

TECHNOLOGY IN AUTOMATED VENDING MACHINES, AUTOMATED RETAIL AND SELF-SERVICE KIOSKS: BIBLIOMETRIC ANALYSIS OF THE SCIENTIFIC LITERATURE FROM 1994 TO 2024

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ABSTRACT: Vending machines have evolved into automated systems by integrating digital technologies, artificial intelligence, and self-service solutions. This study analyzes research trends in vending machine technology through a bibliometric analysis of scientific literature published between 1994 and 2024. Following PRISMA-2020 guidelines, the study used Scopus and Web of Science and identified a final corpus of 97 articles after applying the selection criteria. The results reveal a growth in scientific production, with a 99.33% increase during the analyzed period and a higher concentration of publications in 2023. The study also identifies the most influential authors, journals, and countries in the field, as well as a thematic evolution from early approaches related to Technology Mapping to current trends associated with Technology Adoption, Virtual Reality, Waste Management, and Quick-Service Restaurants. The co-occurrence analysis identified nine thematic clusters, while emerging keywords such as Community Change, New Technologies, Customer Value, and Sustainability indicate new research opportunities related to technology, users, and sustainability.

Keywords: Innovation, sustainability, user experience, automation, operational efficiency.

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INTRODUCTION

Vending machine technology has evolved in the retail sector thanks to the integration of artificial intelligence (AI) and automation. While they were initially used to dispense snacks and beverages, they now enable automated stores that offer more streamlined shopping experiences and reduce operating costs through automated payment systems and inventory sensors (Pillai et al., 2020). This development has spurred academic interest in consumer behavior, supply chain management, and user experience. Specifically, studies have examined purchase intentions in AI-driven automated stores (Pillai et al., 2020) and the design of self-service kiosks in restaurants, aiming to understand how these technologies are transforming retail and redefining the relationship between consumers and businesses (Park et al., 2021). Furthermore, its influence has extended to other sectors, such as tourism and hospitality, giving rise to various variables discussed in the literature, which analyze biosafety, crisis management, automation, and academic performance (Ivanov et al., 2022).

Furthermore, artificial intelligence has shown its ability to generate value and transform business models, calling for a review of the factors that influence the co-creation of value (Solakis et al., 2022). On the other hand, automated dispensing has also been influenced by the development of technologies such as the Internet of Things (IoT), and its implementation improves cost reduction, process optimization, and decent working conditions. This has made it possible to offer continuous services at reduced costs, track consumption records, and use advanced identification systems with biometric and NFC tools, which have improved companies' operational efficiency by changing how customers interact with products and services (Vakulenko et al., 2019).

These systems enhance the customer experience by enabling fast, convenient purchasing processes, allowing retailers to collect data on preferences and consumption patterns and use it to make decisions and design marketing strategies (Cambra-Fierro et al., 2020).

Therefore, it is necessary to study how consumers are now interacting with these technologies implemented in vending machines, since—as evidenced by analyses of ordering experiences in restaurants—there has been a shift in customers' perception of value, particularly with regard to operational, relational, and service factors (Leung et al., 2021).

Another case studied is the acceptance of vending machines in transportation, where user attitudes and behaviors have been analyzed to support effective integration (Cserdi & Kenesei, 2021). In this sector, innovations in automated teller machines have improved accessibility and service quality (Schmidt, 2020).

However, although research has advanced and contributions are evident in different regions of the world, significant gaps still persist. The literature has analyzed factors related to value co-creation through artificial intelligence in tourism, highlighting the scarcity of studies focused on its application in vending machines (Solakis et al., 2022). Studies have identified the need to further explore the impact of self-service kiosks on the customer experience and retail efficiency (Vakulenko et al., 2018), as well as the need for an agenda for designing interfaces for illiterate and semi-literate users that ensures inclusion (Islam et al., 2023).

Based on the evidence identified in the literature, this bibliometric analysis aims to characterize research trends in vending machine technology to identify the most relevant research topics, emerging areas of interest, and current knowledge gaps. To this end, the following questions are posed:

- In which years has there been the greatest interest in vending machine technology?
- What kind of growth has been observed in the number of scientific articles on vending machine technology?
- Who are the leading researchers in the field of vending machine technology?
- How have the themes of scientific output on vending machine technology evolved?
- What are the main thematic clusters in the field of vending machine technology?
- What are the growing and emerging keywords in the field of vending machine technology research? - Which topics are taking center stage in the design of a research agenda on vending machine technology?

The article is structured systematically: the introduction provides context for the topic and justifies the use of bibliometrics; the methodology outlines the selection criteria, databases, and analysis process; the results highlight relevant topics and emerging areas; the discussion

interprets the findings, implications, and limitations, and guides future research; and the conclusions summarize the main contributions and offer recommendations.

METHODOLOGY

This study conducted an exploratory literature review on vending machine technology using secondary sources. The bibliometric analysis followed the PRISMA-2020 statement guidelines, which incorporate modifications and clarifications reflecting methodological and technological advances in scientific research; although designed for systematic reviews, the guidelines can be adapted to bibliometric studies (Page et al., 2021).

Eligibility Criteria

The inclusion criteria focused on titles and keywords as primary metadata, combining concepts associated with “technology” and “vending machines” and accounting for their terminological variants.

For the exclusion phase, two criteria were established: removing records with indexing errors and conference proceedings. This maintained the relevance of the selected data, ensured appropriate cataloging standards, and guaranteed complete information for analysis.

Source of Information

To collect the data, the Scopus and Web of Science databases were used, selected for their recognition in the academic community as some of the leading indexes of scientific literature and for offering broad disciplinary coverage and advanced metadata tools, which facilitate the extraction of accurate and reliable data and make them ideal for this type of research (Singh et al., 2021).

The selection of references included recent studies and foundational contributions to comprehensively understand the evolution of vending machine technology. Although we prioritized recent publications to identify current trends and emerging developments, we included older documents when they made relevant contributions to the conceptual framework, historical background, or early advances in the field.

The analysis period covered publications from 1994 to 2024, as this timeframe allows for the identification of the historical evolution of vending machine technology—from early developments related to technology mapping to current trends in technology adoption, sustainability, artificial intelligence, and self-service systems. Including literature up to 2024

made it possible to incorporate the most recent advances in the field and to recognize the thematic shifts that have emerged in recent decades.

Search Strategy

To narrow the search, we used inclusion criteria to optimize retrieval of relevant results when designing the search queries, which were adapted to the requirements of the databases and accounted for differences between Scopus and WoS in indexing and search operators. The search queries for each database are presented below:

For the Scopus database:

((TITLE ("vending machines" OR "automated retail" OR "self-service kiosks") AND TITLE ("technology" OR "innovation" OR "advancements" OR "developments")) OR (KEY ("vending machines" OR "automated retail" OR "self-service kiosks") AND KEY ("technology" OR "innovation" OR "advancements" OR "developments"))))

For the Web of Science database:

((TS = ("vending machines" OR "automated retail" OR "self-service kiosks") AND TS = ("technology" OR "innovation" OR "advancements" OR "developments")))

The search equations were designed with consideration for the terminological diversity used in the literature to refer to automated sales and self-service systems. For this reason, we incorporated equivalent terms such as “vending machines,” “automated retail,” and “self-service kiosks,” allowing the inclusion of different technological configurations associated with retail automation. Furthermore, although the search strategies were adapted to the specific syntax of Scopus and Web of Science, the same conceptual structure and search criteria were maintained to ensure comparability between the two information sources.

Data Management

To organize the extracted information, the databases were cleaned and structured in Microsoft Excel®, which facilitated their analysis. Next, to visualize bibliometric indicators, Excel® was used again, and VOSviewer® was implemented; the latter specializes in bibliometric maps that represent relationships between terms and authors in an intuitive and dynamic way (Van Eck & Waltman, 2010).

Search Parameters and Bibliometric Analysis

The literature search was conducted in the Scopus and Web of Science databases in May 2024, covering publications available through December 2024. The defined time frame spanned 1994 to 2024, allowing identification of historical developments and recent trends in vending machine technology, automated retail, and self-service kiosks. We included scientific documents published in English and Spanish, with original articles as the primary document type, and excluded documents with incomplete information, duplicate records, indexing errors, and conference proceedings.

Duplicate records were filtered by comparing titles, authors, publication year, and DOI, retaining only the record with complete bibliographic information. We then exported the data and organized it in Microsoft Excel®, where we classified and validated the included documents.

For bibliometric network analysis, VOSviewer® software was used to analyze keyword co-occurrence and relationships between terms. Maps were constructed using the association strength normalization technique, with the software's default parameters and considering only terms with a minimum frequency of 3 interactions. We interpreted the results by identifying thematic clusters and conceptual relationships among the selected terms.

Selection Process

According to the PRISMA 2020 statement, we recommend indicating the use of automated classifiers and validations to minimize errors (Page et al., 2021). In this study, the researchers developed an in-house classifier in Microsoft Excel® and used it independently during the inclusion and exclusion phases to reduce the risk of omissions or incorrect classifications.

Data Collection Process

According to PRISMA-2020, data collection methods must be detailed, including the number of reviewers and the procedures used to ensure information consistency (Page et al., 2021). In this study, a single author collected, organized, and validated the data using Microsoft Excel® as a supporting tool. This decision allowed the authors to maintain a uniform procedure and avoid potential interference or discrepancies that can arise when multiple reviewers are involved.

Data Elements

The authors collected articles related to the research objective using search queries tailored to each database. Documents with incomplete or unclear information were excluded as “irrelevant texts” because they did not contribute to understanding the topic.

Assessment of the Risk of Bias in the Study

The authors assessed risk of bias using Microsoft Excel® as an automated tool, with collaborative support from all authors. This procedure ensured consistency, integrity, and quality in identifying potential sources of bias that could affect the validity of the results.

Outcome Measures and Synthesis Methods

Based on secondary sources, we analyzed bibliometric indicators such as the number of publications, citations, and the temporal distribution of keywords, providing insight into scientific output and trends in vending machine technology. The characteristics of the studies were then tabulated and compared with the inclusion criteria. The data were prepared by handling missing data and conversions and applying bibliometric indicators of quantity, quality, and structure; this process was applied to documents that passed the three exclusion phases, ensuring an objective and systematic evaluation of scientific output (Durieux & Gevenois, 2010).

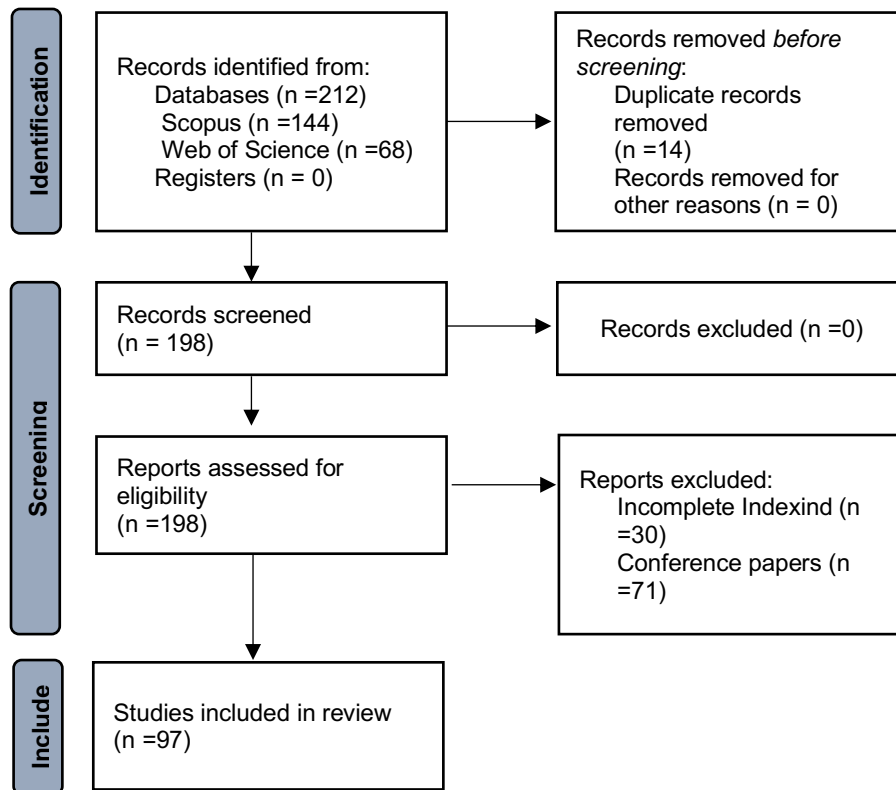
Assessment of Reporting Bias

In conducting this study, we acknowledge the risk of bias arising from the lack of results in the synthesis, particularly reporting bias. There is a possibility of bias toward certain

synonyms used in thesauri such as the IEEE, which could have affected the inclusion criteria, the search strategy, and data collection; likewise, the exclusion of documents with incomplete indexing and conference proceedings may have limited the available information, introducing potential biases in the interpretation of the bibliometric results.

Figure 1

PRISMA Flowchart.

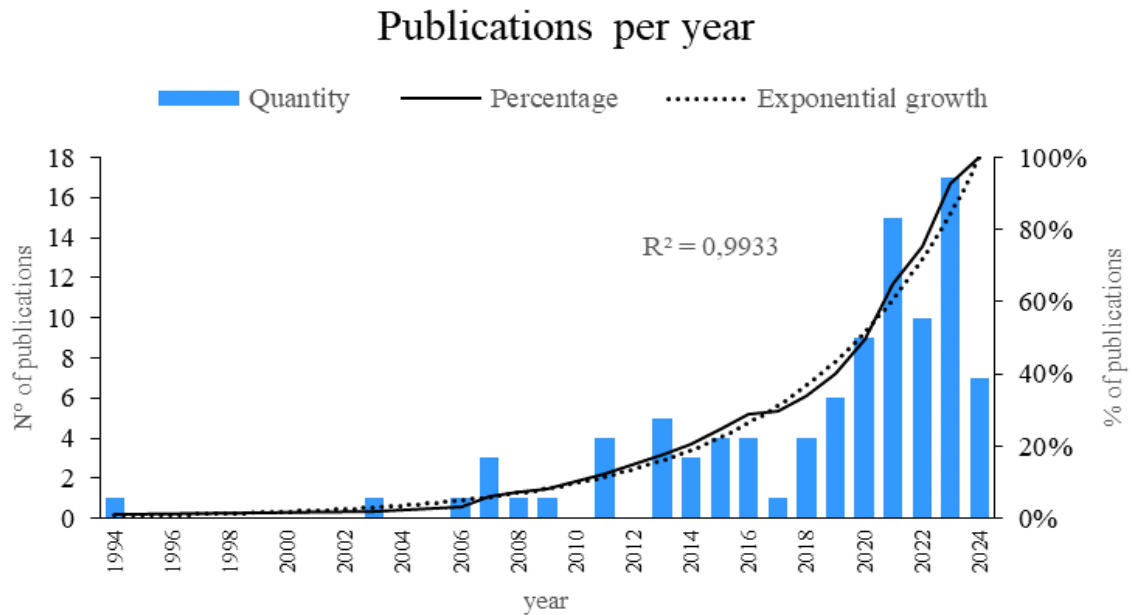


Note. Compiled by the author using data from Scopus and Web of Science.

RESULTS

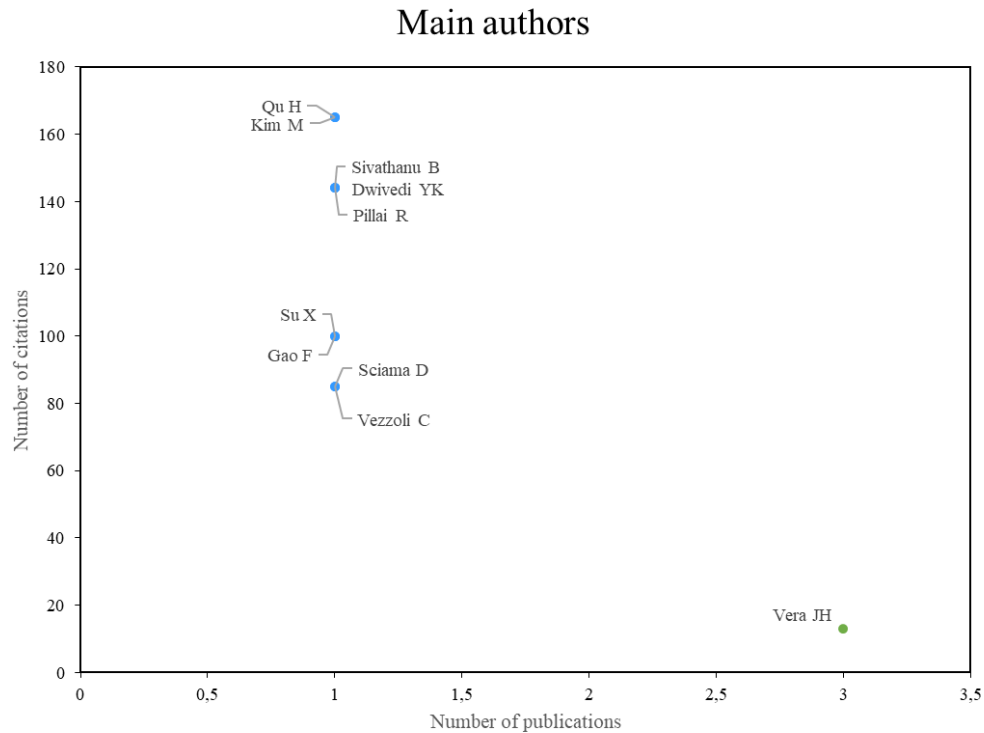
In the initial phase, articles were identified in Scopus and Web of Science using a specific search strategy. Next, duplicates were removed, and three exclusion criteria were applied: records with incorrect indexing, those without full-text access, and those with incomplete indexing or from conference proceedings. Following this process, 97 relevant articles were selected for the bibliometric analysis.

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Figure 2*Publications by Year*

Note. Compiled by the author using data from Scopus and Web of Science.

Two groups were identified among the leading authors. The first includes Qu H, Kim M, Sivathanu B, Dwivedi YK, and Pillai R, who, despite their low productivity, stand out for the high number of citations they have received. The second group, led by Vera JH, is characterized by a high publication output, although with less impact in terms of citations.

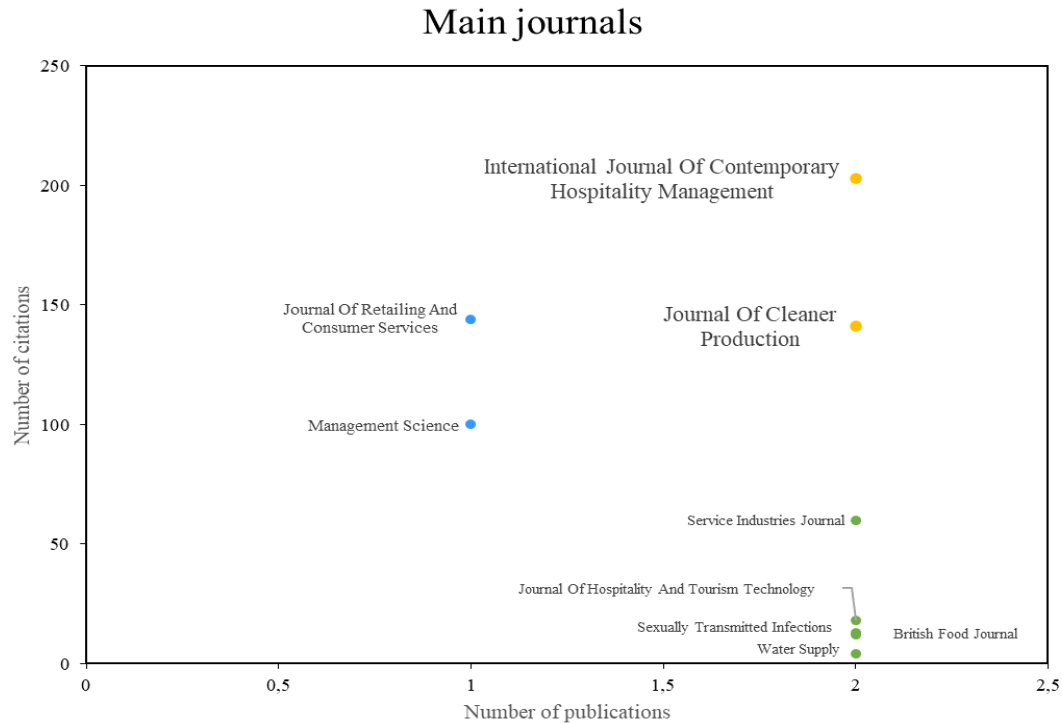
Figure 3*Lead authors*

Note. Compiled by the author using data from Scopus and Web of Science.

The journal analysis revealed three editorial profiles. First, some have high productivity and impact, such as the **International Journal of Contemporary Hospitality Management** and the **Journal of Cleaner Production**. Second, journals with low productivity but high impact include the **Journal of Retailing and Consumer Services** and **Management Science**. Finally, some journals stand out for their high scientific output, including the **Service Industries Journal**.

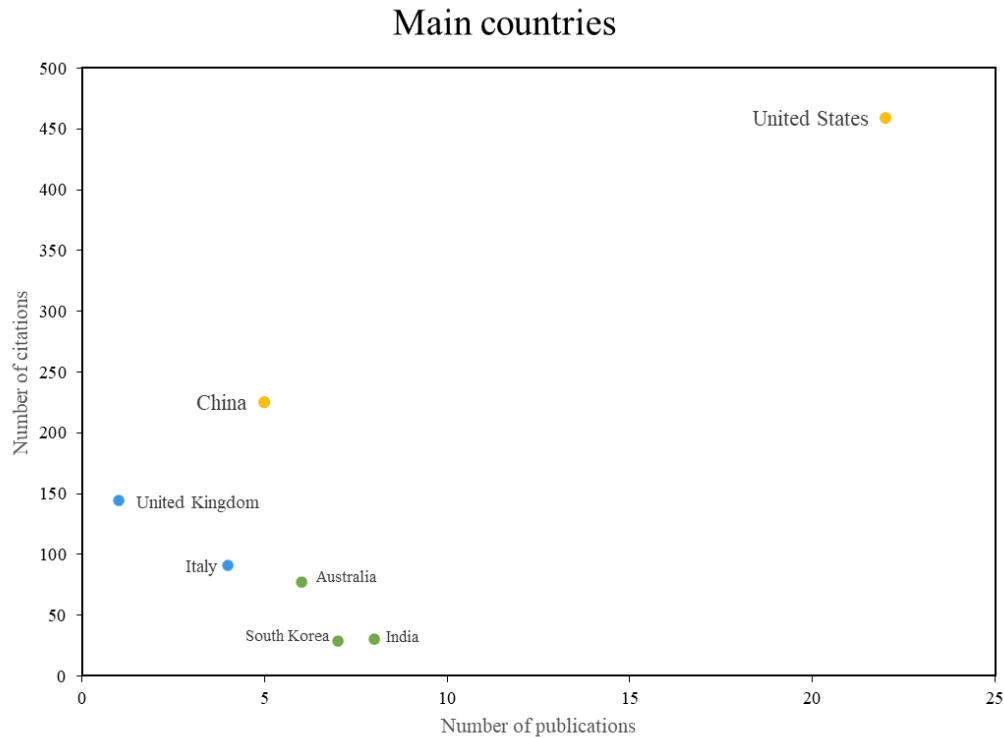
Figure 4

Major Journals



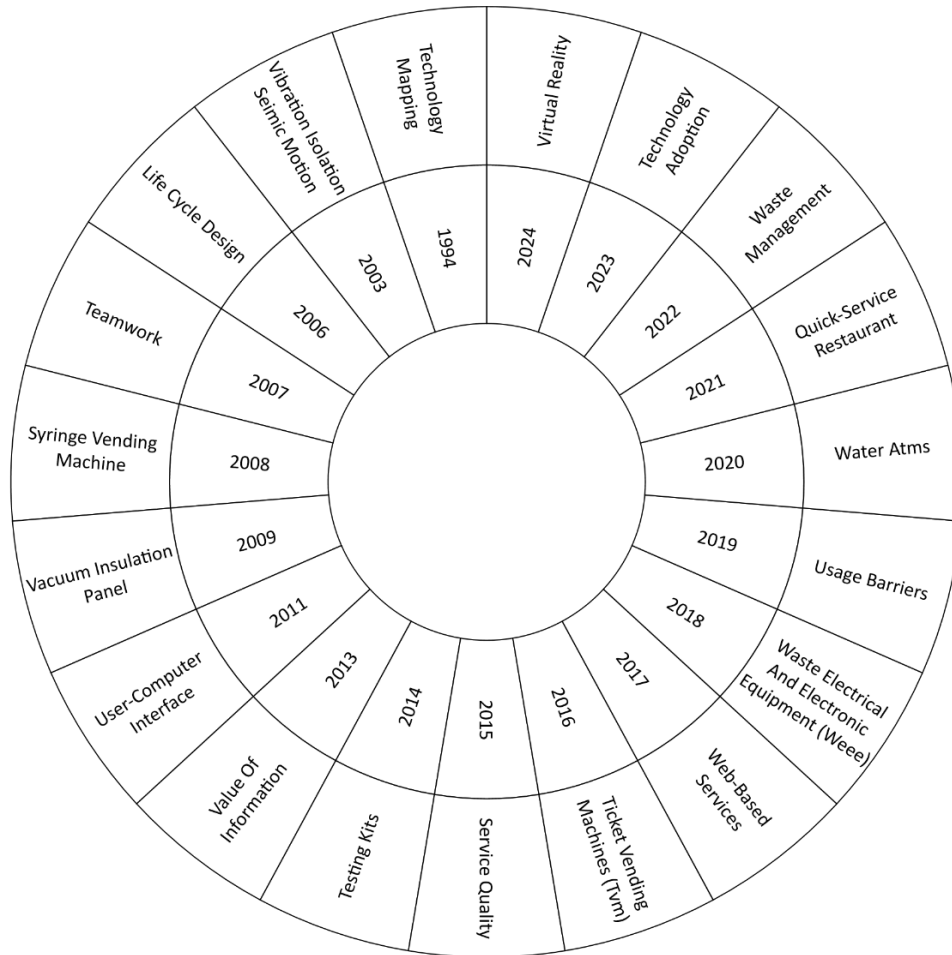
Note. Compiled by the author using data from Scopus and Web of Science.

The country-level analysis identified three distinct groups. The first consists of nations with high productivity and impact, including the United States and China. The second includes countries with low output but high impact, such as the United Kingdom and Italy. Finally, the third group comprises countries with high scientific productivity but fewer citations, with Australia as the most representative example.

Figure 5*Major Countries*

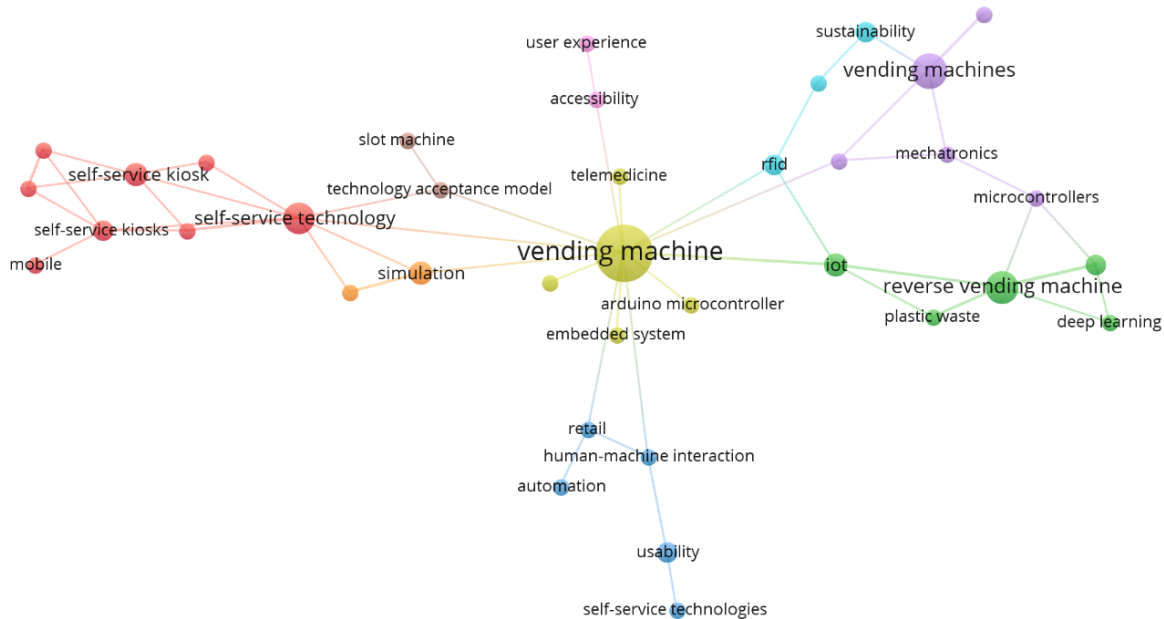
Note. Compiled by the author using data from Scopus and Web of Science.

The thematic evolution shown in Figure 6 illustrates the transformation of the most relevant keywords in the literature on vending machine technology between 1994 and 2024. In the early years, “Technology Mapping” stands out, while in the most recent period, concepts such as “Virtual Reality,” “Technology Adoption,” “Waste Management,” and “Quick-Service Restaurant” prevail, indicating a shift toward current research trends in the field.

Figure 6*Thematic Development*

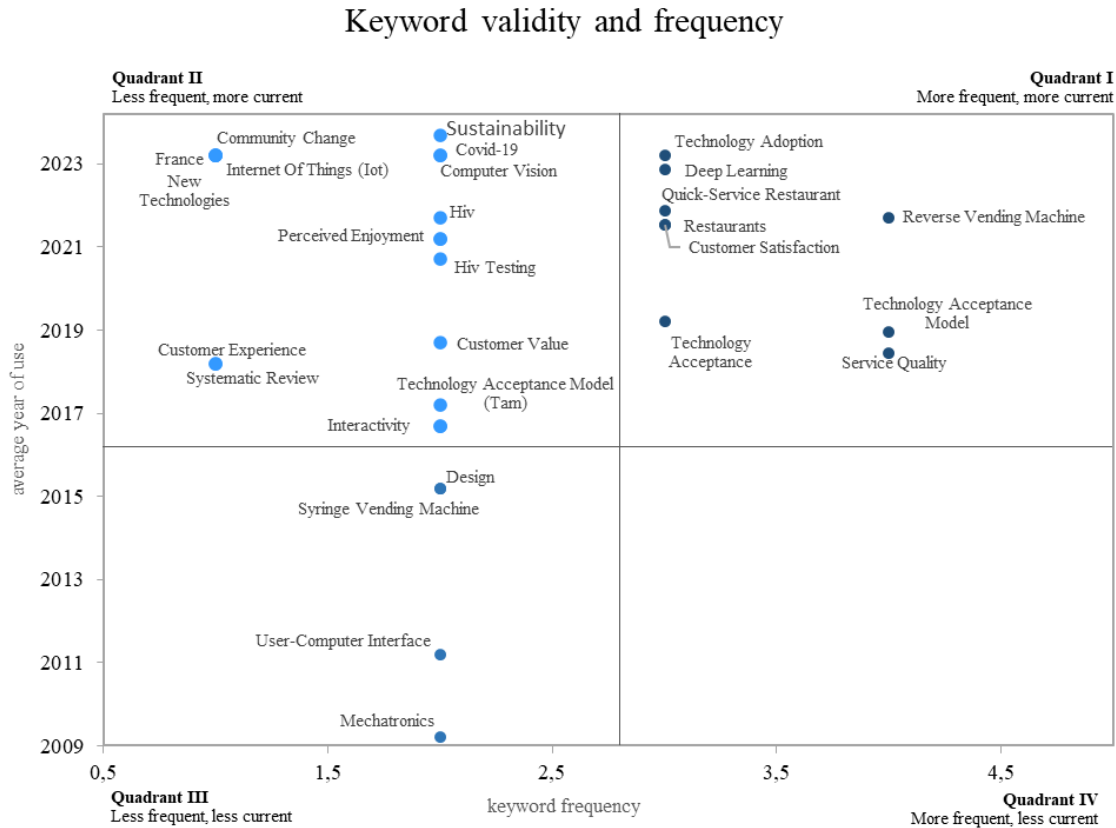
Note. Compiled by the author using data from Scopus and Web of Science.

The keyword co-occurrence network, shown in Figure 7, reveals nine thematic clusters in the literature on vending machine technology. The most relevant cluster is the yellow one, consisting of terms such as “Vending Machine,” “Arduino Microcontroller,” “Embedded System,” and “Telemedicine.” The red cluster follows, associated with “Self-Service Technology,” “Self-Service Kiosks,” and “Mobile.” Additionally, other clusters in blue, green, purple, and orange were identified, reflecting different conceptual affinities in this field of research.

Figure 7*Keyword Co-occurrence Network*

Note. Compiled by the author using data from Scopus and Web of Science.

The study proposes a Cartesian plane (Figure 8) that relates keyword frequency (X-axis) to temporal relevance (Y-axis), allowing terms to be classified into four quadrants. Quadrant 4 groups declining concepts with lower frequency and relevance. Quadrant 2 contains infrequent but emerging terms, such as Community Change, New Technologies, Customer Value, and Sustainability. Finally, Quadrant 1 brings together established and growing concepts, including “Technology Adoption,” “Deep Learning,” “Quick-Service Restaurant,” “Customer Satisfaction,” “Reverse Vending Machine,” “Technology Acceptance,” and “Service Quality.”

Figure 8*Relevance and Frequency of Keywords*

Note. Compiled by the author using data from Scopus and Web of Science.

DISCUSSION

This section provides a detailed analysis of the research findings and presents the resulting practical implications, the study's limitations, research gaps, and the future research agenda regarding vending machine technology.

Analysis of the Growth of the Scientific Literature on Vending Machine Technology

The temporal results identified in this study reflect trends in scientific output recorded in Scopus and Web of Science during the period analyzed. Therefore, interpretations of the years with the highest output are based on the distribution of publications in the selected corpus and do not necessarily represent the full scope of academic output outside these databases.

Scientific output in this field grew significantly in 2021, 2022, and 2023. Two studies stood out in 2023: one on the net benefits of contactless technologies in quick-service restaurants, which demonstrated the moderating effect of social interaction anxiety and language proficiency on their adoption (Lee et al., 2023), and another on the collection of plastic bottles using reverse vending machines with object detection techniques, highlighting their contribution to sustainability (Yaddanapudi et al., 2023).

Prior to 2023, the highlighted studies explored technology acceptance based on variables such as social influence and perceived enjoyment. Based on their analysis, the authors concluded that both factors have been decisive in sectors such as hospitality (Joe et al., 2022). In 2021, an analysis of the adoption of self-service technologies by air travelers in Taiwan showed improvements in user experience and the efficiency of airport processes (Lien et al., 2021).

Analysis of Key Research References on Vending Machine Technology

According to the bibliometric analysis, the leading authors by impact were Qu H with Kim M, Sivathanu B with Dwivedi YK, and Pillai R, while Vera J.H. stood out for productivity. The analysis identified notable works by these authors that provide a theoretical and practical

foundation for travelers' behavioral intentions regarding the use of self-service kiosks in hotels (Kim & Qu, 2014).

Through their research, Pillai et al. (2020) have contributed to our understanding of purchase intent in automated retail stores. In one study, they examined its application to the shopping experience, highlighting its potential to improve competitiveness and customer service.

Vera JH and colleagues, based on their work, have recognized the feasibility and acceptance of digital vending machines for distributing HIV self-tests. Their study shows how these machines can promote public health and expand access to services for key populations (Vera et al., 2019).

In addition, we analyzed leading journals on this topic as points of reference. For example, the **International Journal of Contemporary Hospitality Management** stood out for its output in studies on the customer experience (Kim & Qu, 2014), and the **Journal of Cleaner Production** for its impact on sustainability through the eco-efficient design of NECTA vending machines (Vezzoli & Sciama, 2006). Meanwhile, the **Journal of Retailing and Consumer Services** and **Management Science** contributed theoretical models on retail and omnichannel operations (Paul & Rosenbaum, 2020; Gao & Su, 2018), while **The Service Industries Journal** stood out for its research on gender differences at self-service kiosks (Lee et al., 2013).

By country, the United States and China led in productivity and impact. In the U.S., researchers developed sustainable business models for post-consumer recycling (Tong et al., 2018), and in China, they proposed a framework for innovation in product-service systems (Song et al., 2015). The United Kingdom and Italy stood out for their impact: the former for adopting AI-powered automated retail stores (Pillai et al., 2020) and the latter for the eco-efficient design of NECTA machines (Vezzoli & Sciama, 2006). Finally, Australia stood out in productivity with studies on syringe vending machines in public health programs (Islam et al., 2008).

Analysis of Thematic Trends in Vending Machine Technology

These thematic trends reflect the changes observed in the selected corpus and should be interpreted in light of the established search criteria, the databases consulted, and the terms included in the methodological strategy.

In the early years, technology mapping played a crucial role, enabling researchers to build a solid foundation for developing efficient and effective technological systems. During this initial period, researchers focused on mapping and optimizing available technologies to identify and address technical limitations that would later foster innovation in design and implementation (Venkateswaran & Mazumder, 1994).

Recently, researchers' interests have evolved alongside technology. In 2021, quick-service restaurants garnered significant attention in the literature. Studies that year explored how adopting self-service kiosks shifted how these businesses are managed and operated, highlighting the benefits of speed and efficiency (Rastegar, 2018).

By 2022, waste management had emerged as a critical issue reflecting growing concern for sustainability. That year saw the development of a deep learning-based reverse vending machine, demonstrating that cost-effective solutions could reduce the environmental impact of consumer products (Zia et al., 2022).

Subsequently, research focused on technology adoption. In 2023, studies analyzed its influence on workplace outcomes; while it had previously been shown that implementation improves operational efficiency and the customer experience, they also identified the need for workforce adaptation strategies (Yoon, 2023).

More recently, in 2024, virtual reality was one of the most studied topics and proved to be significant for value creation across various sectors, including tourism. This is because it facilitates co-creation through immersive, personalized experiences for users, which not only enhances the customer experience but also opens new opportunities for innovation in the industry (Solakis et al., 2022).

Analysis of Thematic Clusters Related to Vending Machine Technology

The co-occurrence network analysis allowed us to identify thematic clusters that reveal conceptual affinities in the literature. The most prominent cluster, highlighted in yellow, brings together terms associated with “Vending Machine,” “Arduino Microcontroller,” “Embedded System,” and “Telemedicine,” reflecting the integration of embedded systems and microcontrollers to develop smart, autonomous solutions. Within this framework, the research highlights the importance of user acceptance and showcases user-centered applications in specific contexts, such as smart systems for medication management in the elderly, the implementation of microcontrollers in design and manufacturing projects, and the expansion of medical services through vending machines (Tongnamtiang & Leelasantitham, 2019; Chang et al., 2019; Alemzadeh et al., 2007; Lynch & Connery, 2023).

A second relevant cluster is highlighted in red and includes terms associated with Self-Service Technology, Self-Service Kiosks, and Mobile—all of which relate to the transformation of consumer interactions. In particular, Park et al. (2022) compared service quality dimensions in hotels between human service and self-service technologies, highlighting the advantages and disadvantages of each approach. Likewise, the implementation of the Internet of Things has been explored, emphasizing its impact on operational efficiency and the personalization of the customer experience (Solano et al., 2017).

Analysis of the Frequency and Conceptual Relevance of Vending Machine Technology

The frequency and conceptual relevance analysis showed that Quadrant 2 groups emerging concepts such as “Community Change” and “New Technologies,” which, although used infrequently, are gaining relevance in the field. The former reflects how smart technologies, particularly the IoT, are driving transformations in local communities (Jamme & Connor, 2023). Meanwhile, new technologies linked to the IoT are redefining personalization, interactivity, and efficiency in services (Jamme & Connor, 2023).

For Quadrant 1, we identified well-established concepts in the field, such as Technology Adoption, Deep Learning, Quick-Service Restaurant, Customer Satisfaction, Reverse

Vending Machine, Technology Acceptance, Service Quality, and Technology Acceptance Model, which are fundamental to the field's evolution. Specifically, their use is evident in the design of interactive museum kiosks (Abdul Aziz et al., 2023), in smart advertising (Ou et al., 2023), and in the acceptance of kiosks in restaurants during the pandemic (Baba et al., 2023).

Likewise, menu information quality influences technology acceptance (Han et al., 2020), while kiosks in hotels enhance customer satisfaction (Gupta & Sharma, 2021). In the area of sustainability, the role of reverse vending machines in waste management is highlighted (Rahim & Khatib, 2021), complemented by studies on technology acceptance and service quality in retail (Lee et al., 2013; Kokkinou & Cranage, 2015) and by the Technology Acceptance Model applied to financial services in South Africa (Wentzel et al., 2013).

Classification of Keywords Related to Vending Machine Technology by Function

Table 1 below classifies the main emerging and growing keywords by function. Emerging keywords are grouped by primary function, highlighting concepts gaining relevance and expected to have a significant impact in the near future; similarly, growing and established keywords are classified, representing concepts that are already well established but constantly evolving.

Table 1

Classification of keywords by function. Compiled by the author based on Scopus and Web of Science

Keyword	Related Tools	Applications	Features
Community Change	Social Media, Data Analysis	Improving community engagement	Promotes participation and engagement
New Technologies	Internet of Things (IoT), Artificial Intelligence	Technological innovation	Drives modernization and efficiency
Customer Value	Market Analysis, Satisfaction Surveys	Enhancing the customer experience	Increases customer loyalty

Sustainability	Environmental Management, Renewable Energy	Reducing environmental impact	Fosters corporate social responsibility
Technology Adoption	Technology Implementation, User Training	Payment system integration	Facilitates adoption and adaptation
Deep Learning	Neural Networks, Machine Learning	Personalized recommendations	Improves accuracy and effectiveness
Quick-Service Restaurant	Self-Service Kiosks, Mobile Apps	Order automation	Speeds up service and improves efficiency
Restaurants	Inventory Management, Quality Control	Operational management optimization	Ensures quality and consistency
Customer Satisfaction	Satisfaction Surveys, Feedback Tracking	Improved customer satisfaction	Increases retention and referrals
Reverse Vending Machine	Recycling Technology, Container Identification	Automated container collection	Encourages recycling and responsibility
Technology Acceptance	Market Research, Usability Testing	Payment system acceptance	Fosters trust and adoption
Service Quality	Staff Training, Complaint Management	Improved service experience	Increases satisfaction and loyalty
Technology Acceptance Model	Technology Adoption Models, User Research	User acceptance evaluation	Identifies key factors for adoption

This categorization not only makes it easier to identify relevant keywords, but also provides a useful framework for understanding their practical applications and distinctive characteristics, and helps shed light on the current landscape and future trends in their implementation.

Theoretical Implications

The study provides insight into the evolution of academic interest in the subject by analyzing the conceptual frameworks that have guided key theorists' research. The study reveals trends in dominant themes and emerging areas that point to new lines of research that can address knowledge gaps and under-explored methodological approaches. These approaches could advance the field's theoretical and practical understanding and help consolidate future research agendas.

Practical Implications

The study's results have identified trends related to virtual reality, waste management, and quick-service restaurants. These findings provide the industry with up-to-date insights to align its strategies with market dynamics and consumer expectations. The study also identifies concepts such as the Arduino microcontroller, embedded systems, and telemedicine, highlighting the potential of interdisciplinary research that can scale across economic sectors. The study also notes the emergence of terms related to traceability—such as community change, customer value, and sustainability—along with growing concepts associated with technology adoption and service quality.

These findings have implications for public policy and business strategy, as they guide resource allocation toward knowledge gaps and unmet needs. Furthermore, identifying patterns in sensitive issues, such as data privacy, can contribute to the development of specific regulations, while understanding consumer preferences provides essential insights for designing more effective and sustainable marketing strategies in the vending machine sector.

Limitations

Bibliometrics has some limitations. First, the selection of databases—specifically, the focus solely on Scopus and Web of Science—may exclude relevant publications from other sources and limit the diversity of the analysis to these sources; second, although the PRISMA-2020 methodology is rigorous, it may not reflect all dimensions of a multidisciplinary field such as vending machine technology, overlooking some emerging or cross-cutting trends based

on the selected exclusion criteria; Finally, third, the quality and consistency of the metadata available in the databases may contain errors or inconsistencies that affect the reliability of the results and conclusions obtained.

Research Gaps

Table 2 below categorizes the main research gaps identified, which represent areas of study that require greater attention in future research. These research gaps are derived from an analysis of the existing literature and highlight aspects of the field that have not yet been fully explored.

Table 2

Research Gaps. Compiled by the author based on Scopus and Web of Science

Category	Research Gaps	Justification	Questions for Future Research
Thematic Gaps	1. Integration of Emerging Technologies	As technology advances, there is a growing need to understand how to effectively integrate new technologies—such as artificial intelligence and augmented reality—into vending machines.	How can vending machines incorporate emerging technologies to improve the user experience and operational efficiency? What are the challenges and opportunities associated with this integration?
	2. Socioeconomic Impact of Vending Machines	Although vending machines offer benefits such as convenience and efficiency, they also raise questions about their impact on employment, economic equity, and public health.	What impact do vending machines have on consumption patterns, income distribution, and labor dynamics? How can the socioeconomic challenges associated with these technologies be addressed?
Geographic Gaps	1. Research in Non-Western Contexts	Most research on vending machine technology has focused on Western countries, leaving gaps in our understanding of its adoption and effectiveness in non-Western contexts.	How does the acceptance and use of vending machines vary across different cultural and socioeconomic contexts? What are the specific barriers and facilitators in non-Western contexts?

Interdisciplinary Gaps	2. Comparative Studies Across Countries and Regions	Comparing countries and regions can reveal differences in vending machine adoption and help identify best practices and common challenges.	What factors explain the differences in the adoption of vending machine technology across countries and regions? How can countries learn from one another to improve the implementation and effectiveness of these technologies?
	1. Research on Sustainability and Ecology	There is a growing need to investigate how vending machines can contribute to environmental sustainability, including waste management and reducing ecological impact.	How can vending machines be designed and operated more sustainably? What role do government policies and business practices play in promoting sustainability in this context?
	2. Studies on User Experience and Design	User-centered design is essential to the success of vending machines, which requires a deep understanding of end-users' preferences and needs.	How can vending machines be designed to improve the user experience and encourage greater engagement? What impact does design have on consumers' adoption and acceptance of these technologies?
Temporary Gaps	1. Future Trends in Vending Machine Technology	Given the rapid pace of technological advancement, it is important to investigate emerging trends that may influence the future of vending machines, such as the integration of artificial intelligence and advanced automation.	What emerging technologies could transform the vending machine landscape in the coming years? How can future challenges in this field be anticipated and addressed?
	2. Long-Term Assessment of the Impact of Technologies	Longitudinal studies are needed to better understand the long-term impact of vending machines on retail, public health, and the environment.	What are the long-term effects of adopting vending machine technology across various industries and sectors? How might these technologies evolve to address future challenges and society's changing needs?

Research Agenda

This section presents a roadmap for future studies, based on the identified trends, and proposes relevant research themes for the coming years, according to the analysis presented in Figure 9.

In this regard, one of the main areas of focus for vending machines is the design and distribution of HIV self-testing kits and rapid diagnostic tests. Based on the literature, future research could focus on their effectiveness in promoting access in vulnerable communities, as well as the psychosocial impact of this approach. Additionally, from a public health perspective, the distribution of other over-the-counter products could be explored, such as condoms, antiretroviral medications, and educational materials on prevention and treatment.

Given that the COVID-19 pandemic highlighted the need to implement technologies to protect public health and safety, researchers could further explore how vending machines can be adapted to offer products and services related to disease prevention and control. In particular, research could examine their role in promoting healthy behaviors in public and commercial settings.

Furthermore, as mentioned in various sections of the study, sustainability has become an increasingly important aspect of design and operation in recent years, as efforts to reduce environmental impact and promote responsible business practices have grown. Therefore, assessing the life cycle of vending machines is important to develop strategies that reduce their environmental footprint.

For example, reverse vending machines support container returns as part of sustainability and circular economy initiatives. Although their operational usefulness is recognized, several aspects still require analysis, including efficiency, accessibility, and integration with waste management technologies and reverse logistics processes. As a viable avenue for study, their role in promoting sustainable practices and raising public awareness should be investigated.

Furthermore, service quality is linked to the user experience; in particular, its relationship to dispensing accuracy, ease of use, and customer service processes has been identified.

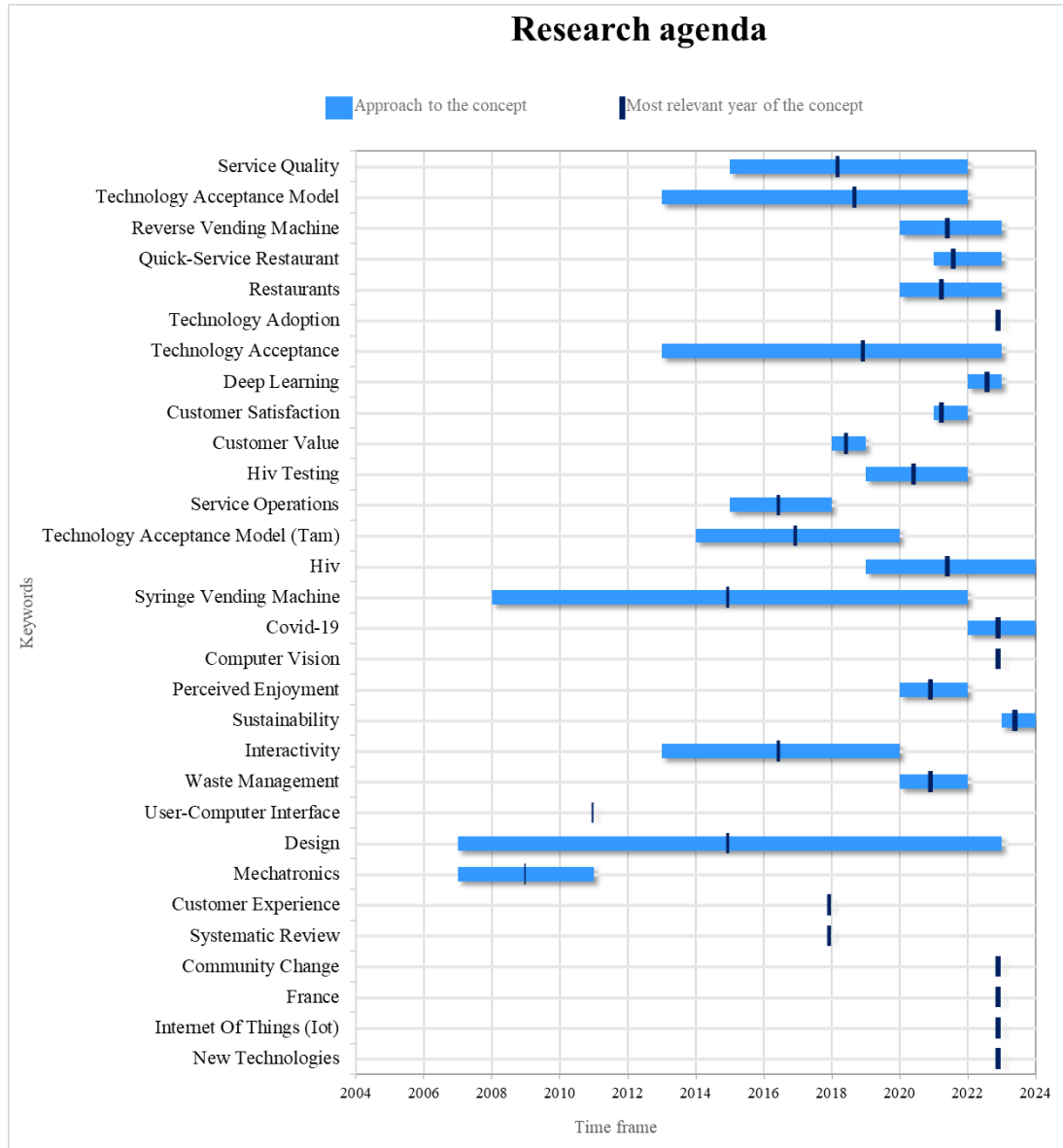
Therefore, future research could focus on anticipating needs to tailor the shopping experience.

The Technology Acceptance Model provides a framework for studying the factors that influence the adoption and use of these solutions. Building on this, further research could explore how to adapt this model to current challenges, such as incorporating security and privacy criteria, the influence of contextual and cultural factors, and characterizing long-term use. In line with this approach, it would be necessary to understand how users trust these tools, focusing on aspects such as data security.

In this regard, deep learning promises opportunities to improve functionality and performance through advanced information processing. Its application enables the identification of useful patterns to tailor the user experience and optimize operational processes, facilitating its implementation in commercial contexts. This requires further exploration of fraud detection, predictive maintenance, and inventory management.

Finally, another potential research path should consider the role of vending machines in quick-service restaurants, a common setting for implementing self-service technologies and automated ordering systems. Therefore, future research could examine how these systems adapt to changing consumer demands, including order customization and contactless payment systems.

In line with these advances, traditional restaurants continue to incorporate technologies into ordering and payment processes to improve their operational management. This opens a field of study aimed at evaluating how artificial intelligence and machine learning can help identify opportunities by collecting and processing data for strategic and operational purposes.

Figure 9*Research Agenda*

Note. Compiled by the author based on data from Scopus and Web of Science.

CONCLUSIONS

The bibliometric analysis highlights current trends in technologies applied to vending machine development and their use across sectors. Thus, scientific output has grown exponentially, with significant peaks between 2021 and 2023, reflecting the field's growing importance in recent years. This development has been driven by leading researchers such as Qu H and Kim M, as well as high-impact journals such as the *International Journal of Contemporary Hospitality Management* and the *Journal of Cleaner Production*. The United States and China lead this research.

Thematic trends show a shift toward more contemporary approaches that incorporate virtual reality, technology adoption, waste management, and fast-food restaurants. Meanwhile, the thematic cluster analysis reveals the consolidation of more specific topics linking concepts such as the Arduino microcontroller, embedded systems, and telemedicine; and other concepts, such as community change and new technologies, are growing areas linked to technology adoption and service quality, which have been identified as emerging keywords that help guide future research projections and potential lines of development.

These findings expand the theoretical understanding of the evolution of vending machine technology, highlighting a shift from approaches centered on technical development to perspectives on technology adoption, user experience, sustainability, and service quality. In this regard, the results help bridge gaps in the literature by showing the need to integrate interdisciplinary approaches that consider both the technological components and the human and organizational factors associated with implementing these solutions. From a practical perspective, the findings offer relevant insights for designers and marketing strategists, who can consider ease of use, personalized experience, user trust, sustainability, and value creation as key factors in designing and positioning automated vending systems. In this way, the research provides a foundation for guiding future decisions on developing technologies better adapted to consumer needs and changing market dynamics.

In response to the research questions, the results showed that the greatest scientific interest in vending machine technology occurred in 2023, followed by 2021 and 2022, indicating a recent concentration of academic output. Additionally, the number of publications increased

by 99.33% during the analyzed period, reflecting the field's expansion. Regarding the leading researchers, authors such as Qu H, Kim M, Sivathanu B, Dwivedi YK, and Pillai R were identified for their scientific impact, while Vera JH stood out for productivity. Similarly, the thematic analysis identified nine research clusters and a shift from initial approaches related to Technology Mapping toward current trends associated with Technology Adoption, Virtual Reality, Waste Management, and Quick-Service Restaurants. Finally, emerging keywords such as Community Change, New Technologies, Customer Value, and Sustainability point to new research opportunities focused on interactions among technology, users, sustainability, and value creation.

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