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Convenience, Opportunities, Risks and Challenges of IoT for Individual and Business Consumers: Systematic Literature Review from 2010 to 2022

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Abstract

IoT offers control over devices and enables users to have real time monitoring, increased efficiency and reduced energy costs. As the technology is in its infancy stage, there are several domains which need to be studied. Researchers have made contributions to analyze the key aspects of IoT including its usage, benefits, risks and requirement for technological infrastructure. Furthermore, studies were conducted from consumer's perspective aiming to know their preferences and adoption behaviors. This systematic review of literature, based on previous studies from 2010 to 2022, aims to enrich literature while presenting the comprehensive and detailed review of 42 articles from 43 journals and international conferences. The reviewed articles have been selected from data bases including Scopus, Web of Science and Science Direct. The theory development, characteristics, context and methodology framework (TCCM) has been used to examine these four aspects in consumer behavior regarding IoT devices. The review presents the overview of research in this area and also presented the future research directions to spur scholarly research. The research's contribution in academia and industry is that it provides the useful information regarding key aspects of IoT while suggesting new ways for further improvements. The research provides key insights to IoT industry and how they can overcome product and adoption related challenges.

Keywords: Benefits of IoT, Challenges of IoT, Consumer preferences of IoT devices, Internet of Things, Risks of IoT.
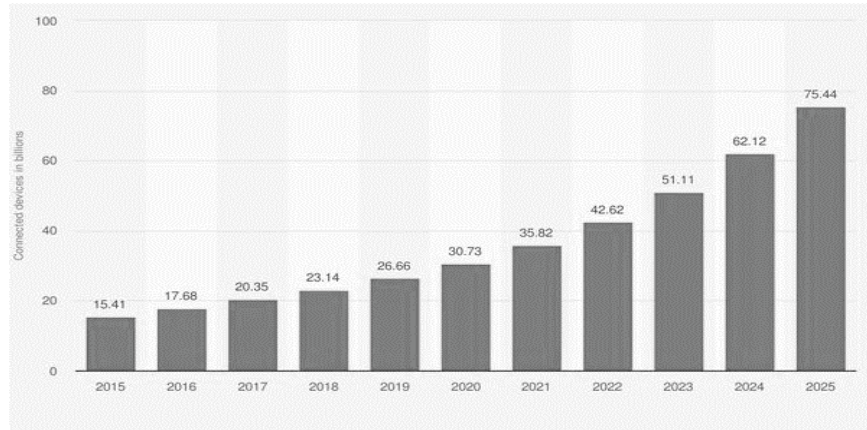**JEL codes**: M31, M150, M160

Introduction

Digital technology has changed the way of businesses and provides the latest solutions to problems faced by people and organizations globally (Wortmann & Flüchter, 2015). This technology has benefitted people in different fields by offering growth and economic benefits to companies (AlHogail, 2018), such as new global market opportunities used for process controls and better monitoring purposes. The internet is the main reason behind the emergence of technologies and connectivity (Rahman & Asyhari, 2020). The Internet of Things (IoT) is the technology trend that has evolved in recent years and is appreciated by people and businesses, it was a part of the third wave of information technology and the fourth industrial revolution which will change the world through its immense benefits and diverse features (Xu, He & Li, 2014). The EU, US, China, and other countries have accepted the importance of promoting the industry along with the development of IoT industry strategies (Wortmann & Flüchter, 2015). As per Hounsell, Shrestha, Piao and McDonald (2009) IoT is a network of devices that have communication network among them and with other internet-enabled devices.

The concept of smart living is based on the use of IoT products that offers control to the user and creates an integrated environment, hence gaining the attention of people and organizations (Pal, Arpnikanondt, Funilkul, & Chutimaskul, 2020). Figure 1 shows the increasing global trend in the use of IoT devices and predicted number of devices in the coming years.

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Figure 1: Number of connected devices (Internet of Things-IoT)
In the world between 2015 and 2025
Source: Cisco

According to Baras and Brito (2017), the purpose of implementing IoT is to "achieve a synergy between different systems, meaning that they should interoperate and communicate automatically to provide innovative services to users". As per Tiwari and Singh (2016, p.67) 'IoT is the "interconnection of sensing and actuating devices providing the ability to share information across platforms through a unified framework, developing a common operating picture for enabling innovative applications". Similarly, Wortmann and Fluchter (2015) suggested that, "at its core, innovation in IoT is characterized by the combination of physical and digital components to create new products and enable novel business models". Smart living is the lifestyle paradigm that is being increasingly adopted by the people (Tsourela & Nerantzaki, 2020). Figure 2 shows the various use cases of IoT in different areas of our lives.
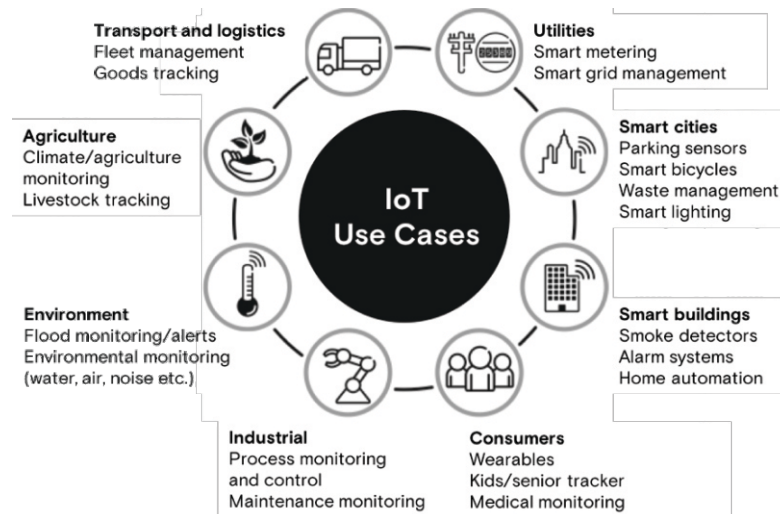

Figure 2: Use cases of IoT
Source: Ericson, 2016

IoT devices have made it possible for users to make their life more controlled, efficient, integrated, productive, and sustainable. As per statistics, by the year 2026, the IoT industry's worth will reach $1111.3 billion (USD) which shows immense growth in this sector, and countries including the USA, and China are actively working in framework designs, innovation proposals, and spectrum planning to promote the sector and encourage novelty. However, every technology comes with risks and challenges which negatively affect the consumer's willingness to buy these products (Jog, Sajeev, Vidwans & Mallick, 2015). The internet and social media shifted the balance of power to consumers instead of manufacturers, making it imperative to study the consumer adoption of IoT products (Yasirandi, Lander, Sakinah & Insan, 2020).

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The IoT industry is still in its infancy stage and there are vulnerabilities and challenges which need to be addressed by experts such as increased privacy risks, inconsistent protocols, physical safety concerns, and cyber security risks. Moreover, IoT has strong implications in industries such as energy, transportation, and electricity while serving as a problem solver and making the processes more efficient (Jalali, Kaiser, Siegel, & Madnick, 2019), allowing it to gain the attention of industry and academic experts who wish to understand the benefits, growth opportunities, and risks associated with it. Despite the rapid advancements and growing adoption of Internet of Things (IoT) technology, there exists a pressing need to comprehensively understand and analyze consumer behavior in the context of IoT devices. While IoT holds the promise of offering control over devices, real-time monitoring, increased efficiency, and reduced energy costs, the technology is still in its infancy stage, and numerous critical domains within this realm warrant in-depth investigation. Researchers have made significant contributions by examining various aspects of IoT, including its utilization, benefits, associated risks, and the required technological infrastructure. However, a distinct gap exists in understanding how consumers perceive, adopt, and interact with IoT devices, their preferences, and the underlying behaviors influencing their choices.While IoT offers various benefits, there is a gap in literature regarding security risks associated with it and privacy concerns of users, therefore in-depth studies are required to investigate the potential negative outcomes of its use. This study aims to fill the gap in the literature and provides key information regarding the theories, contexts, characteristics and methodologies consumer behavior towards IoT technology. Moreover, most of the studies have been conducted in developed countries instead of developing countries. A key contribution of this study is that it provides the summarized information regarding all aspects of IoT while identifying its significant benefits and potential risks.The first section of review has briefly introduced the research area while discussing significance of study. Second section is about methodology in which details of framework has been explained. Third section is about findings of study, while fourth section is about future research directions.

Methodology

In this systematic review the theory development, characteristics, context and methodology framework (TCCM) was used as research methodology. The framework was first developed by Paul and Rosado-Serrano (2019) and has been used in several past reviews (Paul et al., 2017; Rosado-Serrano et al., 2018; Tsiotsou & Boukis, 2022, Terjesen et al., 2013). As per the framework and SPAR-4-SLR protocols by Paul et al., (2021), relevant literature was extracted from three renowned academic data bases namely Web of Science, Scopus and Science Direct, to increase the reliability of research.
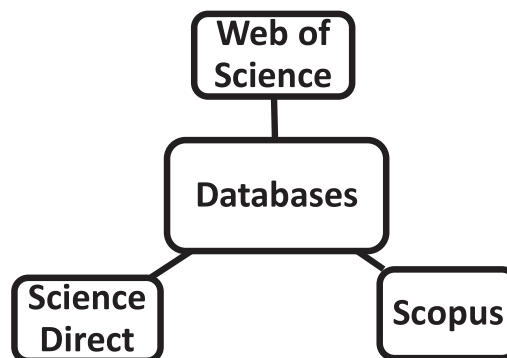
Figure 3: Included databases

Source: Authors

Initially, 123 results were found which were then refined based on language and title. 46 articles were excluded based on irrelevant titles. Shortlisted 77 eligible articles were observed. At this stage, 20 articles were excluded as their abstract was irrelevant. The content of 57 articles was read and 42 most relevant articles were shortlisted which have been included in the study. After getting the list of results obtained from three databases, the next step performed was to filter the results as per set criteria.

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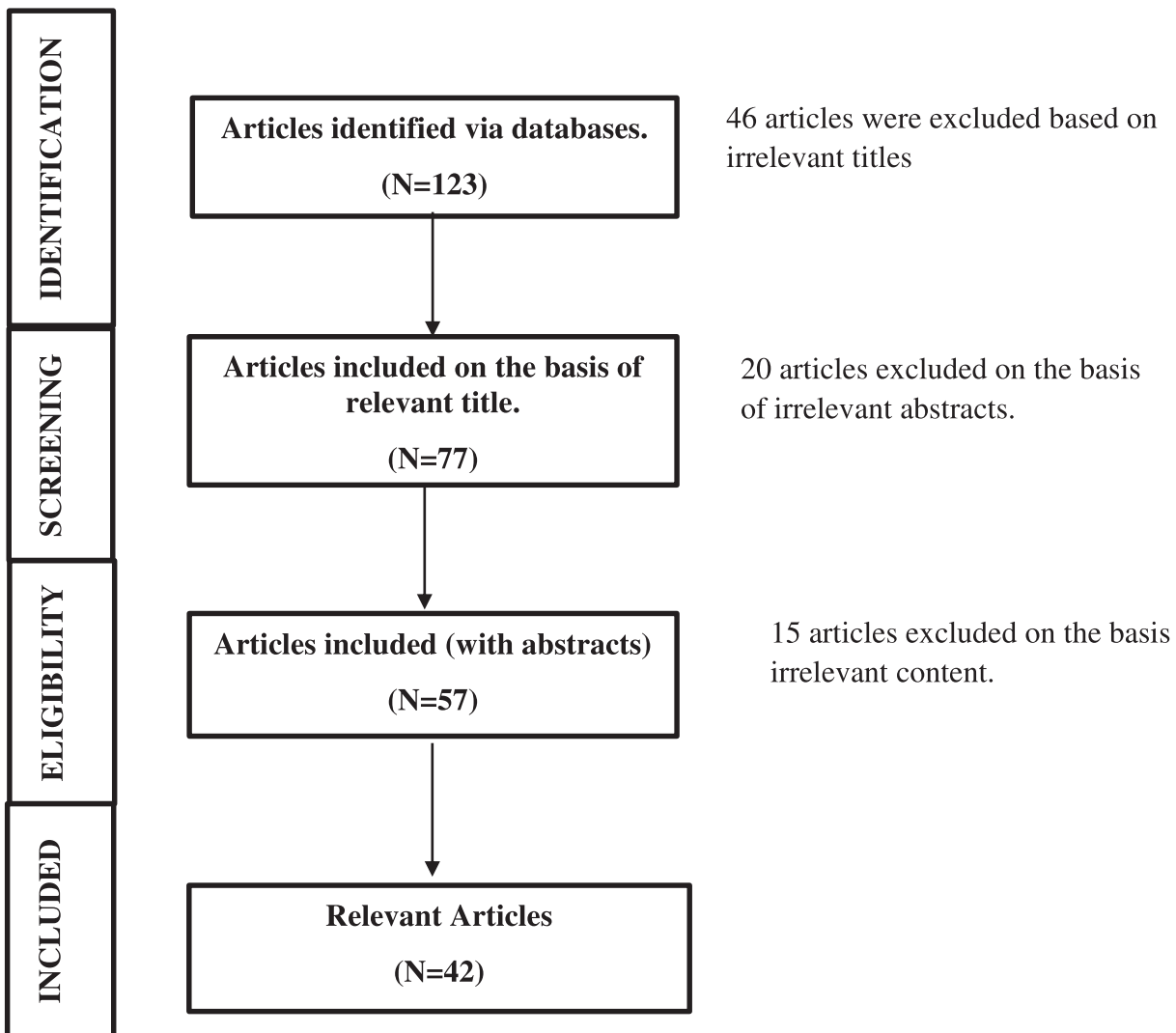
The following criteria were applied for the inclusion of papers in this review.

- Studies that focused on internet of things and its various characteristics
- Studies that focused on IoT adoption behavior of consumers
- Studies that discussed the drivers of IoT adoption by consumers
- Studies that that discussed the comparative approach of IoT adoption in developing and developed countries.

The main research questions which aim to answered through this research are:

- What are the key aspects of IoT, including its usage, benefits, risks, and technological infrastructure requirements, as identified by the literature from 2010 to 2022?
- How do consumers perceive and adopt IoT devices based on the existing literature?
- What are the factors influencing consumer preferences and behaviors regarding IoT devices?
- What are the contextual factors that impact the adoption of IoT technologies?
- What characteristics of IoT devices are highlighted in the literature as significant for consumer adoption?
- Based on the existing literature, what gaps or areas for further research in the field of IoT adoption by consumers have been identified?

This selection criteria is represented in figure 4.

Figure 4: *Selection Criteria of Articles*
Source: Authors

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Findings

A frequency analysis was conducted to describe the findings of this study which are presented as follows. The journals and conferences from where these shortlisted articles have been obtained are in table 1, and figure 3 will help to understand that research is based on valuable studies published in recent years.
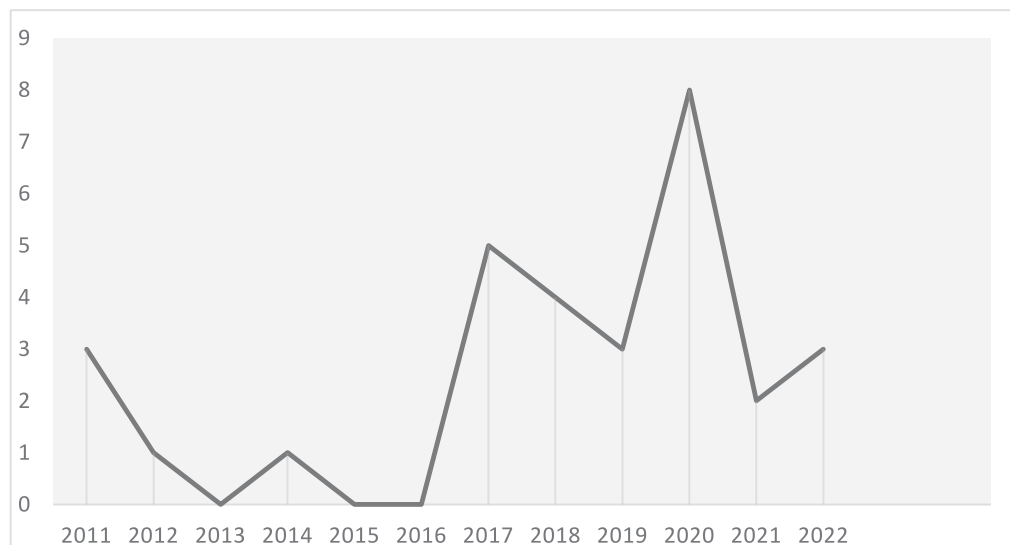
Table 1: Selected Business Journals and conferences

Sr. No.	Name of Journal / Conference		No. of publications
1	Future internet	Journal	1
2	IEEE Internet of things journal	Journal	1
3	International Conference on Information and Communication Technology (ICoICT)	Conference	1
4	Electronic commerce research	Journal	1
5	Journal of Indian business research	Journal	1
6	International Journal of Production Research	Journal	1
7	ACM Asia Conference on Computer and Communications Security.	Conference	1
8	IEEE Security & Privacy	Journal	1
9	2nd European Conference on Electrical Engineering and Computer Science (EECS)	Conference	1
10	International Symposium in Sensing and Instrumentation in IoT Era (ISSI) IEEE	Conference	1
11	2nd International Conference on Big Data and Internet of Things	Conference	1
12	IST-Africa Week Conference IEEE	Conference	1
13	Sensors	Journal	1
14	International Conference on the Economics of Grids, Clouds, Systems, and Services.	Conference	1
15	Information technology and People	Journal	1
16	International journal of consumer studies	Journal	1
17	IEEE Internet of things	Journal	2
18	2nd International Conference on Artificial Intelligence, Management Science and Electronic Commerce (AIMSEC). IEEE	Conference	1
19	ICTE, 2011	Conference	1
20	International Journal of Production Research	Journal	1
21	12th EAD Conference Sapienza University of Rome	Conference	1
22	Journal of International Consumer Market	Journal	1
23	IST-Africa 2011 Conference	Conference	1
24	10th International Conference on Frontiers of Information Technology	Conference	1
24	I.J. Intelligent Systems and Applications	Journal	1
25	Uncertain Supply Chain Management	Journal	1

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| 26	Journal of Cleaner Production	Journal	1
27	International Journal of Information Management	Journal	1
28	Energy and Built Environment	Journal	1
29	Global Transitions Proceedings	Journal	1
30	Proceedings of the 2018 2nd International Conference on Big Data and Internet of Things	Conference	1
31	Technological Forecasting and Social Change	Journal	1
32	IEEE international symposium on circuits and systems (ISCAS)	Conference	1
33	Computer networks	Journal	1
34	Behaviour & Information Technology	Journal	1
35	Journal of Marketing Management	Journal	1
36	IEEE international conference on pervasive computing and communications workshops	Conference	1
37	Global Business and Management Research	Journal	1
38	Energy Nexus	Journal	1
39	Future generation computer systems	Journal	1
40	Spanish Journal of Marketing-ESIC.	Journal	1
41	Journal of Enabling Technologies	Journal	1
	Total		**43**

Source: Authors

Figures 5 below depicts the publishing trend and research orientation of IoT adoption behavior of consumer's research in the last decade (2010–2022). Total of 42 articles have been reviewed in this study. The figure shows the rising trend in number of studies done over the last 13 years, particularly an upsurge from 2017 and shows an increasing trend since then. Most studies have been conducted recently as the technology is rather new and researchers are looking at it from various aspects.

Figure 5: Trends in research

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Source: Authors

In terms of research orientation 45% (19/42) studies are empirical which includes 16 quantitative studies and 3 qualitative study. Whereas 55% (23/42) studies are theoretical which explained the IoT and its usage in different context. These research orientations are represented by figure 6.

Research Orientation
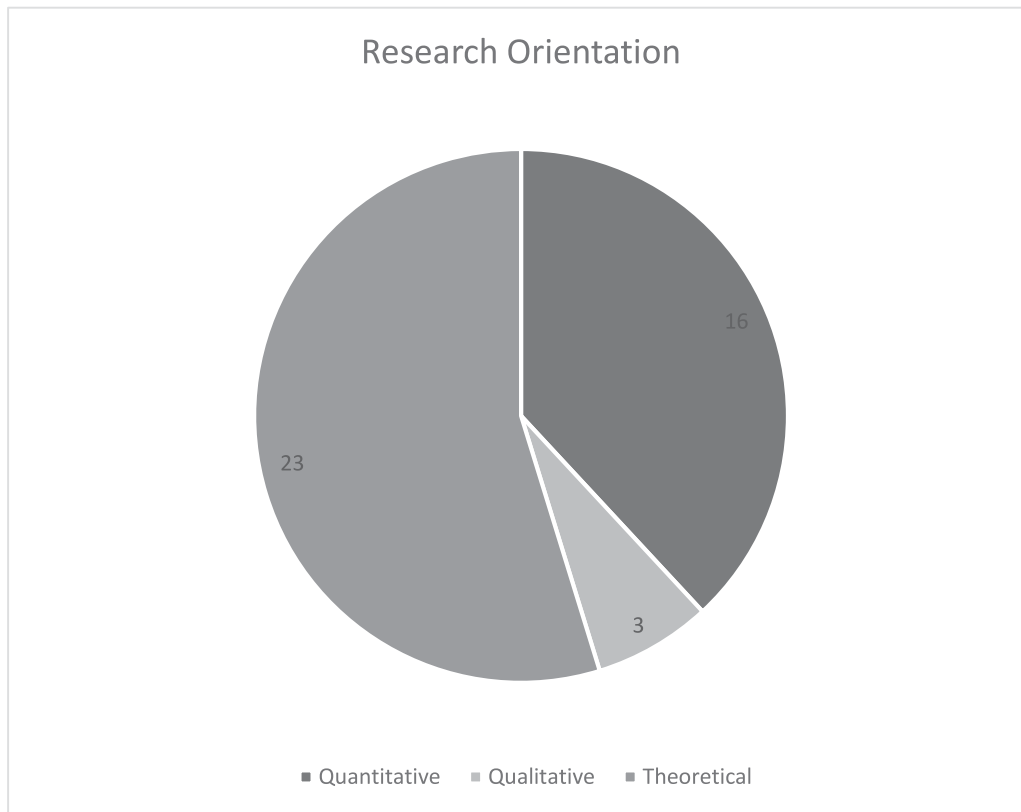
Figure 6: Research orientation

Source: Authors

Theoretical perspective

Various theories have tried to explain the adoption behavior of consumers regarding IoT adoption. Most of the articles included in the study did not include any theory while few articles included only one theory to develop research model.

TAM (Technology Adoption model)

Internet of things has driven innovations in various sectors and created opportunities by connecting objects and consumers through digital realm. The technology adoption model (TAM) aims to explain the adoption and acceptance of new technologies (Jaafreh & Al-abedallat, 2011). In this context, Davis (1986) proposed the TAM model based on modified Theory of Reasoned Action (TRA) to explain the determinants of user acceptance of new information systems. The model has been used in several studies to explain the human behavior towards adoption of new technologies by individual users (Abdullatif, Al-Dokhny & Drwish, 2022) and it explained the key constructs including perceived ease-of-use (PEOU), perceived usability (PU), attitude (AT), behavioral intention (BI) and actual use (U). The authors have discussed how consumers have developed positive attitude towards IoT due to its perceived usability and the resulting convenience. While examining consumer attitude towards IoT, studies discussed challenges and risks perceived in minds of customers regarding its use. The studies which have used TAM while explaining use of IoT are listed in table 2

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Table 2: **Studies based on technology adoption model***:*

Sr.no.	Authors	Year
1	Abdullatif, Al-Dokhny & Drwish	2022
2	Attié & Meyer-Waarden	2022
3	Thangamani, Ganesh, Tanikella, 2& Anumolu	2022
5	Morienyane & Marnewick	2019
5	Jaferah	2018

Source: Authors

United Theory of Acceptance and Use of Technology (UTAUT):

The unified theory of acceptance and use of technology (UTAUT), developed by Venkatesh et al. (2003), brought together the alternative views in users' acceptance of innovation. It suggests that there are four main constructs or direct determinants of behavioral intention. The constructs include performance expectancy, effort expectancy, social influence and facilitating conditions performance expectancy, effort expectancy, social influence and facilitating conditions. According to the model, age gender, experience and voluntariness can moderate the constructs (Venkatesh et al., 2003). It is argued that by assessing these constructs, researchers can predict the consumer's intentions to use the technology. IoT has been proved to be a technology that has extended the benefits of regular internet while providing control to the users, constant connectivity, and data sharing (Tsourela &Nerantzak, 2020).The authors admitted that it brings innovation and efficiency for everyone but still there is more research required regarding consumer perspectives about IoT and their acceptance level. They further added that the most used technology acceptance theories cannot be used to understand the consumer's acceptance and adoption of IoT devices as they have limited extensions. Whereas the Unified Theory of Acceptance and Use of Technology (UTAUT) and later to UTAUT2 models are more able to predict the consumer's adoption of IoT products. Studies that have employed the model in IoT technology adoption are listed in table 3:

Table 3: **Studies based on United Theory of Acceptance and Use of Technology**

Sr.no.	Authors	Year
1	Arfi, Nasr, Kondrateva & Hikkerova	2021
2	Arfi, Nasr, Khvatova 2& Zaied	2021
3	Robles-Gómez, Tobarra, Pastor-Vargas, Hernández & Haut	2021
4	Ronaghi & Forouharfar	2020
5	Almetere, Kelana & Mansor	2020
6	Tűrkeş, Căpuşneanu, Topor, Staraş, Hint, & Stoenica	2020

Source: Authors

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Theory of planned behavior (TPB)

The Theory of Planned Behavior (TPB), presented by Ajzen and Fishbein (1975), aimed to predict the intentions of an individual to engage in certain behavior at specific time and place. The theory was presented to explain the people's ability to exert self-control, and was used in studies to explain the usage behavior of consumers regarding IoT. There are six main constructs of theory of planned behavior which includes attitudes, behavioral intentions, subjective norms, social norms, perceived power and perceived behavioral control. The studies which have employed TPB as theoretical foundation are listed in table 4:

Table 4: **Studies based on Theory of planned behavior**

Sr.no.	Authors	Year
1	Malarvizhi, Manzoor & Jayashree	2021
2	Zaman, Zahid, Habibullah & Din,	2021
3	Hasan, Bao,Miah & Fenton	2021
4	Pal, Arpnikanondt, Funilkul, & Chutimaskul	2020
5	Fu &Wu	2018
6	Mital, Chang,Choudhary, Papa & Pani	2018
7	Yang, Lee & Zo	2017

Source: Authors

Context

Countries

Most of the studies have been conducted in developed countries compared to developing countries as the technology is rather new. Maximum number of studies have been conducted in China, which may be because a large number of manufacturers have their facilities located there and exporting to other parts of world. United States, Europe, Asia and some countries of Africa have been a focus of studies. It has been found that single country analysis is predominant while and there is lack of literature presenting cross country analysis, which is a gap in literature and an avenue for future research. Another gap is that developing countries have been ignored in past literature while they represent high portion of IoT markets worldwide. Table 5 shows the distribution of articles with respect to their location. Table 5 shows the number of studies and respective countries.

Table 5: **Global dissemination of research on Internet of things**

Country	Number of studies
Africa	1
Australia	2
China	9
Global	3
Greece	1
India	5
Indonesia	1
Italy	2
Japan and United states	1
Korea	1

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Malaysia	2
Netherland	1
South Africa	2
Thailand	1
Turkey	1
United Kingdom	2
United States	3
US and Australia	1
Oman	1
Iran	1
Spain	1
	42

Source: Authors

Characteristics

Literature in domain of IoT has been focused on identifying the benefits and opportunities which also acts as antecedents of IoT usage. Moreover, challenges and risks have also been addressed by several studies which directly affects the usage behavior of consumers.

Benefits and opportunities of IoT:

Lu (2018) discussed that the concept of IoT was first introduced in 1990 and gained the attention of Bill Gates, who wrote a book on it, realizing that technology is the future. IoT became an emerging field that involved other disciplines such as construction, energy, health care, resource utilization, biomedicines, and security networks. The author also raised the need for further research while integrating IoT with other disciplines to learn how it can be used by the industries to improve their services. Rimmer (2017), discussed IoT specifically in the financial services industry such as improving the workflow of financial systems for efficiency and better monitoring. Furthermore, the use of IoT is based on the type of user, needs, and banking application, which are determinants of selecting the right software and hardware for the banking companies.

While discussing the use of IoT in the healthcare sector Fattah, Sung, Ahn, Ryu, and Yun (2017) focused on helping the aging world population by using sensors to monitor health conditions and save them from accidents. Ramakrishnan, Gaur, and Singh (2016) also stated that the advances in networks and sensoring allow the users to connect them with hospitals and provide the required services without any delay. Fattah et al (2017) proposed an IoT-based system for patients of Alzheimer's for their better health care provisions.

Li and Song (2011) discussed the benefits of IoT for the manufacturing industry, such as the improvement of the operating performance of companies while helping them to reduce their costs. The study was conducted in China where the industry is quite mature. Zhou, Pei, Liua, Fua, and Pardalos (2020) have found that rapidly changing business environment and increased operational costs led companies to operate as virtual organizations. Such companies using IoT-based networks can save costs, provide high-quality service, quickly respond to clients and react to global changes swiftly. Table 2 has summarized the key benefits of IoT, identified in previous studies and how it helps to improve the lives of people. The table has also included the future research direction provided by the authors for new researchers.

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Table 2: Benefits of IoT

Sr. No.	Author	Year	Benefit of IoT	Future research direction
1	Coetzee & Eksteen	2011	Developing/emerging economies can benefit from IoT and provide smart service devices to environment IoT provides control, real time information and increases energy efficiency	Business, policy and technical aspects of IoT need to be studied in various aspects Devise integrated solutions while managing the potential privacy and security risks
2	Li & Song	2011	IoT increases the operational efficiency of manufacturing It helps companies control their bills by real-time monitoring	IoT companies need to conduct studies to present the efficiency level of IoT products Research is required to understand how IoT can add value to existing businesses
3	Rimmer	2017	Use of IoT to improve financial services Control thefts and monitor ATM withdrawals	Further research is required to implement the payment model between financial institutions
4	Fattah, Sung, Ahn, Ryu & Yun	2017	IoT can be used to monitor the aged population Suggested AIP system can be used to help patients of Alzheimer's patients to live a better life	Research is needed to improve/develop new systems to embed IoT in the health industry
5	Sun Lu	2018	Integration of IoT with other disciplines can improve efficiency	Studies required to provide supportive policies by government Development of standards is required for developing countries
6	Atlam, Alenezi, Allasafi & Wills	2018	The integration of IoT with block chain can be a strong combination to manage data, reduce risks and prevent privacy threats	As it's a new technology security is one the biggest challenge and required attention of experts and researchers Lack of computational resources and storage space issues needs attention
7	Rous, Janssen & Herder	2020	IoT has the capacity to deal with larger amount of data, link it from multiple sources, reduce operational costs and improve speed and efficiency	Studies are required to develop legal framework for its successful implementation, Moreover research is needed to study linking heterogeneous data from heterogeneous sources can cause data quality issues and create misleading information
8	Zhou, Pei,Liua,Fua & Pardalos	2020	Virtual firms based on IoT and sensors can save costs and improve efficiencies Interaction and responsiveness has been enhanced	The evidence of research is from China, therefore more studies are required from different regions to support results

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| 9 | Lawal & Rafsanjan | 2021 | IoT can be used in residential and commercial building to transform the conventional buildings in smart buildings

Healthcare, educational, restaurants and retail buildings can be most benefitted by IoT | Research can be done to successfully implement the IoT while managing the issues including data storage, processing and privacy |

Challenges and Risks Associated with IoT

Despite the benefits of IoT there are several challenges and risks associated with it. According to Bhatanger (2020), IoT devices, connected to the internet, provide real-time information; hence there is a likelihood of privacy risks and leakage of consumer data to the third parties. Therefore, it is important to obtain consumer consent before allowing the third parties aggregator to process IoT data. Bhatanger (2020) also emphasized the fact that evaluating the consumer privacy risks is an important factor while devising the marketing strategies for IoT products by companies.

In their study of the vulnerabilities and risks of IoT devices, Nakajima et al (2019) suggested that increased dependence on computers is becoming a safety issue for the public. The research was based on data collected from Japanese IoT manufacturing companies and analyzed their vulnerabilities. They found that most companies have vulnerabilities in their manufacturing and batch processing; therefore, they need to communicate with customers about potential risks involved in IoT devices. Jalali, Kaiser, Siegel and Madnick (2019) emphasized the fact that the IoT industry is rapidly growing but it also has some unavoidable consequences. The authors discussed that poor security of devices can have an impact on consumer acceptance of IoT-based products. Jalali et al (2019) also suggested that companies can invest in their cyber security capabilities, monitor the product risk-rewards, take responsibility for security, and capture data at a granularity level that depicts products' measurable benefits for customers.

Li, Guo, and Chen (2018) said that IoT devices are helpful to achieve 'intelligence' along with improving utilization and productivity. The authors used a comparative approach while discussing the policy framework and development of the IoT industry in different countries and found that China, which is the largest manufacturer of sensors and IoT-based devices, still needs to provide a better technological layer to meet the rapid growth in demand for sensors. They also discussed that IoT operating systems and platforms are still weak in China which affects the quality and functionality of their products.
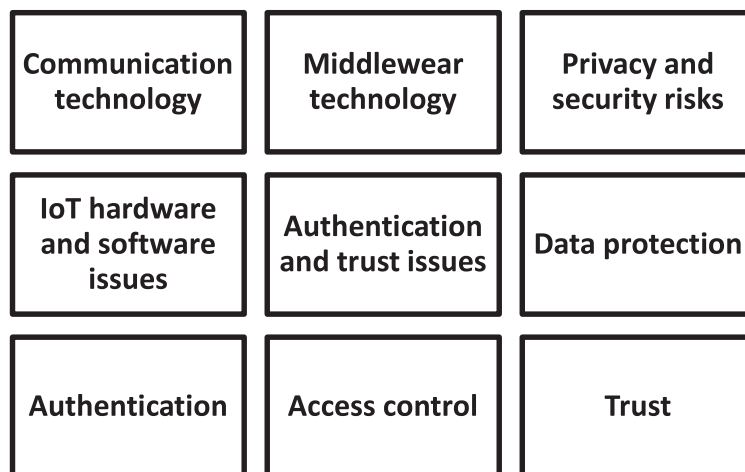
Communication technology	Middlewear technology	Privacy and security risks
IoT hardware and software issues	Authentication and trust issues	Data protection
Authentication	Access control	Trust

Figure 7: Risks and challenges of IoT

Source: Author

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IoT Adoption Behavior by Individual and Business users

Tsourela and Nerantzak, (2020) stated that some of the most influencing factors which affect the consumer acceptance and adoption of IoT products are security and privacy issues, personal characteristics, cost factors, and environmental factors.

Pal, Arpnikanondt, Funilkul, and Chutimaskul (2020) found that people living in developed countries are more likely to accept IoT products as compared to people living in developing countries. Alptekýn and Alptekin (2018) said that the increased awareness about new technologies and the wish to have more control over devices are the factors behind their rapid acceptance of new products. In their study, the authors found that enjoyment, subjective norms, and the effect of usefulness are the most important determinants of consumer adoption. Pal et al (2020) also suggested that integration of AI with IoT and cloud can be a successful combination and catch the attention of most consumers. Yasirandi et al (2020) have conducted a study in Indonesia and found that consumer adoption of IoT is greatly influenced by the policies and regulations of a certain country. The poor supportive policies and technological challenges greatly influence the consumer's perception of new technology. The authors suggested that communication networks, regulatory information technology knowledge, and affordable prices can drastically improve consumer's acceptance of IoT products. Shamshoddin, Khader, and Gani (2019) have also confirmed that companies should closely observe consumer preferences and consider them as an essential condition for working. The authors also proposed a neighborhood-based collaborative filtering model (SN-CFM) which recommends the products by predicting consumer preferences based on the similarity of the consumers and neighborhood products. Dong, Chang, Wang, and Yan (2017) conducted a study in China to see the usage of IoT systems in China and found that user's belief is not constant and it changes over time, based on their experience. They further added that the relationship between perceived ease of use and perceived enjoyment has the power to enhance consumer's experience. Dong et al (2017) also stated that experiences that come from outside marketing stimulate and predict the consumer's feelings about new products.

As per Brous et al. (2018) IoT adoption by organizations bears huge consequences and has the capacity to change the business process with automation. The author further suggested that moving towards new technologies and integrating them in system could be helpful to gain competitive advantage and improve efficiency. As per Herder et al. (2011) bringing innovation and adding new technologies can be challenging for organizations as they need stakeholder consultations, consider political tradeoffs due to lengthy process but the successful implementation can reduce process complications. The authors also found in their study that many organizations wrought about IoT changes based on their personal preferences of key people involved in process. Solomins and Spross (2011) said that there has not been any attention paid towards asset management through IoT which can actually be very rewarding and bring improvements. Though right use of IoT, organizations can see the difference in their work efficiency and performance. Table 3 shows the details of all the included research articles and conference papers along with their main themes and key findings.

Methodologies

Data Collection Methods and Analysis Techniques

The review has included 42 studies and 16 of them have used quantitative research methods. The survey has been used by those studies for data collection. Most of studies are done in single country context, therefore, the data has been collected from one country showing the limitation of study. There was only one qualitative study which used questionnaire for data collection and analysis was performed on that. Large number of studies have theoretical studies which examined the phenomenon from various aspects. Quantitative studies have used various software for data analysis such as SPSS, smart PLS and Amos. The qualitative study has been done using Envivo software for analysis. Table 3 includes all the details regarding studies which have been included in the review along with their research area, research design and key findings of study.

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Table 3

Summary of Conceptual and Empirical Research on internet of things

#	Authors & Years of Publication	Main Themes	Name of Journals / Conferences	Research Design	Main Findings	Category
1	(Atzori, Iera, & Morabito, 2010)	Highlights benefits, risks, applications of IoT. IoT integration with other disciplines	Computer networks	Theoretical	Described the benefits and risks of IoT while mentioning that scalability and efficiency issue still need to be addressed	Benefits, risks of IoT
2	(Coetzee & Eksteen, 2011)	Highlights benefits of IoT for developing/emerging economies while dealing with challenges	IST-Africa 2011 Conference	Theoretical	Described the utilization of internet for people and organizations Provided an overview of IoT risks and challenges while claiming that these can be major hurdles in IoT, but did not suggest ways to deal with challenges	Benefits and challenges of IoT
3	(Li and Song, 2011)	Analyzed operational efficiency of IoT in China Development of IoT Industry in China and regional differences	2nd International Conference on Artificial Intelligence, Management Science and Electronic Commerce (AIMSEC). IEEE	Quantitative	Analyzed the regional difference and the development balance from the perspective of the industry chain. Analysis of the technical efficiency from the perspective of industry chain. Lack of comparison between regions affected results	Benefits of IoT
333333	(Hongwei, Yan, Zuoan and Yuzhao, 2011)	Consumer acceptance of IOT technologies Role of perceived structural assurances	ICTE, 2011	Quantitative	Explored the intention of use IoT technologies based on the technology acceptance model (TAM) Role of IoT acceptance and consumer attitude towards IoT technologies. The study only focused on	Consumer acceptance of IoT

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					structural issues and ignored other variables	
5	(Khan et al, 2012)	Addresses the development trends of IoT and explaining the features and applications	10th International Conference on Frontiers of Information Technology	Theoretical	Identified several application of IoT in our lives i.e. prediction of natural disaster, industry application, water security monitoring, design of smart homes and medical applications	Applications and benefits of IoT
6	(Chen, Zhu, Li & Hu, 2014)	Status of IoT development in China, policies, and challenges	IEEE Internet of things	Theoretical	Challenges from research, industries, and the government regarding promotion of IoT industry Provided three-layer architecture and acting standards for future development.	Challenges of IoT
7	(Aono, Lajnef, Faridazar, & Chakrabartty, 2016)	Using IoT to monitor the condition of civil infrastructure	IEEE international symposium on circuits and systems (ISCAS)	Theoretical	Suggested path to implement IoT in assessing and keeping track of civil infrastructure	IoT application
8	(Dorri, Kanhere, Jurdak, & Gauravaram, 2017)	Use of Blockchain-approach to improve IoT security in smart homes	IEEE international conference on pervasive computing and communications workshops (PerCom workshops)	Theoretical	Current solutions for IoT, particularly for smart homes, are not substantial. Suggested low cost methods to deal with such issues.	IoT privacy and security risks
9	(Rimmer, 2017)	Role of IoT based cloud platforms in the Banking sector	IST-Africa Week Conference IEEE	Qualitative	Proposed an architecture to set up a cloud-based payment service for the Banking sector	Benefits of IoT
10	(Fattah, Sung,Ahn, Ryu & Yun, 2017).	Role of AIP services using standard-based IoT platforms and heterogeneous IoT products in the health care sector	Sensors	Theoretical	Proposed a tool, which is created that allows people to create AIP services efficiently.	Benefits of IoT

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11	(Vitali, Venanzio Arquilla & Tolino, 2017)	Analyzed the role of Design in the development of smart and interactive products for the consumer market,	12th EAD Conference Sapienza University of Rome	Theoretical	Demonstrated how new technologies based on IoT can increase efficiency and comfort Discussed the role of crowd-funding to boost the industry	Benefits of IoT
12	(Rahim, 2017)	Scope of IoT and Data Analytics for Developing Countries	International Conference on the Economics of Grids, Clouds, Systems, and Services.	Theoretical	Opportunities and importance of IoT for developing nations especially in Africa exploitation IoT potential and share IoT Technologies best-practices through the involvement of innovation communities and stakeholder	IoT in developing countries
13	(Dong, Chang, Wang & Yan, 2017)	Cognitive experience of Chinese customers regarding usage of IoT products	Information technology and People	Quantitative	Investigated moderating role of cognitive experience of consumers while using TAM Key driving factors in consumers' intention and behavior of using IoT systems	The customer experience of IoT products
14	(De Cremer, Nguyen, & Simkin, 2017)	Uncovers the risks and issues of IoT	Journal of Marketing Management	Theoretical	The dark-side of IoT should be addressed and move in the direction of more effective marketing practices.	Risks of IoT
15	(Leong, Ping, & Muthuveloo, 2017)	Determinants of adoption of IoT in the case of smart cities	Global Business and Management Research	Quantitative	Performance expectancy, etc., had a significant relationship with respect to IoT adoption. Experience moderates the relationship between these variables and behavioral intention to adopt IoT.	IoT adoption
16	(Alptekýn, & Alptekin, 2018)	Discussed decision support tool to introduce a design of smart, connected products in terms of typical	2nd European Conference on Electrical Engineering and Computer Science (EECS)	Quantitative	Proposed a tool to integrate sustainability into IoT design by considering energy efficiency and resources usage	Customer expectations regarding IoT

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		customer expectations.				
17	(Li, Guo, & Chen, 2018)	Development challenges of IoT in China	International Symposium in Sensing and Instrumentation in IoT Era IEEE	Theoretical	discussed issues regarding IoT development from an academic perspective suggested further improvements in the Chinese IoT industry	Challenges of IoT
18	(Lu, 2018)	Analyzed the stage of IoT development in China Contribution of China in IoT industry	Proceedings of the 2018 2nd International Conference on Big Data and Internet of Things	Quantitative	Presented multi-disciplinary cross-integration development trend of IoT in China Analyzed the development stage of IoT in the Chinese Industry	Benefits of IoT
19	(Reyna, Martín, Chen, Soler, & Díaz, 2018)	Analysed the advantages and challenges of IoT integration with Blockchain	Future generation computer systems	Theoretical	While integration of Blockchain and IoT is beneficial, the challenges and issues cannot be overlooked and need to be studied further	Challenges and opportunities of IoT
20	(Allhoff & Henschke, 2018)	Provides the foundation of ethical issues associated with IoT	Internet of things	Theoretical	Key ethical issues involved in adoption of IoT includes informed consent, privacy, information security, physical safety and trust	Ethical issues in IoT
21	(Atlam, Alenezi, Allasafi and Wills, 2018)	Integration of IoT and block chain for solving data and security issues	I.J. Intelligent Systems and Applications	Theoretical	Current IoT structures involves several issues of security and needs improvements Block chain can provide better peer to peer distribution network as a solution of security and scalability issues	IoT application and challenges
22	(Sivathanu, 2018)	Using behavioral reasoning theory to understand adoption of IoT based wearable	nal of Enabling nologies	Quantitative	Convenience and advantage offered by IoT based wearable devices are a major cause of their adoption. While usage and risk barriers prevent the	IoT adoption

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		devices to monitor health			adoption of such technologies	
23	(Shamshoddin, Khader, and Gani, 2019)	Predicting consumer preferences in the electronic market based on IoT devices	Electronic commerce research	Theoretical	A neighborhood-based collaborative filtering model (SN-CFM) has been Introduced to predict consumer preferences The model recommends the products by predicting consumer preferences based on the similarity of the consumers and neighborhood products	Consumer preferences
24	(Nakajima, Watanabe, Shioji, Akiyama & Woo, 2019)	Identification of vulnerabilities and their patches for the consumer IoT products	ACM Asia Conference on Computer and Communications Security.	Theoretical	Provided stark contrast in the vulnerability disclosures Highlighted alarming IoT vendor practices	Risks of IoT
25	(Jalali, Kaiser, Siegel, Madnick. 2019)	Focused to explain the cyber security risk in IoT technologies	IEEE Security & Privacy	Theoretical	Proposed 'Icebrug Model' for IoT products Used comparative approach to explain value and exploitation of Iot products	Risks of I0T
26	(Bhatnagar and Kumra, 2020)	Understand the motivation of consumers to share data through IoT devices and what are their key privacy concerns	Journal of Indian business research	Theoretical (experiment-based)	There are five consumer motivators (personal innovativeness, enjoyment of helping, anticipated extrinsic rewards, moral obligations, and venting negative feelings) that contribute to eWOT intention. Advance the understanding of human interaction with the computer though use of prototype	Risks involved in IoT

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#	Authors & Years of Publication	Main Themes	Name of Journals / Conferences	Research Design	Main Findings	Category
27	(Zhou , Pei , Liu , Fu & Pardalos, 2020)	Performance of IoT based companies Role of decentralization of operational decision authority facilitates	International Journal of Production Research	Theoretical	Operational decision authority facilitates the positive effects of operational resource on performance Provided directive guidance for IoT-based VEs to cultivate and acquire specific superior resources	Performance of IoT
28	(Chatterjee, 2020)	Identifying factors affecting the use of IoT by the potential users in a developing country	Behaviour & Information Technology	Quantitative	Both social media and WOM have almost an equal impact on the use of IoT in a developing country	Consumer perspective of IoT
29	(Zhou, Pei, Liu, Fu & Pardalos, 2020)	Effects of member enterprises' resource occupation on the performance of the IoT-based venture enterprise	International Journal of Production Research	Quantitative	Information and operational resources are positively associated with both business and market performance Strategic decision authority decentralized to SMEs with superior information enhances overall performance	Benefits of IoT
30	(Straker, Mosely & Wrigley, 2020)	Investigate current traditional market research (TMR) with deep customer insights (DCI) theory Utilization of the internet of things (IoT) for international firms	Journal of International Consumer Market	Quantitative	Understanding of the opportunity a technological intervention for international firms Provide a practical examination of IoT use in the field	Benefits of IoT
31	(Rous, Janssen and Herder, 2020)	Identifies IoT adoption behavior by organization and what key challenges are faced by them	International Journal of Information Management	Theoretical	IoT can benefit the organizations on operations and also help them manage data well. Risks of IT includes higher implementation costs, security risks, lack of trust and awareness.	Benefits and risks of IoT adoption

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#	Authors & Years of Publication	Main Themes	Name of Journals / Conferences	Research Design	Main Findings	Category
32	(Tsourela and Nerantzak, 2020)	Factors affecting consumer behavior regarding IoT products and applications	Future internet	Theoretical	facilitated appropriation, perceived usefulness, and perceived ease of use act as mediators and influence consumers' attitude and behavioral intention towards IoT The model used in research is rather old	Consumer Acceptance of IoT
33	(Pal, Arpnikanondt, Funilkul, and Chutimaskul, 2020)	Adoption and intention of IoT products acceptance	IEEE Internet of things journal	Theoretical	VAM (Value-based adoption model) has proved to be the greatest predictive power Enjoyments are the most strong factor influencing consumer intentions to buy IoT products	Consumer intention of IoT adoption
34	(Yasirandi, Rahmat., et al, 2020)	Adoption of IoT technology and challenges	International Conference on Information and Communication Technology (ICoICT)	Theoretical	The majority of respondents were not even aware of IoT technology People in developing countries are far behind in usage of the latest technologies though they believe it can help them improve quality of life	Consumer adoption and challenges involved
35	(Lawal and Rafsanjani, 2021)	Trends, benefits, risks, and challenges of IoT implementation in residential and commercial building	Energy and Built Environment	Qualitative	Presented recent approaches of IoT adoption in residential and commercial buildings. Suggested the use of present technologies with IoT technologies to come up with better solutions	Trends and risks of IoT
36	(Neeli and Patil, 2021)	Stated concerns in IoT regarding security and privacy	Global Transitions Proceedings	Quantitative	Discussed the issues in IoT realization Identified the major risks and challenges of IoT	Background, challenges concerning open, privacy, security aspects of IoT
37	(Saheb, Cabanillas, & Higueras, 2022)	Asses risks and benefits of IoT with respect to use of smart-watches	Spanish Journal of Marketing-ESIC.	Quantitative	Benefits of IoT lead to use of smart-watches Risks of IoT do not affect usefulness of smart watches but do affect how easy they are to use	IoT risks and benefits

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#	Authors & Years of Publication	Main Themes	Name of Journals / Conferences	Research Design	Main Findings	Category
					Further research can determine other risks and factors that impact adoption of IoT technology	
38	(Lee, Romzi, Hanaysha, Alzoubi & Alshurideh, 2022)	Benefits and challenges of IOT adoption	Uncertain Supply Chain Management	Quantitative	The study has revealed that most manufacturing companies are not aware that the latest technology, such as IoT, and how it can benefit their organizational performance	Adoption behaviors of IoT in manufacturing organizations
39	(Hu, Shahzad, Abbas & Liu, 2022	Adoption of the Green Industrial Internet of Things by manufacturing firms	Journal of Cleaner Production	Quantitative	Eco-sustainability motivations such as eco-efficiency, eco-effectiveness, eco-responsiveness, and eco-legitimacy lead to the adoption of the GIIoT.	Industrial IoT adoption and impact of advanced green technologies
40	(Kasilingam & Krishna,2022)	Adoption and willingness to pay for internet of things services by consumers	International journal of consumer studies	Quantitative	Perceived playfulness, personal innovativeness, and convenience value strongly affects the attitude and intention of IoT services use.	Factors affecting use of IoT devices by users
41	(Alraja, 2022)	Discusses risks related to (IoT) in health sector, taking gender differences into account.	Technological Forecasting and Social Change	Quantitative	Different results were observed for both genders. Risk perception might impact behavioral intention towards the use of IoT.	IoT adoption and application
42	(Obaideen, Yousef, AlMallahi, Tan, Mahmoud, Jaber, & Ramadan, 2022)	Understanding SMART irrigation systems with respect to IoT	Energy Nexus	Qualitative	IoT decreases the total cost of using technology for irrigation. Suggested ways to implement SMART irrigation systems	Application of IoT

Source: Author

Conclusion and Future Research Directions

Internet of things has gained immense attention from technological and academia experts and it has proven to be revolutionary future technology. It not only provides control of appliances and real-time monitoring but also improves energy efficiency and cost reduction. The studies which have been included in the research have analyzed IoT from different aspects while suggesting ways to improve products.

Following the TCCM framework, the future research needs to make major contribution in field of theory.

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Theory

There are theories and models, such as technology acceptance model, unified theory of acceptance and use of technology, to explain consumer behavior and technology adoption preferences by new users of IoT products. Future research can be done on consumer acceptance of IoT products while using Hofstede's Cultural Dimension (HCD) theory which can help understand how culture plays a role in constituting consumer's behavior and adoption of new products. As the technology is new, new theoretical dimensions can be useful to enhance the drivers of IoT adoption. Selvaraj and Sundaravaradhan (2020) suggested that security of data is a major concern for users so theories which address these concerns might significantly contribution towards literature.

Context

Studies have been done in the context of specific countries such as China, it is recommended to explore dimensions of IoT in different countries. At the same time it is important to conduct cross country analysis and comparative approach to produce more interesting results. Furthermore, research is required to analyze the key concerns regarding IoT adoption by the consumers and how information technology experts can make an effective contribution to address the concerned areas, and introduce IoT applications and products. Considering the vulnerability of technology and privacy concerns of users, more research is required to analyze the technological challenges in developing countries as they are still lacking in establishing the infrastructures for security networks. Furthermore, research can be done on policy-making framework for IoT as it is an emerging industry and needs the closer attention of policymakers and regulators.

Characteristics

Future research is required to integrate IoT with other disciplines, and assess how optimized meta heuristic techniques can be used to understand consumer preferences in the IoT market. It is also important to investigate potential negative consequences of IoT. Furthermore, the increased dependence on connectivity can lead to higher losses if the system faces an error. Therefore, new theories can be built in areas such as social commerce and consumer-computer interaction.

As IoT is the future of the world which is unified, pervasive, and seamless technology, therefore, the deployment of IoT devices at large scales requires well-designed standards and intelligent systems. Hence, studies can be done to analyze how it will become an inevitable trend in the IT industry while dealing with energy sustainability, interoperability, security, and privacy. While expanding the body of knowledge, future studies can be done to predict the benefits of IoT in the SME sector, telecom companies and financial institutions.

Methodology

The review has found that there is extensive scope in this area which can be explored while using different methodologies. Most literature used theoretical study method, hence it is suggested to conduct more studies using qualitative and quantitative methods. Understanding consumer behavior in domain of IoT using qualitative approach will give more objective results which can be used to enhance the quality of products and improve service experience of users. Furthermore, cross country analysis can direct IoT companies toward further innovation and better service quality. Focus group discussion can be used by researchers while focusing on security concerns   associated with IoT technology.

Practical Implications

The research has substantial practical implications for both industry and academia. In terms of industry, it underscores the critical need for a proactive approach to risk management and data privacy. As the Internet of Things (IoT) continues to expand its influence, companies in this field must prioritize the development of secure and resilient networks. Addressing concerns related to network dependence, connectivity issues, and data privacy is essential to gaining consumer trust and fostering widespread adoption. Furthermore, the study emphasizes the

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diversification of IoT applications. Companies should explore and capitalize on these prospects to cater to specific market needs and broaden their reach. From an academic standpoint, the research points to numerous promising areas for future investigation. It encourages scholars to delve into less-explored domains within the IoT landscape, seeking innovative solutions to its challenges. Given the multidisciplinary nature of IoT's impact, collaboration between researchers from diverse fields is essential. This approach can yield a holistic understanding of IoT's implications. Investigating consumer behavior related to IoT is crucial to grasp the psychological and cultural factors influencing technology adoption. Ethical and privacy concerns associated with IoT should also be at the forefront of academic inquiry. Developing ethical frameworks and guidelines for responsible IoT practices can provide valuable insights to both industry and society, contributing to the sustainable and ethical growth of IoT technology.

Conclusion

The recent literature aims to explain the internet of things (IoT) and its role in our lives. Various domains of IoT have been in discussion while highlighting its usefulness in homes and businesses, consumer perspective and adoption behavior and key challenges associated with it. IoT devices not only offer control over devices, but also increased the energy efficiency and provide real time information about device status. There have been increased usage of IoT devices in security, healthcare, education and energy sectors but still there are many other areas which these can be used to enhance performance and gain control. This research is a systematic review which is based on the articles published during last decade in highly credible databases. TCCM framework was used in methodology while discussing theory, context, characteristics and methodology. It has been found that literature discusses benefits and potential of IoT but there are several risks which are associated with technology such as increased dependence on network and connectivity and risks of privacy and data leakage. The companies offering IoT devices need to pay attention towards these challenges as they are major hurdles in its adoption by general consumers. Moreover, it is important to understand the different psychological needs of consumers in developing and developed countries and educate them about usage of IoT devices, to make life easier. The review not only provided useful insights from previous literature but also provided future research direction which can help researchers make significant contributions. This research contributes to academia by providing the summarized information regarding IoT which is a latest technology and has the potential to change lives. The study extends the literature to analyze the technology from business perspective and its potential benefits in various industries.

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