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User acceptance and adoption of smart homes: A decade long systematic literature review

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A B S T R A C T

This survey aims to provide a coherent and bibliometric overview of the theories and constructs employed in smart homes acceptance and adoption literature. To achieve the study aims, we conducted a systematic search for every article related to the SH concept, services and applications, user acceptance and adoption, and integrated IoT home appliances and devices, in 10 major library databases, namely, IEEE Digital Library, ACM Digital Library, Association for Information Systems (AIS), Elsevier, Emerald, Taylor and Francis, Wiley InterScience, Springer, Inderscience, and Hindawi. These databases contain literature focusing on smart home adoption using IoT technology. 40 research articles of journal and peer-reviewed conferences were found relating to our research objective, presented and distributed chronologically, by publisher, country, theory and model, key construct, and with full bibliometrics for each article. Additionally, this survey includes a word cloud and a taxonomy of the entire factors used to understand users' acceptance and adoption of smart homes in different contexts and applications. This study has many advantages in covering the current research gap in the literature and also the researchers identify theoretical and practical research implications, research limitations, and recommendations for improving the acceptance and usage of smart homes literature.

1. Introduction

The Internet of Things (IoT) is a new paradigm that aims to create a dynamic worldwide network connecting billions of heterogeneous smart objects capable of sensing, collecting, sharing, and exchanging information with one another anytime and anywhere (Atzori, Iera, & Morabito, 2010; Borgia, 2014; Mashal et al., 2015; Middleton, Koslowski, & Angela, 2018; Xu, He, & Li, 2014). Smart objects include computers, smart phones, sensors, actuators, smart lighting, smart power meters, and smart locks. The number of connected IoT smart objects was 212 billion in 2020 worldwide, the global market is expected to be worth between $3.9 and $11.1 trillion by 2025 (Al-Fuqaha, Guizani, Mohammadi, Aledhari, & Ayyash, 2015; Manyika et al., 2015).

IoT has created a huge number of powerful and innovative applications that enable object-to-object interaction and communication, allowing smart objects to collect data and monitor their environment to identify and properly resolve problems without human intervention. IoT applications also enable human-to-object interactions to allow users to control their smart objects. Potential IoT applications cover several interesting areas of everyday life such as smart grid (Farhangi, 2010), healthcare (Pang et al., 2015), assisting people with disabilities (Domingo, 2012), smart home and home automation (Kelly,

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Suryadevara, & Mukhopadhyay, 2013), smart city (Theodoridis, Mylonas, & Chatzigiannakis, 2013), environmental monitoring and management (Fang, Xu, Zhu, et al., 2014), water resource management (Fang, Xu, Pei, et al., 2014), supply chain management (L. Li, 2013), and smart transportation (Lin et al., 2017), smart grid (Mashal, 2021, 2022), among others. These applications will soon play a leading role and will have a considerable impact on every aspect of individual users' lives.

Among the various aforementioned IoT applications, Smart Homes (SHs) are the most important application with a broad range of capabilities and great benefits. SHs aim to improve residents' quality of life by equipping a residence with a communications network to connect smart devices and appliances together. Smart devices and appliances are remote-controlled and accessed through mobile phones or personal computers over the Internet by the user (Augusto & Nugent, 2006; Kelly et al., 2013; Li, Yigitcanlar, Erol, & Liu, 2021). A typical SH could contain more than 500 smart devices and appliances (Middleton et al., 2018). For example, users will be able to open and close doors at their SH remotely over the Internet. SH studies have focused on design, implementation, technology, and architecture. However, not enough studies have explored user perception and acceptance of SHs, and few models have been proposed (W. Li, Yigitcanlar, Liu, & Erol, 2022).

For the purposes of this study, we define SH acceptance as users' intention to use or actual use of SH technologies and services. Understanding various factors and issues of SH acceptance is very important to fully profit from its potential. The results of this study will help SH providers to design and implement a more efficient solution by taking these outcomes into consideration during the design and development of SHs. Consequently, it will aid effectively in marketing and promoting SHs and in expanding their services. Moreover, reliable guidelines and significant insights are derived for providers to develop more appealing and interesting SH solutions.

Accordingly, this paper comprehensively reviews and investigates the state-of-the-art of users' acceptance of SHs to better understand and identify which factors have a significant effect on them. The authors conducted an in-depth review of acceptance models and theories used in the SH domain, analyzed and evaluated them, highlighted characteristics and features of each model, and contrasted similarities and differences between them. The authors believe that the findings of this paper contribute to advancing research in the area of SH. To the best of the author's knowledge, no comprehensive and detailed systematic review on SHs acceptance exists in the literature.

The rest of this paper is organized as follows. Section 2 gives an overview of the architecture and components of SHs. Section 3 highlights various models and theories used for technology acceptance and adoption. Section 4 presents the method used in this paper. Section 5 introduces statistics on the selected articles. Section 6 discusses in detail the most frequently used factors for SH acceptance and adoption extracted from the selected papers. Section 7 presents a conclusion, implications and recommendations. Finally, Section 8 discusses the limitations of this study.

2. Smart homes

SHs are homes that are equipped with sensors, actuators, and smart appliances which can store data, process data, communicate with other smart appliances, send alerts, and respond to their user's commands. SHs improve people's quality of life by facilitating monitoring of the surrounding environment. For example, sensors detect the presence or absence of a person in a specific part of the SH and switch on or off a smart bulb, accordingly, thus optimizing and reducing the consumption of energy in homes. SHs allow users to control and monitor their appliances. For instance, users can remotely switch bulbs on or off over the Internet (Augusto & Nugent, 2006; Wilson, Hargreaves, & Hauxwell-Baldwin, 2015). SHs provide a variety of services such as for security, health, assisted living, communication, convenience and comfort, and energy efficiency which can be grouped into three categories: lifestyle support, energy consumption and management, and safety.

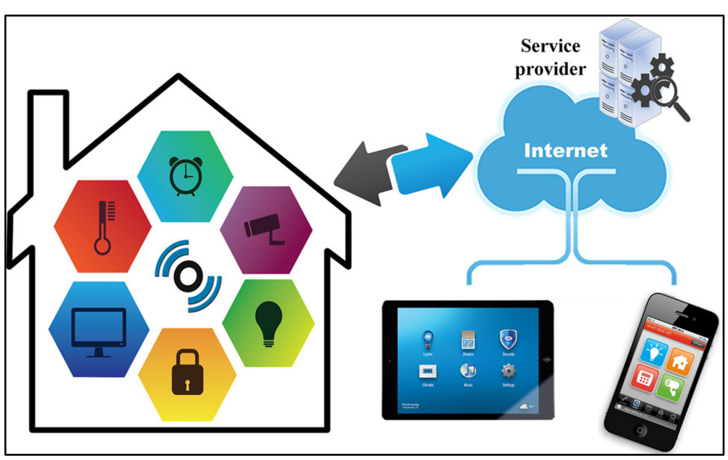

Fig. 1. Smart Home Architecture

SHs are implemented using a three-layer architecture, namely, application layer, network layer, and sensing layer. Sensing layer is the bottom layer where different home appliances collect data from the surrounding environment. Collected data are sent to the network layer through an SH gateway (Chung et al., 2014). The network layer, in turn, sends the data to the application layer using the Internet. SH service providers run a number of platforms in the application layer at the cloud which collect, integrate, process, and analyze received data from home appliances (Bing, Fu, Zhuo, & Yanlei, 2011; Wu, Liao, & Fu, 2007). This architecture enables SHs to make autonomous decisions without owner interference and provide assistive and personalized services. SHs use various communication technologies to provide connectivity to smart appliances and devices such as ZigBee, Bluetooth, Wi-Fi, and Z-Wave (Ahmadi et al., 2019; Mocrii, Chen, & Musilek, 2018; Toschi, Campos, & Cugnasca, 2017). Fig. 1 shows a SH architecture.

3. Technology Acceptance Models and Theories

In information systems literature, technology acceptance research spotlights factors that influence the acceptance of a given technology or system and analyze users willing to use and benefit from the potential and possibilities of a given technology or system. Dillon and Morris defined user acceptance of new information technology as "the demonstrable willingness within a user group to employ information technology for the tasks it is designed to support" (Dillon & Morris, 1996). Adoption is a related term that is used as a synonym for acceptance. These two terms are usually used interchangeably. There are several models and theories that study and explain user acceptance and adoption of new technologies and describe user behaviors and attitudes toward those technologies. Theories include the Theory of Reasoned Action (TRA) (Ajzen & Fishbein, 1973), Innovation Diffusion Theory (IDT) (Rogers, Singhal, & Quinlan, 2014), Theory of Planned Behavior (TPB) (Ajzen, 1991), Diffusion of Innovation (DOI), Unified Technology Acceptance and Use of Technology (UTAUT) (Williams, Rana, & Dwivedi, 2015), Technology Acceptance Model (TAM) (Davis, 1989). These models differ from each other based on factors they consider. In the following subsections, we describe those models.

3.1 Theory of Reasoned Action (TRA)

TRA is a solid conceptual model developed in 1975 for sociological and psychological research. TRA identifies two factors as determinants of a person's behavior. The first factor being attitude toward a behavior which is the positive or negative feelings of the individual about performing the target behavior (Fishbein & Ajzen, 1977). Attitude toward a behavior is the determined beliefs of everyone about that behavior. The second factor is the subjective norm which is the individual's perception that persons important to him/her think he/she should or should not perform the behavior. The subjective norm toward a behavior is determined by a person's normative beliefs about that attitude.

3.2 Theory of Planned Behavior (TPB)

TPB is the successor to TRA. The TPB model is an extension of TRA that uses the same two factors of TRA namely, behavioral attitude and subjective norms. TPB adds a new factor called perceived behavioral control (PBC). PBC is determined by the availability of resources and opportunities and skills to achieve outcomes. In TPB, behavioral attitude and subjective norms indirectly affect an individual's behavior through the individual's behavioral intention, PBC affects individual's behavior directly and indirectly through the individual's behavioral intentions (Jose K & Sia, 2022).

3.3 Technology Acceptance Model (TAM)

TAM is the most widely used model to study technology acceptance and adoption. TAM is another extension of the TRA model. TAM presented the attitude toward using a technology factor of TRA and eliminated the other TRA factor subject norms (Altamimi, Al-Bashayreh, AL-Oudat, & Almajali, 2022; Muk & Chung, 2015). Behavioral intention (BI) is influenced by one's attitude toward using a technology. TAM adds two belief factors, namely, Perceived Usefulness (PU) and Perceived Ease of Use (PEoU) with considerable impact on the individual's attitude. PU is the degree to which an individual believes that using a certain technology will enhance his or her performance. PU is specified to have an independent effect on BI. PEoU is the degree to which an individual believes that using a certain technology will be effortless. Moreover, PEoU influences PU. Furthermore, TAM adds other different factors known as external factors that influence an individual's attitude.

In order to overcome TAM limitations and improve its predictive power, TAM2 was proposed to extend TAM (Venkatesh & Davis, 2000). In order to understand the determinants of the PU, TAM2 includes further factors or constructs that affect PU. Two groups of constructs were added with a direct effect on PU. The first group is the subjective norm which represents the social influence and captures both image and subject norms. The second group are the cognitive factors which include result demonstrability, job relevance, and output quality. Moreover, TAM2 removed the ATT component from the model (Holden & Karsh, 2010). TAM3 is a new variant that includes factors or constructs that affect perceived ease of use (Venkatesh & Bala, 2008). Two groups of factors were added, namely, anchors and adjustments. Anchors represent the beliefs regarding the use of technology (enjoyment and objective usability). Adjustments represent the beliefs formed by the direct experience of a technology (external control, computer self-efficacy, computer anxiety, and computer playfulness).

3.4 Unified Theory of Acceptance and Use of Technology (UTAUT)

UTAUT was developed by Venkatesh and Morris by combining and tailoring constructs from previous acceptance theories and models (Venkatesh, Morris, Davis, & Davis, 2003). UTAUT identified four factors of users' behavioral intention to use and accept a new technology, namely, effort expectancy, performance expectancy, social influence, and facilitating conditions. Moreover, UTAUT identifies four moderating variables, namely, gender, experience, age, and voluntariness of use.

4. Research Aims, Questions and Method

Overall, research on smart homes acceptance, usage and adoption is dynamic and diverse in terms of smart home services, applications, utilized theories and conceptual framework. Therefore, the current survey aims to understand the literature of smart homes acceptance from the user perspective, and to provide valuable insights on the contributed factors that were used in the literature and the spots of the knowledge gaps. In addition, this survey aims to shed the lights on the researchers' efforts to understand the mostly used theories and extension factors, with association to smart homes' different contexts and settings.

Thus, this study formulates the following research questions to meet the objectives of the systematic review:

RQ1: How many research papers were published on SH acceptance between 2012 and 2022?
RQ2: What is the current research trend for SH acceptance?
RQ3: What models, theories and frameworks are used to study SH acceptance?
RQ4: What are the methods and approaches most applied on SH acceptance?
RQ5: What factors influence SH acceptance?
RQ6: What are the most used constructs in SH acceptance areas?

To answer the research questions in this study, various search keywords are used in the search. Firstly, a preliminary search in the search engines was conducted by selecting and retrieving all relevant papers and to provide the maximum number of publications. The keywords searched are "smart homes", "smart-homes" "smart houses", "IoT homes", "IoT Smart Homes", "automated homes", "smart residentials", "smart apartments", "Intelligent homes", "Intelligent houses". Those search words were associated with "acceptance", "adoption" and "usage". Moreover, keywords are combined using terms "OR" and "AND" to generate advanced strings to retrieve articles.

Keywords are used to search ten major scientific libraries to find the primary studies. The following digital libraries were searched:

1. ACM Digital Library
2. Association for Information Systems (AIS)
3. Emerald
4. Hindawi
5. IEEE Digital Library
6. Inderscience
7. Elsevier
8. Springer
9. Taylor and Francis
10. Wiley InterScience.

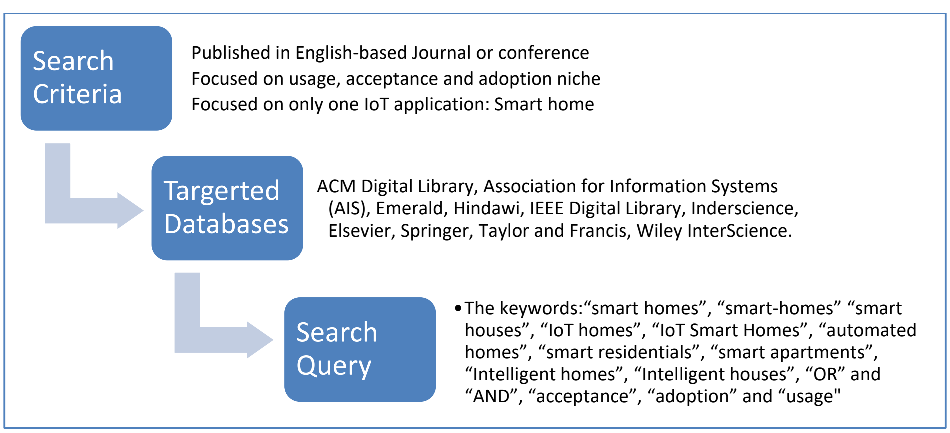

Fig. 2. Flowchart of Survey criteria, targeted databases and search query

The exact query text considered for the research aim is shown in Fig. 2. The advanced search options excluded short communications and letters gaining access to up-to-date scholarly works relevant to our study on smart homes adoption. After the initial removal of irrelevant and duplicate papers, articles were included in two iterations of screening and filtering to ensure eligibility criteria. The inclusion criteria included the following: (1) The article is written in English. (2) The article is focused on smart homes acceptance and adoption. (3) The subject is limited to only smart homes. In technical details, the articles were classified using a taxonomy index on a Microsoft Excel sheet, through a large collection of highlights and comments. As a result, all articles from the early mentioned databases were analyzed in depth to give readers a holistic and integrative perspective of smart homes literature.

The subsequent steps involved defining inclusion and exclusion criteria that are used to assess and examine retrieved papers for a careful selection of the papers that are most relevant to the research questions. Firstly, the paper discusses SH acceptance, adoption and acceptance factors. Secondly, the paper is scientifically sound. Exclusion criteria remove papers that are not relevant to the research questions. Papers falling foul of the exclusion criteria were removed. The reasons for excluding papers are: the papers are not written in the English language, the papers are listed in databases other than those above, the papers provide a theoretical model without results or findings. Some studies, such as Paetz et al. (Paetz, Dütschke, & Fichtner, 2012), have proposed a management system to test residents' acceptance. However, these studies focus on technical issues and do not consider user perspectives, and thus, were excluded. We have also excluded papers that focus on specific smart medical devices, because those papers focus on the healthcare system and Ambient Assisted Living (AAL) acceptance rather than SHs themselves (Ahn, Kang, & Hustvedt, 2016; Alaiad & Zhou, 2017; Alsulami & Atkins, 2016). Moreover, papers focusing on the general concept of IoT acceptance are also excluded (Gao & Bai, 2014; Hsu & Lin, 2016, 2018), as are papers on specific IoT applications, such as smart grid adoption and smart meter adoption (Broman Toft & Thøgersen, 2015; Chou & Gusti Ayu Novi Yutami, 2014; Chou et al., 2015). In this research, we consider studies that focus on general users.

5. Results

The proposed query resulted in 394 papers: 16 from ACM Digital Library, 18 from Association for Information Systems (AIS), and 59 from Emerald, 36 from Hindawi, 24 from IEEE Digital Library, 101 from Inderscience, 24 from Science Direct, 51 from Springer, 44 from Taylor and Francis, and 21 from Wiley. After studying the titles and abstracts, 239 papers were excluded further, for a total of 155 articles. The final full-text review excluded 90 articles, resulting in 65 articles in total which were found related to smart home IoT technology acceptance and adoption. After a careful check of the articles content, methodology, and contribution, and looking for the factors that drive users' acceptance and adoption of smart homes, 25 articles were excluded because of the failure to meet the inclusion criteria, the final number of included papers was 40. The selected papers are listed in Appendix Table 1. Finally, the content of the papers that fulfilled the inclusion criteria was analyzed to extract detailed statistics. The next section presents the results. In order to answer research questions, this systematic literature review produced several classifications. In this section, we present bibliometric information on selected papers. All the 40 selected papers are published in peer-reviewed journals and international conferences. Of the 40 selected papers, most are published in peer-reviewed journals. Twenty-eight papers (around 70%) are published in journals, while eleven papers (around 28%) are published in peer-reviewed conferences, and only one in book form. This section describes and analyzes selected papers and provides classifications for them.

5.1 Distribution of Publications Chronologically

Modest number of papers were published from 2012 to 2017. The number of published papers increased in 2018 and 2019 to seven papers. Five papers were published in 2020, seven papers were published in 2021, whereas only four papers were published in 2022. The number of papers is expected to increase as the research in the area of SH acceptance and adoption is increasing. Table 2 shows the distribution of selected papers by publication year.

Table 2
Research Papers based on Publication Year

Year	Number of papers	Reference
2012	1	(Coughlan et al., 2012)
2013	1	(Balta-Ozkan, Davidson, Bicket, & Whitmarsh, 2013)
2014	3	(Balta-Ozkan, Amerighi, & Boteler, 2014; Bao, Chong, Ooi, & Lin, 2014; Ehrenhard, Kijl, & Nieuwenhuis, 2014)
2015	1	(Luor, Lu, Yu, & Lu, 2015)
2016	1	(S. Kim & Yoon, 2016)
2017	3	(Y. Kim, Park, & Choi, 2017; E. Park, Cho, Han, & Kwon, 2017; Yang, Lee, & Zo, 2017)
2018	7	(Hwang, Suk, Kim, & Hong, 2018; Nikou, 2018; D. Pal, Funilkul, Vanijja, & Papasratorn, 2018; Eunil Park, Kim, Kim, & Kwon, 2018; Sanguinetti, Karlin, & Ford, 2018; Shin, Park, & Lee, 2018; Yang, Lee, & Lee, 2018)
2019	7	(Hubert et al., 2019; Klobas, McGill, & Wang, 2019; M. Lee, 2019; Marikyan, Papagiannidis, & Alamanos, 2019a; Nikou, 2019; Salomon & Müller, 2019; Ahmed Shuhaiber & Mashal, 2019)
2020	5	(Aldossari & Sidorova, 2020; Baudier, Ammi, & Deboeuf-Rouchon, 2020; Gross, Siepermann, & Lackes, 2020; Ji & Chan, 2020; Mashal, Shuhaiber, & Daoud, 2020)
2021	7	(Ayan & Türkay, 2021; Etinger, Jeger, & Babić, 2021; Oyinlola Ayodimeji, Janardhanan, Marinelli, & Patel, 2021; Debajyoti Pal, Zhang, & Siyal, 2021; Shanthana Lakshmi & Deepak, 2021; Sharma & Kuknor, 2021; Vrain & Wilson, 2021)
2022	4	(Sorwar, Aggar, Penman, Seton, & Ward, 2022; Zhang & Liu, 2022a, 2022b; Zhang & Luo, 2022)

5.2 Bibliometric Overview

Table 3 describes information on the 40 selected papers which are: paper ID, paper reference, number of citations of the paper, publication type (conference or journal), journal or conference name, and publisher name. Only fourteen journal papers are highly cited with a count of 100 citations or higher. Balta-Ozkan et al. (2013) receives the highest citation count with 646 citations. At the next level, Yang et al. (2017) receives a citation count of 297. With respect to conference papers, Coughlan et al. (2012) is the most cited paper receiving 56 citations. Most conference papers have low citations and some have zero citation. The reason for these zero citations is that they are relatively new with not enough time to accumulate citations. In the near future, we expect that these papers will gain additional citations.

Table 3
Bibliometric Distribution of Selected Articles

ID	Reference	Citation	Publication Type	Journal/Conference name	Publisher
1	(Coughlan et al., 2012)	56	Conference	IEEE International Conference on Green Computing and Communications, Conference on Internet of Things, and Conference on Cyber, Physical and Social Computing	IEEE
2	(Balta-Ozkan et al., 2013)	646	Journal	Energy Policy	Elsevier
3	(Bao et al., 2014)	38	Journal	International Journal of Mobile Communications	Inderscience
4	(Balta-Ozkan et al., 2014)	141	Journal	Technology Analysis & Strategic Management	Taylor & Francis
5	(Luor et al., 2015)	84	Journal	Maturitas	Elsevier
6	(S. Kim & Yoon, 2016)	16	Conference	International Conference of Design, User Experience, and Usability	Springer
7	(Eunil Park et al., 2018)	134	Journal	Universal Access in the Information Society	Springer
8	(E. Park et al., 2017)	236	Journal	IEEE Internet of Things	IEEE
9	(Yang et al., 2017)	297	Journal	Industrial Management & Data Systems	Emerald
10	(Y. Kim et al., 2017)	254	Journal	Total Quality Management & Business Excellence	Taylor & Francis
11	(Yang et al., 2018)	157	Journal	Journal of Sensors	Hindawi
12	(Hwang et al., 2018)	4	Conference	International Conference on Human Interface and the Management of Information	Springer
13	(Baudier et al., 2020)	130	Journal	Technological Forecasting & Social Change	Elsevier
14	(Shin et al., 2018)	209	Journal	Technological Forecasting & Social Change	Elsevier
15	(Hubert et al., 2019)	175	Journal	European Journal of Marketing	Emerald
16	(M. Lee, 2019)	21	Journal	International Journal of Human–Computer Interaction	Taylor & Francis
17	(Aldossari & Sidorova, 2020)	111	Journal	Journal of Computer Information Systems	Taylor & Francis
18	(Nikou, 2018)	11	Conference	Twenty-Sixth European Conference on Information Systems (ECIS2018)	AIS
19	(Mashal et al., 2020)	17	Journal	International Journal of Electronic Marketing and Retailing	Inderscience
20	(Ahmed Shuhaiber & Mashal, 2019)	141	Journal	Technology in Society	Elsevier
21	(Salomon & Müller, 2019)	2	Book	Digitalen Wandel gestalten: Transdisziplinäre Ansätze aus Wissenschaft und Wirtschaft (English: Shaping Digital Change: Trans-Disciplinary Approaches from Science and Industry)	Springer
22	(Marikyan et al., 2019a)	7	Conference	18th IFIP WG 6.11 Conference on e-Business, e-Services, and e-Society, I3E 2019	Springer
23	(Nikou, 2019)	110	Journal	Telematics and Informatics	Elsevier
24	(Ji & Chan, 2020)	13	Journal	Energy Research & Social Science	Elsevier
25	(Klobas et al., 2019)	61	Journal	Computers and Security	Elsevier
26	(Ehrenhard et al., 2014)	134	Journal	Technological Forecasting & Social Change	Elsevier
27	(Sanguinetti et al., 2018)	57	Journal	Energy Research & Social Science	Elsevier
28	(Vrain & Wilson, 2021)	18	Journal	Environmental Innovation and Societal Transitions	Elsevier
29	(Ayan & Türkay, 2021)	2	Conference	2021 Innovations in Intelligent Systems and Applications Conference (ASYU)	IEEE
30	(Debajyoti Pal et al., 2021)	28	Journal	Technology in Society	Elsevier
31	(Zhang & Liu, 2022a)	4	Journal	The Annals of Regional Science	Springer
32	(Shanthana Lakshmi & Deepak, 2021)	2	Conference	Machine Learning for Predictive Analysis	Springer
33	(Sharma & Kuknor, 2021)	0	Conference	2021 IEEE International Conference on Technology Management, Operations and Decisions (ICTMOD)	IEEE
34	(Oyinlola Ayodimeji et al., 2021)	0	Conference	Advances in Interdisciplinary Engineering	Springer
35	(Etinger et al., 2021)	0	Conference	International Conference on Applied Human Factors and Ergonomics	Springer
36	(Gross et al., 2020)	10	Conference	International Conference on Business Informatics Research	Springer
37	(D. Pal et al., 2018)	82	Journal	IEEE Access	IEEE
38	(Sorwar et al., 2022)	3	Journal	Informatics for Health and Social Care	Taylor & Francis
39	(Zhang & Luo, 2022)	0	Journal	Economic Change and Restructuring	Springer
40	(Zhang & Liu, 2022b)	9	Journal	Journal of Environmental Planning and Management	Taylor & Francis

5.3 Distribution of Papers by Publisher

The subject of SH acceptance and adoption is important for many journals and publishers. The famous publisher Elsevier published the highest number of papers at 12. Springer comes in second place with 11 published papers, followed by Taylor and Francis publishing 6 papers then IEE with 5 papers. Both Emerald and Inderscience published 2 papers. Hindawi and ASI come last with 1 paper each. The researchers could not find any paper published by Wiley or ACM that met the inclusion criteria. Fig. 3 shows the distribution of selected papers by publisher.

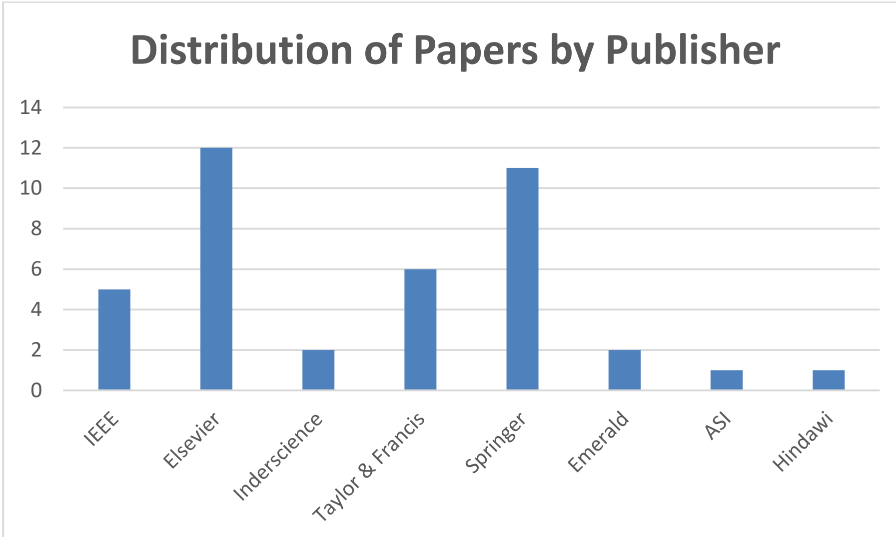

Fig. 3. Distribution of papers by publisher

5.4 Distribution of Papers by Country

Selected papers included in this literature review were conducted in fifteen countries. Korean authors have been the most productive with nine papers. Second are authors from the UK with six papers followed by China with five papers and Germany with 3 papers. Jordan, Finland USA, India, Thailand, Australia have contributed with two papers each. Remaining countries contribute with one paper each. Figure 4 shows the distribution of papers by country.

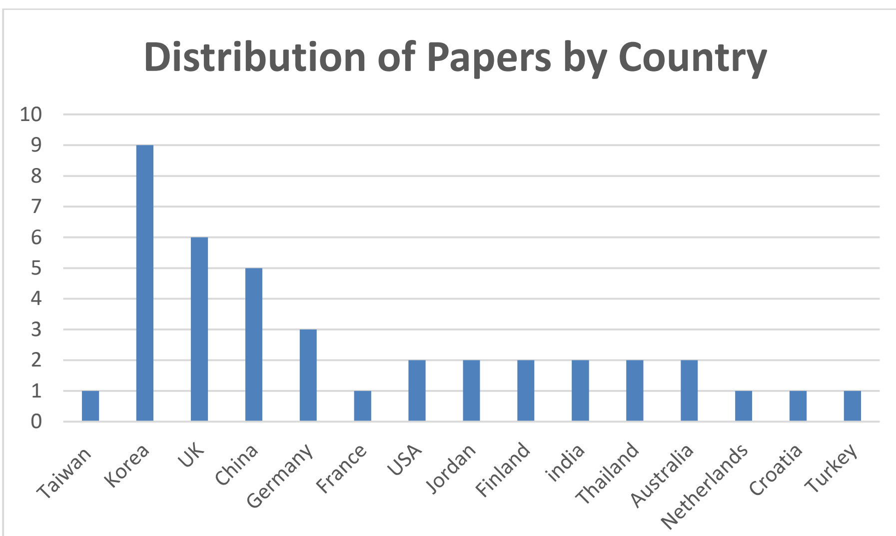

Fig. 4. Distribution of papers by country

6. Discussion

In this section, the most important SH acceptance and adoption models and factors are surveyed and discussed.

6.1 Theories and Models Comparison

Most of the papers are based on the quantitative research method. Of the 40 selected papers, 35 (87%) use the quantitative method, while only five papers (13%) use qualitative methods. Papers using quantitative methods can be divided into two categories: formal models and generic models. In formal models, the authors used existing models that were specifically designed to study technology acceptance and adoption such as TPB, TAM, and UTAUT or a modification or extension of these models by integrating their constructs together. On the other hand, the authors of papers using generic models did not use conventional models; instead, they designed their own models using different techniques.

Analysis of the 40 papers using quantitative methods shows that 36 papers (90%) used the formal model while only 4 papers (10%) used generic models to investigate SH acceptance and adoption. Regarding formal models, comparing papers according to used models shows that TAM is the most applied model. TAM is used in 11 different papers. TPB and UTAUT models were used in three papers each. Moreover, a combination of various models was used. For example, a combination of UTAUT + TAM has been used twice, while a combination of the Value-based Adoption Model (VAM) and TAM, a combination of VAM + Elaboration Likelihood Model (ELM) have been used in one paper each. Table 4 shows the distribution of models and theories used in the selected papers.

Table 4
Distribution of Models and Theories in the Selected Papers

Theories and models	Number of papers	Reference
TAM	11	(Ayan & Türkay, 2021; Bao et al., 2014; Coughlan et al., 2012; Gross et al., 2020; Mashal et al., 2020; D. Pal et al., 2018; E. Park et al., 2017; Eunil Park et al., 2018; Shin et al., 2018; Ahmed Shuhaiber & Mashal, 2019; Zhang & Liu, 2022a)
UTAUT	3	(Oyinlola Ayodimeji et al., 2021; Salomon & Müller, 2019; Sorwar et al., 2022)
TPB	3	(Yang et al., 2017; Zhang & Liu, 2022b; Zhang & Luo, 2022)
VAM + TAM	1	(Y. Kim et al., 2017)
Generic Model	4	(M. Lee, 2019; Luor et al., 2015; Debajyoti Pal et al., 2021; Yang et al., 2018)
VAM + Elaboration Likelihood Model (ELM)	1	(Hwang et al., 2018)
UTAUT + TAM	2	(Baudier et al., 2020; Etinger et al., 2021)
Qualitative	5	(Balta-Ozkan et al., 2014; Balta-Ozkan et al., 2013; Coughlan et al., 2012; Ehrenhard et al., 2014; S. Kim & Yoon, 2016)
IDT + TAM + Risk theory	1	(Hubert et al., 2019)
UTAUT 2	2	(Aldossari & Sidorova, 2020; Shanthana Lakshmi & Deepak, 2021)
Diffusion of Innovation (DOI) + TAM + UTAUT2	1	(Nikou, 2018)
Task-Technology Fit (TTF) + TAM	1	(Marikyan et al., 2019a)
TAM, IDT, Consumer Perceived Innovativeness (CPI)	1	(Nikou, 2019)
KPI evaluation system	1	(Ji & Chan, 2020)
TRA	1	(Klobas et al., 2019)
Diffusion of Innovation	2	(Sanguinetti et al., 2018; Vrain & Wilson, 2021)
VAM	1	(Sharma & Kuknor, 2021)

6.2 SHs Acceptance Key Constructs

Overall, 71 different constructs were determined from the selected papers. In order to have a better understanding of the constructs, a word cloud is established to visually underscore the constructs in terms of frequency and citations. As shown in Figure 5 below, the most cited terms and constructs are: behavioral Intention (36 times), Attitude (21 times), perceived usefulness (20 times), and perceived ease of use (13). On the other hand, some constructs, such as financial risk, were found the least important and rarely used. It is noticed that the majority of the research papers followed decent and highly-cited theories to understand SH acceptance and adoption in relevant contexts and tried to extend those theories by focusing each time on a certain dimension that lies under the authors' interest or concern. In addition, it is noteworthy that some research papers were using the same variable/construct with different labels, using contrast of the concepts, or combining them in one construct, such as 'perceived risk', 'perceived privacy risks', 'perceived security risks', 'security', 'privacy', 'security controls', 'privacy controls', and others. For example, the automation construct in paper (Yang et al., 2017) is the same as perceived automation in paper (Yang et al., 2018). In addition, it is noteworthy that the literature focused on the users' attitudes towards and behavioral intention of using smart homes. This is now clear by having the high frequency of using the terms 'behavioral intentions' and 'attitude towards' constructs, which indicates that the vast amount of the current research work found in literature dealt with perceptions and intentions, and that not much research work focused on the actual usage and real adoption experiences of smart homes from the user perspective.

Fig. 5. Word Cloud of Constructs

Also, the researchers classified the factors in several categories based on their common category and functionality (as in Fig. 6). As a result, five categories were included in the taxonomy: social factors, interpersonal and psychological factors, risks factors, service factors, and cultural factors. It is worth mentioning that some categories were put on focus more than other categories. For instance, many research studies focused on risk factors, service factors and interpersonal factors more than the social factors and the cultural factors. In addition, some categories included a large variety of factors, such as the service factors that include many technological and technical aspects of an SH service or application and from different perspectives. In addition, many research studies were utilizing one or more constructs from each category without an excessive focus on the holistic view of smart home acceptance and usage, as factors could come from different perspectives and categories to fill in the full puzzle of SH adoption in one context or application. We can also see that some external variables, such as trust, were included in the acceptance model as a construct of few interpersonal dimensions associated with trusting beliefs (reliability, competence and integrity), whereas trust could be better understood from other levels, such as disposition to trust, institution-based trust, and trust intentions. In the following paragraphs we discuss the most used constructs.

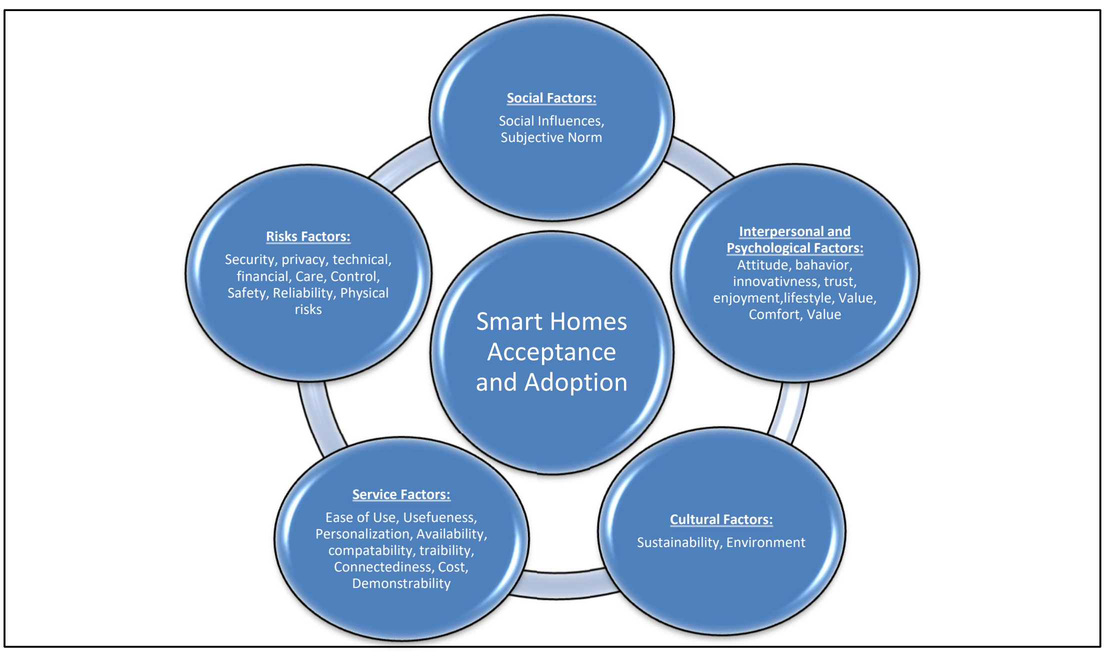

Fig. 6. Categories of factors of Smart Homes Acceptance and Usage

6.3 Behavioral Intention

Behavioral intention (BI), or intention to use, is defined as the desire to use an SH service (Kim et al., 2017). In many instances, researchers named the BI construct 'usage intention' (Baudier et al., 2020; Hubert et al., 2019; Mashal et al., 2020; E. Park et al., 2017; Eunil Park et al., 2018; Ahmed Shuhaiber & Mashal, 2019), whereas in a few cases a slightly different caption, such as 'adoption intention' (Yang et al., 2018) and 'purchase intention' (Shin et al., 2018) was used. The construct 'intention to use' is usually measured by an individual's willingness to use SH services if available, his/her intention to use them whenever possible and in his/her life if he/she has access to them (Aldossari & Sidorova, 2020; Baudier et al., 2020; Hubert et al., 2019). The BI construct is sourced in technology theories such as TAM, UTAUT, and in psychology-based theories such as TRA and TPB, and is highly cited in SH adoption literature.

6.4 Perceived Usefulness

Perceived Usefulness (PU) is an important construct that reflects the utility of using new technology. Originally, PU was defined as "subjective probability that using a specific application system will increase his or her job performance" (Bao et al., 2014). In the SH context, PU is defined as the degree to which a user believes that using or living in an SH would enhance his/her quality of life (Mashal et al., 2020). Similarly, PU is also defined as the "degree of improved performance of the user after using an SH service (external and cognitive benefit)" (Y. Kim et al., 2017). TAM defines a relationship between PU and Attitude toward (ATT). In this relationship, PU influences ATT toward using a technology (Al-Bashayreh, Almajali, Altamimi, Masa'deh, & Al-Okaily, 2022; A. Shuhaiber, Mashal, & Alsaryrah, 2019b).

6.5 Perceived Ease of Use

Originally, Perceived Ease of Use (PEoU) is defined as "the degree to which an individual perceives using the new information technology as being free of effort" (Bao et al., 2014). In the SH field, PEoU is defined as the degree to which a user believes that interacting with an SH is understandable and clear and does not require physical and mental effort (Bao et al., 2014; Eunil Park et al., 2018), or does not require significant mental effort (E. Park et al., 2017). Several previous studies found that PEoU significantly determines ATT toward using a technology (Aldossari & Sidorova, 2020; Hwang et al., 2018; Mashal et al., 2015; Ahmed Shuhaiber & Mashal, 2019), which are in line with the original TAM proposition that indicates that PEoU has a positive influence on PU.

6.5 Social Influence

Social Influence (SI) is defined as "the extent to which a user believes that others think he or she uses the new technology" (Bao et al., 2014). Persons significant to an individual usually provide valuable evaluations and opinions, which could influence, and affect said person's decisions. Many studies emphasized the impact of SI on users' acceptance of a technology. For instance, one study shows that friends and families may play an important role in terms of their decisions to adopt mobile SH (Bao et al., 2014). Similarly, SI in the form of others' opinions or suggestions within a social system norm is positively associated with the intention to use SH service (Yang et al., 2017). Another supporting result comes from (Mashal et al., 2020), which shows that SI has a direct significant influence on residents' intention to use SH devices and technologies and could also impact the usefulness of those devices. Reversely, one result from (B. Lee, Kwon, Lee, & Kim, 2017) states that social connectedness between users and SH devices can improve perceived social support in a SH context, which shows the mutual relationship between SIs and SH adoption in terms of effects and impact. SI is users' perceptions of social pressures to accept and live in SHs. SHs are still a new concept for general consumers and thus have received considerable attention from researchers (FakhrHosseini et al., 2022).

6.6 Trust

Trust (TR) in SHs is a main influencer for users to start accepting and using SHs. TR is defined as users' confidence in the reliability and trustworthiness of SHs (Mashal et al., 2020; Ahmed Shuhaiber & Mashal, 2019). TR in SHs could determine whether SH services would really save customers money in future (Balta-Ozkan et al., 2013). Consumers' lack of TR, on the other hand, might come from the notion that energy suppliers and SH producers would only be motivated by profit and that any financial savings by using SH devices would not be passed on to the consumer (Balta-Ozkan et al., 2013). Consequently, lack of users' TR in SHs could lead to a slow adoption of SH technology. Many papers tested the effect of TR on both ATT toward using and BI to use SHs. Luor et al. (Luor et al., 2015) showed that residents' TR in SHs positively influences their ATT toward these SHs. Similarly, TR is found to have a significant influence on intention to use SH within the Jordanian context (Mashal & Shuhaiber, 2019; Mashal et al., 2020; Ahmed Shuhaiber & Mashal, 2019). One study discussed the role of institutional TR in perceiving privacy risk of smart home IoT services and indicated a significant negative correlation, which in turn affects negatively perceived benefits of those SH services (Al-Bashayreh, Almajali, Al-Okaily, Masa'deh, & Samed Al-Adwan, 2022; M. Lee, 2019).

6.7 Perceived Cost

Perceived Cost (PC) is an important factor that affects the decision of users to use a technology (Balta-Ozkan et al., 2014; Eunil Park et al., 2018; A. Shuhaiber, Mashal, & Alsaryrah, 2019a). Most of the time, PC technology tends to slow acceptance and adoption rates (Mashal et al., 2020). As indicated by one study in Europe, the decision to buy or lease SH technology seems to be driven largely by cost considerations (Balta-Ozkan et al., 2014). The cost of the SH technology is not only about purchasing or leasing expenses, but also associated with additional costs such as maintenance and repairing costs (Eunil Park et al., 2018), which could also play a role in consumers' decisions to adopt it. Thus, PCs in the SH context are defined as ''concerns related to the costs used in purchasing, maintaining, and repairing the essential components in the services and systems'' (Eunil Park et al., 2018). However, the cost of SH technology should be considered against increasing energy prices and a desire to reduce costs through household energy savings in order to understand the feasibility of this technology. PC is examined in several empirical studies, which indicate that PC of SH technology is significantly and negatively impacted in South Korea (E. Park et al., 2017; Eunil Park et al., 2018), Jordan (Mashal et al., 2020) but not in China for mobile SH adoption (Bao et al., 2014).

6.8 Perceived Enjoyment

Perceived Enjoyment (PE) is defined as "the extent to which the activity of using SHs is perceived to be enjoyable in its own right, apart from any performance consequences that may be anticipated" (Mashal et al., 2020). Another definition of PE is "the extent to which the use of SH services is perceived to be playful and enjoyable" (Eunil Park et al., 2018). One more, not very common, definition of PE is the "degree of pleasure the user feels by using an SH service (internal and emotional benefits)" (Y. Kim et al., 2017). Overall, PE is associated with fun, pleasure, and joyful feelings toward using SH devices and services. PE is considered one of the motivational factors of accepting and using SH technology (Eunil Park et al., 2018). PE, as intrinsic and characterized by emotional benefits, is also considered by one study to be the most important factor in attitudes on home SH IoT services, followed by effectiveness and efficiency (Hwang et al., 2018). PE of SH services was positively related to users' intention to use the services and is also related to the perceived ease of use of this technology. Similarly, PE was found to be a strong predictor for consumers' ATT toward IoT home devices (Aldossari & Sidorova, 2020; Hwang et al., 2018).

6.9 Compatibility

Compatibility (COM) in the IoT field is defined as the capacity for integration with existing systems and with other existing devices (Bao et al., 2014). SH COM indicates how seamless and ubiquitous automated interactions are among the connected SH devices, although they may be offered by different brands and manufacturers. COM also includes the connection between the SH devices and the wireless network platform that is employed (Eunil Park et al., 2018) and requires connections and communications infrastructure among various internal and external home devices (Shin et al., 2018). It was assumed that greater SH COM leads to faster rates of adoption, as consumers tend to avoid brand changing when it comes to a purchase decision (Hubert et al., 2019). SH COM in China is found to have a significant influence on mobile SH adoption and perceived ease of use (Bao et al., 2014). In one Austrian study, it was found that one of the most important determinants of intention to use is COM of the SH application (Hubert et al., 2019). In an indirect way, perceived COM of SH services was found to have a positive impact on a service's Perceived Usefulness, which in turn impacts the intention to use those technologies (Eunil Park et al., 2018). Similarly, perceived COM is also found to significantly influence usefulness and ease of use of smart technology, then affecting consumers' attitudes and behavior toward using it (E. Park et al., 2017; Shin et al., 2018).

6.10 Perceived Security Risks

The construct Perceived Security Risks (PSRs) is defined as "potential loss of control over personal information, such as when information about you is used without your knowledge or permission. The extreme case is where a consumer is 'spoofed', meaning a criminal uses their identity to perform fraudulent transactions" (Hubert et al., 2019). PSRs that could be associated with SH technology could be in the form of unauthorized access by hackers or attackers to SH appliances, which negatively affect the control of home appliances via the controller mobile devices using wireless communications (Bao et al., 2014; Hammi, Zeadally, Khatoun, & Nebhen, 2022; Klobas et al., 2019; Risteska Stojkoska & Trivodaliev, 2017). More serious security concerns may also include malfunction in the SH service which leads to device and network deficiencies (Hubert et al., 2019; Ahmed Shuhaiber & Mashal, 2019). This situation becomes even more serious as the security of the SH devices and services reflect on home security itself, especially for external devices such as doors, gardens and alarm systems. PSRs are not only associated with technical and network issues (Eunil Park et al., 2018), but also with physical security such as loss of, theft of or damage to a smartphone as the main smart-home controller (Balta-Ozkan et al., 2014). These security concerns can hinder consumers' acceptance and usage of SH appliances and services (Aldossari & Sidorova, 2020). Studies have shown that PSRs can significantly and negatively influence consumer intention to use SH technology (Ahmed Shuhaiber & Mashal, 2019), and that security risk is the strongest predictor of the overall risk perception that negatively impacts intention to use (Hubert et al., 2019). The overall risk perception displays differential effects. However, other studies found no significant relationship between perceived technology security risk and mobile SH adoption (Bao et al., 2014). However, security is also discussed in literature as perceived security, a secure and safe environment which is associated positively with SH adoption (Balta-Ozkan et al., 2014; Bao et al., 2014; Baudier et al., 2020; Eunil Park et al., 2018). Perceived security, also called system reliability, is defined as "users' perspectives toward the protection level against the potential threats when using SH services" (Eunil Park et al., 2018). Specifically, SH devices and services provide users with real-time information that can improve safety and security by sending alerts and notifications in the event of unauthorized access or intrusions, for instance, by detectors for glass breakage and smoke or gas emissions, which in turn maintains home security (Baudier et al., 2020).

Whereas studies support the significant impact of safety and security on intention to use SH technology mediated by performance expectancy (Baudier et al., 2020), other research found that perceived security has no significant impact on PU in the extended SH TAM model (Eunil Park et al., 2018).

6.11 Perceived Privacy Risks

Perceived Privacy Risks (PPRs), the twin sister of PSRs, is also considered an important predictor of SH adoption and resistance, and several studies couple these two constructs either as a one construct (Balta-Ozkan et al., 2014; Balta-Ozkan et al., 2013) or in a second order construct as perceived overall risk (Hubert et al., 2019; Ahmed Shuhaiber & Mashal, 2019; Wang, McGill, & Klobas, 2020). As a separate construct, PPR is considered as "concern for the management of personal information and privacy regarding SH service" (Y. Kim et al., 2017). Privacy risks are associated with the concern that "personal information is likely to be leaked and used for unintended purposes" (Hwang et al., 2018) and willingness to provide personal information (D. Kim, Park, Park, & Ahn, 2019). PPR are associated with privacy concerns (Kowatsch & Maass, 2012; H. Lee, 2020), loss of consumer freedom (Mashal et al., 2020), accessing someone else's data (S. Kim & Yoon, 2016), and with "the infringement of personal information that occurs while using a service" (Shin et al., 2018). PPRs essentially inhibit SH acceptance (Hong, Nam, & Kim, 2020; Marikyan, Papagiannidis, & Alamanos, 2019b; Schomakers, Biermann, & Ziefle, 2020; Wilson, Hargreaves, & Hauxwell-Baldwin, 2017). PPRs significantly and negatively influence perceived value and intention to use SH technology (Y. Kim et al., 2017). In addition, PPRs significantly and negatively influence users' ATT toward SH adoption (Hwang et al., 2018), and negatively influence perceived benefits (M. Lee, 2019). Interestingly, privacy protections were found to have no significant influence on users' ATT toward smart home adoption (Shin et al., 2018). Similarly, privacy concerns have no influence on BI to use SHs and its devices (Wright, Shank, & Yarbrough, 2022).

6.12 Attitude Toward

Users' Attitude toward (ATT) technology usage has been extensively used in extended versions of technology theories such as TAM, UTAUT, and in psychology-based theories such as TRA and TPB, and is highly cited in SH adoption literature (Aldossari & Sidorova, 2020; Hwang et al., 2018; Mashal et al., 2020; Nikou, 2019; Shin et al., 2018; Ahmed Shuhaiber & Mashal, 2019). In SH literature, this construct could be defined as the degree of a user's positive or negative evaluation or feelings about using smart homes (Ahmed Shuhaiber & Mashal, 2019). The ATT toward SHs is usually measured by determining the extent of the customer's desire or favorable feelings toward smart homes, and whether the concept is liked and considered a good idea to have one. This construct is well measured and used in most of the previous studies and demonstrates validity and reliability for almost all studies in SH literature (D. R. Nascimento, Ciano, Gumz, & Fettermann, 2022; Débora Rosa Nascimento, Tortorella, & Fettermann, 2022).

6.13 Facilitating Conditions

Facilitating Conditions (FCs) are sourced from the UTAUT (Venkatesh et al., 2003) and were originally proposed to serve as PBC, conditions and COM, where each of these variables is operationalized to include aspects of the technological and organizational dimensions that are designed to remove barriers to users. It is defined as "the degree to which an individual believes that an organizational and technical infrastructure exists to support use of the system" (Venkatesh et al., 2003). This construct has been utilized in SH literature in several studies (Aldossari & Sidorova, 2020; Baudier et al., 2020; Salomon & Müller, 2019), by using almost the same measures, such as possessing the necessary resources and knowledge to use SHs, and to what extent SHs are compatible with existing households and whether there is a specific person or group available to provide help and support when needed.

6.14 Effort Expectancy

Effort Expectancy (EE) was originally defined as "the degree of ease associated with the use of the system" (Venkatesh et al., 2003) and reflects on three variables: perceived ease of use (TAM/TAM2) and complexity in Model of Personal Computing (PC) utilization (MPCU). Similar to FCs, this construct has been used in several SH studies (Aldossari & Sidorova, 2020; Baudier et al., 2020; Salomon & Müller, 2019). EE captures the ease of using SH technology, interacting with smart home devices and services, and how easy it is for users to become skillful at using SH devices, services and applications.

6.15 Performance Expectancy

Performance Expectancy is defined as "the degree to which an individual believes that using the system will help him or her to attain advances in job performance" (Venkatesh et al., 2003). This construct reflects on the following variables: PU, job-fit, relative advantage, extrinsic motivation, and outcome expectations. Consistent with EE and FCs, performance expectancy is used in the same references (Aldossari & Sidorova, 2020; Baudier et al., 2020; Salomon & Müller, 2019), indicating the usage of UTAUT to conduct the associated quantitative studies. Performance expectancy captures the usefulness of SH technology and devices, accomplishing home activities more quickly and easily, and increasing people's productivity to perform their daily home activities.

7. Conclusion, Implications and Recommendations

The paper has offered a systematic review of SH adoption as one IoT recent application. We first introduced the concept of SHs in terms of technology, devices, services and applications. Then, by identifying articles from the most popular databases and by following a rigorous review process, we discussed and critically synthesized the findings under three themes, namely, bibliometric information on selected papers (by publisher, country, and year), distribution of models and theories employed, and all constructs used in selected papers. The subsequent sections present the theoretical and practical implications as well as the main limitations of our research work.

7.1 Theoretical Contributions

Based on this systematic literature review, this research has several theoretical implications. Firstly, it is noted that much research uses the extended TAM model whereas very little adopts UTAUT (the first and second versions) or other technology theories although well-known and highly cited and recognized in the technology adoption arena. This is probably due to the popularity of TAM, its simplicity, and the ability to extend it by using external variables that suit the targeted application and context. However, it is suggested that future adoption research may consider other theories especially when better suiting a certain context and application.

It is also noteworthy that the reviewed research studies used more than 71 external variables to predict users' attitudes and behaviors toward SH adoption, which indicates variety and the multidimensional aspects of accepting and using SH services and applications, but with greater focus on certain aspects over others. SH adoption research has focused more so on technical aspects and psychological factors and SIs than personal and environmental factors. Consequently, we recommend greater focus on significant, if not more significant factors such as energy saving, caring technology, intelligent partners, and health support.

In addition, this literature review indicates employing the same constructs with different names several times. Although they are highly significant, and to avoid re-inventing the wheel, we think that researchers need to consider the most recent aspects and trends of smart technologies, as published by Middleton et al. (2018), such as calm technology, intelligent interactivity, green IT solutions, and environment sustainability.

Moreover, many of the studies reviewed were found to investigate SH services in general, and/or much other research was conducted by employing convenience sampling of high education students. Although this practice is fully accepted and helpful for many research studies' aims and designs, this could significantly limit the research findings and results. Therefore, it is recommended that more future research focuses on discovering the adoption factors of specific SH applications and solutions, and surveying more specific samples such as housewives, patients, elderly people and people with special needs in order to discover more hidden adoption factors and enrich the SH literature.

7.2 Practical Implications

This research has several practical implications. Firstly, and since technical attributes are confirmed by researchers as having a significant influence on adoption, this research invites individual SH technology manufacturers to offer more integrated SH solutions by connecting several SH devices together. This would support technology compatibility (e.g. interconnectedness, trialability, security, etc.) and should reduce potential technical issues raised by integrating different brands (Forestal & Li, 2022). In addition, more customized SH applications and services are recommended not only to address customers' requirements, but also to achieve customer enjoyment and intimacy. However, this might require understanding people's recent technology habits, trends and lifestyles in order to determine what SH devices are to be connected, what sorts of services are to be offered and in what way. In a more personalized fashion, we think that SH vendors and technology providers should appeal to target-specific customer clusters such as the elderly, persons with special needs, children, obese teens, alcoholic persons, and tailor SH technology accordingly based on their daily needs and preferences.

8. Directions for Future Research and Research Limitations

As for future research directions, we suggest scholars in the field of smart homes consider cultural factors to better understand SH acceptance and usage in certain contexts and environments. The utilization of some of the cultural dimension of Hofstede, such as individualism/collectivism, uncertainty avoidance, indulgence/restraint, masculinity/femininity, and power distance can contribute to the smart home's literature (Pirzada, Wilde, Doherty, & Harris-Birtill, 2022). In addition, we recommend researchers examine the impact of relatively new constructs on SH adoption associated with technology calmness, green IT, user innovativeness, affective technology, personal traits and characteristics (such as openness, introversion, and extraversion) for a more contemporary perspective. These terms are considered trends in the smart technology literature and could be strongly associated with accepting and using a smart home. Additionally, we recommend testing SH acceptance and adoption on specific user segments such as the elderly, persons with special needs, children or busy parents to obtain richer insights into what factors can influence their behavior and intentions to use SHs as well as their intentions to continue using the technology. This is important as the acceptance factors are deeply associated with the users' attributes and demographics and can significantly vary for one users' category to another. Moreover, researchers may consider focusing on experiences more than perceptions to better understand the actual usage and the intention to use smart homes. This requires a demo display, or a proof of concept experience for users in order to provide more accurate responses and feedback. This could be done by approaching users through datasets and analyzing the data quantitatively to get a clearer picture. Furthermore, we urge scholars in this field to qualitatively investigate the acceptance factors of smart homes in certain contexts. As per the previous studies, little qualitative work had taken place to understand the smart homes acceptance, whereas qualitative research can reveal users' opinions, reasons, motivations and feelings about smart homes with rich insights and focus. In detail, researchers may follow actions, research approaches, narrative research, and phenological research and ethnographies in order to explore, collect rich data about smart homes perceptions and interactions, or to collaboratively connect research to practice, and describing and interpreting users' real experiences. Ideally, we can also suggest the development and validation of a more comprehensive adoption model, where all relevant factors of one context are included, including risks, social, cultural, service (technical) and interpersonal factors. By selecting factors from each category, correlating them through multiple regression direct and indirect paths, and extending the most recent and a highly cited theory, the new model should provide a holistic view of smart homes acceptance and usage, and it should provide more intense findings where mediated variables are taking part of the model and perhaps twist what had been discovered already about this literature to come up with genuine contribution and new knowledge. This endeavor can result in extending the current well-established theories such as the development and validation of UTAUT3 or TAM4, or establishing new rigid theories of acceptance and usage that can show more adaptability and flexibility to this sort of emerging technology, especially that smart home technology could be associated with different forms of platforms and applications.

There are some limitations for this study. First, the papers reviewed in this study were retrieved from the famous eight online databases. There might be other related papers published in other journals discussing SH acceptance. Second, non-English papers were excluded from this study. The authors believe papers on SHs have been published in other languages. Third, this study excludes papers that only present a model without testing it. However, those studies may suggest interesting and significant constructs and provide insights into SH acceptance.

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Appendix

Table 1
Selected Papers

	Reference	Research Method	Sample Size	Country	Theory	Research Findings
1	(Coughlan et al., 2012)	Qualitative and Quantitative	35	UK	TAM	PU, PEoU, privacy, knowledge and awareness are important for intention to use.
2	(Balta-Ozkan et al., 2013)	Qualitative	12	UK	-	Perceived cost is a barrier for the adoption of SHs. Perceived cost includes installation costs, repair and maintenance costs.
3	(Bao et al., 2014)	Quantitative	310	China	TAM	PU, SI, and COM influence adoption of mobile SH. SI, PEoU, and perceived secure environment have a direct and positive influence on PU.
4	(Balta-Ozkan et al., 2014)	Qualitative	6 workshops 24–30 participants in each workshop	UK, Germany, and Italy	-	Additional types of smart home services, considering the assisted living, health and security, non-energy aspects. Different perceptions of smart homes in European countries. The role of utilities and government are important factors to be considered.
5	(Luor et al., 2015)	Quantitative	190	Taiwan	Generic Model	PU and TR positively affect attitudes toward smart home functions (home entertainment, home security, and home automation). PC negatively affects attitudes toward each function.
6	(S. Kim & Yoon, 2016)	Qualitative	37	Korea	-	SH adoption is related to user's lifestyle. Customer care and privacy are barriers to SH adoption.
7	(Eunil Park et al., 2018)	Quantitative	799	Korea	TAM	COM, connectedness, PBC, system reliability, and enjoyment were positively related to the users' intention to use SH services, a negative association between the PC and usage intention was found.
8	(E. Park et al., 2017)	Quantitative	1057	Korea	TAM	COM, connectedness, and PBC have positive influence on the SH acceptance behavior of users. PC has a negative influence.
9	(Yang et al., 2017)	Quantitative	216	Korea	TPB	TR in service provider, security/privacy risk, and mobility affect SH services adoption.
10	(Y. Kim et al., 2017)	Quantitative	269	Korea	VAM and TAM	Privacy risk and innovation resistance limit perceived value. Perceived benefit was found to have a strong positive effect on perceived value.
11	(Yang et al., 2018)	Quantitative	216	Korea	Generic Model	Reliability, interconnectivity, and automation are important factors.
12	(Hwang et al., 2018)	Quantitative	100	Korea	VAM + ELM	PCs, privacy risk, non-monetary, costliness, and unaffordability had negative effects on ATT toward SH services. Enjoyment was the most important factor in ATT toward SH, followed by effectiveness and efficiency.
13	(Baudier et al., 2020)	Quantitative	316	France	UTAUT + TAM	Performance Expectancies and habit have a strong influence on BI. SI has no impact on the BI. Comfort/convenience, health, and safety/security have direct influence on performance expectancies and habit, while sustainability is less relevant.
14	(Shin et al., 2018)	Quantitative	310	Korea	TAM	COM, PEoU, and PU have significant positive effects on adoption and diffusion of SHs.
15	(Hubert et al., 2019)	Quantitative	409	Germany	TAM + IDT + Risk Theory	Risk perception is an inhibitor of BI mediated through PU. COM and PU are an important determinant of BI to use SHs.
16	(M. Lee, 2019)	Quantitative	198	Korea	Generic Model	TR in the service provider negatively influences PPR and PSR. Institutional TR does not influence them. PPR and PSR do not influence perceived benefit. Institutional TR has a positive influence on perceived benefit. TR in service provider does not influence perceived benefit.
17	(Aldossari & Sidorova, 2020)	Quantitative	343	USA	UTAUT2	Performance expectancy, EE, SI, hedonic motivation, TR, security risk, and price value are all significant predictors of SH acceptance.
18	(Nikou, 2018)	Quantitative	156	Finland	TAM+DOI+UTAUT2	ATT toward, PU, relative advantage, and SI were found to influence BI to use SHs. PEoU has no influence on ATT toward using SHs.
19	(Mashal et al., 2020)	Quantitative	258	Jordan	TAM	User awareness, TR, PE, personalization, PU, and PEoU influence ATT toward SH. ATT toward and SI impact the BI.
20	(Ahmed Shuhaiber & Mashal, 2019)	Quantitative	258	Jordan	TAM	TR, awareness, enjoyment, perceived risks, PU, PEoU influence both ATT toward and the BI to use SHs.
21	(Salomon & Müller, 2019)	Quantitative	496	Germany	UTAUT	Performance expectancy, FCs, SI, and the EE are important factors for SH acceptance.
22	(Marikyan et al., 2019a)	Quantitative	422	UK	TTF + TAM	perceived technology-fit influences use behavior, satisfaction, PU, PEoU. PU affects use behavior which in turn affects satisfaction. Hedonic value and utilitarian value have effect on perceived technology-fit. PEoU affects PU. Privacy risk and financial risk does not affect perceived technology-fit.
23	(Nikou, 2019)	Quantitative	156	Finland	TAM + IDT + CPI	COM, PU, and PEoU affect BI. trialability has no effect on the BI, however, it affects directly PU and PEoU. PC negatively affects BI.
24	(Ji & Chan, 2020)	Quantitative	2391	China	KPI Evaluation System	Technical Performance, economic performance and risk resistance were found effective with different weights.
25	(Klobas et al., 2019)	Quantitative	400	Australia	TRA	Perceived security risks negatively and significantly influence people's attitude and their perceived control over this technology, which in turn impact the intention to use it.
26	(Ehrenhard et al., 2014)	Qualitative	14	Netherlands	-	Price has a strong influence on user behavior intention to use smart home.
27	(Sanguinetti et al., 2018)	Quantitative	709	USA	DoI	Comfort, convenience, security, and enjoyment were important factors for some users' clusters. However, cost and energy savings are not.
28	(Vrain & Wilson, 2021)	Quantitative	713	UK	DOI	Interpersonal communication and social media have big impact on SH adoption

29	(Ayan & Türkay, 2021)	Quantitative	386	Turkey	TAM	PU, PEoU influence both ATT toward and the BI to use SHs.
30	(Debajyoti Pal et al., 2021)	Quantitative	463	Thailand	Generic Model	Three privacy aspect (individual skills, legal & policy, and technological) effects user resistance of SHs.
31	(Zhang & Liu, 2022a)	Quantitative	643	China	TAM	PEoU, PU, and knowledge positively influence BI to adopt SHs. Perceived risk negatively influences BI to adopt SHs.
32	(Shanthana Lakshmi & Deepak, 2021)	Quantitative	148	India	UTAUT2	PE, TR, trialability, and tech-savvy significantly influence adoption of SHs.
33	(Sharma & Kuknor, 2021)	Quantitative	98	India	VAM	Perceived value (PU, perceived fees, and status symbol) affects BI to use SHs.
34	(Oyinlola Ayodimeji et al., 2021)	Quantitative	53	UK	UTAUT	PE, EE, SI, and FC influence the BI to adopt SHs.
35	(Etinger et al., 2021)	Quantitative	186	Croatia	UTAUT + TAM	PC (price of devices), privacy, need for training and education negatively affect BI.
36	(Gross et al., 2020)	Quantitative	327	Germany	TAM	Perceived security, PEoU, comfort positively influence the PU. ATT positively influence BI. PC didnt have negative influence on the adoption of SH.
37	(D. Pal et al., 2018)	Quantitative	239	Thailand	TAM	Self-capability, SI, COM, automation, and effect BI using SH. Connectivity and enjoyment have no Influence on BI.
38	(Sorwar et al., 2022)	Quantitative	60	Australia	UTAUT	PU, TR are critical predictor of BI of SHs.
39	(Zhang & Luo, 2022)	Quantitative	629	China	TPB	Ambiguity tolerance, ATT, COM, environmental knowledge, and PBC affect BI toward SHs adoption.
40	(Zhang & Liu, 2022b)	Quantitative	587	China	TPB	ATT, PBC, information publicity, COM, environmental consciousness effect BI to adopt SHs. SI does not affect BI.