Visualization Analysis of the Current Status and Development Trends of Mobile Payment Based on Citespace

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ABSTRACT

The COVID-19 pandemic outbreak has significantly affected the global economy while accelerating mobile payment development. In the information technology era, visualization technology serves as the most effective tool for extracting valuable insights from complex data and presenting information clearly. This study employs CiteSpace to analyze mobile payment literature (1998–2023) from Web of Science and CNKI databases, examining representative countries, annual publication volumes, keywords, and co-citation patterns from macro to micro perspectives. By comparing domestic and international research landscapes, we forecast industry trends and provide reference value for researchers. Findings indicate that European nations pioneered mobile payment research and maintain substantial influence. A global cooperation network has now emerged to advance this field. Research consistently prioritizes user acceptance through ongoing exploration. Recent technological advancements drive continuous innovation with heightened focus on security.

Keywords: Mobile payment, CiteSpace, visual analysis, status, development trends

INTRODUCTION

Globally, financial transactions and payment methods continuously evolve, driving modern economic development (Popelo, Dubyna, & Kholiavko, 2021). While the COVID-19 pandemic impacted national economies and consumer spending, it simultaneously accelerated e-commerce industry advancement (Ilieva et al., 2022). Traditional currencies and paper checks are gradually being replaced by rapidly emerging electronic payments and digital currencies (Lee, Yan, & Wang, 2021). Mobile payment systems now fundamentally transform transactional processes, financial management, and business interactions. Concurrently, new digital lifestyles—including online shopping, payments, and education—are proliferating (Gomber et al., 2018).

According to the China Internet Network Information Center (CNNIC), China had 1.079 billion internet users by June 2023, reflecting an 11.09 million increase since December 2022 with 76.4% penetration. Online payment users reached 943 million (87.5% of internet users), marking a 31.76 million growth. Online payment transaction volumes maintain steady growth, as illustrated in Figure 1 (Data from CNNIC).

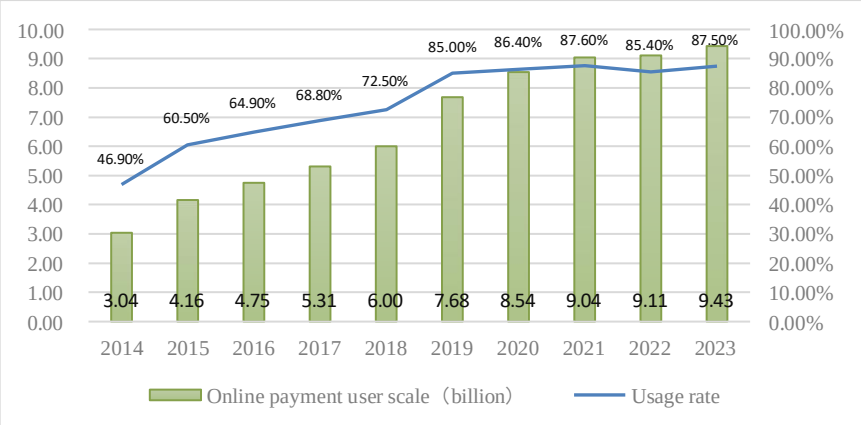

Figure 1 Online Payment User Scale and Usage Rate From 2014 to June 2023

The emergence of mobile payment systems marks an extraordinary milestone in financial and technological history (Panetta, Leo, & Dell, 2023). Mobile payment—defined as conducting financial transactions via mobile devices—replaces cash, checks, and physical cards with electronic transfers for purchases, money movement, and bill payments (León, 2021). These systems deliver unmatched convenience and efficiency, enabling instant access to financial services through simple touch interactions. Today, mobile payments have not only become indispensable to daily life but also drive economic growth and technological innovation. Beyond mere transactions, they fundamentally transform fund management, commerce, and interactions with financial institutions (Mützel, 2021).

Mobile payment systems enable users to conduct transactions, transfer funds, and access financial services conveniently through mobile applications, websites, or specialized platforms. These systems are transforming traditional business models and accelerating the transition toward a cashless, interconnected global economy. They have redefined consumer behavior and expectations, establishing new benchmarks for efficiency, security, and convenience.

However, mobile payment adoption introduces significant challenges. Data privacy concerns, cybersecurity risks, and regulatory compliance have emerged as critical discussion points. Furthermore, compared to traditional financial systems, these novel payment mechanisms present distinct legal and regulatory implications requiring thorough examination and resolution.

Consequently, research on mobile payment systems holds high relevance, as it encompasses financial ecosystems, business practices, and societal structures. To map the field's current landscape and future trajectory, the CiteSpace visualization tool is employed to analyze high-impact literature. Analysis focuses on three dimensions:

(1) Representative national research contributions

(2) Keyword co-occurrence patterns

(3) Co-citation networks of seminal works

This approach reveals the dynamic evolution of mobile payment systems and projects future research directions. Comparative examination of domestic and international scholarship enables a more comprehensive understanding of this rapidly evolving field.

LITERATURE REVIEW

Mapping knowledge domains was a graphical and serialized knowledge spectrum used to display the knowledge evolution process and knowledge structure (Chen, et al., 2015). Garfield (1955) introduced the idea of applying citation indexing for literature retrieval, and he also developed a series of mature conceptual tools to study the dynamic development of science. This greatly changed the way scientometricians studied scientific communities and laid the foundation for basic knowledge graphs. Price (1965) pointed out that the citation network was similar to the "topographic map" of contemporary scientific development and proposed a method of using citation networks to study the development context of contemporary science. Since then, analyzing citation networks has become a common method for studying the development context of science. It should be noted that the famous German scientometrician Kretschmer (1999) made significant contributions to the development of knowledge graphs through his research on a three-dimensional spatial model of scientific collaboration.

Chen (2002) believed that in-depth theoretical and practical research on scientific knowledge graphs would become a central topic in the future. Therefore, the concept of the scientific knowledge graph was proposed in a symposium organized by the National Academy of Sciences in 2003. Since then, with the development of information visualization, a variety of tools for creating scientific knowledge graphs have emerged (Chen et al., 2008). These included the business network analysis software "Ucinet" developed by Borgatti, Everett, and Freeman (2002), the large-scale complex network analysis tool "Pajek" written by Batagelj and Mrvar (2004),

the visual knowledge analysis software "Citespace" jointly developed by Professor Chen (2006) and the WISE Laboratory of Dalian University of Technology, the specialized literature measurement freeware "Bibexcel" developed by Persson, Danell, and Wiborg (2009), the edge dynamics software "Gephi" based on the Java Virtual Machine by Bastian, Heymann, and Jacomy (2009), and the literature knowledge unit-specific visualization software "VOSviewer" developed based on VOS visualization technology by VanEck and Waltman (2010).

Among them, CiteSpace knowledge visualization software has suddenly emerged and become one of the most popular knowledge mapping tools. The fundamental principles of CiteSpace are explained in the paper "CiteSpace II: Detecting and Visualizing Emerging Trends and Transient Patterns in Scientific Literature" by Chen (2006). As of October 25, 2023, this paper had been cited 5,747 times on Google Scholar (GS). The Chinese version of the paper, authored by Chen, Hou, and Liang (2009), has also been cited 552 times on GS. Due to the distinctive characteristics of the CiteSpace knowledge graph, CiteSpace has been rapidly and widely used, leading to several literature reviews on the application of CiteSpace and its knowledge graph.

Hou and Hu (2013) were among the early adopters of CiteSpace, using it to analyze the disciplinary distribution and functionality of papers utilizing CiteSpace in both WoS and CNKI. Hu, Sun, and Wu (2013) reviewed the current situation of knowledge graph application in China and stated: "After the introduction of CiteSpace and knowledge graph drawing methods, domestic scholars' research on this topic has shown a spurt." Zhao (2012) conducted a survey of the current state of knowledge graph applications in China based on CiteSpace. The study discussed important issues existing in CiteSpace applications from four aspects: search of domain documents, detection of mutation words, time zone segmentation and threshold setting of related parameters, and map interpretation. Since the outbreak of the new crown epidemic, changes have occurred in all aspects. Wan, Dawod, Chanaim, and Ramasamy (2023) conducted scientific measurements using CiteSpace to deeply research literature on IoT-assisted COVID-19 research. This has provided clearer insights into methods to contain the epidemic, bringing many conveniences to people's lives.

Since May 2012, the Knowledge Graph project released by Google has announced the construction of the next-generation intelligent search engine. This initiative introduced the concept of knowledge graphs in the field of search engines and began to be widely applied. At present, many large-scale general knowledge graphs have been established. In 2012, the Wikimedia Foundation initiated the Wikidata project to make Wikipedia more precise by providing better data. In terms of applications, Google Knowledge Graph and Microsoft search engine Satori are both designed based on multi-data fusion to enhance search engine results and improve search experience. The Institute of Computing Technology at the Chinese Academy of Sciences has developed a prototype system based on the Open Knowledge Network (OpenKN) to build a knowledge graph using Open Knowledge Network data.

Wu, Yang, Lai, and Lin (2016) began with the construction of a knowledge graph and proposed a definition of a knowledge graph based on existing research results: a knowledge graph is a structured semantic knowledge base that describes the physical world in symbolic form, encompassing concepts, and their interrelationships. With the rapid development of the digital age and widespread applications across various industries, although mobile payment systems have made significant progress, this area is still full of potential and challenges. Scientific knowledge graphs hold important research and application value and will be more widely studied and applied. In this study, the advantages of CiteSpace will be leveraged to conduct an in-depth analysis of the literature related to mobile payment systems. This analysis aims to provide a better understanding of the primary developments and trends within this field.

Data Acquisition and Method

Data Collection

The Web of Science Core Collection database contains more than 12,000 of the world's most authoritative and high-impact academic journals, dating back to 1900. WoSCC is one of the important sources of scientific information (Chen et al., 2012). The research in this study will use the search term "mobile payment" to explore literature published from 2004/01/01 to 2023/12/31. This period (2004-2023) was chosen due to

PayPal's rise to prominence as a significant online payment system in the early 2000s, prompting many researchers to study mobile payment during this time. Search terms include the following: TS (topic search) = "Mobile payment". The selected language is "English," and the selected document types are "Article" and "Review Article." Choose "Plain Text File" for the file format and "Full Record and Cited Reference" for the record content. Ultimately, 1038 documents were obtained as data sources.

Bibliometric Analysis and Tools

CiteSpace is a software package commonly used for bibliometric visual analyses. It can visualize academic references, authors, or journals and create co-occurrence network maps of keywords, authors, countries, and institutions for a specific topic (Chen et al., 2012). In this study, the following CiteSpace parameters were utilized: time slice (2004 to 2023) with a year for each slice set to 1. Depending on the type of analysis performed, different node types were selected. The selection criteria in CiteSpace were as follows: g-index = 25, Top N = 50, Top N% = 10%/100. The thresholding parameters included citation (c), co-citation (cc), and cosine coefficient thresholds (ccv) set at 2/2/20, 4/3/20, and 3/3/20, respectively. Usage 180 = 50, Usage 2013 = 50 were selected, with no citations, pruning selected with Pathfinder, pruning sliced networks, and pruning the merged network. Visualization was selected with Cluster view and show merged network. This study extracted literature data on mobile payment from the WoSCC database and analyzed it from different angles, including keyword cluster analysis, citation burst detection, country and institutional analysis, and subject category analysis.

RESULTS AND DISCUSSION

This study presents the analysis results and discussions of mobile payment research in two stages: (1) Descriptive analysis and retrieval, which includes the distribution of countries/regions, institutions, authors/co-cited authors, and co-cited journals. (2) Conducting an in-depth analysis of the topic, combining bibliometrics and visual analysis to describe the evolution of the topic in this field, and identifying the characteristics and trends of mobile payment research.

Descriptive Analysis

The changes in the number of articles can be visualized to observe the development status and trend of a research field. As shown in Figure 2, the number of Mobile payments published articles, it was shown that there were five articles published from 1999 to 2004. These five articles were published in conference journals, which can be seen as the beginning stage of exploration. Therefore, this study will start in 2004. Since 2004, it can be seen that there has been a gradual increase in the number of studies on Mobile payment. By 2012 the number of articles published this year was more than ten. The rapid development of the Internet has also contributed to the progress of the payment industry. The expanding field of mobile payment research and the deepening of research content indicates that the field has received active attention from various researchers. As of 2023, the number of articles published in the current year has reached 185. From the trend, it can be concluded that mobile payment is multiplying. This growth is expected to continue in the coming years, making it an important field of study. Additionally, with the continuous development of technology, new payment methods will be created, further driving the growth of the payment industry.

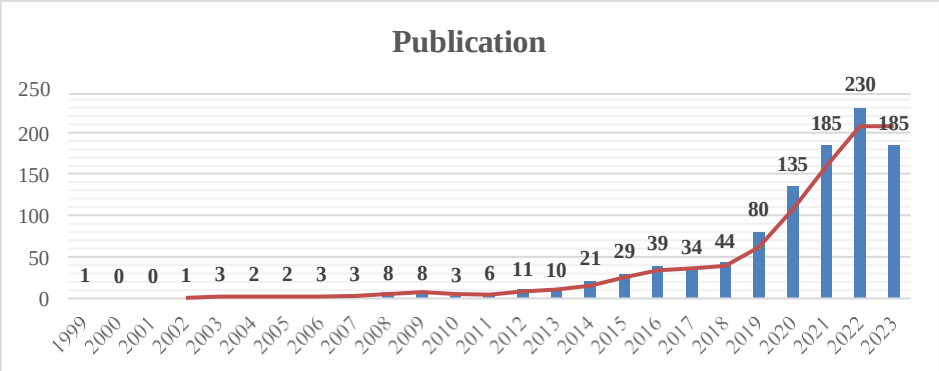

Figure 2 The Publication of Mobile Payment from 1999 to 2023

Distribution of Countries/Regions and Institutions in the Mobile Payment

Table 1 and Table 2 displayed the number of publications, total number of papers, and centrality of the top 15 countries/regions (84 in total) and institutions (350 in total) that had published on mobile payment. Figure 3 and Figure 4 illustrated the visualization of the research countries/regions and institutions that had published mobile payment literature in WoSCC. From this data, it was evident that these countries/regions and institutions formed a complex network of relationships, reflecting close cooperation among them. The larger the node, the greater the number of publications in that country, and the width of different colored circles indicate the number of publications per year. The color of the connecting line between the nodes indicates the time when the two nodes first cooperated, and the thicker the connecting line, the deeper the cooperation between the two countries (Chen et al., 2012). Centrality represents the importance of a particular node in the network (Chen et al., 2012). Therefore, the more central a country/region or institution was, the more publications it had from other countries/regions or institutions. After implementing the "Removal-duplication" function in CiteSpace, a total of 1,038 mobile payment research papers were obtained between 2004 and 2023. The visualization of countries conducting mobile payment research was generated with the help of pruning parameters (based on Pathfinder/Pruning sliced networks and Pruning the merged networks).

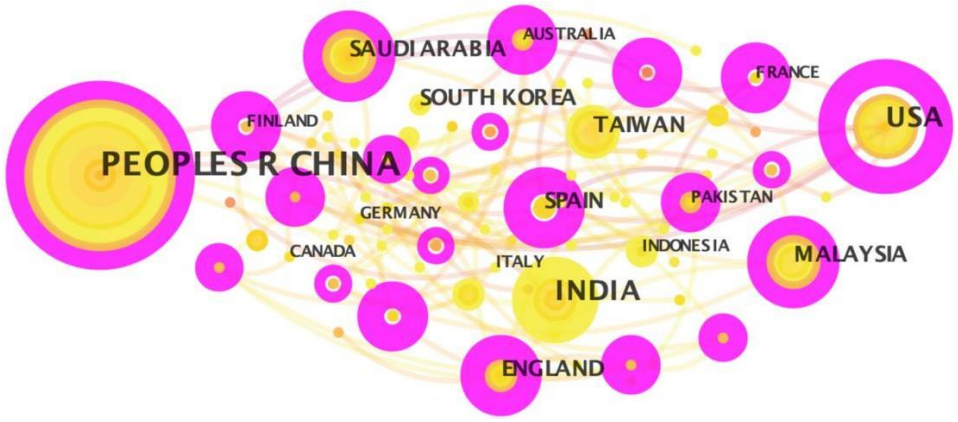

Figure 3 Countries/regions Cooperation Network Map

After running the software, the network contained 100 nodes and 98 links with a density of 0.0281 (as shown in Figure 1). Table 1 listed the 15 countries/regions with the most mobile payment studies. According to the number of studies, China had the highest number of publications, totaling 325, followed by the United States with 131 and India with 130, followed by Taiwan, China with 84, and Malaysia with 77. Although China had the largest number of articles, it ranked seventh (0.17) in terms of comparative centrality. This indicated that mobile payment in China was at a booming stage. However, another point that could not be ignored was that the number of articles in Chinese was concentrated at the start of 2018, which also indicated that in recent years, China had also conducted more in-depth research and innovation in the field of mobile payment. Furthermore, with development, China's mobile payment technology and experience had also provided reference and guidance for other countries and regions. This was also evidenced by the citation volume of the articles issued. Shao et al. (2019) had 197 citations, and Cao et al. (2018) had 178 citations. It is worth noting that nodes (countries/regions) with high centrality measures did not necessarily have high "counts" (counts represented the number of publications). This suggested that China was not cooperating extensively with other countries in terms of publications.

Table 1 The Top 15 Countries/regions Contributing to Publications on Mobile Payment

Rank	Country/region	Counts	Centrality
1	China	325	0.17
2	USA	131	0.63

3	India	130	0.04
4	Taiwan	84	0
5	Malaysia	77	0.11
6	South Korea	71	0
7	Spain	46	0.45
8	England	38	0.22
9	Saudi Arabia	35	0.17
10	Australia	33	0.28
11	Germany	29	0.04
12	Indonesia	28	0
13	Finland	22	0.73
14	France	21	0.57
15	Pakistan	21	0.13

Finland, France, and Spain had 22, 21, and 46 articles. It was observed that these three countries did not have a large number of articles, but their centrality was relatively high: Finland (0.73), France (0.57), and Spain (0.45). Finland ranked first in centrality (0.73), with the highest cited article from Finland (433) published in 2007, indicating relatively early engagement in the study, with only three articles on mobile payments in 2007. Mallat (2007) explored consumer attitudes towards mobile payments, offering an in-depth qualitative analysis of the research. Dahlberg's articles on mobile payments, published in 2008 and 2015, had citations of 382 and 271. Karjaluoto etal., (2019) also contributed to mobile payment research with 152 citations. It was evident that Finland had started its mobile payment research earlier and had a relatively long history in the field.

Table 1 also indicated that Spain (0.45), the UK (0.22), and Australia (0.28) followed in terms of centrality and also had a certain number of publications. Therefore, it could be concluded that Europe has been in a leading position in the field of mobile payment. Furthermore, the articles demonstrated that research and development efforts covered various aspects, including technological innovation, market demand, laws, and regulations. The results of this research were not only applied in Europe but also had an important impact on the global mobile payment industry. Additionally, the distribution of countries revealed that both developed and developing countries were actively conducting big data-related research. Mobile payment research has garnered the attention of countries worldwide, making it a global research hotspot and key issue.

Figure 4 Institutions Cooperation Network Map

After the software was run, the network contained 350 nodes and 378 links, with a density of 0.0046 (as shown in Figure 2). The number of articles published by institutions was represented by the size of the node. The larger the node, the greater the number of articles published, and vice versa. Centrality measured the importance of a node and reflected its significance in the network. Mobile payment publications were authored by 350 institutions. According to the list of the top 15 institutions engaged in mobile payment research (as shown in Table 2), the Indian Institute of Management (33) also had the highest centrality, which was 0.06. It was followed by the University of Granada (27), UCSI University (19), Universiti Tunku Abdul Rahman (18), and Hong Kong Polytechnic University (16).

Table 2 The Top 15 Institutions Contributing to Publications on Mobile Payment

Rank	Instituton	Counts	Centrality
1	Indian Institute of Management (IIM System)	33	0.06
2	University of Granada	27	0
3	UCSI University	19	0.02
4	Universiti Tunku Abdul Rahman (UTAR)	18	0.02
5	Hong Kong Polytechnic University	16	0
6	Universiti Malaya	10	0.01
7	Chinese Academy of Sciences	10	0
8	State University System of Florida	10	0
9	Xi'an Jiaotong University	9	0
10	Zhejiang University	9	0
11	Peking University	9	0
12	King Saud University	8	0.01
13	Sungkyunkwan University (SKKU)	8	0
14	Universiti Teknologi Malaysia	7	0.01
15	Beihang University	7	0

It was observed from these data that various institutions did not publish many papers in the field of mobile payment, but there were 350 institutions in total. This also indicated that mobile payment was valued by various research institutions and was in a stage of exploration and development. Additionally, research on mobile payment was concentrated in universities, as evident from the distribution of institutions, which were widely spread across countries. Figure 4 showed that the cooperation network among various institutions was relatively close, indicating frequent academic exchanges between institutions, which also promoted the international development of mobile payment. It was worth noting that judging from the documents issued by various institutions, mobile payment cooperation and communication likely began around 2017, indicating that research on mobile payment had entered a new stage of discussion. This collaboration among different institutions was crucial for the development of mobile payment and signified the maturity of the mobile payment industry. Furthermore, this cooperation would facilitate the expansion and wider adoption of mobile payment.

Distribution of Authors on Mobile Payment

Using pruning parameters to obtain the Author Map (based on Pathfinder/Pruning sliced networks and Pruning the merged networks): the network contained 428 nodes and 337 links, with a density of 0.0037 (as shown in Figure 5). A total of 428 authors contributed to mobile payment research. In terms of the number of studies (as shown in Table 3), the most prolific author was Liebana (22), followed by Tan (14) and Ooi (14). Liebana, who had published the most articles, released 3 articles in 2014 for the first time and 22 articles as of 2023. The first article had 278 citations. The article mainly studied the user's acceptance of mobile payment using age as an adjustment. In 2018, the attitude towards mobile payment from consumers to merchants was further studied, indicating the increasing development of mobile payment. In 2020, there was once again an examination of the use of mobile payments in emerging markets and further development of mobile payments in 2022 in the context of COVID-19. It could be seen that the author discussed the development of mobile payment in-depth step by step and the process of its acceptance in the market environment.

Figure 5 Author Cooperation Network Map

Liebana published 22 articles with a total of 1,719 citations. Tan published 14 articles with a total of 1,650 citations and looked at the whole picture, showing that there were relatively few isolated points. The network connections between various groups were close, indicating that there was close academic cooperation among authors in this field. The research on mobile payment was at the stage of cooperation, discussion, and learning. The research in this field was becoming more and more mature, and researchers in this field were becoming more and more interconnected. This would provide a platform for researchers to share resources and ideas and to promote the progress of this field.

Table 3 The Top 15 Authors and Cited Authors on Mobile Payment

Rank	Author	Count
1	Liebana-cabanillas, Francisco	22
2	Tan, Garry Wei-Han	14
3	Ooi, Keng-Boon	14
4	Munoz-leiva, Francisco	10
5	Lee, Voon-Hsien	10
6	Loh, Xiu-Ming	9

7	Gong, Xiang	8
8	Lee, Matthew K O	7
9	Zhang, Kem Z K	7
10	Hew, Jun-Jie	7
11	Rana, Nripendra P	7
12	Leong, Lai-Ying	7
13	Sanchez-fernandez, Juan	6
14	Singh, Nidhi	6
15	Dwivedi, Yogesh K	6

Distribution of Co-Cited Journals for Mobile Payment

The cited journal graph of the mobile payment study was obtained by pruning parameters (based on Pathfinder/Pruning sliced networks and pruning the merged networks). The network contained 1,108 nodes and 4,530 links, with a density of 0.0074 (as shown in Figure 6). It was found that 1,108 journals published a total of 14,990 papers related to mobile payment. Table 4 presents the number of publications and centrality of the top 15 cited journals (out of a total of 1,108) that published papers on mobile payment, along with the publication country and Impact Factor (IF) of each publication. These 15 journals published 6,223 papers, accounting for 41.51% of the total records, significantly contributing to the field and reflecting a high degree of concentration. In terms of frequency, Computers in Human Behavior emerged as the most prolific journal, publishing 599 papers related to mobile payment, with an IF of 9.9. It was followed by MIS Quarterly, which published 565 articles, with an IF of 8.51, and Electronic Commerce Research and Applications, which published 553 articles, with an IF of 6.

Table 4 The Top 15 Cited Journal and Impact Factor on Mobile Payment

Rank	Cited Journal	Count	Centrality	Country	IF
1	Comput Hum Behav	599	0.13	UK	9.9
2	Mis Quart	565	0.02	USA	8.51
3	Electron Commer R A	553	0.02	Netherlands	6
4	Int J Inform Manage	460	0.01	Netherlands	21
5	Inform Manage-Amster	429	0	Netherlands	9.9
6	J Retail Consum Serv	423	0.02	UK	10.4
7	Decis Support Syst	379	0.21	Netherlands	7.5
8	J Bus Res	370	0.11	Netherlands	11.3
9	Int J Bank Mark	369	0.02	UK	6.3
10	Ind Manage Data Syst	368	0.02	UK	4.22

11	Internet Res	365	0.07	Canada	7.4
12	J Marketing Res	351	0.03	UK	8.4
13	Technol Forecast Soc	342	0	USA	12
14	Inform Syst Res	339	0	USA	7.2
15	Telemat Inform	311	0	UK	8.5

Each journal's impact factor (IF) was obtained from the Journal home page accessed on March 2023.

Journals with higher impact factors were likely to have higher citation frequencies, indicating adherence to accepted standards and practices. Additionally, these journals represented diverse fields such as computer science, operations research, business, and management, reflecting the interdisciplinary nature of the mobile payment academic field. Moreover, they served as a reliable source of information, facilitating access to relevant studies for researchers, thereby enhancing the credibility of ongoing research in this area. In terms of centrality (as shown in Table 4), Decision Support Systems ranked first with a centrality of 0.21, followed by Computers in Human Behavior (0.13), and Journal of Business Research (0.11). Nodes with high centrality were represented as purple rings in Figure 6, with the thickness of the purple ring indicating the betweenness centrality value, signifying the importance of these journals in the research field.

Figure 6 Journal Co-citation Network Map

In-Depth Analysis

Distribution of Category Analysis in Mobile Payment

Every article indexed in the Web of Science Core Collection (WoSCC) was assigned to one or more categories, with a total of 93 categories included in this study. In Table 5, the top 15 categories of mobile payment research were listed. Notably, the distribution revealed 292 articles focused on Business, 192 articles on Computer Science and Information Systems, and 113 articles on Management. Although other categories were less frequent, they held the potential to offer fresh insights to researchers in the field. For instance, categories such as Environmental Studies and Green & Sustainable Science & Technology represented emerging perspectives that could enrich mobile payment research. Within the CiteSpace analysis framework, nodes exhibiting high centrality measures in the category network served as crucial connectors between different research domains. This connectivity played a pivotal role in shaping the trajectory of specific research fields. For instance, Table 4 illuminated that within the realm of mobile payment, the Business category emerged as a standout with the highest productivity centrality score of 0.34. This finding accentuated the

pivotal role of Business-related research in catalysing advancements and shaping the trajectory of innovation in mobile payment technologies.

Table 5 Top 15 Categories of Mobile Payment

Rank	Category	Count	Centrality
1	Business	292	0.34
2	Computer Science, Information Systems	192	0.49
3	Management	113	0.09
4	Telecommunications	99	0
5	Information Science & Library Science	82	0.4
6	Engineering, Electrical & Electronic	81	0.29
7	Computer Science, Interdisciplinary Applications	49	0.69
8	Environmental Sciences	49	0.11
9	Economics	45	0.07
10	Computer Science, Theory & Methods	44	0.06
11	Green & Sustainable Science & Technology	38	0.02
12	Environmental Studies	38	0.18
13	Computer Science, Artificial Intelligence	36	0.19
14	Psychology, Multidisciplinary	34	0.09
15	Business, Finance	34	0.12

Figure 6 illustrated the category bursts in the Mobile payment literature extracted from the Web of Science Core Collection (WoSCC). Burst analysis, a method commonly employed to discern emerging research frontiers in various fields (Chen et al., 2012), was utilized to scrutinize the evolving landscape of mobile payment research. Through the application of burst detection algorithms, recent shifts in the content of mobile payment research became apparent. Beginning in 2004, an explosion of categories across multiple disciplines was observed in the field. This surge not only signified the dynamic evolution of mobile payment research but also hinted at potential emerging trends within the domain. As depicted in Figure 6, the research domain of mobile payment began to intersect with diverse disciplines. Since 2004, there has been a notable proliferation of application-oriented studies in the mobile payment domain. This expansion spanned a broad spectrum, encompassing aspects ranging from user experience to global cooperation, from technological advancements to sustainable development, and intelligence applications to social impact analyses. Consequently, mobile payment applications have permeated into an extensive array of fields, marking the advent of an integrated network of applications with mobile payment systems at its core. This network entails a multitude of stakeholders, including developers, financial institutions, and governmental bodies. Understanding the functioning of this intricate network and its ramifications on the global economy become increasingly imperative. Therefore, delving into the dynamics of this network is crucial for elucidating its operational mechanisms and comprehending its broader socio-economic implications.

Table 6 Category Burst Detection Based on WoSCC Data

Subject Categories	Strength	Duration		2004 - 2023
Computer Science, Information Systems	5.14	2004	2012	
Computer Science, Theory & Methods	3.2	2004	2006	
Computer Science, Interdisciplinary Applications	6.23	2006	2017	
Telecommunications	8.11	2011	2018	
Computer Science, Software Engineering	4.1	2013	2019	
Engineering, Industrial	4.03	2014	2015	
Engineering, Electrical & Electronic	5.26	2015	2019	
Computer Science, Hardware & Architecture	3.99	2015	2017	

The categories investigated in Mobile payment were derived through cluster analysis by selecting pruning parameters (based on Pathfinder/Pruning sliced networks and Pruning the merged networks): the network comprised 93 nodes and 114 links, with a density of 0.0266 (as shown in Figure 7). It was noted from the figure that 10 categories were identified based on category clustering. In addition to the keyword "mobile payment," dynamic ridesharing system, using vibration cue, modeling adoption, sclera recognition, qualitative study, and new context were also taken into account. From these clustered words, it was evident that mobile payment was closely intertwined with daily life. Concurrently, during the exploration of mobile payment, greater attention was directed towards user experience and security. Safety research also hinged on technological advancements. Another significant finding from the clustered keywords was the predominant focus of research methods on mobile payment on qualitative research, which implied an in-depth exploration of user attitudes, behaviors, and motivations behind mobile payment. Simultaneously, this underscored a gap in other research methods, indicating the necessity to actively explore new research methodologies to conduct comprehensive investigations into the development of mobile payment. Lastly, concerning New context, this suggested that researchers had applied mobile payment technology to novel scenarios or fields. For instance, research on mobile payment applications in specific industries (medical, tourism, education) or environments (remote areas, rural areas).

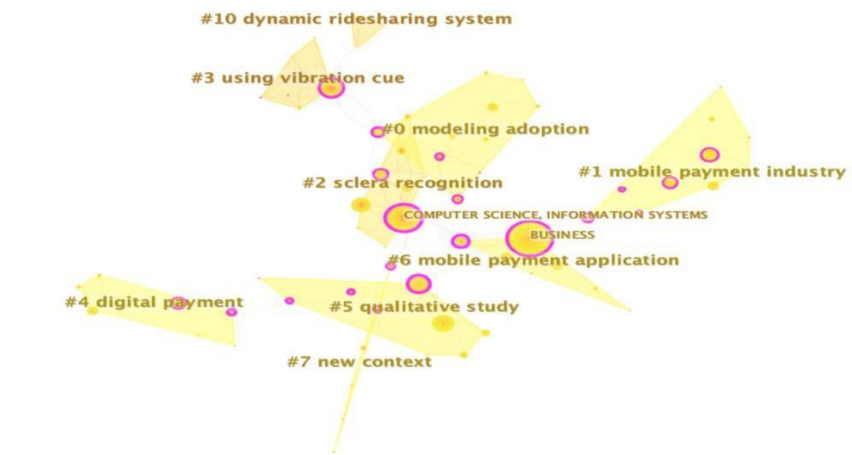

Figure 7 Category Clustering Map on Mobile Payment

Distribution of Co-Cited References in Mobile Payment

When a group of documents was frequently cited together with other documents, it indicated a specific research topic. Each cluster member was cited by the same set of citing articles more frequently than other clusters. This study was based on 39,894 valid references cited in 1013 records in the dataset and applied the document co-citation analysis method to visualize the field of mobile payment. The synthetic network of co-cited references in the Mobile payment study was depicted in Figure 8, consisting of 914 nodes and 2371 links, with a density of 0.0057. Through cluster analysis, which generated 220 clusters labeled with title terms extracted from citing articles using the Log-likelihood ratio (LLR) algorithm. Compared with the latent semantic indexing (LSI) algorithm, which focused on identifying common themes, the LLR algorithm tended to emphasize unique topics.

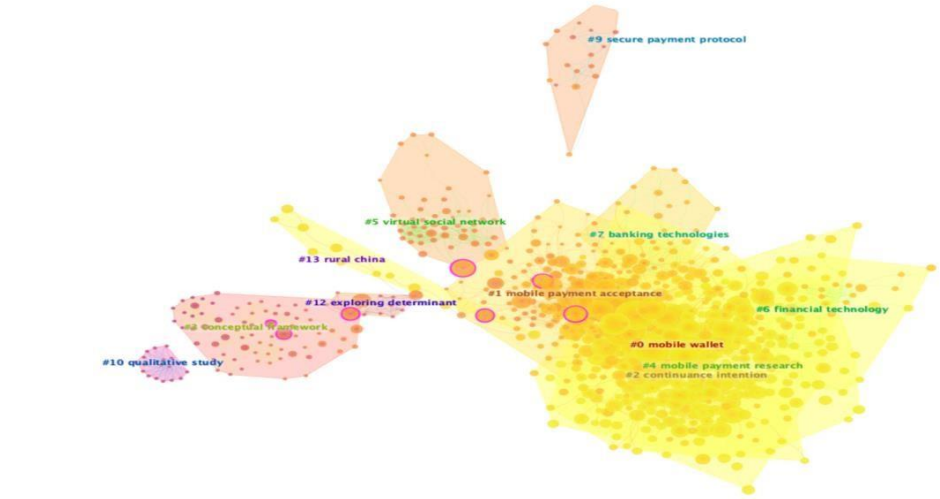

Figure 8 Document Clustering Map on Mobile Payment

Figure 8 illustrated 12 clusters, including #0 Mobile Wallet, #1 Mobile Payment Acceptance, #2 Continuance Intention, #3 Conceptual Framework, #4 Mobile Payment Research, #5 Virtual Social Network, #6 Financial Technology, #7 Banking Technologies, #9 Secure Payment Protocol, #10 Qualitative Study, #11 Exploring determinant, #12 Rural China. Each cluster represented a different aspect of the mobile payment problem and topic. For example, the bright yellow area in the middle was labeled #7 Banking Technologies, indicating that cluster #7 was cited by papers on topics related to Banking Technologies. The color of the convex hull of each cluster represented the average year calculated based on the publication year of the cluster members. Additionally, the brighter the color, the closer a cluster's mean year was to the present. The quality of co-cited clusters should meet the criteria of modularity and weighted average contours and deserve further study.

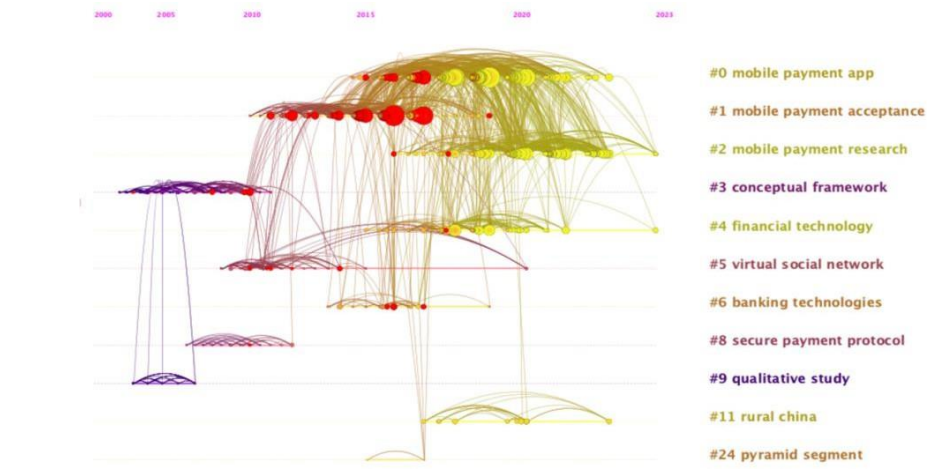

Figure 9 Co-citation Timeline Visualization of the 11 Clusters

A timeline view of the clusters, illustrating the origin, evolution, and time span of each cluster, is presented in Figure 9. The disappearance of clusters may not necessarily imply a waning interest among scholars in the field, but rather an ongoing exploration of new research directions. In Figure 9, the members of each cluster are arranged chronologically along the horizontal axis, while the clusters are vertically displayed based on their size. The figure exhibits 11 clusters with members: #0 Mobile payment app (157), #1 Mobile Payment Acceptance (148), #2 mobile Payment Research (67), #3 Conceptual Framework (69), #4 Financial Technology (40), #5 Virtual Social Network (49), #6 Banking Technologies (27), #8 Secure payment Protocol (l20), #9 Qualitative Study (18), #11 Rural China (11), #24 Pyramid Segment (12). The red circle indicates the high explosion point. This timeline view, coupled with an examination of journal research content, reveals that the mobile payment field is focused on enhancing user acceptance through application development and design. Simultaneously, there is a growing emphasis on convenience and security in the exploration process. These aspects signify emerging discussion directions, and further in-depth research in the field of mobile payment should integrate considerations of sustainable development. Moreover, it is noteworthy that research on mobile payment is increasingly focusing on segmentation, aiming to customize design and development to different regions, demographic groups, and usage scenarios, thereby advancing the goal of inclusive finance and aligning more closely with sustainable development objectives.

Table 7 provides a comprehensive overview of the top 25 co-cited references ranked by the strongest citation burst, offering valuable insights into the most influential and impactful works within the scholarly domain. The duration listed in the table delineates the temporal span from the initial year of publication to the final year, thereby presenting a chronological perspective on the evolution and longevity of scholarly discourse surrounding these references. Notably, the red-highlighted section within the table signifies a period of heightened citation activity, indicating a phase characterized by significant scholarly engagement and interest in the referenced works. Citation strength serves as a pivotal metric in assessing the impact and significance of scholarly contributions within the academic community. This metric reflects the frequency and volume of citations that an individual article or collection of articles has garnered over time, highlighting the extent to which it has been acknowledged and referenced by peers and scholars. A high citation intensity is indicative of widespread recognition and acclaim, signifying that the referenced materials are deemed essential references for supporting and advancing scholarly research endeavors across diverse disciplines and subject areas.

Table 7 The Top 25 Co-cited References with the Strongest Citation Burst

References	Strength	Duration		2004-2023
Schierz PG, 2010, ELECTRON COMMER R A	14.01	2011	2015	
Kim C, 2010, COMPUT HUM BEHAV	10.81	2011	2015	
Yang SQ, 2012, COMPUT HUM BEHAV	19.55	2014	2017	
Venkatesh V, 2012, MIS QUART	10.35	2014	2017	
Lu YB, 2011, INFORM MANAGE-AMSTER	10.1	2014	2016	
Liébana-Cabanillas F, 2014, INT J INFORM MANAGE	13.98	2015	2019	
Zhou T, 2013, DECIS SUPPORT SYST	13.87	2015	2018	
Tan GWH, 2014, TELEMAT INFORM	12.9	2015	2019	
Liébana-Cabanillas F, 2014, COMPUT HUM BEHAV	11.28	2015	2019	

Dahlberg T, 2015, ELECTRON COMMER R A	23.59	2016	2020	
Slade EL, 2015, PSYCHOL MARKET	15.11	2016	2020	
Teo AC, 2015, IND MANAGE DATA SYST	11.73	2016	2020	
Yang YQ, 2015, IND MANAGE DATA SYST	11.31	2016	2020	
Pham TTT, 2015, TECHNOL SOC	10.89	2016	2020	
Arvidsson N, 2014, INT J BANK MARK	9.5	2016	2019	
Dennehy D, 2015, J INNOV MANAG	8.79	2016	2020	
Slade E, 2015, J STRATEG MARK	14.1	2017	2020	
Thakur R, 2014, INTERNET RES	13.95	2017	2019	
Oliveira T, 2016, COMPUT HUM BEHAV	34.18	2018	2021	
de Kerviler G, 2016, J RETAIL CONSUM SERV	11.77	2018	2021	
Morosan C, 2016, INT J HOSP MANAG	10.69	2018	2021	
Koenig-Lewis N, 2015, SERV IND J	10.63	2018	2020	
Ooi KB, 2016, EXPERT SYST APPL	9.53	2018	2021	
Qasim A, 2016, INFORM SYST FRONT	8.57	2018	2021	
Khalilzadeh J, 2017, COMPUT HUM BEHAV	13.66	2019	2023	

Analysis of Keywords

Keywords are typically the core and essence of an article, serving as a high-level summary and condensation of the article's topic. Keywords with high frequency are often used to identify hot issues in a research field (Chen et al., 2012), providing a macroscopic reflection of the research hotspots within a certain period. Furthermore, keywords can also be instrumental in identifying potential topics for future research, tracking trends, and determining further research directions. In order to explore the research hotspots, developmental contexts, and future trends of mobile payment, this study conducted keyword co-occurrence analysis, keyword cluster analysis, and keyword burst analysis on literature spanning from 2004 to 2023.

Keyword Co-Occurrence Knowledge Map

This study analyzed the keyword co-occurrence knowledge graph to illustrate the evolution of the mobile payment field (keywords were extracted from 1038 records). The categories studied in mobile payment were determined by pruning parameters (based on Pathfinder/Pruning sliced networks and Pruning the merged networks). The network contained 142 nodes, 179 links, with a density of 0.0179 (as shown in Figure 10). In the keyword co-occurrence knowledge graph, node size represented the frequency of keyword co-occurrence. Changes in node color and connections between nodes represented keywords appearing at different times and the different times for establishing connections between them. The thickness of connections represented the

co-occurrence intensity between nodes. As seen from the co-occurrence map in Figure 10, in addition to the keyword search based on mobile payment in this article, nodes such as Information technology, Adoption, and User acceptance followed mobile payment. This indicated that technology, innovation, and acceptance were research trends in the field of mobile payment. Additionally, the closely connected nodes and connections in the figure showed that research on mobile payment was establishing a closely connected network. This co-occurrence network diagram provided a comprehensive and clear perspective on the research topic in the field of mobile payment.

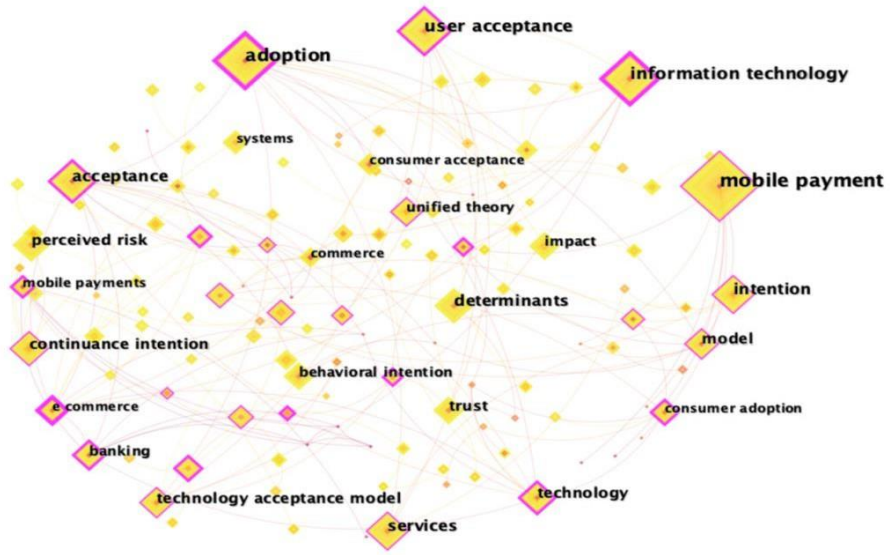

Figure 10 Keywords Co-Occurrence Network Map

Keywords with high centrality and frequency represented issues of common concern to researchers within a period, signifying research hotspots. The importance of a node's position in the network reflected its significance in the field. The higher the co-occurrence frequency of keywords and the higher the centrality, the more important the node was in the field (Chen, 2017). However, high frequency did not necessarily equate to high centrality, and vice versa. The keyword co-occurrence frequency table was shown in Table 8. Excluding "mobile payment," it was observed from the table that "adoption" ranked first in both centrality (0.52) and frequency (271). "Information Technology" followed with centrality (0.42) and frequency (223), while "User Acceptance" held centrality (0.24) and frequency (210). It was evident that the primary keywords studied in mobile payment included "Adoption," "Technology," and "Acceptance." Additionally, other prominent keywords comprised "model" (0.15), "services" (0.12), "intention" (0.1), "trust" (0.05), and "Perceived risk" (0.03). Indeed, these terms collectively highlighted key areas of concern in the field, providing valuable insights into the complexities and challenges associated with mobile payment systems.

Table 8 Top 15 keywords Co-Occurrence on Mobile Payment

Rank	Keywords	Count	Centrality
1	Mobile Payment	466	0.11
2	Adoption	271	0.52
3	Information Technology	223	0.42
4	User Acceptance	210	0.24
5	Acceptance	150	0.3
6	Intention	146	0.1

7	Determinants	138	0.02
8	Services	135	0.12
9	Model	123	0.15
10	Perceived Risk	120	0.03
11	Trust	116	0.05
12	Continuance Intention	112	0.14
13	Technology	98	0.31
14	Technology Acceptance Model	92	0.19
15	Unified Theory	83	0.1

Keyword Cluster Analysis

In order to further analyze the keywords of mobile payment research, this study used cluster analysis and selected a timeline map to observe the evolution of each cluster over time to gain further insights into the key research contents in the field of mobile payment from a micro perspective (as shown in Figure 11). As a result, a total of 11 clusters were generated, numbered from #0 to #10. Each cluster was displayed from left to right according to the distance of the years and sorted from top to bottom according to the cluster size. The colored curve represented the co-occurrence relationship between cluster tag words, and its color changes represented age changes.

As can be seen from Figure 11, excluding mobile payment, there were 11 clusters: #0 is continuance intention, #1 Consumer acceptance, #2 Technology acceptance model, #3 Word-of-mouth, #7 Services adoption, #8 Utaut2, #9 Financial inclusion, #10 Perceived usefulness. The top ranked item by citation counts is (2008) in Cluster #6, with citation counts of 466. The second one is (2008) in Cluster #1, with citation counts of 271. The third is (2012) in Cluster #8, with citation counts of 223. The 4th is (2014) in Cluster #2, with citation counts of 210. The 5th is (2007) in Cluster #4, with citation counts of 150. The 6th is (2015) in Cluster #3, with citation counts of 146. The 7th is (2014) in Cluster #2, with citation counts of 138. The 8th is (2014) in Cluster #2, with citation counts of 135. The 9th is (2010) in Cluster #6, with citation counts of 123. The 10th is (2017) in Cluster #0, with citation counts of 120.

Figure 11 Keyword Clustering Timeline Map

#0 "Continuance Intention": This cluster focused on users' willingness and motivation to continue using the mobile payment system. The research mainly involved users' satisfaction with the system, habitual usage behaviour, and service expectations. #1 "Consumer Acceptance": This cluster focused on consumer attitudes and acceptance of mobile payment systems. The research mainly involved the investigation and analysis of consumers' awareness, trust, and ease of use of mobile payment systems. #2 "Technology Acceptance Model": This cluster studied the technology acceptance model of mobile payment systems, involving the application and verification of classic technology acceptance models (such as TAM) and its extended models (such as UTAUT). #3 "Word-of-Mouth": This cluster studied the impact of word-of-mouth communication of mobile payment systems on user adoption behaviour. The research mainly included the impact of word-of-mouth on user attitudes, wishes, and behavioral intentions. #7 "Services Adoption": This cluster studied the adoption of mobile payment services, focusing on users' usage behavior, preferences, and influencing factors for different types of payment services. #8 "UTAUT2" (UTAUT2 model): This cluster focused on the application and verification of the UTAUT2 model in mobile payment research, and mainly explored the impact and mechanism of each factor in the model on user adoption behavior. #9 "Financial Inclusion": This cluster focused on the role of mobile payment systems in promoting financial inclusion. Research addressed the impact and role of mobile payment systems on financial inclusion among low-income people, rural areas, and developing countries. #10 "Perceived Usefulness": This cluster studied users' perceived usefulness of the mobile payment system, that is, how useful the system was to them personally or at work. The research mainly explored users' perceptions and feelings about system functions, efficiency, and convenience. These clusters deeply studied various aspects of mobile payment systems from different perspectives, providing important theoretical and practical references for understanding and optimizing the development of mobile payment systems.

Keyword Burst Analysis

CiteSpace employed a mutation detection algorithm to identify Burst items with a high frequency change rate within a specific time frame from a vast array of keywords. The term "Burst words" pertains to specialized terms that experienced a sudden increase in occurrence within the literature during a given year. CiteSpace is equipped with the capability to detect burst words, enabling it to identify emergent terms with rapid frequency changes from literature in relevant fields, thereby determining the research frontier in a particular field (Chen, 2017). For this study, the network node type was set to keywords, and the Term Type selected was Burst Terms. Keyword burst analysis will display the top 18 keywords with the strongest citation burst (as shown in Table 9). The durations chart the time span from the first to the last year of publication. The red-highlighted portions of the table represent periods of high citation activity, indicating that this phase is characterized by high academic engagement and interest in cited works. Citation strength is a key metric for assessing the impact and significance of scholarly contributions within academia

Table 9 Top 18 Keywords with the Strongest Citation Bursts

Keywords	Strength	Duration		2004 - 2023
Mobile Payments	4.17	2006	2019	
Commerce	5.62	2007	2017	
Mobile Commerce	4.07	2007	2017	
Model	3.85	2010	2014	
Perceived Ease	3.42	2010	2015	
E Commerce	3.09	2010	2014	

Consumer Acceptance	5.44	2013	2016	
Social Influences	5.17	2015	2020	
Services Adoption	3.75	2015	2019	
Antecedents	3.32	2016	2018	
Services	3.07	2016	2017	
Empirical Examination	7.91	2018	2020	
Credit Card	5.55	2018	2019	
Exploring Consumer Adoption	4.42	2019	2020	
Behavioral Intention	3.81	2019	2020	
Social Media	3.69	2021	2023	
Mobile Payment Systems	3.69	2021	2023	
Perspective	3.08	2021	2023	

Based on the keywords in Table 9 and the Timeline Map in Figure 11, it can be observed that there were four research stages in the field of mobile payment. Early exploration stage (2004-2008): During this period, mobile payment was primarily in its initial exploration phase, with research focusing on technical feasibility, consumer acceptance, and the establishment of payment systems (Chen, 2008; Mallat, 2007). Development and popularization stage (2009-2013): With the gradual maturation and increasing popularity of mobile payment technology, research shifted towards the practical application of mobile payment systems, consumer adoption behavior, and the expansion of payment services (Schierz etal., 2010; Kim et al., 2010). Rapid growth stage (2014-2018): During this phase, mobile payment rapidly evolved into one of the mainstream payment methods, leading research to concentrate on the security, user experience, and business model of mobile payment systems (Olivera et al., 2016; Qasim &Abu-Shanab, 2016). Maturity and optimization stage (2019-2023): As the mobile payment market continued to mature and competition intensified, research began to focus on optimizing the mobile payment system, enhancing user satisfaction, and constructing and standardizing the mobile payment ecosystem (Chang & Ferreira, 2019; Sufyan & Mas, 2022).

CONCLUSIONS

This study finds that the current research landscape in mobile payment primarily encompasses user experience and adoption research. Researchers delve into users' engagement with mobile payment applications, examining their acceptance of mobile payment, usage motivations, and perceptions of security and convenience (Kim et al., 2010; Wong et al., 2020). As mobile payment gains widespread adoption, security and privacy protection have emerged as central research themes. Scholars investigate secure payment technologies, user privacy safeguards, and users' trust in mobile payment security (Yang et al., 2015; Liebana et al., 2020).

Regarding business models and ecosystems, research focuses on collaborative dynamics and profit allocation among ecosystem stakeholders, alongside business model innovation and competitive interactions between different payment frameworks (Liebana et al., 2014; Patil et al., 2020). Additionally, mobile payment's cross-disciplinary nature has spurred growing interest in interdisciplinary research, where scholars analyze influencing factors and developmental trends from multifaceted perspectives (Oliverira, 2016; Ooi, 2016). The

integration of emerging technologies such as blockchain and artificial intelligence has also become a prominent research focus, with studies exploring their application potentials in mobile payment and their impacts on transaction security and efficiency (Pal et al., 2020; Faridi & Siddiqui, 2020).

The key research focuses and emerging trends in mobile payment prominently include intelligent payment solutions. As artificial intelligence technology advances, intelligent payment has emerged as a core research domain, encompassing areas such as user behavior analysis via big data, machine learning-driven intelligent risk control, and automated transaction optimization (Dhanasekaran & Kasi, 2019; Teng & Khong, 2021). Globalization has also shaped research on cross-border payment systems, addressing technical standardization, regulatory harmonization, and payment settlement mechanisms across jurisdictions (Zetzsche et al., 2021; Bindseil & Pantelopoulos, 2022). Meanwhile, studies on the socioeconomic impacts of mobile payment have gained traction, examining its effects on financial inclusion, shifts in consumption patterns, and business model innovation (Siano et al., 2020; Pal et al., 2020, 2021).

The rise of blockchain technology and digital currencies has introduced new dimensions to mobile payment research. Researchers focus on blockchain's applications in secure transaction verification, decentralized finance (DeFi) integration, and the developmental trajectory of central bank digital currencies (CBDCs) (Zhang & Huang, 2022; Islam et al., 2022). Additionally, payment standards and regulatory frameworks hold significant importance in the field. Scholarly attention centers on the formulation and global harmonization of payment protocols, as well as the adaptive adjustment of regulatory policies to balance innovation and risk management (Ahmed et al., 2021; Brunnermeier & Landau, 2023).

This study offers empirical insights through CiteSpace-based visual analysis of the current landscape and emerging trends in mobile payment research. The findings reveal that new key research themes and developmental trajectories continue to emerge in the field of mobile payment. Researchers are expected to deepen their exploration of critical areas such as mobile payment technologies, business model innovation, and security mechanisms, thereby driving further development and innovation in the mobile payment domain.

Limitations and Suggestions

In terms of keyword selection, various keywords have been used in research on mobile payments, such as "mobile payment," "electronic payment," "digital payment," and "online payment." However, in this study, only "mobile payment" was selected as the keyword. This selection limits the breadth and comprehensiveness of the research, potentially resulting in the omission of other relevant studies in the field. Therefore, future research should consider using a wider range of keywords to enhance comprehensive understanding of the field.

Regarding database selection, this study used only Web of Science as the data source. Although Web of Science is an important and authoritative academic database, relying solely on a single database may lead to the omission of certain research. Therefore, future research should consider integrating multiple databases (e.g., Scopus, Google Scholar, IEEE Xplore) to ensure data comprehensiveness and diversity, thereby improving the accuracy and reliability of results.

By expanding keyword scope and database usage, future research will be able to more comprehensively cover the latest developments and trends in mobile payments, providing more comprehensive reference materials for academic research and practical applications.

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