Athens Journal of Tourism 2025, 11: 1-33
https://doi.org/10.30958/ajt.X-Y-Z

Technological Advancements in Hospitality through Python-based Bibliometric Analysis

By Michail Toanoglou[*], *Thomas Krabokoukis*[±] *& Evangelos Papadimitriou*[○]

This paper presents a bibliometric analysis of academic literature at the intersection of technology and hospitality, using Python-based scripting and VOSviewer. A four-stage methodological framework is employed to identify trends, group research into thematic clusters, and explore key topics and their interconnections. First, co-occurrence analysis reveals seven clusters related to technological innovation, digital transformation, artificial intelligence, and post-COVID-19 strategies. Second, articles are assigned to clusters, and top keywords are extracted using Term Frequency–Inverse Document Frequency (TF-IDF), highlighting the thematic focus of each cluster. Third, Latent Dirichlet Allocation (LDA) identifies five dominant topics per cluster, offering insights into the evolving structure of hospitality research. Finally, a topic-based cluster interaction analysis reveals strong connections, particularly among clusters on digital transformation, sustainability, and technology adoption, while others, such as sustainability and customer satisfaction, appear more isolated. These findings suggest emerging or niche areas within the broader discourse. The study contributes methodologically by offering a replicable, data-driven framework for future bibliometric research and thematically by revealing the multidimensional impact of technology in hospitality. By integrating bibliometric techniques with established theories such as the Technology Acceptance Model and Diffusion of Innovation, this work supports a multidisciplinary approach to understanding technological shifts in hospitality scholarship.

Keywords: *Technology in Hospitality, Digital Transformation, Bibliometric Analysis, Artificial Intelligence in Tourism, Sustainability in Tourism, TAM, DOI.*

Introduction

Bibliometric analysis has become an essential tool for understanding the evolving landscape of scholarly research. Notably, within the Scopus database, the use of the keywords "bibliometric analysis" OR "literature analysis," reveals a significant acceleration in the number of publications from 2019 onward. This growth peaked in 2020 and 2021, with an annual increase rate exceeding 50%. This surge is likely attributable to external factors such as technological advancements and heightened research activity in emerging fields. This growing emphasis on bibliometric and content-based mapping approaches also aligns with previous

[*]Professor, ESSEC Business School, France & EPOT - Scientific Tourism Think Tank, Greece.
[±]Appointed Lecturer, Department of Economics, University of Western Macedonia & EPOT - Scientific Tourism Think Tank, Greece.
[○]EPOT - Scientific Tourism Think Tank, Greece.

efforts to assess thematic shifts in tourism scholarship as highlighted by Kyrkilis & Nikolaidis, (2022).

By systematically examining publication patterns, keyword usage, and thematic developments, researchers can gain valuable insights into prevailing trends and emerging areas of interest within specific fields. Previous studies have effectively employed bibliometric analysis using Python to explore various facets of the research landscape. For instance, Krabokoukis (2023a) utilized Python for keyword-based clustering of papers using terms derived from VOSviewer, thereby facilitating a deeper understanding of research themes. Similarly, Krabokoukis and Polyzos (2023) employed VOSviewer to generate clusters that delineate research foci across different geographic regions, revealing the specific areas of study prevalent in each locale. Furthermore, Krabokoukis et al. (2024) conducted a comprehensive analysis of papers based on their methodologies, specifically identifying relevant keywords, and categorizing the papers into corresponding groups, thus providing insights into the diverse approaches adopted in the literature. Additionally, Zeng et al. (2024) utilized Python, MySQL, AI sentiment analysis, and Tableau to examine tourism safety publications. These methodologies underscore the potential of bibliometric tools in elucidating complex research dynamics and highlight the significance of systematic analysis in mapping the evolving contours of academic inquiry. However, a search in Scopus using the keywords "bibliometric analysis" OR "literature analysis" AND "hospitality" OR "tourism" AND "python" yields only two papers, indicating that Python has not been sufficiently leveraged in related studies within the tourism sector, and that there is a lack of studies grounding their methodological approach in established theoretical frameworks.

Theoretical frameworks play a crucial role in guiding research and interpreting findings. For instance, the Technology Acceptance Model (TAM) is one of the most influential models in explaining technology adoption and has been widely used to this end (Li et al., 2024; Mogaji et al., 2024; Sujood et al., 2024). TAM posits that an individual's acceptance and use of a technology are determined primarily by two factors: perceived usefulness (the degree to which a person believes that using a particular system would enhance their job performance) and perceived ease of use (the degree to which a person believes that using a particular system would be free of effort) (Sujood and Pancy, 2024). In the context of this study, TAM provides a framework for understanding how hospitality and tourism professionals and consumers adopt new technologies, such as AI, digital platforms, and big data tools. Additionally, the Diffusion of Innovation Theory offers insights into how innovations spread within a population and helps explain how new ideas and technologies are disseminated (Babolian & Jaszus, 2024; Xu et al., 2024). This theory describes the process by which an innovation is communicated through certain channels over time among the participants of a social system. Key elements of this theory include the characteristics of the innovation (e.g., relative advantage, compatibility, complexity, trialability, and observability) and the stages of the adoption process (Babolian &Jaszus, 2024; Shin & Baek, 2024; Xu et al., 2024). In the context of this study, the Diffusion of Innovation Theory is particularly relevant for examining the adoption of broader technological trends and innovative practices in the hospitality and tourism industries, such as sustainable practices or virtual

tourism experiences. These theories provide valuable frameworks for examining the dynamics of technology integration in the hospitality sector.

The study aims to conduct an in-depth bibliometric analysis by employing a novel and integrated methodology consisting of four key steps. First, a co-occurrence analysis will identify patterns and trends within the literature. Next, the significance of keywords within established clusters will be assessed through Term Frequency–Inverse Document Frequency (TF-IDF) analysis. This will be followed by the implementation of topic modeling techniques, specifically Latent Dirichlet Allocation (LDA), to uncover latent thematic structures within the dataset. Finally, the interrelationships among the extracted topics will be examined to elucidate their broader implications for the research landscape. This systematic integration of diverse bibliometric approaches, transcending the limitations of isolated methods, constitutes a significant methodological contribution to the field.

What distinguishes the present study is its systematically structured, four-stage methodological framework, which offers a distinctive and cohesive thematic synthesis. While prior research may have employed individual techniques such as co-occurrence analysis, TF-IDF, or LDA, this study sequentially integrates these methods to establish connections between emergent technological themes with managerial, operational, and consumer-centered dimensions of the hospitality sector. The novelty lies in this deliberate combination and ordering of analytical techniques, along their targeted application to the hospitality domain, thereby yielding a more holistic and nuanced understanding than previously available. Furthermore, the automation of key analytical steps through custom-developed Python scripts enhances both the reproducibility and computational efficiency of the study.

Based on this methodological framework, the paper addresses the following four research questions.

1. What patterns and trends can be identified in the literature through keyword co-occurrence analysis? This question helps identify factors that may influence 'perceived usefulness' and 'perceived ease of use' (TAM), or the 'adoption rate' of innovations (DOI).
2. Which keywords are most significant within identified clusters, and how do they contribute to understanding the research landscape?
3. How can topic modeling techniques be applied to extract underlying themes from the literature within the selected database?
4. What relationships exist between identified topics, and how do they inform the overall research landscape in the chosen field?

What distinguishes the present study is not merely its application of bibliometric and topic modeling techniques. While prior research has mapped trends or focused on individual domains, this study introduces a structured thematic synthesis that connects emergent technologies with managerial, operational, and consumer-centered dimensions in a replicable and scalable manner. The remainder of the manuscript is structured as follows. Section 2a comprehensive overview of the database utilized in the analysis, along with a detailed description of the study's methodological framework. Section 3 presents an in-depth examination of the results obtained from

the bibliometric analysis, highlighting key patterns and trends. Finally, Section 4 discusses the main findings, offers critical insights into the evolving research landscape, and proposes directions for future investigation.

Methodology and Data

Dataset

To construct the database for this study, a comprehensive search was conducted within the Scopus database using the keywords "technology" and "hospitality" in the fields of Title, Abstract, and Keywords. The search was limited to articles published between 2010 and 2024, focusing exclusively on English-language journals. Table 1 presents a detailed overview of the search results, including the search string used for data retrieval. The Scopus database was selected due to its reputation for providing high-quality scholarly articles and its capability to export substantial datasets in CSV format.

Table 1. *Data Retrieval Constraints and Parameters for the Scopus Database*

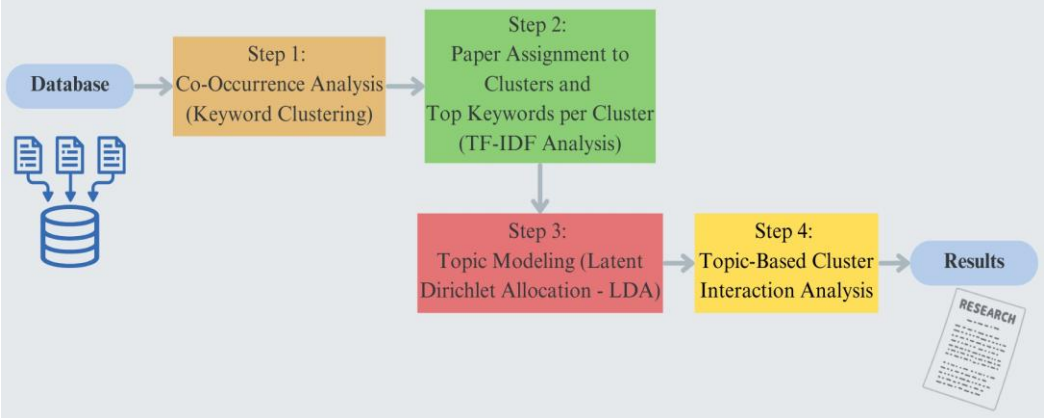
Database	**Scopus**
Search field:	Title, Abstract, Keywords
Keywords:	technology, hospitality
Open access:	All
Years:	2010-2024
Author name:	All
Subject area:	All
Publication stage:	All
Document type:	Article
Source title:	All
Affiliation:	All
Funding sponsor:	All
Country:	All
Source type:	Journal
Language:	English
Search string:	TITLE-ABS-KEY (technology AND hospitality) AND PUBYEAR > 2009 AND PUBYEAR < 2026 AND (LIMIT-TO (SRCTYPE , "j")) AND (LIMIT-TO (DOCTYPE, "ar")) AND (LIMIT-TO (LANGUAGE, "English"))
Data extracted:	October 2, 2024
Number of publications:	1.485

Source: Authors' own elaboration

Methodological Framework

To address the research questions posed, the analysis is conducted through a systematic four-stage process, as shown in Figure 1, which provides a visual overview of the methodological framework.

Figure 1. *Methodology Framework*



Source: Authors own elaboration

Each color in the figure corresponds to a specific research question. Research Question 1 is addressed in Stage 1, Research Question 2 is explored in Stage 2. Research Question 3 is analyzed in Stage 3, and Research Question 4 is examined in Stage 4. The four-stage framework is described below:

1. **Co-occurrence Analysis (Keyword Clustering)**: A co-occurrence analysis was conducted using VOSviewer to identify thematic clusters of keywords. This step provided an initial mapping of the research field and revealed the most prominent areas of focus.
2. **Paper Assignment and Keyword Extraction (TF-IDF)**: Each article was automatically assigned to one or more of the identified clusters, based on the presence of cluster-specific keywords. To highlight the thematic focus of each cluster, Term Frequency–Inverse Document Frequency (TF-IDF) was applied, extracting the most significant keywords.
3. **Topic Modeling (LDA)**: Latent Dirichlet Allocation (LDA) was employed to uncover latent thematic structures within each cluster. This allowed for the identification of five dominant topics per cluster, providing deeper insights into the thematic composition of the literature.
4. **Cluster Interaction Analysis**: A topic-based interaction analysis was conducted to examine the degree of similarity and overlap across clusters. By calculating similarity metrics, the study revealed the extent to which research themes are interconnected or remain isolated.

This systematic integration of co-occurrence analysis, keyword weighting, topic modeling, and interaction mapping constitutes a novel methodological approach. The technical details of implementation, including preprocessing steps and Python scripts, are provided in Appendix A and B.

Results

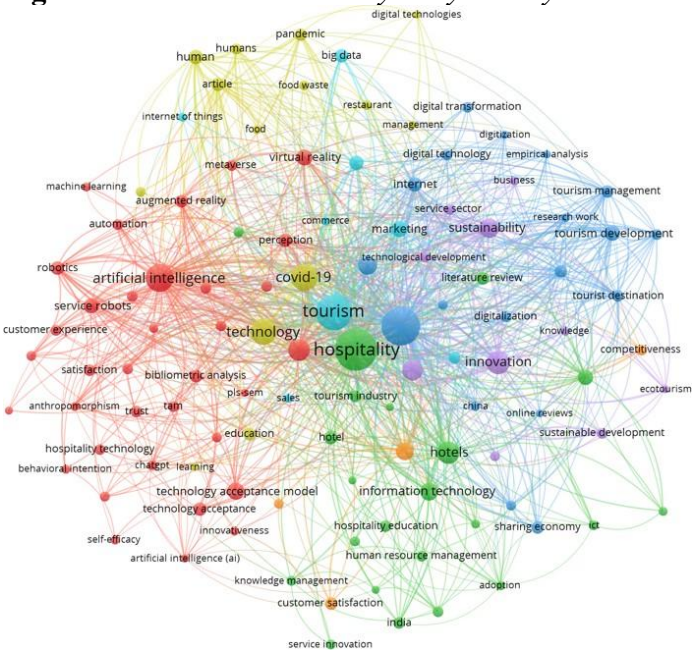
Step 1: Co-Occurrence Analysis (Keyword Clustering)

The co-occurrence analysis was performed using the VOSviewer software, a widely recognized tool for bibliometric mapping, to identify key thematic clusters within the body of research. A minimum threshold of 10 keyword occurrences was set to ensure the analysis focused on terms of significant relevance and frequency within the dataset. This process yielded a total of 5,915 unique keywords from the database. Of these, 112 keywords met the predefined occurrence threshold and were consequently included in the clustering process. These keywords were systematically grouped into seven distinct clusters, each representing a thematic area of focus in the research field.

The resulting clusters provide a structured overview of the major topics and their interrelationships, facilitating a clearer understanding of the intellectual landscape within the field. The distribution of keywords across these clusters is illustrated in Figure 2, which visually represents the co-occurrence network of keywords. Each cluster in the figure is color- coded to indicate its thematic group, with the size of the nodes corresponding to the frequency of keyword occurrences.

The co-occurrence map highlights that clusters centered on AI, adoption, and digital transformation dominate the field, with large nodes such as “AI”, “digital transformation”, and “adoption”. By contrast, terms linked to sustainability and customer satisfaction appear less central, suggesting a thematic imbalance. From a DOI perspective, this indicates that innovations with an immediate operational advantage diffuse more rapidly. At the same time, more complex or long-term practices such as sustainability face slower integration into mainstream discourse.

Figure 2. *Co-occurrence Analysis by all Keywords*



Source: Authors own elaboration

Cluster 1 (red), AI & Automation in Hospitality: This cluster focuses on the integration of artificial intelligence (AI) and automation within the hospitality sector. Key terms include "anthropomorphism," "artificial intelligence," and "robotics," which reflect the increasing reliance on AI technologies to enhance customer experiences and operational efficiency. The presence of terms like "ChatGPT" and "service robots" underscores the trend of utilizing advanced technologies to improve service delivery and customer interaction in hospitality settings. Given this high frequency of these keywords, this cluster is labeled accordingly. Additionally, the keyword "COVID-19 pandemic" indicates the influence of the pandemic on the acceleration of technological adoption in this field. The shift toward automation represents a considerable change in how service work is organized (Tuomi and Ascencao, 2023). Hospitality management literature has begun to conceptualize this transformation, suggesting a move away from mechanical and analytical tasks toward service roles that emphasize intuition and empathy. Furthermore, it is increasingly important for hotels to create distinctive and immersive experiences by leveraging disruptive technologies such as AI, Machine Learning, the Internet of Things (IoT), and Blockchain, while ensuring economic affordability for guests (Aggarwal and Mittal, 2024; Han et al., 2024). Bibliometric analysis shows that the perceived usefulness of AI in increasing operational efficiency and enhancing customer experiences is a major driver of its adoption (TAM). For example, the high weighting of "ChatGPT" and "service robots" suggests that their perceived usefulness in providing 24/7 customer service, automating routine tasks, and personalizing interactions is driving their adoption. Additionally, the sector is in the process of AI adoption, where factors such as technological and organizational complexity can influence the rate and extent of adoption (DOI). For instance, the discussion of 'ChatGPT' and 'service robots' highlights both the relative advantage of these innovations and the potential challenges associated with their implementation.

Cluster 2 (green), Technology Adoption in Hospitality: This cluster highlights the factors influencing the adoption of technology within the hospitality sector and is labeled accordingly. Keywords such as "adoption," "competitive advantage," and "consumer behavior" illustrate the importance of understanding customer preferences and market trends to successfully implement technological solutions. The inclusion of "hospitality education" and "hospitality management" reflects the necessity of ongoing training and development to facilitate effective technology adoption by enhancing both hospitality professionals' and customers' perceived ease of use and perceived usefulness (TAM). Furthermore, the presence of keywords like 'competitive advantage' suggests that technology's perceived relative strategic and operational benefits in enhancing business performance is a significant driver of its adoption (DOI).

Cluster 3 (blue), Digital Transformation in Tourism: Centered on the digital transformation of the tourism industry, this cluster includes terms like "digital technology," "digitalization," and "tourism management" and is labeled accordingly. The presence of "digital transformation" and "online reviews" emphasizes the significance of digital tools and platforms in enhancing customer engagement and streamlining operations. Furthermore, the keywords "Airbnb" and "sharing economy" suggest a shift toward more innovative, technology-driven models within the tourism

landscape. The analysis indicates that the adoption of these innovations is transforming how tourism businesses operate, market themselves, and interact with customers. Specifically, the emphasis on 'online reviews' and 'social media' suggests that tourism businesses perceive these platforms as highly useful for enhancing customer engagement, gathering valuable feedback, and improving marketing effectiveness (TAM). This aligns with broader research showing that digital transformation in tourism spans multiple areas, including city and urban planning, social media, data analytics, and digital destination marketing (Madzik et al., 2023). While TAM helps explain the adoption of specific digital tools, the Diffusion of Innovation Theory (DOI) provides additional context by framing digital transformation as a macro-level innovation diffusing through the tourism sector, driven by factors such as relative advantage and compatibility. However, successfully navigating this transformation also requires addressing challenges such as ensuring that tourism professionals possess the necessary skills to leverage digital tools (Marx et al., 2021) and developing comprehensive strategies that integrate technological advancements with human capital development.

Cluster 4 (yellow), post-COVID-19 Management and Learning: This cluster examines the changes in management practices and learning within the hospitality and tourism sectors following COVID-19. Keywords such as "COVID-19," "learning," and "pandemic" indicate a focus on adapting to new challenges and leveraging lessons learned during the pandemic, and the cluster is labeled accordingly. The inclusion of "management," "performance," and "service quality" highlights the need for enhanced strategies to navigate the evolving landscape of the hospitality industry in a post-pandemic world. The analysis indicates that the urgency and need for contactless solutions spurred by the crisis accelerated the adoption of digital technologies (DOI). This aligns with studies showing how the pandemic boosted the uptake of online learning (Pokhrel & Chhetri, 2021) and forced educators, learners, and managers to re-evaluate how technology could be used to maintain service quality and facilitate learning, shifting perceptions of usefulness and ease of use (TAM).

Cluster 5 (purple), Sustainability and Innovation in Hospitality: This cluster addresses the themes of sustainability and innovation within the hospitality sector. Keywords like "sustainability," "ecotourism," and "innovation" reflect the growing emphasis on sustainable practices and innovative solutions to address environmental concerns, and the cluster is labeled accordingly. The inclusion of terms such as "business" and "customer satisfaction" suggests recognition of the importance of balancing profitability with sustainability in hospitality operations. Results indicate a growing interest in sustainable practices, but their adoption varies depending on perceived relative advantage, complexity, and compatibility (DOI). For example, the perceived usefulness of sustainability practices such as cost savings, enhanced reputation, and increased customer loyalty is a significant factor driving adoption (TAM).

Cluster 6 (light blue), Big Data and IoT in Food Management: Focused on the role of big data and the Internet of Things (IoT) in food management, this cluster includes keywords such as "big data," "food waste," and "technology.", and is labeled accordingly. The presence of terms like "decision making" and "food" indicates a strong relationship between data analytics and effective food management practices.

Results indicate that food service managers' perceived usefulness of big data and IoT in improving food management and decision-making, such as by reducing food waste and optimizing resource allocation, is a key driver of their adoption (TAM). This aligns with the emphasis on 'customer satisfaction,' suggesting that leveraging data-driven insights to enhance efficiency in food service can indirectly improve customer experiences. However, the technical and data integration complexities associated with implementing big data and IoT systems may influence the rate of adoption (DOI). The use of smart technologies in other sectors, such as agriculture, where the integration of IoT, cloud computing, machine learning, and artificial intelligence is revolutionizing management practices, offers a model for potential applications in the hospitality industry (Idoje et al., 2021).

Cluster 7 (orange), Enhancing Competitiveness: This cluster explores strategies for enhancing competitiveness within the hospitality and tourism sectors. Keywords such as "competitiveness," "marketing," and "service quality" indicate a focus on differentiating services and improving overall business performance, and the cluster is labeled accordingly. The presence of terms like "customer experience" and "trust" highlights the importance of building strong customer relationships to foster loyalty and drive competitive advantage. Results indicate that hospitality businesses are adopting innovations, such as smart hospitality technologies, to improve their market position and customer satisfaction, driven by the perceived relative advantage and compatibility of these innovations with organizational goals (DOI). For example, the perceived usefulness of technologies that enhance customer satisfaction, such as personalization tools and customer relationship management systems, is a key driver of their adoption (TAM). This aligns with the concept of smart hospitality, which introduces disruptive innovations that reshape the entire hospitality ecosystem by leveraging smart cities and smart tourism to create agile business ecosystems within networked destinations, further enhancing competitiveness and customer engagement (Buhalis et al., 2023). Such thematic isolation echoes earlier observations that certain subfields in tourism, such as rural development or family-run enterprises, often remain disconnected from technological discourses (Koutsou & Milonopoulos, 2021).

To gain a preliminary understanding of the interactions among the clusters, a basic analysis was conducted to identify the common keywords shared between them. This analysis is summarized in Table 2. Among the 112 keywords spanning the seven clusters, the terms "tourism/tourist" and "technology" are particularly noteworthy, as they appeared in multiple clusters. This is expected, given that these keywords served as focal points in the Scopus search used to compile the dataset.

The keyword "management" appears across clusters 2, 3, and 4, underscoring its significance in various contexts within the hospitality and tourism sectors. This highlights the critical role of effective management strategies in navigating the complexities of these industries. Similarly, the recurrence of " COVID-19" in clusters 1 and 4 reflects the profound impact of the pandemic on contemporary research, particularly concerning strategies for recovery in a post-pandemic environment (Krabokoukis, 2023a). The keyword "digital" is present in clusters 3 and 4, emphasizing the essential function of digital technologies in transforming modern management practices and improving service quality following the pandemic (Buhalis et al., 2023; Madzik et al., 2023). Furthermore, the occurrence of "satisfaction" in both clusters 1

and 5 illustrates the increasing recognition of customer satisfaction as a key driver of success, influencing both technology adoption and sustainability initiatives within the hospitality industry (Veloso et al., 2022; Krabokoukis, 2023b).

Table 2. *Distribution of Common Keywords across Thematic Clusters*

Keyword	Cluster
Management	2, 3, 4
Covid-19	1, 4
Tourism/tourist	1, 2, 3, 5
Technology	1, 2, 3, 4, 5
Digital	3, 4
Satisfaction	1, 5

Source: Authors own elaboration

The uneven distribution of common keywords could be meaningful. For instance, "satisfaction" appears in only two clusters ("AI & Automation", and "Sustainability"), but is absent from the cluster "Digital Transformation", even though TAM emphasizes user perceptions as central to adoption. This could suggest that research in the hospitality sector has yet to systematically link customer satisfaction with the processes of technological adoption. This gap could be an opportunity for future work to integrate consumer psychology with TAM and DOI perspectives.

Step 2: Paper Assignment to Clusters and Top Keywords per Cluster (TF-IDF Analysis)

Building on the methodology outlined by Krabokoukis and Polyzos (2023) in their study "A Bibliometric Analysis of Integrating Tourism Development into Urban Planning", an automated article categorization script was employed to classify the articles into thematic clusters. The script, detailed in Step 2 of the Appendix, utilizes the keywords identified from the VOSviewer analysis to assign each paper in the database to its corresponding cluster. Out of the 1,485 articles in the database, 1,456 were assigned to one or more clusters, revealing a considerable degree of thematic overlap and interaction. This observation aligns with the findings of Step 1, which highlighted shared keywords across clusters. The co-classification of these articles underscores the interconnected nature of the research themes, emphasizing the cross-cutting influence of key topics. The results of this classification are presented in Table 3, which provides a comprehensive overview of the distribution of articles across the thematic clusters.

Table 3. *Distribution of Articles across Thematic Clusters*

Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Cluster 6	Cluster 7
1002	1445	279	1365	753	810	136

Source: Authors own elaboration

Most articles were categorized under Cluster 2 (Green), focusing on Technology Adoption in Hospitality, with a total of 1,445 articles. This was followed by Cluster 4 (Yellow), which addresses post-COVID-19 Management and Learning, comprising 1,365 articles, and Cluster 1 (Red), centered on AI & Automation in Hospitality,

which includes 1,002 articles. In contrast, Cluster 3 (Blue), which pertains to Digital Transformation in Tourism, and Cluster 7 (Orange), focused on Enhancing Competitiveness, garnered the fewest articles, with 279 and 136 papers respectively. Cluster 5 (Purple), Sustainability and Innovation in Hospitality, and Cluster 6 (Light Blue), Big Data and Marketing in Tourism, occupy a middle ground with 753 and 810 articles respectively. To delve deeper into the thematic focus of each cluster, the automated script described in Step 2 was used to extract the top-10 keywords per cluster, along with their corresponding weights. These keywords and their relative importance are summarized in Table 4, offering a clearer insight into the distinctive research themes within each cluster.

Table 4. *Top Keywords per Cluster with Weights*

Cluster 1		**Cluster 2**		**Cluster 3**		**Cluster 4**	
Keyword	**Weight**	**Keyword**	**Weight**	**Keyword**	**Weight**	**Keyword**	**Weight**
Tourism	43,26	Tourism	55,63	Tourism	14,92	Tourism	53,05
Study	35,45	Hospitality	47,55	Research	9,82	Study	45,18
Hospitality	34,93	Study	47,35	Study	9,68	Hospitality	44,79
Service	32,16	Research	42,72	Digital	9,54	Research	40,48
Research	31,79	Industry	41,21	Hospitality	9,52	Industry	38,97
Technology	31,29	Technology	40,48	Industry	8,36	Technology	38,92
Industry	28,84	Service	39,73	Hotel	8,32	Service	36,89
Hotel	26,15	Hotel	37,92	Technology	7,79	Hotel	35,61
Ai	24,81	Use	30,21	Technologies	6,64	Use	28,86
Use	23,05	Technologies	27,40	Service	6,50	Data	25,91

Cluster 5		**Cluster 6**		**Cluster 7**	
Keyword	**Weight**	**Keyword**	**Weight**	**Keyword**	**Weight**
Tourism	30,67	Tourism	39,53	Service	8,08
Study	25,74	Hospitality	28,38	Customer	6,59
Hospitality	25,43	Research	27,74	Study	5,48
Industry	25,05	Study	27,47	Hotel	5,29
Hotel	23,05	Industry	24,65	Satisfaction	5,23
Research	22,75	Technology	23,30	Tourism	4,95
Technology	21,21	Service	20,75	Hospitality	4,74
Service	20,40	Hotel	18,98	Technology	4,61
Innovation	16,79	Data	17,89	Industry	4,52
Business	16,21	Use	17,20	Quality	4,48

Source: Authors' own elaboration

In Cluster 1 (AI & Automation in Hospitality - red), "Tourism" stands as the most prominent keyword, with a weight of 43.26, followed by "Study" (35.45) and "Hospitality" (34.93). This reflects the strong focus on tourism and hospitality research in the context of AI and automation, signifying the sector's emphasis on technological advancements (Tuomi & Ascencao, 2023; Aggarwal & Mittal, 2024; Han et al., 2024). In Cluster 2 (Technology Adoption in Hospitality - green), "Tourism" (55.63) and "Hospitality" (47.55) again dominate, underscoring the integration of technology within these industries. Other keywords such as "Industry" and "Service" highlight the sector's emphasis on operational efficiency and improved service delivery through technology adoption (Buhalis et al., 2023).

Cluster 3 (Digital Transformation in Tourism - blue) displays a more diverse thematic focus. Here "Tourism" (14.92) and "Research" (9.82) are followed by "Digital" (9.54) and "Technology" (7.79), indicating the growing significance of

digital technologies in reshaping tourism practices (Marx et al., 2021; Madzik et al., 2023). Cluster 4 (Post-COVID-19 Management and Learning - yellow) features a strong emphasis on "Tourism" (53.05) and "Study" (45.18), reflecting academic interest in post- pandemic recovery strategies. The presence of "Service" (36.89) and "Technology" (38.92) highlights the critical role of digital adaptation in transformation hospitality services during the post-COVID-19 era (Pokhrel & Chhetri, 2021).

In Cluster 5 (Sustainability and Innovation in Hospitality - purple), the most significant keywords are "Tourism" (30.67) and "Study" (25.74), followed closely by "Hospitality" (25.43) and "Industry" (25.05). The term "Innovation" (16.79) also carries substantial weight, underscoring the sector's increasing commitment to sustainable and innovative practices (Krabokoukis, 2023a). Cluster 6 (Big Data and IoT in Food Management - light blue), is led by "tourism" (39.53) and "hospitality" (28.38), while "technology" (23.30) and "data" (17.89) illustrate the growing reliance on analytics and digital tools for decision-making marketing within tourism and hospitality (Solazzo et al., 2022). Finally, Cluster 7 (Enhancing Competitiveness - orange) is characterized by keywords such as "Service" (8.08), "Customer" (6.59), and "Satisfaction" (5.23). These terms emphasizing the importance of customer-centric strategies in driving competitiveness within the industry (Sharma & Kamble, 2021; Talón-Ballestero et al., 2022).

Step 3: Topic Modeling (Latent Dirichlet Allocation - LDA

At this stage, the analysis delves deeper into the clusters to uncover the underlying topics that emerge within each group. In the Table for the Topics of Clusters from Step 3 in the Appendix C, the primary topics for each cluster are presented in detail, alongside their most significant keywords and corresponding weights. Table 5 offers a summary of these topics, showcasing the focus areas and thematic concentrations identified through the LDA analysis.

Table 5. *Topics per Cluster*

	Cluster 1	**Cluster 2**	**Cluster 3**	**Cluster 4**
Topic 0	Understanding technology's role in hospitality	The role of technology in hospitality research	Digital transformation in hospitality	Service innovation through technology in hospitality
Topic 1	Transformative impact of AI and robotics in hospitality services	Innovations in hospitality management	The interplay of tourism and hospitality research	Tourism and hospitality research trends
Topic 2	Technological advances and educational insights in hospitality	Enhancing services delivery through technology	Utilizing technology for business improvement in hospitality	Sustainable practices in hospitality management
Topic 3	Broad implications of technology in the hospitality industry	The intersection of education and hospitality training	Investigating hospitality research methodologies	Technology utilization in hospitality education

Topic 4	Innovation in customer service and management in hospitality	Data-driven insights in hospitality management	Data-driven approaches in hospitality services	Digital transformation in tourism and hospitality

	Cluster 5	**Cluster 6**	**Cluster 7**
Topic 0	Technology adoption and service performance in hospitality	Data utilization in tourism and hospitality	Customer satisfaction in hospitality services
Topic 1	Research trends in hospitality and tourism	AI applications in hospitality research	Hotel research and customer insights
Topic 2	Customer perceptions of hotel technology	Implications of research in the hospitality industry	Quality of service in hospitality and tourism
Topic 3	Data-driven innovation in tourism and hospitality	Perceptions of technology use in hospitality	Technology and customer satisfaction in service delivery
Topic 4	Development trends in hospitality technology	Technological advancements in tourism management	Analyzing service quality and customer satisfaction

Source: Authors own elaboration

In Cluster 1 (red), titled "AI & Automation in Hospitality," five distinct topics emerge, each delving into various facets of technology's integration into the hospitality and tourism sectors. Topic 0 is primarily shaped by keywords such as "technology," "study," and "hospitality," which hold the greatest significance, followed by secondary including "tourism," "industry," "research," "customer," "service," "use," and "model." This topic explores how technology is perceived and utilized within the hospitality sector, highlighting the importance of research in understanding its impact (Singh, 2023). Topic 1 is influenced predominantly by the terms "study," "service," "technology," "perceived," "use," and "hospitality," with secondary relevance assigned to "model," "hotel," "intention," and "findings." This topic investigates the role of AI and robotics in hospitality services, focusing on their transformative effects on service delivery and customer interactions (Lu et al., 2024; Fu et al., 2024). Similarly, Topic 2 is primarily shaped by keywords such as "hospitality," "study," and is secondarily influenced by "technology," "tourism," "industry," "research," "findings," "hotel," "students," and "learning." This topic examines how technological advancements intersect with educational aspects and business management within the tourism sector (Akyurek et al., 2024; Gao, 2025; Rong et al., 2025). Topic 3 is significantly influenced by "tourism," "hospitality," "research," "industry," and "technology," with secondary emphasis on "study," "paper," "future," "analysis," and "literature." This topic addresses broader technological implications for the hospitality industry, exploring economic and operational outcomes (Buhalis et al., 2023; León-Gómez et al., 2023; Aggarwal & Mittal, 2024; Han et al., 2024). Finally, Topic 4 is shaped by keywords such as "study," "innovation," "hospitality," "data," "service," "customer," "technology," "tourism,"

"management," and "students." This topic investigates how technological innovations enhance customer service and operational practices in the hospitality sector, emphasizing the importance of data in driving management strategies and improving customer satisfaction (Bilgihan & Ricci, 2024).

In Cluster 2 (green), titled "Technology Adoption in Hospitality," five distinct topics emerge, each highlighting different dimensions of technology's role in enhancing hospitality education and industry practices. Topic 0: The Role of Technology in Hospitality Research is primarily shaped by keywords such as "study," "hospitality," "research," and "technology," underscoring the significance of academic inquiry into the adoption and impact of technology in the hospitality sector. Secondary terms such as "findings," "perceived," "use," "value," and "model" provide further context, emphasizing the multifaceted nature of technology's integration in tourism and hospitality (Omran et al., 2024). Topic 1: Innovations in Hospitality Management is influenced mainly by "hospitality," "study," and "technology," with secondary emphasis on "industry," "research," "tourism," "hotel," "data," "innovation," and "findings." This topic investigates how technological advancements drive innovation and operational effectiveness within the hospitality industry (Buhalis et al., 2023; León-Gómez et al., 2023; Aggarwal & Mittal, 2024; Han et al., 2024). Topic 2: Enhancing Service Delivery through Technology revolves around keywords such as "tourism," "hospitality," "service," "research," and "study." It delves into the integration of various technologies, including digital tools and robotics, to improve service delivery and customer experiences (Madzik et al., 2023). Topic 3: The Intersection of Education and Hospitality Training is characterized by keywords such as "learning," "students," and "hospitality," with secondary terms including "education," "study," "technology," "management," "teaching," and "training." This topic highlights the role of technology in shaping hospitality education and professional training methodologies (Akyurek et al., 2024; Gao, 2025). Finally, Topic 4: Data-Driven Insights in Hospitality Management focuses on keyword "hospitality," supported by secondary terms such as "study," "industry," "hotel," "data," "technology," "information," "based," "hotels," and "research." This topic examines how data-driven decision-making contributes to operational efficiency and guest satisfaction within the hospitality sector.

In Cluster 3 (blue), titled "Digital transformation in Tourism," five distinct topics emerge, each examining different aspects of technology's influence within the hospitality and tourism sectors. Topic 0: Digital Transformation in Hospitality is primarily shaped by keywords such as "hospitality," "study," with secondary terms including "technology," "digital," "tourism," "online," "research," "industry," "hotel," and "social." This topic explores the impact of digital innovations on the hospitality landscape and highlights ongoing research efforts aimed at adapting to technological change within the industry. Topic 1: The Interplay of Tourism and Hospitality Research centers on "tourism," "research," and "hospitality," with secondary emphasis on "study," "technology," "industry," "paper," "economy," "service," and "analysis." This topic investigates the interconnectedness of tourism and hospitality research, focusing on how various factors influence service delivery and economic outcomes. Topic 2: Utilizing Technology for Business Improvement in Hospitality is influenced mainly by "hospitality" and "technology," with secondary keywords such as "study," "research," "data," "digital," "tourism,"

"industry," "use," and "business." It examines how technological tools and data analytics enhance operational efficiency and customer service within hospitality businesses. Topic 3: Investigating Hospitality Research Methodologies centers on "hospitality," "research," and "study," with secondary emphasis given to "service," "technology," "data," "services," "hotels," "industry," and "hotel." This topic focuses on the methodologies employed in hospitality research and their role in advancing domain-specific knowledge. Lastly, Topic 4: Data-Driven Approaches in Hospitality Services is shaped by keywords such as "study," "hotel," "industry," "hospitality," "technology," "research," "service," "data," "digital," and "online." This topic explores the role of data-driven insights in optimizing service delivery and operational strategies within the hospitality sector.

In Cluster 4 (yellow), titled "Sustainability and Innovation in Hospitality," five distinct topics emerge, each addressing various dimensions of service delivery, technological, integration and environmental considerations in hospitality and tourism. Topic 0: Service Innovation through Technology in Hospitality is primarily influenced by keywords such as "study," "service," "technology," and "hospitality," with secondary terms including "hotel," "research," "use," "findings," and "perceived." This topic examines the role of technological advancements in that enhance service quality and customer satisfaction within the hospitality industry. Topic 1: Tourism and Hospitality Research Trends are shaped mainly by keywords like "tourism," "hospitality," "research," and "industry," with additional emphasis on "technology," "paper," "study," "analysis," and "future." This topic explores emerging research trends that impact both sectors especially regarding technology and future developments. Topic 2: Sustainable Practices in Hospitality Management focuses on keywords such as "food," "waste," "hospitality," "learning," "study," "environmental," "technology," "management," "students," and "green." It examines the environmental implications of hospitality practices, particularly food waste management and integrating sustainable practices into the industry. Topic 3: Technology Utilization in Hospitality Education is influenced primarily by "hospitality," "study," and "technology," with secondary keywords like "industry," "data," "students," "hotel," "management," "use," and "research." This topic focuses on the integration of technology into hospitality education and how it prepares students for the evolving demands of the industry. Finally, Topic 4: Digital Transformation in Tourism and Hospitality is shaped by keywords such as "tourism," "hospitality," "study," "industry," with secondary terms including "technology," "digital," "business," "innovation," "research," and "technologies." This topic investigates the digital transformation in tourism and hospitality, emphasizing the innovative approaches that drive competitiveness and long-term business success.

In Cluster 5 (purple), titled "Sustainability and Innovation in Hospitality," five distinct topics emerge, each highlighting various aspects of the interplay between technology, service delivery, and industry performance in hospitality and tourism. Topic 0: Technology Adoption and Service Performance in Hospitality is primarily influenced by keywords such as "study," "hospitality," "technology," and "service," with secondary terms including "research," "industry," "AI," "performance," "use," and "findings." This topic investigates how the adoption of new technologies, including artificial intelligence, improves service performance and customer

experiences within the hospitality sector. Topic 1: Research Trends in Hospitality and Tourism is shaped mainly by keywords like "tourism," "hospitality," "study," and "research," with additional emphasis on "technology," "industry," "innovation," "performance," "analysis," and "hotel." This topic explores emerging research trends that influence both tourism and hospitality industries, particularly in terms of innovative practices and performance metrics (Dowlut & Gobin-Rahimbux, 2023; Fatima & Elbanna, 2023; Luekveerawattana, 2024). Topic 2: Customer Perceptions of Hotel Technology focuses on keywords such as "hotel," "study," "technology," with secondary terms like "research," "hospitality," "use," "tourism," "customer," "industry," and "perceived." It examines customer perceptions of technology used in hotels and its impact on their overall experience. Topic 3: Data-Driven Innovations in Tourism and Hospitality is influenced primarily by "tourism," "hospitality," "study," "research," "industry," "technology," "data," "analysis," "innovation," and "service." This topic addresses the role of data analytics in driving innovations and improving service delivery within the hospitality sector. Finally, Topic 4: Development Trends in Hospitality Technology is shaped by keywords such as "hospitality," "industry," "tourism," with secondary terms including "technology," "research," "paper," "technologies," "study," "development," and "business." This topic explores technological developments technology development within the hospitality and tourism sectors and their implications for business growth and sustainability.

In Cluster 6 (light blue), titled "Big Data and IoT in Food management," five distinct topics arise, each focusing on different facets of research, technology, and industry dynamics within the hospitality and tourism sectors. Topic 0: Data Utilization in Tourism and Hospitality is primarily influenced by keywords such as "tourism," "data," and "hospitality," with secondary emphasis on "service," "study," "research," "technology," "industry," "services," and "customer." This topic examines the critical role of data in enhancing service delivery and operational efficiency within the tourism and hospitality industries. Topic 1: AI Applications in Hospitality Research centers around keywords like "tourism," "research," "hospitality," and "AI," with additional focus on "service," "study," "industry," "technology," "digital," and "technologies." This topic explores the integration of artificial intelligence in hospitality, analyzing its transformative potential and implications for service and customer interaction. Topic 2: Implications of Research in the Hospitality Industry is shaped by the keywords "hospitality," "tourism," "industry," "research," and "study," along with secondary terms such as "technology," "paper," "value," "findings," and "implications." This topic investigates the impact of research findings on industry practices, emphasizing the importance of applying research to create value in hospitality and tourism. Topic 3: Perceptions of Technology Use in Hospitality focuses on keywords like "study," "tourism," "technology," and "hospitality," with secondary keywords including "use," "research," "social," "perceived," "model," and "findings." This topic examines how perceptions of technology influence its adoption and usage within the hospitality sector. Lastly, Topic 4: Technological Advancements in Tourism Management is influenced by keywords such as "tourism," "study," "hospitality," "research," "technology," "management," "hotel," "technologies," "industry," and "use." This topic delves into the advancements in

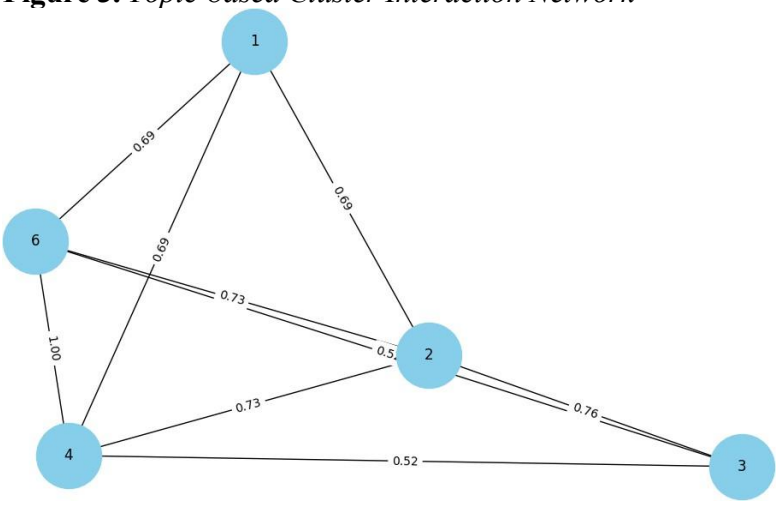
technology that are shaping tourism management practices, highlighting their relevance to enhancing operational efficiency and customer satisfaction.

In Cluster 7 (orange), titled "Customer Experience and Service Quality in Hospitality," five distinct topics are identified, each exploring various dimensions of customer satisfaction, service quality, and research. Topic 0: Customer Satisfaction in Hospitality Services is primarily influenced by keywords such as "service," "customer," "satisfaction," and "study," with secondary emphasis on "services," "hospitality," "management," "industry," "technology," and "research." This topic investigates the factors affecting customer satisfaction and the role of service quality in improving experiences. Topic 1: Hotel Research and Customer Insights focuses on keywords like "study," "hotel," "hotels," and "research," with additional emphasis on "hospitality," "customer," "technologies," "technology," "business," and "service." This topic examines hotel-related research, customer preferences, and the integration of technology to optimize service delivery. Topic 2: Quality of Service in Hospitality and Tourism is shaped by keywords such as "service," "hospitality," "study," "technology," and "industry," with secondary terms including "tourism," "quality," "research," "SST," and "model." This topic explores how service quality contributes to customer satisfaction in both sectors, emphasizing the need for high standards. Topic 3: Technology and Customer Satisfaction in Service Delivery focuses on keywords such as "service," "technology," "study," "customer," and "satisfaction," with secondary emphasis on "hospitality," "industry," "quality," "research," and "tourism." This topic investigates the role of technological tools in enhancing satisfaction and service quality. Lastly, Topic 4: Analyzing Service Quality and Customer Satisfaction is influenced by keywords like "service," "research," "study," "hospitality," and secondary terms such as "quality," "tourism," "technology," "SST," "analysis," and "satisfaction." This topic explores how service quality metrics correlate with customer satisfaction in hospitality settings.

Step 4: Topic-Based Cluster Interaction Analysis

The network density is calculated at 0.90, signifying a high degree of interconnectedness among the various clusters. This elevated density indicates that the topics within the clusters frequently interact and share relevant content, suggesting a rich landscape of relationships in the field of hospitality and tourism research, as evidenced in previous stages of analysis. However, Clusters 5, labeled as AI in Hospitality, and 7, titled Service Quality and Customer Satisfaction, exhibit lower connectivity, both scoring below 0.5. This suggests that these clusters are somewhat isolated, lacking strong links with the others and potentially addressing more niche aspects of the broader topic. These relationships are illustrated in Figure 3, which visually represents the connectivity and interaction strengths among the different clusters.

Figure 3. *Topic-based Cluster Interaction Network*



Source: Authors own elaboration

Clusters 4, known as Sustainable Practices in Hospitality, and 6, referred to as Technological Advancements in Tourism, achieve a perfect density score of 1. This indicates robust internal cohesion, where topics within the clusters are not only well-connected but also share overlapping discussions. Interaction scores reveal significant relationships involving Cluster 1, (AI & Automation in Hospitality), which shows a connection of 0.69 with both Cluster 6 and Cluster 4, and a slightly stronger score of 0.76 with Cluster 2 (Technological Innovations in Hospitality). These scores suggest that these clusters are closely aligned, contributing to a unified understanding of technology's role in the sector.

Furthermore, Cluster 3, titled Digital Transformation in Hospitality, has moderate interaction scores of 0.52 with both Cluster 4 and Cluster 6. suggesting a degree of connectivity but not as strong as Cluster 1. The interaction between Cluster 2 and Cluster 3 is notably high at 0.76, underscoring a strong thematic alignment between digital transformation and technological innovation in hospitality research. Additionally, the connection between Cluster 2 and Cluster 6 is substantial (0.73), emphasizing the interrelated nature of technological advancements across domains from general adoption to specific applications such as food management. This reinforces the broader trend of technological integration across hospitality subsectors.

Clusters 5, titled Sustainability, and Innovation in Hospitality, and 7, titled Service Quality and Customer Satisfaction, are observed to be relatively isolated, exhibiting lower connectivity with the other clusters. This suggests that they may address more niche aspects of the broader research landscape. In the case of Cluster 5, the relatively lower connectivity might be attributed to a combination of factors. While sustainability is a growing concern within the hospitality industry, it's specific applications may constitute a niche subject area, potentially involving specialized methodologies such as environmental science frameworks, life cycle assessments, or green certification systems which are distinct from the more technology- oriented approaches predominant in other clusters. Additionally, sustainability research often emphasizes long-term outcomes and systemic change,

which may not directly align with the immediate operational concerns addressed by clusters focused on technology, AI, or digital innovation. It could also be argued that sustainability in hospitality represents an emerging interdisciplinary field, with researchers beginning to fully explore its integration with technology adoption, digital transformation, and operational performance. For example, while there is increasing academic and industry interest in "smart and sustainable" practices, this line of inquiry may still be at a nascent stage of development.

Cluster 7 presents a somewhat different dynamic. While competitiveness and customer satisfaction are central theme in business and management literature, the cluster's emphasis on "customer experience" and "trust" may result in limited interdisciplinary overlap with the technology-centric clusters. Cluster 7 likely draws heavily from disciplines such as marketing, consumer psychology, and behavioral economics, which may have less established links with the technological and operational frameworks that dominate Clusters 1 through. 4. Its focus on relational constructs, such as trust and satisfaction, is reflected in its top keywords, which exhibit fewer direct connections to the technological lexicon (e.g., "AI," "robotics," "digital transformation") that drives the connectivity in other clusters. This aligns with the interpretation that customer-centric literature, while crucial for hospitality, may form a distinct theoretical and methodological domain, somewhat detached from the emergent tech-based research agendas.

These interpretations remain tentative, and further investigation is required to fully elucidate the reasons behind the lower inter-cluster connectivity of Clusters 5 and 7. While the bibliometric analysis provides a valuable macro-level overview, complementary qualitative research, such as systematic reviews, expert interviews, or citation context analysis, could offer deeper insights into the disciplinary boundaries, knowledge flows, and potential integration pathways across the evolving hospitality and tourism research landscape.

The interaction network reveals a highly connected research landscape (density = 0.90), confirming rapid diffusion of technological themes across most subfields. However, Clusters 5 (Sustainability & Innovation) and 7 (Customer Satisfaction & Competitiveness) remain relatively isolated, with interaction scores below 0.5. This isolation could indicate that sustainability research and customer-centered studies operate as parallel domains rather than being integrated into the core technological discourse. From a TAM and DOI perspective, while adoption and efficiency dominate, terms such as perceived usefulness in sustainability or ease of use in customer-facing technologies do not seem to be systematically connected.

Discussion

To enhance clarity and facilitate comparison across clusters, the findings were synthesized, that aligning each cluster with the key constructs of TAM and DOI lens. Table 6 demonstrates that while TAM and DOI explain much of the adoption dynamic in hospitality, several domains remain weakly integrated into the core discourse. These blind spots suggest opportunities for future research and underline the need for theoretical expansion beyond traditional adoption models.

Table 6. *Theoretical Interpretation of Clusters through TAM and DOI*

Cluster	Key Themes	TAM Lens	DOI Lens	Identified Gaps / Implications
AI & Automation	ChatGPT, service robots, automation	Strong perceived usefulness for efficiency and enhanced service delivery.	High relative advantage and observability, but adoption hindered by complexity.	Need for research on balancing automation with personalized service in hospitality.
Technology Adoption	Mobile apps, e-services, customer-facing tools	Reinforces both ease of use and usefulness as key predictors of adoption.	Wide diffusion due to high compatibility with existing practices.	Overemphasis on adoption models; limited exploration of long-term customer impacts.
Digital Transformation	Online reviews, digital platforms, e-tourism	Tools that directly enhance engagement strengthen perceived usefulness.	Rapid diffusion driven by compatibility and observability.	Lack of research connecting digital platforms with broader strategic outcomes.
Post-COVID-19 Management	Contactless tech, crisis-driven adoption	Pandemic shifted perceptions of necessity and ease of use.	Acts as an external shock accelerating diffusion across the sector.	Need for theoretical integration of crisis-driven adoption into long-term frameworks.
Sustainability & Innovation	Green practices, sustainable hotels	Perceived usefulness is less directly visible to managers and customers.	Adoption slowed by complexity and limited observability.	Sustainability remains peripheral to mainstream tech discourse; calls for integration.
Big Data & IoT in Food Management	Data analytics, IoT sensors, waste reduction	High usefulness for resource optimization and efficiency.	Diffusion moderated by technical complexity and integration costs.	Few studies link big data adoption with customer trust and satisfaction.
Customer Satisfaction & Competitiveness	Service quality, trust, competitiveness	Underexplored connection between perceived usefulness and customer experience.	Low connectivity (isolation) suggests weak diffusion links to other clusters.	Highlights a theoretical disconnect: customer-centric constructs not fully tied to adoption theories.

Source: Authors own elaboration

The network density of 0.90 confirms that hospitality technology research is highly interconnected. However, the weaker ties of Clusters 5 and 7 emphasize an uneven diffusion of technological themes across the field. As AI, big data, and digital adoption are examined rapidly, sustainability and customer satisfaction remain partially detached domains.

From this analysis, several key contributions can be identified. First, the findings highlight a lack of integration between sustainability and technology adoption research, suggesting that environmentally oriented innovations remain peripheral to the mainstream technological discourse in hospitality. Second, there is limited theoretical engagement with customer experience literature in the context of digital transformation, despite the centrality of satisfaction and trust in the hospitality domain. Third, while adoption studies dominate the field, relatively few contributions link adoption outcomes to long-term competitiveness and strategic performance. By situating these bibliometric patterns within TAM and DOI, the study shows that hospitality research not only reflects global technological trends but also reveals sector-specific challenges. These include the challenges of integrating sustainability into digital strategies and the theoretical gap between customer-centric approaches and technology adoption models.

Overall, the analysis highlights both the strengths and the shortcomings of current hospitality research. On the strengths side, the high network density confirms that technological adoption is advancing rapidly and in increasingly interconnected ways. However, on the shortcomings side, the marginal position of sustainability and customer satisfaction clusters challenges the comprehensiveness of prevailing theoretical frameworks. While TAM and DOI explain much of the adoption dynamic, additional theoretical integration is required to capture underexplored but critical domains such as environmental practices and customer experience.

The paper's findings extend TAM by illustrating how perceived usefulness and ease of use vary across technological domains, from AI and automation to big data and digital platforms. Additionally, enrich DOI as the evidence shows that adoption trajectories differ significantly. Some innovations diffuse rapidly due to clear relative advantage and compatibility, while others remain peripheral because of higher complexity and lower observability. This nuanced understanding demonstrates how bibliometric approaches can move beyond methodological contribution to inform and advance theory-building in hospitality.

Closing, the results also offer practical guidance for managers navigating technological transformation. The strong interconnections among clusters indicate opportunities for integrated strategies that simultaneously enhance operational efficiency and customer engagement. Conversely, the relative isolation of sustainability and customer satisfaction clusters serves as a warning for the embodiment of green practices and customer-centric approaches into digital strategies for long-term competitiveness.

Conclusions

Python was employed to conduct an in-depth analysis of the literature concerning the terms "technology" and "hospitality," utilizing a novel four-stage approach. In the first stage, a co- occurrence analysis was performed, which identified seven distinct clusters and highlighted common keywords among them, indicating varying degrees of interconnectivity. In the second stage, the articles were classified into these clusters to determine the primary thematic areas of focus. The top 10 keywords for each cluster were then identified, along with their corresponding weights. This integrated four-

stage methodology represents a novel and robust framework for conducting bibliometric analyses in the hospitality domain. In the third stage, Latent Dirichlet Allocation (LDA) was used to identify five primary topics within each cluster, providing a deeper understanding of the thematic structure. This comprehensive process effectively addressed the paper's research questions.

For the first research question, the co-occurrence analysis revealed seven distinct clusters, each representing a key thematic area: AI and automation in Hospitality, Technology Adoption, Digital Transformation in Tourism, Post-COVID-19 Management, Sustainability and Innovation, Big Data and IoT in Food Management, and Service Quality and Customer Satisfaction. The analysis revealed two groups: Clusters 5 and 7 showed interaction scores below 0.5 and demonstrate lower connectivity, suggesting that they represent more niche or disciplinary-isolated domains. In contrast, the remaining clusters exhibited higher interaction scores, suggesting stronger interrelations. The strongest connection was observed between Clusters 4 and 6, followed by notable links between Cluster 2 and Clusters 3, 4, and 6.

For the second research question, TF-IDF was employed to extract the top 10 keywords for each cluster, revealing their unique thematic emphases. For example, Cluster 1 emphasizes terms such as "service," "technology," and "AI," illustrating a strong focus on automation and artificial intelligence, Cluster 3 highlighted terms like "digital" and "technology," reflecting the significance of digital tools in tourism. Collectively, these finding illustrate the multidisciplinary nature of the research in the domain and the convergence of technological and managerial themes hospitality studies.

Addressing the third research question, LDA was used to uncover five key topics within each cluster. For instance, within Cluster 1, Topic 1 explored the transformative role of AI and robotics in hospitality operations. In Cluster 2, Topic 0 emphasized the role of technology in advancing hospitality research, particularly through data and innovation. These insights demonstrate the value of topic modeling in identifying sub-themes and specific research trajectories within broader thematic areas.

For the fourth research question, the topic-based cluster interaction analysis revealed a high network density of 0.90, indicating strong interconnectivity among most clusters. Clusters 1, 4, and 6 showed the highest interactions scores, suggesting a shared thematic orientation toward technological transformation. In contrast, Clusters 5 and 7 were relatively isolated, likely reflecting narrower or discipline-specific areas of inquiry such as environmental sustainability or customer experience. Clusters 1, 4, and 6 showed strong interactions, suggesting a unified understanding of technology's transformative role. In contrast, Clusters 5 and 7 showed lower connectivity, indicating more niche areas of focus.

From a methodological standpoint, this study offers a replicable and adaptable framework for conducting large-scale bibliometric and topic modeling analyses in the hospitality and tourism domain. The integration of VOSviewer, Python-based TF-IDF and LDA analysis, and network interaction metrics provides a robust multi-layered approach for exploring research trends, thematic development, and inter-cluster relationships. The identified clusters and associated keywords -topics structures can serve as reference points for future research aiming to identify gaps,

emerging themes, or opportunities for interdisciplinary collaboration. From an applied perspective, the findings offer valuable insights for practitioners in the hospitality industry. The identified themes, ranging from AI integration and big data analytics to sustainability practices and customer satisfaction, highlight current technological and managerial trends with direct implications for strategic planning, operations, and workforce training. The emphasis on customer-centric topics such as satisfaction, trust, and perceived value also reinforces the need to align digital innovation with the human aspects of hospitality service delivery.

Throughout this study, the Technology Acceptance Model (TAM) and the Diffusion of Innovation (DOI) theory provided valuable theoretical lenses. TAM was instrumental in explaining technology adoption patterns within Clusters 1, 2, 3, and 6, where perceived usefulness and ease of use were key drivers of acceptance. The findings largely support TAM's assertion but also extend its application by incorporating hospitality-specific factors, such as the balance between automation and personalized service. DOI theory contributed to interpreting the broader diffusion patterns observed in Clusters 3, 4, 5, and 7, where factors like relative advantage, complexity, and external shocks, such as the COVID-19 pandemic, played a role in accelerating or constraining innovation adoption. These frameworks collectively enriched the analysis and provided structure to the interpretation of findings across clusters. In conclusion, this study contributes both methodologically and thematically to the hospitality and tourism literature. It advances a hybrid bibliometric topic modeling approach that enables scalable and systematic reviews of academic corpora. Thematically, it reveals how the sector has organized around emergent technologies, and digital transformation with clusters reflecting varying degrees of adoption, innovation, and customer integration. These findings carry theoretical implications, suggesting that uneven integration across subfields reflects different stages of technology diffusion and adoption maturity. Future research could build upon this framework by applying similar methods across time series datasets, expanding the scope of analysis, or delving deeper into specific clusters to investigate how academic and industry discourses evolve in response to technological change.

This study demonstrates that a bibliometric framework is not merely a technical exercise but a means of advancing hospitality scholarship. By situating large-scale text mining within TAM and DOI, the research reveals both the strengths of current adoption trajectories and the blind spots where theoretical integration is lacking. Future work could continue to bridge methodology frameworks with theory, building and ensuring that bibliometric tools serve as catalysts for developing richer understandings of technology, sustainability, and customer experience in hospitality. For practitioners, the results highlight the need to align technological adoption with strategic objectives that balance efficiency, innovation, and customer value.

References

Aggarwal S, Mittal A (2024) Futuristic hospitality conceptualized: DASH – decentralized autonomous and smart hotel system. *Journal of Open Innovation: Technology, Market, and Complexity* 10(1): 100223. https://doi.org/10.1016/j.joitmc.2024.100223

Akyürek S, Genç G, Çalık İ, Şengel Ü (2024) Metaverse in tourism education: A mixed method on vision, challenges and extended technology acceptance model. *Journal of Hospitality, Leisure, Sport & Tourism Education* 35: 100503. https://doi.org/10.1016/j.jhlste.2024.100503

Babolian Hendijani R, Jaszus K (2024) The rise of virtual food tourism experiences: Integrating diffusion of innovation theory and self-determination theory. *Tourism and Hospitality Management* 30(2): 249–258. https://doi.org/10.20867/thm.30.2.8

Bilgihan A, Ricci P (2024) The new era of hotel marketing: Integrating cutting-edge technologies with core marketing principles. *Journal of Hospitality and Tourism Technology* 15(1): 123–137. https://doi.org/10.1108/JHTT-04-2023-0095

Buhalis D, O'Connor P, Leung R (2023) Smart hospitality: From smart cities and smart tourism towards agile business ecosystems in networked destinations. *International Journal of Contemporary Hospitality Management* 35(1): 369–393. https://doi.org/10.1108/IJCHM-04-2022-0497

Dowlut N, Gobin-Rahimbux B (2023) Forecasting resort hotel tourism demand using deep learning techniques – A systematic literature review. *Heliyon* 9(7): e18385. https://doi.org/10.1016/j.heliyon.2023.e18385

Egger R, Yu J (2022) A topic modeling comparison between LDA, NMF, Top2Vec, and BERTopic to demystify Twitter posts. *Frontiers in Sociology* 7: 886498. https://doi.org/10.3389/fsoc.2022.886498

Fatima T, Elbanna S (2023) Advancing sustainable performance management in the hospitality industry: A novel framework based on a health-inclusive balanced scorecard. *Tourism Management Perspectives* 48: 101141. https://doi.org/10.1016/j.tmp.2023.101141

Fu M, Fraser B, Arcodia C (2024) Digital natives on the rise: A systematic literature review on generation Z's engagement with RAISA technologies in hospitality services. *International Journal of Hospitality Management* 122: 103885. https://doi.org/10.1016/j.ijhm.2024.103885

Gao T (2025) Research on the design of online gamified tourism education activities based on Moodle platform. *Entertainment Computing* 52: 100823. https://doi.org/10.1016/j.entcom.2024.100823

Han H, Kim S (Sam), Hailu TB, Al-Ansi A, Loureiro SMC, Kim JJ (2025) Determinants of approach behavior for ChatGPT and their configurational influence in the hospitality and tourism sector: A cumulative prospect theory. *International Journal of Contemporary Hospitality Management* 37(1): 113–139. https://doi.org/10.1108/IJCHM-07-2023-1072

Higgott O (2022) PyMatching: A Python package for decoding quantum codes with minimum-weight perfect matching. *ACM Transactions on Quantum Computing* 3(3): 1–16. https://doi.org/10.1145/3505637

Idoje G, Dagiuklas T, Iqbal M (2021) Survey for smart farming technologies: Challenges and issues. *Computers & Electrical Engineering* 92: 107104. https://doi.org/10.1016/j.compeleceng.2021.107104

Jones P (2022) Plant-based food in the hospitality industry: An exploratory case study of leading fast food outlets. *Athens Journal of Tourism* 9(2): 63–76. https://doi.org/10.30958/ajt.9-2-1

Krabokoukis T (2023) Technology tools in hospitality: Mapping the landscape through bibliometric analysis and presentation of a new software solution. *Digital* 3(1): 81–96. https://doi.org/10.3390/digital3010006

Krabokoukis T (2023) Exploring the state of research on tourism sustainability: A bibliometric analysis in the post-COVID era. *Highlights of Sustainability* 2(2): 50–61. https://doi.org/10.54175/hsustain2020005

Krabokoukis T, Polyzos S (2023) A bibliometric analysis of integrating tourism development into urban planning. *Sustainability* 15(20): 14886. https://doi.org/10.3390/su152014886

Krabokoukis T, Polyzos S, Kantianis D (2024) Mapping the landscape of transport infrastructure and regional development: A comprehensive bibliometric analysis. *Theoretical and Empirical Researches in Urban Management* 19(1): 5–29.

León-Gómez A, Santos-Jaén JM, Palacios-Manzano M, Garza-Sánchez HH (2023) Unlocking sustainable competitive advantage: Exploring the impact of technological innovations on performance in Mexican SMEs within the tourism sector. *Environment, Development and Sustainability* 27(2): 3481–3511. https://doi.org/10.1007/s10668-023-04025-y

Li F (Sam), Zhu D, Lin M-T (Brian), Kim PB (2024) The technology acceptance model and hospitality and tourism consumers' intention to use mobile technologies: Meta-analysis and structural equation modeling. *Cornell Hospitality Quarterly* 65(4): 461–477. https://doi.org/10.1177/19389655241226558

Lu L, Hua M, Sun X, Zou R, Lin B (2024) AI robots over sommeliers? Exploring the service provider effect on diners' wine ordering decisions at restaurants. *International Journal of Hospitality Management* 122: 103879. https://doi.org/10.1016/j.ijhm.2024.103879

Luekveerawattana R (2024) Enhancing innovation in cultural heritage tourism: Navigating external factors. *Cogent Social Sciences* 10(1): 2301813. https://doi.org/10.1080/23311886.2024.2301813

Madzík P, Falát L, Copuš L, Valeri M (2023) Digital transformation in tourism: Bibliometric literature review based on machine learning approach. *European Journal of Innovation Management* 26(7): 177–205. https://doi.org/10.1108/EJIM-09-2022-0531

Marx S, Flynn S, Kylänen M (2021) Digital transformation in tourism: Modes for continuing professional development in a virtual community of practice. *Project Leadership and Society* 2: 100034. https://doi.org/10.1016/j.plas.2021.100034

Mogaji E, Viglia G, Srivastava P, Dwivedi YK (2024) Is it the end of the technology acceptance model in the era of generative artificial intelligence? *International Journal of Contemporary Hospitality Management* 36(10): 3324–3339. https://doi.org/10.1108/IJCHM-08-2023-1271

Omran W, Ramos RF, Casais B (2024) Virtual reality and augmented reality applications and their effect on tourist engagement: A hybrid review. *Journal of Hospitality and Tourism Technology* 15(4): 497–518. https://doi.org/10.1108/JHTT-11-2022-0299

Pokhrel S, Chhetri R (2021) A literature review on impact of COVID-19 pandemic on teaching and learning. *Higher Education for the Future* 8(1): 133–141. https://doi.org/10.1177/2347631120983481

Rong A, Jianwei S, Xiaowei X (2025) Intelligent entertainment robots based on path navigation planning in tourism intelligent services and user entertainment experience analysis. *Entertainment Computing* 52: 100829. https://doi.org/10.1016/j.entcom.2024.100829

Sharma R, Kamble Z (2021) Shifting paradigms in human resource management while striving for service excellence in the tourism industry. In Thirumaran K, Klimkeit D, Tang CM (Eds.), *Service excellence in tourism and hospitality* (pp. 177–190). Springer International Publishing. https://doi.org/10.1007/978-3-030-57694-3_12

Shin H, Baek S (2023) Unequal diffusion of innovation: Focusing on the digital divide in using smartphones for travel. *Journal of Hospitality and Tourism Management* 55: 277–281. https://doi.org/10.1016/j.jhtm.2023.04.012

Singh G, Raheja S, Sharma R (2023) Elevating hospitality with smart hotel technologies: A guest-centric perspective. *IEEE Engineering Informatics Conference* 1–9. https://doi.org/10.1109/IEEECONF58110.2023.10520539

Solazzo G, Maruccia Y, Lorenzo G, Ndou V, Del Vecchio P, Elia G (2022) Extracting insights from big social data for smarter tourism destination management. *Measuring Business Excellence* 26(1): 122–140. https://doi.org/10.1108/MBE-11-2020-0156

Subba B, Gupta P (2021) A tfidfvectorizer and singular value decomposition based host intrusion detection system framework for detecting anomalous system processes. *Computers & Security* 100: 102084. https://doi.org/10.1016/j.cose.2020.102084

Sujood B, Bano N, Siddiqui S (2024) Consumers' intention towards the use of smart technologies in tourism and hospitality industry: Integration of TAM, TPB and trust. *Journal of Hospitality and Tourism Insights* 7(3): 1412–1434. https://doi.org/10.1108/JHTI-06-2022-0267

Sujood, Pancy (2024) Travelling with open eyes! A study to measure consumers' intention towards experiencing immersive technologies at tourism destinations by using an integrated model of TPB and TAM captured through the lens of S-O-R. *International Journal of Contemporary Hospitality Management* 36(11): 3906–3929. https://doi.org/10.1108/IJCHM-11-2023-1771

Talón-Ballestero P, Nieto-García M, González-Serrano L (2022) The wheel of dynamic pricing: Towards open pricing and one-to-one pricing in hotel revenue management. *International Journal of Hospitality Management* 102: 103184. https://doi.org/10.1016/j.ijhm.2022.103184

Tlali LT, Musi ML (2021) Gender equality and empowerment through corporate social responsibility in ecotourism at Malealea, Lesotho: A qualitative study. *Athens Journal of Tourism* 8(4): 247–268. https://doi.org/10.30958/ajt.8-4-3

Tuomi A, Ascenção MP (2023) Intelligent automation in hospitality: Exploring the relative automatability of frontline food service tasks. *Journal of Hospitality and Tourism Insights* 6(1): 151–173. https://doi.org/10.1108/JHTI-07-2021-0175

Veloso CM, Magalhães D, Sousa BB, Walter CE, Valeri M (2021) Encouraging consumer loyalty: The role of family business in hospitality. *Journal of Family Business Management*. https://doi.org/10.1108/JFBM-10-2021-0134

Xu YH, Yang FX, Leong MM (2024) In-destination online shopping: A new tourist shopping mode and innovation for cross-border tourists. *Tourism Recreation Research* 49(6): 1427–1440. https://doi.org/10.1080/02508281.2023.2212353

Yang H, Kim J, Lee W (2023) Analyzing the alignment between AI curriculum and AI textbooks through text mining. *Applied Sciences* 13(18): 10011. https://doi.org/10.3390/app131810011

Zeng L, Li RYM, Zeng H (2023) Weibo users and academia's foci on tourism safety: Implications from institutional differences and digital divide. *Heliyon* 9(3): e12306. https://doi.org/10.1016/j.heliyon.2022.e12306

Appendix

A. Technical Implementation

Tools and Environment	• Software: VOSviewer (for keyword co-occurrence analysis) • Programming Language: Python (executed in Google Colab) • Libraries: pandas, scikit-learn (TF-IDF, TfidfVectorizer), gensim (LDA topic modeling), nltk (text preprocessing), networkx (network analysis)
Data Preprocessing	• Conversion of text to lowercase • Removal of punctuation, special characters, and stopwords • Tokenization of abstracts and keywords • Construction of a document–term matrix for subsequent analysis
Step 2 – Paper Assignment & TF-IDF	• Cluster assignment: Articles were matched to clusters based on keyword presence in titles and abstracts. • TF-IDF extraction: The TfidfVectorizer function from scikit-learn was used to compute keyword weights, allowing the identification of the top-10 keywords per cluster.
Step 3 – Topic Modeling (LDA)	• The gensim library was applied to perform Latent Dirichlet Allocation. • Parameters: 5 topics per cluster. • The model was trained on the processed abstracts to extract latent thematic structures.
Step 4 – Cluster Interaction Analysis	• Cosine similarity was applied to compare keyword sets across clusters. • A similarity threshold of 0.5 was used to filter meaningful connections. • Network visualization was generated using networkx, representing clusters as nodes and their similarity relationships as edges.

B. Python Scripts

Step 1: Data Reading and Cluster Assignment

```
import pandas as pd
from sklearn.feature_extraction.text import TfidfVectorizer
import numpy as np

# Reading the data
df = pd.read_csv('scopus.csv')

# List of clusters and their associated keywords
clusters = {
   "Cluster 1": ["anthropomorphism", "artificial intelligence", "artificial intelligence
(ai)", "augmented reality", "automation",
            "behavioral intention", "bibliometric analysis", "chatgpt", "consumption
behavior", "covid-19 pandemic", "customer experience",
            "higher education", "hospitality and tourism", "hospitality technology",
"innovativeness", "machine learning", "metaverse",
            "perception", "pls-sem", "robotics", "robots", "satisfaction", "self-efficacy",
"service robot", "service robots",
            "structural equation modeling", "systematic review", "tam", "technology
acceptance", "technology acceptance model",
            "technology adoption", "tourism and hospitality", "trust", "virtual reality"],
```

```
    "Cluster 2": ["adoption", "competitive advantage", "hospitality", "hospitality
education", "hospitality management", "hospitality services",
                  "hotel", "hotels", "human resources management", "ict", "india",
"information and communication", "information systems",
                  "information technology", "knowledge management", "literature review",
"malaysia", "mobile technology", "service innovation",
                  "smart tourism", "tourism industry"],

    "Cluster 3": ["airbnb", "china", "digital technology", "digital transformation",
"digitalization", "digitization", "empirical analysis",
                  "hospitality industry", "internet", "online reviews", "research work", "sharing
economy", "social media", "tourism development",
                  "tourism economics", "tourism management", "tourism market", "tourist
behavior", "tourist destination"],

    "Cluster 4": ["article", "consumer behavior", "covid-19", "digital technologies",
"education", "food", "food waste", "human",
                  "humans", "learning", "management", "pandemic", "restaurant",
"technology"],

    "Cluster 5": ["business", "ecotourism", "hotel industry", "innovation", "knowledge",
"performance", "service sector", "sustainability",
                  "sustainable development", "technological development"],

    "Cluster 6": ["big data", "blockchain", "commerce", "decision making", "internet of
things", "marketing", "sales", "tourism"],

    "Cluster 7": ["competitiveness", "customer satisfaction", "self-service technology",
"service quality"]
}

# Function to check which clusters each paper belongs to
def assign_cluster(title, abstract):
    assigned_clusters = []
    for cluster_name, keywords in clusters.items():
        for keyword in keywords:
            if keyword.lower() in title.lower() or keyword.lower() in abstract.lower():
                assigned_clusters.append(cluster_name)
                break
    return assigned_clusters

# Create a new column 'Assigned Clusters' with the cluster assignment for each paper
df['Assigned Clusters'] = df.apply(lambda row: assign_cluster(row['Title'],
row['Abstract']), axis=1)

# Result: Number of papers per cluster
cluster_counts = {cluster_name: 0 for cluster_name in clusters.keys()}
multiple_clusters = 0

for assigned_clusters in df['Assigned Clusters']:
```

```
    if len(assigned_clusters) > 1:
        multiple_clusters += 1
    for cluster in assigned_clusters:
        cluster_counts[cluster] += 1

# Print the number of papers assigned to each cluster
print("Number of papers assigned to each cluster:")
for cluster, count in cluster_counts.items():
    print(f"{cluster}: {count}")

print(f"\nNumber of papers assigned to multiple clusters: {multiple_clusters}")
```

Step 2: Extracting Top Keywords Using TF-IDF

```
# Function to extract the top keywords for each cluster using TF-IDF
def get_top_keywords(cluster_abstracts, top_n=10):
    vectorizer = TfidfVectorizer(stop_words='english')
    tfidf_matrix = vectorizer.fit_transform(cluster_abstracts)
    feature_names = vectorizer.get_feature_names_out()
    tfidf_scores = tfidf_matrix.sum(axis=0).A1
    sorted_indices = tfidf_scores.argsort()[::-1][:top_n]
    top_keywords = [(feature_names[i], tfidf_scores[i]) for i in sorted_indices]
    return top_keywords

# Example: Extracting top keywords for each cluster
for cluster in df['Assigned Clusters'].explode().unique():
    cluster_papers = df[df['Assigned Clusters'].apply(lambda x: cluster in x)]
    if len(cluster_papers) > 0:
        top_keywords = get_top_keywords(cluster_papers['Abstract'])
        print(f"\nTop keywords for {cluster}: {top_keywords}")
```

Step 3: Latent Dirichlet Allocation (LDA) Topic Modeling

```
import pandas as pd
from gensim import corpora
from gensim.models import LdaModel
import nltk
from nltk.corpus import stopwords
import re

# Ensure stopwords are downloaded
nltk.download('stopwords')

# List of stopwords
stop_words = set(stopwords.words('english'))

# Function for text preprocessing
def preprocess_text(text):
    # Remove special characters and convert to lowercase
    text = re.sub(r'\W+', ' ', text.lower())
    # Remove stopwords
    text = ' '.join([word for word in text.split() if word not in stop_words])
    return text

# Function for LDA Topic Modeling
```

```
def lda_topic_modeling(cluster_abstracts, num_topics=5):
    # Data preparation
    processed_abstracts = [preprocess_text(abstract) for abstract in cluster_abstracts]
    tokenized_abstracts = [doc.split() for doc in processed_abstracts]

    # Create dictionary and corpus
    dictionary = corpora.Dictionary(tokenized_abstracts)
    corpus = [dictionary.doc2bow(text) for text in tokenized_abstracts]

    # Train the LDA model
    lda_model = LdaModel(corpus, num_topics=num_topics, id2word=dictionary,
passes=15)

    return lda_model

# Example: Apply LDA for each cluster
for cluster in df['Assigned Clusters'].explode().unique():
    cluster_papers = df[df['Assigned Clusters'].apply(lambda x: cluster in x)]
    if len(cluster_papers) > 0:
        lda_model = lda_topic_modeling(cluster_papers['Abstract'], num_topics=5)
        print(f"\nTopics for {cluster}:")
        for idx, topic in lda_model.print_topics(-1):
            print(f"Topic {idx}: {topic}")
```

Step 4: Topic-Based Cluster Interaction Analysis

```
from sklearn.feature_extraction.text import TfidfVectorizer
from sklearn.metrics.pairwise import cosine_similarity
import networkx as nx
import matplotlib.pyplot as plt

# Create keyword lists for each cluster
cluster_keywords = {
    1: 'tourism study hospitality service research technology industry hotel ai use',
    2: 'tourism hospitality study research industry technology service hotel use
technologies',
    3: 'tourism research study digital hospitality industry hotel technology technologies
service',
    4: 'tourism study hospitality research industry technology service hotel use data',
    5: 'tourism study hospitality industry hotel research technology service innovation
business',
    6: 'tourism hospitality research study industry technology service hotel data use',
    7: 'service customer study hotel satisfaction tourism hospitality technology industry
quality'
}

# Vectorization for cosine similarity calculation
vectorizer = TfidfVectorizer()
X = vectorizer.fit_transform(cluster_keywords.values())

# Cosine similarity between clusters
similarity_matrix = cosine_similarity(X)
```

```
# Print similarity matrix
print("Cosine Similarity Matrix between clusters:")
print(similarity_matrix)

# Create a graph from the similarity matrix
G = nx.Graph()

# Add nodes and edges based on similarity
clusters = list(cluster_keywords.keys())
for i in range(len(clusters)):
    for j in range(i + 1, len(clusters)):
        if similarity_matrix[i, j] > 0.5:  # Threshold increased to avoid irrelevant
connections
            G.add_edge(clusters[i], clusters[j], weight=similarity_matrix[i, j])

# Plot the similarity network
pos = nx.spring_layout(G)
plt.figure(figsize=(10, 6))
nx.draw(G, pos, with_labels=True, node_size=3000, node_color='skyblue',
font_size=12)
labels = nx.get_edge_attributes(G, 'weight')
nx.draw_networkx_edge_labels(G, pos, edge_labels={k: f'{v:.2f}' for k, v in
labels.items()})
plt.title("Cluster Similarity Network")
plt.show()

# Network density analysis
density = nx.density(G)
print(f"Network density: {density:.4f}")
```

B. Table for the Topics of clusters from Step 3

Cluster 1	
Topic 0	0.012*"technology" + 0.011*"study" + 0.010*"hospitality" + 0.008*"tourism" + 0.007*"industry" + 0.007*"research" + 0.007*"customer" + 0.006*"service" + 0.006*"use" + 0.005*"model"
Topic 1	0.018*"study" + 0.017*"service" + 0.013*"technology" + 0.012*"perceived" + 0.011*"use" + 0.010*"hospitality" + 0.008*"model" + 0.008*"hotel" + 0.008*"intention" + 0.008*"findings"
Topic 2	0.015*"hospitality" + 0.014*"study" + 0.009*"technology" + 0.008*"tourism" + 0.007*"industry" + 0.006*"research" + 0.006*"findings" + 0.006*"hotel" + 0.006*"students" + 0.006*"learning"
Topic 3	0.025*"tourism" + 0.020*"hospitality" + 0.017*"research" + 0.012*"industry" + 0.010*"technology" + 0.009*"study" + 0.008*"paper" + 0.006*"future" + 0.006*"analysis" + 0.005*"literature"
Topic 4	0.009*"study" + 0.008*"innovation" + 0.006*"hospitality" + 0.006*"data" + 0.006*"service" + 0.006*"customer" + 0.005*"technology" + 0.004*"tourism" + 0.004*"management" + 0.004*"students"
Cluster 2	

Topic 0	0.015*"study" + 0.014*"hospitality" + 0.012*"research" + 0.012*"technology" + 0.008*"findings" + 0.008*"perceived" + 0.007*"use" + 0.007*"value" + 0.007*"model" + 0.007*"tourism"
Topic 1	0.016*"hospitality" + 0.013*"study" + 0.011*"technology" + 0.010*"industry" + 0.007*"research" + 0.007*"tourism" + 0.007*"hotel" + 0.007*"data" + 0.006*"innovation" + 0.005*"findings"
Topic 2	0.021*"tourism" + 0.015*"hospitality" + 0.012*"service" + 0.011*"research" + 0.011*"study" + 0.010*"industry" + 0.009*"technology" + 0.006*"digital" + 0.005*"technologies" + 0.005*"robots"
Topic 3	0.018*"learning" + 0.017*"students" + 0.010*"hospitality" + 0.009*"education" + 0.008*"study" + 0.007*"technology" + 0.006*"management" + 0.006*"teaching" + 0.005*"training" + 0.005*"research"
Topic 4	0.010*"hospitality" + 0.007*"study" + 0.007*"industry" + 0.007*"hotel" + 0.006*"data" + 0.005*"technology" + 0.005*"information" + 0.005*"based" + 0.005*"hotels" + 0.004*"research"
Cluster 3	
Topic 0	0.012*"hospitality" + 0.011*"study" + 0.009*"technology" + 0.009*"digital" + 0.008*"tourism" + 0.008*"online" + 0.008*"research" + 0.007*"industry" + 0.006*"hotel" + 0.006*"social"
Topic 1	0.027*"tourism" + 0.011*"research" + 0.010*"hospitality" + 0.008*"study" + 0.007*"technology" + 0.006*"industry" + 0.005*"paper" + 0.004*"economy" + 0.004*"service" + 0.004*"analysis"
Topic 2	0.012*"hospitality" + 0.011*"technology" + 0.009*"study" + 0.008*"research" + 0.007*"data" + 0.007*"digital" + 0.006*"tourism" + 0.006*"industry" + 0.005*"use" + 0.005*"business"
Topic 3	0.015*"hospitality" + 0.012*"research" + 0.012*"study" + 0.007*"service" + 0.007*"technology" + 0.007*"data" + 0.007*"services" + 0.006*"hotels" + 0.006*"industry" + 0.006*"hotel"
Topic 4	0.012*"study" + 0.009*"hotel" + 0.008*"industry" + 0.008*"hospitality" + 0.007*"technology" + 0.007*"research" + 0.006*"service" + 0.006*"data" + 0.006*"digital" + 0.005*"online"
Cluster 4	
Topic 0	0.017*"study" + 0.014*"service" + 0.012*"technology" + 0.011*"hospitality" + 0.009*"hotel" + 0.009*"research" + 0.008*"use" + 0.007*"findings" + 0.007*"perceived" + 0.007*"customer"
Topic 1	0.018*"tourism" + 0.018*"hospitality" + 0.016*"research" + 0.010*"industry" + 0.009*"technology" + 0.007*"paper" + 0.006*"study" + 0.006*"analysis" + 0.005*"technologies" + 0.005*"future"
Topic 2	0.008*"food" + 0.008*"waste" + 0.007*"hospitality" + 0.007*"learning" + 0.007*"study" + 0.006*"environmental" + 0.005*"technology" + 0.005*"management" + 0.004*"students" + 0.004*"green"
Topic 3	0.015*"hospitality" + 0.013*"study" + 0.011*"technology" + 0.008*"industry" + 0.007*"data" + 0.007*"students" + 0.006*"hotel" + 0.006*"management" + 0.006*"use" + 0.005*"research"
Topic 4	0.014*"tourism" + 0.011*"hospitality" + 0.011*"study" + 0.010*"industry" + 0.009*"technology" + 0.007*"digital" + 0.006*"business" + 0.006*"innovation" + 0.005*"research" + 0.004*"technologies"
Cluster 5	

Topic 0	0.015*"study" + 0.011*"hospitality" + 0.010*"technology" + 0.010*"service" + 0.008*"research" + 0.007*"industry" + 0.007*"ai" + 0.006*"performance" + 0.006*"use" + 0.006*"findings"
Topic 1	0.014*"tourism" + 0.012*"hospitality" + 0.012*"study" + 0.010*"research" + 0.009*"technology" + 0.007*"industry" + 0.006*"innovation" + 0.005*"performance" + 0.005*"analysis" + 0.005*"hotel"
Topic 2	0.013*"hotel" + 0.012*"study" + 0.010*"technology" + 0.009*"research" + 0.008*"hospitality" + 0.007*"use" + 0.006*"tourism" + 0.006*"customer" + 0.006*"industry" + 0.006*"perceived"
Topic 3	0.009*"tourism" + 0.009*"hospitality" + 0.008*"study" + 0.007*"research" + 0.006*"industry" + 0.006*"technology" + 0.005*"data" + 0.004*"analysis" + 0.004*"innovation" + 0.004*"service"
Topic 4	0.020*"hospitality" + 0.017*"industry" + 0.015*"tourism" + 0.008*"technology" + 0.008*"research" + 0.007*"paper" + 0.007*"technologies" + 0.006*"study" + 0.006*"development" + 0.006*"business"
Cluster 6	
Topic 0	0.017*"tourism" + 0.012*"data" + 0.010*"hospitality" + 0.009*"service" + 0.008*"study" + 0.008*"research" + 0.007*"technology" + 0.006*"industry" + 0.005*"services" + 0.005*"customer"
Topic 1	0.028*"tourism" + 0.016*"research" + 0.015*"hospitality" + 0.012*"ai" + 0.008*"service" + 0.008*"study" + 0.007*"industry" + 0.007*"technology" + 0.007*"digital" + 0.006*"technologies"
Topic 2	0.020*"hospitality" + 0.019*"tourism" + 0.012*"industry" + 0.012*"research" + 0.010*"study" + 0.008*"technology" + 0.007*"paper" + 0.006*"value" + 0.005*"findings" + 0.005*"implications"
Topic 3	0.017*"study" + 0.012*"tourism" + 0.012*"technology" + 0.011*"hospitality" + 0.009*"use" + 0.008*"research" + 0.007*"social" + 0.007*"perceived" + 0.007*"model" + 0.007*"findings"
Topic 4	0.009*"tourism" + 0.008*"study" + 0.007*"hospitality" + 0.007*"research" + 0.007*"technology" + 0.006*"management" + 0.005*"hotel" + 0.005*"technologies" + 0.005*"industry" + 0.004*"use"
Cluster 7	
Topic 0	0.016*"service" + 0.015*"customer" + 0.010*"satisfaction" + 0.010*"study" + 0.008*"services" + 0.008*"hospitality" + 0.007*"management" + 0.007*"industry" + 0.007*"technology" + 0.006*"research"
Topic 1	0.013*"study" + 0.013*"hotel" + 0.011*"hotels" + 0.010*"research" + 0.009*"hospitality" + 0.008*"customer" + 0.007*"technologies" + 0.007*"technology" + 0.006*"business" + 0.006*"service"
Topic 2	0.016*"service" + 0.014*"hospitality" + 0.011*"study" + 0.010*"technology" + 0.010*"industry" + 0.008*"tourism" + 0.007*"quality" + 0.006*"research" + 0.006*"sst" + 0.005*"model"
Topic 3	0.023*"service" + 0.014*"technology" + 0.012*"study" + 0.012*"customer" + 0.010*"satisfaction" + 0.009*"hospitality" + 0.009*"industry" + 0.008*"quality" + 0.007*"research" + 0.007*"tourism"
Topic 4	0.014*"service" + 0.013*"research" + 0.011*"study" + 0.010*"hospitality" + 0.008*"quality" + 0.008*"tourism" + 0.007*"technology" + 0.007*"sst" + 0.006*"analysis" + 0.006*"satisfaction"