Strategic Management Insights

Article

Intelligent convergence: Digital Technology Integration Driving the Dynamic Evolution and Future Outlook of Online Communities

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Abstract: This paper examines the transformation of online communities under rapid digital technology advancement, focusing on changes in structure, interaction, and governance. Based on a bibliometric analysis of 139 studies from the Web of Science (2004-2024) using HistCite and CiteSpace, the study outlines the technological and organizational dynamics shaping community evolution. Findings indicate that community structures have shifted through three main stages: early centralized platforms grounded in Web 2.0, subsequently evolving into collaborative networks supported by cloud-based tools, and ultimately developing into intelligent ecosystems integrating AI, blockchain, and immersive technologies. This trajectory highlights the ongoing co-development of technology and organizational form. The study also shows that human-machine interaction significantly reshapes user behavior, as algorithmic content curation enhances distribution efficiency and personalization while generating challenges such as reduced transparency, limited originality, and tensions between large-scale expansion and the maintenance of knowledge diversity. Technological progress further promotes innovations in governance and value creation by improving platform quality and user experience, enabling practices such as refined marketing, enhanced knowledge sharing, and broader resource accessibility, although overly rigid rule systems may still create constraints. Keyword clustering identifies research hotspots including knowledge management, trust, human-machine collaboration, and platform quality. The study suggests that future work should focus on the impact of emerging technologies, transparency in algorithmic systems, inclusive interaction design, adaptable governance structures, and the long-term co-evolution of technology and community forms, offering insights for building sustainable and resilient digital community ecosystems.

Keywords: digital technology; online community; artificial intelligence (AI)

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1. Introduction

The rapid iteration of digital technologies is reshaping the operational logic and structural patterns of online communities [1]. Their development-from early information-exchange platforms to more intricate socio-technical ecosystems-reflects successive technological waves. Beginning with the interaction architecture formed by Web 2.0 and mobile communication, and advancing toward AI, blockchain, and immersive environments, this trajectory highlights growing technological integration and diversified value creation. Across different stages, technology continuously reduced interaction barriers, enabled centralized information exchange, and later supported collaborative networks through tools such as cloud-based services. In the current phase, intelligent systems enhance content distribution, strengthen trust mechanisms, and create immersive interaction, producing substantial changes in both community operations and governance foundations.

Despite these advancements, a series of structural challenges have also emerged. Algorithmic opacity may weaken transparency, excessive reliance on technical rules can constrain user autonomy, and the expansion of communities often generates tensions between scale and long-term resilience. These issues illustrate the need to understand how online communities evolve in tandem with technological innovation and how stable interaction environments can be maintained.

Against this background, this study examines how digital technologies drive the dynamic evolution of online communities and identifies key mechanisms influencing their development. The analysis focuses on three core dimensions.

(1) Technology-driven evolution: How iterative technological upgrading guides the transition from static structures to collaborative networks and, eventually, to intelligent human-machine ecosystems, and what mechanisms explain this co-evolution.

(2) Human-computer interaction: How intelligent technologies reshape behaviors such as knowledge creation, interaction patterns, and value formation, and what new forms of human-machine collaboration and related trust issues arise.

(3) Governance and value creation: How digital tools improve platform quality, support resource optimization, and generate economic and social value, and how emerging governance models may alleviate constraints caused by rigid technical systems.

The remainder of this paper is structured as follows. Section 2 presents the research design, including methods and tools. Section 3 summarizes overall findings from the bibliometric analysis. Section 4 further analyzes citation networks, keyword co-occurrence, and clustering results. Section 5 integrates these insights to outline the key dimensions of technology integration and potential research directions. The final section discusses contributions, limitations, and future work.

2. Samples and Research Methods

This study employs bibliometric analysis to map the research landscape of digital technology applications in online community management. This method helps identify major trends, research gaps, and influential studies, offering a comprehensive understanding of how technology is adopted and studied in this field.

2.1. Data Collection

Literature was retrieved from the Web of Science Core Collection. To ensure coverage and accuracy, search terms were designed around technology-related concepts and community-related descriptors in both topic fields (TS) and titles (TI), including terms such as "community resilience" and "community sustainability." The filtering rules were: (1) publication years from 2004 to 2024, (2) categories limited to "Business" or "Management," and (3) document type restricted to journal articles. Based on these criteria, 139 articles were selected, including several addressing AI use in community management.

2.2. Bibliometric Tools

HistCite Pro 2.1 and CiteSpace 6.3.R1 (64-bit) were used for analysis. HistCite supports citation-based mapping, helping identify core publications and research trajectories. CiteSpace uses visualization methods such as keyword co-occurrence and frequency analysis to reveal structural patterns and shifts in research attention. With HistCite, we summarized publication trends, identified influential journals, and produced citation maps. Combined with literature review, this enabled clarification of major developmental phases, primary themes, and methodological tendencies. CiteSpace was used to generate co-occurrence networks, keyword trend maps, and clustering diagrams to highlight research hotspots. Additionally, we analyzed 22 highly cited studies and 8 recent publications focused on AI in community management to examine how digital

technology integration influences the evolution of online communities, organizational practices, and user engagement, providing support for subsequent research directions.

3. Descriptive Analysis

Analysis of the 139 Web of Science articles using HistCite reveals clear publication trends. Between 2004 and 2011, annual output was low, never exceeding ten articles. A surge occurred from 2014 to 2016, peaking at 17 publications in 2014. Since 2019, especially after 2022, publication numbers have risen sharply, reflecting growing interest in integrating advanced digital technologies, particularly artificial intelligence (AI), into online community management. This trend underscores AI-community integration as an emerging focus, built on the foundation of early Internet technologies (2000-2010) and accelerated by advances in big data, cloud computing, and IoT, alongside factors promoting digital innovation.

The period from 2004 to 2009 marked the rise of internet and mobile technologies. Since 2009, technologies such as AI, cloud computing, the metaverse, and quantum computing have rapidly developed, making their application in online community management a prominent academic and practical concern. The integration of digital technologies is driven by three main factors. First, it helps communities better meet user needs. Growing internet use has increased demand for information, making online communities central for knowledge sharing and learning. Big data and AI support efficient content organization and personalized recommendations, while VR and AR enhance social interaction and immersive experiences. Second, technology improves platform quality. High-speed networks enable reliable data transmission and seamless communication through text, voice, and video, while analytics allow administrators to optimize features and strategies based on user behavior. Third, digital technology enhances commercial value. Communities of shared interest enable targeted marketing, precision advertising, and premium services, expanding revenue opportunities.

AI has emerged as a key driver in this evolution (Figure 1). Although research on AI in online communities is still developing, initial progress is evident. Increasing awareness and supportive policies have fueled academic interest. Future research will explore underlying influence mechanisms, refine human–machine collaboration models, and assess AI's advantages and limitations, providing a theoretical foundation and practical guidance for the intelligent development of online communities.

Figure 1. Line graph of sample article distribution by year (2004-2024).

Building on the annual distribution patterns of research growth observed (particularly the rise of AI-related studies), this study will employ citation network analysis (HistCite) to identify key evolutionary pathways and milestone papers in the

field. Through keyword co-occurrence, saliency, and clustering analysis (CiteSpace), we aim to map the evolution of research hotspots and pinpoint current focal points. This approach will provide deeper insights into the developmental trajectory and current landscape of integrated research between digital technologies and online communities.

4. Literature Metrology Analysis

4.1. Histcite Citation Mapping

Based on analyzing citation relationships, a citation timeline was generated using HistCite to map the intellectual structure of international journal literature on digital technology in online community management. The resulting citation graph reveals closely interconnected research themes with frequent mutual citations. To balance visual clarity with meaningful citation patterns, 22 key papers were selected for analysis (see figure 2). Each node represents a publication, with node size corresponding to citation frequency. The numbers inside nodes indicate automatically assigned document IDs, while arrows denote citation relationships within the dataset. The network comprises 22 nodes and 12 links, demonstrating both strong thematic connections between digital technology and online community management research, as well as significant cross-citation patterns.

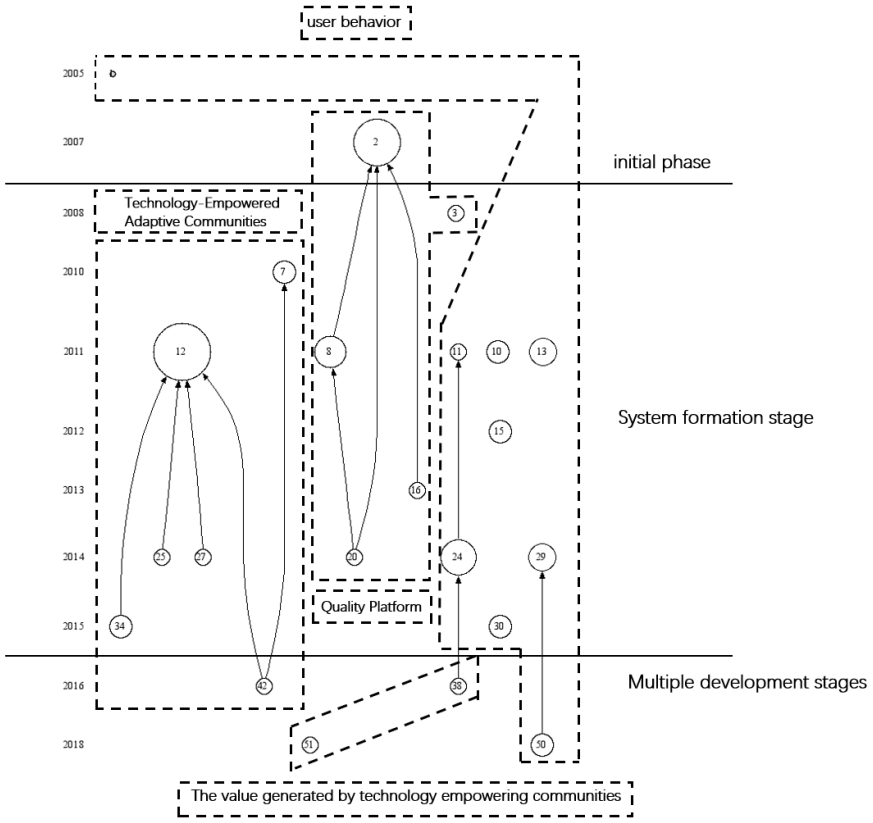

Figure 2. Citation mapping of digital technology in community management.

The chart presented above illustrates the significant changes in research related to digital technology and online communities between 2004 and 2018. The subsequent gap from 2019 to 2024 coincides with the period of rapid advancement in AI. The following section will analyze this recent, AI-driven phase from 2018 to 2024, allowing for a complete overview of the field's evolution across the entire two-decade timeframe.

4.1.1. Germination Stage (2004-2007)

Prior to 2005, hierarchical nodes were labeled as "gap," reflecting both a lack of highly-cited literature and the early developmental stage of integrating digital technology with social networks. During this initial period, research at the intersection of "digital technology" and "social networks" remained in its infancy. Scholars primarily conducted static analyses of communities, drawing heavily on traditional organizational theories such as bureaucracy and market mechanisms. These studies generally assumed that communities exhibited stable membership structures, clearly defined goals, and fixed patterns of interaction.

The earliest research in the past two decades emerged in 2005 with Document 1. This study integrates collaborative filtering theory and fuzzy set modeling to explore how specific buddy-finding techniques can address issues in existing virtual communities, including information overload, low response rates, difficulties in establishing effective partnerships, and lack of precise matching mechanisms. The research indicates that buddy-finding technology in mobile environments helps users find like-minded partners within virtual communities, resolves information overload, and satisfies users 'social and informational needs [2]. In 2007, Hsiu-Fen Lin and colleagues developed an extended acceptance model, providing a research framework to examine how online (information quality, system quality, service quality) and offline (offline activities) characteristics impact virtual community sustainability. Using structural equation modeling based on survey data from 165 community members, they found that digital technology-related factors such as system quality, information quality, and service quality significantly influence users' perceived usefulness and usability of virtual communities. These findings enhance community members' sense of belonging and willingness to use virtual platforms, thereby improving community sustainability [3].

In summary, during this early period of digital technology's initial integration into social communities, scholars developed various static research models. The existing literature primarily focused on the positive impacts of these technologies on community development, with most studies highlighting their role in meeting user needs. However, these investigations remained limited to static analytical frameworks.

4.1.2. System Formation Stage (2008-2015)

During this phase, research on digital technology in online communities became more systematic, with highly cited literature highlighting the transformation of virtual communities from static groups into dynamic, fluid ecosystems. Mobility frameworks, such as resource flows and ASA processes, were applied to explain how communities sustain vitality, providing theoretical support for technical designs that reduce participation costs and enhance resilience. Key themes include digitally driven dynamic communities, platform quality improvement, and technology's impact on user behavior.

Digitally driven dynamic communities emphasize fluidity over fixed structure. Generative responses such as evolving roles, participation guidance, dynamic boundaries, and technological affordances help communities balance tension and resist rapid disintegration [4]. Subsequent studies identified patterns like chaotic generation, joint shaping, and defensive curation, demonstrating how digital technologies shape knowledge management. Features such as editing tools and discussion pages support knowledge transformation and coordination, balancing evolution and preservation [5]. Technology choices influence participation costs and thematic consistency, which in turn affect community size, resilience, and sustainability [6]. Participant characteristics and prior experience also shape knowledge sharing, with technological filtering sometimes reinforcing group boundaries [7]. Multi-stakeholder studies show that diverse value orientations-financial, cognitive, ethical, and service-related-interact with digital platforms to create dynamic socio-material configurations [8].

Platform quality improvements further sustain communities. Web 2.0 tools, including wikis, blogs, and RSS feeds, lower barriers to content creation and management, while high-speed networks enable seamless communication. Enhanced system, information, and service quality influence perceived usefulness and trust, promoting participation and knowledge sharing [9-12].

User behavior studies indicate that technology features shape engagement, knowledge contribution, and trust. IT design, community management, and social network support influence in-role and extra-role participation, facilitating information exchange and sustaining contributions [13-20].

Overall, this stage illustrates how digital technologies enable dynamic, resilient communities by supporting knowledge collaboration, improving platform quality, and shaping user participation, providing empirical and theoretical foundations for subsequent intelligent community development.

4.1.3. Diversification Development Stage (2016 - Present)

The HistCite citation map outlines research from 2004 to 2018 but underrepresents 2019-2024 due to its focus on highly cited earlier works. To capture recent trends, eight AI-focused studies from 2019-2024 were added to the framework, along with key papers numbered 42, 38, 51, and 50, forming a more complete representation of this stage.

This period emphasizes two main areas: the value generated by digitally empowered communities and AI applications in community settings. Articles 38 and 51 demonstrate social and information value creation. For instance, online health communities can reduce urban-rural health disparities by facilitating social support, while credible information enhances adoption of online word-of-mouth [21,22]. AI and online communities form a dynamic, complementary relationship: communities provide large-scale data for AI training, while AI improves content recommendations, engagement, and community health.

Recent studies show AI reshapes community interaction, content quality, and trust, often through human-machine collaboration, raising ethical considerations [23]. Examples include integrating adaptive chatbots into gaming communities to enhance engagement and self-regulation [24], and frameworks for AI-enhanced customer communities that balance automation with oversight [25]. Research on cybercrime and consumer communities further illustrates how AI and technology co-create value, improve engagement, and facilitate knowledge sharing [26-28].

AI applications in health Q&A forums demonstrate its capacity to enhance answer quality by predicting and guiding responses, while topic network analysis identifies emerging technologies and trends using social sentiment and natural language processing [29,30]. Overall, this stage highlights diversified applications of AI and digital technologies in communities, emphasizing value co-creation, improved management, and informed engagement.

4.2. Keyword Co-occurrence and Clustering Analysis

Earlier articles tend to accumulate more citations over time, which limits how well HistCite citation maps can capture current research directions [31]. To address this, the present study turned to CiteSpace for additional analysis. Using CiteSpace, we created keyword co-occurrence maps, keyword burst detection diagrams, and keyword cluster charts from the sample literature. Co-occurrence analysis works mainly by identifying high-frequency keywords that appear together in the same publications. Citation analysis helps surface emerging research hotspots, and keyword bursts-sharp rises in how often a term is used over a given period-can signal where the field is heading. Cluster analysis groups related keywords or themes based on how frequently they co-occur across the literature. The resulting cluster maps visualize how keywords or themes relate to one another and highlight the central terms within each group [32].

Based on keywords generated by CiteSpace, we removed common terms such as "context", "impact", and "antecedents". Additionally, keywords like "community" and "technology" were excluded as they failed to effectively convey the research focus and direction. After this filtering process, the remaining keywords with over five occurrences included: social media, participation, knowledge contribution, trust, word of mouth, technology acceptance, e-commerce, collaboration, knowledge sharing, customer satisfaction, user acceptance, and behavior. These can be broadly categorized into "social media and network environment", "technology adoption and usage", "user behavior and interaction", and "business and e-commerce value" (Figure 3).

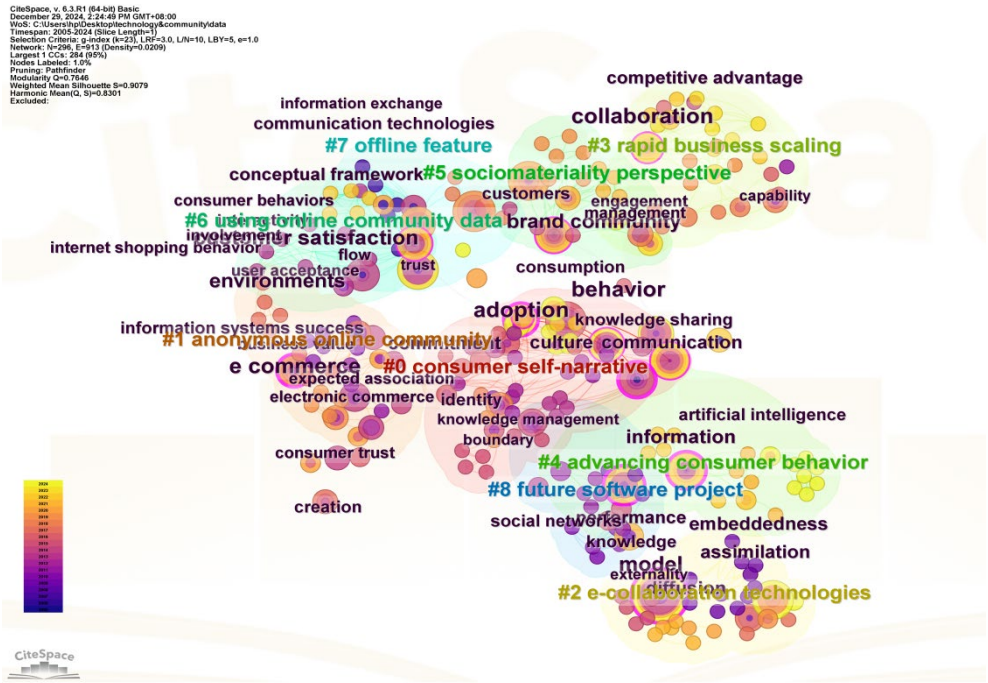

Figure 3. Citation mapping of digital technology in community management.

As shown in Figure 4, the citation intensity of "social networks" was relatively high during the period from 2008 to 2010. This is consistent with the research on static communities. In the early stage of the study, scholars focused on the composition structure and background of online communities, as well as some static characteristics such as the impact of specific features on communities.

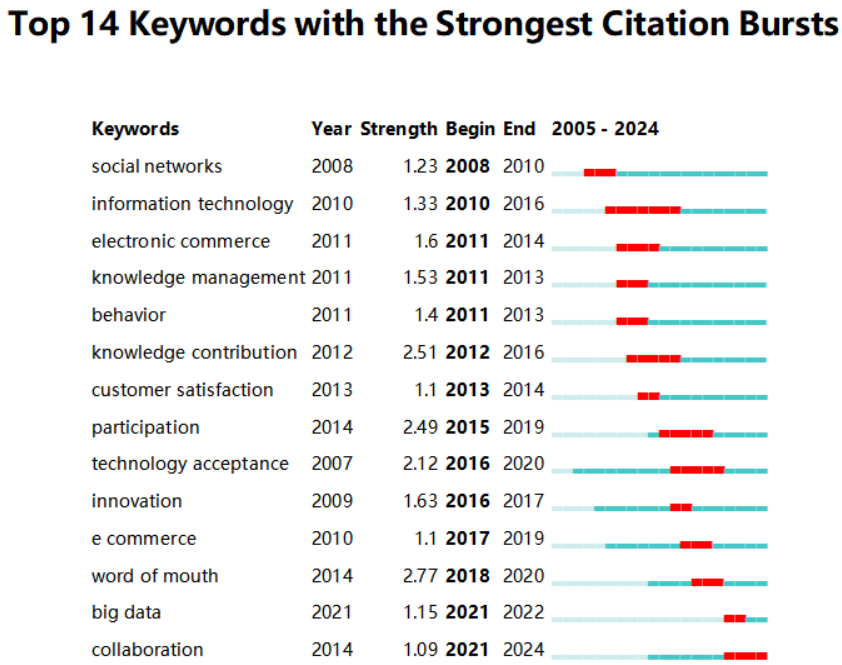

Figure 4. Keyword emergence of digital technology and community relationship research.

Since 2010, "information and digital technology" gradually replaced "social networks" as the primary research focus during this period, reaching a citation peak between 2010 and 2016. The emerging keywords during this time primarily exhibited user-centric characteristics such as "e-commerce", "knowledge management", "behavioral patterns", "knowledge contribution", "customer satisfaction", "engagement", and "technology adoption". These keywords emerged mainly due to technological advancements and researchers' shift in perspective from static virtual communities to dynamic, fluid virtual communities, reflecting the urgent need for community adaptation to new technologies in the digital economy context. During this phase, research priorities began shifting toward how science and technology adoption significantly impacts community user behavior. The sudden emergence of "innovation" in 2016 not only indicated that previous studies on dynamic communities had established a relatively complete framework but also marked the initiation of innovative research exploring how "digital technology" empowers "communities".

The keyword "e-commerce", first emerging in 2010, regained prominence between 2017 and 2019 as researchers refocused on a new wave of digital technology -- AI (Artificial Intelligence). The subsequent rise of other buzzwords like "word-of-mouth", "big data", and "collaboration" in 2017--2024 further validated earlier speculations about e-commerce's resurgence. During this period, research focus shifted toward exploring AI-powered community integration, including studies on user attitudes toward big data-empowered social networks and human-machine collaboration.

Figure 5 illustrates the keyword emergence mapping in online community management through C-Space, revealing nine major research domains: knowledge management, trust, open innovation, human-machine collaboration, artificial intelligence (AI), platform quality and development, community value, user perception and behavior, and social networks. These components collectively form a comprehensive framework encompassing three dimensions: the integration and application of digital technologies in online communities, the catalytic role of technological choices in shaping user behaviors, and the dynamic evolution of communities driven by digital advancements.

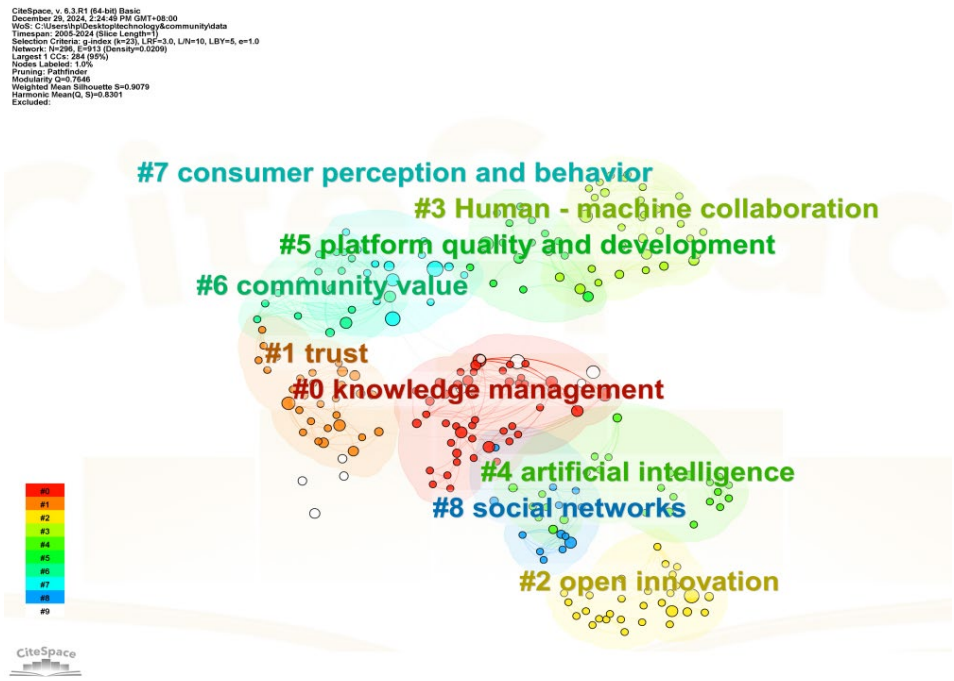

Figure 5. Keyword clustering of digital technology and community relationship research.

5. Discussion

5.1. Iterative Upgrading of Digital Technology and Community Evolution

Online communities have evolved through three phases. Early Web 2.0 tools (blogs, BBS) enabled centralized, text-based interaction under manual oversight. Mid-phase communities adopted collaborative editing and cloud infrastructure, promoting decentralization, dynamic networks, and knowledge democratization. From 2016, AI, blockchain, and immersive technologies fostered human-machine collaboration, enabling algorithm-driven governance, immersive social scenarios, and data-driven services (Table 1). This evolution demonstrates an interactive relationship between technology and community forms, producing hybrid, symbiotic structures.

Table 1. Digital technology iteration and online community evolution.

Evolution Stage	Core Technologies	Structural Characteristics	Key Transformations
Early (2004-2007)	Web 2.0 (Blogs, BBS)	Centralized; unidirectional communication; text-based; human-administered	Establishment of UGC model
Mid (2008-2015)	Collaborative editing; Cloud computing	Decentralization; dynamic networks; elastic infrastructure	Knowledge democratization; dynamic governance
Intelligent (2016-2024)	AI, Blockchain, 5G, VR/AR	Algorithm-driven governance; immersive scenarios; human-AI symbiosis	Automated rule enforcement; spatial expansion; data-driven decision making

5.2. Human-Computer Interaction and User Behavior

Technology adoption determinants expanded from perceived usefulness and ease of use to complex user-algorithm interactions. Longitudinal data indicate three patterns:

personalized recommendations extend session duration but reduce content diversity, predictive models guide behavior with high accuracy, and trust mediates participation.

AI supports knowledge production, help seeking, and relationship formation. Automated agents handle most support requests, algorithmic suggestions shape social ties, and recommendation systems restructure networks, improving knowledge exchange efficiency (Table 2). Behavioral outcomes include higher-quality contributions and an enhanced sense of belonging. Conversely, algorithmic opacity reduces trust, active users gain disproportionate benefits, and rural users face adoption barriers. System redesign and management interventions can improve content quality and knowledge sharing.

Table 2. Influence of human-computer interaction on user behavior.

Dimension	Core Characteristics	Technology-Mediated Pathways
Behavioral Drivers	Generational shifts; algorithmic guidance; trust environment	Perceived usefulness → Adoption; information filtering → Attention; system usability → Trust
Behavioral Shifts	Originality loss; help-seeking migration; network restructuring	AI tools → efficiency-originality tradeoff; intelligent agents → help priority; recommendation systems → social network change
Outcomes	Contribution quality; immersive belonging; reduced autonomy; resource inequality; access gaps	Reputation systems → quality; VR/AR → presence; algorithmic opacity → trust deficit; technical gaps → access disparity

Key research gaps include mixed effects of technical features, limited cross-platform studies, inconsistent incentives, and limited understanding of emerging technologies such as AI, VR, and blockchain. Addressing these gaps requires adaptive algorithms, long-term experiments, and cross-cultural research.

5.3. Digital Technology and Community Governance

Technology reshapes value creation across commercial, social, and platform dimensions. Big-data marketing and knowledge seeding enhance user engagement and content contributions. Socially, platforms can redistribute resources and strengthen community belonging through immersive technologies. Platform tools improve system reliability, information quality, and service responsiveness, supporting sustained participation.

Challenges include technological rigidity, where initially supportive rules may later constrain innovation, and the scale–resilience trade-off, where lower participation barriers support growth but may reduce long-term resilience and knowledge diversity (Table 3). Effective governance requires balancing these factors to maintain both community scale and adaptability.

Table 3. Influence of digital technology on community governance.

Dimension	Carriers & Manifestations	Governance Impact
Business Value	Big-data marketing; knowledge seeding	Precision targeting → demand conversion; incentives → content stimulation
Social Value	Resource-sharing systems; VR/AR	Cross-regional allocation; affective bonding
Platform Value	System optimization; AI co-creation	Multidimensional enhancement; sustained participation

Infrastructural Rigidity	Rule-modification systems	Institutionalized rules → innovation constraints
Scale-Resilience	Admission policies; content moderation	Barrier reduction → growth; algorithmic curation → reduced diversity

Current research on digital technology's impact on online communities is growing rapidly. Scholarly work mainly follows three lines of inquiry. First, from the community standpoint, technological upgrades have transformed community structures-from early centralized models to decentralized, dynamic forms, and more recently toward intelligent human-machine ecosystems. At the same time, changes in how people interact with technology are significantly reshaping user behavior, leading to new algorithm-driven, symbiotic patterns. Finally, from the administrator's perspective, this co-evolution of technology and behavior enables new forms of governance-automating rules, enabling value co-creation, and supporting inclusive resource allocation-though it also introduces core tensions such as rigid governance and the difficulty of balancing growth with resilience. The following sections outline future research directions for each of these areas.

5.4. Future Research Directions

Future research should focus on understanding how emerging digital technologies continue to shape online communities and user behavior. Key directions include exploring the influence of advanced immersive environments and multi-technology integrations, such as AI combined with blockchain, on community structure, governance, and interaction patterns. Cross-cultural studies are needed to examine how different societal values and norms affect technology adoption and community evolution. Longitudinal and causal studies are particularly important to capture behavioral changes over time, including generational differences and the adaptation challenges of older users. Additionally, research should address algorithmic transparency, user trust, behavioral autonomy, and the delineation of human and machine responsibilities, to guide the development of sustainable and adaptive human-machine collaboration. Finally, investigating flexible governance mechanisms that balance community scale with resilience, while ensuring inclusive participation, will help advance theoretical understanding and practical insights into the evolving socio-technical dynamics of online communities.

6. Conclusions

A review of 139 core publications shows that digital technologies have transformed online communities from simple forums into complex socio-technical ecosystems. Early Web 2.0 tools enabled large-scale information exchange, while cloud-based co-editing supported collaborative projects like Wikipedia. Recently, AI, blockchain, and immersive media have created hybrid human-machine spaces where algorithms and users jointly shape knowledge and co-create value.

Technological change and community evolution interact recursively: new technologies solve past limitations and enable unforeseen organizational forms. Recommendation systems and conversational agents reshape user behavior, favoring efficient knowledge production, AI-assisted help, algorithm-driven social ties, and value co-creation dependent on feedback, autonomy, and shared identity.

For platforms, these trends improve reliability, information quality, responsiveness, engagement, and resource allocation. Yet challenges remain: algorithmic opacity erodes trust, uneven access deepens digital divides, rule-by-code limits experimentation, and rapid growth can reduce resilience.

Future development requires adaptive governance that balances scale with resilience, aligns technology to community growth, explores decentralized autonomous structures, and strengthens ethical safeguards. Research should study emerging technologies like metaverse applications and post-quantum systems, develop models linking participation

costs and thematic consistency to behavior, and evaluate tools such as token-based rewards and AI-assisted moderation.

These findings also inform consumer engagement, brand-user relationships, and monetization of user-generated content, emphasizing that responsible innovation must balance technological potential with ethical safeguards. Limitations include reliance on Web of Science and management-focused literature, suggesting future reviews incorporate broader interdisciplinary sources.

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