachel, I., and Sundararajan, S., indicates another distinct research group. On the right, the red cluster, centered around Saravanan, K. S., shows another set of connected researchers.

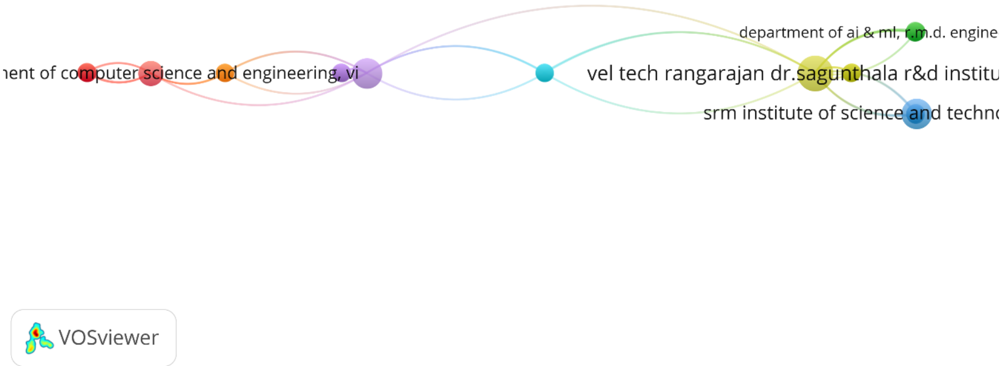

Figure 5. Affiliation Visualization

Source: Data Analysis Result, 2026

Figure 5 shows the relationships between various institutions and departments involved in the field of computer science and engineering. The central node, labeled Department of Computer Science and Engineering, is highly connected to several other institutions, such as Vel Tech Rangarajan Dr. Sagunthala R&D Institute and SRM Institute of Science and Technology. The color coding suggests different clusters or groups of institutions and departments, with each institution or department contributing to the research network. This map highlights the collaborative landscape of research in the field, indicating how different institutions are interconnected and contribute to the broader research ecosystem.

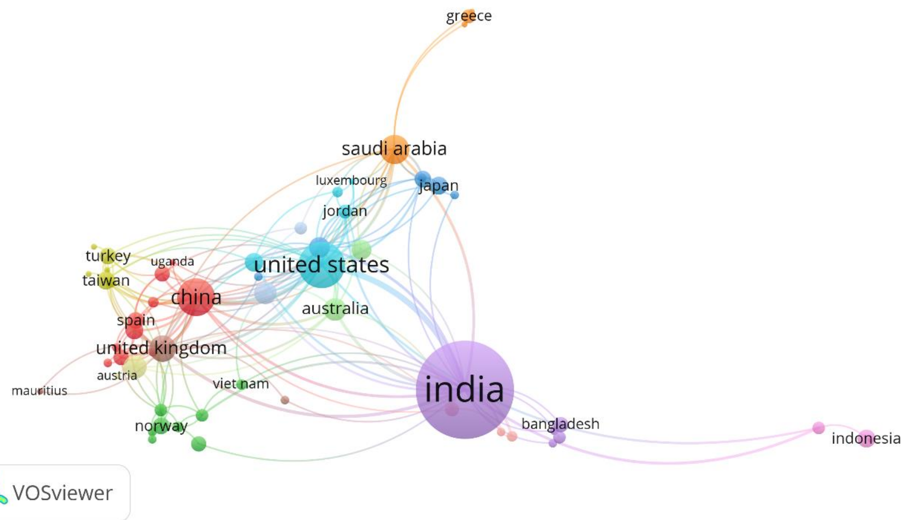

Figure 6. Country Visualization

Source: Data Analysis Result, 2026

Figure 6 represents the global collaboration landscape in research, showing the connections between different countries. The central node, India, is the most prominent and highly connected, indicating its central role in the research network. Surrounding India are countries like China, United States, and United Kingdom, which form a dense cluster, suggesting strong research ties with India. The map also highlights regions like Australia, Saudi Arabia, and Japan, with fewer but notable connections to other countries. On the periphery, countries such as Greece, Bangladesh, and Indonesia are connected, showing more localized or emerging collaborations. The overall structure suggests a robust and widespread international network, with a concentration of connections in Asia, North America, and Europe.

Discussion

This network map of global research collaboration illustrates the interconnectedness of various countries in the research landscape. India emerges as the central hub of the network, with extensive ties to major research powerhouses like the United States, China, and the United Kingdom. This suggests that India plays a pivotal role in driving research initiatives and collaborations, particularly in fields where these countries have traditionally been dominant. The dense connections between these countries point to shared research interests and the formation of strong academic or scientific partnerships, indicating a healthy flow of knowledge and resources across these nations.

Additionally, countries such as Australia, Saudi Arabia, and Japan form distinct but noticeable clusters around India, showcasing the expanding research networks beyond the traditional Western and Eastern powerhouses. These countries may be focusing on region-specific challenges or emerging technologies, while also integrating into global conversations. The connections among these countries reflect the increasing globalization of research, with more nations participating in joint studies, publications, and cross-border collaborations in various scientific domains, including technology, healthcare, and sustainable development.

On the fringes of the map, countries like Greece, Bangladesh, and Indonesia appear to have relatively fewer connections with the central clusters but are still involved in global research networks. These countries' presence in the network highlights their growing participation in international collaborations, which may be driven by the need to address local issues or capitalize on global research trends. This evolving pattern suggests that as emerging economies and regions continue to invest in research and development, they will increasingly become integral parts of the global academic ecosystem, fostering diverse collaborations and contributing to knowledge production on a global scale.

CONCLUSION

This study highlights the dynamic and interconnected nature of global research collaboration, with India positioned as a central player in the academic and scientific network. The strong ties between India, the United States, China, and the United Kingdom underscore the importance of these nations in driving global research agendas. The increasing participation of countries like Australia, Saudi Arabia, and Japan further emphasizes the expanding scope of research collaboration, transcending traditional boundaries. Additionally, emerging countries such as Greece, Bangladesh, and Indonesia demonstrate the growing inclusivity of global research networks, fostering a more diverse and interconnected academic ecosystem. As research becomes increasingly collaborative and borderless, this study underscores the need for continued international cooperation to address global challenges and drive innovation.

REFERENCES

[1] S. H. Kalange, D. A. Kadam, A. B. Mokal, and A. A. Patil, "Smart retailing using IOT," *Int. Res. J. Eng. Technol.*, vol. 4, no. 11, pp. 263–268, 2017.

[2] G. Singh, S. Srivastav, A. Gupta, and V. Garg, "Companies adoption of IoT for smart retailing in industry 4.0," in *2020 International Conference on Intelligent Engineering and Management (ICIEM)*, IEEE, 2020, pp. 487–492.

[3] H.-T. Jamme and D. S. Connor, "Diffusion of the Internet-of-Things (IoT): A framework based on smart retail technology," *Appl. Geogr.*, vol. 161, p. 103122, 2023.

[4] A. Jayaram, "Smart retail 4.0 IoT consumer retailer model for retail intelligence and strategic marketing of in-store products," *Proc. 17th Int. Bus. horizon-INBUSH ERA-2017, Noida, India*, vol. 9, 2017.

[5] M. Roe, K. Spanaki, A. Ioannou, E. D. Zamani, and M. Giannakis, "Drivers and challenges of internet of things diffusion in smart stores: A field exploration," *Technol. Forecast. Soc. Change*, vol. 178, p. 121593, 2022.

[6] C. C. Sobin, "A survey on architecture, protocols and challenges in IoT," *Wirel. Pers. Commun.*, vol. 112, no. 3, pp. 1383–1429, 2020.

[7] K. R. Štofková, F. Bajza, P. Janošková, and M. Kováčiková, "Proposal of innovative smart solutions for retail store in order to support competitiveness and sustainable development," *Front. Comput. Sci.*, vol. 6, p. 1328913, 2024.

[8] A. Saroliya and M. Agrawal, "Smart Retail Environments: An Extensive Analysis of IoT-Based Transformation and its Effectiveness on Customer Experience Enhancement (CEE)," in *EPJ Web of Conferences*, EDP Sciences, 2025, p. 1036.

[9] S. Thilagavathi, K. S. Nivethitha, P. Preeti, and D. T. Vikram, "IoT based smart retail system with social distancing for covid19 outbreak," in *Journal of Physics: Conference Series*, IOP Publishing, 2021, p. 12030.

[10] M. E. Isharyani, B. M. Sopha, M. A. Wibisono, and B. Tjahjono, "Smart retail adaptation framework for traditional retailers: A systematical review of literature," in *2021 IEEE International Conference on Industrial Engineering and Engineering Management (IEEM)*, IEEE, 2021, pp. 143–147.

[11] C. Barbieri and E. Mahoney, "Why is diversification an attractive farm adjustment strategy? Insights from Texas farmers and ranchers," *J. Rural Stud.*, vol. 25, no. 1, pp. 58–66, 2009.

[12] N. Donthu, S. Kumar, D. Mukherjee, N. Pandey, and W. M. Lim, "How to conduct a bibliometric analysis: An overview and guidelines," *J. Bus. Res.*, vol. 133, pp. 285–296, 2021.

[13] M. Wazid, A. K. Das, V. Odelu, N. Kumar, M. Conti, and M. Jo, "Design of secure user authenticated key management protocol for generic IoT networks," *IEEE Internet Things J.*, vol. 5, no. 1, pp. 269–282, 2017.

[14] O. Vermesan and P. Friess, *Internet of things applications-from research and innovation to market deployment*. Taylor & Francis, 2014.

[15] T. M. Fernández-Caramés and P. Fraga-Lamas, "Towards the Internet of smart clothing: A review on IoT wearables and garments for creating intelligent connected e-textiles," *Electronics*, vol. 7, no. 12, p. 405, 2018.

[16] A. Raja Santhi and P. Muthuswamy, "Influence of blockchain technology in manufacturing supply chain and logistics," *Logistics*, vol. 6, no. 1, p. 15, 2022.

[17] H. P. Breivold and K. Sandström, "Internet of things for industrial automation--challenges and technical solutions," in *2015 IEEE International Conference on Data Science and Data Intensive Systems*, IEEE, 2015, pp. 532–539.

[18] Q. V. Khanh, N. V. Hoai, L. D. Manh, A. N. Le, and G. Jeon, "Wireless communication technologies for IoT in 5G: Vision, applications, and challenges," *Wirel. Commun. Mob. Comput.*, vol. 2022, no. 1, p. 3229294, 2022.

[19] T. H. Pranto, A. A. Noman, A. Mahmud, and A. K. M. B. Haque, "Blockchain and smart contract for IoT enabled smart agriculture," *PeerJ Comput. Sci.*, vol. 7, p. e407, 2021.

[20] Y. Siriwardhana, C. De Alwis, G. Gür, M. Ylianttila, and M. Liyanage, "The fight against the COVID-19 pandemic with 5G technologies," *IEEE Eng. Manag. Rev.*, vol. 48, no. 3, pp. 72–84, 2020.

[21] M. H. Y. Moghaddam and A. Leon-Garcia, "A fog-based internet of energy architecture for transactive energy management systems," *IEEE Internet Things J.*, vol. 5, no. 2, pp. 1055–1069, 2018.