Internet of Things: A systematic Literature Review

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Overview paper

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Internet of things (IoT) is an emerging technology that is being used widely. The literature has no agreement regarding the factors that affect the adoption of IoT. The purpose of this study is to review the literature systematically using Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). Following this method, 69 articles were included in this review. A frequency analysis was conducted. The findings showed that number of articles reduced during COVID19. Higher education has the highest numbers of articles. Emerging economies are active in research about IoT. Technology acceptance model (TAM) is still the dominant adoption theory with majority of the reviewed articles are using quantitative method and large sample size to meet the assumption of using structural equation modeling. The most important predictors are the perceived usefulness, perceived ease of use, social influence, privacy, security, and trust. Other factors also included the variables of UTAUT. Decision makers are recommended to focus on usefulness and simplifies the process of using IoT as well as to create awareness about the application of IoT. Future studies are recommended to narrow the scope to one industry and to conduct more studies using mixed method or qualitative approach. More studies in developing countries are needed to explain the adoption of IoT.

Povzetek: V tem preglednem članku so analizirani faktorji, ki vplivajo na uspeh IoT sistemov.

1 Introduction

Internet of things (IoT) is a new technology that has attracted the attention of researchers and policy makers. From historical background, the IoT was introduced in 1999 and grow steadily during the 2000s [1]. In 2016, the adoption rate reached 11% and increased to 18% in 2018. However, the growth rate decreased to 8.20% in 2020 due to the outbreak of COVID19 which has slowed down the growth in this technology [2]. Nevertheless, the importance of the technology and its implications has increased after the COVID19 with the trend of turning digital all around the world. The expected growth of adoption is projected to reach 11.9% during the period of 2021-2024 [3]. Number of devices that uses the IoT technology has increased massively during the last ten years to reach a 26.7 billion in 2019 and is expected to reach 75 billion by 2025 [4]. Figure 1 shows the actual and expected growth of technology adoption of IoT.

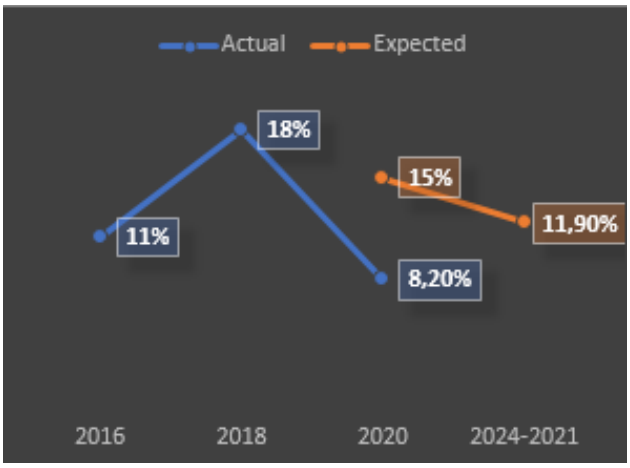

Figure 1: Actual and Expected Growth of IoT (Self-developed)

The drop in the adoption rate was examined in prior literature. Studies have no agreement regarding the factors that contribute to the adoption. While prior literature related the issue to the perception of individuals such as usefulness and ease of use [5], [6] other believe that it is more related to technological factors such as privacy, risk, trust, and security [7]–[9] or service quality of IoT [10] [11], [12]. The findings of prior literature regarding this matter is mixed and agreement has not yet to be reached. For instance, in term of the findings regarding the variables are varied with researchers found mixed result. Majority of previous studies found that variables such as performance expectancy (PE), effort expectancy (EE), and social influence (SI) are critical for the adoption of IoT [13]–[16]. On the other hand, EE and SI were found insignificant predictors of IoT adoption in other studies [17]. Similar conflicting result were found for attitude toward the IoT ([18], privacy [9], and security [19].

The differences in the findings could be related to the notion that prior literature deployed several types of theories. For instance, several studies indicated that

technology acceptance model (TAM) is one of the widely used adoption theory in IoT context [20], [21]. Further, prior review studies are limited in term of the number of articles i.e., 14 articles in [22] or in term of coverage between 1999-2017 in the study of [23], 2008-2020 in the study of [24] or the focus on the learning style and outcome using IoT such as in the study of [25]. Therefore, to understand the findings of prior literature and to draw a direction for future work, this study aims to review the literature and provides the audiences with recommendations to further their understanding regarding the factors that can contribute to the adoption of IoT. The following sections discuss the research methodology followed by a summary of reviewed articles as well as the findings, discussion, and conclusion.

2 Research methodology

Since this study is a literature review, the methodology is discussed to enable the reader to understand the process of selecting the articles. The literature of IoT adoption was reviewed systematically using Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). Keywords that are related to the topic were search in reliable databases such as the Web of Science (WoS), Scopus, ACM digital library, and IEEE Xplore. In addition, other sources such as google scholar were searched. The inclusion of Google Scholar because it include most of articles and they might be in an open access form. The key words include (("Internet of thing*" OR "IoT") AND ("Adoption of IoT" OR "Adoption of Internet of thing*") AND ("Factors" OR "Predictor*")). The internet of things might be written either in full or in short as IoT.

In total 921 articles were recorded. Duplicated articles were removed and this has resulted in reducing the articles to 541. A total of 147 articles were removed based on year of publication and language. Article must be published between 2017-2022 and written in English.

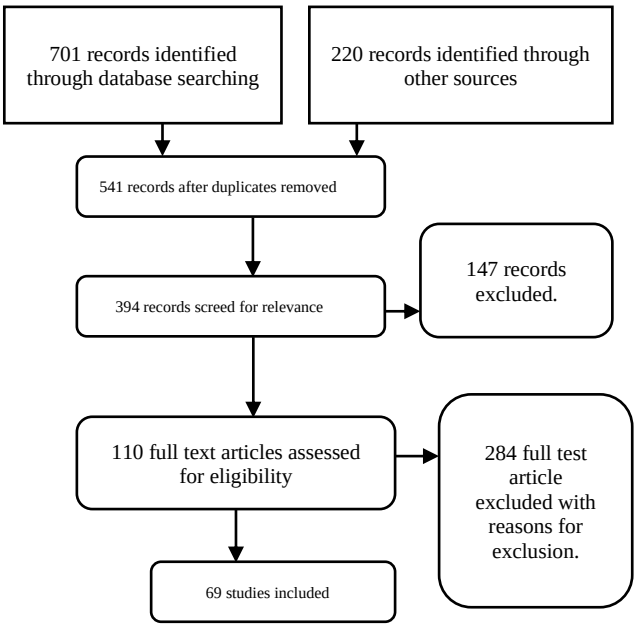

Figure 2: Process of selecting the articles

A total of 284 articles were removed with reasons for exclusion. These articles were either technical, does not Figure 2 shows the process of selecting the articles. Test hypotheses or include factors, or not in the information technology scope. 110 articles were fully read and this has resulted in including 69 articles in this study. The removed articles were not related to IoT adoption.

3 Summary of reviewed studies

This review study includes 69 articles. The articles are divided based on the theoretical underpinning theory or based on the countries. In this section, the article is reviewed based on dividing the countries on economic classification into the developed countries, emerging economies, and developing countries. Within each group, the theoretical underpinning theory is highlighted.

3.1 Developed countries

Several studies examined the adoption of IoT in developed countries. Developed countries here refer to North America and European countries as well as Australia.

3.1.1 UTAUT

Studies that have deployed the UTAT such as the study of [13] in Poland which examined the behavioural intention (BI) toward using IoT among young users. UTAUT was deployed and the findings showed that personal innovativeness affect the PE and habit which in turn affect habit and BI. Habit affect the BI to adoption IoT. In France, UTAUT2 was deployed by [26] to examine the intention to use IoT in healthcare. The findings are mixed. Accessibility, compatibility, and availability have significant effect on PE. Habit, PE, price value, and privacy concern (-) have positive effect on intention to use IoT while effort expectancy, facilitating condition, hedonic motivation, personal innovativeness, and social influence have insignificant effect on intention to use IoT.

The effect of EE and SI were also found not significant in the study of [27] in Spain who deployed UTAUT to examine the adoption of IoT among lecturers. The findings also showed that PE, FC, and attitude toward using technology have positive effect on BI. Additionally, age had a significant and positive effect on performance expectancy and effort expectancy. Wissal et al. (2021) examined the adoption of IoT E-healthcare in France using UTAUT model and found that performance expectancy and effort expectancy affected the adoption of IoT. Financial cost has a negative effect on adoption of IoT. Age is a significant moderator while gender is not.

3.1.2 TAM

The TAM model has been used in several studies as well. For example, in the USA, [7] examined the adoption of IoT using the TAM model in the agriculture sector. The findings showed that trust affects positively the perceived value and negatively the perceived risk. Perceived value affected positively and perceived risk affected negatively

the IoT adoption [7]. In Netherland, the study of [18] examined the adoption of smart IoT devices using TAM model and found that IoT skills affect directly the use of IoT. PU and PEOU are significant predictor of attitude but attitude of people toward IoT has no significant effect on the IoT use.

TAM was also deployed in the study of [28] in UK to examine the adoption of IoT in public sector. The findings showed that PU, empowerment, and information privacy affect the perceived value. However, information social support has no significant effect on perceived value. The perceived value affect the continuous use intentions. In New Zealand, [29] TAM deployed and the findings showed that PU, subjective norms, and trust affected the intention to use. Privacy concerns and PEOU have an insignificant effect on the intention to use IoT smart connected devices.

3.1.3 Combined theories

Researchers also combined more than one theories to explain the adoption of IoT. In a global study, [17] combined TAM2 with UTAUT2, to examine the adoption of IoT smart home. The finding showed that safety security, health, and convenience comfort affected the performance expectancy and habit. On the other hand, performance expectancy and habit affected the intention to use IoT. Effort expectancy, social influence, hedonic motivation, price value, and personal innovativeness have insignificant effect. In Greece, [30] combined TAM, TAM2, UTAUT, and TPB to examine the BI adoption of IoT products and Applications. The findings showed that cyber resilience affected facilitated appropriation. Social influence and trust affected the PEOU while PEOU, trust, facilitated appropriation, social influence, and cognitive instrumentals affected the PU. PU and PEOU affected attitude. Attitude affected BI.

Lu [31] in US examined the adoption of IoT using DOI and TAM. The findings showed that PEOU, PU, compatibility, and visibility affected the BI which in turn affected the well-being and perceived value. Elodie and Lars [32] in France deployed TAM, DOI, gratification theory, and privacy calculus theory to examine the intention and real use of IoT smart connected devices. The results referred to the importance of privacy issue.

3.1.4 Other approach

Ali et al. [33] conducted interviews with 40 students, academic, and non-academic staff in UK to examine the adoption of IoT. The study deployed ANT theory framework. The findings showed that there are three themes for using the IoT in higher education. The first is the expected effort, expected performance, and facilitating environmental conditions.

Studies that have not deployed theories but tested hypotheses. These studies included studies such as the study of [9] in UK examined the experimental based performance assessment of IoT and found that Trust in technology, risk, network online, and security affected the experimental based performance assessment of IoT. Privacy has insignificant effect. Aggarwal et al [34] examined the adoption of IoT by consumer for purchase intention in US. the findings showed that IoT risk knowledge has negative effect on purchase intention. Perceived device coolness and riskiness also have important positive and negative role respectively. IoT security concern moderated the effect of coolness and riskiness. In Italy, [35] did not deploy theory and examined the hypotheses related to the adoption of IoT in the transport and logistics industry. The findings showed that Firm size, absorptive capacity, and perceived benefits affected the IoT adoption. Age has negative effect. Perceived cost and innovative capacity has insignificant effect on the adoption of IoT.

In US, [36] did not deploy any theory to examine the continued intention to use IoT in several industries using hypotheses design. The findings showed that IoT awareness affected privacy and security. Privacy and security affected trust which in turn affected the intention to use IoT. The effect of awareness on trust was mediated by privacy and security. Trust also mediated the effect of awareness on IoT intention to use. In UK, [37] examined the awareness and the ability to implement IoT in business organizations using hypotheses design. The findings showed that access to information, collaboration with source, and lack of standardization affected awareness of IoT. Integration of IoT products, enhanced products and services, gain competitive advantage affected the business strategy to implement the IoT.

In France, the study of [38] examined the usage of smart services such as IoT in banking industry by testing hypotheses, individual mobiguity, self-congruence, perceived security risk, perceived complexity, perceived government surveillance, and general skepticism toward IoT are important for the resistance to smart services such as IoT. Content analysis was used in the study of [39] to examine the use of IoT in the Swedish public sector. The findings showed that complex ecosystem interplay of public and private actors, including lack of common guidelines, sparsity of expertise, and each respective agency's evolving roles in an increasingly connected society.

3.2 Emerging economies

Several studies have been conducted in emerging economies. In the following sections, the study are briefly discussed based on theoretical adoption theory.

3.2.1 TAM

In China, [40] examined the use of IoT smart home using TAM. The findings showed that PEOU, perceived intelligence, perceived convenience, and perceived privacy risk affect the PU. PEOU and perceived privacy risk affect the intention to use IoT. Cognitive experience moderated the effect of PEOU and perceived privacy risk on PU. Affect experience moderated only the effect of PEOU on PU. Intention to use IoT affect the actual use of IoT. Wang [41] used TAM to examined the BI of using IoT among users of Library in China. Information quality and information environment quality affected PU and

PEOU. PEOU affected PE. PEOU and PU affected attitude which in turn affected the BI and mediated the effect of PU on BI. In Saudi Arabia, [42] examined the adoption of IoT among consumers using TAM model. The findings showed factors that affect trust can be grouped into three categories. First the product related factors, followed by social influence related factors and the security related factors. The trust is expected to have direct effect on the intention to use IoT.

TAM was also used in the study of [43] to examine the BI toward IoT adoption in healthcare in India. The findings showed that trust and privacy concern affected PU and BI. Privacy concern and PEOU affected PU and PU affected BI. Singh and Msibi [21] in South Africa examined the adoption of IoT in higher education using TAM and deploying a mixed method. The findings of the study showed that factors of TAM as well as the positive attitude toward PEOU, PU, along with user satisfaction have impact on the adoption of IoT. Alanazi and Soh [44] in Saudi Arabia examined the adoption of IoT in healthcare sector using TAM and found mixed findings. Variables such as cost, PU, and privacy were more related to the adoption of IoT compared with attitude, and connectedness. Respondents do not differ based on gender.

In Malaysia, TAM was deployed by [45] to examine the attitude and intention to use IoT in universities. The findings showed that PU only affected attitude. PEOU did not affect attitude. PU and attitude affected the intention use IoT. In Turkey, [6] examined the intention to use IoT using TAM among Firm employees. The findings showed that PEOU and SI affected the PU. In addition, PU, PEOU, and social influence affected the intention to use IoT. PU mediated the effect of PEOU and social influence on intention to use IoT.

3.2.2 UTAUT

UTAUT was deployed alone in previous studies. For example, UTAUT was also deployed in the study of [15] to propose a model of IoT adoption among public universities in Saudi Arabia. The study proposed that variables of UTAUT such as PE, EE, SI, and FC along with psychological capital will affect the adoption of IoT by students. Behavioural intention is a mediating variable in this study between the actual usage of IoT and the independent variables.

3.2.3 Combined Theories

Studies in emerging economies combined several theories to explain the adoption of IoT. Shin [46] in South Korea used the IS success, TRA, and TPB to examine the adoption of IoT wearable devices. The findings showed that content, system, and service quality affected utility value and hedonic value. Utility and hedonic value affect the satisfaction which in turn affected coolness and affordance and the user quality experience of IoT. Pal et al. [47] in IoT smart home in Thailand examined the usage using multidimensional development theory as well as innovation resistance theory. The findings showed that user skill have negative effect on smart home privacy concern while technological aspect and legal and policy aspect have positive effect. Home IoT and smart home privacy concern affect positively the user resistance. [5] examined the effectiveness and the explanatory power of three theories such as TAM, TPB, and TRA in explaining the adoption of IoT smart device in India. The findings showed that the explanatory power of the three models are medium to low. Similarly, [48] examined the same theories and found that the results supported the TAM. The analysis reported that PU had a significant influence on respondent's intention to use IoT based smart devices. The effect of PEOU is found to contribute more than PU on the intention to use smart devices.

TAM, UTAUT, and DOI were combined in the study of [49] in Malaysia to examine the IoT usage. The study proposed a framework where the independent variables are expected to have a significant effect on the IoT usage. TAM, DOI, technological innovativeness, privacy calculus theory, and protection motivation theory were combined in the study of [50] in Turkey to examine the BI to use IoT in healthcare. The findings showed that perceived advantage (PA), image, and PEOU constructs have a significant effect on intention to adopt IoT healthcare technology products.

In the study of [19] in Iran, the author deployed TAM and DOI to examine the attitude, BI, and use of IoT. The findings showed that privacy affected observation while access control did not. Observability, trialability, compatibility, policy enforcement, and PU affect the attitude toward use. Trust has a positive relationship with compatibility. Mobile security did not affect the PEOU. Secure middleware affected PU. PEOU has insignificant effect on attitude toward using IoTs in smart transportation.

The model of IS success and UTAUT were combined in the study of [10] to examine the acceptance of IoT in Public university in Indonesia. The findings showed that information, system, and service quality affected the end user satisfaction and acceptance of IoT. The end user satisfaction affected the acceptance of IoT. In India, [51] combined the behavioural reasoning theory and the DOI to examine the adoption of IoT in healthcare wearable devices. The findings confirmed that the reason for adoption of IoT based healthcare wearables is affected by ubiquitous, relative advantage, compatibility, and convenience while the reason against adoption of IoT based healthcare wearables is related to usage barrier, traditional barrier, and risk barrier. Value of openness to change affected the reason for adoption and against the adoption while it does not affect the attitude toward the IoT based healthcare wearables. Reason for adoption and reason against the adoption affect the attitude and together with attitude affect the adoption intention of IoT based healthcare wearables.

Khan et al. [52] In China examined the willingness to adopt IoT using DOI and TAM. The findings showed that relative advantage, compatibility, and trialability affected the perceived novel benefits and perceived performance. Perceived novel affected perceived performance, and both affected the willingness to adopt IoT. Other studies were conceptual in nature such as the study of [53] in Malaysia which aimed to examine the adoption of IoT among oil and gas sector. The study

deployed TOE and DOI and proposed that there are three categories of factors that can affect the adoption of IoT.

3.2.4 Other theories and approach

DOI was also deployed in reviewed studies. For instance, in the study of [54] in India examined the adoption of cloud of things in SMEs using DOI theory. The findings showed that cost saving, relative advantage, sharing and collaboration, security, and privacy affect the intention to adopt cloud of things. Hsu and Lin [55] deployed value based adoption model (VAM) in Taiwan to examine the IoT services. The findings showed that PU, perceived enjoyment, and perceived privacy risk (-) affected the perceived value which in turn affected the adoption of IoT. Perceived fee has insignificant effect. Shin and Hwang [56] deployed the IS success model in healthcare in South Korea and found that the adoption of IoT is more related to the quality and the satisfaction of the users with the technology. The findings showed that Information, system, and service quality affect utility and hedonic which in turn affected satisfaction. Satisfaction affect coolness and affordance. Coolness and affordance affect the quality of user of IoT. Utility and hedonic played mediating roles.

Studies that did not deploy theories and tested hypotheses were also found in the literature. For instance, In India [57] examined the intention to use and willingness to pay for adopting IoT product. Playfulness, innovativeness, and convenience were the most important factors. Attitude played a mediating role. In a more generic study to identify the factors that affect the adoption of IoT in Indian public sector, the study of [58] found that people, technologies, process, and data security as well as competitive advantage are the factors of using IoT in public sector in India. The study also found that interoperability played a mediating role.

In Romania, [59] no theory was deployed. However, a set of hypotheses were tested. The findings showed that IoT adoption affected intra and extra university connectivity, excellence in teaching activity, excellence in learning activity, data security and integrity, and additional resources. Education policies affected the IoT adoption. In Romania also and in tourism sector, [60] examined the adoption of IoT and found that convivence, awareness, habits, cost, age, and education have significant effect on the adoption of IoT by tourists. [61] in India examine the awareness and adoption of IoT in education. There is variation in the awareness among students regarding the cost, safety and convivence. In Brazil, a qualitative study was conducted by [62] to examine the adoption of IoT in Business organizations. The findings showed that the case study approach has shown that there are four categories of factors that are the internal, external, IoT technological, and suppliers' dimensions that are critical for the adoption of IoT.

Among the reviewed studies, some studies have conducted a review of the literature to understand the status of the adoption of IoT. For instance, [22] reviewed 14 articles pertaining to the adoption of IoT in education. The findings showed that digital literacy is critical for students to enhance their knowledge, skill, and performance. Kassab et al. [23] reviewed 89 articles between 1999-2017 pertaining to the adoption of IoT in higher education and concluded that most of studies conducted in China, US, and Spain. The challenges of using IoT in education include security, scalability, and humanization. Similarly, a review study conducted by [24] included reviewing 410 articles between 2008-2020 showed that most of published articles were in US and there is an increase interest in IoT during the COVID19. Razzaque [25] reviewed the literature and concluded that learning style will have a positive effect on the learning outcome. Adopting IoT play a significance role on learning style and learning outcome.

3.3 Developing countries

Several studies have been conducted in developing countries. For instance, a study of [63] in Kenya, indicated that the usage of IoT in higher learning has become essential. Nevertheless, a study by [64] discussed the usage of IoT in developing countries and concluded that there are several benefits and challenges that might face the adoption of IoT which still in its infancy stage in developing countries. In this study, the articles are classified based on their theoretical adoption theory.

3.3.1 UTAUT

Hashim and Al-Sulami [65] examined the adoption IoT among students and lecturers in Iraq using UTAUT and found that SI, EE, security, and PE affected the BI which in turn along with FC affected use behaviour. Ireda et al [66] in educational sector in Libya, deployed UTAUT2 to proposed a model of cloud IoT adoption. The study proposed individual factors, institutional factors, technological factors, and demographic factors for the adoption of IoT. Similarly, UTAUT2 was also deployed by [14] in Pakistan to propose a model of IoT adoption in higher education. Variable of UTAUT2 such as PE, EE, SI, FC, hedonic motivation, and price value as well as other variables such as privacy risk, security risk, trust, and demographics were proposed to affect the acceptance of IoT. In 2021, [67] in Pakistan also proposed a model of acceptance of IoT in higher education using UTAUT2.

3.3.2 TAM

In Bangladesh, [20] deployed TAM to examine the adoption of IoT. The findings showed that PEOU, awareness and trust, affordability and ability, and PU affected the adoption of IoT. In Palestine Local government, TOE was deployed in the study of [68] to examine the adoption of IoT. The findings showed that organizational factors, technological factors, environmental factors, relative advantage, safety, and political factors are all important. The variables are due to gender, age, scientific qualification, field of specialization, total years of experience, and managerial level.

3.3.3 Combined theories

Previous studies also combined more than one theory to explain the variation in IoT adoption. TAM and UTAUT were used in the study of Thuya (2020) in Vietnam to examine the adoption of IoT among Consumers. the findings showed that perceived innovativeness affected PEOU, PU, and attitude. Social influence, perceived risk, PEOU, and PU affected adoption intention. Rico-Bautista et al. (2021) proposed a model to examine four technology such as IoT, cloud computing, AI, and big data in smart universities. The author concluded that the most widely used theories in IoT adoption is TPB, TAM, TRA, UTAUT, and UTAUT2.

TAM was combined with IS success and cognitive theory to examine the adoption of IoT in public sector in Pakistan. Service quality, information quality, and system quality affected the PEOU. Decision transparency and trust in government affected public trust. Service collaboration, service effectiveness, Service transparency, and public engagement affected the PU. PEOU, PU, and public trust affected the usage behavior which in turn affected public value creation. PEOU and PU affected public trust [71]. In similar approach, TAM, UTAUT, and TPB were combined in the study of Hu et al. (2020) to examine the adoption of IoT in public sector in Pakistan. The findings showed that PE, information privacy, and trust in government affect the public trust. SI and FC affected the digital society affinity. Digital society affinity affected perceived value and intention to use. Perceived value affected the intention to use IoT.

TAM, DOI, and UTAUT were used by Alhasan et al. (2020) to examine the adoption of IoT among healthcare personnel in Iraq. The findings revealed that compatibility and image of the DOI factors, have a significant impact on the PEOU, PU, and BI, but trialability has a significant impact on PEOU and PU and insignificant impact on BI. Privacy and cost significantly impacted doctors' BI to use. Computer self-efficacy significantly influenced the PEOU, PU, and BI to use. Furthermore, PEOU has a significant impact on PU and attitude. PU has a significant impact on attitude, which, in turn, significantly impacts doctors' behaviour toward the intention to use it.

3.3.4 Other approach

Al-Hashimy et al. (2019) in Iraq, did not deploy a theory but examined hypotheses. The findings showed that awareness, security, cost, government support, collaboration, and professional behaviour affected positively the IoT adoption Healthcare. Mashal and Shuhaiber, (2019) in Jordan examined the adoption of IoT smart home. The author included personal factors and social influence factors. The findings showed that user awareness, perceived cost, perceived enjoyment, personalization, user trust, and social influence affect the intention to buy IoT smart home.

4 Findings

The findings of this article is based on frequency analysis. Excel was used to draw the figures based on their frequency in the 69 articles.

4.1 Year of publication

Year of publication is shown in Figure 3. It shows that the number of articles has increased steadily over the years. From 2017 to 2020, number of articles has shown increasing trend. As shown in the figure, the number of articles reduced after 2020 and this could be due to the focus on the COVID19 or due to the notion that articles in this study were reviewed until February 2022.

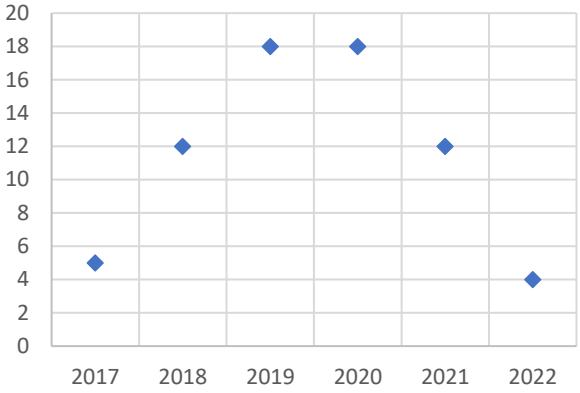

Figure 3: Year of Publications

4.2 Countries

Figure 4 shows the distribution of articles based on countries. It shows that based on country analysis, India received the highest number of articles followed equally by US, UK, and Pakistan. In term of economic classification, number of articles in emerging economies (44%) is the highest followed by developed countries (30%) and developing countries (26%).

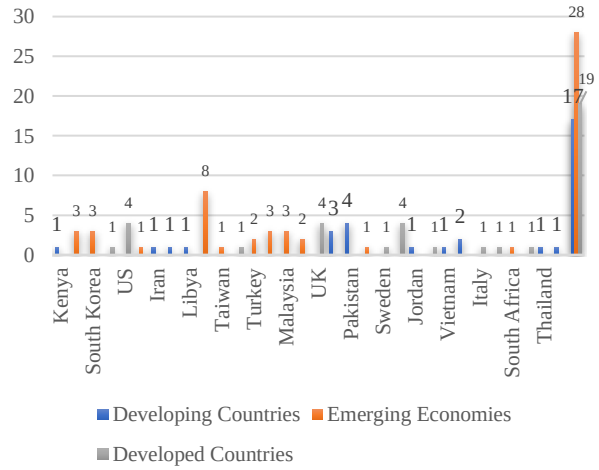

Figure 4: Distribution of Studies based on countries and economics category

4.3 Industry

The IoT has been used in several industry. One of the industry that received the highest number of articles (28%) in the higher education. This includes the application of IoT in smart university, library, and learning management system (LMS). The second industry, is the consumer industry (15%) and it includes the young consumers, product and services that are obtained using IoT by consumers. Third is the business organization (14%) which includes SMEs, services and manufacturing companies. Healthcare (12%) and public sector (12%) were also among the frequently examined industries. Figure 5 shows the distribution based on industry.

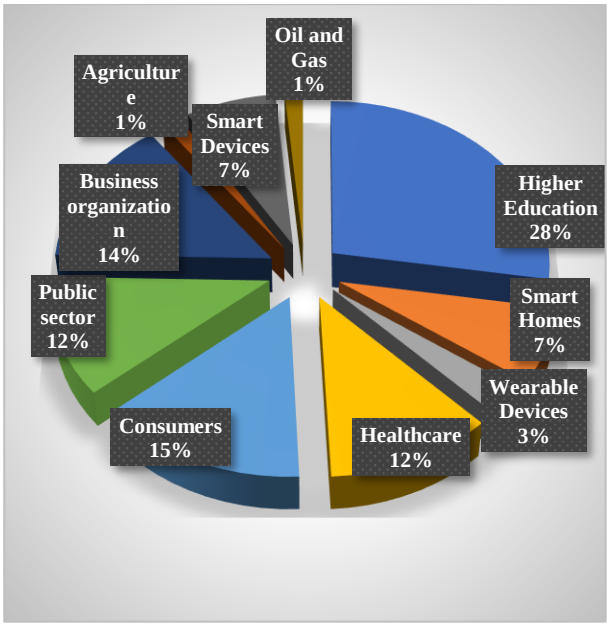

Figure 5: Distribution of articles based on Industry

4.4 Theoretical framework

Theories that have been deployed by researchers to examine the adoption of IoT is shown in Figure 6. It shows that TAM is the highest deployed model followed by UTAUT. Other models such as Technology organization environment framework (TOE), diffusion of innovation (DOI), Information system success (ISS), value added model (VAM), and ANT theory. The reviewed studies included 42% single theory followed by 30% multiple theories and 28% did not use any theory.

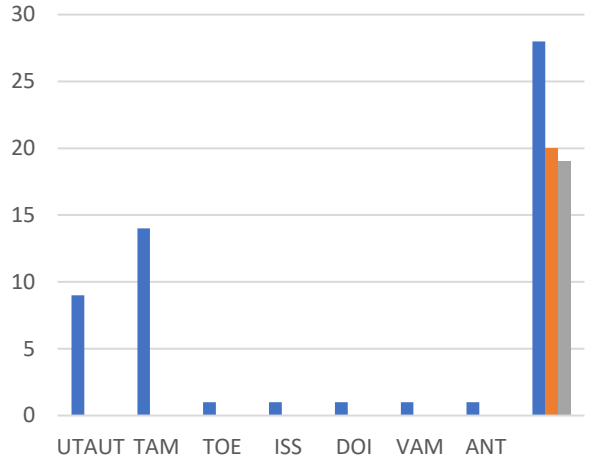

Figure 6: Distribution of Study based on Theory

4.5 Approach

The reviewed studies can be divided into five approach. The quantitative studies accounted to 75% followed by the conceptual papers with 9%, the review articles 7%, qualitative studies accounted to 6% and 3% are mixed method. Figure 7 shows the approach that has been used in previous studies.

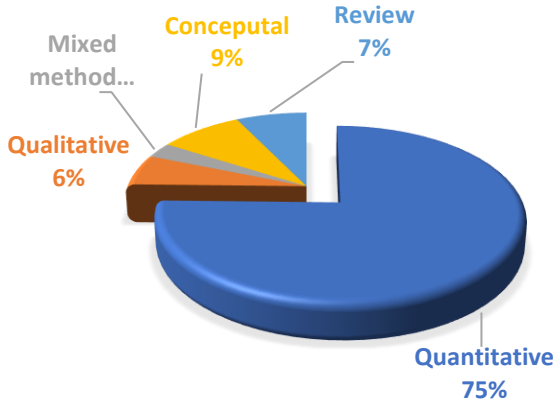

Figure 7: Distribution of Studies based on approach

4.6 Sample size

Among the quantitative studies, 51% have used a sample size between 62 and 352 respondents. A total of 34% of the reviewed studies used a sample size between 352 and 642. 7% has used a sample size between 652 and 932. 2% of the studies were having large sample size of more than 1000 responses. Overall, the mean of sample size account to 389 with minimum sample size of 62 responses and maximum of 2007 respondents. Figure 8 shows the sample size.

4.7 Data analysis

The data analysis technique is given in Figure 9. Data analysis can be divided into first generation such as SPSS

and second generation such as the structural equation model which includes Smart Partial Least Square (PLS) and Analysis of a Moment Structure (AMOS). SPSS was deployed in 21% of the studies while PLS in 44% and AMOS in 35%. This makes the second-generation accounts to 79% while the first generation received 21%. Figure 9 shows the distribution of studies based on approach and data analysis techniques.

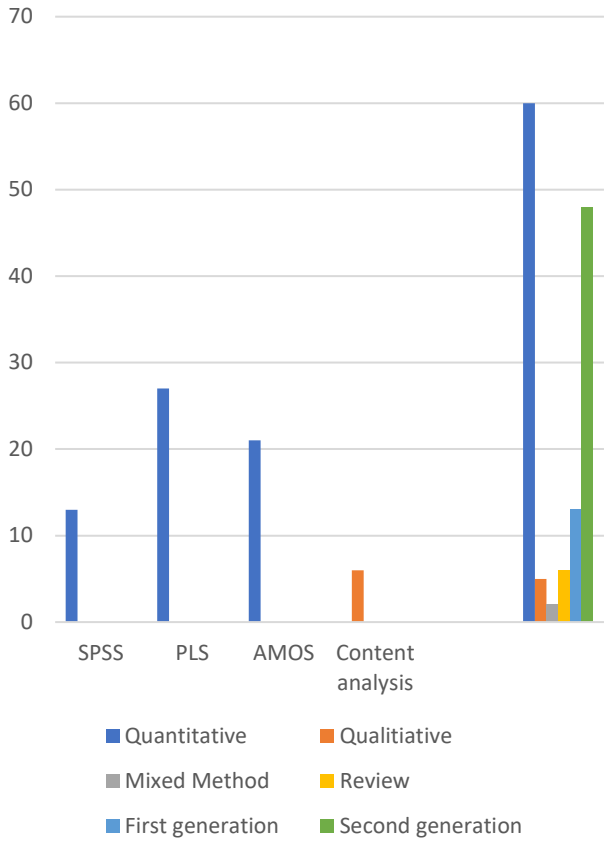

Figure 9: Data Analysis Technique and Approach

4.8 Important Predictors of IoT adoption

Based on a frequency analysis of the 69 articles that has been reviewed in this study, the highest frequent variable is the perceived usefulness (PU) followed by perceived ease of use (PEOU), social influence (SI), privacy, security, trust, effort expectancy, performance expectancy, facilitating condition, and attitude. Other factors were less frequent in the reviewed studies. Figure 10 shows the frequency of factors.

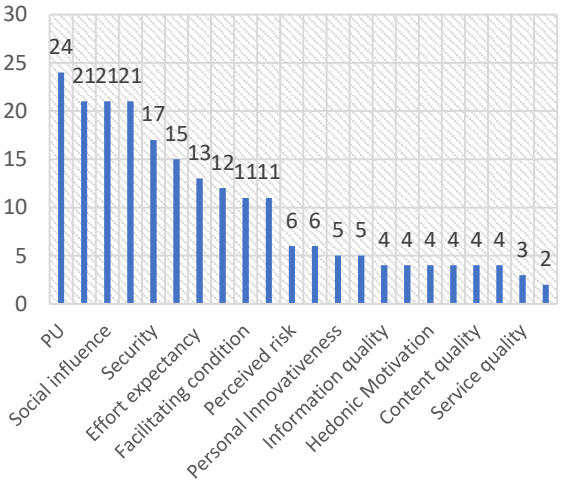

Figure 10: Frequency of Factors

5 Discussion

This study was conducted to assess the status of the literature regarding the adoption of IoT. The study deployed PRISMA technique of systematic literature review. The study included 69 articles. The findings showed that number of articles published about the IoT has decreased during COVID19. The adoption rate also decreased to 8.2% in 2020 from 18% in 2018. Developing countries still suffer from lack of studies in term of IoT while there is an increasing trend in the number of studies in emerging economies such as India. Higher education is receiving more attention with the application of IoT is deployed in smart learning and library followed by consumers, business organizations, and healthcare. Lack of studies can be seen in sectors such as wearable devices, agriculture, and oil and gas.

In term of theoretical framework, TAM is still the dominating theory in IoT. However, UTAUT is increasing being used by researchers. Other theories such as DOI, TOE, ISS is less frequently used. Interestingly, the literatures are still dominant by a single theory or no theory were hypothesised or developed based on the context of the study rather than a theory of adoption. The quantitative approach is deployed by the majority of reviewed studies with lack of mixed or qualitative approach. Sample size ranged between as less than 100 respondents to over than 2000 respondents. Mean of sample size is above the cut-off value of using SEM as recommended by researchers such as Kline (2015) and Hair et al. (2017). This explains the increase use of Smart PLS and AMOS as technique for data analysis that requires high number of responses compared with SPSS.

The important predictors of IoT based on the reviewed studies are the TAM variables such as PU and PEOU. This is also in line with the findings that TAM is the most widely used theoretical adoption theory in IoT. The predictors also indicated that social influence from UATAT and other variables which do not belong to any adoption theory such as privacy, security, and trust. In addition, other variables of UTAUT which include the effort expectancy, performance expectancy, facilitating

condition along with attitude from TAM are the most critical factors for IoT adoption across industries and countries.

Decision makers that intended to enhance the adoption of IoT have to focus on these predictors and to enhance the usefulness of using the IoT as well as simplifies the process. Social influence which is the influence of others on the individual's decision to adopt a technology is critical and this can be enhanced by understand and the awareness about the benefits of IoT across industries. Since IoT is involved in smart homes, medical applications, and other informational-based applications, the privacy and security are critical factors for enhancing the adoption of IoT. Decision makers have to focus on improving the privacy by acting on laws and regulation that protect the users.

6 Conclusion

This study was a literature review based on existing studies in five years period. The study is limited to the searching criteria, timeframe, and keywords. To extend the findings, future researcher are recommended to conduct more review of the literature using different terms such as to focus on one industry such as higher education, medical care, and public sector. The number of studies dropped between 2020-2022, more studies are needed to examine the adoption of IoT after the outbreak of COVID19. Industries such as oil and gas, agriculture received less attention and future work are recommended to examine the predictors of IoT adoption in these industries. TAM is still the most widely used and number of studies that combined more than one theory is limited. Future work are recommended to deploy other adoption theories and to combine TAM with TOE or TAM with ISS. This might help in explaining the variation in the IoT adoption.

The literature is dominated by quantitative approach, other approach such as mixed method or qualitative approach is recommended for developing countries since the literature is still emerging in these countries and they have the minimal number of articles. The sample size should be above 200 responses to meet the cut-off values to use the SEM. The future studies are recommended to develop a framework based on the important predictors which can include the variables of TAM as well as security, trust, privacy, and social influence along with other less examined variables such as awareness, connectivity, and IT knowledge to understand the adoption of IoT among industries and countries.

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