

Article

Research Trend of the Unified Theory of Acceptance and Use of Technology Theory: A Bibliometric Analysis

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Abstract: Information technology-acceptance research has always been a research hotspot. In 2003, Venkatesh established the unified theory of acceptance and use of technology (UTAUT), which pushed information technology-acceptance research to a new climax. This study uses bibliometrics, Bibliometrix, and CiteSpace software to conduct data mining and quantitative analysis on 1694 research papers in the UTAUT in the Web of Science core collection database from 2003 to 2021 (the data update time is 13 August 2021). Combined with a visual bibliometric analysis, this paper makes an in-depth discussion on the UTAUT model from the aspects of research trends, research fields, main research journals, authors/institutions, national or regional cooperation networks, etc. This study comprehensively and systematically shows the evolution track and characteristics of the UTAUT. On this basis, the future development trend of the UTAUT is put forward.

Keywords: bibliometrix; CiteSpace; the unified theory of acceptance and use of technology (UTAUT); bibliometrics; knowledge map



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1. Introduction

The rapid development of information technology has penetrated all societies, economies, work, and life, causing significant changes in the social economy, mode of production, and consumption structure. The value of information technology supporting productivity development can only be reflected when accepted, used, and continuously used. The research affecting information technology acceptance and use decision-making has gradually become a research hotspot in technological innovation. Although COVID-19’s destructive power continues to shape the global business ecosystem, a significant trend remains unchanged: steadily moving towards digital priority. IDC, a research organization, recently released its forecast for the worldwide information and communications technology (ICT) industry in 2022 and beyond. By 2024, digital priority enterprises will realize empathic customer experience and a flexible operation mode by transferring 60% of all technology and service expenditure to “as a service” and “result-centered” modes [1]. The information technology acceptance model is based on behavioral science and social psychology. Scholars study the organizational behavior and personal behavior in information technology adoption from the user’s perspective and summarize the behavior laws in technology adoption. It can help enterprises analyze a user’s behavior and the influencing factors for accepting new information technology in information technology. Information system research experts are committed to studying how users accept new technologies and have achieved many research results. These research results include the theory of reasoned action [2], the technology acceptance model (TAM) [3], the technology acceptance extension model (TAM2) [4], the unified theory of acceptance and use of technology [5], etc. These models take personal use intention or behavior as dependent variables and a personal

belief in using information technology as independent variables. Scholars clarify how people's acceptance of information technology is determined by internal beliefs, attitudes, and other factors.

At present, information technology acceptance research has always been a hot research field. Since Davis et al. [3] proposed the technology acceptance model (TAM), a large number of theoretical models have emerged, including the technology acceptance extension model (TAM2), and so on [4]. The theory of prosperity has also led some scholars to analyze these typical information technology acceptance theories in depth. They try to increase the exploration ability of the model and unify the concept of cross-overlap among various theoretical models. Then, they identify the key factors affecting user acceptance in the new technology environment, analyze the advantages and disadvantages of different theoretical models, integrate and expand the existing theoretical models, and improve the overall explanatory power. Venkatesh's research team put forward the UTAUT [5]. Researchers tested the model through large-scale empirical research, and they found that the UTAUT has a higher explanatory power than previous models. This research pushed the research of information technology acceptance to a climax. Combining the existing UTAUT-related research will help determine the research status and reveal both the current problems and some cutting-edge research directions. At present, there are many kinds of literature on the research of the UTAUT. This literature mainly takes a particular industry or field as the research object, combined with the UTAUT model, to study information technology acceptance factors.

For example, Amrouni and Arshah [6] analyzed the 41 most-crucial pieces of literature of the UTAUT used in E-government. They summarized the most important (cited) articles, authors, journals, and countries. A literature review can analyze, summarize, sort out, and comment on the current research results and existing problems in a certain period. However, this method is usually based on the induction and summary of existing research. Scholars have intense subjectivity in literature selection. In the case of numerous research results, there are inevitably omissions. Moreover, this literature mainly takes a particular field as the research area, lacks international vision, and cannot accurately grasp the development of user information technology-acceptance in different fields.

Bibliometrics is a crucial method to evaluate scientific research. It has significant objectivity and advantages in quantitative and modeling macro research. At present, the UTAUT is also developing. Combined with bibliometrics and visual analysis software, this paper profoundly analyzes the research results and application practice of the UTAUT. It explores the evolution track and future research trends based on the UTAUT, which will help to shorten the research gap covered by theory and practice. It provides a theoretical reference for sustainable information technology acceptance research.

2. Literature Review

The UTAUT has attracted the attention of many scholars since being proposed in 2003 [5]. It is recognized as a relatively mature model for studying the adoption of information systems and obstacles, as shown in Figure 1. Venkatesh's research team [5] proposed the UTAUT based on eight user-acceptance models of great significance at that time, including the theory of reasoned action, the technology acceptance model, the motivational model, the idea of planned behavior, a model combining the technology acceptance model and the view of planned behavior, the model of PC utilization, the innovation diffusion theory, and social cognitive theory. Venkatesh and Morris empirically tested the UTAUT through the longitudinal data of users' use of information technology in four organizations. In this model, scholars found that behavioral intention and use behavior are affected by four key determinants: performance expectancy, effort expectancy, social influence, and facilitating conditions. In addition, the model also introduces four regulatory variables: gender, age, experience, and voluntariness of use. The longitudinal research test in the other two organizations found that the UTAUT model can explain 70% of the variance of behavioral intention, which is much better than any of the original eight models. The

results show that performance expectancy is the determinant of behavioral intention in most cases and has a more significant impact on male and young users. The effect of effort expectancy on behavioral intention is also affected by gender and age. It has a more substantial impact on women and elderly users, decreasing with experience. The effect of social influence on behavioral intention depends on all four regulatory variables.

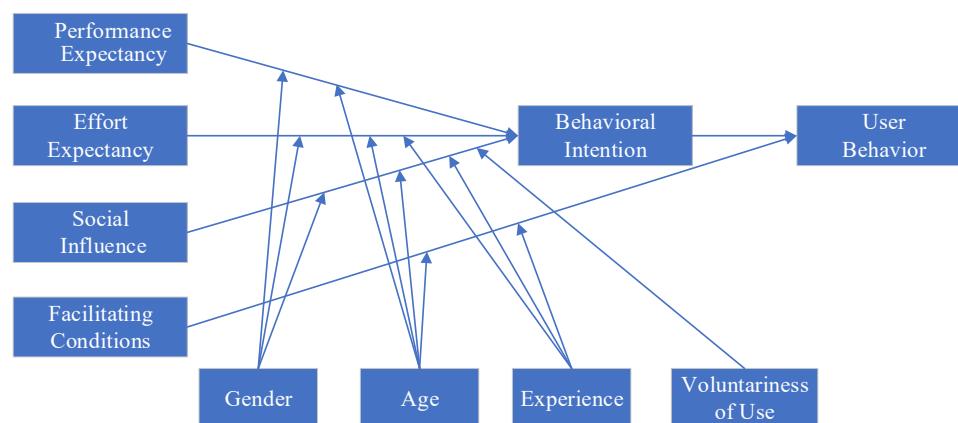


Figure 1. The unified theory of acceptance and use of technology (UTAUT) model.

Bibliometrics uses the quantitative statistical method to analyze the literature quantitatively. This method allows researchers to quickly grasp the current research field's basic information and development status. The quantitative analysis can more intuitively explain the relationship between the analysis literature units through graphics and visualization to understand the research status, research hotspots, and development trends in this field. At present, scholars have carried out a bibliometric analysis on the relevant research of the UTAUT and achieved some results. For example, bibliometric analysis and CiteSpace were used to analyze the articles, authors, and keywords in the cited data related to the TAM and the UTAUT as of 2010 [7]. VOSviewer and Tableau software was used to analyze 163 extended unified theory of technology acceptance and use (UTAUT2) documents from 2012 to 2019, including relevant research types, theories, frameworks, methods, author collaborations, and journals publishing research in this field [8]. The method of literature analysis and the SciVal Scopus and Google Trends tools were used to analyze UTAUT content search-trend statistics [9]. Using the bibliometric analysis method and VOSviewer and CiteSpace visualization software, the researchers discussed the research stage, hot issues, research limitations, and future frontier of the relevant literature on technology adoption published from 1997 to 2020 [10]. The existing bibliometric analysis is based mainly on publications, journals, keywords, countries, institutions, and authors, but there is a lack of research on the evolution trend of hot topics.

The international overview research based on the UTAUT model increases year by year. It includes mainly reviews and analyses. It includes a systematic review and analysis of articles using the UTAUT, UTAUT2, and citations of original UTAUT papers [11–14]. Although literature reviews can analyze the research status and existing problems of existing research results in a certain period, the method is subjective, and the number of articles analyzed is limited. Because the research scope is mainly limited to regional scale, research space, and time scale, researchers can not accurately grasp the global trend of the UTAUT. With the rapid development of information technology, academic research related to the comprehensive science and technology acceptance model has also increased significantly in the past two years, increasing the difficulty of tracking relevant literature in the field of information technology acceptance. The mission of providing users with a better experience through information technology also requires researchers to deeply and comprehensively understand the UTAUT. Therefore, this paper aims to fill this gap by studying the evolution trend of the UTAUT. Researchers will continue to use bibliometrics and related software packages to analyze and evaluate the relevant literature of the UTAUT

from 2003 to 2021 in the Web of Science database. Through this study, researchers can directly and objectively identify the research trend of the UTAUT and, at the same time, clarify the evolution process of related topics in different stages of the UTAUT to provide scientific references for the research directions of the UTAUT in the future.

However, at present, the relevant research in the field of the UTAUT mainly focuses on the statistical analysis of the publication of relevant papers and the co-occurrence analysis of authors and research institutions. Few scholars focus on the evolution trend of relevant highly cited literature, the historical citation of core literature, and hot topics in different stages of the UTAUT and extended models. With the rapid development of information technology, academic research related to the UTAUT model has also increased significantly in the past two years, increasing the difficulty of tracking relevant literature in the field of information technology acceptance. The mission of providing users with a better experience through information technology also requires researchers to deeply and comprehensively understand the evolution process of research topics related to the UTAUT. Given this, this paper will continue to use Bibliometrix and CiteSpace software for scientific metrology and visual network analysis [15,16]. This paper makes a comprehensive quantitative analysis and evaluation of the relevant literature in the field of the UTAUT from 2003 to 2021 in the Web of Science core collection database. This study will offer a detailed and complete picture of the research in UTAUT-related areas from a global perspective and clarify the overall knowledge framework of the UTAUT research. At the same time, it defines the evolution process and future research directions of related topics in different stages of the UTAUT. This paper helps to objectively reveal the research status of the UTAUT and provides a scientific reference for the research directions of the UTAUT in the future. It has a particular reference significance for information science research in other fields.

3. Data Sources and Research Methods

3.1. Bibliometric Data Sources

For practical analysis, this paper limits the retrieval and query of bibliometric data to the unified theory of acceptance and use of technology (UTAUT)-related literature contained in the Web of Science core collection database (the SCI-Expanded, SSCI, CPCI-S, CPCI-SSH, and the A & HCI database) from 2003 to 2021. The search format is “topic—(UTAUT * or “the unified theory of acceptance and use of technology”)”; the asterisk (*) indicates that the word includes all words containing its root and singular and plural forms. The final search query found 1694 articles related to the UTAUT.

3.2. Research Methods

To comprehensively and accurately mine and intuitively display the relevant research of the UTAUT model, the author plans to draw the knowledge map with the help of Bibliometrix and CiteSpace software [15,16]. Knowledge maps have high application value in analyzing discipline structure, describing scientific research cooperation, discovering research hotspots, and predicting research frontiers. Combined with bibliometric analysis, this study extracts the core topics to clarify the evolution process of the UTAUT model research, focuses on the international research frontier, and provides a reference for this field's development.

3.2.1. Research Software

Using bibliometrics to measure academic research is the key to today's academic research. This paper uses Bibliometrix and CiteSpace software to study the bibliometric analysis tool in the R environment. It is designed for non-coders and provides many options, including source, document, author, conceptual structure, social structure, and other categories. In addition, it allows obtaining multiple results in the form of tables and graphs. The authors of [15] proposed an open-source bibliometrics software package for comprehensive bibliometrics analysis.

CiteSpace is a knowledge-visualization software developed by Chinese scholar Dr. Chen Chaomei for Web of Science in 2004. It is a citation network visualization software based on co-citation analysis written in Java language. This software can mine citation space and provide a co-occurrence analysis function among other knowledge units, such as cooperation among authors, institutions, and countries. Chen [16] used CiteSpace software to study mass extinction (1981–2004) and terrorism (1990–2003). In addition, he cooperated with experts in related fields to verify the optical network's notable trends and critical points.

3.2.2. Research Plan

Bibliometric analysis is widely used as an essential tool for summarizing the historical research results of an academic field and revealing the future research trends. This paper analyzed the literature related to the UTAUT through the R-package bibliometrics. Combined with bibliometric visualization, this paper discussed the research status, direction, and theme evolution of the UTAUT.

This paper will help the relevant research determine the latest literature trends on the UTAUT and provide an essential reference for developing and applying information technology in related enterprises. The article's organization is as follows: The first part is the introduction. The second part introduces the literature review. The third part introduces data sources and research methods. The fourth part describes the visual analysis of literature measurement results, including literature description characteristics, annual scientific outputs, main research journals, main research journal articles, main research authors, institutions, and relevant countries, and the evolution analysis of critical topics.

Finally, the fifth part discusses the summary and limitations of the research results. Specifically, this review answers four research questions:

RQ1. What is the current research status of the UTAUT?

RQ2. What is the distribution of the main research forces in the field of the UTAUT?

RQ3. What are the research hotspots in the field of the UTAUT?

RQ4. What are the future research priorities and directions in the field of the UTAUT?

4. Bibliometric Results Analysis

4.1. Literature Description Features Analysis

Table 1 provides the descriptive characteristics of the literature related to the UTAUT. This paper, finally, identified 1694 documents, which used 3915 author keywords, and our search period was from 2003 to 2021. Thus, a total of 4194 authors have written these documents.

Table 1. Description characteristics of literature related to UTAUT research.

Description	Results
Timespan	2003–2021
Sources (Journals, Books, etc.)	844
Documents	1694
Average years from publication	4.18
Average citations per document	26.06
Average citations per year per doc	3.615
References	47,237
Keywords Plus (ID)	1541
Author's Keywords (DE)	3908
Authors	4194

4.2. Annual Scientific Yield Analysis

To a certain extent, the publication situation directly reflects the research level and research enthusiasm of a particular discipline or field. The research period of the unified theory of acceptance and use of technology is from 2003 to 2021, and the trend of

the total research annually published articles shows in Figure 2. With the first UTAUT paper [5] published in MIS Quarterly, there have been no other related documents from 2004 to 2005, but the output of papers has increased with time. Since 2006, records have increased significantly, divided into stable development (2006–2014) and rapid development (2015–2021).

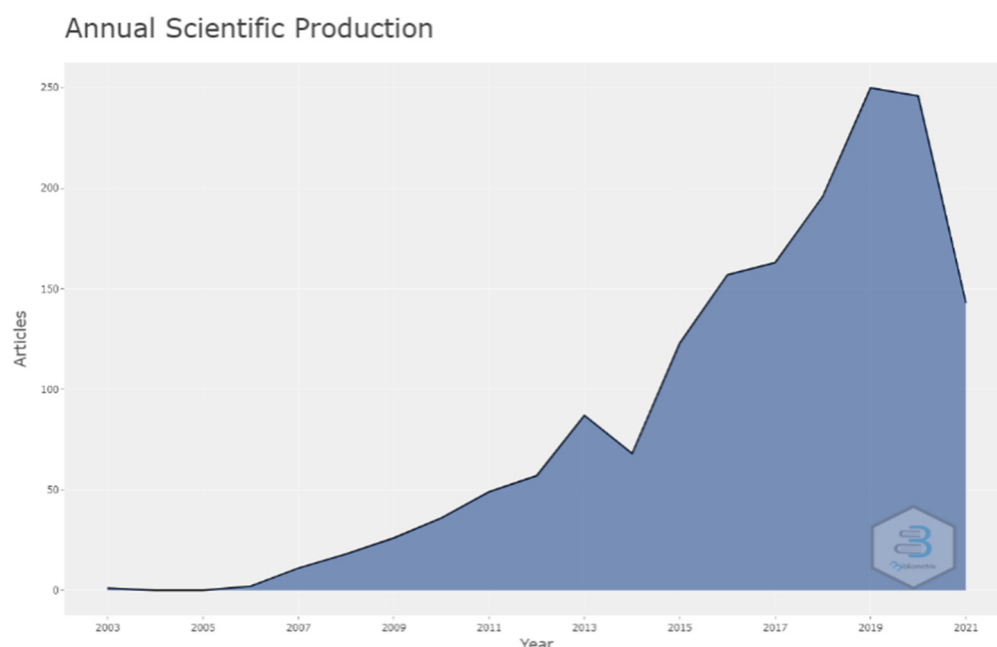


Figure 2. UTAUT research documents published from 2003 to 2021.

The interlinkages between central themes, countries, and relevant research institutions can provide valuable insights. Figure 3 shows the three-field plot analysis of the UTAUT-related literature. This paper analyzes the literature center topics, countries, and institutions associated with the UTAUT. It shows the interaction between the most relevant author keywords (left), countries (middle), and research institutions (right). The analysis identified the most commonly used keywords in the UTAUT-related research by authors and relevant research institutions in different countries. Research on top keywords, governments, and relevant institutions shows that scholars' research keywords in the field of the UTAUT mainly include "UTAUT," "UTAUT2", "technology acceptance," "technology option", and "TAM." Figure 3 shows the relevant literature on the topic of the "UTAUT" in studying a unified theory of technology acceptance and use, most of which Chinese scholars write. The United States has published a relatively wide range of research on "technology acceptance" and "technology option" in UTAUT-related fields. In addition, among the research institutions, the University of Michigan, the University of Malaysia, and Swansea University strongly influence the research associated with the UTAUT.

4.3. Main Research Journals Analysis

Table 2 lists the information of the top 20 international authoritative journals publishing research results related to the UTAUT. According to Bradford's law, journals are divided into three fields. Area 1 is the core source for publishing articles on the UTAUT. This area is the core area representing journals with essential publications. Overall, this paper finds that, among 844 journals, 44 belong to core field 1, and the rest belong to core fields 2 and 3. This discovery will expand the research perspective for scholars in this field to choose target journals in the future.

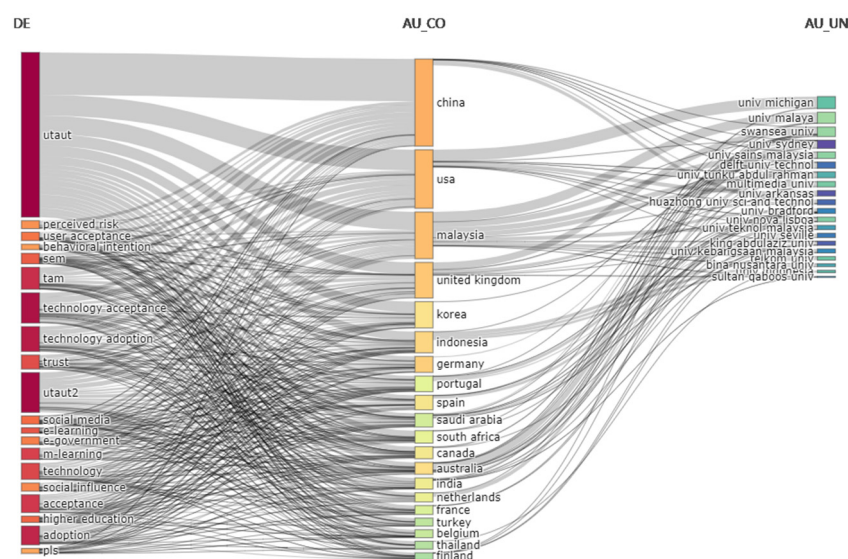


Figure 3. Three-field plot of literature in the field of the UTAUT.

Table 2. Ranking of journals according to Bradford's Law.

Sources	Rank	Freq	CumFreq	Zone
Computers in Human Behavior	1	41	41	Zone 1
Sustainability	2	36	77	Zone 1
International Journal of Information Management	3	31	108	Zone 1
Education and Information Technologies	4	25	133	Zone 1
Behaviour and Information Technology	5	21	154	Zone 1
International Journal of Mobile Communications	6	18	172	Zone 1
Journal of Medical Internet Research	7	18	190	Zone 1
Advanced Science Letters	8	16	206	Zone 1
International Journal of Medical Informatics	9	16	222	Zone 1
Telematics and Informatics	10	16	238	Zone 1
BMC Medical Informatics and Decision Making	11	15	253	Zone 1
Information Development	12	15	268	Zone 1
Information Systems Frontiers	13	14	282	Zone 1
Technology in Society	14	14	296	Zone 1
British Journal of Educational Technology	15	13	309	Zone 1
Computers and Education	16	13	322	Zone 1
International Journal of Environmental Research and Public Health	17	13	335	Zone 1
Industrial Management and Data Systems	18	11	346	Zone 1
Interactive Learning Environments	19	11	357	Zone 1
Journal of Retailing and Consumer Services	20	11	368	Zone 1

Journals such as *Computers in Human Behavior*, *Sustainability*, and *The International Journal of Information Management* are essential for publishing the UTAUT literature. Researchers can see from the UTAUT related literature in these three core journals. For example, reference [17] proposed a mobile bank user-adoption model based on the UTAUT. Furthermore, reference [18] extended the UTAUT by integrating perceived credibility and social norms and proposed a user-adoption model to search for and book restaurants using mobile applications. Finally, reference [8] combined the task–technology matching model, the UTAUT, and the initial trust model, and proposed the mobile banking user-adoption model. The discovery of main research journals will help scholars in this research field to choose target journals and expand their research perspectives in the future.

4.4. Main Research Author Analysis

Figure 4 shows the top 20 authors in the research on the UTAUT from 2003 to 2021, based on the h index. According to statistics, Dwivedi has the most decisive influence. First, Dwivedi et al. [19] used the UTAUT model to analyze the cross-border comparison of m-health, which helps decision makers develop more acceptable mobile medical service systems. Secondly, Oliveira ranks second in influence. Oliveira et al. [20] combine the task–technology matching model, the UTAUT, and the initial trust model for users' use of mobile banking. The model is tested based on 194 samples from Portugal and a partial least squares test in the proposed conceptual model. It is found that convenience and behavioral intention directly affect the adoption of mobile banking. At the same time, it is found that initial trust, performance expectancy, technical characteristics, and task–technology matching impact behavioral intention. Rana ranks third based on the h index.

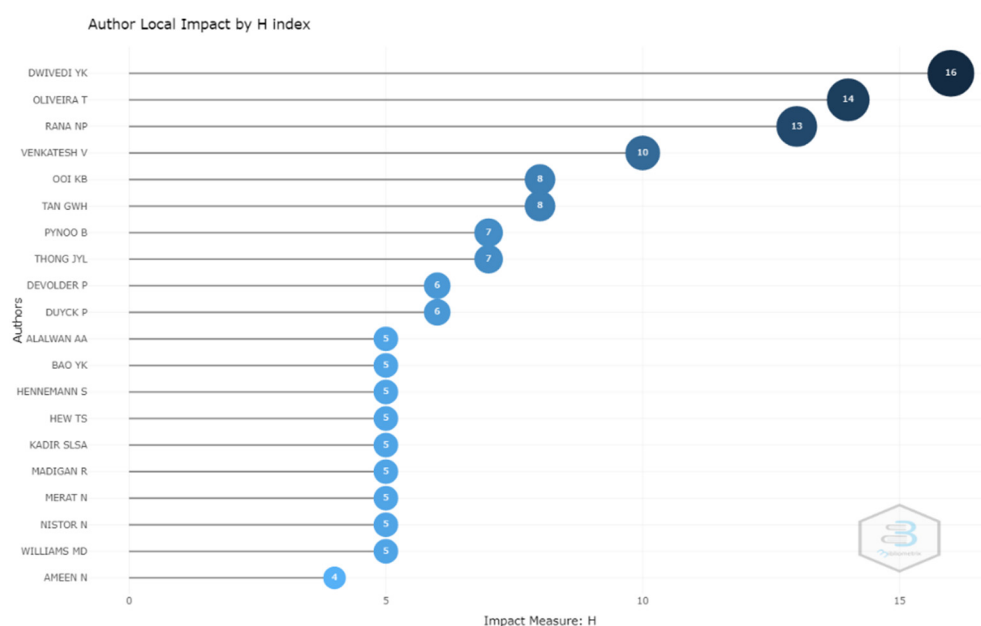


Figure 4. Top 20 influential authors in the field of the UTAUT.

Rana combined the UTAUT to establish a suitable E-government system, adopted the model, and collected 419 citizens' data in India for verification. The results show that the E-government adoption model explains the behavioral intention variance of up to 66%, the appropriate and acceptable fitting index level, and the significant relationship between each hypothesis et al. [21]. In addition to the top three authors of high-yield papers, Venkatesh ranked fifth in influence. Figure 5 shows the trend of articles published by scholars in related fields of the UTAUT over time. After Venkatesh et al. put forward the UTAUT model in 2003, they continued to pay attention to the research field of the UTAUT from 2003 to 2021.

4.5. Highly Cited Literature Analysis

Table 3 shows that Venkatesh's articles have been highly cited for many years. This scholar is a core figure in researching the UTAUT-related fields. Since 2003, Venkatesh has been committed to studying the UTAUT. From the first two highly cited authors, researchers can see his important position in the theoretical research of the UTAUT.

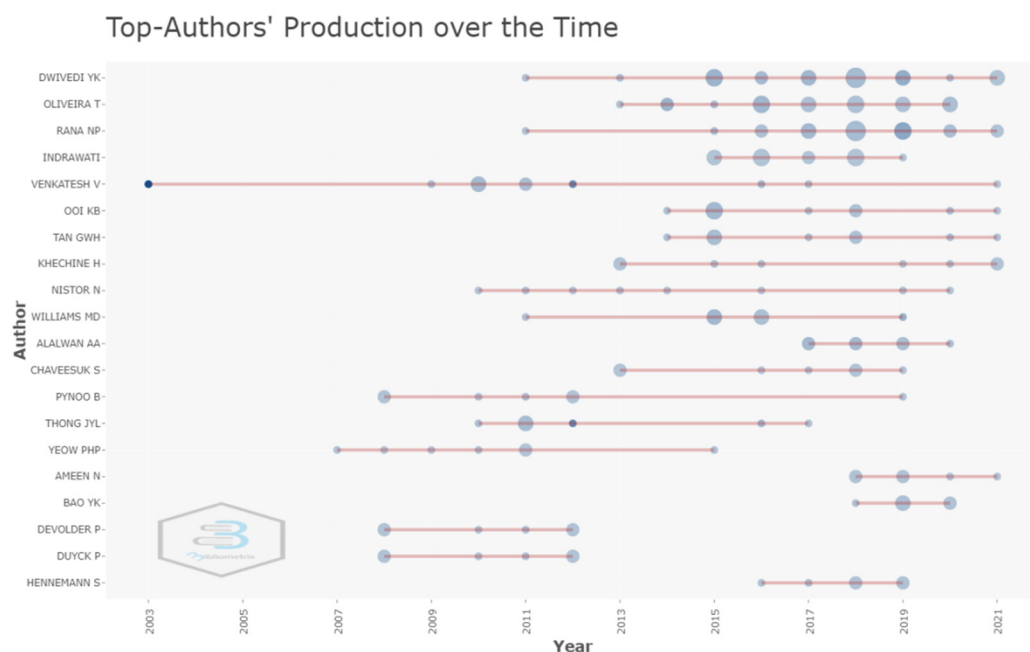


Figure 5. Authors' production over time in the field of the UTAUT.

Table 3. Top 10 most globally cited documents in UTUAT research.

Authors	Year	Sources	Titles	Total Citations
Venkatesh, V.	2003	<i>MIS Quarterly</i>	"User acceptance of information technology: Toward a unified view"	11,622
Venkatesh, V.	2012	<i>MIS Quarterly</i>	"Consumer acceptance and use of information technology: Extending the unified theory of acceptance and use of technology"	2844
Zhou, T.	2010	<i>Computers in Human Behavior</i>	"Integrating TTF and UTAUT to explain mobile banking user adoption"	559
Wang, Y.S.	2009	<i>British Journal of Educational Technology</i>	"Investigating the determinants and age and gender differences in the acceptance of mobile learning"	484
Martins, C.	2014	<i>International Journal of Information Management</i>	"Understanding the internet banking adoption: A unified theory of acceptance and use of technology and perceived risk application"	419
Van Raaij, E.M.	2008	<i>Computers and Education</i>	"The acceptance and use of a virtual learning environment in China"	399
CHIU, C.M.	2008	<i>Information and Management</i>	"Understanding web-based learning continuance intention: The role of subjective task value"	371
Venkatesh, V.	2016	<i>Journal of the Association for Information Systems</i>	"Unified theory of acceptance and use of technology: A synthesis and the road ahead"	317
Heerink, M.	2010	<i>International Journal of Social Robotics</i>	"Assessing acceptance of assistive social agent technology by older adults: the Almere model"	313
Venkatesh, V.	2011	<i>Information Systems Journal</i>	"Extending the two-stage information systems continuance model: Incorporating UTAUT predictors and the role of context"	291

Venkatesh et al. [5] published "User Acceptance of Information Technology: Toward a unified view is the foundation of the UTAUT theory" in *MIS Quarterly*. Furthermore, the author preliminarily constructs the UTAUT. Venkatesh, Thong, and Xu [22] published "Consumer acceptance and use of information technology: Extending the unified theory of acceptance and use of technology", which extends the UTAUT model to study consumers' acceptance and use of technology. In addition, he integrated hedonic motivation, price value, and habit into the UTAUT. Compared with the UTAUT, the extension proposed in

the extended UTAUT2 has substantially improved behavioral intention and differences in interpretation in technical use.

Zhou, Lu, and Wang [17] proposed a mobile banking user-adoption model in which performance expectancy, task–technology matching, social influence, and convenience significantly influence users' adoption. This article ranks third in the global citation.

Wang, Wu, and Wang [23] took 330 respondents in Taiwan Province as research objects and adopted the structural equation model to verify it with the research model. The results show that learning expectation, effort expectancy, social influence, playability, and learning self-management are all critical factors that affect the behavioral intention of mobile learning. This article ranks fourth in the global citation.

Martins, Oliveira, and Popovic [24] from Universidade NOVA de Lisboa combined the UTAUT with perceived risk to explain the behavioral intention and use behavior, collecting 249 compelling cases in Portugal. The research results support the UTAUT model, such as performance expectancy, effort expectancy, social influence, and perceived risk, positively affecting users' adoption intention.

Van Raaij and Schepers [25] extended the TAM2 model and added three influencing factors: subjective norm, personal innovation in the information technology field, and computer anxiety. The data came from 45 Chinese students who took the EMBA program. This paper analyzed the differences between students' acceptance and use of a virtual learning environment. The results show that perceived usefulness directly impacts using a virtual learning environment. Perceived ease of use and subjective norms have indirect effects only through perceived usefulness. Finally, personal innovation ability and computer anxiety only directly impact perceived ease of use.

In addition, Venkatesh, Thong, and Xu [13] studied 3159 Hong Kong citizens and analyzed the impact of E-government technology on user behavior. The research shows that the existing UTAUT extensions can be divided into four types: new exogenous, new endogenous, regulatory, and outcome mechanisms.

4.6. National Cooperation and Document Issuance Analysis

The refinement of the cooperation network represents the depth of discipline exchange, and the amount of national documents represents a country's research investment in the discipline field. The map of national network cooperation in the UTAUT-related fields is shown in Figure 6. The connecting line between the two nodes represents the cooperative relationship between the two countries. The thicker the connecting cable, the closer the relationship between them, and vice versa.

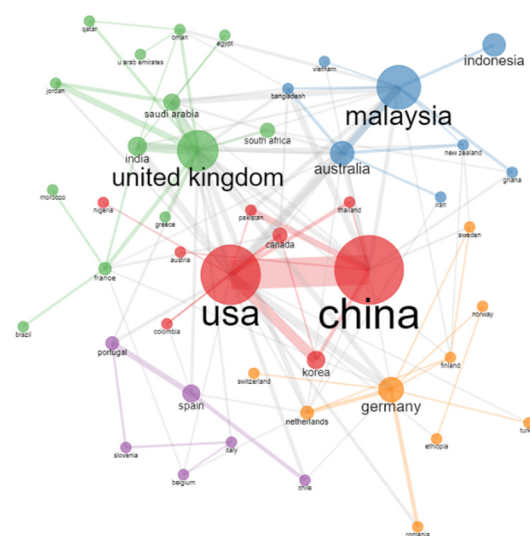


Figure 6. National network cooperation map in UTAUT research.

By analyzing the national network cooperation map of the UTAUT literature, the researchers found that scholars from the United States, China, South Korea, and Canada had the most extensive exchanges in the field of the UTAUT. At the same time, the United Kingdom has also established cooperative relations with scholars from India and Saudi Arabia in related fields. In addition, China also has certain harmonious relations with Pakistani and Korean scholars in relevant fields. At the same time, British scholars also communicate with Indian Scholars from Saudi Arabia, and other countries have also established cooperative relations in relevant fields. In addition, Chinese scholars also have specific unified concerns with scholars from Pakistan and South Korea in appropriate areas. At the same time, British scholars also communicate with Indian Scholars from Saudi Arabia, and other countries have also established cooperative relations in relevant fields. In addition, Chinese scholars also have specific harmonious concerns with scholars from Pakistan and South Korea in appropriate areas.

In addition, Chinese scholars also have certain cooperative relations with scholars from Pakistan and South Korea in relevant fields. China, the United States, and Malaysia have the most significant network nodes and represent extensive international cooperation influence. China has the most considerable number of articles, reaching 564, followed by the United States (390) and Malaysia (287), followed by the United Kingdom, with 208.

At present, the author shows the international cooperation of scholars in the UTAUT research field in Table 4. Chinese scholars cooperated with American scholars to publish 37 articles, ranking first. American scholars collaborated with Korean scholars to publish 13 articles, ranking second. The trend of cooperation between relevant research institutions in the UTAUT research topics is gradually deepening. Table 4 shows the situation of national collaboration in more than eight articles.

Table 4. Publication of papers by countries in cooperation.

from	to	Frequency
CHINA	USA	37
USA	KOREA	13
UNITED KINGDOM	INDIA	12
UNITED KINGDOM	SAUDI ARABIA	12
USA	MALAYSIA	12
MALAYSIA	AUSTRALIA	9
USA	GERMANY	9
USA	INDIA	9
CHINA	BANGLADESH	8
CHINA	PAKISTAN	8
MALAYSIA	SAUDI ARABIA	8
UNITED KINGDOM	JORDAN	8
USA	AUSTRALIA	8

4.7. Research Topics and Future Research Directions

The keywords of an article can express its main content, and its frequency can measure the importance of related topics in a specific field. Therefore, combined with the frequency of keywords, the scholar can quantitatively analyze the research field of the UTAUT. Co-word analysis is an important content of bibliometrics. It mainly explores the phenomenon that professional terms which can express the research theme or research direction appear in a document, judge the relationship between articles in the field, and show the discipline's research content and structure. In this paper, 1694 literature was selected for analysis, and 3915 keywords were extracted from these records.

To show the evolutionary footprint of the UTAUT research more intuitively, scholars use CiteSpace to analyze the network of literature co-words. This study examines the keywords provided by the author in the data set, selecting the standard history slice of network nodes for one year. CiteSpace keyword-clustering analysis yielded 539 nodes and 1101 connections for the convenience of the study. The network density is 0.0076.

Based on the clustering algorithm, 18 clusters can be obtained. Considering that the cluster with fewer members is not as representative as the cluster with more members, this paper selects fewer than 25 keywords and retains 12 main clusters. Each cluster has no less than 25 keywords. The knowledge graph of keyword clustering is shown in Figure 6. It mainly concentrated on “consumer health technologies”, “E-health”, “user acceptance”, “virtual reality”, “technology acceptance”, “integration”, “innovation”, “technology adoption”, “UTAUT2”, “mobile learning”, “perception”, “consumer behavior”, etc.

In Figure 7, the circle nodes represent the keywords in the cluster on the right. The larger the node, the higher the frequency of keywords. The time of nodes in the timeline view is when keywords first appear, and the color changes from excellent to warm, indicating that the time changes from early to near. The color and thickness of the inner ring of the node indicate the times of occurrence in different periods.

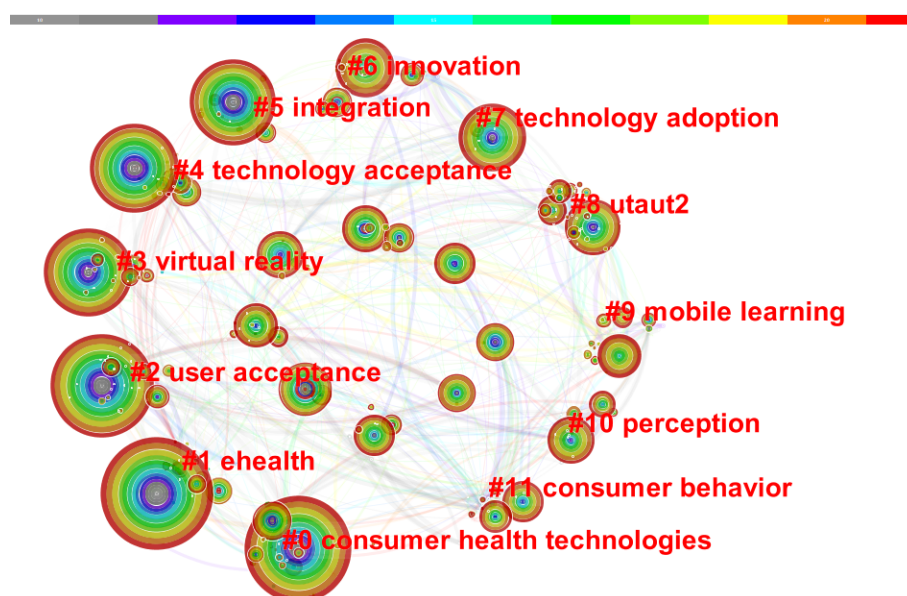


Figure 7. Cluster map of the UTAUT keyword co-occurrence network.

Table 5 lists the primary information of 12 main clusters by scale, the number of members of each group. The “silhouette” score can reflect the homogeneity or consistency of clustering, which means that the silhouette score can evaluate clustering quality. The clustering contour value in Table 5 is close to 1, which indicates that the clustering result is convincing.

Cluster 0 shows how the UTAUT model can help the sustainable development of consumer health technology. In this process, through bibliometric analysis, we can find that “consumer health technologies” focus on the UTAUT-related research from 2003 to 2021, which is composed of 42 nodes. This clustering is formed around the problems related to consumer health technologies. For example, regarding co-occurrence frequency, the most critical node is a smartphone, which shows that the UTAUT, as a technology-acceptance model, is widely used in consumer health technology, especially in the research combined with smartphones [26]. In this cluster, reference [27] used the extended UTAUT2 to study the impact of users’ intention to use smartphones and mobile applications. The results show that habit and social influence are the main factors affecting behavior intention. Reference [28] predicted the application of COVID-19 contact tracking combined with the UTAUT model. Cluster 0-related studies mainly mention some challenges brought by health technology.

Table 5. Critical points of UTAUT research based on cluster analysis.

Cluster #	Cluster Size	Silhouette	Average Year of Formation	Cluster Name	Selected Keywords
0	42	0.901	2017	Consumer health technologies	Smartphone; mobile payment; health; mobile intervention; privacy concern; mobile phone
1	42	0.817	2016	E-health	Perception; attitude; self-efficacy; antecedent; personal innovativeness; M-health; care; E-health; PLS-SEM; quality; ease mobile application; privacy
2	38	0.967	2011	User acceptance	information technology; user acceptance; model; usage; extension; impact; banking; perspective; experience; continuance intention
3	35	0.926	2011	Virtual reality	behavioral intention; gender; information; education; meta-analysis; intrinsic motivation; decision; belief
4	34	0.931	2013	Technology acceptance	Acceptance; technology; perceived usefulness; perceived ease; TAM; E-government; developing country; task–technology fit; barrier
5	32	0.89	2016	Integration	Online; consumer adoption; teacher; facilitating condition; customer satisfaction; purchase intention
6	32	0.887	2016	Innovation	Internet; innovation; innovativeness; success mobile commerce; electronic commerce
7	30	0.872	2013	Technology adoption	Intention; system; technology adoption; social influence; internet banking; consumer; information system
8	28	0.873	2013	UTAUT2	UTAUT2; trust; perceived risk; structural equation model; commerce; acceptance model; culture; hedonic motivation
9	27	0.82	2013	Mobile learning	higher education; E-commerce; M-learning empirical examination; performance; framework; usage intention; E-learning
10	26	0.964	2012	Perception	Perception; attitude; antecedent; ease
11	25	0.74	2014	Consumer behavior	Service; behavior; consumer acceptance; initial trust; age; planned behavior; consumer behavior

Cluster 1 emphasizes the role of the UTAUT model in realizing the sustainability of “E-health” user acceptance. At the same time, it reveals that the critical factor in implementing the UTAUT is “self-efficiency,” which is used to measure a person’s trust or strength in completing tasks and goals. Reference [29] used the extended UTAUT model to investigate the determinants of consumers’ behavioral intention to use mobile applications. The results show that performance expectancy, effort expectancy, facilitating conditions, hedonic motivation, and habits are significantly related to the behavioral purpose of using mobile applications. Reference [30] studied the potential factors that may affect the future use intention of mobile medical services, such as reliability, privacy, responsiveness, empathy, information quality, and convenience, trust, and scalability. At the same time, effort expectation and performance expectation are essential structures that affect users’ overall perception of mobile medical services.

Cluster 2 focuses on user acceptance. Constantly seeking to ensure user acceptance is a sustainable management challenge. Several models have been developed and validated in different contexts to help explain technology acceptance. Among these models, the UTAUT is the most robust and influential model to predict user acceptance of information technology [31]. Reference [32] used the UTAUT model to analyze doctors’ acceptance of the technology of the clinical decision support system. The results show

that the research model is acceptable. In addition, performance expectation and effort expectation significantly impact physicians' willingness to use technology. Paper [33] believed that the rapid development of artificial intelligence (AI) technology promotes AI-based intelligent products.

Cluster 3 explains the relationship between the UTAUT and "virtual reality." In this clustering, Venkatesh et al. [5] published "User acceptance of information technology: Towards a unified view" in MIS Quarterly, and proposed the UTAUT model, which provides a valuable tool for managers who need to evaluate the possibility of the successful introduction of new technologies, and helps them understand the driving factors of acceptance to actively design interventions (including training, marketing, etc.) for user groups who may not be inclined to adopt and use the new system. Reference [34] discussed various virtual-reality applications and evaluated their acceptability. There are two types of related research. The first research is based on the technology acceptance model, mainly TAM. The second type of study did not use a specific model. Different variables evaluate the technical acceptance of virtual reality. The results of these two categories of studies show that perceived usefulness and perceived ease of use are important variables to consider, as well as variables as perceived enjoyment and emotions.

Cluster 4 involves assessing the UTAUT to achieve the "technology acceptance" sustainable development goal. The keyword of this clustering is acceptance, which indicates that acceptance is one of the most concerned influencing factors of the UTAUT. Reference [35] discussed the critical factors for the adoption of mobile banking services. The author extends the UTAUT theory by integrating trust, security, and privacy factors. The results of [36] show that facilitating conditions, perceived service quality, trust in the government, and social influence were significant predictors of the intention of university students to adopt and use e-government services. Interestingly, performance expectancy, effort expectancy, and trust in the internet were not significant determinants of the intention to use E-government services.

Cluster 5 addresses issues related to sustainable integration using the UTAUT. Users from different countries and professional backgrounds may show different attitudes towards technology. Previous studies have provided isolated evidence of the relationship between learning technology acceptance and culture, lacking an integrated description [37]. Reference [38] proposed an E-sports consumption model based on the extended UTAUT model. The results show that four determinants (namely, hedonic motivation, price value, effort expectation, and flow) are identified as the key factors affecting E-sports consumers' E-sports game intentions. Reference [39] used the UTAUT and E-service quality integration to determine the determinants of online banking adoption. The two theories explain the change in users' willingness to adopt online banking. The UTAUT model is extended to four E-service quality dimensions: website design, customer service, assurance, and reliability. In future related research, it is suggested that relevant researchers pay attention to technology and service quality factors in other E-commerce fields (such as online booking or online shopping websites) and test the integration of the UTAUT model.

Cluster 6 refers to the model and research framework for developing new "innovation" using the UTAUT model. Internet factor is the research focus of innovation theme in the UTAUT. Reference [40] uses the UTAUT to determine the factors affecting mobile self-service retail banking technology adoption in this cluster. The results show that the main determinants of mobile banking adoption intention are technology-related factors, expressing innovation, expected performance, and social influence. Reference [41] believes that more and more devices connected to the internet pave the way for a new era of internet-of-things (IoT) computing. Based on the UTAUT2, this paper tested consumers' acceptance of the IoT in the innovative home environment. The results show that performance expectation, force expectation, social influence, hedonic motivation, and price value are essential predictors of intelligent home acceptance and use. Future research can use their proposed UTAUT2 model to study the acceptance of intelligent homes.

Cluster 7 reveals the UTAUT's sustainable focus on technology adoption. The intention factor is the research focus of technical advice in the UTAUT. Reference [42] studies how ICT service providers win back opponents of previous-generation technologies. Combined with the UTAUT, the author establishes a model to predict the opponents' willingness to reselect technology. Technology adoption research has incorporated normative beliefs from the adopter's social environment into the adoption model. the UTAUT2 is considered to be the most comprehensive theory to understand the adoption of a single technology. Reference [43] found that trust, personal innovativeness, perceived risk, attitude, and self-efficacy were the five top-most UTAUT2 extensions.

Cluster 8 mainly focuses on the sustainable research of the UTAUT extended model "UTAUT2". In this cluster, "trust," "successful risk," and "structural equation model" are closely related to the concepts and topics related to the UTAUT. Venkatesh extended the UTAUT to study consumers' acceptance and use of technology. Based on the UTAUT, the author adds hedonic motivation, price value, and habit factors, and puts forward the UTAUT2, which increases the model's explanatory power to 74% [22]. Reference [44] believes that collaborative technical characteristics, individual and group characteristics, task characteristics, and situational characteristics predict performance expectancy, effort expectancy, social influence, and facilitating conditions in the UTAUT. Reference [45] empirically analyzed the UTAUT2 model, which enhances the information quality to determine the determinants of the continuous use intention of food-delivery software applications.

Cluster 9 shows that the UTAUT also carries out sustainable mobile learning research. In this cluster, reference [46] studied the determinants affecting employees' willingness to use mobile devices and software for knowledge transfer in knowledge management and established the corresponding UTAUT model. The model includes new variables of relative availability and user autonomy and contemporary links between determinants. The author uses the structural equation modeling method to verify the model. Exploring the acceptance of technology and using mobile devices to stimulate learning, features such as practicability and ease of use positively impact students' motivation to use mobile devices when learning the language [47]. In addition, reference [48] believes that future biomedical informatics research, especially the research on human and organizational problems, can focus on how to realize the value-added use of the UTAUT and solve thorny workflow problems.

Cluster 10 presents the sustainable research of the UTAUT on perception. Van Raaij [25] constructed a conceptual model to explain the differences in students' acceptance and use of a virtual learning environment. The model extends TAM2, including subjective norms, personal innovation in information technology, and computer anxiety. The results show that perceived usefulness directly impacts the use of a virtual learning environment, and perceived ease of use and subjective norms have an indirect impact only through perceived usefulness. Reference [49] integrated quick response code (QR) in the classroom, which has been essential for promoting active learning and distributed learning. The TAM and the UTAUT2 are the theoretical bases for studying students' perceptions. It is suggested that experimental research on the effectiveness of QR codes be carried out in the future. Reference [50] used the UTAUT questionnaire to propose the perception and acceptance of social robots in the physical rehabilitation scene. It is recommended to conduct a study on integrating social robots into multiple places for future work. At the same time, it is recommended to consider the limitations of the size, pathologies, and social-cultural profiles.

Cluster 11 emphasizes the research of the UTAUT on the sustainable development of consumer behavior. The scholar explores consumer behavior in the enterprise supply chain through the UTAUT research. This study contributes to a better understanding of potential consumer behavior [51]. In this cluster, reference [52] explored the determinants of stock investors' willingness to use mobile stock trading. The author constructs a comprehensive research model that improved the UTAUT and risk perception. The results reveal three positive determinants (i.e., performance expectancy, effort expectation, and social influence)

and three negative determinants (i.e., security risk, economic risk, and operational risk). These factors significantly affect the behavioral willingness of stock investors to use mobile stock trading. Reference [53] used unified and innovative diffusion theories to build a structural equation modeling method accepted by the un-crewed automatic space shuttle. It is suggested that researchers consider it in future research and investigation assumptions. Compatibility could serve as an even stronger predictor of the behavioral intention to use automated shuttles in public transport than performance expectation. Reference [54], based on the norm activation model (NAM) and the UTAUT, provides explanations for the normative behavior in the use of information technology (IT). Future work suggests assessing whether the outcome model of normative behavior applies to other types of normative behavior.

Bibliometric analysis shows that the topic of the UTAUT is very vivid and promotes future research. Researchers can deeply analyze the main research objectives in the field of the UTAUT. These topics mainly include consumer health technologies, E-health, user acceptance, virtual reality, technology acceptance, integration, innovation, technology advice, UTAUT2, mobile learning, perception, consumer behavior, etc. Through the visualization research results of the UTAUT, this paper finds that the UTAUT model appears in different industries' research fields. Therefore, scholars need to pay more attention to the independent research on UTAUT connectivity and its future sustainability. At the same time, its integration advantages in the fields of interest are analyzed. The UTAUT model helps to improve the business competitiveness and sustainable performance of enterprises. In the future, it can be considered to narrow the gap between expected and actual uses by affecting the predicted UTAUT structure [55]. From the perspective of user acceptance, researchers can deeply compare various technology-acceptance models in future research. At the same time, combined with the extended UTAUT model, the influencing factors of behavior intention are investigated [56].

On the other hand, the development of intelligent technology is still growing, and the evaluation of the UTAUT's contribution to supporting the sustainability of intelligent technology is still missing. Combined with the UTAUT survey and analysis, it is concluded that there are significant differences in the social impact of the adoption of relevant technologies. How to improve researchers' understanding of intelligent technology adoption and non-adoption by revealing the different effects of different peer groups on adoption intention and its antecedents needs to be supplemented and deepened in future research [57]. From the perspective of realizing the sustainable development of "technology acceptance" to accurately compare and study the performance of the UTAUT model under different conditions, it is considered that the measurement of the model must remain unchanged under different conditions. Consumers in other countries may respond differently to the same technology, and consumers in the same region may respond differently to different technologies [58]. Therefore, future research should consider the possible differences due to the non-invariance of measurement.

In addition, the keyword-clustering results are represented according to the timeline view. Researchers can more clearly understand the spatio-temporal evolution footprint of the UTAUT model's sustainable development through the timeline view. As shown in Figure 8, the research results show that the UTAUT model first appeared in 2003. From 2003 to 2006, the UTAUT began to attract attention. From 2007 to 2010, researchers analyzed technology use, user intention, and behavior in different fields of information systems. Relevant research fields include higher education, mobile learning, etc., indicating that user adoption of information technology models is an important research field. From 2011 to 2014, scholars considered analyzing the dynamics of user perception and technology used to extend the UTAUT model, and more comprehensively understood the empirical verification of various vital elements affecting user perception at different stages of information technology user experience. In the UTAUT literature research since 2015, relevant scholars have integrated relevant research backgrounds and multiple dimensions of the UTAUT expansion, focusing on consumer health technology and E-health. The acceptance

of information technology in health-related topics has gradually attracted the attention of academia.

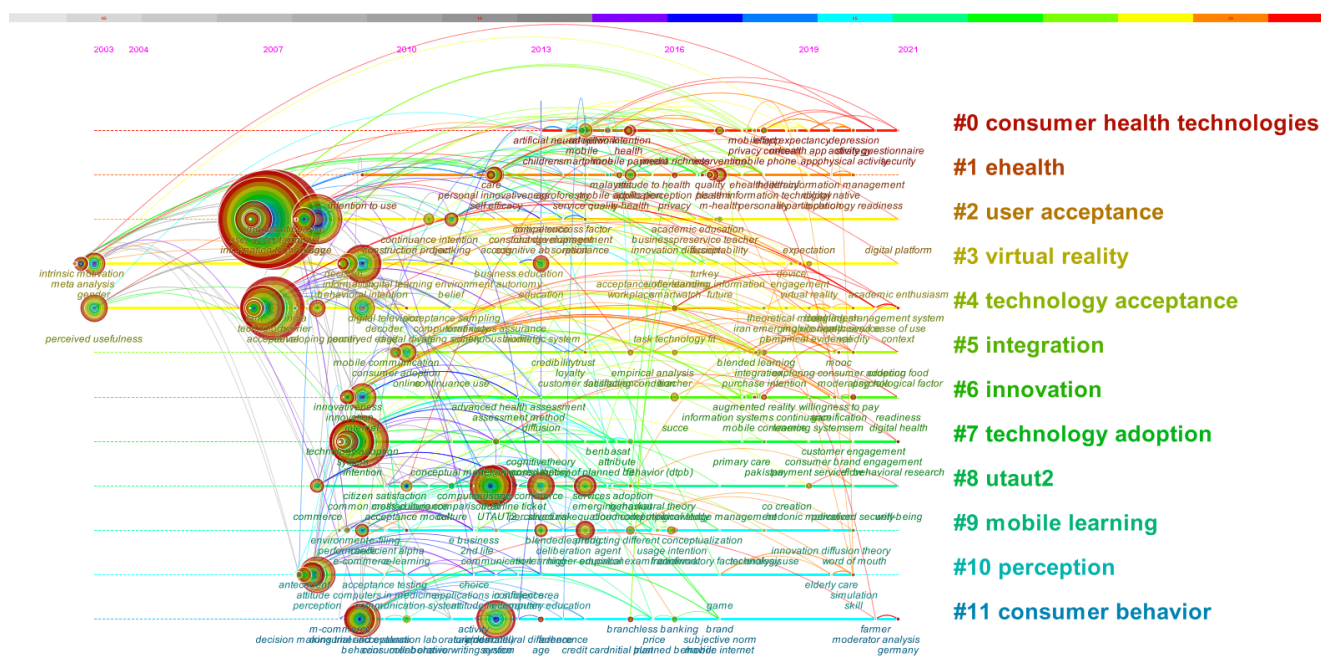


Figure 8. Timeline view of the UTAUT keyword clustering map.

5. Conclusions

Technology acceptance theory and related models are effective methods for explaining and predicting whether technology can be adopted and used by users. They are significant to an understanding of users' attitudes and behavioral intentions towards technology. This study uses Bibliometrix and CiteSpace to visually analyze the literature related to the UTAUT included in the core collection database of the Web of Science (including the SCI-Expanded, SSCI, CPCI-S, CPCI-SSH, and the A & HCI database). This study clusters based on relevant journals, relevant core literature, or specific subject areas, aims to rationalize and systematize the existing scientific literature, and dynamically presents the research progress on how to use the UTAUT and its extended model to promote the adoption of information technology users in different industries over time. This paper may help deepen the understanding of researchers and practitioners' understanding of the acceptance of information technology among users and promote the development of the topic, in theory. This paper draws the following conclusions:

Firstly, China has the most significant number of articles, reaching 564; followed by the United States and Malaysia, followed by Britain. This study shows that these countries have a high centrality in the UTAUT, which is essential to the UTAUT. In terms of international cooperation, scholars worldwide have established extensive and close cooperative relations. For example, Chinese scholars and American scholars have jointly published 37 articles, ranking first; American scholars and Korean scholars jointly published 13 papers, ranking second. This trend means that the research on the UTAUT in academic circles has gradually formed an international cooperative network.

Secondly, this paper uses Bradford's law to analyze the journals published in UTAUT-related fields. It is found that 44 of the 844 journals in which the UTAUT literature is located belong to the core field 1. Journals such as Computers in Human Behavior, Sustainability, and The International Journal of Information Management are essential for publishing the UTAUT. At the same time, the study found that the two articles published by Venkatesh scholars in MIS Quarterly belong to the two most-cited literature. These research results are helpful for relevant scholars to select target journals and better understand the research progress of the UTAUT in the field of information technology user acceptance.

Then, by analyzing the keyword co-word network map of UTAUT, the researchers found that the fundamental research topics of the UTAUT mainly include: consumer health technology, E-health, user acceptance, virtual reality, technology acceptance, integration, innovation, technical advice, UTAUT2, mobile learning, perception, and consumer behavior. At the same time, by observing the relationship between keywords and time axis in the field of the UTAUT, researchers found that the UTAUT was almost synchronized with the development of information technology. For example, early research topics focused on mobile technology and users' acceptance of its services. With the continuous emergence of new technologies, research topics gradually increase and refine. There is multi-angle research, such as acceptance of artificial intelligence technology and its service users [59]. Through the cluster analysis of high-frequency keywords in the field of the UTAUT, this paper concludes that researchers should strengthen the analysis of users' willingness to adopt new technologies at different temporal and spatial scales. At the same time, a focus on how to realize the value-added use of the UTAUT is suggested as well.

Finally, the bibliometric analysis of this study shows that the subject of the UTAUT now seems to focus on the development of new digital technology and data analysis. The UTAUT is universal, which can be applied to information technology acceptance and use in different fields. At the same time, the study found that the UTAUT is scalable. The UTAUT has been tested in different application scenarios; researchers have also made diversified expansion attempts on the theoretical framework. The attempts enrich or modify the existing models and form a theoretical model with new explanatory power. This expansion attempt also increases the reliability of the research conclusions and obtains more users' intentions. At the same time, the related technology acceptance research shows an interdisciplinary trend. These research results have promoted the development of information technology acceptance research.

Of course, users' acceptance and adoption of information technology is a complex and dynamic process. At present, scholars' research results focus mainly on the influencing factors and mechanisms of personal information technology acceptance. From the perspective of sociocultural and business research, a specific area worthy of more attention is to identify and improve the drivers of the UTAUT transparency and trust, including legal issues, such as clarifying data ownership. Future research can track the development of this field by paying attention to more relevant literature. This study hopes to deepen and further the quantitative analysis of the research scope and topics related to the UTAUT and help scholars understand the latest content of the UTAUT. At the same time, this paper also hopes to provide references and suggestions for future users to accept and adopt information technology sustainability research.

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