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THE EVOLUTION OF DIGITAL TRANSFORMATION IN THE FOOD AND BEVERAGES (F&B) SECTOR: A BIBLIOMETRIC PERSPECTIVE

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Abstract:

The rapid advancement of digital technologies has significantly reshaped industries worldwide, with the Food and Beverages (F&B) sector increasingly recognized as a critical area for digital transformation. While digitalization in this sector plays a vital role in improving operational efficiency, enhancing consumer engagement and promoting sustainability, scholarly research on its evolution remains fragmented and requires systematic examination. This study addresses this gap by conducting a bibliometric analysis to explore the development, trends and intellectual structures of digital transformation in the F&B sector. Data were collected from the Scopus database using advanced search techniques with the keywords "digital transformation," "digitalization," and "food and beverages," resulting in a dataset of 932 publications. To ensure data accuracy and consistency, OpenRefine was employed for cleaning and harmonization, while the Scopus analyzer provided descriptive statistics and graphical insights. Furthermore, VOSviewer software was used to generate network visualizations, including co-authorship, keyword co-occurrence and citation analyses, which enabled the identification of research patterns and thematic clusters. Here, the results reveal a sharp increase in publications after 2020, driven largely by the impact of the COVID-19 pandemic and the accelerated adoption of Industry 4.0 technologies. The United States, Italy and the United Kingdom emerged as the leading contributors, while emerging economies such as Indonesia, India and Malaysia are gaining prominence. Highly cited articles were largely concentrated on themes of sustainability, innovation and digital technology integration, with "innovation," "sustainable development," and "industry 4.0" among the most frequent keywords. Overall, this study provides a comprehensive overview of the intellectual landscape of digital transformation in the F&B sector, offering valuable insights for researchers, practitioners and policymakers to advance future research and guide strategic innovation.

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Keywords:

Digital Transformation, Digitalization, Food and Beverages

Introduction

The Food and Beverage (F&B) industry has been experiencing profound changes over the last several decades, facilitated by the rapid development of digital technologies. This change, commonly known as digital transformation, involves digital tools and processes across various parts of the industry, including production, supply chain management, marketing and customer engagement. The impetus for this transformation stems from the need to enhance efficiency, sustainability and competitiveness in a rapidly changing global market. The COVID-19 pandemic further accelerated this shift, compelling businesses to adapt to new operational models and digital solutions to survive in an increasingly unstable marketplace (Vitsentzatou et al., 2022). This paper examines the development of digital transformation in the F&B sector, highlighting key technological advancements, their impact on industry practices and the challenges and opportunities they present.

Digital transformation in the F&B sector is complex, involving the adoption of various technologies to improve operational efficiency, sustainability and customer experience. One significant aspect is the integration of smart kitchen technologies, which automate cooking and service processes, use 3D printing for customized food designs and utilize a network of interconnected physical devices known as the Internet of Things (IoT) for precise control of cooking parameters (Keskin, 2025). Note that these innovations enhance efficiency and offer new possibilities for food preparation and presentation, reflecting the broader trend of digital gastronomy.

Other than that, the adoption of digital tools in the F&B sector is motivated by the need to tackle sustainability challenges. Digitalization supports the application of circular economy principles, enabling more efficient management of food waste and loss. For instance, Artificial Intelligence (AI) and data analytics can be used to develop smart value chain tools that identify sustainable alternatives for waste management in the industry (Telukdarie et al., 2024). This approach minimizes environmental impact and aligns with the increasing consumer demand for sustainable and eco-friendly products.

Consequently, the digital transformation journey of century-old SMEs in the F&B sector reveals a diverse range of digital maturity stages, from technology avoidance to pioneering adoption (Ari & Temizkan, 2025). These stages are influenced by both intrinsic motivations and external pressures, highlighting the unique challenges faced by traditional businesses in embracing digital change. The study highlights the significance of balancing internal and external drivers to manage the complexities of digital transformation effectively.

Moreover, the role of digital marketing in the F&B sector has become increasingly prominent. The integration of digital platforms, social media and emerging technologies such as AI and augmented reality has revolutionized marketing strategies, enabling businesses to reach and engage with consumers more effectively (Suryani et al., 2025). This shift is especially noticeable in the COVID-19 pandemic context, which necessitated rapid adaptation to digital

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marketing channels to maintain customer relationships and drive sales (Vitsentzatou et al., 2022).

Digital transformation is regarded as a decisive factor in ensuring efficiency and innovation in the agri-food industry's production. Agriculture 4.0 as a concept includes the application of progressive technologies like AI, big data analytics and IoT to streamline agricultural processes and improve their sustainability (Scuderi et al., 2020; Vahdanjoo et al., 2025). These technologies enable real-time monitoring and decision-making, enhancing supply chain visibility and minimizing waste. However, the adoption of these innovations is often hindered by technical barriers, privacy concerns and the need for interdisciplinary collaboration to address complex challenges (Vahdanjoo et al., 2025).

Note that the digitalization of supply chains is another crucial aspect of the F&B sector's transformation. Technologies like AI, blockchain and big data analytics are being leveraged to improve traceability, transparency and efficiency in supply chain operations (Wandhekar et al., 2024). This digital shift enhances operational efficiency and promotes sustainability goals by facilitating better resource management and reducing environmental impact. Furthermore, the integration of digital tools in supply chain management is particularly beneficial for organic food products, where consumer demand for natural and sustainable options is driving the need for enhanced traceability and quality control (Wandhekar et al., 2024).

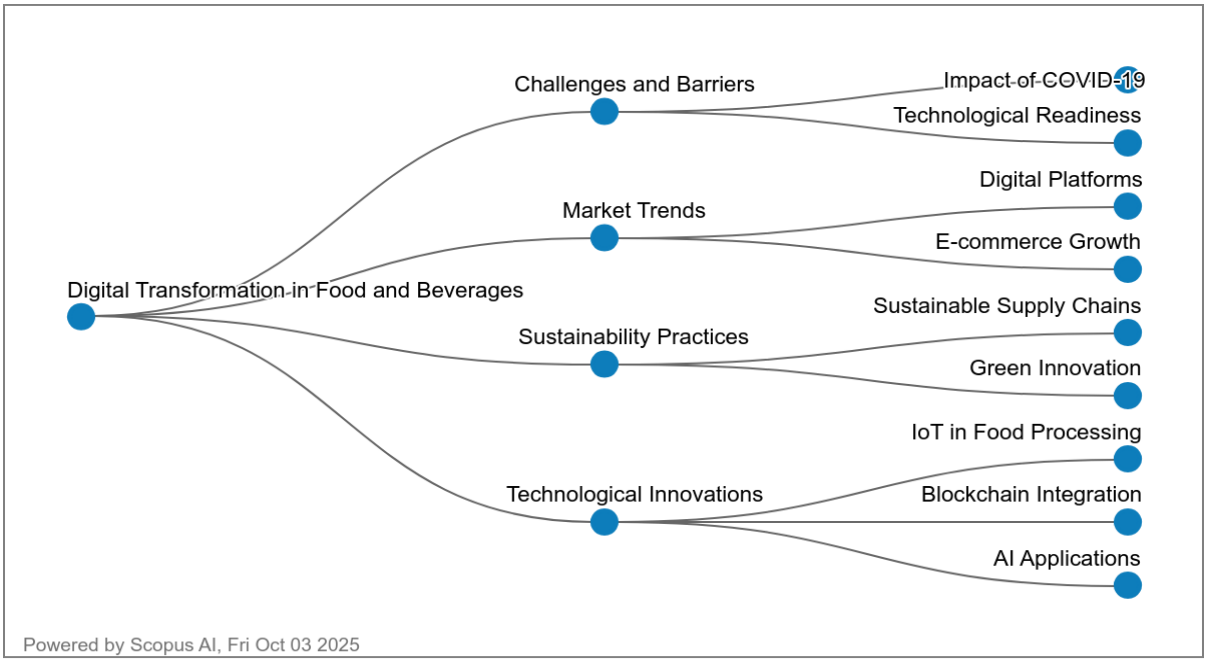

Figure 1: Concept Map of Digital Transformation in the F&B Sector

Figure 1 illustrates the evolving digital transformation landscape in the F&B sector, highlighting four key dimensions: challenges and barriers, market trends, sustainability practices and technological innovations. The challenges include technological readiness and the disruptive impact of COVID-19, which accelerated the sector's adoption of digital solutions while exposing preparedness gaps. Moreover, market trends emphasize the growing role of digital platforms and the rapid expansion of e-commerce, reshaping consumer behavior and business models. Sustainability practices are increasingly prioritized through sustainable

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supply chains and green innovation, aligning the sector with global environmental and social goals. Technological innovations further drive this transformation, with applications such as IoT in food processing, blockchain integration for transparency and traceability, as well as AI for process optimization and consumer engagement. Collectively, these factors demonstrate that digital transformation in the F&B sector is a response to external pressures and a strategic shift towards resilience, efficiency and sustainability, positioning the industry for long-term competitiveness in an increasingly digital economy.

In conclusion, the evolution of digital transformation in the F&B sector is marked by the adoption of diverse technologies designed to enhance efficiency, sustainability and customer engagement. Although substantial progress has been achieved, challenges such as technical limitations, privacy issues and the necessity for interdisciplinary collaboration still persist. Hence, addressing these challenges will be crucial for the continued advancement of digital transformation in the industry, ensuring that businesses can leverage the full potential of digital tools to enhance their operations and meet the evolving demands of consumers.

Research Question

This study is structured around five key areas of discussion, guided by the following Research Questions (RQs).

RQ1: What are the publication trends in the digitalization of the F&B sector over time?
RQ2: Which are the ten most cited articles in this field?
RQ3: Which countries contribute the most publications?
RQ4: What are the most frequently used keywords in the literature?
RQ5: How are international collaborations structured through co-authorship by countries?

Methodology

Bibliometrics refers to the systematic process of gathering, organizing and analyzing bibliographic data obtained from scientific publications (Alves et al., 2021; Assyakur & Rosa, 2022; Verbeek et al., 2002). In addition to producing basic descriptive statistics such as identifying core journals, publication years and influential authors (Wu & Wu, 2017), bibliometric research employs advanced analytical methods, including document co-citation analysis, to reveal intellectual connections and research dynamics within a field. A rigorous literature review necessitates an iterative approach involving the refinement of keywords, comprehensive searching and critical in-depth evaluation to ensure the construction of a robust and reliable body of knowledge (Fahimnia et al., 2015). Guided by this principle, the present study focused on high-impact publications, as they offer valuable insights into the theoretical foundations and knowledge structures that shape the research domain. To ensure data accuracy and reliability, Scopus was utilized as the primary database for data collection (Al-Khoury et al., 2022; di Stefano et al., 2010; Khiste & Paithankar, 2017). Consequently, data were obtained from Elsevier's Scopus, which is renowned for its extensive coverage and global relevance, focusing on publications from 2005 to October 2025 for subsequent bibliometric analysis. Once the dataset was completed, OpenRefine was employed to perform data cleaning and resolve inconsistencies, ensuring standardized formatting, removing duplicates and enhancing the overall reliability of the analysis results (Hill, 2016).

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Data Search Strategy

This study employed the Scopus database to search for relevant publications because it is widely recognized for its broad coverage and reliability in academic research. The advanced search string applied was TITLE-ABS-KEY (("digital transformation" OR "digitalization" OR "innovation" OR "digital technology") AND ("food and beverage" OR "food and beverages" OR "F&B" OR "food services" OR "F&B services" OR "beverage industry" OR "F&B industry")), with the results limited to publications between 2005 and 2025 (PUBYEAR > 2004 AND PUBYEAR < 2026) and restricted to English-language studies (LIMIT-TO (LANGUAGE, "English")) (refer Table 1). The search was conducted in October 2025 to capture the most recent data. Screening was also applied, including only English-language publications within the given timeframe, while excluding non-English studies and those published before 2005 (see Table 2). Here, the chosen timeline reflects the increasing significance of digital transformation in the F&B sector, especially over the past two decades. From this process, a total of 932 publications were identified. These publications cover areas such as technological innovation, supply chain digitalization, business model changes, consumer engagement and sustainability, providing a solid basis for bibliometric analysis.

Table 1: The Search String

Database	Search String
Scopus	TITLE-ABS-KEY (("digital transformation" OR "digitalization" OR "innovation" OR "digital technology") AND ("food and beverage" OR "food and beverages" OR "F&B" OR "food services" OR "F&B services" OR "beverage industry" OR "F&B industry")) AND PUBYEAR > 2004 AND PUBYEAR < 2026 AND (LIMIT-TO (LANGUAGE , "English"))
	Access date: October 2025

Table 2: The Selection Criterion in Searching

Criterion	Inclusion	Exclusion
Language	English	Non-English
Timeline	2005 – 2026	< 2005

Data Analysis

VOSviewer is a widely used bibliometric software developed by Nees Jan van Eck and Ludo Waltman at Leiden University, the Netherlands (van Eck & Waltman, 2010, 2017). Designed to facilitate the visualization and analysis of scientific literature, the software excels in generating network visualizations, clustering related items and producing density maps that uncover structural patterns within research domains. Other than that, its capabilities extend to analyzing co-authorship, co-citation and keyword co-occurrence networks, allowing researchers to gain a comprehensive understanding of intellectual landscapes. The platform's intuitive interface, coupled with regular updates, ensures dynamic and efficient exploration of large bibliographic datasets. Furthermore, its ability to compute bibliometric indicators, customize visualizations and integrate with multiple data sources makes it a valuable tool for both novice and experienced researchers seeking deep insights into evolving scholarly fields.

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Datasets containing information such as publication year, title, author name, journal, citation and keywords in PlainText format were extracted from the Scopus database, covering the period from 2005 to December 2025. These datasets were analyzed using VOSviewer version 1.6.20, which utilizes advanced clustering and mapping techniques to produce visual representations of bibliometric networks. Unlike traditional Multidimensional Scaling (MDS), which primarily depends on similarity measures such as cosine and Jaccard indices, VOSviewer positions items in low-dimensional spaces where the distance between them represents their degree of relatedness (van Eck & Waltman, 2010; Appio et al., 2014). Its methodological distinctiveness lies in the use of Association Strength (AS_ij), calculated as:

$$AS_{ij} = \frac{C_{ij}}{w_i w_j},$$

which quantifies the proportional relationship between the empirically observed co-occurrence frequency of items *i* and *j* and their expected co-occurrence frequency under the null hypothesis of statistical independence between *i* and *j* (Van Eck & Waltman, 2007).

Findings

The findings section illustrates the results of the bibliometric analysis conducted to address the five research questions outlined in this study. It highlights publication trends, influential articles, contributing countries, key research themes and international collaboration patterns within the digitalization of the F&B sector.

Research Trends in Digital Transformation of the F&B Sector Studies

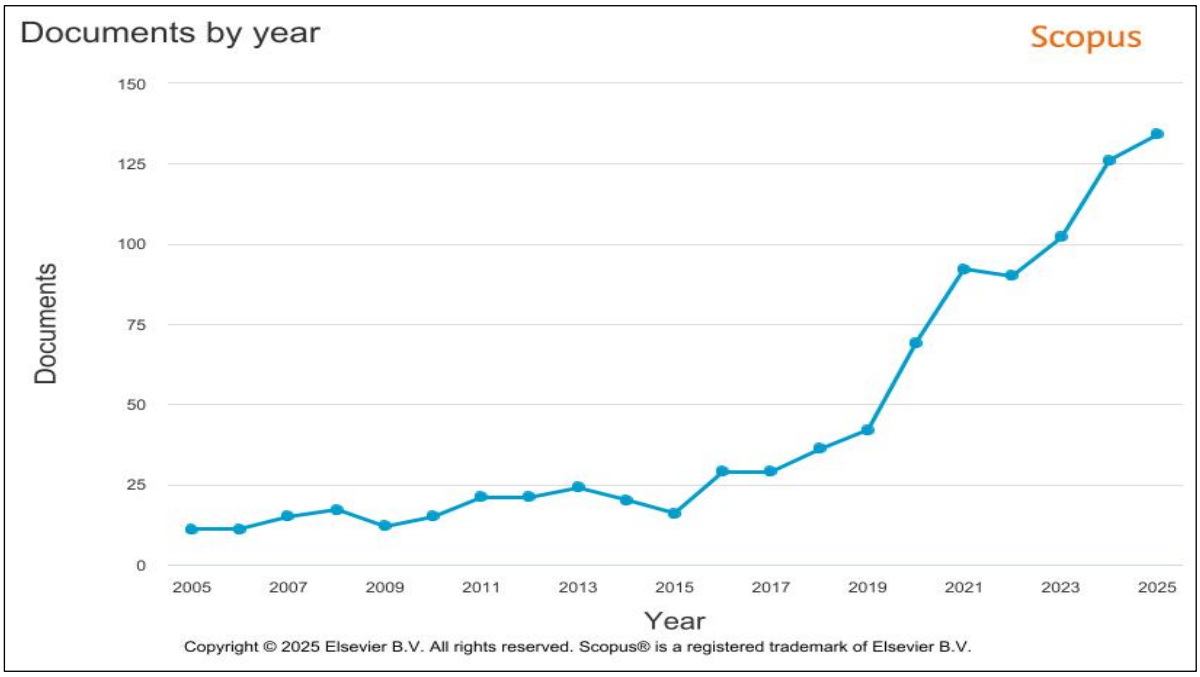

Figure 2: Annual Publication Trends on Digital Transformation of the F&B Sector

The publication trend on digital transformation in the F&B sector from 2005 to 2025 reveals a steady but modest growth in the early years, followed by a sharp rise beginning in 2018 and peaking in 2025 with 134 documents. Figure 2 depicts that between 2005 and 2015, the number of publications remained relatively low, averaging fewer than 20 documents per year, which suggests that the topic was still emerging and had not yet gained strong scholarly attention.

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From 2016 onwards, there is a visible upward trajectory, with gradual increases until 2019, after which the growth rate accelerated more significantly. This pattern reflects the rising global importance of digital technologies, particularly in service-based sectors like F&B, where digital platforms, automation and online delivery systems have begun reshaping industry practices.

The sharp rise after 2020 can be largely attributed to two main factors: the disruptive impact of the COVID-19 pandemic and the growing integration of Industry 4.0 technologies. The pandemic compelled F&B businesses to adopt digital solutions such as online ordering, contactless payments and delivery platforms, which in turn stimulated scholarly interest and academic output. Moreover, global policy agendas like the United Nations' Sustainable Development Goals (SDGs) and national digital economy frameworks encouraged researchers to explore themes such as digital supply chains, green innovation and consumer behavior in digital environments. Note that the consistent rise in publications through 2024 and 2025 indicates that digital transformation in the F&B sector has become an established research domain, reflecting its critical role in shaping resilience, competitiveness and sustainability in the post-pandemic era.

Most Cited Articles Between 2005 and 2025

The list of the most cited articles highlights how research on digital transformation in the F&B sector is strongly connected to broader themes of sustainability, innovation and technology adoption, as depicted in Table 3. The most cited paper by Mirabella et al. (2014), with 904 citations, focuses on food manufacturing waste valorization, highlighting the significance of sustainable practices in the global food industry. Other widely cited studies, such as Cuerva et al. (2014) and Notarnicola et al. (2017), also emphasize environmental and innovation-related aspects, published in the Journal of Cleaner Production, a high-impact journal in sustainability research. Therefore, this shows that sustainability-driven innovation is a central concern within F&B transformation studies. Additionally, the presence of articles like Vermesan and Friess (2014) on the Internet of Things and Scuotto et al. (2017) on social networking and innovation performance demonstrates the influence of Industry 4.0 technologies and digital tools in shaping the sector's future.

More recent publications reflect the growing role of digital technologies and global disruptions. For example, Galanakis et al. (2021), with 384 citations, analyzed innovations in the food sector during COVID-19, showing how the pandemic accelerated digital adoption. Similarly, Elia et al. (2021) highlighted digital technologies in cross-border e-commerce, underscoring the relevance of digital exports. Articles by Martín-Ríos et al. (2018) on food waste management and Zhang et al. (2022) on advanced food packaging materials also gained significant attention, linking technological advancement with sustainability. Although older, Tukker et al. (2010) continued to be influential due to their focus on household consumption impacts. Overall, the high citation counts indicate that research combining sustainability, digital innovation and industry disruptions attracts greater scholarly attention, as these areas address both global challenges and practical needs in the transformation of the F&B sector.

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Table 3: Most Cited Article

No.	Authors	Title	Year	Source title	Cited by
1	Mirabella et al. (2014)	Current options for the valorization of food manufacturing waste: A review	2014	Journal of Cleaner Production	904
2	Cuerva et al. (2014)	Drivers of green and non-green innovation: Empirical evidence in Low-Tech SMEs	2014	Journal of Cleaner Production	500
3	Notarnicola et al. (2017)	Environmental impacts of food consumption in Europe	2017	Journal of Cleaner Production	436
4	Galanakis et al. (2021)	Innovations and technology disruptions in the food sector within the COVID-19 pandemic and the post-lockdown era	2021	Trends in Food Science and Technology	384
5	Vermesan & Friess (2014)	Internet of things applications: From research and innovation to market deployment	2014	Internet of Things Applications from Research and Innovation to Market Deployment	302
6	Elia et al. (2021)	Resources and digital export: An RBV perspective on the role of digital technologies and capabilities in cross-border e-commerce	2021	Journal of Business Research	281
7	Martín-Ríos et al. (2018)	Food waste management innovations in the foodservice industry	2018	Waste Management	271
8	Scuotto et al. (2017)	The effect of social networking sites and absorptive capacity on SMES' innovation performance	2017	Journal of Technology Transfer	245

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9	Zhang et al. (2022)	Recent advances in polymers and polymer composites for food packaging	2022	Materials Today	224
10	Tukker et al. (2010)	The Impacts of household consumption and options for change	2010	Journal of Industrial Ecology	203

Highest Research Contributions by Country

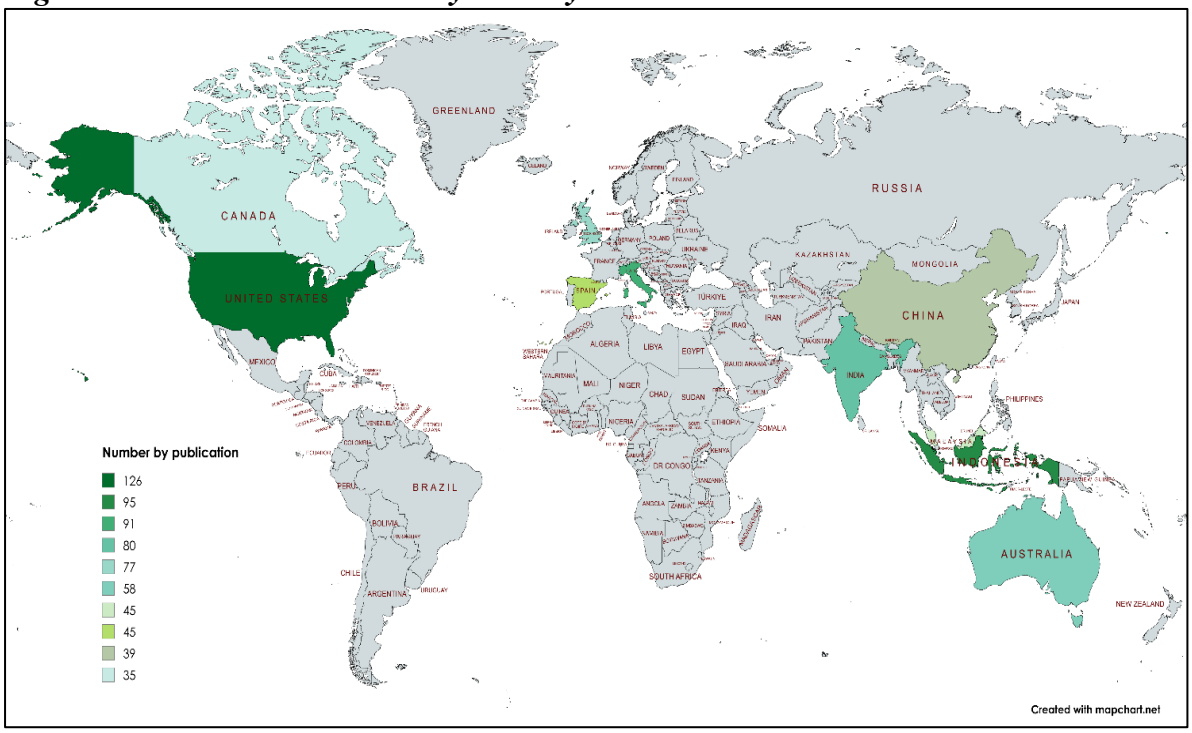

Figure 3: Geographical Distribution of Research Publications on Digital Transformation of the F&B Sector

Figure 3 illustrates the number of publications by country. As can be seen, the analysis reveals that the United States leads with 126 documents, followed by Indonesia (95), Italy (91), India (80) and the United Kingdom (77). This indicates that both developed countries and emerging economies are actively contributing to research on digital transformation in the F&B sector. The strong position of the United States can be linked to its advanced digital infrastructure, strong research institutions and the presence of global F&B companies that continuously invest in digital innovation. European countries, for instance, Spain, Italy and the United Kingdom, also record high contributions, reflecting the region's policy focus on digital economy strategies and sustainable food systems. These results show that digital transformation in F&B has become an international research interest that spans across regions with different economic strengths.

Emerging economies such as Indonesia, India and Malaysia also make notable contributions, reflecting rapid digital adoption and increasing use of online platforms in their F&B industries. In Indonesia, the high number of studies may be explained by its large consumer base, growing e-commerce market and supportive government policies promoting digitalization. India and

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Malaysia also show strong interest, supported by national digital economy agendas and the expansion of digital food delivery and service platforms. On the other hand, China's relatively lower number (39 documents) may be due to the exclusion of publications written in Chinese that are not indexed in Scopus. Overall, the results suggest that while developed countries often provide theoretical and policy frameworks, emerging economies are driving applied research and practical insights into how digital transformation is reshaping the F&B sector.

Analysis of Keyword Co-occurrence

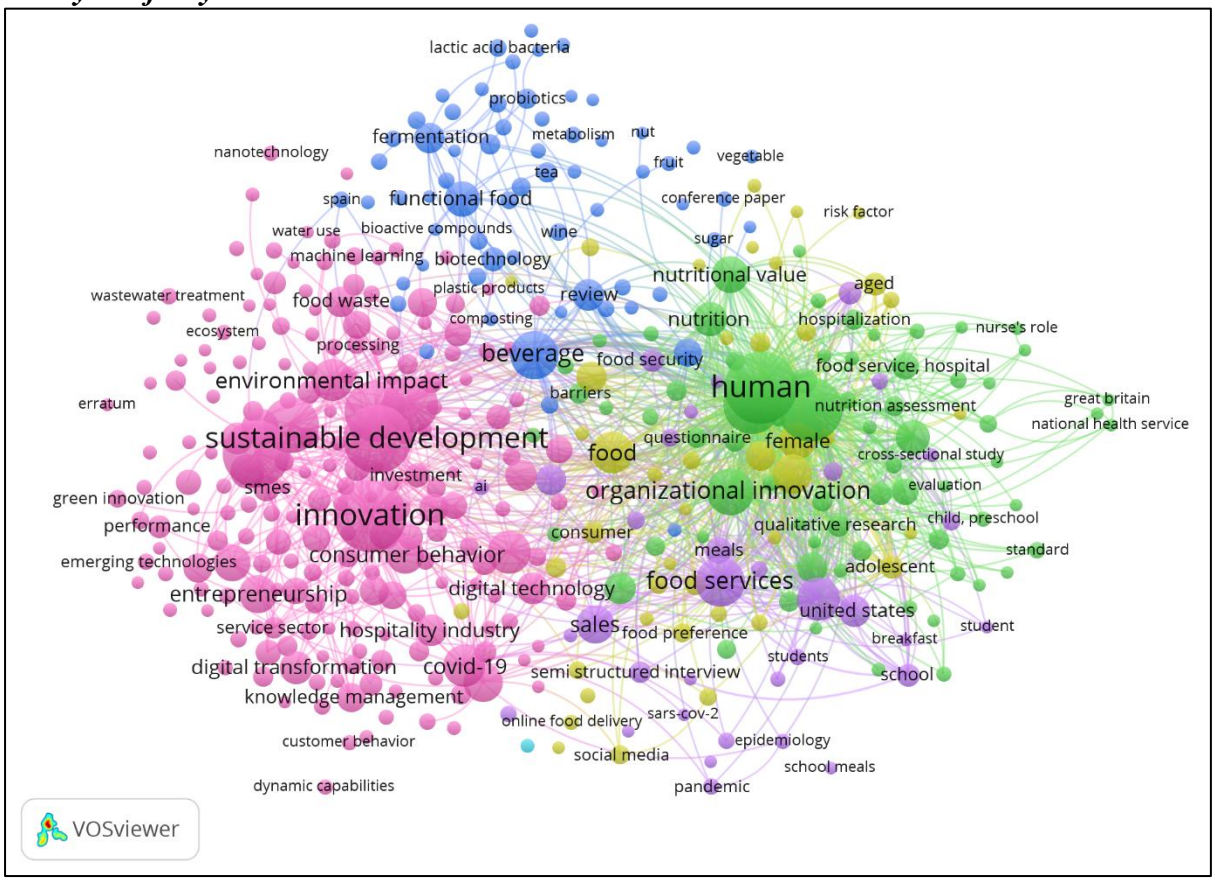

Figure 4: Network Visualization Map of Keywords' Co-Occurrence

The co-occurrence analysis of author keywords in VOSviewer is a bibliometric technique used to identify the relationships and thematic linkages between frequently used terms in scientific publications. By mapping how often specific keywords appear together, this method allows researchers to visualize clusters of related concepts and detect dominant themes, emerging topics and research gaps. In this study, the analysis was conducted using the full counting method, applying a minimum threshold of five occurrences for keyword inclusion. Based on Figure 4, out of 3,674 total keywords, 418 met the threshold and a minimum cluster size of five was applied, resulting in six distinct clusters. This setting ensures that only terms with meaningful recurrence and strong connections are included, while smaller, less relevant terms are excluded. The network visualization represents keywords as nodes, where node size indicates frequency of use and links represent their co-occurrence strength, providing an overview of intellectual structures in the field.

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The findings reveal that highly occurring keywords such as "innovation" (132), "human" (132), "sustainable development" (117), "food and beverage industry" (113) and "industry 4.0" (80) form central nodes in the network, reflecting the intersection between digital transformation, sustainability and the evolving dynamics of the F&B sector. The inclusion of "human" indicates the presence of people-oriented studies focusing on consumer behavior, health and user experience. The emergence of terms like "digital transformation" (31), "digitalization" (24), "artificial intelligence" (18) and "blockchain" (7) highlights the growing integration of advanced technologies into food systems, while the inclusion of "sustainable development," "food waste," and "circular economy" underscores the parallel concern for environmental and social impacts. The clustering of these keywords contributes to the body of knowledge by demonstrating how digital technologies are increasingly linked with sustainability practices, consumer behavior and innovation within the F&B industry. This provides evidence of a multidisciplinary research landscape, showing how digital transformation is studied as both a technological advancement and a driver of sustainable growth, reflecting the sector's shift towards resilience and global competitiveness.

International Collaboration and Co-Authorship Patterns by Country

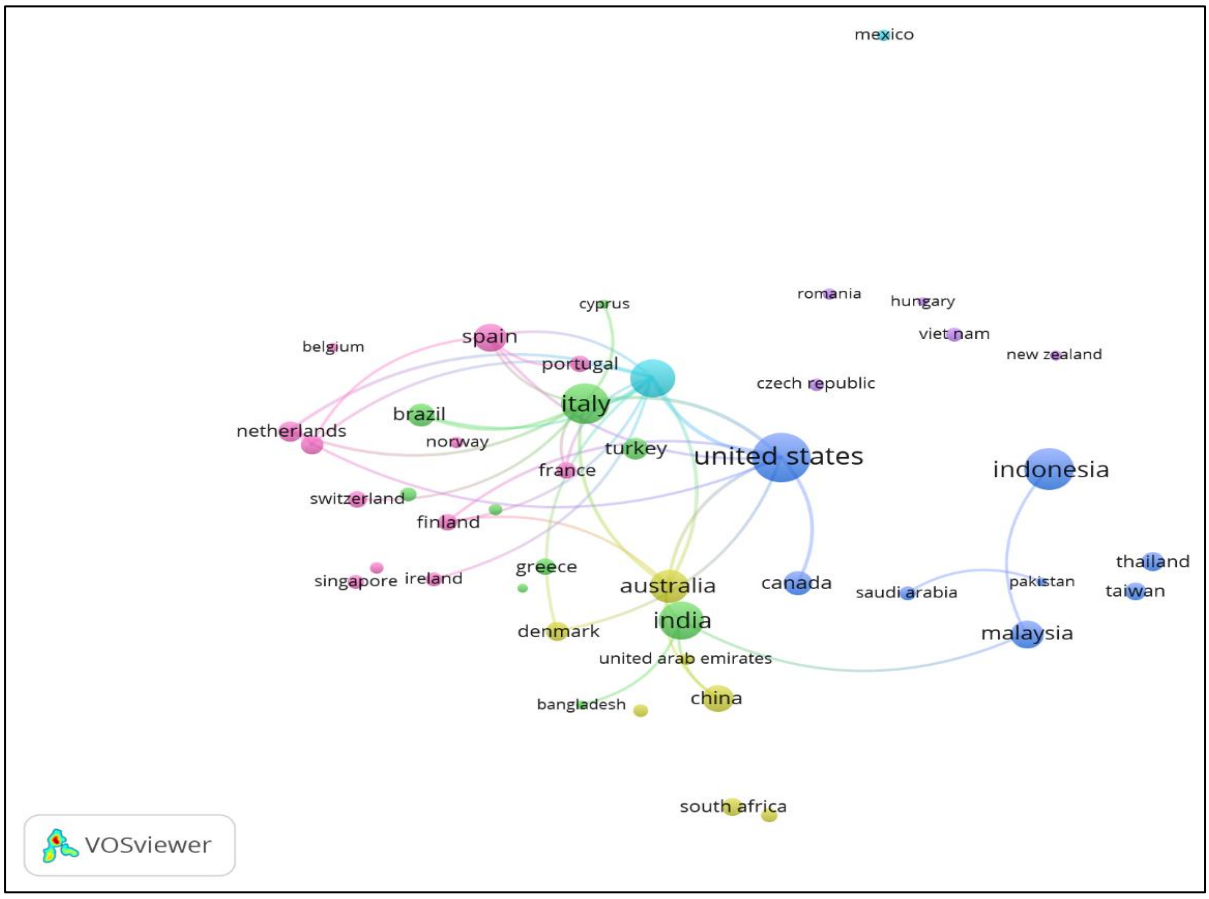

Figure 5: Network Visualization Map of Co-Authorship by Countries'

The co-authorship by countries analysis in VOSviewer is a bibliometric method used to examine collaborative research networks across nations. By mapping how authors from different countries co-publish, the analysis highlights the level of international cooperation, research productivity and influence of various countries within a particular field. Note that each node represents a country, with its size reflecting the number of documents produced. The links

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illustrate collaborative relationships and the link strength measures the intensity of such cooperation. In this study, the full counting method was applied with a minimum threshold of five documents. Based on Figure 5, out of 94 countries, 44 met the threshold and a minimum cluster size of five was set, resulting in six clusters. This configuration ensured that the analysis focused on countries with sufficient research output and significant collaborative connections, providing a structured map of global research partnerships in digital transformation within the F&B sector.

The findings reveal Italy, the United States and the United Kingdom as the most influential countries, not only in terms of the number of documents but also in citations and strong collaborative links. Notably, Italy achieves the highest citation impact (4,468). Emerging contributors such as India, Indonesia and Malaysia demonstrate growing research activity, although with lower citation counts, which suggests a more recent entry into the global discourse. European countries like Spain, Germany and the Netherlands, alongside Australia and Canada, further strengthen the network by contributing to high-quality publications and cross-border collaborations. On the other hand, the generation of six clusters reflects the formation of distinct regional and international research hubs where advanced economies often lead in theoretical and methodological contributions while emerging economies focus on applied research related to digital adoption in F&B. Taken together, this analysis contributes to the existing body of knowledge by showing how international collaboration enhances the development of diverse perspectives, accelerates the diffusion of digital transformation practices and supports the alignment of global F&B research with sustainability and innovation agendas.

Conclusion

This study aimed to investigate the evolution of digital transformation in the F&B sector using a bibliometric approach, addressing questions related to research trends, influential publications, contributing countries, thematic keywords and international collaborations. The analysis confirms that scholarly attention to this topic has grown rapidly, particularly after 2020, reflecting the influence of global disruptions such as the COVID-19 pandemic and the increasing adoption of Industry 4.0 technologies. Hence, the findings show that the United States, Italy and the United Kingdom lead in research contributions, while emerging economies such as Indonesia, India and Malaysia are becoming more visible in this field. The most cited articles emphasize sustainability, innovation and technology adoption, indicating that research is positioned at the intersection of digital transformation and sustainable development. Keyword co-occurrence analysis further illustrates how digitalization is closely tied to concepts such as food systems, innovation capability and consumer behavior. Meanwhile, co-authorship networks reveal active collaboration between advanced and emerging economies, strengthening knowledge exchange and global perspectives.

This research contributes to the field by offering a comprehensive overview of the intellectual and thematic structures that shape digital transformation in the F&B sector. The insights gained here highlight how digital technologies are drivers of innovation and enablers of sustainability and competitiveness in the global food system. Practical implications emerge for policymakers, industry practitioners and academic institutions seeking to strengthen digital adoption strategies, build sustainable supply chains and enhance consumer engagement through digital platforms. Nevertheless, the study is constrained by its reliance on Scopus as the sole database and the exclusion of non-English publications, which may result in the underrepresentation of

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certain regions. Future studies could broaden the scope by integrating multiple databases, incorporating qualitative reviews, or focusing on regional case studies to deepen understanding. In conclusion, bibliometric analysis proves to be a valuable tool for mapping trends, identifying research gaps and guiding strategic directions. This underlines the significance of this study in advancing both academic discourse and practical applications of digital transformation in the F&B sector.

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