Factors influencing the acceptance of IoT devices in a smart home environment

by

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STUDENT DECLARATION

I declare that while registered as a candidate for the research degree, I have not been a registered candidate or enrolled student for another award of the University or other academic or professional institution.

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ABSTRACT

The Internet of Things (IoT) has emerged as a promising subsegment within the global Information and Communication Technology (ICT) market, as a result of the quick advancements in communication technologies and infrastructure.

A number of smart IoT devices in a smart home setting have been introduced in the market for the convenience of consumers. The amount of IoT devices being released to the market which possess characteristics of the Artificial Intelligence (AI) and IoT technology has increased rapidly with data suggesting the growth of sales of such devices in the UK market (Government Office for Science, 2021). While the sales of smart IoT devices are on the rise, consumer acceptance rates of smart devices such as smart lighting, plugs, bathroom scales, smoke alarms and smart baby monitors indicate a very low rate of ownership in the UK households. (Government Office for Science, 2021). This discrepancy can be attributed to various factors, with privacy, security concerns and trust in IoT providers emerging as significant obstacles. Understanding the specific nature of these concerns along with a multitude of other relevant factors and their impact on consumer behaviour is crucial for industry stakeholders to effectively address the challenges and promote wider acceptance of smart home devices.

While the previous versions of technology acceptance models were constructed for various technological innovations with focus on technology of those times, their focus was not on the IoT technology. The user behaviour of IoT technology in a home environment is receiving significant attention from studies applying technology acceptance models recently however these studies aim to assess the applicability of historical models to this newly emerged technology whereas the current research aims to develop a technology acceptance model of IoT devices (TAM-IOT) within the home environment including the key factors from historical models along with most recent contemporary factors such as perceived risks and trust in IoT providers that are significant from a consumer's perspective.

This thesis aimed to study the factors influencing the acceptance of IoT devices using Technology Acceptance Model (TAM) (Davis, 1989) as a guiding theory along with its various extensions such as TAM2 (Venkatesh and Davis, 2000), TAM3 (Venkatesh and Bala, 2008), Unified Theory of Acceptance and Use of Technology model (UTAUT) (Venkatesh et al., 2003) and UTAUT2 (Venkatesh, Thong and Xu, 2012). The main aim of the study was to identify and reinstate the impact of attitude on behavioural intention of consumers and study the diverse relationships between factors influencing the consumer behaviour towards IoT devices.

The study achieved its aims by pragmatist methodology of exploratory study to identify the choice of factors to develop a hypothetical deductive approach tested using questionnaires as a quantitative research method. The acquired data was analysed using techniques such as structural equation modelling, least square regression etc. to derive the ranking of factors determining the hierarchy of the factors and finally leading to the development of a Technology Acceptance Model of Internet Of Things (TAM-IOT). The results of the studies indicated that socio-demographic variable of education had a significant moderating impact on the relation between perceived ease of use and intention to buy/use as well as between perceived usefulness and intention to buy/use. However, other moderators such as age, gender and income level showed less statistical significance with p values >0.05 not supported by the sample data for this study and hence were rejected disapproving their significant moderation impact in previous studies.

Several individual path coefficients proved to be statistically reliable specially the perceived usefulness and attitude influencing the intention to buy/use IoT devices, it was noteworthy to find that the combined effect of all the factors on overall model of technology acceptance affected the fit statistics making it advisable for further research for accurate future estimations. The study enabled the ranking of factors significant to the overall model with trust in IoT providers along with perceived usefulness and attitude as one of the most significant factors and social influence as the least significant factor affecting the intention to buy/use smart IoT devices.

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ABBREVIATIONS

Abbreviation	**Full form**
A	Attitude
AI	Artificial Intelligence
AIC	Akaike Information Criterion
API	Application Programming Interface
AU	Automation
AVE	Average Variance Extracted
BCS	British Computer Society
BIC	Bayesian Information Criterion
C	Compatibility
CFA	Confirmatory Factor Analysis
CFI	Comparative Fit Index
CNET	Computer Network
CR	Composite Reliability
CSV	Comma Separated Value
CTAM-TPB	Combined Technology Acceptance Model - Theory of Planned Behaviour
CTV	Canadian Television Network
CUTAUT	Compatibility-Unified Theory of Acceptance and Use of Technology
DOI	Diffusion Of Innovation
DSMT	Digital Survey Management Tool
DTPB	Decomposed Theory of Planned Behaviour
EFA	Exploratory Factor Analysis
FTC	Federal Trade Commission
GCSE	General Certificate of Secondary Education
GETAMEL	General Extended Technology Adoption Model for E-Learning
GFI	Goodness of Fit Indeces
GMTA	General Model of Technology Adoption
GOF	Goodness Of Fit
H	Hedonic Motivation
HM	Hedonic Motivation
I	Innovativeness
IB	Intention to buy/use
ICT	Information and Communication Technology
IDC	International Data Corporation
IDT	Innovation Diffusion Theory
IoT	Internet of Things
IS	Information System
ISCED	International Standard Classification of Education
IT	Information Technology
IU	Intention to Use
LDA	Large Domestic Appliances
M	Mobility
M2M	Machine to Machine
MATH	Model of Adoption of Technology in Households

MM	Motivational Model
MMMU	Motivational Model of Microcomputer Usage
MPCU	Model of Personal Computer Utilisation
NFI	Normed Fit Index
NNFI	Non Normed Fit Index
P	Positive Self Image
PBC	Perceived Behavioural Control
PC	Perceived Cost
PC	Personal Computer
PCI	Perceived Characteristics of Innovating
PEOU	Perceived Ease Of Use
PFIoT	Perceived Features of Internet of Things
PhD	Doctor of Philosophy
PHR	Physical Risk
PR	Privacy Risk
PSI	Positive Self Image
PU	Perceived Usefulness
PV	Psychological Variables
RFID	Radio Frequency Identification
RMSEA	Root Mean Square of Error of Approximation
S	Self-Efficacy
SCO	Smart Connected Objects
SCOT	Social Construction Of Technology
SCT	Social Cognitive Theory
SE	Self-Efficacy
SEM	Structural Equation Modelling
SH	Smart Home
SI	Social Influence
SPSS	Statistical Programme for Social Sciences
SR	Security Risk
SRMR	Standardised Root Meansquare Residual
TAM	Technology Acceptance Model
TAM2	Technology Acceptance Model 2
TAM3	Technology Acceptance Model 3
TAMC	Technology Adoption Model Canvas
TAM-IOT	Technology Acceptance Model of Internet Of Things
TIB	Theory of Interpersonal Behaviour
TLI	Tucker Lewis Index
TPB	Theory of Planned Behaviour
TRA	Theory of Reasoned Action
TTF	Technology Task Fit
TV	Television
UK	United Kingdom
UTAUT	Unified Theory of Acceptance and Use of Technology
UTAUT2	Unified Theory of Acceptance and Use of Technology 2

VAM	Value-based Adoption Model
VPA	Virtual Personal Assistant
ZB	Zetta Bytes

LIST OF SYMBOLS

Symbols	Name
H_0	Null hypothesis
H_1	Alternate hypothesis
χ	Chi
Σ	Small Sigma
β	Beta
R	Correlation
R^2	Co-efficient of determination
ε	Margin of error
ṕ	Population proportion
Z	Z score
$\sum$	Summation
$\overline{x_1}$	Sample mean
σ^2	Standard deviation
T	Test statistic
~	Tilde
=	Equals to

CHAPTER 1 INTRODUCTION

This chapter is an introduction to the research study titled “Factors influencing the acceptance of IoT devices in a smart home environment.” The discussion includes the research inquisitiveness along with an introduction to the concept of IoT, smart home environment along with clearly identified research context and scope. The chapter also highlights the rationale for the study, research gaps linked to the research question, aims and objectives along with research implications. A summary of each of the chapter in this thesis is also included in this chapter providing the understanding of the overall structure of the thesis.

Why are people buying IoT devices? – The research inquisitiveness.

“The smartphone is no longer just a device that we use, it’s become the place where we live,” (Miller et. al. 2021). The technology of smart phones is becoming a norm for a wide group of people, while other groups are still using conventional phones with their reasons for not accepting this device in their lives, which sparks an intuition to research this consumer behaviour. A vast majority is seen using this once so-called new technology as if it has been a part of their lives for ages. New technologies such as mobile banking, online shopping, or even the use of collaboration platforms such as Teams and Zoom in the recent times ignites a thought of how these technologies are shaping people’s lives and have now become the norm of living.

There is differing evidence in acceptance of technology where some technologies are accepted at a fast-pacing rate (Government Office for Science, 2021) and others which have failed drastically, vouching for the need to be replaced by new acceptable technology. Technologies are becoming obsolete quicker than innovations (Ra et. al. 2019), urging a need for the technology innovators to add new and emerging products in the already vast pool of technologies at a faster rate than before.

Innovation and technological developments have led to enormous possibilities in the field of Artificial Intelligence (AI) such as self-driving cars, fridges that order milk automatically when depleted (CTV News, 2017) or smart speakers which can answer questions on specific products or companies. Taken together, the above-mentioned examples illustrate the power of AI and IoT. This technology has the ability to make computers and machines perform things automatically by emulating intelligent behaviour to the extent that human beings are needed on a minimalist level for a variety of tasks such as selecting music to play (Kurzweil, 1990; Schalkoff, 1990; Rich and Knight, 1991; Russell and Norvig, 2010).

1.1 Internet of Things (IoT):

The global business landscape has evolved about 25 years after the Internet was made commercially available (Kannan and Li., 2017). The internet has become an indispensable tool for people, which is present in their homes or in their pockets and is thereby evident in their daily lives (Rodriguez et. al. 2022). The world has learnt to live with and adapt to the fact that it is connected to a hitherto unheard-of network of information and that communication technologies are more widely available.

The Internet of Things (IoT) is a new paradigm that aims to create a dynamic worldwide network connecting billions of heterogeneous smart objects capable of sensing, collecting, sharing, and exchanging information with one another anytime and anywhere (Atzori, Iera, & Morabito, 2010; Borgia, 2014; Mashal et al., 2015; Middleton, Koslowski, & Angela, 2018; Xu, He, & Li, 2014). Smart objects include computers, smart phones, sensors, actuators, smart lighting, smart power meters, and smart locks. The number of connected IoT smart objects was 212 billion in 2020 worldwide, the global market is expected to be worth between $3.9 and $11.1 trillion by 2025 (Al-Fuqaha, Guizani, Mohammadi, Aledhari, & Ayyash, 2015; Manyika et al., 2015). There is a growing interest of scientific research in the recent days in the area of the Internet of Things (IoT), (Kumar, 2019). This idea was first presented by Kevin Ashton in 1999 during a presentation for PandG to explain how a global network of internet-connected sensors might process and comprehend environmental data without human intervention. In 2009, Ashton said it best in this quote from an article in the RFID Journal:

“If we had computers that knew everything there was to know about things – using data they gathered without any help from us – we would be able to track and count everything, and greatly reduce waste, loss and cost. We would know when things needed replacing, repairing or recalling, and whether they were fresh or past their best.” (Ashton, 2009).

Whilst the traditional internet provides connections between users for exchanging information, IoT provides autonomous communication functions among objects using sensors and the components included in each object (Park et al. 2017). Owing to these functions, the functionality and specific details of IoT technologies have been studied with regard to converging sensor networks, as well as in pervasive and ubiquitous computing. The literature review on the term IoT exhibits a wide scale of differences with nearly 139 different definitions found in Sergio (2022) (Appendix 1), with each definition supporting a different perspective and a different supporting interest.

According to Stolzfus (2020), "**internet of things**" refers to the idea of common physical objects being connected to one another and recognising one another via an internet connection and being able to identify themselves to other devices and send and receive data. Several other studies define IoT from a similar perspective considering the Internet of things as a network of objects with autonomous communication capabilities that are connected to the internet (Park et al., 2017; Perera, Lui and Jayawardena, 2015).

An IoT system can be described as a collection of interconnected smart devices and objects that are provided with unique identifiers that are able to communicate and transfer data without human or computer interaction in order to fulfil a desired goal. (Allioui and Mourdi, 2023). It embraces a variety of technologies, services, and standards. IoT involves people, objects and data as major agents.

This research uses the definition according to Agarwal and Das (2012) as cited in Sergio (2022) “Internet of Things (IoT) is a global network, which allows the communication between human-to-human, human-to-things and things-to-things, which is anything in the world by providing unique identity to each and every object". (Agarwal and Das, 2012).

There are several smart IoT devices available for the convenience of consumers that can be used both inside a home setting as well as outside the home setting. The amount of devices being released to the market which possess characteristics of the Artificial Intelligence (AI) and IoT technology has increased rapidly (Ukpanah, 2024). There were more than 50 billion IoT devices as of 2020, which are expected to generate 4.4 zettabytes of data, compared to just 100 billion gigabytes in 2013. A 28.7 percent compound annual growth rate is expected in that number through 2025. (Stojkoska and Trivodaliev, 2017).

IoT is a widely researched subject area in recent times with studies undertaken in understanding the use and acceptance of IoT in a variety of sectors (Kahlert, Constantinides and Vries, 2017), geographical areas (Mashal and Shuhaiber, 2018; Wright 2017) as well as from different perspectives such as consumer and industrial use. Some examples of this research include study of the factors affecting the perception of potential users (Kessler and Martin, 2017) or specific technology such as Voice Activated Shopping (Sorensen 2019) or acceptance of automated messaging apps in banking industry (Richad et al. 2019). Whilst these studies focussed on IoT devices, they are mainly external to the home settings.

Balta-Ozkan et al. (2013, 2014) investigated concerns of potential customers regarding home automation devices such as cost, reliability interoperability etc. Security and privacy issues have been evident in the concerns expressed in using such technological devices within the home settings (Aldossari and Siddorova 2018).

1.2 Rationale

A new forecast from International Data Corporation (IDC) estimates that there will be 41.6 billion connected IoT devices, or "things," generating 79.4 zettabytes (ZB) of data in 2025. (IDC, 2020). The total installed base of Internet of Things (IoT) connected devices is projected to amount to 75.44 billion worldwide by 2025, a fivefold increase in ten years (Statista.com 2016). Forecasts vary but concerns over the role of government in security of consumers has been challenged. In response to huge forecast figures of IoT devices UK Government announced policy regulations for security concerns raised over these IoT devices (UK Government, 2024). This data clearly emphasises the continued legacy of adopters as described in the Diffusion of Innovation theory by Rogers 1962 which is evident in the number of consumers adopting this technology in 2020 proving the forecasts accurate (Statista, 2016). Hence this study will focus on the behavioural element of adopters of smart IoT devices within a home environment.

Considering the rapid growth of IoT technology and smart home applications, it is crucial for both professionals and practitioners to understand the adoption process of potential consumers. Detailed knowledge can be obtained about this technological trend from a theoretical perspective if research is undertaken to study the factors influencing the adoption.

1.3 Smart home environment

RECENT LITERATURE ADDED HERE

Among the various aforementioned IoT applications, Smart Homes (SHs) are an important application with a broad range of capabilities and great benefits (Wijaya and Jayadi, 2022). SHs aim to improve residents' quality of life by equipping a residence with a communications network to connect smart devices and appliances together. Smart devices and appliances are remote-controlled and accessed through mobile phones or personal computers over the Internet by the user (Augusto & Nugent, 2006; Kelly et al., 2013; Li, Yigitcanlar, Erol, and Liu, 2021). A typical SH could contain more than 500 smart devices and appliances (Middleton et al., 2018). For example, users will be able to open and close doors at their SH remotely over the Internet. Significant attention has been paid to home appliances, where smart technology has become intensively re searched and practically applied (Marikyan, Papagiannidis and Alamanos, 2019). SH studies have focused on design, implementation, technology, and architecture. However, not enough studies have explored user perception and acceptance of SHs, and few models have been proposed (Li, Yigitcanlar, Liu, and Erol, 2022).

In recent years, the term smart has become synonymous with any technology that boasts some level of artificial intelligence. The ability to gather information from its surroundings and react accordingly is the essential characteristic of smart technology (Mpinganjira, 2013). Fuelled by the advantages provided by smart technology and a possible large global market, interest in smart home technology has skyrocketed among researchers (Mpinganjira, 2013). In the field of home automation and management, the smart home has become a very promising sector.

Smart home refers to a phenomenon where the rapidly changing IoT technology is applied to the residential environment, and therefore, it cannot be defined in a single concept. The concept of smart home defined by various organisations and studies as presented in the table 1 below.

Table.1.1 Definitions of smart home

Source	Definition
Korea Association of Smart Home (Kim, Park and Choi, 2017)	A human-centred smart life environment created by converging IT to the residential environment, thereby increasing convenience and welfare, and enabling a safe lifestyle.
King (2003)	A dwelling incorporating a communications network that connects the key electrical appliances and services, and allows them to be remotely controlled, monitored, or accessed.
Balta-Ozkan, Boteler, and Amerighi (2014)	Smart home is a residence equipped with a communications network, linking sensors, domestic appliances, and devices, that can be remotely monitored, accessed, or controlled and which provide services that respond to the needs of its inhabitants.

The term "**smart home**," also known as "smart-house and home automation," refers to the use of Information and Communication Technologies (ICT) in home control and maintenance, "ranging from controlling appliances to automation of home features," (Stojkoska and Trivodaliev, 2017. p-1454). According to Hayes (2019), a smart home is "a convenient house arrangement where appliances and equipment can be automatically managed remotely from any internet-connected area in the world using a mobile or other networked device,"

For the purposes of this study, a smart home is defined as a “residence equipped with computing and information technology, which anticipates and responds to the needs of the occupants, working to promote their comfort, convenience, security and entertainment through the management of technology within the home and connections to the world beyond” (Aldrich, 2003). According to Marikyan, Papagiannidis, and Alamanos (2019), a smart home is the collection of domestic appliances, smart devices, and sensors that are integrated into an intelligent home network that offers control, monitoring, support, and responsive services and embraces a range of financial, social, sustainability, security, and health-related benefits to their users.

DIFFERENCE BETWEEN IOT DEVICES AND SMART HOME TECHNOLOGY

As one of the key elements of this research is assessing the acceptance of IoT devices in a smart home environment, it is essential to understand the link between a smart home and IoT. As discussed earlier, IoT is the interconnection of devices via the internet, allowing them all to send and receive data, without the need for human interaction. Smart home is a significant part of IoT, where internet-connected appliances and devices are automatically controlled, often with a mobile phone (Hayes, 2024). The IoT technology has been introduced into the home environment in the forms of connected gadgets, such as the home theatre, window, thermostat, lock remote controls, smart lights, smart fridge, smart furniture, smart speakers etc. (Arm Solutions, 2022). Internet of Things devices in a smart house can be categorised in two groups. The first group consists of devices that require two-way communication whilst the second group consists of one-way connection household appliances such as a smart TV, lighting system and charger (Alohali, Merabti, and Kifayat, 2014). An example of the first group is solar panels that require bi-directional communications to provide non-essential power to the utility company as well, and the alternating current is expected to receive a signal from the utility provider to reduce power density. However, the second group only needs one connection to send the electricity consumption data. Devices in the second group have higher resource capabilities compared to those in the first group. (Alohali, Merabti, and Kifayat, 2014).

A number of such smart devices have now become available in the market with sales of such devices growing faster than ever. In the UK, 52% of internet households have a voice assistant device, compared to 49% of households in the US (Easton 2021).

The difference in acceptance level of different technological devices is exhibited in the figure below (Government Office for Science, 2021) where there is a significant difference of ownership of different type of smart devices within UK households ranging from a high ownership of smart television with 51% ownership. However, there is an ongoing debate around classification of smart TV as an IoT device. Lewandowsky (2023) suggests that despite being able to connect to the internet and communicate with other devices, smart TVs are not a crucial component of the Internet of Things ecosystem; instead, their primary purpose is media consumption. In contrast to smart security cameras or thermostats, smart TVs don't have the ability to collect data via sensors and operate autonomously. For any device to be considered as an IoT device one of the essential features is its ability to operate without human intervention or control (Anderson, 2023). Nonetheless, majority of the studies contend that because smart TVs can connect to the internet and share data, they should still be included in the Internet of Things ecosystem. (Frackiewicz, 2013; Yusufov and Kornilov, 2013; Anufrienko, 2019). In addition to receiving software updates, they can interact with other smart home appliances like speakers or lighting controls and offer tailored content recommendations depending on user preferences. Frackiewicz (2023) argues that while traditional TVs may not be considered IoT devices, smart TVs have the potential to become an integral part of the IoT ecosystem. With their internet connectivity and ability to communicate with other devices, smart TVs can enhance the viewing experience and create a more connected home environment. Although Yusufov and Kornilov (2013) argue TVs have an Ethernet port or a Wi-Fi module and can run applications, which are uniquely addressable along with the ability to be enhanced, indicating consideration of Smart TV platforms within an IoT-environment, they also identified one of the major limitations of smart TVs limited ability due to restrictions posed by some platforms. Due to strictly limited Application Programming Interface (API) some Smart TVs are restricted to running applications in background, thus reducing capabilities of using these platforms in very important role of data processing. Consequently, we can argue that even though it has some IoT features, its main purpose as a media consumption device distinguishes it from other networked devices that actively take part in automation and data exchange. (Yusufov and Kornilov, 2013) Ultimately, the context and research problem enable the way forward for this research. Whilst smart TV has the highest ownership rate within the UK as a smart device at 51%, according to Figure 1(Government Office for Science, 2021), revised statistics according to Ukpanah (2024) indicate the latest ownership rate of smart tv in UK household which stands at 67% followed by smart speakers at 35%. Of the top ten popular devices, smart meters and smart locks are the least popular smart devices. Whereas another survey according to Bashir (2024) 83% of consumers declared owning a smart TV and or smart speaker. It is interesting to research the significant difference in acceptance of other smart devices i.e. smart speakers such as Alexa and Echo with 22% ownership and 35% (Ukpanah, 2024) to the least popular devices such as smart bathroom scales, smart smoke alarms and smart baby monitors with only 1% households owning these devices.

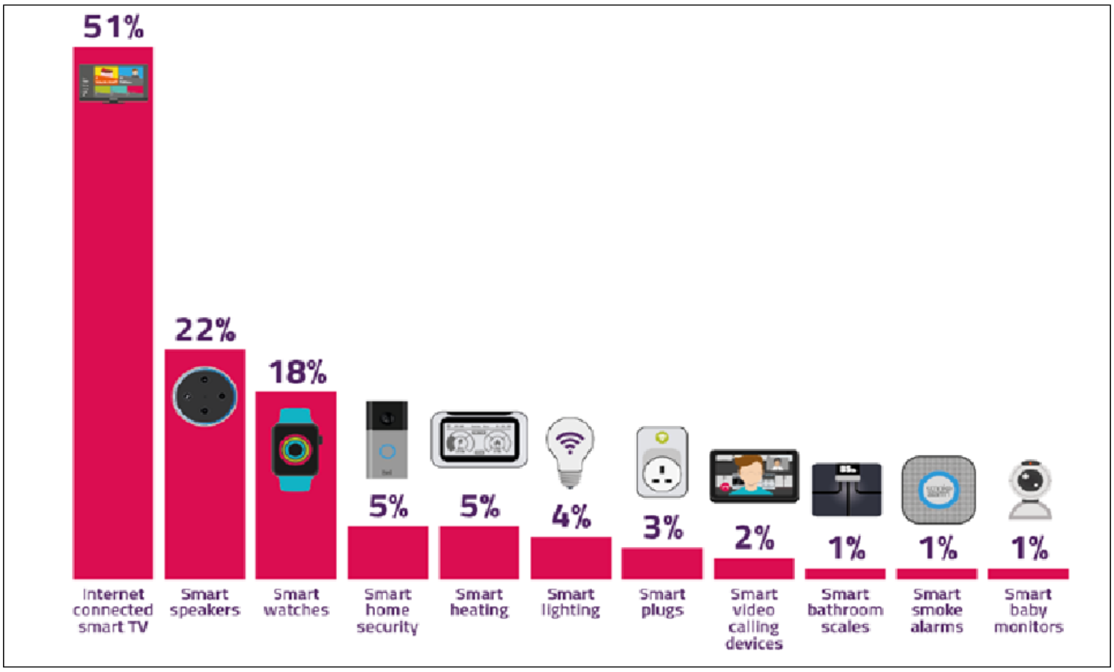

Figure 1. 1 Percentage of UK households with different types of internet-connected devices, 2020 (Government Office for Science (2021)

It may be inferred from the above figure that smart TVs have had a higher rate of acceptance in UK households compared to smart smoke alarms and smart baby monitors or any other IoT device in question. Being primarily used as an entertainment device, a television makes its way to consumers households faster than others. One of the reasons of a lower ownership rate of devices such as smart plugs (3%) and smart lighting (4%) could be due to compatibility issues. However it would be presumptuous to consider this issue as a driving force behind the low ownership rate. This necessitates the need for research into this area to know the motivation behind buying these devices. With this in mind, this research aims to identify the factors influencing the consumer's acceptance of IoT devices the results of which can be correlated to this secondary data.

Although the data suggests a significant ownership rate of some of the IoT devices in the UK, the adoption of this technology by a large majority of the households remains questionable specifically with the exception of smart TVs. This vouches for the need of a comparable number of studies understanding the acceptance behaviour and overall factors influencing the acceptance of these devices. The number of people who own smart devices like Amazon Alexa and Google Home increased by 12% in the UK, 13% in the US, and 18% in Canada in comparison to the 2020 data (Easton, 2021). This data served useful in leading to the insight into why people buy IoT devices, what factors influence this behaviour and how these factors influence consumer's behaviour. Having answers to these key questions would enlighten a marketer's knowledge of identifying the reasons of consumers behaviour in terms of accepting the new technology of IoT devices.

1.4 Research gaps, question, aims and objectives

While extant research examined many factors affecting adoption of technology (Abdullah and Ward, 2016; Alalwan, Dwivedi and Rana, 2017; Coeurderoy and Guilmot, 2014; Wang et. al 2019,) these studies focused on a variety of technologies such as e-learning, e-banking or general Information System. Several studies have been undertaken to understand the acceptance of smart home devices (Magara, et. al., 2024; Kraemer and Flechais, 2018) using selected factors, however the wholistic impact of these factors examining IoT devices remains an area for further research (San-Martín and Herrero, 2012). Thus, this study aims to identify how various factors influence the behavioural intention of consumers in the UK in relation to the acceptance of IoT devices within a smart home environment. The research inquisitiveness, review of literature on IoT and smart home environment lead to the main research question for this study:

How do various factors influence the behaviour of consumers in the UK in relation to the acceptance of IoT devices within a smart home environment?

Research aims and objectives

The review of the early theories in consumer behaviour as well as technology adoption indicate various research gaps that need to be addressed. A wide range of factors have been studied in the past leading to chaotic abundance of positions in the field of technology adoption (Park et al 2017), which vouches for a need of identifying relevance of factors with regards to IoT devices (Research aim 1).

Research aim 1: To identify the effect of relevant factors on attitudes of consumers toward IoT devices.

Theoretical studies such as TAM (Davis, 1989) and its various extensions TAM2, TAM3, UTAUT and UTAUT2 as well as empirical studies (Wilson, Hargreaves, and Hauxwell-Baldwin, 2017; Vrain and Wilson, 2021; Kessler and Martin, 2019; Richad et al., 2019) using these theoretical models have dismissed the role of attitude in consumer behaviour and hence this study proposes to reinstate the role of attitude by examining the effect of attitude towards IoT devices on buying intentions (Research aim 2).

Research aim 2: To examine the effect of consumer's attitudes toward IoT devices on their buying intentions.

An SLR of the wide range of factors studied amounted to identification of 51 different factors (Yadegari, Mohammadi and Masoumi, 2024) Table 4.1 however there is limited research on a ranking order of these factors and hence this research aims to organise these factors into categories to develop a ranking order of factors (Research aim 3).

Research aim 3: To develop a ranking order of factors influencing the acceptance of IoT devices.

The research gaps identified in the review of these historical theories in consumer behaviour as well as technology adoption imply a wide range of existing knowledge and a need for new organised knowledge in the field of technology acceptance specifically for IoT devices (Research aim 4).

Research aim 4: To build a model of the factors influencing acceptance of IoT devices.

<u>Research Objectives:</u>

This research aimed to achieve the following research objectives, in order to answer the above research question and research aims:

RO1: Identify the research population of adopters using criteria developed in the literature.

RO2: Apply data collection methods.

RO3: Organise and analyse the data acquired from the data collection activities.

RO4: Present findings and conclusions of the research in the form of thesis.

1.5 Research context and scope

When most people think of connectivity, they typically think of computers, tablets, and smartphones. The Internet of Things envisions a society in which nearly everything is networked and capable of intelligent communication. The Internet of Things (IoT) has become widely accessible and evolved beyond its initial focus on machine-to-machine (M2M) applications for industry and business (Kumar, 2019). IoTs are expanding at a very rapid rate. Nearly any physical object can become a part of the IoT if it's connected to the internet to communicate, be controlled, or exchange information. Anything from a webcam to a smart appliance that could be controlled with a smartphone app is an IoT device**.** Even larger objects such as self-driving cars or planes are becoming IoTs, or are at least enhanced by critical IoT components, such as the sensors and actuators mounted on larger ship or jet engines to ensure they are operating efficiently.

There is a wide range of devices that could class as an **IoT device** along with other smart devices which could range from wearable devices to home appliances. This study focusses on the acceptance of a selected IoT devices used to collaborate a range of functions within a home environment such as playing an audio and controlling smart home to keep consumers organised, informed, safe, connected and entertained. It would not be feasible to study all the IoT devices due to the extent to which these have been developed and used in different spheres of a consumer's life and hence selected smart **IoT devices** which form a part of the **smart home environment** will be studied as a part of this research. It is essential to note that other IoT devices such as a driverless car, although an IoT device will have a distinct consumer behaviour compared to an IoT device used within a home environment For e.g. Trust in a self-driving car will differ significantly to trust in a smart fridge (Alolayan, 2014). Hence only the IoT devices within home environment are a part of this research.

As discussed earlier smart home is a significant part of IoT, where internet-connected appliances and devices are automatically controlled, often with a mobile phone.

(Albany et. al 2022). Various studies have been undertaken to study the acceptance of technology by individuals, however a smart IoT device is a technology that differs substantially from many other existing technologies as it is more directly embedded into individual's routine. It also requires a far more resourceful infrastructure to be used. For e.g., accepting an IoT device without other connectable devices undermines the purpose of buying such technology and hence it requires an overarching change in the people's way of living and accepting a range of devices to use this technology.

It is also useful to clarify the term **adoption**. Biljon and Renaud (2008) state that technology adoption is a process that starts with the user becoming aware of the technology whereas ends with the user embracing the technology and making full use of it. Technology acceptance, as opposed to adoption, is an attitude towards a technology, and it is influenced by various factors (Biljon and Renaud, 2008). This research intends to focus on technology acceptance and not the overall adoption behaviour.

Various studies have identified the limitations, acknowledging the difference between intention to buy/use (Park et al. 2017; Wang, Chen, and Chen, 2017; Baudier, Ammi, and Deboeuf-Rouchon, 2020 etc.) and actual buying behaviour (Abdullah and Ward, 2016; Singh, Gaur, and Ramakrishnan, 2017; Wang et al. 2019 etc.). Studying the intention to buy/use IoT devices by adopters in their smart home environment is considered significant to achieving the aims of this research and establishing the scope of this research instead of studying the usage behaviour. Due to the different rate of acceptance of IoT devices it would be presumptuous to attempt to study the usage behaviour. This research focusses on home environment where consumers have more control over their behaviour with it being a voluntary setting and hence it is deemed sufficient to measure self-reported behavioural intention of the consumer.

This research uses the following terms:

Attitude is defined as an individual's favourable or unfavourable feelings and evaluations about performing a particular behaviour (Fishbein and Ajzen, 1975, p-11) and thereby consumer attitude considers this feeling of consumers towards a product. In studying the factors influencing the adoption of IoT devices, it is important to study how attitude is influenced by several different factors. This may be different to a **consumer buying intention** which is consumers' willingness to buy a given product at a specific time or in a specific situation, (Morwitz, 2012). It is important to note that a consumer may have a positive attitude towards IoT devices but may still not be intending to buy these devices. Hence it is significant to examine both these variables and their relationship and impact on the overall acceptance of IoT devices.

A user's acceptance behaviour of new information technology and information systems can be explained by several models such as Theory of Reasoned Action (TRA) (Fishbein and Ajzen,1975), Theory of Planned Behaviour (TPB) (Ajzen, 1985), Technology Acceptance Model (TAM) (Davis, 1989), Motivational Model of Microcomputer Usage (MMMU) (Igbaria, Parasuraman and Baroudi, 1996), Social Cognitive Theory (SCT) (Bandura, 1996), TAM2 (Venkatesh and Davis, 2000), Unified Theory of Acceptance and Use of Technology Theory (UTAUT) (Venkatesh et al., 2003), UTAUT-2 (Venkatesh, Thong and Xu 2012). The aim of this research is to contextualize the most well-known models, examine them, and determine the most relevant factors for IoT devices, appropriate for the current study by undertaking an extensive literature review. This research uses TAM (Davis, 1989) as its guiding theory which encompasses the core factors such as Perceived Ease of Use, Perceived Usefulness and their impact on behavioural intention along with an addition of several factors derived from different theories.

To address the primary research question, a comprehensive list of factors studied in the existing literature review needed to be determined and thereby the most relevant factors for the UK consumers in accepting the smart home IoT devices were identified for this research (Table 9), thereby limiting the scope of this research to the selected factors. The selection of the factors is discussed in Chapter 3 of this thesis.

1.6 Contributions of the study

The amount of literature available focusing on technology acceptance is vast and often complex. Prevalence of several models developed and tested in different environments is beneficial on one hand but leads to confusion on the other. This research aimed to build a model of technology acceptance specifically for the IoT devices within a smart home environment, thereby strengthening the conceptual knowledge of existing technology adoption theories.

A wide range of factors have been studied in the past leading to chaotic abundance of positions in the field of technology adoption (Park et al. 2017). This research not only studied the impact of various historical and new factors on attitude toward IoT devices but also aimed to create a ranking order of these factors. The proposed model aims to organise and rank 17 such factors into categories leading to a more cohesive understanding of technology acceptance.

Literature review suggested that technology acceptance model developed by a pioneering researcher Davis in 1989 and extension to this model focused on technology acceptance in organizational settings whereas technology not being confined to workspaces in the current day and age and transitioning into consumer's home space showcased the involvement of technology in all spheres of human lives. Technology has now become the way of life, and it was important to identify why and how the adopters permit the use of such IoT devices in their personal life. Although models such as MATH (Brown and Venkatesh, 2005) aimed to develop a technology adoption model for the household settings, the technology studied was that of a Personal Computer (PC) and hence its applicability to IoT devices may be limited. The resulting model of this research will be a unique model for IoT devices with applicability in the home environment.

The demographic uniqueness of UK adopters was accounted for in this research leading to the development of UK specific model and providing grounds for future research on applicability of this model in other geographical areas and thereby a comparison between countries will also be possible.

This research intends to examine the role of perceived risk on privacy and security on adopter's mindsets and their attitude. An in-depth analysis of adopter's perception of these risks and expectations from the IoT providers will enable the development of recommendations for the IoT providers, which includes the parameters of provisions to ensure privacy and security of consumers of IoT devices aiding the providers to target the adopters to access a wider scale of the market than prevalent.

The rate at which the technology has developed leading to palm top computers in terms of smart devices we have, validates the need for a modern theory to understand the behaviour of these consumers in an everchanging technological environment. This study aims to provide an understanding of these behaviours.

1.7 Research implications

The research helps to identify several key factors that affect buyers' psychological, social, and personal decisions by examining the impact of demographics and social influence on people's decisions. (Venkatesh and Davis, 2003; Venkatesh, Xu and Thong, 2012). These studies help understand how buyers think, feel, and decide (Kowalczuk, 2018) thereby enabling businesses to determine how best to market their products and services. This helps marketers predict how their customers will act, which aids in designing appropriate marketing strategies. Understanding people's behaviour and attitudes is the crucial factor for industries to predict whether a technology and specifically IoT devices, will be accepted. This knowledge not only helps marketers in targeting the right customer demographics but also tailor strategies for consumer differentiation to create and retain customers of new technological devices.

Several research studies have been undertaken since the theories of technology acceptance were developed – showing continuous addition to the knowledge area. (Mashal and Shuhaiber, 2018; Chang and Naam, 2021; Alam et al. 2020 and Yang and Lee, 2018) Some of these studies established proposed theoretical foundations Abdulla and Ward (2016) whereas other empirical studies examined the application of such theories in different sectors (Zhong et. al. 2022; Chen et. al., 2023; Kim and Moon, 2023). These models contribute significantly to the theoretical basis for examining IT acceptance and use in consumer context (Grover and Lyytinen, 2015). Hence elements from each of these theories have been used in this study as a theoretical underpinning for examining the acceptance of IoT devices within a smart home environment. Smart home technologies are distinct from other Information and Technology because they are more directly embedded into individual routines. Therefore, rather than replicating and validating a particular model, this study attempts to develop a comprehensive technology acceptance model for IoT devices within the smart home environment using relevant factors from the existing models.

1.8 Overview of Thesis

This thesis is composed of 8 chapters and appendices. Below is a short summary of each of the chapter main contents.

Chapter 1 – Introduction

This chapter includes an introduction on Internet of Things (IoT), Smart home environment along with the list of research question, aims and objectives. It also establishes the research context and scope with possible research implications, overview of thesis and structure.

Chapter 2 – Literature review

This chapter will provide a synthesis of literature on IoT adoption in a smart home environment highlighting the review of the theories surrounding technology adoption of IoT as well as Smart home technology which encapsulates the focus of this study.

An in-depth analysis of empirical studies in IoT will be undertaken in order to identify the research gaps.

Chapter 3 – Theoretical overview

This chapter provides a historical background to the evolution of consumer behaviour theories, innovation and adopter categories as well as development of technology acceptance models over years, aiming to identify the positioning of this research study in the wide pool of literature.

Chapter 4 – Conceptual framework and hypothesis development

This chapter provides an overview of empirical studies in the field of technology acceptance using a wide range of factors proposed in the previous models as well as relationships studied, choice of the most relevant factors following a scientific approach to factor selection leading to proposed conceptual model followed by the development of hypothesis and finally leading to, classification of factors.

Chapter 5 – Methodology

This chapter discusses the underlying research philosophy for this study, sampling methods used to identify an appropriate sample, development of the research tool using development of constructs and their reliability and validity testing, the process of chosen data collection method and proposed data analysis approach.

Chapter 6 – Data Analysis

The chapter includes application of a range of statistical techniques to the data collected as described in the previous chapter. This includes computing of descriptive statistics, correlation of factors, chi-square analysis, confirmatory factor analysis and structural equation modelling leading to the development of the final model of technology acceptance of IoT devices in a smart home environment.

Chapter 7 – Discussion

This chapter includes findings from the data analysis techniques applied in the previous chapter along with the interpretation. This chapter reviews the research objectives and the alignment of findings against the objectives, leading to the testing of model with respect to the goodness of fit and performance.

Chapter 8 – Conclusion

The final chapter in the thesis includes theoretical and practical implications, recommendations from this research study, contribution along with identification of limitations of the study and implications for future research.

1.9 Summary

This chapter included an overview of the foundation of research inquisitiveness in the subject along with the discussion on IoT in recent times. This was followed by the discussion of IoT and a range of devices within the smart home environment. The rationale for the study provided the foundation for the discussion of several research gaps this study aims to address through the research question leading to the research aims and objectives distinctly identifying the constraints using the research context and scope. Several proposed contributions of this study were highlighted in this chapter followed by an outline of the research implications in context of business and marketing environment. The next chapter will include a detailed review of literature in the field of smart home technology acceptance and IoT technology acceptance to further the discussion on research gaps.

CHAPTER 2 LITERATURE REVIEW

2.1 Introduction

This chapter will provide a synthesis of literature on IoT adoption in a smart home environment highlighting the review of the theories surrounding technology adoption of IoT and more particularly smart home technology which encapsulates the focus of this study. An in-depth analysis of empirical studies in IoT has been undertaken in order to identify the research gaps.

2.2 Smart home and IoT devices within a smart home environment

Smart home technology, which integrates various devices to automate and enhance home living, is gaining traction due to its promise of convenience, energy efficiency, and security. However, the widespread adoption of these systems remains dependent on factors beyond mere availability. Research on the technology acceptance of smart home systems has focused on understanding how users perceive, adopt, and engage with these technologies. This literature review outlines key studies and theoretical frameworks that have shaped the understanding of technology acceptance in the context of smart homes.

Chakraborty et.al. (2022) highlighted the recent advancements in the field of smart home literature in his comprehensive study of smart home system providing a bird's-eye view of the overall concept, attributes, technological aspects, and features of modern smart home system. A snapshot of selected studies undertaken to study the acceptance of smart homes and smart home technologies is presented in the table 2 below.

2.3 Empirical studies on technology acceptance

An overview of studies undertaken in the field of technology acceptance of smart devices or in broader terms IoT devices over the last decade indicated a focus on understanding the attitudes, adoption behaviour, factors of acceptance as well as barriers to accepting the new technology within households. Below is a table highlighting the table in a chronological order of these studies published in reputable journals over the last decade. It is essential to note that this summary is based on an exploratory exercise undertaken to study themes of research in the field and may not be considered as an exhaustive list of research.

Table 2. 1 Overview of empirical studies undertaken on smart home and smart home technologies

Theme 1	Technology adoption models and extensions to TAM
	Mashal and Shuhaiber (2018) Chang and Naam (2021) Alagoz and Hekimoglu (2012) Gruzd, Staves and Wilk (2012) Nunkoo and Ramkissoon (2012) Coeurderoy, Guilmot and Vas (2014) Li and Hsu (2016) Alalwan et al. (2017) Wang, McGill and Klobas (2020) Pal et al. (2018) Baabdullah 2018; Afonso (2019) Gupta, Manrai and Goel (2019) Venkatesh and Davis (2000) Bouhlel et al. (2010) Lu (2019) Kahlert, Constantinides and De Vries (2017) Kim, Park and Choi (2017) Park et al (2017) Shin, Park and Lee (2018) AlHogail (2018), Alam et al. (2020) Yang and Lee (2018) Venkatesh et. al (2012)
Theme 2	Privacy, security and trust issues
	Kraemer and Flechais (2018) Cannizzaro et.al. (2020) Sharma et al. (2020) Magara and Zhou (2024) Nemec Zlatolas, Feher and Hölbl (2022)
Theme 3	Diverse smart home devices
	Wang (2017) Lin, Wang and Hung (2020) Baabdullah (2018) Afonso (2019) Yang and Lee (2018) Balta-Ozkan et al. (2013) Shin, Park, and Lee (2018) Mashal and Shuhaiber (2018) Wang (2018) Wu, Wu and Chang (2016) Tetteh and Amponsah (2020)

	Aldossari and Sidorova (2018) Zhong et. al (2022) Han and Yang (2018). Chen et al. (2023) Kim and Moon (2023)
Theme 4	Barriers and socio-economic factors
	Shin, Park, and Lee (2018) Mitzner et al. (2019) Wang (2017) Golant (2017) Aldunate and Nussbaum (2013) Seymour et.al. (2024) Balta-Ozkan (2013) Miu et. al. (2019) Nemec Zlatolas, Feher and Hölbl (2022) Wilson, Hargreaves and Hauxwell-Baldwin (2017) Kahlert et al. (2017)
Theme 5	Prime focal setting of technology acceptance studies
	Aldossari (2018), Balta-Ozkan et al. (2013) Alalwan, Dwivedi and Rana (2017) Bassarir-Ozel, Turker and Nasir (2022)
Theme 6	Demographics and cultural influences
	Mashal and Shuhaiber (2018) Shin, Park, and Lee (2018) Sallimon (2018) Kumar et al. (2016) Gupta, Manrai and Goel (2019), Wright (2017) Tetteh and Amponsah (2020) Cannizzaro et al. (2020) Singh et al. (2017) Sorwar et al. (2023) Kim and Moon (2023) Marikyan, Papagiannidis and Alamanos (2021)
Theme 7	User acceptance and behavioural factors
	Marikyan, Papagiannidis and Alamanos (2021) Yang et al. (2016) Chen et al. (2023)
Theme 8	Sustainability and energy management
	Große-Kreul (2022) Strengers and Macmillan (2013) Miu et. al. (2019)
Theme 9	Impact of external factors
	Umair et al. (2021) Ghafurian, Ellard and Dautenhahn (2023)

A number of themes are evident based on recurring patterns, focus areas and conceptual approaches within these studies found in table 2.1. A detailed list of these studies can be found in Appendix 7. These themes enable us to understand the broader landscape of technology acceptance of smart devices over the past decade. Some of these themes have been discussed below:

2.3.1 Technology Acceptance Models and extensions to TAM

Several variations of TAM (David, 1989) and related studies have been used widely to examine the consumer behaviour and attitudes towards IoT and smart devices. Mashal and Shuhaiber, 2018; Chang and Naam, 2021). Constructs such as Perceived Ease Of Use (PEOU), Perceived Usefulness (PU) and Intention to use (IU) have been used by a number of studies as determinants of technology acceptance. (Alagoz and Hekimoglu 2012; Gruzd, Staves and Wilk, 2012; Nunkoo and Ramkissoon 2012; Coeurderoy, Guilmot and Vas 2014; Li and Hsu 2016; Alalwan et al. 2017; Wang, McGill and Klobas 2020; Pal et al. 2018; Baabdullah 2018; Afonso 2019; Gupta, Manrai and Goel 2019; Davis 1989; Venkatesh and Davis 2000).

Studies within this theme highlight the pertinence of established acceptance model like TAM (Davis 1986) to the smart home and IoT context, by identifying perceived ease of use and perceived usefulness as primary motivators of technology acceptance. Extended models from the empirical studies imply addressing IoT specific factors such as automation, privacy and security.

Researchers use TAM extensively to investigate customer electronic purchasing behaviour (e-purchasing) in **different environments** and **purchasing situations** (Alagoz and Hekimoglu, 2012; Bouhlel et al., 2010; Nunkoo and Ramkissoon, 2012). TAM as studied by Alagoz and Hekimoglu, 2012; Nunkoo and Ramkissoon, 2012 found attributes of perceived ease of use (PEOU) and perceived usefulness (PU) act as strong determinants and predictors when explaining the attitude of potential consumers towards technology directly, and behavioural intention indirectly towards using a technology. Social norms and ethical concerns were not the determinant of behavioural intention according to some of these theories. The adoption of technology explained by TAM was through linking a person's belief in his/her attitude towards the use of technology (Nunkoo and Ramkissoon, 2012).

Where TAM and other models used Information Systems' acceptance it is important to know the difference between and IS and IoT. **Information system**, an integrated set of components for collecting, storing, and processing data and for providing information, knowledge, and digital products (Sun and Zhang, 2006) whereas IoT system can be described as a collection of interconnected smart devices and objects that are provided with unique identifiers that are able to communicate and transfer data without human or computer interaction in order to fulfil a desired goal.(Lu, 2019) This research will focus on Internet of Things as a technology which is very peculiar with regards to the earlier technologies this world has encountered, and hence the adoption models developed from studying the behaviour of individuals towards those technologies may be classed as specific to those technologies, necessitating the need to develop a more relevant model with regards to this specific technology.

As the objective, scope and functioning of IoT devices varies with different organizations, researching the usefulness of the TAM model along with other variables could provide a greater understanding of adoption of IoT devices by consumers. Most studies examining the adoption of IoT devices within a smart home environment have used extension of TAM model to study factors influencing adoption (Mashal and Shuhaiber, 2018; Chang and Naam, 2021) or barriers of adoption (Afonso, 2019). These studies have been country specific, mostly adapting the variables from existing models, however this research intends to adopt relevant variables for IoT devices from each of the theories to create a model specific to IoT devices and mostly used TAM (Kahlert, Constantinides and De Vries (2017) Kim, Park and Choi (2017) Park et al (2017) Shin, Park and Lee (2018) AlHogail (2018), Alam et al. (2020) Yang and Lee, 2018) whereas this study not only intends to use TAM as the main underlying theory but also uses factors from other theories such as UTAUT model to test technology acceptance process of IoT devices. The constructs of synthesized UTAUT model can provide insight into the factors that influence the intention to use IoT devices along with other constructs from previous models. As the Smart home IoT devices has a large consumer base, the moderating role of demographics in the UTAUT model can provide a better understanding of the perceptions important to demographic groups that may influence their adoption behaviour.

Although Venkatesh et. al (2012) aimed to develop a unified theory of acceptance and use of technology, the findings are applicable to organisational setting instead of homes due to being developed in an organisation setting. It covered studying a wide range of core determinants which will be used in this research; however, a range of other moderators are essential keeping in mind the type of technology of IoT devices and specifically the setting in which these are used. This research intends to use TAM as one of the fundamental models of technology acceptance and focussing on the limitations and advancements in newer models. It is important to acknowledge that although UTAUT model was developed with the intention of unifying various models of technology adoption, it certainly needs to be reviewed in current times and it may not be possible to apply the model in its entirety to specific technological products and the environments in which they are used and key constructs from past models such as IDT, TRA, TPB, TAM, and MMMU will be useful in achieving one of the fundamental aims of this study, to develop a model of acceptance of IoT devices.

2.3.2 Privacy, Security and Trust issues

Over the last decade consumers have grown increasingly conscious of privacy and security concerns over technology and specifically devices within the home environment (Magara, et. al., 2024; Kraemer and Flechais, 2018). Consumer trust in these IoT devices is evident as one of the critical factors influencing technology acceptance particularly with the rise of inter-connected IoT devices that collect and transmit data (Cannizzaro et.al., 2020). Sharma et. al (2019) focused on mobile Internet of Things Studies highlighting requirements of new solutions, which can collectively resolve the issues related to security, privacy, and trust in smart M-IoT without compromising the performance and complexity of operations. Studies in this theme (Magara & Zhou, 2024 and Nemec Zlatolas et al., 2022) depict findings of privacy concerns having a negative impact on acceptance of technology. Privacy concerns especially in terms of data sharing and surveillance create barriers to IoT acceptance. Nonetheless perceived trust in IoT providers or manufacturers leads to higher likelihood of technology acceptance.

2.3.3 Diverse smart home devices

The overarching theme of the literature selected is some sort of technology ranging from mobile phones (Wang, 2017), mobile banking (Lin, Wang and Hung, 2020), games (Baabdullah, 2018), smart speakers (Afonso, 2019) to virtual personal assistants (Yang and Lee, 2018). Several sources focus on research within the smart home environment (Balta-Ozkan et al., 2013; Shin, Park, and Lee, 2018; Mashal and Shuhaiber, 2018; Aldossari, 2018) and making the **product category** an importance classification factor for such studies.

This theme of studies focussed on device features, accessibility, and technical design that influence user acceptance of these devices. Although research in adoption of AI technologies such as smart home devices (Balta-Ozkan et al., 2013; Wang, 2018) within home settings have been done within the UK and other countries, specific emphasis on smart home devices family including voice assistants such as Alexa and Echo, smart lighting, smart heating, smart furniture, smart fridge, smart security, smart watches have not been the focus of many studies. The adoption of these devices has been studied individually in various studies such as Afonso (2019) for smart speakers, Han and Yang (2018) personal assistants, Wu, Wu and Chang (2016) smart watch, Kim and Moon (2023) smart washing machines and various studies on smart home technology such as Tetteh and Amponsah (2020), Shin, Park and Lee (2018), Aldossari and Sidorova (2018). Smart devices like wearable IoT, washing machines, and energy management systems emphasized personalized usability.

Growing popularity of AI-enabled technologies such as smart speakers like Alexa, Echo and Google Home etc are studied as a part of IoT adoption. (Zhong et. Al 2022; Chen et.al. 2023) The importance of user-friendly interfaces (e.g., Zhong et al., 2022 for voice assistants) and emotional satisfaction (e.g., Chen et.al., 2023) were found to be central in this theme. A significant part of these research is focussed on the usability, trust and privacy implications of these devices. Convenience and ease of use are major advantages offered by voice-controlled devices, but these also poses concerns around data privacy and trust in providers of these devices. Findings from these studies suggest a balancing act played by users between appreciation of convenience and their concerns over privacy (Yang and Lee, 2018 and Han and Yang, 2018). However, privacy issues remain a focal point to understand the consumer behaviour.

2.3.4 Barriers and socio-economic factors

As new technologies have developed, a number of studies have been undertaken to study the behavioural elements of different **age groups** (Shin, Park, and Lee 2018; Mitzner et al., 2019; Wang, 2017; Golant, 2017) within different sectors showcasing a range of determinants (Aldunate and Nussbaum, 2013) and **barriers to technology adoption.**

Researchers have taken alternate strands to identifying the technology acceptance behaviour by identifying barriers to technology adoption including socioeconomic factors (Seymour et.al. 2024; Balta-Ozkan, 2013) Socioeconomic factors such as costs(Miu et. al. 2019), security, perceived risks (Nemec Zlatolas, Feher, Hölbl 2022; Wilson, Hargreaves and Hauxwell-Baldwin, 2017) play a crucial role in determining access to IoT technologies thereby hindering the adoption in certain demographics. Structural factors like socio-economic class, digital literacy, and affordability were cited as barriers (e.g., Singh et al., 2017). Fear of technological autonomy (e.g., Kahlert et al., 2017) and perceived complexity were additional challenges finding an uneven diffusion of smart devices in different income levels.

2.3.5 Prime focal setting of technology acceptance studies

Adoption in a household setting for personal use (Aldossari, 2018), in a business setting for a number of business processes and systems (Balta-Ozkan et al., 2013) as well as adoption by customers of the business, Alalwan, Dwivedi and Rana (2017), Bassarir-Ozel, Turker and Nasir (2022) for business setting etc. have been looked at in several studies.

2.3.6 Demographics and cultural influences

A global drive is evident in the number of studies undertaken in Jordan (Mashal and Shuhaiber, 2018), South Korea (Shin, Park, and Lee, 2018), Malaysia (Sallimon 2018), India (Kumar et al., 2016; Gupta, Manrai and Goel, 2019 and Singh et al., 2017), US (Wright 2017; Marikyan, Papagiannidis and Alamanos, 2021), Sub Saharan Africa (Tetteh and Amponsah, 2020), UK (Cannizzaro et al., 2020), Australia (Sorwar et al., 2023) and many more. A clear difference in the affluence, facilitating conditions and economic state and its impact on technology adoption in different **geographical area** is evident from the above studies. Each of these studies are conceptualised to the context of the country and some make generalisations applicable globally.

2.3.7 User acceptance and behavioural factors

User acceptance and behavioural factors are pivotal in understanding the adoption of IoT and smart home devices, with numerous studies exploring the psychological and demographic influences that shape user behaviour. Theories such as the expectation-confirmation model, the theory of planned behaviour, and value-based models have been instrumental in explaining adoption dynamics. Marikyan, Papagiannidis, and Alamanos (2021) emphasized the role of usability and perceived ease of use in driving acceptance using Technology Task Fit model of technology acceptance, while Yang et al. (2016) highlighted the importance of emotional needs in fostering positive attitudes toward smart home devices. Demographic studies further reveal tailored approaches are essential, as Chen et al. (2023) demonstrated the unique requirements and preferences of older adults and seniors. Collectively, these studies underscore that successful adoption hinges on aligning technological design with user expectations, emotional considerations, and demographic diversity.

2.3.8 Sustainability and energy management

Sustainability and energy management are critical themes in the adoption of IoT technologies, particularly smart home devices. Research highlights how smart energy systems and increased awareness of sustainability influence user behaviour and adoption. Große-Kreul (2022) and Strengers and Macmillan (2013) emphasize the role of environmental awareness and the potential of IoT devices, such as smart energy systems, to promote energy efficiency and reduce carbon footprints. However, challenges remain in bridging the gap between the potential of these technologies and user perceptions. Miu et al. (2019) explored this disconnect in their study on smart thermostats in British homes, revealing confusion and varied user experiences that hinder the effective utilization of these devices. These findings suggest that while sustainability and energy efficiency motivate IoT adoption, addressing usability challenges is essential to unlocking their full potential.

2.3.9. Impact of external factors

The impact of external factors, particularly significant global events, has been a critical theme in understanding IoT adoption dynamics. The COVID-19 pandemic, for instance, profoundly influenced the usage and adoption of smart home technologies, as explored by Umair et al. (2021). Their study highlighted post-pandemic shifts in consumer behaviour, with increased reliance on IoT devices to facilitate remote work, healthcare, and daily living in socially distanced environments. Furthermore, external factors extend beyond behavioural changes to encompass mental well-being. Ghafurian, Ellard, and Dautenhahn (2023) investigated potential correlations between mental health and ownership of specific smart home devices, suggesting that these technologies may have nuanced psychological impacts depending on their usage and purpose. Together, these studies underscore the interplay between external factors and IoT adoption, emphasizing the multifaceted ways such influences shape technology trends.

2.4 Research gaps

The above literature reviewed enabled the researcher to identify key trends in the research within the subject area of smart home. There is a growing interest evident in studies focusing on various elements of the IoT devices technology and its integration into households. Whilst there is extensive knowledge each study undertaking a different perspective of factors of technology acceptance, the wholistic impact of these factors remains to be examined at depth (San-Martín and Herrero, 2012). Areas such as impact of pandemic (Umair et.al 2021) and sustainability and energy management are underrepresented in the review (Große-Kreul, 2022; Strengers, and Macmillan 2013; Miu et. al., 2019). Research focusses on several devices within the IoT family of devices such as smart wearable devices (Park, 2020), smart appliances (Alolayan, 2014; Kim and Moon, 2023) and thermostats (Miu et. al. 2019) etc. however the key features of IoT devices such as mobility, compatibility and automation and its impact on perceived usefulness of these devices remains an area requiring further attention.

A global drive is evident in the number of studies undertaken in Jordan (Mashal and Shuhaiber, 2018), South Korea (Shin, Park, and Lee, 2018), Malaysia (Sallimon 2018), India (Kumar et al., 2016; Gupta, Manrai and Goel, 2019), US (Wright 2017), Sub Saharan Africa (Tetteh and Amponsah, 2020), UK (Cannizzaro et al., 2020) and many more. A clear difference in the affluence, facilitating conditions and economic state and its impact on technology adoption in different **geographical area** is evident from the above studies. Each of these studies are conceptualised to the context of the country and some make generalisations applicable globally. Psychological variation is caused by genetic differences between populations, and cognitive style is inherited genetically (Mesoudi, 2016). The way people think in eastern countries may be significantly different to the way people think in western countries. Psychologists are uncovering the surprising influence of geography on our reasoning, behaviour, and sense of self. (Robson, 2017). Human psychology and thereby consumer behaviour is distinctive in different countries and hence the results of these empirical studies may not be applied without testing in UK.

2.5 Summary

This chapter provide an overview of the extant research undertaken in the field of technology acceptance with specific emphasis on smart homes and smart home technology. The chapter provided a detailed discussion of literature on IoT adoption in a smart home environment highlighting the review of the theories surrounding technology acceptance of IoT devices and more particularly smart home technology which encapsulates the focus of this study. Researchers covered a wide range of themes as identified in this chapter ranging from empirical studies using TAM (Davis, 1989) to more contemporary issues of privacy, security and trust related studies. The themes also included studies focussing on sustainability and energy management using smart technology and impact of external factors such as Covid-19 on consumer behaviour towards IoT devices. An in-depth analysis of empirical studies in IoT has been undertaken in order to identify the research gaps.

CHAPTER 3 THEORETICAL OVERVIEW

3.1 Introduction

Following on from the overview of IoT and conceptual clarity of terminology used in this research as well as identification of research gaps as discussed in the previous chapter, this chapter aims to review the theories in technology acceptance by critically analysing theories of consumer behaviour and technology adoption as well as several empirical studies with a view to identifying ideas to allow the progression of this research analysis and, possibly, gaps in knowledge that need to be bridged for a research project on factors influencing the acceptance of Internet of Things (IoT) devices within a smart home environment.

3.2 Evolution of theories in adoption

The evolution of adoption is dated a few decades ago from the roots of behavioural studies consumer behaviour branching into two main subcategories of psychological studies and social sciences discipline. This study includes a discussion dating back from 1962, when Rogers developed one of these theories i.e., Innovation Diffusion Theory (IDT), initially developed to explore the diffusion of innovation/ideas and later applied to study the adoption of technology (Rogers, 1962) ranging to General Extended Technology Adoption Model for E-Learning (GETAMEL) by Abdulla and Ward (2016) and a conceptual framework developed on Technology Adoption Model Canvas (TAMC) recently by Anton et. al (2024).

The figure below summarises the evolution of theories over the last few decades. A selection of major theories has been discussed in this paper whose contribution and relevance have been found applicable to the aims and objectives of this research.

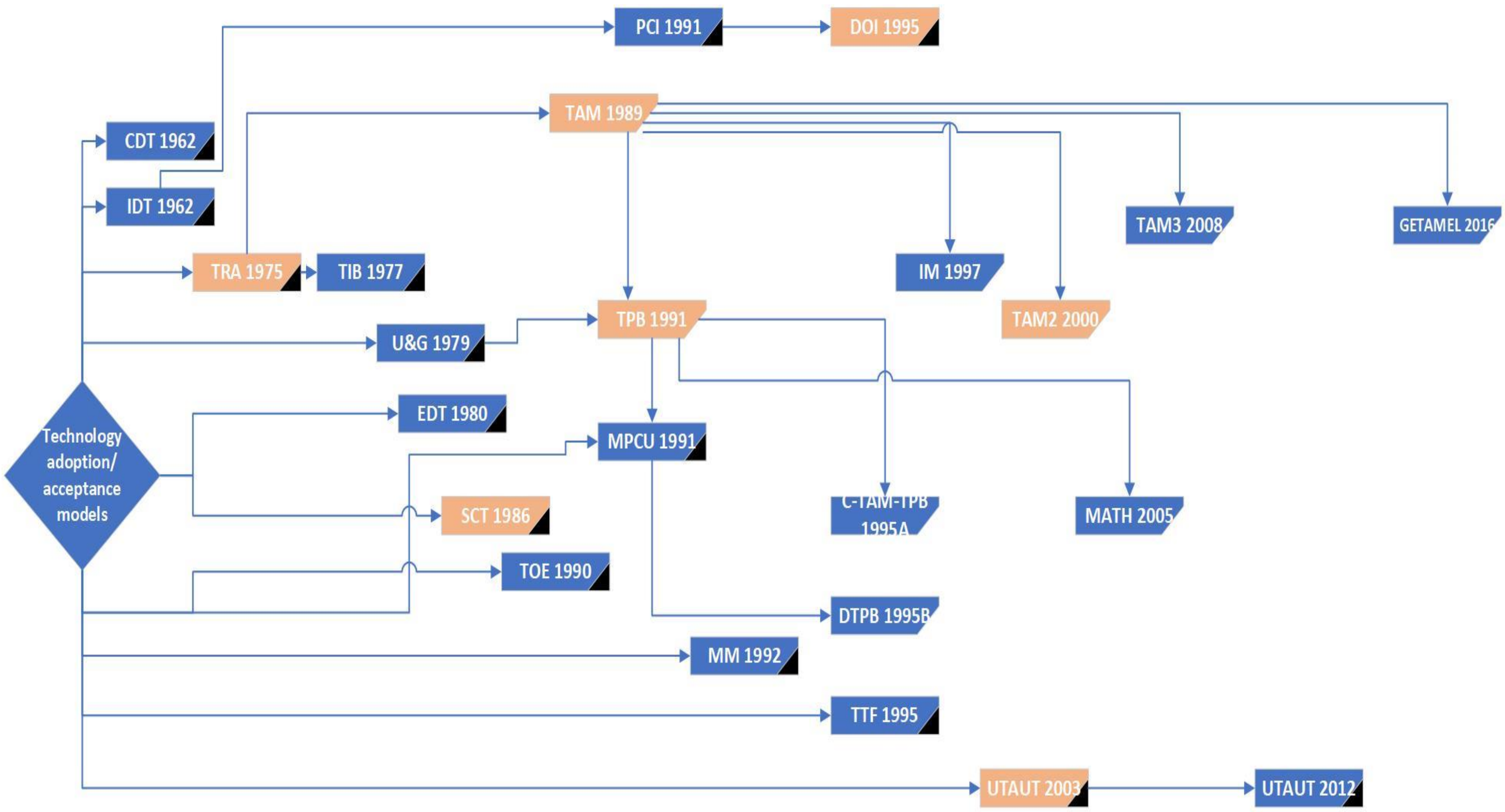

Figure 3. 1 Chronological Evolution of adoption theories

3.3 Classification of theories

From the above figure of evolution of a wide range of theories in the field of understanding consumer behaviour, this section attempts to classify the theories into categories to review the contribution of each theory within the field of technology adoption/acceptance. These theories can be classified in the following categories as per the figure below:

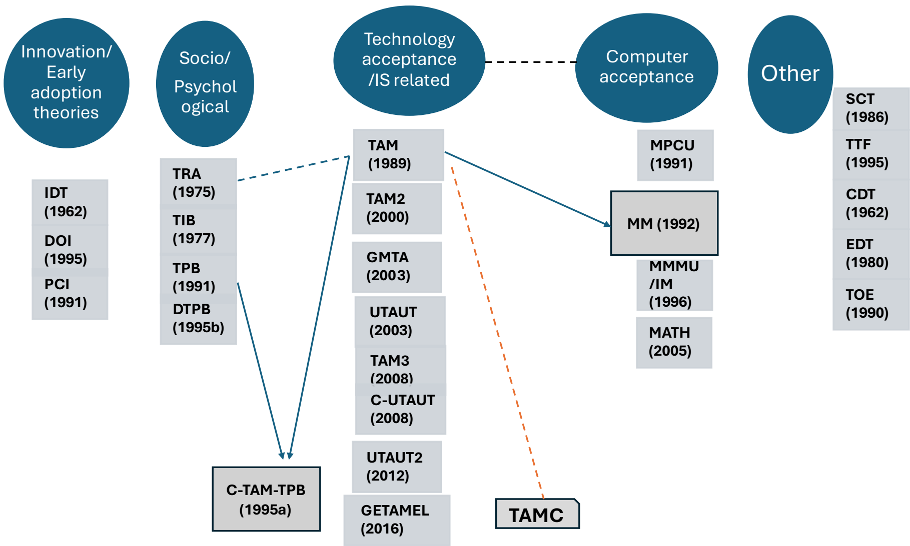

Figure 3. 2 Classification of theories

A brief description of selected most popular theories (Yadegari, Mohammadi and Masoumi 2024) from the above figure have been discussed in the section below. This discussion will provide an essential overview of underlying evolution of theories to support the theoretical foundation of this research.

3.4 Innovation and Early Adoption

3.4.1 Innovation Diffusion Theory/Diffusion of Innovation

The IDT (Innovation Diffusion Theory), also known as Diffusion of Innovation (DOI), was populated by Everett Rogers in 1962. The innovation-decision process refers to the subjective attitude of the user to the subject of a new product or technology, considering whether to adopt the innovation, then taking practical action, and making a second confirmation of the behaviour. Thus, according to DOI, the innovation decision-making process consists of the following five phases: the knowledge stage, persuasion stage, decision stage, implementation stage, confirmation stage. Rogers (1983) describes the knowledge stage as “individual exposed to the innovation's existence and gains some understanding of how it functions” (Rogers 1983, p.20), persuasion as the development of attitude towards the innovation, decision stage as determining whether or not to use the innovation, implementation stage as trying the innovation and confirmation stage as reinforcement that the innovation is positive. Sahin and Thompson (2006) and Hayden (2014) summarise Innovation diffusion theory which is divided into two aspects, one is people’s acceptance of innovation, the other is the rate of innovation spread or spread in the crowd after people accept innovation. The acceptance degree or the decision-making process of the innovation is related to the characteristics of the innovation itself, and the innovation of its own characteristics has five aspects, one is the comparative advantage, compatibility, complexity, experimental and observability. IDT mainly focuses on the consideration and analysis of social attribute factors. On the basis of communication theory, it analyses the diffusion process of innovation information or innovation entity between social systems. Diffusion pathways can be divided into two categories: mass media and interpersonal communication.

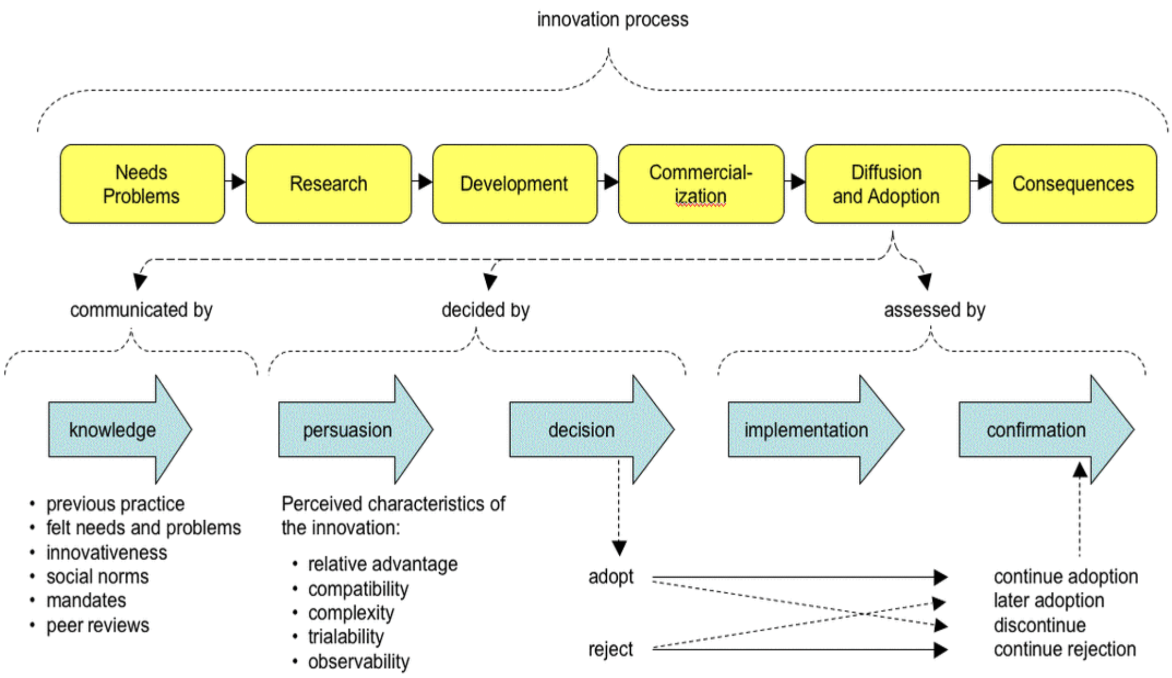

Figure 3. 3 Innovation Diffusion Theory Adapted from) Denning Institute (2021)

Rogers (1995) explains that adoption of innovation is a time-consuming process and the rate at which diffusion of innovation takes place becomes significant for individuals or organisations that are concerned with adoption of innovation. Rogers defines diffusion as "the process by which an innovation is communicated through certain channels over time among the members of a society" (Rogers 1995, p.5). He defines innovation as an idea, practice, or object that is perceived as new by an individual or other unit of adoption' (Rogers, 1995, p.11). It has been suggested (Prescott and Bhardwaj, 1995) that diffusion of innovation theory (DOI) provides a "rewarding base for expanding our understanding of IT adoption, implementation, and infusion" (p.19). His diffusion of innovation theory focuses on the adoption of innovation from a sociological perspective and has been successfully applied in the Information Systems (IS) context to explain the adoption of innovations (Moore and Benbasat, 1991; Tornatzky and Klein, 1982). The DOI model of Rogers (1995) examines a diversity of innovations by introducing four constructs (innovation, communication channel, time, and social system) which influence the spread of a new idea. The DOI model integrates three major components: adopter characteristics, characteristics of an innovation, and innovation decision process. In the **innovation decision** step, five steps namely knowledge, persuasion, decision, implementation, and confirmation take place through a series of communication channels among the members of a similar social system over a period of time. In the **characteristics of an innovation** step, five main constructs; relative advantage, “the degree to which an innovation is perceived as better than the idea it supersedes” (Rogers 1995, p.15); compatibility ”the degree to which an innovation is perceived as being consistent with the existing values, past experiences, and needs of potential adopters” (Rogers 1995, p.15); complexity “the degree to which an innovation is perceived as difficult to understand and use'” (Rogers 1995, p.15)., trialability “the degree to which an innovation may be experimented with on a limited basis” (Rogers 1995, p.16)., and observability “the degree to which the results of an innovation are visible to the others” (Rogers 1995, p.16)., were proposed as effective factors of any innovation acceptance.

Tornatzky and Klein (1982) assert that relative advantage, compatibility, and complexity are the three most relevant constructs for the adoption of innovation. Other researchers such as Moore and Benbasat (1991) have successfully extended the model and added image, result demonstrability, visibility, and ease of use. The five elements of Rogers’ DOI theory have considerable domination in the innovation diffusion studies and have been successfully adapted to study the diffusion of technological innovation (Tung and Reick 2005).

The DOI not only has been used at both organizational and individual levels but also, offers a theoretical foundation to discuss adoption at a global level. It focusses more on the system characteristics, organisational attributes and environmental aspects and has less power in explanatory elements as well as it is less practical for prediction of outcomes compared to other adoption models.

Rogers (1971) suggests that adoption occurs in a time sequence and adopters can be classified into categories based upon how long it takes for individuals to begin using the new idea. Adopter characteristics categorise adopters as early adopters, innovators, laggards, late majority, and early majority.

Innovators are eager to try new ideas, to the point where their venturesomeness almost becomes an obsession. Usually, innovators have substantial financial resources, and the ability to understand and apply complex technical knowledge. (Rogers, 1971). **Early adopters** tend to be integrated into the local social system more than innovators. People in the early adopter category seem to have the greatest degree of opinion leadership in most social systems. They provide advice and information sought by other adopters about an innovation. The early adopter is usually respected by his or her peers and has a reputation for successful and discrete use of new ideas (Rogers, 1971). Members of the **early majority category** will adopt new ideas just before the average member of a social system. (Rogers, 1971). The **late majority** are a sceptical group, adopting new ideas just after the average member of a social system. (Rogers, 1971). **Laggards** are traditionalists and the last to adopt an innovation (Rogers, 1971).

3.4.2 Perceived Characteristics of Innovating theory

The Perceived Characteristics of Innovating (PCI) theory measures knowledge users' perception of an innovation according to eight characteristics of innovations as outlined by Rogers (1983)'s Diffusion of Innovations theory (Moore & Bensabat, 1991). This model was developed by expanding DOI by adding three additional features, image, voluntariness, and behaviour. The PCI was initially developed to analysed individuals' perceptions of information technology innovations (Moore & Bensabat, 1991) whereby voluntariness affects users' decision to reject or accept an innovation.

3.5 Socio-Psychological sciences theories

3.5.1 Theory of Reasoned Action (TRA) and Theory of Planned Behaviour (TPB)

Whilst Innovation Diffusion Theory may be interpreted as an umbrella concept to adoption behaviour, Fishbein and Ajzen's Theory of Reasoned Action (TRA) is based in social psychology with the hypothesis that behaviour change originates from beliefs about behaviour (Fishbein and Ajzen, 1975).

TRA introduced two core independent construct: attitude toward behaviour and subjective norm, which are tied to behavioural and normative beliefs. Also studied as subjective norms in historical theories, social influence is considered as one of the key factors influencing adoption of technology. Subjective norm is defined as "the person's perception that most people who are important to him, think he should or should not perform the behaviour in question" (Fishbein and Ajzen, 1975, p.302).

To understand the factors influencing adoption and acceptance of technology, information systems research has taken a wider perspective to study the factors affecting adopter's behaviour to adopt the technology. Fishbein and Ajzens's (1975) TRA provides a firm theoretical foundation for the stream of information systems research with an objective to predict behaviour of individuals to adopt a particular technology. The TRA is concerned with determinants of consciously intended behaviours (Malhotra and Galletta, 1999) and has influenced conceptualization of models predicting IT acceptance (e.g. Technology Acceptance Model TAM, Davis, 1989). Drawn from social psychology, the TRA states that beliefs influence attitude, which lead to intentions, and finally to behaviours.

Ajzen (1985) expanded on the theoretical framework of TRA and proposed the Theory of Planned Behaviour (TPB) by including the construct perceived behavioural control (PBC) to address situations in which individuals lack substantive control over a specific behaviour (Ajzen 1991). As the TPB is a modification of TRA, the determinants attitude and subjective norm are defined in TPB, just the way they were defined in TRA. The TPB suggests that behaviour can be explained by behavioural intention, which is influenced by attitude, subjective norms, and perceived behavioural control. Perceived Behavioural Control (Venkatesh et al. 2003) is "the perceived ease or difficulty of performing the behaviour" (Ajzen 1991, p.188) and in context of IS research, "perceptions of internal and external constraints on behaviour" (Taylor and Todd 1995b, p.149). The extent to which an individual perceives to have necessary resources to perform the behaviour is measured by perceived importance of that resource to successful performance of the behaviour (Agarwal and Prasad 1999). An example in the usage of an IT such as Internet might be beliefs related to the extent to which an individual perceives to have access to high-speed Internet connection measured by beliefs related to perceived importance of high-speed connection to use Internet (Agarwal and Prasad 1998).

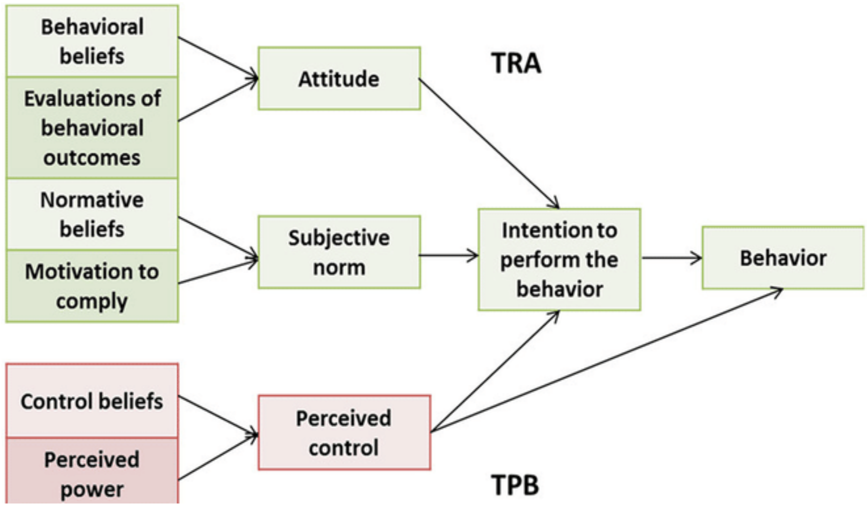

Figure 3. 4 *TRA and TPB*

Adapted from LaCaille (2013)

Owing to its ability to predict behaviour in context specific situation, the theory of planned behaviour has received broad support in empirical studies of social psychology (Ajzen 1991; Ajzen and Madden 1986; Taylor and Todd 1995), marketing (Chiou 1998), and information technology (Fusilier and Durlabhji 2005; Pavlou and Fygenson 2006).

Since the TRA focuses on behaviours that people decisively enact, the theory is limited in terms of being able to predict behaviours that require access to certain opportunities, skills, conditions, and/or resources (Eagly and Chaiken 1993). Additionally, certain intentions do not necessarily play a role in terms of connecting attitudes and behaviour. According to a study conducted by Bagozzi and Yi (1989) the performance of a behaviour is not always preceded by a strong intent. In fact, attitudes and behaviours may not always be linked by intentions, particularly when the behaviour does not require much cognitive effort. However, the impact of subjective norms on intention to perform a behaviour needs to be assessed which forms one of the hypotheses of this research and discussed in the next chapter.

3.5.2 Decomposed Theory of Planned Behaviour

In an attempt to generalize the impact of belief structures on behaviour, in a variety of research settings, Taylor and Todd (1995b) proposed Decomposed Theory of Planned Behaviour (DTPB) based on TPB (Ajzen, 1991) that provides a greater insight into the factors influencing IT usage by decomposing the attitudinal, normative and control beliefs that are generalizable across situations and not specialized to each context (Fu, Farn, and Chao 2005) In a comparative study of TAM, TPB and DTPB, Taylor and Todd (1995) observed that DTPB provided increased explanatory power for intentions as compared to TAM and TPB. Despite TAM's prediction abilities in comparison to other models, researchers in IT have taken the advantage of its parsimonious nature and successfully adapted it to achieve empirical results.

This theory did not add any additional factors to the existing theories of TAM or TPB and hence considered insignificant to the review but essentially included to see the evolution of theories in the field of technology adoption.

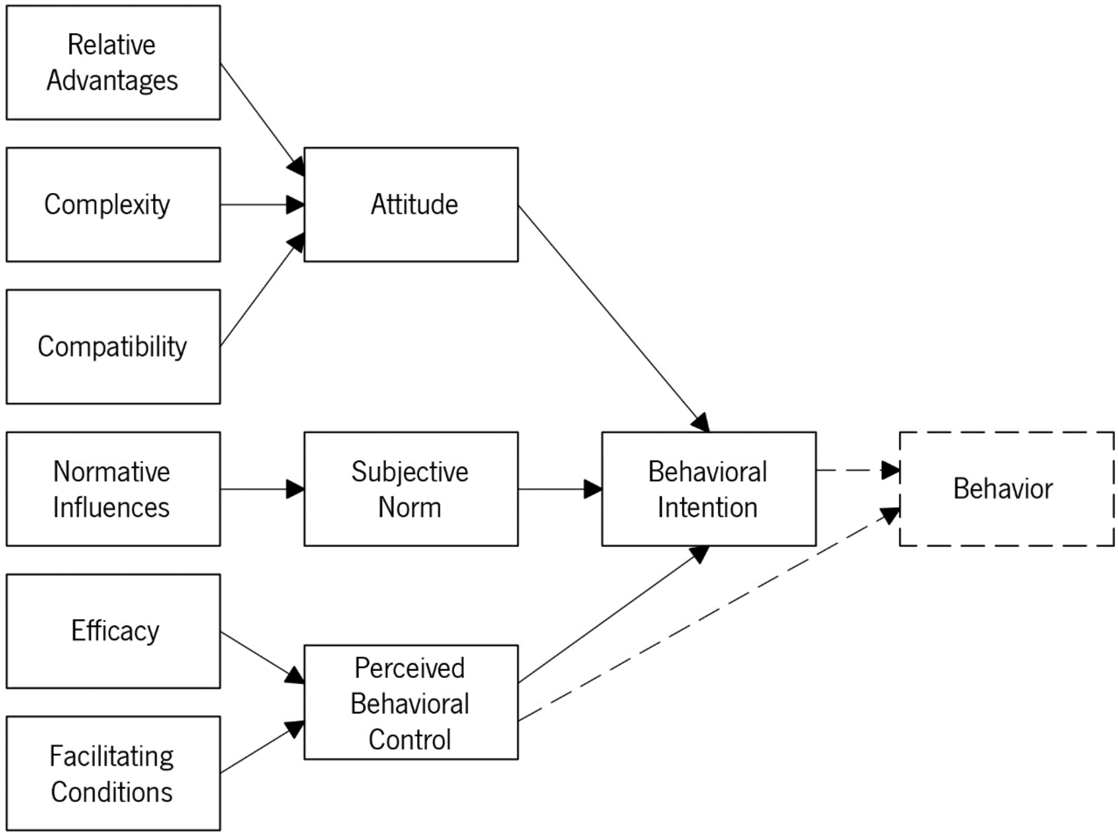

Figure 3. 5 DTPB

Adapted from Taylor and Todd, (1995a)

3.6 Technology acceptance theories

3.6.1 Technology Acceptance Model (TAM)

The Technology Acceptance Model (TAM) was proposed by Davis in 1989 to predict and explain user acceptance of various information technologies in organisations. According to Davis, Bagozzi, and Warshaw (1989), "the goal of TAM is to provide an explanation of the determinants of computer acceptance that in general is capable of explaining user behaviour across broad range of end-user computing technologies and user populations, while at the same time being both parsimonious and theoretically justified" (p.985).

Davis, Bagozzi and Warshaw’s (1992) definition of extrinsic motivation i.e., "extrinsic motivation refers to the performance of an activity because it is perceived to be instrumental in achieving valued outcomes that are distinct from the activity itself" (p.1112) also related to the definitions of McGuire (1974). External variables such as objective system characteristics, training, computer self-efficacy, user involvement in design, and the nature of implementation process are theorized to influence behavioural intention to use, and ultimately usage, indirectly via their influence on perceived usefulness and perceived ease of use” (Davis 1996, p. 20). Also, in this study of Davis, Bagozzi and Warshaw, 1992, "intrinsic motivation refers to the performance of an activity for no apparent reinforcement other than the process of performing the activity per se" (p.1112) whereas Deci and Ryan (1985) and Vallerand (1997) referred to intrinsic motivation as the perceptions of pleasure and satisfaction derived from performing the behaviour itself.

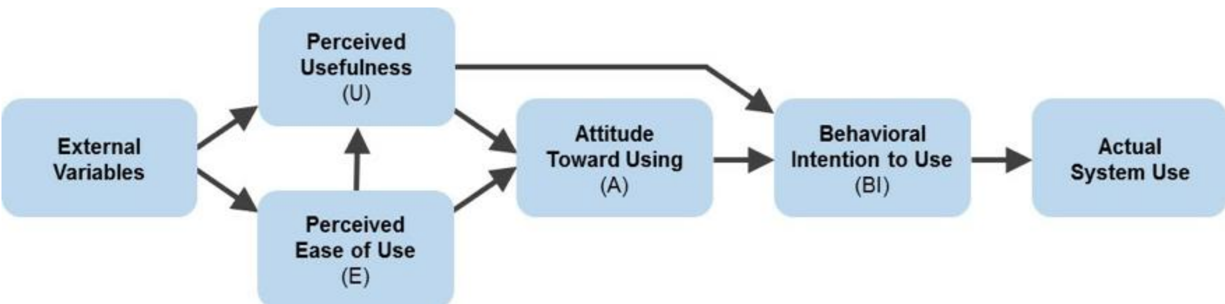

Figure 3. 6 TAM

Adapted from Davis (1985)

Davis (1993) suggested that the perceived usefulness construct may reflect considerations of the “benefits” and “costs” of using the target system. In an attempt to predict the usage behaviour, in case of mandatory settings. The variable of attitude and its impact of behavioural intention was considered in the original proposed TAM (Davis, 1989), which was subsequently removed from extensions to TAM in TAM2, UTAUT, TAM3 and UTAUT2. The TAM was extended to include the subjective norms as an additional predictor of intention to use (Venkatesh and Davis, 2000, Venkatesh et al. 2003). According to Robey (1996), TAM’s theoretical contribution has helped researchers understand information systems usage and acceptance behaviours. As noted by Malhotra and Galletta (1999) the TAM model has emerged as one of the most influential models in the stream of research in IS acceptance and usage.

TAM mainly focusses on IS technology whereas IoT devices may not be exclusively categorised as IS due to its peculiar characteristics as discussed earlier. However, this theory contributes significantly in providing a strong conceptual framework to this study by providing the majority of the core factors studies to understand the acceptance of IoT devices within a smart home environment.

3.6.2 TAM 2

The study focussing on antecedents of perceived usefulness and Behavioural Intention is known as TAM2 (Venkatesh and Davis, 2000). The TAM2 was proposed by adding two groups of constructs: social influence (image, subjective norms and voluntariness) and cognitive (result demonstrability, job relevance and output quality) to TAM, to improve the predictive power of perceived usefulness. Therefore, for both voluntary and mandatory environments, TAM2 is more general. The only exception is related to subjective norm which have influence in mandatory settings but *not in voluntary settings such as home environment*. The second study identified constructs that influence on perceived ease of use. The antecedents of perceived ease of use have been divided to two major groups, namely, adjustments and anchors. The general beliefs regarding the use of computer systems have been put in anchors group (enjoyment and objective usability) while beliefs that are formed on the basis of direct experience of given system are included in adjustments set (external control, computer self-efficacy, computer anxiety, and computer playfulness).

Subjective norms which have been identified as an exception to the applicability of TAM2 to this study. TAM2 concluded that subjective norms have an influence in mandatory settings and not in voluntary settings. This research is predominantly studying the behaviour influences in a home setting and hence this factor along with the image factor needs further reasoning.

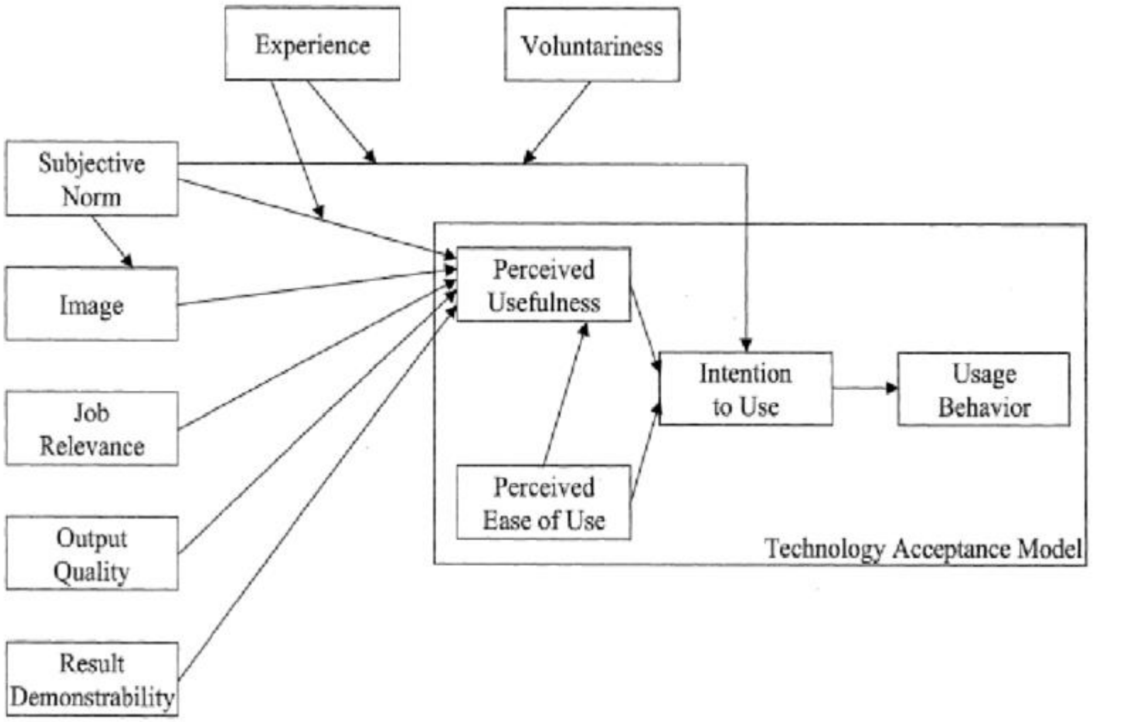

Figure 3. 7 TAM2

Adapted from Venkatesh and Davis (2000)

3.6.3 Unified Theory of Acceptance and Use of Technology (UTAUT) model

In an attempt to progress towards a unified view of user acceptance, Venkatesh et al. (2003) conducted a study to review eight theoretical models and synthesize their findings to propose a Unified Theory of Acceptance and Use of Technology (UTAUT) model. Venkatesh et al. (2003) empirically compared the eight 'individual acceptance models', namely, TRA, TAM, MMMU, TPB, C-TAM-TPB, MPCU, IDT, SCT, with four core determinants of intention and usage of information technology: performance expectancy, effort expectancy, social influence and facilitating conditions. This unified model was tested empirically and found to outperform the eight individual models. In an empirical application, while the previous models explain between 17 and 53 percent of the variance in user intentions to use information technology, the UTAUT model explained about 70 percent of the variance in behavioural intention to use a technology and about 50 percent of the variance in technology use (Venkatesh, Thong and Xu, 2012). In this perspective, Venkatesh et al. (2003, p. 425) argued that "UTAUT provides a useful tool for managers needing to assess the likelihood of success for new technology introduction and helps them understand the drivers of acceptance in order to proactively design interventions."

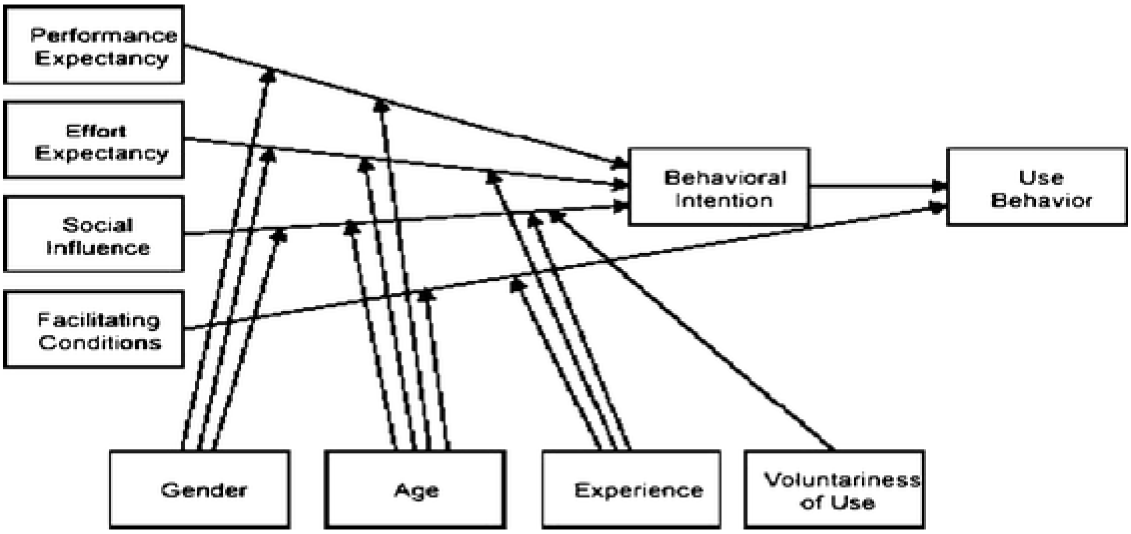

Figure 3. 8 UTAUT

(Venkatesh et al. 2003)

In their study, data from four organizations was used over a six-month period with three points of measurement. The UTAUT model also explains the moderating effect of demographics on the intention to use the technology. Though it has provided encouraging results in different organizational settings, it has not been tried for individuals adopting home devices. Although the aim of UTAUT was to develop a unified theory, the findings are applicable to organisational setting instead of homes. It covered studying a wide range of core determinants such as performance expectancy and effort expectancy similar to PU and PEOU from TAM (Davis, 1989).

The key relevance of this theory is the role of moderators such as age and gender will be used in this research, keeping in mind the type of technology of IoT devices and specifically the setting in which these are used.

3.6.4 TAM 3

Venkatesh and Bala (2008) combined the TAM2 (Venkatesh and Davis, 2000) and the model of the determinants of perceived ease of use (Venkatesh, 2000) and developed an integrated model of technology acceptance known as TAM3 shown in figure below. The authors developed the TAM3 using the four different types including the individual differences, system characteristics, social influence, and facilitating conditions which are determinants of perceived usefulness and perceived ease of use. In the TAM3 model, the perceived ease of use to perceived usefulness, computer anxiety to perceived ease of use and perceived ease of use to behavioural intention were moderated by experiences. It may also be argued that using experience as a moderator may not be relevant in the case of adopting IoT devices as the study is primarily focussed on the acceptance of such devices in a home setting.

The TAM3 research model was tested in real-world settings of IT implementations in organisational setting.

Computer efficiency and anxiety may be termed differently for this study as the technology in question remains that of a higher level than a computer. Perceived enjoyment is an element that needs further study in the home environment.

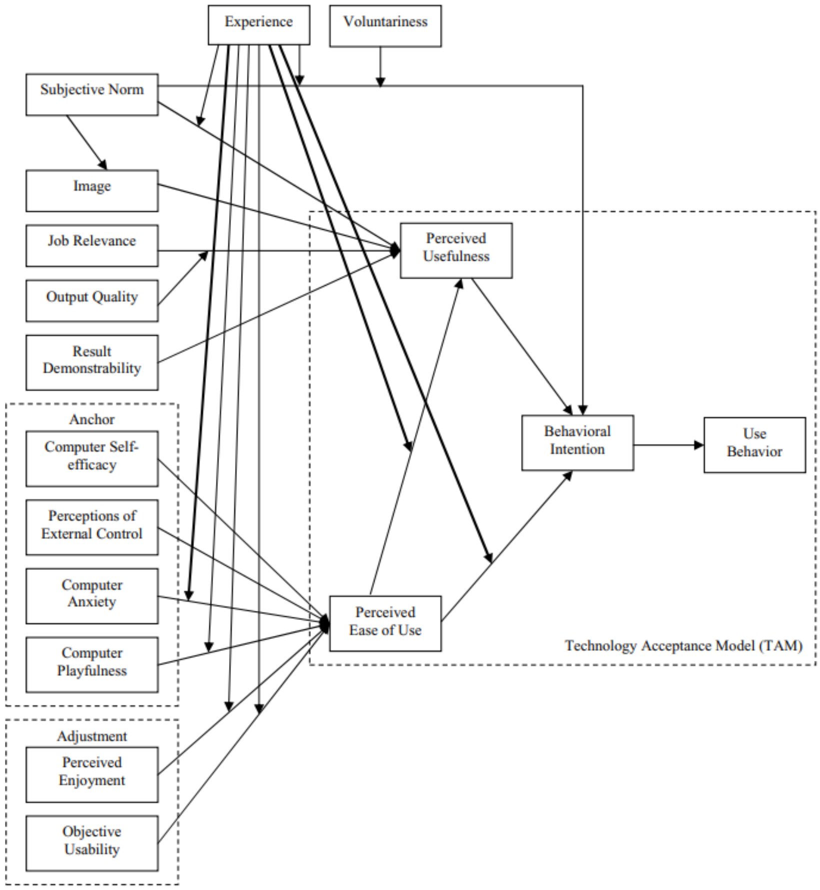

Figure 3. 9 TAM 3

Venkatesh and Bala (2008)

3.6.5 Unified Theory of Acceptance and Use of Technology 2 (UTAUT2) model

Despite the wide acceptance of the UTAUT, Venkatesh, Thong and Xu (2012) incorporated three other constructs into the UTAUT: hedonic motivation, price value, and habit, extending UTAUT into UTAUT2. Hedonic motivation is considered an intrinsic value that is derived fun from consumers' technology usage. Price value is the consumers' belief that the benefits of technology overweight its monetary cost. Habit has the definition of previously learned automated technology usage. (Venkatesh, Thong and Xu 2012). However, in UTAUT2, voluntariness of use was dropped as moderator since consumers have no organisational mandate and, in many situations, consumer behaviour is voluntary (Venkatesh et al., 2012). Compared to UTAUT, the extensions proposed in UTAUT2 produced a substantial improvement in the variance explained in behavioural intention. The predictive ability of UTAUT2 theory is much higher in comparison to UTAUT; explaining about 74 percent of the variance on consumers' behavioural intention to and 52 percent of the variance in consumers' technology usage of focal technology (Venkatesh et al., 2016). Several researchers stress the importance of UTAUT2 dimensions in IoT adoption (Baudier, Ammi, and Deboeuf-Rouchon, 2020; Gao, Li and Luo, 2015; Aldosarri and Sidorova 2018).

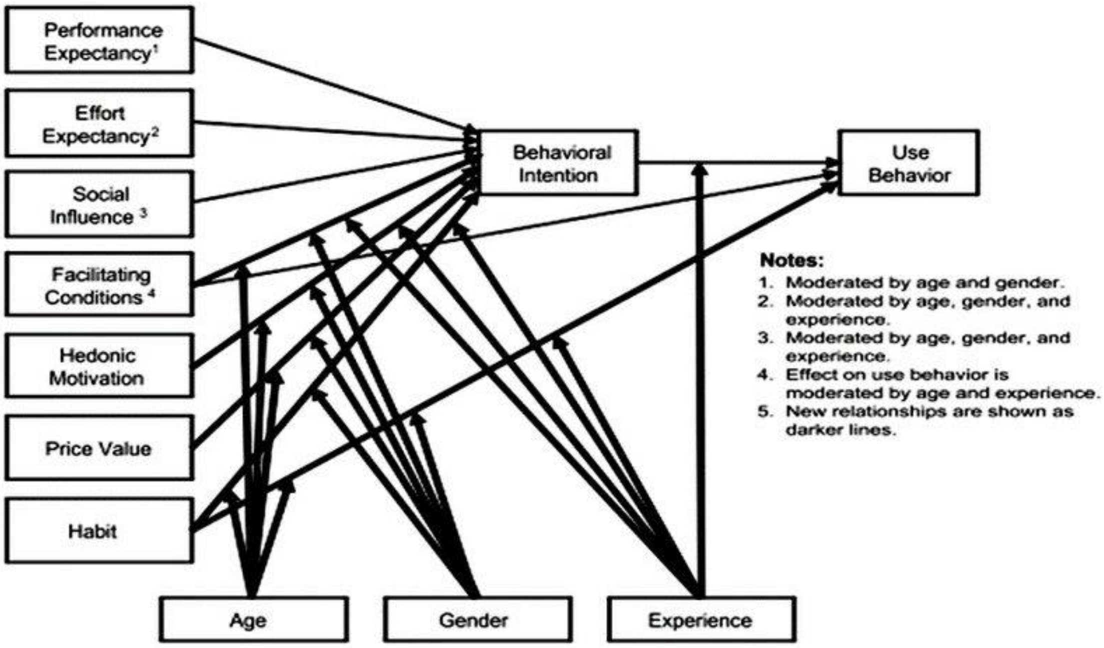

Figure 3. 10 UTAUT2

Adapted from Davis, Thong and Xu (2012)

3.6.6 Other extensions of TAM

Models such as General Model of Technology Adoption (Barnes and Huff, 2003), C-UTAUT (Bouten, 2008), C-TAM-TPB (Taylor and Todd, 1995a) and more recently GETAMEL (Abdullah and Ward, 2016) and TAMC (Anton et. al 2024) GMTA were found as recent extensions to TAM studies among other empirical studies using TAM (Yang et al., 2017; Han and Yang 2018; Kahlert, Constantinides and De Vries 2017; Kim, Park and Choi 2017; Park et al. 2017; Singh, Gaur and Ramakrishnan 2017; Yang, Lee and Zo 2017). Bouten (2008) integrated compatibility beliefs developed by Karahanna, Agarwal (2006) into the UTAUT model developed by Venkatesh et. al. (2003) to improve the explanatory power of the UTAUT model whereas Mathieson et al. (2001) did an extensive comparison of TAM and TPB combining the individual strengths of both the theories to develop General Model of Technology Acceptance (Barnes and Huff, 2003) focussing on the influence of perceived user resources. The C-TAM-TPB (Taylor and Todd, 1995a) also predicts that perceived behavioural control will have a direct effect on behaviour in addition to its indirect effect through intentions. Perceived usefulness and perceived ease of use are determinants of attitude, whereas perceived ease of use directly affects perceived usefulness (Taylor and Todd, 1995a)

Where GETAMEL was developed as a General Extended Technology Adoption Model for E-Learning using 2 core constructs of TAM PEOU and PU, and found self-efficacy as the best predictor of student's PEOU of e-learning systems (Abdullah and Ward, 2016) whereas TAMC, based on DOI and UTAUT theories, is a proposed conceptual framework that aims to provide a solution for Food Service microbusinesses towards a 'smarter' and more sustainable future by guiding the evaluation of both microbusinesses' readiness and the factors driving/impeding them towards/from adopting smart technology. (Anton et. al. 2024) Self-efficacy is found to be an important characteristic of adopters and hence it is used in this study.

3.7 Computer acceptance related theories

3.7.1 Motivational Model of Microcomputer Usage (MMMU)

According to this model, both extrinsic and intrinsic motivators affect the new technology acceptance or rejection (Igbaria, Parasuraman and Baroudi, 1996). This model posited perceived fun as intrinsic motivator and perceived usefulness as extrinsic motivator which influence on behaviour (computer usage) and attitude (computer satisfaction). Apart from these factors, user acceptance (actual behaviour) is directly and indirectly affected by perceived usefulness, computer anxiety, computer satisfaction, and perceived fun. Also, perceived fun and perceived usefulness have both direct and indirect (via satisfaction) influence on adoption. Besides, perceived usefulness effects on perceived fun. Additionally, computer anxiety negatively affects two factors perceived fun and perceived usefulness. Also, it has been confirmed that satisfaction of computer has a direct influence on usage

One of the most relevant elements of this theory is that of fun also studied as enjoyment in TAM3 and hedonic motivation in UTAUT2 and perceived enjoyment in Motivational Model (MM) (Davis, Bagozzi and Warshaw, 1992), which is to be used as hedonic motivation for this research provides a foundation to study the impact of perceived fun on behavioural intention. However, due to the presence of fun factor in other theories such as MM, TAM3 and UTAUT2 as well as the context of this theory being the acceptance of a computer system, the significance of MMMU is restrained for this research.

3.7.2 Model of Adoption of Technology in Households (MATH)

Brown and Venkatesh (2005) developed model of adoption of technology in the household (MATH) and further proposed and tested a theoretical extension of MATH by arguing that key demographic characteristics that vary across different life cycle stages of households. The results from survey responses of 746 households that had not yet adopted a PC showed that the integrated model, including MATH constructs and life cycle characteristics, explained 74% of the variance in intention to adopt a PC for home use, a significant increase over baseline MATH that explained 50% of the variance. This theory refined understanding of the moderating role of household life cycle stage on adoption of technology in households.

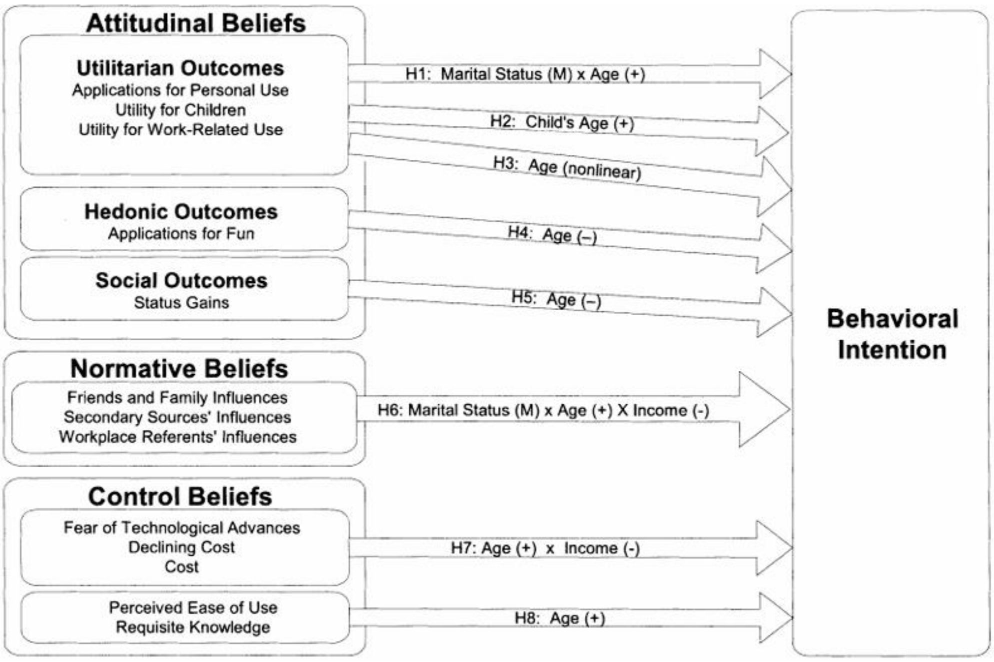

Figure 3. 11 MATH

Adapted from Brown and Venkatesh (2005)

One of the pioneering studies focussing on the adoption of technology in households, Brown and Venkatesh (2005) conducted this research to study the direct impact of multiple factors such as utilitarian, hedonic and social outcomes as well as normative and control beliefs on behavioural intention. The focus of the study was the then new technology of a Personal Computer which is significantly different to today's technology as discussed earlier in peculiarity of IoT devices. Although the technology is significantly different the fundamental factors affecting the behavioural intention have the potential to be studied in the context of IoT devices in a smart home environment.

3.8 Other theories

3.8.1 Social Cognitive Theory

Inspired by social psychology, Social Cognitive Theory (SCT) started as the Social Learning Theory (SLT) in the 1960s by Albert Bandura. It developed into the SCT in 1986 and posits that learning occurs in a social context with a dynamic and reciprocal interaction of the person, environment, and behaviour.

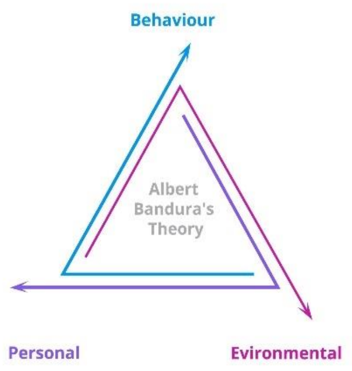

Figure 3. 12 Social Cognitive Theory model

Adapted from Bandura (1996)

The unique feature of SCT is the emphasis on social influence and its emphasis on external and internal social reinforcement. The SCT considers the unique way in which individuals acquire and maintain behaviour, while also considering the social environment in which individuals perform the behaviour. The theory considers a person's past experiences, which factor into whether behavioural action will occur. These past experiences influence reinforcements and expectations, all of which shape whether a person will engage in a specific behaviour and the reasons why a person engages in that behaviour. Bandura (1996) proposed that human behaviour is caused by personal, behavioural and environmental influences, which interact bi-directionally in order to predict both group and individual behaviour. Moreover, it can identify methods which can change and modify behaviour (Rana et al. 2015 – Extended SCT). In the SCT model, behavioural influences are chiefly focused on usage, performance, and adoption issues. However, personal influence is any personality, cognitive and demographic aspects characterizing a person. On the other hand, the environmental influence includes physical and social factors both of which are physically external to the individual. The SCT is an inseparable triadic structure that all three factors constantly influence one another, reciprocally determining each other. The SCT model is integrated to evaluate the information technology usage by using some constructs including self-efficacy, outcome expectations performance, anxiety, affect, and outcome expectations personal.

It is arguable that this model has not been used for many empirical studies due to its limited propositions and applicability but it is included purely to show the evolution of technology acceptance models.

3.8.2 Task Technology Fit Model (TTF)

According to Goodhue and Thompson (1995), Task-technology Fit (TTF) emphasizes individual impact. Individual impact refers to improved efficiency, effectiveness, and/or higher quality. Goodhue and Thompson (1995) assumed that the good fit between task and technology is to increase the likelihood of utilization and also to increase the performance impact since the technology meets the task needs and wants of users more closely. This model is suitable for investigating the actual usage of the technology especially testing of new technology to get feedback. The task-technology fit is good for measuring the technology applications already release in the marketplace like in the google play store or apple store app (iTunes) etc.

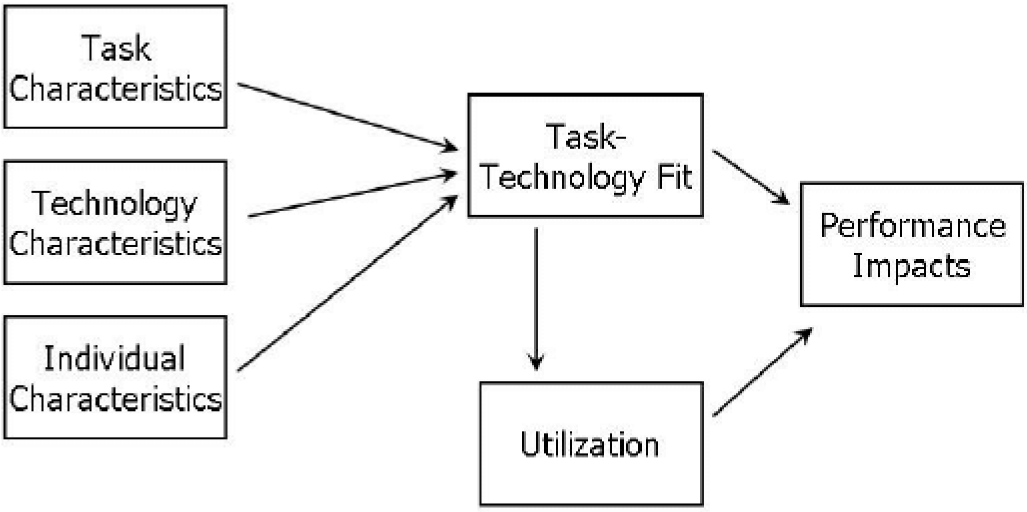

Figure 3. 13 TTF

Adapted from Goodhue and Thompson (1995)

However good this theory's conclusions may be, they are limited to testing of technology for specific tasks, also undertaken in organisational setting. A key element important for this research is that of the actual technology in question and how it is perceived to be able to perform a range of functions for the user. This element needs further study with reference to IoT devices and the user's perception of the variety of functions it can perform which may be influence the adopters. TTF is primarily used to assess the technology fit to tasks within organisational setting, however one can apply the measures to a home setting to test and model this theory in a voluntary context specially with regards to the role of individual characteristics in the acceptance of technology.

3.9 Evaluation of technology acceptance/adoption theories

A comparative analysis can be found in the table below evaluating each of the theory discussed above leading to either a significant contributor or insignificant to the current study.

Table 3. 1 Evaluation of theories

Theory	Developer and year	Field of development	Strengths	Weaknesses	Significance to the current study
IDT/DOI	Rogers 1962/1995	Social Science/Innovation	Ability to study any kind of innovation. Explains and predicts the rate of adoption factors of innovation	General theory. It doesn't indicate how attitude impacts on accepting and rejecting decisions or how innovation factors affect decisions	Innovator characteristics
PCI	Moore and Benbassat 1991	Social Science/Innovation	Extenstion to IDT/DOI with additional features of voluntariness, image and behaviour	Similar to IDT/DOI	Characteristics of Image and its role in technology acceptance
TRA	Ajzen and Fishbein 1975	Social Psychology	Fundamental theories of human behaviour, designed to explain virtually any behaviour	General doesn't refer to other variables that affect behavioural intention.	Role of attitude
TPB	Ajzen 1991	Social Psychology	Successfully applied to understanding of individual acceptance and usage of many different technologies	Suggests that behaviours are already planned and it doesn't refer to other variables that affect BI	Role of attitude
DTPB	Taylor and Todd 1995b	Social Psychology	Expanded by including some factors from IDT making it more managerially relevant in influencing adoption and usage	Similat to TPB, it decomposes the contructs of TPB but still suggests that behaviours are planned.	No additional factors other than of TPB and hence insignificant for this study
TAM	Davis 1989	IT field	Powerful model for technology applications. Replaced TRA's attitude with PEoU and PU. Less general than TRA and TPB	Doest include subjective norms along with a number of other variables. Simple model	All core constructs. This is the main guiding theory with additional factors from other studies
TAM2	Venkatesh and Davis 2000	IT field	Explains PU and PEoU in terms of social influence which includes subjective norms. It also explains the changes in acceptance over time as users gain experience in using technology	specify how expectancies influence behaviour Methodological limitation 2 constructs (job relevance and output quality) measured using 2 items only	Social Influence, Image
C-TAM-TI	Taylor and Todd 1995a	IT field	Combines TPB from social psychological with TAM from IT field for better use of TPB in technology acceptance	TAM constructs are not fully reflected. Behavioural planning factor is not stated	Only a combination of two theories TAM and TPB and hence not significant for this study
UTAUT	Venkatesh et. al 2003	IT field	Multidimensional evaluation of innovation, robust model. Moderators include age and gender	Factors such as risk, trust and specific features of Iot devices not considered	Moderating role of age and gender on technology acceptance is relevant to this study
TAM3	Venkatesh and Bala 2008	IT field	Model developed in organisational setting, comprehensive model, and extension to TAM and TAM2	Self-reported one item on estimation of usage of system Measurement of objective usability may be questionable as this was not explicitly measured through any item, rather	Image, subjective norms and perceived enjoyment - factors applicable to this study
UTAUT2	Venkatesh, Thong and Xu 2012	IT field	Hedonic motivation, price value and habit introduced as an extension to the previous model.Substantial Improvement in variance explained.	Individual characterisitics not studied, which may be influential in explaining behvaiours	Price value and Habit studied as a unique variables in this model are not applicable to the current study. Rest all other variables have been studied in previous models
GETAMEI	Abdullah and Ward 2016	IT field/Education	Extension of TAM, applied to e-learning. Clear relationships and impact concluded.	Focussed on technology within educational enviroment. Behaviours may be different in different settings	Extension of TAM to learning environment. This study uses TAM itself
MPCU	Thompson, Higgins and Howell 1991	IT field	Suitable to predict individual acceptance of many technologies. Successful in understanding and explaining the usae behaviour with a voluntary causative	Complexity factor has computer and technology usage and indirect impact on perceived short term consequences	Not significant to IoT devices
MM	Davis, Bagozzi and Warshaw 1992	Social Psychology	Applications in motivational studies, learning and health care. Can be applied to study new technology adotpion and use	Many more factors are required to be suitable to study technology acceptance	Not significant to IoT devices
MMMU/I	Igbaria, Parsuraman and Baroudi 1996	Computer usage in work setting	Categories of intrinsic and extrinsic factors. Influence of fun on adoption	Similar factors used in other theories	Fun in workplace may be different to fun in a voluntary setting.
MATH	Brown and Venkatesh 2005	PC in household setting	Impact of life cycle stages on acceptance of PC in households	Impact directly on behavioural intention. Other factors not considered	PC acceptance may not be similar to IoT devices acceptance, hence model cannot be relicated fully.
SCT	Bandura 1986	Cognitive field	Triadic structure	Limited propositions and applicability	Not significant
TTF	and Thompso	IT field	Investigate actual usage for obtaining feedback	technology for specific tasks	Role of individual characteristics

Adoption models rooted on a diversity of theories for example, Innovation Diffusion Theory (IDT). is from sociology, Theory of Reasoned Action (TRA) is from social psychology (Bouten, 2008), TIB, (Triandis, 1977) TPB and SCT are psychosocial theories (Gagnon, Sanchez and Pons, 2006). All three theories have proven their effectiveness in predicting and explaining a variety of human behaviours in differing contexts. On the other hand, TRA and TPB differ from DOI in the sense that the former focuses on explaining the behaviour of individuals. The latter concentrates on adoption decisions in which the organizational characteristics play a key role, not the individual. SCT and TPB integrate the notion of perceived outcomes when forecasting behaviour while DOI and TAM focus solely on beliefs about the technology. DOI, TAM and TPB adopt a unidirectional perspective towards causal relationship, in which environmental constructs affect cognitive beliefs, which affect attitudes and behaviours whereas SCT relies on the bidirectional nature of causation in which behaviour, emotional and cognitive factors and environment constantly and mutually affect each other (Carillo, 2010).

Another model, rooted in the theory of human behaviour is the Model of PC Utilization (MPCU) introduced by (Thompson, Higgins and Hogwell, 1991). On the other viewpoint, TIB, TPB and SCT theories are similar and conceptually overlap, however, SCT and TPB have been used more frequently in the study of behaviour than has TIB (Triandis, 1977). The TIB includes all aspects of the TPB model, however it includes additional components that add to its predictive power, namely that of habits and facilitating conditions (Woon and Pee, 2004). Similarly, there are some overlapping factors between DOI and TAM such as complexity and perceived ease of use, relative advantage and perceived usefulness (Carter and Belanger, 2005). Likewise, facilitating condition used by UTAUT (Venkatesh et. al. 2003) captures notions of Ajzen’s (Ajzen 1991) perceived behavioural control, Thompson, Higgins’s (Thompson, Higgins and Hogwell, 1991) facilitating conditions and Moore and Benbasat’s (Moore and Benbasat, 1991) compatibility construct.

Most information system researchers have not made a distinction between the affective component of attitudes (which have a like/dislike connotation) and the cognitive component or beliefs (which are the information a person holds about an object, issue, or person). Perlusz (2004) argued that both cognitive processes and emotional and affective elements influence behaviours have been so far largely sceptical about feelings and emotions. With few exceptions such as Venkatesh (2000), technology acceptance models make use of predictors that are exclusively cognitive, relating the adoption and actual behaviour of a new technology to attitudes, beliefs and perceptions (Davis, 1989; Davis, Bagozzi and Warshaw, 1992; Ajzen, 1991; Rogers, 1995). Technology adoption researchers often conceptualized emotions as negative effects such as computer anxiety (Perlusz, 2004; Venkatesh, 2000; Lowenstein et. al. 2001), fears and worries (Sjoberg, 1998). In contrary, positive emotions like happiness, interest, joy, contentment and enthusiasm have been largely neglected (Perlusz, 2004). Some of the previous models focus on internal antecedents of behaviour like attitudes, values and intentions while others focus more on external issues such as norms, incentives and institutional constraints. Besides, a quantity of models does not provide clear guidelines for the operational definition of the variables within the model such as TIB (Robinson, 2009).

3.10 Research Positioning

Technology acceptance theories/models' comparison showed a range of constructs and moderators studied in order to study their impact on various technologies of the time both in voluntary and organisational settings. Below is a summary of factors used in various studies such as Theory or Reasoned Action (TRA) (Fishbein and Ajzen, 1975) Technology Acceptance Model (TAM) (Davis, 1989); Model of PC Utilization (MPCU); (Thompson et. Al 1991); Combined TAM and TPB (C-TAM-TPB) (Taylor and Todd, 1995) Decomposed Theory of Planned Behaviour (DTPB) Taylor and Todd (1995) Task Technology Fit (TTF) model (Goodhue and Thompson, 1995), Motivational Model of Microcomputer Usage (MMMU) (Igbaria, Parasuraman and Baroudi, 1996) with an aim to develop technology acceptance model along with the main independent variables and moderators analysed.

Table 3. 2 Overview factors in technology acceptance theories/models

Theory/Model	Constructs/ Independent variable	Moderators	Explained variance. R^2	Reference
1. Theory of Reasoned Action (TRA)	1.Attitude towards behaviour 2.Subjective norms	Experience Voluntariness	0.36	(Fishbein and Ajzen, 1975)
2. Technology Acceptance Model a) TAM2	1.Perceived usefulness 2.Perceived Ease of Use 3.Subjective norms	Experience Voluntariness	0.53	(Venkatesh and Davis, 2000)
b) TAM including gender	1.Perceived usefulness 2.Perceived Ease of Use 3.Subjective norms	Gender Experience	0.52	
3. Motivation Model	Intrinsic motivators Extrinsic motivators	None	0.38	(Igbaria, Parasuraman and Baroudi, 1996).
4. Decomposed Theory of Planned Behaviour (DTPB) a) TPB including voluntariness	1.Attitude towards behaviour 2.Subjective norms 3. Perceived behavioural control	Experience Voluntariness	0.36	Taylor and Todd (1995)
b) TPB including gender	1.Attitude towards behaviour 2.Subjective norms 3.Perceived behavioural control	Gender Experience	0.46	
c) TPB including age	1.Attitude towards behaviour 2.Subjective norms	Age Experience	0.47	

	3.Perceived behavioural control			
5. Combined Technology Acceptance Model and theory of Planned Behaviour C-TAM-TPB	1.Attitude towards behaviour 2.Subjective norms 3.Perceived behavioural control 4. Perceived Usefulness	Experience	0.39	Taylor and Todd, 1995
6. Model of PC Utilisation MPCU	1.Job fit 2. Complexity 3.Long term consequences 4. Affect after use 5. Social factors 6. Facilitating conditions	Experience	0.47	Thompson, Higgins and Howell (1991)
7. IDT	1.Relative advantage 2.Ease of use 3.Result demonstrability 4. Trialability 5.Visibility 6.Image 7.Compatibility 8. Voluntariness of use	Experience	0.40	Rogers (1995)
8. SCT	1.Outcome expectation 2.Self-efficacy 3.Affect 4.Anxiety	None	0.36	Bandura (1996)
9. UTAUT	1.Performance 2.Effort expectancy 3. Social influence 4.Facilitating conditions	1.Gender 2.Age 3.Experience 4.Voluntariness	0.69	Venkatesh et al. (2003)
10. UTAUT2	1.Performance 2.Effort expectancy	1.Age 2.Gender 3.Experience	0.73	Venkatesh, Thong and Xu 2012)

	3. Social influence 4.Facilitating conditions 5.Hedonic motivation 6.Price value 7.Habit			
11. MATH	1.Attitudinal beliefs 2.Normative beliefs 3. Control beliefs		0.74	Brown, and Venkatesh (2005)

Amidst the wide pool of theories developed in the area of technology acceptance, the researcher found essential elements such as perceived usefulness, perceived ease of use, behavioural intention from prior theories TAM (Davis, 1989) and attitude from TRA (Fishbein and Ajzen, 1975) and original TAM that have been used in this research as core category of factors influencing the technology acceptance of IoT devices. The factors are discussed in the later chapter of conceptual framework and hypothesis development.

When a technological change is implemented, end-users may decide to adopt it or resist it based on their perception as well as evaluation of the features of an innovation (Kim and Kankanhalli,2009). After analysing the literature on technology acceptance, it appears that a number of theories were developed focussing on the acceptance of technology as discussed in the previous chapter. Amongst them were Theory of Reasoned Action (TRA) (Fishbein and Ajzen, 1975), Theory of Planned Behaviour (TPB) (Ajzen 1985) both stem from social psychology to understand the impact of attitude on behvaioural intention and thereby the actual behaviour. Other theories include Technology Acceptance Model (TAM) (Davis, 1989); Model of PC Utilization (MPCU); (Thompson et. Al 1991); Combined TAM and TPB (C-TAM-TPB) (Taylor and Todd, 1995) Task Technology Fit (TTF) model (Goodhue and Thompson, 1995), Motivational Model of Microcomputer Usage (MMMU) (Igbaria, Parasuraman and Baroudi, 1996) focussing on acceptance of Information Systems (IS). The factors affecting the acceptance of technology of IS differed noticeably from the factors influencing the adoption of traditional products.

Researchers in Information Systems (IS) are confronted with choice of different models that explain user acceptance of new technology.

There have been extensions to these acceptance models and contributions were made through TAM 2 (Venkatesh and Davis, 2000) which added causal determinants to perceived usefulness and social influence prior to the UTAUT model was developed in 2003 and TAM 3 (Venkatesh and Bala, 2008) – where computer efficiency, the perception of external control, computer anxiety and perceived enjoyment are found as additional determinants.

This research focusses on Internet of Things as a technology which is very peculiar in comparison to the earlier technologies this world has encountered, and hence the adoption models developed from studying the behaviour of individuals towards those technologies may be classed as specific to those technologies, necessitating the need to develop a more relevant model with regards to this specific technology.

3.11 Conclusion

This chapter analysed theories of consumer behaviour such as TRA and TPB along with technology adoption theories such as TAM and its various extensions. A chronological overview of development of theories in the area of consumer behaviour and technology acceptance was developed ranging from 1962 (Rogers, 1962) to the more recent GETAMEL in 2016(Abdullah and Ward, 2016). This chapter also classified these theories into 5 different categories for a more critical evaluation of each of the groups and their contribution to the technology acceptance literature. Several empirical studies addressing the elements from each of the theory were also covered with a view to position the focus of this research to identify the factors influencing the acceptance of Internet of Things (IoT) devices within a smart home environment. Following from the discussion of an overview of extant research in the development of consumer behaviour theories and various technology adoption models, the next chapter will focus on the empirical studies undertaken applying the historical theories aimed at deriving the significant factors for the development of a conceptual framework for this study. The next chapter will use the key factors from the theories discussed in this chapter to develop a series of hypothesis to be tested under hypothetical deductive analysis.

CHAPTER 4 CONCEPTUAL FRAMEWORK AND HYPOTHESIS DEVELOPMENT

4.1 Introduction

Previous chapters included an overview of the concept of Internet of Things (IoT), conceptual clarity on the terms used in this research along with an overview of the development of technology adoption theories. This chapter provides an overview of empirical studies in the field of technology acceptance using a wide range of factors proposed in the previous models as well as relationships studied, which will enable the identification of gaps in the subject area that needs to be bridged. This chapter focusses on the aim of choosing the most relevant factors using a semi-systematic approach to factor selection leading to proposal of a conceptual model followed by the development of hypothesis and finally leading to, classification of factors in order to collect relevant knowledge to achieve the research objective of developing a hierarchy of factors.

4.2. Overview of factors in empirical studies using technology adoption models

It is important to critically analyse empirical studies applying several technology adoption theories with a view to identify ideas to develop a conceptual framework on factors influencing the acceptance of Internet of Things (IoT) devices within a smart home environment.

4.2.1 Technology adoption models in studies

A number of research studies have been undertaken since the theories were developed - showing continuous addition to the knowledge area. Some of these studies established proposed theoretical foundations whereas other empirical studies examined the application of such theories in different sectors. Several research studies combined theoretical insights with the investigation of practical issues resulting in either a consensus with the existing theories (Taylor and Todd, 1995b) or a contradiction to part of theories which provided added elements widening the horizons of technology adoption in different contexts. (Taylor and Todd 1995a).

A snapshot of factors used in selected empirical studies undertaken to study the acceptance of smart homes and smart home technologies is presented in the table 4 below. These studies used TAM, extensions of TAM or other theories as a primary theory, testing various factors of those theories in different contexts. (Yang et al., 2017; Han and Yang 2018; Kahlert, Constantinides and De Vries 2017; Kim, Park and Choi 2017; Park et al. 2017; Singh, Gaur and Ramakrishnan 2017; Yang, Lee and Zo 2017).

Table 4. 1 Summary of factors in technology acceptance theories/models

Study	**Title**	**Primary Theory**	**Determinants**
Yang et al., 2017	Smart home in Korea	TPB	Intention to use, attitude, perceived behavioural control, subjective norm, automation, mobility, interoperability, physical risk, trust in service provider and security/ privacy risk
Han and Yang (2018)	Understanding adoption of intelligent personal assistants: A parasocial relationship perspective	PSR Para Social Relationship	Task attraction - PSR Task attraction - satisfaction Social attraction - PSR Physical attraction - PSR Security/Privacy risk - PSR PSR- satisfaction Satisfaction - continuance intention toward IPA
Kahlert, Constantinides and De Vries (2017)	The relevance of technological autonomy in the customer acceptance of IoT services in retail	TAM	Usefulness Ease of use Enjoyment Behavioural control Credibility Technology trust Compatibility Degree of Autonomy
Kim, Park and Choi (2017)	A study on the adoption of IoT smart home service: using Value-based Adoption Model	VAM Value Based Adoption Model TAM Technical Acceptance Model	Perceived sacrifice negative effect on perceived value Perceived benefit positive effect on perceived value Perceived Value positive effect on intention to use Perceived Value positive effect on attitude Attitude positive effect on intention to use Variety seeking positive effect on

			intention to use Variety seeking moderating effect on each route
Park et al (2017)	Comprehensive Approaches to User Acceptance of Internet of Things in a Smart Home Environment	TAM	Attitude - Intention to use Perceived usefulness - Intention to use Perceived usefulness - attitude Perceived ease of use - attitude Perceived ease of use - Perceived usefulness Perceived enjoyment - Perceived usefulness Perceived connectedness - Perceived usefulness Perceived connectedness - Perceived usefulness Perceived connectedness - Perceived ease of use Perceived compatibility - Perceived usefulness Perceived compatibility - Perceived ease of use Perceived control - Perceived ease of use Perceived costs - Intention to use
Singh, Gaur and Ramakrishnan (2017)	Internet of Things – Technology Adoption Model in India	TAM	Perceived Usefulness External Organisation Variables Internal Organisational Variables Perceived Ease of Use Behavioural Intention to use
Yang, Lee and Zo (2017)	User acceptance of smart home services: an extension of the theory of planned behaviour	TPB	Attitude and intention to use Subjective norm and intention to use Perceived behavioural control and intention to use Exogeneous variables Automation Mobility Interoperability Security/privacy risk and physical risk Trust - positively associated to attitude Trust - positively associated to subjective norms Trust - positively associated to perceived behavioural control
Shin, Park and Lee (2018)	Who will be smart home users? An analysis of adoption and diffusion of smart homes	TAM	Demographic variables plus characteristics of smart homes such as network effects between services, protection of personal information

AlHogail (2018)	Improving IoT Technology Adoption through Improving Consumer Trust	TAM	**Product related:** Functionability and reliability Helpfulness Ease of use perceived usefulness **Social influence related:** Social network Community interest **Security related:** Product/service security Perceived risk.
Yang and Lee (2018)	Understanding user behavior of virtual personal assistant devices	TAM	Perceived usefulness -behavioural intention to use Perceived enjoyment - behavioural intention to use portability - perceived usefulness Automation - Perceived usefulness Content quality - perceived usefulness Content quality - perceived enjoyment
Salimon et al (2018)	User adoption of smart home technologies in Malaysia: Integration of TAM3, TPB, UTAUT2 and extension of their constructs for a better prediction	TPB, TAM3 and UTAUT2	Computer self-efficacy Computer Anxiety Attitude Subjective norm Perceived Behavioural Control (PBC) Perceived Security Automation Mobility Trust Hedonic motivation
Mashal and Shuhaiber (2018)	What makes Jordanian residents buy smart home devices? - A factorial investigation using PLS - SEM		Social Influence Personal factors Trust Awareness Perceived Enjoyment Device factors Personalisation Availability Cost
Afonso (2019)	Understanding Smart-Speakers Adoption in Portugal: A Unified Theory of Acceptance and Use of Technology applied in the		Performance Expectancy Effort Expectancy Social Influence Facilitating Conditions Hedonic Motivation Price Value

	Portuguese Consumer Market		Habit Behaviour Intention
Cannizzaro et al. (2020)	Trust in the smart home: Findings from a nationally representative survey in the UK	SCOT Social Construction of Technology	Awareness Ownership Experience Trust Satisfaction Intention to use.
Al-Husamiyah and Al-Bashayreh (2022)	A comprehensive acceptance model for smart home services	TAM IDT TPB	perceived convenience, perceived connectedness, perceived cost, perceived privacy risk
Attie and Meyer-Waarden (2022)	The acceptance and usage of smart connected objects according to adoption stages: an enhanced technology acceptance model integrating the diffusion of innovation, uses and gratification and privacy calculus theories	TAM	social image, privacy concerns, and innovativeness impact SCOs' perceived usefulness, intention to use, real use and well-being.
Sorwar et al. (2023)	Factors that predict the acceptance and adoption of smart home technology by seniors in Australia: a structural equation model with longitudinal data	UTAUT	Trust and Perceived usefulness
Kim and Moon (2023)	Understanding Consumer Acceptance of Smart Washing Machines: How Do Female Consumers' Occupations Affect the Acceptance Process?	TAM	Antecedents (i.e., subjective norms and product involvement with washing machines), Belief variables (i.e., perceived ease of use, perceived usefulness, and perceived enjoyment) Acceptance intention

4.3 Factor selection

Chaotic abundance of factors studied in theories as well as empirical studies as highlighted in the literature review earlier lead to one of the most crucial challenges for the researcher in this study with an identification of nearly 51 different factors studied in previous studies (Yadegari, Mohammadi and Masoumi, 2024). This meant an organised approach to factor selection was essential for a rigorous attempt to select the most suitable factors for the study. The research scope, question, aims and objectives were used as fundamental platform to base the factor choice.

The following criteria were used in phases to determine the most appropriate and relevant factors for this study:

1. As several factors are used simultaneously by different theories, the significance of the factor in the findings of these studies was used as an important criterion for the selection of the factor.
2. Factors were also either selected or filtered bearing in mind the research aims and objectives and there by the scope of the study.
3. The extent to which the factor was found as researched in the literature review (some extensively studied factors, and some factors were studied minimally, number of papers, context etc was considered)
4. A list of factors was obtained from the main guiding theory of this research i.e. PEOU, PU, Intention to buy/use as well as adapted from other theories such as attitude and social influence. This list of core factors was deemed to be used in its entirety to meet the aims of this research.

Following steps were followed sequentially:

1. An in-depth reading of literature was undertaken to understand the foundation theories of technology adoption to identify the factors.
2. A list of all variables/factors was prepared from the reading of the literature.
3. Over 51 different factors were found evident in the list which were then classified using 4 major categories (Core factors, Internal factors, External factors and Technology specific factors)

4. Since not all the factors could be examined due to the limitations of the scope of this research, it was essential to prepare a ranking order sheet to be used for rating by participants in semi-structured interviews.
5. Selection criteria determined to be choice of most highly ranked factors in each category of Internal, external, technology specific and demographic variables). The core factors and demographic variables were selected using the research aims, objectives and scope and on the basis of literature review.
6. Factor selection of the most highly ranked factors by the respondents was done in each category.

Table 4. 2 List of factors categories

Core	Internal	External	Technology specific	Demographic
Attitude	Personality	Facilitating conditions	Compatibility	Age
Intention to buy/use	Lifestyle	Habit	Mobility/ Portability	Gender
PU (Relative advantage)	Innovativeness	Media influence	Observability	Income
PEOU (Complexity)	Self-efficacy	Perceived power	Trialability	Education
Social influence	Positive self-image	Perceived control	Interoperability	Experience
Usage of technology	Receptivity to change	Hedonic motivation	Automation	Ethnicity
Result demonstrability	Computer anxiety	Financial risk	Perceived cost	Voluntariness of use
	Awareness/Knowledge	Perceived privacy risk	Visual attractiveness	Marital status
	Self-presentation	Security risk		Household composition
	Social status	Physical risk		Employment status
	Internal stress	Trust in providers		Location
	Variety seeking	External stress		
	Behavioural control	Time risk		
	Beliefs	Expert advice		

4.4 Exploratory phase for factor selection

An insight into the abundance of factors evident in the literature review chapter of this study indicated the need for filtering and carefully selecting factors relevant to the study. This stage of factor selection included several professional dialogues with academics such as supervisors and director of studies. This enabled the development of a number of factors used in studies focusing on consumer behaviour and social sciences. However, this stage did not provide the exclusive list of factors to be used in the study as each of the factor discussed had its own strength and limitation of application in a wide variety of contexts.

The exploratory phase of the research was divided into two parts, the first one being conducting semi-structured interviews followed by a structured follow up of comparing the findings to the theories identified from the literature review. Qualitative interviewing is in line with the pragmatist perspective (Merriam, 2002), which is in-line with the overall research design of this research. According to Savin-Baden and Major (2013) "Interviews are the most common method of gathering data for qualitative research" (p. 357), which is similar to Creswell and Clark's (2017) views. Interviews are defined as a specialized pattern of interaction, for a specific purpose, and focus on specific content (Creswell and Clark, 2017; Merriam, 2002; Stake, 2005; Yin, 2014). Semi-structured interviews were conducted with 10 participants following the research inquisitiveness to identify the factors affecting the decision making of why people buy IoT devices/smart devices in general and specifically within households. The selection criteria used to choose the participants was based on purposive sampling as well as a prerequisite of ownership of smart IoT devices. Any person that did not own smart devices were deemed unsuitable to provide with the data required for this study and hence was not included in the sample.

Using a semi-structured type of interview in this study allowed participants to freely express themselves in a natural setting. Semi-structured questions tend to be open-ended to obtain in-depth information and allowing participants to express their perspectives freely (Merriam, 2002). Some questions are set in advance and can be modified in the process of interviewing based on the responses from interviewees (Creswell and Clark, 2017; Merriam, 2002) which provided the basis of providing a list of factors as shown in the table 4.3 whereby the participants were required to rank factors in each of the five categories. It was important to be observant during these interviews in order to collect relevant data and it was also helpful to take notes in this process (Lincoln & Guba, 1985).

The responses from the semi-structured interviews were analysed from the interview notes as well as the factor ranking sheets. Since this stage was conducted on an informal basis using purposive sampling using friends, family and work colleagues, several insights were developed informing the choice of the highest ranked factors in each of the categories.

Table 4. 3 Ranking order of factors in interviews

Internal	Overall Rank	External	Overall Rank	Technology specific	Overall Rank
Personality	9	Facilitating conditions	14	Compatibility	4
Lifestyle	4	Habit	12	Mobility/ Portability	2
Innovativeness	3	Media influence	10	Observability	7
Self-efficacy	2	Perceived power	9	Trialability	8
Positive self-image	1	Perceived control	13	Interoperability	6
Receptivity to change	7	Hedonic motivation	4	Automation	3
Computer anxiety	6	Financial risk	8	Perceived cost	1
Awareness/ Knowledge	5	Perceived privacy risk	3	Visual attractiveness	5
Self-presentation	14	Security risk	2		
Social status	8	Physical risk	5		
Internal stress	10	Trust in providers	1		

Variety seeking	12	External stress	11		
Behavioural control	13	Time risk	6		
Beliefs	11	Expert advice	7		
1st three ranked selected		**1st five ranked selected**		**1st four ranked selected**	

The rationale for choosing a selected number of factors from each of the above categories was based on the findings of literature review as discussed in table 3.2 and table 4.1 where significance of each of the factor in their contribution towards understanding the consumer behaviour of accepting technology was eminent. Factors in the external category were found to be more contributing than factors in the internal category. Although the number from each category that of 1st three from internal and first five from external was chosen on literature review findings, the respondents in the exploratory stage fully influenced the final choice on the basis on their ranking of these factors.

4.5 Discussion of factors and hypothesis

Elements of characteristics of an innovation suggested by IDT aka DOI theory by Rogers (1962) is considered to be a vital factor for this research intending to study their impact on technology acceptance of IoT devices. It also aims to study the element of complexity of an innovative technology and its impact on developing attitude towards behavioural intention and usage of technology. According to Rogers (1962) classification of individuals in a social system is based on innovativeness, classifying the adopters is of key interest in this research as it aims to identify factors influencing their behaviour of adoption of a new technology. Other key characteristics include training, experience, and support (Jacobsen, 1998), and gender difference (Buabeng-Adoh, 2018). The role of adopters in accepting various technologies ranging from electric vehicles (Hardman 2019) to smart and connected sensors (Tang and Ho, 2019) is accentuated in various studies such as Dedehayir et al. (2017) and Tobbin and Adjei (2012), that highlighted the characteristics of adopters. Tobbin and Adjei (2012) demonstrate that users who adopt mobile money services have higher levels of independent judgment making, novelty seeking and opinion leadership than those who do not adopt. It is important to understand adopters and how their experiences influence or are influenced by the social system's structures, or the perception of attributes of an innovation. Consequently, it becomes important to understand and identify the factors that influence the adopters' attitude towards technology by identifying and knowing who the participants specific to the study are how and why they adopt the technology. This will be discussed as a criterion for selecting appropriate representative sample for this research in the later chapter of methodology.

4.5.1 Factor analysis

Following the review of existing models and empirical studies undertaken applying these models, a more scientific and detailed list of factors and related hypothesis has been developed.

These factors were compiled in line with the theories of IDT (Rogers, 1983), TRA (Fishbein and Ajzen 1975), TPB (Ajzen 1985), TAM (Davis 1989), TAM2 (Venkatesh and Davis, 2000), UTAUT (Venkatesh et al., 2003), TAM3 (Venkatesh and Bala, 2008). UTAUT2 (Venkatesh, Thong, and Xu, 2012). Below is the table 4 showing the underlying core determinants adapted from the models for this study.

Table 4. 4 Underlying core determinants of the models described in this study.

Models →	IDT	TRA	TPB	TAM	TAM2	TAM3	UTAUT	UTAUT2
Variables ↓								
Attitude		X	X					
Behavioural intention		X	X	X	X	X	X	X
Perceived usefulness / performance expectancy	X*			X	X	X	X	X
Perceived ease of use / effort expectancy	X**			X	X	X	X	X
Subjective Norm (Social influence)	X	X	X		X	X	X	X
Psychological factors								
• Personal innovativeness	X							
• Self-efficacy						X		
• Positive self-image					X			
Perceived features								
• Compatibility	X							
• Mobility*								
• Automation*								
Perceived cost (studied as price value)								X
Demographic variables								
• Age							X	X
• Gender							X	X
• Level of income*								
• Level of education*								
Hedonic motivation						X		X
Perceived risk*								
Trust*								

Variable * New variables not found in major technology acceptance theories/models
X* studied as relative advantage.X** studied as complexity.

4.5.2 Detailed list of factors affecting adoption in prior studies

A number of studies have been undertaken to understand the factors affecting the technology adoption. A snapshot of studies undertaken to study the factors have been given in the table 4.5 below.

Table 4. 5 Studies using a range of factors

Factor	Existing studies
Psychological factors	
Innovativeness (7 papers)	Rogers (1971); Midgley and Dowling (1978); San, Martin and Herrero (2012); Bartels and Reinders, (2011); Alagoz and Hekimoglu (2012); Baudier, Ammi, and Deboeuf-Rouchon, (2018); Wang et al. (2019).
Self-efficacy (8 papers)	Bandura, (1986); Huffman, Whetten and Huffman, (2013); Venkatesh and Bala (2008); Adesina and Ayo (2010); Ozturk et al. (2016); Abdullah and Ward (2016); Coeurderoy, Guilmot and Vas (2014); Alalwan, Dwivedi and Rana (2017); Sharma et al. (2016).
Personality	X
Self-image (6 papers)	Moore and Benbasat (1991); Wang, McGill and Klobas (2020); Barbarossa et. al. (2015); Yeh, Wang, Yieh (2016); Takayam et. al. (2012); Mijin et. al. (2019).
Beliefs/values	X
Lifestyle (10 papers)	Lee et al. (2009); Anderson and Golden (1984); Harrell and Frazier, (1999); Blackwell, Miniard, and Engel (2001); Murry, Lastovicka, and Austin (1997); Ostrom et al. (2015); Yu (2011); Swinyard and Smith, (2003); Sarrina Li (2013).
Attitude (9 papers)	Ajzen (1985); Aboelmaged and Gebba (2013); Au and Enderwick (2000); Yang and Lee (2018); Dwivedi et al. (2017); Sohail and Al-Jabri (2014); Cheong and Park (2005); Hsiao (2013); Hussein, Oon and Fikry (2017).
Behavioural Intention	Ajzen (1991); Venkatesh et al. (2003); Venkatesh, Thong, and Xu, (2012).
Perceived attributes	

Effort expectancy/ Perceived ease of use **13 papers**	Alagoz and Hekimoglu (2012); Gruzd, Staves and Wilk (2012); Nunkoo and Ramkissoon (2012); Coeurderoy, Guilmot and Vas (2014); Li and Hsu (2016); Alalwan et al. (2017); Wang, McGill and Klobas (2020); Pal et al. (2018); Baabdullah (2018); Afonso (2019); Gupta, Manrai and Goel (2019); Davis (1989); Venkatesh and Davis (2000).
Performance expectancy / Perceived usefulness **22 papers**	Alagoz and Hekimoglu (2012); Gruzd, Staves and Wilk (2012); Nunkoo amd Ramkissoon (2012); Coeurderoy, Guilmot and Vas (2014); Li and Hsu (2016) Alalwan et al. (2017); Wang, McGill and Klobas (2020); Pal et al. (2018); Baabdullah (2018); Afonso (2019); Gupta, Manrai and Goel (2019); Aldunate and Nussbaum (2013); Davis (1989); Mathieson (1991); Adams, Nelson and Todd, (1992); Hendrickson, Massey and Cronan, (1993); Gefen and Straub (2000); Karahanna, Straub and Chervany (1999); Gefen (2000); Bai and Gao (2014); Wu and Zhang (2014); Alalwan et al. (2018).
Relation of PU and PEOU **14 papers**	Moore and Benbasat (1991); Thompson et al. (1991); Venkatesh and Davis (1996); Chin and Gopal (1995); Venkatesh (1999); Hubert et al. (2017); Boer et al. (2019); Chen et al. (2009); Davis (1989); Davis, Bagozzi and Warshaw (1989); Lee (2009); Gefen and Straub (2000); Venkatesh and Davis (2000); Childers et al. (2001).
Perceived feature of IoT	
Compatibility **5 papers**	Rogers (1983); Al-Majali and Nik Mat (2011); Islam and Rahman (2016); Ozturk et al. (2016); Pliatsikas and Economides (2022).
Trialability **2 papers**	Rogers (1983); Lee et al. (2011).
Interoperability **3 papers**	Geraci et al. (1991); Pagani (2004); Yang et al. (2017).
Mobility/Portability **2 papers**	Park et al. (2014); Yang et al. (2017)
Automation **3 papers**	Parasuraman and Riley (1997); Luor et al. (2015); Augusto and Nugent (2006).

Perceived cost/Price value **4 papers**	Shin (2009); Kim (2008); Kim (2014); Alolayan (2014).
Social Influence / Subjective norms **18 papers**	Fishbein and Ajzen (1975); Venkatesh and Davis (2000); Taylor and Todd (1995); Triandis (1979); Rogers (1962); Bandura (1996); Gruzd, Staves and Wilk (2012); Coeurderoy, Guilmot and Vas (2014); Alolayan (2014); Li and Hsu (2016); Wu, Wu and Chang (2016); Alalwan et al. (2017); Pal et al. (2018); AlHogail (2018); Baabdullah (2018); Mashal and Shuhaiber (2018); Afonso (2019); Gupta, Manrai and Goel (2019).
Hedonic Motivation **17 papers**	Li and Hsu (2016); Alalwan et al. (2017); Baabdullah (2018); Salimon, Gorondutse and Abdullah (2018); Afonso (2019); Vejacka (2015); Abdullah and Ward (2016); Wu, Wu and Chang (2016); Kahlert, Constantinides and Vries (2017); Park et al. (2017); Yang and Lee (2018); Mashal and Shuhaiber (2018) Lowry et al. (2013); Ndubisi and Sinti (2006); Venkatesh, Thong and Xu, (2012); Bagozzi, (2007); Pal et al. (2018).
Perceived Risks	
Privacy **13 papers**	Han and Yang (2018); Wang, McGill and Klobas (2020); Yang et al. (2016); Gebhart (2020); Boucher and Hackett (2017); Maheshwari (2017); Chou and Yutami (2014); Townsend, Montoya and Calantone (2011); Cannizzaro et al. (2020); Eastlick, Lotz and Warrington (2006); Kim (2008); Gefen and Straub (2000); Dinev and Hart (2006).
Security **11 papers**	Han and Yang, (2018); Wang et al. (2019); Balta-Ozkan et al. (2013); Gebhart (2020); Boucher and Hackett (2017); Maheshwari (2017); Chou and Yutami (2014); Eastlick, Lotz and Warrington (2006); Kim (2008); Gefen, Karahanna and Straub (2003); Dinev and Hart (2006).
Financial risk **1 paper**	Wang et al. (2019).
Physical risk **2 papers**	Jose and Malekian (2015); FTC (2015).

Trust **16 papers**	Doney and Cannon (1997); Luhmann (1979); Pavlou (2003); Ring and Van de Ven (1994); Gefen (2000); Li and Hsu (2016); Ziefel, Rocker and Holzinger (2011); Alagoz and Hekimoglu (2012); Nunkoo and Ramkissoon (2012); Lin, Wang and Hung (2020); Lee (2009); Wu and Chen (2005); Mashal and Shuhaiber (2018); Pal et al. (2018); Kahlert, Constantinides and Vries (2017); Luor et al. (2015).
Facilitating conditions **3 papers**	Ajzen (1991); Dwivedi et al. (2017); Baabdullah (2018).
Habit **3 papers**	Kim, Malhotra and Narasimhan (2005); Venkatesh, Thong and Xu (2012); Kim, Kaufmann and Stegemann (2014).
Demographic factors	
Age **5 papers**	Coskun, Kaner, Bostan (2018); Mennicken, Vermeulen, Huang (2014); Shin, Park and Lee (2018); Luor et al. (2015); Pal et. al. (2018).
Gender **8 papers**	Yang et al. (2017); Yang, Lee and Zo (2017); Shin, Park, and Lee (2018); Nikou (2019); Wu, Wu and Chang (2016); Rauschnabel, Brem and Vens (2015); Coskun, Kaner, Bostan (2018); Mennicken, Vermeulen, Huang (2014).
Level of education **4 papers**	Baudier, Ammi, and Deboeuf-Rouchon (2018); Shin, Park and Lee (2018); Coskun, Kaner, Bostan (2018); Mennicken, Vermeulen, Huang (2014).
Income **8 papers**	Balta-Ozkan et al. (2013); Balta-Ozkan et al. (2014); Williams, Bernold and Lu (2007); Yang et al. (2017); Yang, Lee and Zo (2017); Shin, Park, and Lee (2018); Coskun, Kaner, Bostan (2018); Mennicken, Vermeulen, Huang (2014).

More than 51 factors were identified in the preliminary compilation of factors studied in various theories which needed to be filtered to identify the most relevant factors. Some of the criteria used to determine the relevance of these factors, was findings from studies highlighting the significance of each of the factor in studying a specific technology, area of studies, prime focus of the study i.e., organisational, or personal setting etc. Several studies focused mainly on technology acceptance in organizational settings (Coeurderoy, Guilmot and Vas, 2014), whereas some focused on specific sectors related to retail, banking, construction, education etc. **Intention to buy/use, Perceived Ease of Use** and **Perceived Usefulness** from TAM (Davis, 1989) remained the concrete foundation of majority of the papers becoming the most important research factors for this study followed by **psychological variables** such as **innovativeness** (Rogers, 1983), **self-efficacy** (Venkatesh and Bala, 2008), **positive self-image** (Venkatesh and Davis, 2000), showing a significant impact on the attitude towards technology. However, the role of **attitude** seemed to be vanishing from empirical research based on TAM and extensions of TAM. The research aim guided the selection of attitude factor to study its impact on behavioural intention of acceptance of IoT devices within a smart home environment.

Demographic variables such as **age** (Venkatesh et al., 2003; Wang, Chen, and Chen, 2017), **gender** (Venkatesh et al., 2003; Venkatesh, Thong, and Xu, 2012 and Pliatsikas and Economides, 2022), **level of income** (Tobbin and Adjei, 2012) and **level of education** (Baudier, Ammi and Deboeuf-Rouchon, 2020; Cannizzaro et al., 2020) were found statistically significant factors in these studies. It was found from the theoretical overview that moderation role of age and gender was studied in UTAUT (Venkatesh et. al. 2003 and UTAUT2 Venkatesh, Thong and Xu, 2012) whereas income as a moderator was studied in MATH (Brown and Venkatesh, 2005). Level of education as a moderator was not found in any of the underpinning theories. However empirical studies applying these foundation theories studied this role and found it to be significant (Pliatsikas and Economides, 2022).

Social Influence also studied as subjective norms is evident in all the studies listed in Table 4 except TAM, laying significant importance on the impact of this variable. Several empirical papers studied impact of social influence in a variety of settings (Coeurderoy, Guilmot and Vas, 2014; Pal et al., 2018). With this research being in a home setting, it is important to study the influences of social groups on people’s intention to buy/use IoT devices.

In the current era of stringent legislations of General Data Protection Regulation 2018 on providers, it is critical to know the consumer perspective of contemporary variables such as **perceived risk** (Cannizzaro et al., 2020; Wilson, Hargreaves, and Hauxwell-Baldwin, 2017) along with **trust (**Ziefel, Rocker and Holzinger, 2011) and its impact on their acceptance of technology. These variables have been added following a review of several empirical studies.

Hedonic motivation also termed as fun or perceived enjoyment, was identified as a relevant intrinsic factor in many studies (Venkatesh and Bala, 2008; Venkatesh, Thong, and Xu, 2012) where consumers accepted technology out of entertainment or fun. The impact of fun element of acceptance of IoT devices is significant in recent empirical studies Mashal and Shuhaiber (2018).

Some of the **perceived features** of technology originally proposed by Rogers (1983) in IDT and further used by Goodhue and Thompson (1995) in his Task Technology Fit (TTF) model such as **compatibility** (Pliatsikas and Economides, 2022) needs to be particularly studied keeping in mind the IoT technology and its unique features which distinguishes it from other technologies. **Mobility** and **automation** variables under the category of perceived features of the technology of IoT devices, are unique characteristics of these devices derived from the definition of IoT devices used in this study (Sergio, 2022). These variables are considered significantly important determinants affecting the acceptance of these devices (Salimon, Gorondutse and Abdullah, 2018)

Perceived cost was found in very few studies in the literature review (Pliatsikas and Economides, 2022), however considering the technology and inter-connectedness of devices vouches for a substantial investment in this technology and it is vital to study the impact of perceived cost on the acceptance of IoT devices in smart home environment. A grouped list of factors based on review of theories is provided in table 4.5 above.

The following table 5 showcases the importance of various variables found in existing prominent studies of technology acceptance justifying the selection of each of the factor in this study. A combination of selection criteria was followed for selecting the relevant papers to be included in the literature review and thereby in this sector to identify the significance of factors influencing the acceptance of technology. This research used a variety of search words in various journal platforms such as Sciencedirect, Elsevier, Researchgate as well as Google Scholar to locate reputed journal articles within the field of technology adoption. Abstract reading of nearly 750 articles lead to a filtered list of 250 articles identified with studies focusing on factors listed below. The line of enquiry for choosing the articles followed a rigorous criterion of assessing the research question, authors argument, credibility through citations, peer-reviews etc.

Table 4. 6 Factor significance in previous studies

Factors	Numerical count of studies in the literature review	Illustrated level of significance and of the factor in prominent studies	Corresponding study
Behavioural intention/Intention to buy/use	35	R^2=0.40 (r= 0.63) in TAM R^2 = 0.49 in TAM 2 R^2 = Between 0.31 to 0.36 in TAM3 R^2 = 0.36 to 0.39 in UTAUT R^2 = 0.44 to 0.44 in UTAUT 2	TAM (Davis, 1989), TAM2 (Venkatesh, 2000), TAM3 (Venkatesh and Bala, 2008). UTAUT (Venkatesh et al., 2003), UTAUT2 (Venkatesh, Thong, and Xu, 2012)
Perceived attributes of the technological innovation (performance expectancy and effort expectancy)	35	Performance expectancy P value of 0.009 (R^2 = 0.16) Effort expectancy P value of 0.016 (R^2 = 0.15)	Baabdullah (2018)
Sociodemographic variables (Age, gender, level of education, income)	31		
✓ Age		Age has a negative impact	Wang, Chen, and Chen (2017)
✓ Gender		Significant difference between genders p = 0.003	Pliatsikas and Economides (2022)
✓ Level of income		Significant difference between income levels p = 0.047	Pliatsikas and Economides (2022)
✓ Level of education		Considered significant at p < 0.01	Cannizzaro et al. (2020)
Attitude	25	Most significant β = .51	Rauschnabel and Ro (2016)
Psychological variables (Innovativeness, self-efficacy, self-image etc.)	24	Best predictor of PEOU- Self-Efficacy (β = 0.352),	Abdullah and Ward (2016)

Subjective norms/Social Influence	20	Social influence one of the most influential ($R^2 = 0.21$)	Baabdullah (2018)
Perceived risk (privacy, security and physical risk)	18	Security as the most significant factor	AlHogail (2018)
Perceived features of IoT devices (compatibility, mobility, automation)	17		
✓ Compatibility		Compatibility considered significant	Park et al. (2017)
✓ Mobility		Identified as important contributors	Salimon, Gorondutse and Abdullah 2018)
✓ Automation		Identified as important contributors	Salimon, Gorondutse and Abdullah 2018)
Hedonic motivation	17	Best predictor of PU – ($\beta = 0.452$)	Abdullah and Ward (2016)
Trust	16	Trust as the most significant factor	Alalwan, Dwivedi and Rana (2017)
Perceived cost	4	Considered significant	Park et al. (2017)

- R^2 – a statistical measure that represents the proportion of the variance for a dependent variable that's explained by an independent variable.
- P-value is the level of marginal significance within a statistical hypothesis test, representing the probability of the occurrence of a given event.
- Beta (β) refers to the probability of Type II error in a statistical hypothesis test.

The above table is a preliminary table included the results from individual studies, which may not be directly comparable across several studies.

The semi-systematic or a narrative review also included filtering out factors that may not fit in the scope of this study. This included least studied variables as well as identified limitations from existing studies regarding validity and level of significance of the resulting factors. Where a study identified the factor to be least significant provided grounds for elimination of these factors from this study. Habit and facilitating conditions have been significant in their impact on the usage behaviour and as this research does not intend to study the usage behaviour, these factors have not be selected as relevant for this study. Owing to issues with measurement and possibility of difference in opinions and lack of conclusive evidence regarding personality, beliefs and values as well as lifestyle, these factors have not be covered in the scope of this research.

4.5.3 Factors not included in this research:

Table 4. 7 Excluded factors

Factor	
× Beliefs and values	Not covered in the scope of this research
× Ethnicity	Not covered in the scope of this research
× Personality	Lack of conclusive evidence on measurement of the variable and hence not covered in the scope of this research
× Lifestyle	Lack of conclusive evidence on measurement of the variable and hence not covered in the scope of this research
× Experience	Relevant to usage and hence not covered in the scope of this research
× Relative advantage (studied in PU)	Not studied as the name variable, instead studied as perceived usefulness
× Complexity (studied in PEOU)	Not studied as the name variable, instead studied as perceived ease of use
× Observability	Since this research is focusses on technology acceptance in a home setting it rendered to limitations of observability.
× Trialability	Trialability is a common feature included in numerous products and hence may be of low significance affecting buying intention
× Interoperability	Important factor for IoT devices but merged as willingness to interconnect along with buying intention variable (Studied as a dependant variable instead of independent variable)
× Facilitating conditions	Relevant to usage and hence not covered in the scope of this research
× Habit	Relevant to usage and hence not covered in the scope of this research
× Media influence	Not covered in the scope of this research
× Perceived power	Not covered in the scope of this research
× Perceived control	Considered not significant (Kahlert, Constantinides and Vries, 2017)
× Usage of technology	Not covered in the scope of this research

This research will focus on the following factors in line with the IDT (Rogers, 1983), TRA (Fishbein and Ajzen 1975), TPB (Ajzen 1985), TAM (Davis 1989), UTAUT (Venkatesh et al., 2003), UTAUT2 (Venkatesh, Thong and Xu, 2012) along with the added factors of hedonic motivation from TAM 3 (Venkatesh and Bala, 2008) in order to develop and test an integrated model of the factors influencing consumer acceptance of IoT devices. An in-depth discussion of these factors along with the hypotheses will be discussed in the chapter.

- Demographic variables (age gender, education etc)
- Psychological variables (innovativeness, self-efficacy and positive self-image)
- Attitude
- Intention to buy/use
- Perceived attributes of the technological innovation (performance expectancy and effort expectancy)
- Perceived features of IoT devices (compatibility, mobility and automation)
- Perceived cost
- Subjective norms/Social Influence
- Hedonic motivation
- Perceived risk (privacy, security and physical risk)
- Trust

This research intends to use the key proposition made by the Theory of Reasoned Action (Fishbein and Ajzen, 1975) that of impact of attitude and subjective norms on intention to perform a behaviour and thereby the actual behaviour as it tries to apply these series of impact on the acceptance and usage of IoT devices.

To summarise this study uses the following operational definitions of the chosen factors:

Table 4. 8 Operational definitions

Factor	Operational definition
Innovativeness	a personality characteristic that motivates people to try new things before they have any expertise with a certain technology.
Self-efficacy	The degree to which a person believes that they can use IoT devices.

Positive self-image	The positive personal view, or mental picture, that individuals have of themselves.
Attitude	An individual’s favourable or unfavourable feelings and evaluations towards IoT devices.
Perceived Ease of Use	Degree to which a task is perceived as not requiring physical, mental, or learning effort.
Perceived Usefulness	An individual’s belief that using a particular device will enhance their productivity or support in the daily tasks.
Compatibility	The degree to which an innovation is perceived as being consistent with the existing systems, values, past experiences and needs of potential adopters
Mobility	The capacity to access IoT devices while on the go
Automation	The execution of tasks by smart devices without human intervention.
Perceived costs	The concerns on the costs in buying, installing, maintaining, and operating IoT devices in smart home environment.
Social Influence	The extent to which a user perceives that important people believe he or she should buy and use smart homes devices.
Hedonic motivation	The fun or pleasure derived from using IoT devices
Privacy risk	unauthorised access to the IoT home devices by others and potential loss from disclosing personal user information.
Security risk	Potential to cause economic hardship to data or network resources/concern that criminals will hack their smart devices.
Physical risk	The danger that users of IoT devices could hurt themselves or others due to hacking, abuse, or malfunction.
Trust in IoT providers	Users' confidence that selling parties are truthful, dependable, and reliable.
Intention to buy/use	A desire to buy/use smart IoT devices.

A review of historical development of technology adoption theories as well as various empirical studies undertaken to apply these theories has supported the compilation of a number of factors to be studied in this research thereby developing a hierarchy of these factors and ultimately leading to the aim of developing an integrated model of technology acceptance of IoT devices in a smart home environment. The proposed model in brief:

4.5.4 Proposed Model

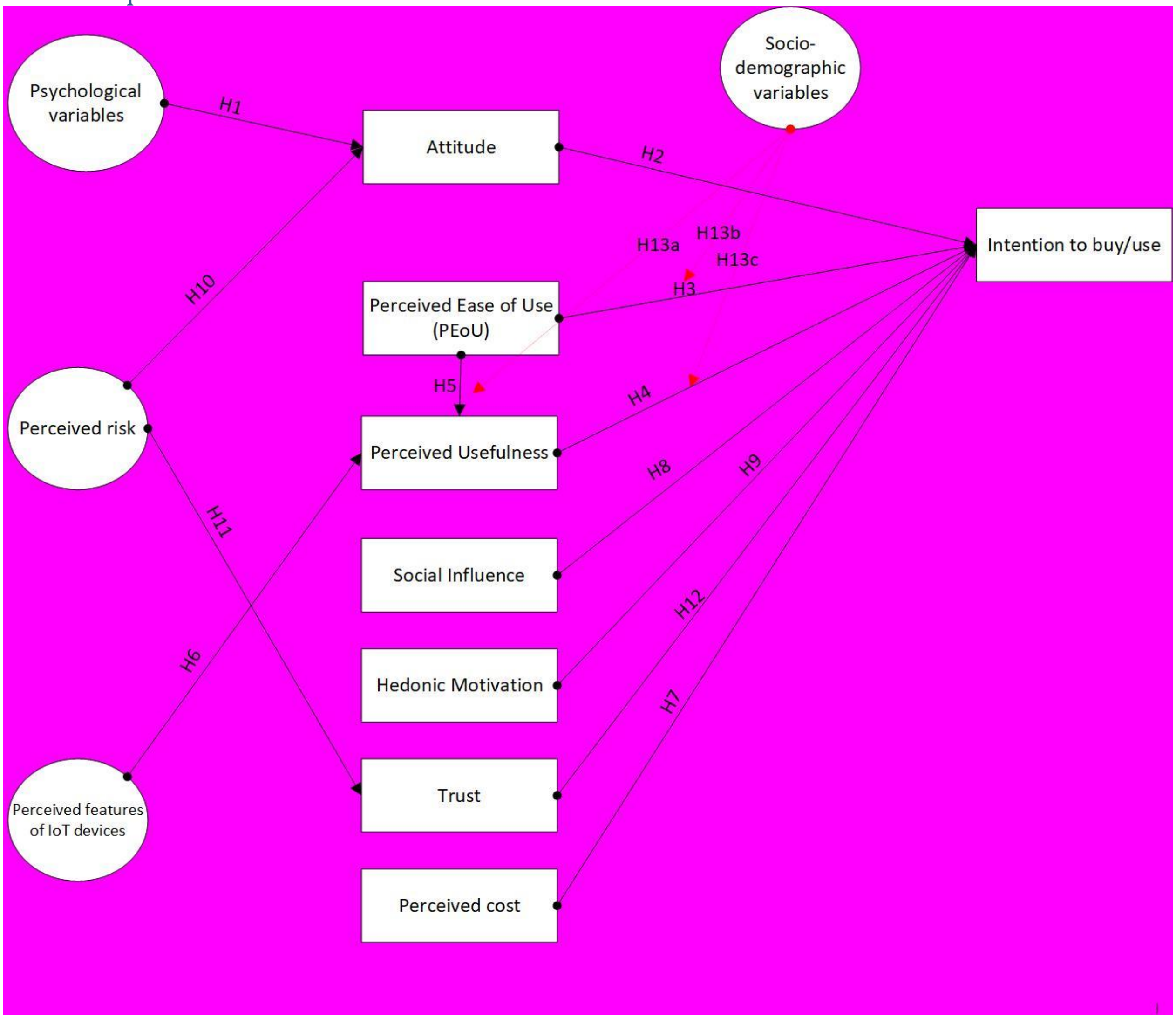

Figure 4. 1 Proposed model

The above figure shows the proposed research model and depicts the hypothesized relationships between the constructs within the TAM, IDT, TRA, TPB, UTAUT.

In addition to the main constructs, a number of demographic variables such as age, gender, level of education and previous experience with smart home technology will be used as control variables to investigate if these variables impact the path relationships in the model.

Contribution to the IT literature

One of the key findings from the literature studied implied the focus as studying the adoption rather than acceptance. (Davis, 1989, Venkatesh et. al. 2003, Venkatesh, Thong and Xu, 2012) This research aims to develop an acceptance model rather than adoption model. The key difference between the two is existing models assess the behaviour of embracement of technology by studying the usage whereas the proposed model studies the creation of a favourable/unfavourable feeling leading to intention to buy.

This study offers to study the unique relationships shared between 17 of the chosen factors as a result of the exploratory study as well as the literature review. Several of these factors are proposed to have an impact on the formation of attitude towards the IoT devices and thereby on Intention to buy/use. This study aims to reinstate the role of attitude which has been overlooked in the recent technology adoption research.

The technology forming the fundamental base for this research is that of IoT devices which offers unique features such as compatibility, mobility and automation. These features of IoT devices make this study unique offering to develop a model specifically of a technology which is significantly different to other technologies such as a personal computer technology used in the previous models developed (Davis, 1989, Venkatesh et. al, 2003; Venkatesh, Thong and Xu, 2012; Brown and Venkatesh, 2008)

This study proposed a combination of four different socio-demographic variables such as age, gender, level of income and level of education to be moderating the relationships between the key theoretical factors of PEOU, PU and intention to buy. The moderating role of age and gender was studied in UTAUT and UTAUT2, whereas of income in MATH but the moderating impact of level of education is a unique proposition of this study.

The current age domineering around the threat of privacy and security resulting from the use of technology, factors such as perceived risks and trust in IoT providers is proposed to be key determinants of intention to buy/use IoT devices. This model includes these factors to assess their role in overall consumer behaviour toward IoT devices.

Whereas previous models originated in either an organisational setting focussing on usage of computer system or in a household setting focussing on a personal computer, this research aims to develop a model specifically focussing on IoT devices within a home environment.

A detailed discussion of each of the variable and the derived hypothesis is included as under.

4.6 Variables:

Grouped under two headings of psychological and demographic variables determining the essence of their roots of subjective or objective were used to categorise the variables. On this basis variables such as age, gender, level of education, computer efficacy and cognitive abilities have been classed as demographic variables as they remain objective whilst beliefs, values, personality, personal innovativeness, self-efficacy, and self-image have been classified as subjective psychological variables.

4.6.1 Psychological variables (personal innovativeness, self-image, self-efficacy, etc)

On the basis of some of the characteristics of adopters such as having the greatest degree of opinion leadership, respected, and reputed for successful and discrete use of new ideas (Rogers, 1971), a number of psychological factors can be derived determining the impact of each individual characteristics on the attitude towards technological innovation. Psychological variables are considered having a major impact on the attitude and thereby on behaviour intention and behaviour of individuals towards technological innovation. (Williiams, Rana and Dwivedi, 2015). However, these variables are indirectly related to the measured variables and are hard to observe directly because they are a summary of complex internal processes and behaviour and hence these are considered as second order variables for this study. Variables such as personal innovativeness (Rogers, 1962), self-image (Moore and Benbasat,1991); self-efficacy (Bandura, 1986), lifestyle (Anderson and Golden, 1984), have been profoundly evident in studies related to technology adoption in the past and provide a strong base to be included in this study.

H1: Consumer personality traits (e.g., innovativeness) have a positive/negative impact on his/her attitude toward IoT devices.

4.6.1.a. Innovativeness

One of such prominent variables is that of personal innovativeness. Rogers (1971) used this as the criterion for adopter categorization. Innovativeness is defined as the degree to which an individual is relatively early in adopting a new idea than other members of a social system. Innovativeness is considered "relative" in that an individual has either more or less of it than others in a social system (Rogers, 1971) Innovativeness indicates behavioural change, the ultimate goal of most diffusion programs, rather than cognitive or attitudinal change (Rogers, 1971 p-243).

Personal innovativeness is “the degree to which the individual is receptive to new ideas and makes innovation decisions independently of the communicated experience of others” (Midgley and Dowling, 1978, p. 49). Customers with high levels of personal innovativeness are more likely to see technological advancements favourably and be able to navigate the challenges of utilising new technologies in the context of information technology (San Martin and Herrero, 2012). Personal innovativeness is a personality characteristic that motivates people to try new things before they have any expertise with a certain technology. As a result, innovative customers are a desirable group for organisations to start the adoption of new technologies and to foster innovation. Bartels and Reinders, (2011), Alagoz and Hekimoglu (2012); Baudier, Ammi, and Deboeuf-Rouchon, (2020); Wang et al. (2019) all discussed innovativeness in the context of online food ordering, acceptance of smart homes by students and acceptance of Green Building Technologies (GBTS) in the construction market. The studies unanimously identified innovativeness as having a positive impact on the adoption behaviour.

H1a: Innovativeness has a positive impact on attitude towards IoT devices.

4.6.1.b. Self-efficacy

Self-efficacy originates from social cognitive theory of Bandura, (1986). Individual self-efficacy affects how people behave, how much energy they are willing to expend, and how much effort they are willing to put forth to meet specific obstacles (Bandura, 1986). It is the belief that a person has regarding his or her ability to do a task (Huffman, Whetten and Huffman, 2013; Ozturk, et al., 2016). According to Bandura's hypothesis, people who have high levels of self-efficacy are more inclined to see challenging tasks as challenges to be overcome rather than as something to be avoided. The degree to which a person believes that they can use a computer to do a certain task or job is thus characterised as "computer self-efficacy," one of the variables of TAM 3. (Venkatesh and Bala, 2008).

This is consistent with Bandura's definition of self-efficacy from 1982, which stated that it is the "generative capability in which cognitive, social and behavioural subskills must be organized into integrated courses of action to serve innumerable purpose" (Bandura, 1982). Although other studies (Adesina and Ayo, 2010; Ozturk et al., 2016) have indicated a link between computer self-efficacy and the adoption of IT/IS based services, the nature of the association is still up for debate. Self-efficacy has also been identified as a best predictor by Abdullah and Ward (2016) for e-learning acceptance whilst Coeurderoy, Guilmot and Vas (2014) classed self-efficacy as having a direct influence on the speed of technological adoption and (Alalwan, Dwivedi and Rana 2017; Sharma et al., 2016) revealed a substantial and favourable link between self-efficacy and adoption. However other studies reported a negative relationship (Ozturk et al., 2016). These contradictions show that the study is inconclusive, and a contingent variable is necessary to resolve the contradictions. This study focuses on the variable of self-efficacy instead of computer self-efficacy as the IoT devices may not be limited to just computer and hence this study includes the following hypothesis:

H1b: Self-efficacy has a positive impact on the attitude towards IoT devices.

4.6.1.c. Self-image

Self-image was defined as “the degree to which use of an innovation is perceived to enhance one’s image or status in one’s social system” (Moore and Benbasat, 1991 p. 195). Self-image is the personal view, or mental picture, that individuals have of themselves. Self-image is the mental picture, generally of a kind that is quite resistant to change, that depicts not only details that are potentially available to an objective investigation by others (height, weight, hair colour, etc.), but also items that have been learned by persons about themselves, either from personal experiences or by internalizing the judgments of others. Self-image is an “internal dictionary” that describes the characteristics of the self, including such things as intelligent, beautiful, ugly, talented, selfish, and kind. These characteristics form a collective representation of self and affects an individual’s behaviour.

There is a strong indication of impact of self-image where Wang, McGill, and Klobas (2020) found self-image as having a positive on behavioural intention and that on actual usage of the product. Self-image has been found to play a role in adoption of electric cars (Barbarossa et. al. 2015) smartphone brand loyalty (Yeh, Wang and Yieh, 2016) and in undertaking home automation projects (Takayam et. al. 2012). Mijin et. al. (2019) studied the moderating impact of self-image in a study of attitude towards electronic medical record systems through PEOU and PU. However, the literature review suggests lack of sufficient research undertaken to study the impact of positive self-image on attitude towards IoT devices.

We propose that potential users with a positive self-image may perceive that using smart home devices will enhance their image and that this will impact their attitude towards IoT devices. Therefore, we propose that:

H1c: Positive Self-Image has a positive impact on attitude towards IoT devices.

4.6.2 Attitude

Attitude is considered as one of the major constructs of TBP, which has an impact on behaviour (Ajzen, 1985). It demonstrates how a person's expectations of how his actions will turn out, whether they are positive or not, are based on their own assessments (Aboelmaged and Gebba, 2013). According to Au and Enderwick (2000), the cognitive process that represents a prospective adopter's positive or negative affection about accepting a technology, such as smart homes, is attitude toward adoption (Yang and Lee, 2018). However, a number of researchers have found that the adoption of new technology behaviour is a complex phenomenon that necessitates different models in various contexts, and that the more positive the attitude, the stronger the behavioural intention and which may lead to corresponding or desired behaviour (Aboelmaged and Gebba, 2013). A meta-analysis of IT acceptance and use literature shows that attitude is a key predictor of behavioural intention, and partially mediates the effects of independent constructs on behavioural intentions. Furthermore, the study reports a tremendous improvement in the explanatory power for behavioural intention when attitude is included in UTAUT (Dwivedi et al. 2017). Applying this to Smart IoT devices, user perceptions toward mobile services determine whether new technology is adopted (Sohail and Al-Jabri, 2014). Numerous earlier research that discovered a favourable association between attitude and intention to buy/use new technologies have verified this (Cheong and Park 2005; Hsiao, 2013; Hussein, Oon and Fikry, 2017). The adoption of IoT devices within smart homes and other associated IT/IS based services has been found as being significantly influenced by a variety of external elements. This statement makes the following hypothesis:

H2: Positive attitude toward IoT devices have a positive impact on intention to buy/use IoT devices.

4.6.3 Perceived Ease of Use / Effort expectancy

Perceived ease of use is a significant factor that directly influences the intention to adopt (Davis, 1989). According to the definition, perceived ease of use "does not require physical, mental, or learning effort" (Davis et. al, 1989). Meaning that the system must be simple to use and self-explanatory, is manageable without too much effort by the typical user. The ease of use has been demonstrated to be a crucial factor influencing the adoption of IT systems (Venkatesh and Davis, 2000). Perceived ease of use) as found in the review of the articles has been studied as an independent factor including Coeurderoy, Guilmot and Vas (2014); Li and Hsu, (2016); Afonso, (2019). The findings of these studies indicated a varied level of impact caused on the attitude of a consumer towards an innovative product or technology. Afonso (2019) argued that effort expectancy had a low impact on the adoption of smart speakers in Portugal whereas Wang (2018) contradicted majority of the studies as he suggested effort expectancy did not have an impact on perceived benefits of smart home devices. A number of studies focussed on the impact of effort expectancy on attitude. Due to the difference in results of various studies, effort expectancy or perceived ease of use of individual product or technology needs further study. Also, the complexity of a technology is known to have an impact on ease of use and especially if the technology consists of a combination of services and product (Dodgson et al. 2008). IoT devices satisfy this complexity definition and hence is included in this research.

H3: Perceived ease of use (PEOU) positively affects the intention to buy/use smart IoT devices.

4.6.4 Perceived Usefulness/ Performance expectancy

Perceived usefulness is defined as “an individual’s belief that using a particular system will enhance their productivity or support in the daily tasks” (Davis, 1989). Indicating how the technology supports daily tasks for a smart home by automating routine tasks and saving energy, chores such as shutting out the lights and adjusting the blinds, among others. Perceived usefulness has been proven to affect the user’s attitude and behavioural intention towards new technologies. In a majority of studies examining the nature and relationship of PU and PEOU to behavioural intention, PU has been found consistently to have a direct impact on the behavioural intention to use (Mathieson 1991, Adams, Nelson and Todd, 1992; Hendrickson, Massey and Cronan, 1993; Gefen and Straub 2000; Karahanna, Straub and Chervany, 1999; Gefen 2000). PU is the most prominent and potent predictor of people's intention to use the technology, according to research by Bai and Gao (2014) who developed an integrated model to identify factors impacting people's willingness to use IoT technology. It has also been assessed that perceived usefulness can be used as a good indicator when predicting an individual’s acceptance towards a technology (Wu and Zhang, 2014). Majority of the studies attempted to study the perceived usefulness with a unanimous conclusion of the positive impact of perceived usefulness on attitude towards a product or technology (Gruzd, Staves and Wilk, 2012; Coeurderoy, Guilmot and Vas 2014; Li and Hsu, 2016; Alalwan et al. 2018; Wang, 2017; Wang, 2018; Pal et al., 2018; Yang et al., 2018; Yang and Lee, 2018; Afonso, 2019; Gupta, Manrai and Goel, 2019 etc.).

One of the key issues with smart home devices that has been brought up is that users do not always understand the true value of the products, and the industry struggles to offer a targeted quantity of goods (BCS, The Chartered Institute for IT 2017). Therefore, it is regarded as crucial to consider this factor in our research and examine how it impacts the intention to use smart home devices technology.

H4: Perceived Usefulness (PU) positively affects the intention to buy/use IoT devices.

4.6.5 Perceived Usefulness and Perceived Ease of Use

According to Davis (1989), PU and PEOU are the primary determinants of technology acceptance and hence, the two key constructs of TAM are assumed to affect the intention to use. These two fundamental TAM characteristics are thought to have an impact on intention. Additionally, PEOU, which is a person's evaluation of the effort required to learn a technology and make it usable, influences one's view of its utility as well as their intention, both directly and indirectly (through PU). It is important to understand the relationship between the two factors, that of perceived ease of use and perceived usefulness. It may be argued that if a consumer finds a technology easy to use it can have a direct impact on the perceived usefulness of the same technology. A few studies have found that PEOU directly affected the behavioural intention to use along with PU (Moore and Benbasat 1991, Thompson et al. 1991; Venkatesh and Davis 1996; Chin and Gopal 1995; Venkatesh 1999). Some authors such as Hubert et al. (2017) in the context of acceptance of smartphone-based mobile shopping and de Boer et al. (2021) in the context of IoT acceptance by households show that PU is an important determinants of IT acceptance and can explain a large proportion of variance in the intention to use an innovation. Moreover, PEOU which is the individual’s assessment of the effort associated with the usability and the learning of a technology, not only influence the intention both directly and indirectly (through PU), but also influence the perception of their usefulness (Chen et al., 2009; Davis, 1989; Davis, Bagozzi and Warshaw, 1989; Lee, 2009). Gefen and Straub (2000) pointed out the inconsistency of PEOU in relation to its correlation with usage behaviour. The explanation for the inconsistency was related to the intrinsic and extrinsic aspect of tasks related with Information Technology (IT). The findings of this study suggest that it is the type of task that seems to determine whether PEOU directly affects use-intention.

This study suggests that PEOU would affect adoption of IoT devices indirectly through its effect on PU, as the easier the system is perceived, the more useful it can be (Venkatesh and Davis 2000). The impact of other external variables employed to study their influence on behavioural intention is fully mediated by these beliefs of PU and PEOU (Davis, Bagozzi and Warshaw, 1989). In TAM, extrinsic motivation is clearly captured by the PU construct (Davis, Bagozzi and Warshaw, 1989; Venkatesh and Davis, (2000) as it refers to time saving (Childers et al. 2001).

H5: Perceived ease of use has a positive impact on perceived usefulness of IoT devices.

However, several researchers have argued that PEOU, which refers to the process of leading to an outcome (Childers et al. 2001) does not fully capture the intrinsic motivations (Davis, Bagozzi and Warshaw, 1992; Monsuwé, Dellaert and De Ruyter, 2004; Pavlou 2003), which will also be studied as a part of this research under other headings i.e., Hedonic Motivation.

4.6.6 Perceived features of IoT

Perceived features of IoT construct is based on the IDT (Rogers,1983) where five key attributes namely: relative advantages, compatibility, complexity, trialability and observability, impact the adoption of innovation were proposed. One of the five attributes has been used in this research, i.e., compatibility. Relative advantage explains how innovations can improve consumers' wellbeing and how adoption of new technologies is heavily influenced by the similar advantages associated with their use (Taylor and Todd, 1995). However, as mentioned earlier, relative advantage is similar to the PU in TAM model, thus will not be included in the model. The degree to which an innovation is seen as being simple or complex to understand and/or use is referred to as its complexity (Rogers, 1983). Complexity and PEOU are very similar (Moore and Benbasat, 1991), thus complexity will also not be included in the model. The degree to which the impacts of an innovation are apparent to others is known as observability (observed effects) (Rogers, 1983). Trialability is the extent to which an innovation can be tested out on a small scale (Rogers, 1983). Before deciding whether to adopt or reject a new technology, trialability gives the potential adopter the chance to try an innovation (like smart temperature) for a short period of time. According to Rogers (1983), adopting a new innovation is less risky and unclear when it has been tested out beforehand. Additionally, it has been discovered that allowing users to test out novel technologies before adoption may enhance their likelihood of doing so (Lee et al., 2011). Products in the UK have this attribute inbuilt in the sales packages, where the consumers have the option to trial the product. Although proven to be an important factor in technology adoption due to the remit of this research being home environment trialability and observability have not been included in this research. These factors also ranked lower in the exploratory phase of the methodology providing sufficient grounds to be removed from the study. The factors that ranked higher in the ranking order were compatibility, mobility and automation were included in the study due to their significance to the consumers.

H6: Perceived features of IoT devices have an impact on perceived usefulness of IoT devices.

4.6.6.a. Compatibility

Compatibility as an attribute of IDT refers to the degree to which an innovation is perceived as being consistent with the existing systems, values, past experiences and needs of potential adopters (Rogers, 1983). According to Al-Majali and Nik Mat (2011), compatibility refers to how well an invention satisfies the needs and preferences of potential adopters relative to all other available possibilities. In other words, compatibility refers to a technology's capacity to integrate with potential users' lifestyles. Prior research in IS/IT studies has argued that perceived compatibility plays both moderating and mediating roles in influencing a user's perceptions of such technology (Islam and Rahman, 2016; Ozturk et al. 2016). Additionally, because the compatibility of traditional systems or services can be minimised, it should be viewed as one of the key features of IoT devices (Pliatsikas and Economides, 2022). Therefore, the current study proposes the following hypotheses:

H6a: Compatibility has a positive impact on perceived usefulness of IoT devices.

4.6.6.b. Mobility/Portability

Portability refers to users' feelings about the perceived mobility of specific devices (Park et al. 2014). It is directly related to the functionality of mobile devices because it can enhance the service access points of users (Yang et al. 2017). Amazon announced the Amazon Echo Dot and Amazon Tap in 2016, which are both less expensive and smaller than the Amazon Echo but have nearly identical features. Customers can now utilise IoT devices more conveniently than in the past by placing smaller gadgets in each room of their home or by taking them outside. Since customers can utilise IoT devices without regard to space requirements to fulfil their activities, portability can thus be a key element of utilitarian value. Because they are more affordable than their larger versions, such portable gadgets also have an economic advantage. The capacity to access IoT devices while on the go is referred to in this study as mobility. Thus, this study proposes the following hypothesis:

H6b: Mobility has a positive impact on perceived usefulness of IoT devices.

4.6.6.c. Automation

Parasuraman and Riley (1997) defined automation as "the execution by a machine agent of a function that was previously carried out by a human." Luor et al. (2015) argued that automation has been widely adopted because it can improve affordability and simplicity in a smart home. Fully proactive automation, which is the long-standing dream of a smart home, can be realized by AI (Augusto and Nugent 2006). The current study defines automation as the execution of tasks by smart devices such as Virtual Personal Assistant (VPA) devices without human intervention, thereby significantly improving users' job performance and lives by such means as automatically receiving missed calls/emails, informing users of their personal work schedules, and noticing breakdowns of linked home appliances. Further, Luor et al. (2015) showed that the automation function is positively related to residents' perceived usefulness of IoT devices.

H6c: Automation has a positive impact on perceived usefulness of IoT devices.

4.6.7 Perceived high cost

Cost is an important factor which affects users' usage decision and tends to affect the adoption of new technology. Prior studies on information-oriented services introduced the definition of perceived cost as" the concerns on the costs consumed in buying, using, and repairing the component of a particular system or service" (Shin, 2009). Based on this definition, the definition of perceived cost used in the present study is" the concerns on the costs in buying, installing, maintaining, and operating IoT devices in smart home environments" (Shin, 2009). Costs can take form of several types, such as smart devices purchase cost, infrastructure installation cost, communication cost viz broadband services or mobile network costs, subscription cost as well as maintenance costs. Although there are many benefits and barriers to employing new and innovative services or goods, one of the biggest barriers to their distribution has been cost (Kim, 2008; Kim, 2014). This suggests that users will probably think carefully about whether the advantages of a certain service outweigh the disadvantages. Therefore, perceived cost can be one of the factors affecting the consumers' intention to use smart homes devices. Previous studies had incorporated cost in their models to understand users' intention to adopt smart homes. For instance, Alolayan (2014) found that cost is the most significant issue in determining users' intention to purchase smart homes' devices, such as smart fridge. Thus, this study incorporates cost as an essential factor impacting the intention to use smart IoT devices.

H7: Perceived high cost has a negative impact on the intention to buy/use IoT devices.

4.6.8 Subjective norms/Social Influence

Social influence is defined as the extent to which a user perceives that important people believe he or she should buy and use smart homes devices, which are influenced by the judgment of these significant people. Social Influence is the construct that assesses the impact of the opinion of people that the user values on whether or not to use technology (Venkatesh et al. 2003). Despite being present under different names, such as subjective norms in TRA (Fishbein and Ajzen 1975), TPB (Ajzen, 1985), TAM2 (Venkatesh, 2000), CTAM-TPB (Taylor and Todd, 1995), MPCU (Triandis, 1979), and IDT (Rogers, 1962) models and Environmental influence in SCT (Bandura 1996), they all have a variable that recognizes the impact of third parties on user attitudes.

In the modern era of highly extensive use of technology, personal assessments and views of their friendships and one's social network are very important. Social influence is gaining substantial attention, and numerous research has shown its close connection to intentions to use modern technology. Previous studies (Gruzd, Staves and Wilk, 2012) discovered that social media may be used to improve smart homes, influence predicts intent to purchase and use of smart home technology significantly. For example, Alolayan (2014) indicates that intention to use a smart fridge is influenced by their friends, colleagues, and the community.

Factors related to subjective norms, social network, belongingness, peer pressure etc. were found widely in the studies. More than 16 papers were found to have focussed on studying impact of social influence on behavioural intention. Of them Gruzd, Staves and Wilk (2012); Pal et al. (2018); AlHogail (2018); Baabdullah (2018); Mashal and Shuhaiber (2018); Afonso (2019) and Gupta, Manrai and Goel (2019) are a few. There is a divide in the nature of impact of social influence on behavioural intention where Gruzd, Staves and Wilk (2012); Wang, (2017); Mashal and Shuhaiber (2018); Afonso (2019) class social influence as having a positive impact on behavioural intention, Alalwan, Dwivedi and Rana (2017) found this impact to be neutral in Jordanian banking customers and Pal et al. (2018) also found that social influence had a neutral impact in the smart homes for elderly population studies.

Subjective norms which have been identified as an exception to the applicability of impact of social influence on perceived usefulness. TAM2 (Venkatesh, 2000) concluded that subjective norms have an influence on perceived usefulness in mandatory settings and not in voluntary settings, whereas other constructs within the social influence group such as image and voluntariness can impact in both the settings. This research is predominantly studying the behaviour influences in a home setting and needs further reasoning to study the overall impact of social influence on the intention to use IoT devices.

Due to significant differences reported in the impact of social influence on acceptance, it is imperative that this be studied in this research with specific reference to the acceptance of IoT devices such as Alexa. In environments of voluntary use of a technology, third party influence is seen as influencing the user's perception of the technology in question (Venkatesh and Davis 2000). For the extent of our research, we incorporate social influence construct as a positive variable impacting behaviour intention.

H8 – Social Influence has a positive impact on intention to buy/use IoT devices.

4.6.9 Hedonic motivation

Considered as an intrinsic rather than extrinsic factor, hedonic motivation makes user of information system to be cognitively attached to the platform. A number of studies have incorporated the core constructs of TAM in the last few decades, However, arguments from recent scholars opined that even though these constructs are in the domain of cognition, they emphasize utility (Zhou, 2013) while intrinsic factors such as hedonic motivation has been largely ignored (Lowry et al., 2013; Ndubisi and Sinti, 2006). Further research in TAM studies have included the 'perceived enjoyment' construct to capture the pleasure and satisfaction derived by performing a behaviour and its effect on use-intention. Hedonic motivation is defined by Venkatesh Thong and Xu, (2012, pp.161) as ‟the fun or pleasure derived from using a technology‟. This definition has been supported by a number of scholars who regarded hedonic motivation (otherwise known as entertainment value, fun, and enjoyment) as the performance of certain transaction without any form of benefit other than the process of performing it (Moon and Kim, (2001). Li and Hsu (2016), Alalwan et al. (2018), Baabdullah (2018), Salimon, Gorondutse and Abdullah, (2018) and Afonso (2019) use the term hedonic motivation as opposed to Vejacka (2015); Abdullah and Ward (2016); Wu, Wu and Chang (2016); Kahlert, Constantinides and Vries (2017); Park et al. (2017) etc. who use enjoyment as a factor. A review of these studies shows that although different words such as hedonic motivation or enjoyment are used, they all signify the same meaning to determine the fun aspect of the product or technology. In terms of the findings of these studies hedonic motivation is believed to have a positive impact on behavioural intention (Li and Hsu, 2016; Alalwan et al. 2018; Baabdullah, 2018; Afonso, 2019). Where Vejacka (2015) found that perceived enjoyment is not a significant factor in accepting contactless payment method, Abdullah and Ward (2016); Kahlert, Constantinides and Vries (2017) and Mashal and Shuhaiber (2018) found it as the most influential factor. Owing to the differences in previous studies, it is important to study the impact of perceived fun or hedonic motivation on behavioural intention of consumers to use IoT devices. Using this intrinsic factor will help in reducing the inherent weaknesses of TAM and TPB which has led to involuntary bias in adoption literature toward cognitive beliefs (Bagozzi, 2007).

H9: Hedonic motivation/perceived fun has a positive impact on intention to buy/use IoT devices.

4.6.10 Perceived risk

Perceived risk may be classified as Privacy risk, Security risk, physical risk, financial risk etc. In over 16 papers, privacy and security is generally discussed coherently. Han and Yang, (2018) studied privacy and security risk as one factor whereas Wang, McGill and Klobas (2020) studied privacy, security and financial risk as three different factors. Chou and Yutami (2014) also showed that perceived risk, of which privacy and safety concerns are significant antecedents, negatively affected attitudes toward smart meter adoption. Hence the following hypothesis have been proposed:

H10: Perceived risk associated with IoT devices negatively influences the attitude towards IoT devices.

4.6.10.a. Privacy risk

Users' concern over unauthorised access to the IoT devices by others and potential loss from disclosing personal user information are defined as privacy risk in this study. Townsend, Montoya and Calantone (2011) concluded that privacy has a negative impact meaning if consumers perceive a risk to their privacy, this may negatively affect their acceptance. However, Cannizzaro et al. (2020) further argued that level of awareness of such risk highly influences the acceptance of a product or technology. Security/privacy risk is negatively associated with attitude (Eastlick, Lotz and Warrington, 2006, Kim, 2008), which, in turn, increases user reluctance of interacting with a device (Gefen, Karahanna and Straub, 2003) or disclosing personal information (Dinev and Hart, 2006). The less interaction that occurs, the less likely is an individual will use these devices.

H10a: Privacy risk associated with IoT devices negatively influences the attitude towards IoT devices.

4.6.10.b. Security risk

Security risk is defined as a "circumstance, condition, or event with the potential to cause economic hardship to data or network resources in the form of destruction, disclosure, modification of data, denial of service, and/or fraud, waste, and abuse" (Balta-Ozkan et al., 2013), which also includes the risk of violation of a user's privacy (Yang et al., 2016). IoT devices collect data about residents' lifestyles, such as movement, energy use, and purchase preferences, music preferences etc. in order to support them effectively. As a result, these systems face the challenge of ensuring the safety of personal data (Balta-Ozkan et al., 2014). Therefore, security/privacy risk in this study relates to customers of smart home services' concern that their personal information will be compromised or that criminals will hack their smart devices.

The ability of some systems to discern between the voices of various people is still technically limited (Gebhart, 2020). This highlights the possibility that a hacker could take control of the device systems and steal user data. There have really been hacking situations where Google Home and Amazon Echo devices heard a voice order from a

TV show instead of their owner and carried it out (Boucher and Hackett, 2017, Maheshwari, 2017).

H10b: Security risk associated with IoT devices negatively influences the attitude towards IoT devices.

4.6.10. c. Physical risk

Physical risk should also be taken into account in addition to security/privacy risk. Jose and Malekian (2015) stated that a basic gadget like a fluorescent lamp connected to a IoT home assistant might injure occupants physically (e.g., shatter glass, start a fire, or poison them with mercury). Additionally, the FTC (2015) published a paper explaining the physical risk of smart homes and provided examples like burglars turning off home security systems and hackers taking advantage of home healthcare services. The danger that users of IoT devices could hurt themselves or others due to hacking, abuse, or malfunction is referred to in this study as physical risk. The following hypotheses is proposed by this study in light of the aforementioned literature review:

H10c: Physical risk associated with IoT devices negatively influences the attitude towards IoT devices.

4.6.11 Risk and Trust

In the IoT context, the perceived risks such as privacy, security and physical risks are higher due to the distinctive characteristics of IoT devices and services associated with these devices such as encryption level. This affects the trust in the providers of these IoT devices.

The higher the consumers feel risky in their acceptance decision (Lai, Tong and Lai, 2011; Chen et. al. 2015; Yildirima and Ali-Eldina 2018), the lower is the trust in the providers of these devices and services. Trust is considered an effective variable for decreasing uncertainty and creating a sense of safety (Gao and Bai, 2014), and consequently, trust plays a major role in user’s intention to buy/use. Consumers tend to distrust IoT devices or services that they perceive to be outside of their control, as such devices or services are assumed to carry a too high of a risk (Koien, 2011).

Petrovskaya and Haleem, (2020) implies that consumers who believe that the business is overall trustworthy are more likely to take company's corporate social responsibility (CSR) into account when making purchasing decisions.

This study hypothesises that higher the perceived risk in IoT devices negatively affects the trust in the providers of IoT devices.

H11 Risk and Trust – Perceived risk has a negative impact on trust in IoT devices.

4.6.12 Trust

For many years, it has been believed that trust facilitates buyer-seller transactions by lowering risk or vulnerability (Doney and Cannon, 1997; Luhmann, 1979; Pavlou, 2003; Ring and Van de Ven, 1994). In the sphere of information security, trust has been emphasised as a crucial element in influencing customer behaviour. For instance, Keen et al. (1999) discussed how trust affects consumer-marketer interactions in e-commerce. Trust played a crucial role in the adoption of Internet technologies, according to Gefen (2000). According to Li and Hsu (2016), in online group buying transactions, buyer happiness and perceived vendor quality were both positively correlated.

Ziefel, Rocker and Holzinger, (2011); Alagoz and Hekimoglu (2012); Nunkoo and Ramkisson (2012) studied the impact of trust on attitude whereas Lin et al. (2020) studied the impact of trust on perceived usefulness and found that compliance with regulations can help organisations develop trust in consumers and hence helps in developing a positive attitude towards internet banking. Mashal and Shuhaiber (2018) studied the impact of trust on behavioural intention and found it significant influencer. Pal et al. (2018) and Kahlert, Constantinides and Vries (2017) also found perceived trust to have a positive influence on attitude towards smart homes for elderly.

Researchers have also combined trust with the TPB and discovered that in online services, trust was a significant predictor of attitude, subjective norm, and PBC (Lee, 2009; Wu and Chen, 2005). Another significant problem facing the smart home sector is consumer trust in service providers. According to a CNET (2014) article titled "How

Big Brother's going to peek into your connected home," potential users were concerned about the growth of the smart home industry and data collection by major IT companies like Google. According to Luor et al. (2015), perceptions of trust and attitudes toward smart home services are positively correlated. In this study, "trust in IoT devices providers" is defined as users' confidence that selling parties are truthful, dependable, and reliable." And the following hypothesis has been proposed:

H12 Trust in IoT devices providers is positively associated with intention to buy/use IoT devices.

4.6.13. Control factors - Sociodemographic factors/variables as moderators

Individual differences are usually user factors that include demographic variables and situational variables that account for differences attributable to circumstances such as experience and training (Agarwal and Prasad, 1999). Many technology acceptance studies neglect moderating effects of individual factors, although some do admit that the absence of such characteristics is one of their work’s limitations (e.g., Davis, Bagozzi and Warshaw, 1989). The inconsistencies existing in prior studies imply that perceptions are not equally efficacious in developing usage intentions for everyone (Venkatesh, 2000). The TRA, e.g., indirectly acknowledges such individual differences by asking potential users to assess the importance of each belief (Agarwal and Prasad, 1998). In more recent empirical studies, the role of demographic variables has been studied widely (Reference articles) and review of the articles yields the following individual factors that may have moderating effects: (1) gender; (2) age; (3) level of income and (4) level of education. These moderators and their role have been discussed in detail in the sub sections of this chapter.

4.6.13A Discussion of Sociodemographic factors/variables

Demographic variables such as age, gender, type of education, computer efficacy, cognitive abilities have been widely studied. More than 25 papers (see table 9 of studies using a range of factors) discuss age for example, all the papers discuss some sort of demographic variables. These set of variables have been studied as moderators whereby with a p value <0.05, it indicates that these factors affect the direction and/or strength of the relationship between an independent or predictor variable and a dependent or criterion variable.

Age moderates the impacts of relative advantage and image on adoption and use, moderating most of the major relationships of technology acceptance theories, including UTAUT (Venkatesh et al. 2003, TPB (Ajzen, 1991) and IDT (Rogers, 1962) Additionally, gender has a significant influence on people's beliefs and behaviours, moderating the effects of PU, PEOU, and social factors on the intention to buy/use. The connection between perceived ease of use and intention has been found to be stronger for female and older users, whereas the influence of perceived usefulness on intention was stronger for men and younger users (Venkatesh et al., 2003). When determining Internet continuance use intention for young male users, PU is more significant than PEOU. (Venkatesh et al., 2003).

These variables have been discussed in more detail below.

H13: Sociodemographic characteristics (e. g., gender, age, education, income) have a moderating impact on factors affecting intention to buy IoT devices.

(i) Gender:

Numerous research has discussed gender differences Yang et al. (2017); Yangg, Lee and Zo (2017); Shin, Park, and Lee (2018); Nikou (2019); Wu, Wu and Chang (2016); Rauschnabel, Brem and Vens (2015); Coskun, Kaner, Bostan (2018); Mennicken, Vermeulen, Huang (2014) According to a study by Yang et al. (2017), women were more likely than men to intend to use smart home services (Yang, Lee and Zo, 2017). Shin, Park, and Lee (2018) observed that the elements influencing the adoption IoT devices within smart homes—such as perceived usefulness and compatibility—vary by gender, while Nikou (2019) discovered that women are more affected by perceived costs than men are during the adoption process (Nikou, 2019). Wu, Wu and Chang (2016) argue that gender has no significant effect on the acceptance of smart watches whereas Rauschnabel, Brem and Vens (2015) concluded that male respondent sees higher functional benefits in smart glasses than women thereby influencing the behavioural intention to buy/use.

(ii) Age:

First, it is well known that the perception and requirements of smart homes vary based on the age of the users (Shin, Park, and Lee, 2018). For instance, even if a smart home can offer a practical and simple automation system, most people typically choose to have control over the system rather than have it entirely automated or express concern about the cost of automation (Luor et al. 2015). The elderly population, however, generally has a tendency to respond favourably to the majority of smart devices and sensors connected to health issues, according to several studies. The elderly typically exhibit a positive attitude, particularly on their perception of automation (Pal et al. 2018). Contradicting results have been found with regards to age as a moderator, where Shin, Park, and Lee (2018) concluded that older consumers are more likely to purchase smart homes, Wang, Chen, and Chen (2017) found that age as a moderator has a negative impact on the acceptance of technology as older adults exhibited a negative influence on the behavioural intention to adopt mobile phones.

(iii) Level of education

Studies have supported the existence of educational level differences. It is well known that people with higher levels of education tend to focus more on the value and advantages of cutting-edge technologies (Baudier, Ammi, and Deboeuf-Rouchon, 2020). Similar to this, Shin, Park, and Lee (2018) discovered disparities in the expectations and uptake of smart home devices between groups with high and low education levels.

(iv) Income level

However, there is some debate in this area of study regarding the influence of income level. The expense of the initial purchase, installation, and upkeep of services is a significant impediment to the use of IoT devices (Balta-Ozkan et al., 2013; Balta-Ozkan et al., 2014; Williams, Bernold and Lu, 2007). Contrarily, it's interesting to note that there aren't many research studies that support the effect of income levels on the acceptance of smart IoT devices. For instance, Yang et al. (2017) found that the acceptance of smart home devices may not be directly influenced by income levels (Yang, Lee and Zo, 2017). Indirect effects of income levels were discovered by Shin, Park, and Lee (2018), but they were not statistically significant.

4.6.13B Impact of sociodemographic variables as moderators

Based on several implications highlighted by Sun and Zhang (2006) for future researchers, this study suggested that research on moderating factors is of great value. This is consistent with suggestions from existing studies that contexts could play an important role in user technology acceptance (Davis, 1989; Taylor and Todd, 1995a; Szajna, 1996). It is noteworthy that the major function of moderating factors is explaining the inconsistencies by identifying the individual differences. Its effect in enhancing R^2 is modest. This observation is consistent with prior empirical study (Chin, Marcolin and Newsted, 2003).

The expectations and demands for smart homes have been found to vary depending on the user characteristics (Coskun, Kaner, Bostan 2018; Mennicken, Vermeulen, Huang, 2014) It is vital to study the impact of a range of demographic variables, positively or negatively influencing the behavioural intention to accept IoT devices. 4 of the most widely used demographic variables adapted from UTAUT (Davis 2003) have been adapted for this study as they have been proved to have a prominent moderation effect on impact of consumer's attitude on intention to buy/use IoT devices.

The role of these identified moderators and their impact has been studied on selected relationships in this study. The selection of relationships is based on the key factors adapted from the underlying theory of TAM (Davis, 1989) whereas the moderator role is adapted from the key contribution of UTAUT (Venkatesh et. al 2003) These are listed as below:

a) Moderating role on impact of perceived ease of use on perceived usefulness of IoT devices.
b) Moderating role on impact of perceived ease of use on intention to buy/use IoT devices.

c) Moderating role on impact of perceived usefulness on intention to buy/use IoT devices.

   Factors such as attitude, social influence, hedonic motivation, trust in IoT providers and their relationship with intention to buy IoT devices have not been studied n this study.

   The following hypothesis have been developed on the basis on the above discussion.

H13A: Sociodemographic characteristics (e. g., gender, age, education, income) moderates the impact of perceived ease of use on perceived usefulness of IoT devices.

H13B: Sociodemographic characteristics (e. g., gender, age, education, income) moderates the impact of perceived ease of use on intention to buy/use IoT devices.

H13C: Sociodemographic characteristics (e. g., gender, age, education, income) moderates the impact of perceived usefulness on intention to buy/use IoT devices.

Below is the summary table of all proposed hypothesis of this study.

Table 4. 9 Proposed hypothesis

H1 – Psychological factors have an impact on attitude towards IoT devices.
H1A – Innovativeness has a positive impact on attitude towards IoT devices.
H1B – Self efficacy has a positive impact on attitude towards IoT devices.
H1C – Positive Self-image has a positive impact on attitude towards IoT devices.
H2 Positive Attitude has a positive impact on intention to buy/use IoT devices.
H3 Perceived Ease of Use (PEOU) positively affects the intention to buy/use smart IoT devices.
H4 Perceived Usefulness (PU) positively affects the intention to buy/use IoT devices.
H5 PEOU and PU – Perceived ease of use has a positive impact on the perceived usefulness of IoT devices.
H6 Perceived features of IoT devices have an impact on perceived usefulness of IoT devices.
H6A Compatibility has a positive impact on perceived usefulness of IoT devices.
H6B Mobility has a positive impact on perceived usefulness of IoT devices.
H6C Automation has a positive impact on perceived usefulness of IoT devices.
H7 Perceived high cost has a negative impact on the intention to buy/use smart IoT devices.
H8 Social Influence has a positive impact on intention to buy/use IoT devices.
H9 Hedonic motivation/perceived fun has a positive impact on intention to buy/use IoT devices.

H10 Perceived risks associated with IoT devices negatively influences the attitude towards IoT devices.
H10A Privacy risk associated with IoT devices negatively influences the attitude towards IoT devices.
H10B Security risk associated with IoT devices negatively influences the attitude towards IoT devices.
H10C Physical risk associated with IoT devices negatively influences the attitude towards IoT devices.
H11 Perceived risk has a negative impact on trust in IoT devices providers.
H12 Trust in IoT devices providers is positively associated with intention to buy/use IoT devices.
Moderation
H13A: Sociodemographic characteristics (e. g., gender, age, education, income) moderates the impact of perceived ease of use on perceived usefulness of IoT devices.
H13B: Sociodemographic characteristics (e. g., gender, age, education, income) moderates the impact of perceived ease of use on intention to buy/use IoT devices.
H13C: Sociodemographic characteristics (e. g., gender, age, education, income) moderates the impact of perceived usefulness on intention to buy/use IoT devices.

4.7 Conclusion

This chapter covered the planning and preparation for the next crucial stage of the research i.e. the methods to collect the data and their analysis, which hugely depended on the findings from the literature review. The chapter evaluated the range of factors and identified the selection of factors from existing theories as well as an exploratory phase for identification of the most relevant factors from consumer's perspective. This chapter included outline a methodical approach to identifying factors followed by a detailed discussion on each of the chosen factor and its context for the hypothesis development for this research which lead to the foundation of a conceptual framework for the study. Using the chosen factors in this chapter, the next chapter, methodology will aim to discuss the constructs to be used in order to assess each of the hypothesis developed in this chapter.

CHAPTER 5 METHODOLOGY

5.1 Introduction

The previous chapters reviewed the technology adoption theories and a conceptual framework for this study. This chapter methodology aims to discuss the ways to measure the identified constructs to assess each of the hypothesis developed in the previous chapters. This chapter explains how the hypothesis will be tested. The main sections of this chapter cover the philosophical foundations of the study followed by sampling strategy, data collection, questionnaire design and preliminary data analysis in order to achieve the research objective to develop and apply data collection methods along with their ethical implications.

The studies predominantly use quantitative approach towards studying the acceptance of technology ranging from Alagoz and Hekimoglu (2012) to Cannizzaro et al. (2020) Marikyan, Papagiannidis, and Alamanos, E (2021) using quantitative analysis such as structural equation model, correlation, regression and partial least squares method as a means to analyse and predict the acceptance behaviour towards smart devices. As against this qualitative research has also been adapted by several studies such as Gruzd, Staves and Wilk (2012); Coeurderoy, Guilmot and Vas (2014); Dintoe (2018) etc. use event history, thematic analysis and constant factor analysis to study the behaviour from a qualitative perspective. The suitability of one specific research method cannot be determined by the scale of use of quantitative analysis, however it does provide a foundation on validity and reliability of the studies undertaken. The choice of research methods used in this study are guided by the research question to study the various factors that influence the behavioural intention of adopters in relation to the acceptance of IoT devices within a smart home environment whereby a single method would not enable the researcher to achieve the research aims and hence a mixed method approach was deemed suitable. (Kraemer and Flechais, 2018)

5.2 Research Design

5.2.1 Methodology

The methodology adopted in this study is a mixed-method approach of quantitative and qualitative research. A vast majority of the research studied as a part of the literature review for this research, exhibits the use of a positivist approach, with formal propositions developed in the form of hypothesis to collect and analyse objective data. (Wynn Jr and Williams, 2008; Alagoz and Hekimoglu, 2012, Cannizzaro et al. 2020; Marikyan, Papagiannidis, and Alamanos 2021). So, introduction of qualitative method in this study was a conscious attempt by the researcher to tackle the imbalance and challenge a new thinking that will address any methodological issues that may occur in this study. As the first step of the mixed-method approach, this thesis contains a qualitative analysis which was chosen to explore the most relevant factors for consumers when it comes to accepting/buying IoT devices within a smart home environment. It is important to understand the mechanisms of the underlying relations that lead to the adoption and implementation of different technologies in a more holistic approach by using an explorative qualitative analysis from a realistic perspective (Babbie, 2012; Eisenhardt, 1989; Justesen and Mik-Meyer, 2012).

More so, in terms of questionnaire design, a comprehensive design approach was adopted (Bryman and Bell, 2011), which was informed by the results of the qualitative data analysis of the semi-structured interviews, taking into account the broad set of questions to be asked, type of data, and analysis methods. Also, scientific technology adoption studies must be generalisable, focus on stable independent variables, have ontological assumptions, and use quantitative research methods (Siponen and Tsohou, 2018). (Siponen and Tsohou, 2018) summarised the features of positivist technology adoption research. For instance, the majority of it investigates the distinctive relationships within phenomena, it has formal propositions, uses quantifiable measures for the dependent and independent variables, collects and analyses objective data, tests hypotheses that are generalisable across settings, etc. (Orlikowski and Baroudi, 1991; Siponen and Tsohou, 2018). The consumer questionnaire is used as the second research instrument as this is effective when there is a clear and narrow research focus and there is clarity on the type of information needed (Denscombe, 2010).

Due to the nature of research designs for this study to incorporate operational decisions based on 'what will work best' in finding answers for the questions under investigation, it has enabled a pragmatic approach to conduct research in innovative and dynamic ways to find solutions to research problems. As a result, the mixed method research was adopted for the following reasons (Cresswell, 2003; Blaikie, 2007; cited by Bryman and Bell, 2011).

- Strength of qualitative interviewing method complemented the weakness of the identification of relevant factors from a quantitative survey. Hence the results from the semi-structured interviews fed into the development of survey of the most highly ranked factors according to the interview participants.

- A mixed method approach of interviews and survey provided more detailed evidence of a rigorous approach and reliable data findings of this study.

- Sole use of questionnaires would lead to the constraint of identifying consumer centred and relevant factors affecting their behaviour through questionnaires and hence it aided in answering research questions that survey would have been unable to answer in a timely manner.

- A mixed method approach encourages the use of multiple paradigms and widened the research horizons for better scope and application of this study.

5.2.2 Research Philosophy

The philosophical paradigm refers to a system of beliefs that guide scientific research (Wynn Jr and Williams, 2008). Researchers use a particular philosophical paradigm to generate and interpret knowledge claims about facts (Wynn Jr and Williams, 2008). Taking an objective approach, positivism focuses on testing, confirmation and falsification of hypothesis concerning an objective reality and apprehended reality (Wynn Jr and Williams, 2008). Positivism states that the researcher can observe reality objectively and that there is only one reality, which exists independent of the observer.

Philosophical paradigms can be differentiated in terms of ontology and epistemology. More particularly, ontology refers to the nature of reality and being, while epistemology refers to the evidentiary assessment and justification of knowledge claims (Orlikowski and Baroudi, 1991; Wynn Jr and Williams, 2008). As far as ontology is concerned, the positivists believe that reality and the individual (i.e., the researcher) are separated and are independent. That is, positivistic ontology is dualistic in nature (Weber, 2004). On the other hand, interpretivists believe that the individual interacts with the reality and the understanding of the phenomena is bound to the individual's previous experiences (Weber, 2004). As the lifeworld consists of both subjective and objective characteristics, interpretivist ontology is objective in terms of reflecting intersubjective reality (Weber, 2004). Regarding epistemology, positivists believe that human experience reflects objective and independent reality, and such a reality lays the foundation for knowledge (Weber, 2004). Interpretivists intentionally constitute knowledge that possibly reflects the world, and such knowledge is built within their life-world framework and their particular goals for the work (Weber, 2004).

Pragmatism is a reaction to the views of reality proposed by positivist and interpretivist schools of thinking. Pragmatist research philosophy deals with the facts. It claims that the choice of research philosophy is mostly determined by the research problem. In this research philosophy, the practical results are considered important (Crowther and Lancaster (2008). In addition, according to (Alghamdi 2013) pragmatism does not belong to any philosophical system and reality. Researchers have freedom of choice. They are "free" to choose the methods, techniques, and procedures that best meet their needs and scientific research aims. Pragmatists do not see the world as absolute unity. The truth is what is currently in action; it does not depend on the mind that is not subject to reality and the mind dualism. The most flexible of all research approaches is that of Pragmatism (Crowther and Lancaster (2008) which embraces that research is socially, constructed meaning multiple viewpoints can be usefully applied to research and the purpose of theory is to inform the practice. This may be applicable to the research thesis whereby the research attempts to acquire opinions of the participants recognising the diversity of these opinions and leading to practical relevance informing the businesses to adapt to the needs of their prospective customers of home assistants. (Alghamdi 2013).

This research is based on a pragmatist philosophical paradigm as it follows a mixed method approach to achieve the aims of this research. The data collection for this research included an initial exploratory phase of semi-structured interviews followed by a quantitative data collection using survey. The quantitative data collection part of the research is based on positivist philosophical paradigm whereas interviews part of the research is based on pragmatist approach. Fundamentally, positivism assumes an objective reality and treats the constant conjunction of events as an indicator of a causal relationship (Tsang, 2014). Due to the nature of the study, the researcher found that one method of data collection either a quantitative or a qualitative would not suffice to achieving the research aims of identifying relevant factors and examining their impact on the behavioural intention towards IoT devices. Hence a mixed method approach was taken using the pragmatist philosophy to address the complexity of the research aims.

5.2.3 Research type

Trochim (2006) refers to two "broad methods of reasoning as the inductive and deductive approaches" (p.1). Where induction is explained as moving from the specific to the general, deduction begins with the general and ends with the specific; arguments based on experience or observation are best expressed inductively, while arguments based on laws, rules, or other widely accepted principles are best expressed deductively.

The inductive approach employed as a method of thinking about analysis in grounded theory (Strauss, 1991). To arrive at conclusions, inductive researchers employ open-ended methodologies. As a result, in order to effectively apply the inductive technique, researchers must approach data with an open mind, immerse themselves in it, search for trends and patterns, identify important factors, and then gradually create comprehensive explanations of discoveries.

Deductive research, on the other hand, starts with established theory and builds onto it with collected data, and therefore these studies tend to be confirmatory in approach. Deductive research, according to Jones (2015), is linked to positivist and quantitative research that develops a concept or hypothesis from an established theory and tests a relationship or relationships through data collection. Deductive research begins with the formulation of the research statement followed by the derivation of the statement (hypothesis), and is concluded with the collection of data, the results of which are utilised to support, alter, or contradict the theory that served as the basis for the hypothesis.

The methodology adopted by a scientific study should be consequential to the philosophical stance of the researcher and to the target phenomena to be investigated (Holden and Lynch, 2004). A pragmatic study adopts abductive reasoning that moves back and forth between deduction and induction. In this way, the researcher is actively involved in creating data as well as theories (Goldkuhl 2012; Morgan 2007). This includes both inductive approach with an aim of as well as a hypothetico-deductive approach with the aim of investigating relationships among empirically measurable constructs and the findings usually have predictive power (Tsang, 2014). Quantitative data analysis is a typical research method based on positivism, which requires data collection from questionnaire surveys, experiments, or archival data (Tsang, 2014). The reliability of results largely depends on the sample size (Tsang, 2014).

A number of factors from existing theories will be validated in this research giving an indication of a deductive approach to reasoning whereas the researcher also aims to explore factors which can be added to the equation of impact on user's acceptance of technology considering the present socio-economic circumstances signalling an inductive approach to research. Hence this research will prove to be a combination of both reasoning approaches.

This thesis proceeded with a pragmatism-based inductive methodology to conduct semi-structured interviews at the exploratory phase and a deductive methodology using questionnaire-based data collection and statistical analysis-based hypothesis testing.

5.3 Sampling Strategy

The aim of a survey is to gather unknown information from every unit in a population (Fricker Jr, 2016). Given that it is usually impossible or impractical to survey an entire population, a sample is required for surveys (Fricker Jr, 2016). Sampling is a process of selecting a subset of a group or population to become the foundation of a survey (Fricker Jr, 2016).

5.3.1 Sampling methods

There are two broad categories of sampling that are widely employed, namely, probability sampling and non-probability sampling (Taherdoost, 2018). Probability sampling means that all of the respondents of the sample are selected using a probabilistic mechanism, by which each unit of the population has an equal probability of being selected (Saunders, Lewis, and Thornhill, 2009; Fricker Jr, 2016; Taherdoost, 2018). Typical probability sampling techniques are simple random sampling, systematic sampling, stratified random sampling, cluster sampling, etc. (Fricker Jr, 2016; Taherdoost, 2018). Non-probability samples can also be called convenience samples and are usually selected when the probability of each unit from a population cannot be determined (Fricker Jr, 2016). Non-probability sampling is mostly employed in case study research and qualitative research (Taherdoost, 2018). That is, non-probability sampling can be used in examining real-life phenomena instead of making statistical inferences to a larger population (Taherdoost, 2018). Non-probability sampling techniques consist of convenience sampling, snowball sampling, quota sampling, and purposive or judgmental sampling (Taherdoost, 2018).

Current and potential IoT devices users are the target population of this research's empirical study. It is both impractical and unfeasible to gather data from every member of the population and hence a sample is needed in order to gather information for the hypothesis testing and examining phenomena.

It was intended to reach to the target sample size for this research with the use of probability-based sampling method of stratified sampling, using the profession of academics as the major stratification variable. However, this was consequently revised considering the expert opinion in the challenges of generalizability of the results of this study. Considering that the likelihood of selection for every unit in the population cannot be established, and potential participants choose whether or not to participate (Fricker Jr., 2016; Saunders, Lewis, and Thornhill, 2009), a non-probability sampling strategy was favoured for this study. Convenience sampling, which is less time-consuming and helpful for gathering non-inferential data, is one of the aforementioned sample approaches that is employed for this study (Fricker Jr., 2016; Taherdoost, 2018). The application of the non-probability sampling was found to be preferred for this study. In particular, the researcher selected the convenience sampling as the research was being conducted for the IoT devices' potential adopters residing in the UK only (Dwivedi et al. 2006; Franzosi 2004). As a convenience sample reflects diversified backgrounds and varied traits of the selected IoT devices' potential adopters, it reflects the entire population of the country and hence the results can be generalised with a degree of reliability (Franzosi 2004). Moreover, convenience sampling is more cost-effective and time-effective in nature.

5.3.2 Sample size

The size of a survey's sample can affect how statistical tests turn out. Larger sample sizes typically provide higher statistical power at any given alpha level or significance level, a probability used to determine sample size. However, a very large sample size can also make the test overly sensitive (Hair Jr et al., 2014).

Qualitative – semi-structured interviews

Creswell and Clark (2017) in Designing and Conducting Mixed Methods Research highlight that sample size in qualitative research tends to be smaller due to the depth of analysis. A purposeful interview sample of 10 participants was achieved through the selection of individuals known to the researcher. This purposeful sampling approach provided a variety of participants from diverse backgrounds that produced a broad spectrum of data (Payne and Payne, 2004) although the findings may not be representative of the phenomenon in the wider population (Ritchie et al., 2003), they provided meaningful insights into the selection of relevant factors of technology acceptance for further studies. Also, ten semi-structured interviews are considered within the standard range for qualitative phases in mixed-methods research aimed at exploring themes rather than making generalisations and are commonly accepted to provide saturation in exploratory studies (Guest, Bunce and Johnson (2006).

Quantitative – surveys

As stated by (Barlett, Kotrlik and Higgins, 2001), for surveys intended to attain 0.05 alpha level or significance level thresholds, with the goal of gathering ongoing data, aiming for a population size greater than 4000, and determining the minimum sample length is 119. For research that employ Structural Equation Modelling (SEM) based on covariance as using models with more than seven constructs in the analysis technique, the suggested sample size is over 100 (Hair Jr et al., 2014). With an initial response of 122 from 2,500 invitees, the size may indeed seem low, yet in survey research, response rates between 5-20% are typical, particularly when convenience sampling is used, as noted in Quantitative Research Methods for the Social Sciences (De Vaus, 2013). A further 85 responses were obtained leading to a sample size of n= 207. De Vaus suggests that survey validity often hinges more on the representativeness of the responses rather than sheer size, especially when convenience sampling is the only feasible option due to access constraints. Fowler (2014) in Survey Research Methods emphasizes that while larger samples generally improve statistical power, smaller samples can still yield valid insights, provided the sample sufficiently represents the population under study and aligns with the study's specific aims and design. This can be particularly true for exploratory analyses where broader inferences are not necessarily the primary focus.

5.3.3 Sampling frame

Identification of an appropriate and accessible sampling frame to choose the most representative sample for this study is critical in this study.

Original sampling frame:

The researcher's vast experience in academics lead to the development of a list of contacts in various well-known universities in the UK like University of Bolton, Oldham University, John Moore's University, Manchester College, Sheffield Hallam University, Lancaster University, Blackpool College etc. Key contacts from these universities were contacted formally to get the approval to reach out to the identified sampling frame. Any additional responses received within the window will be welcomed and included in the sample.

Revised sampling frame:

Considering the limitations of accurately calculating the probability of selecting an appropriate sample considered representative of the overall population, this was subsequently revised, and a more generalised sample was considered for the final empirical study.

An anticipation of 10% survey response from 2500 invites for completion of the survey lead to an estimated sample size of 250 participants who were to be reached from the areas within the UK using personal and professional contacts. Users of social media such as WhatsApp, Facebook and Instagram were targeted considering their willingness to be a part of the wider community accepting new forms of communication.

Professional network of LinkedIn as well as various Post Graduation Research groups from across the country were used to maximise the reach out for the required sample. Use of social/professional media, Virtual Learning Environment (VLE) and Teams platform vouched for an indication of use of technology by these potential users of technology.

An approximate total of 2500 users were invited using social media advert (Appendix 6) on multiple channels with an expected response rate of 10% - 15%. Other venues for recruiting the respondents for this study included liaising with local authority, community and neighbourhood learning centers, local schools, and mosques etc.

However, only a 5% response rate was achieved leading to a total of 125 responses received for the study. A typical survey response rates can lie anywhere in the region between the 5% to 30% range with an average online rate of 44.1%, while those surveys distributed from unknown senders tending to be at the lower end of this scale (Wu, Zhao and Fils-Aime, 2022).

5.4. Questionnaire design

Qualtrics software a Digital Survey Management Tool (DSMT) was used to develop the questionnaire, which came with the feature of transferring the collected data to various formats including excel csv file which was used for data analysis. The full questionnaire consists of 57 questions in total. Specifically, there were 52 items measuring 21 main constructs, 4 items measuring 7 moderating relationship, and 4 additional questions about demographic characteristics (Appendix 3). The measure items of the main variables were adapted from previously validated measurements in the literature (Appendix 2). Furthermore, it is generally accepted that the statistical methods (e.g., factor analysis) used to validate the scientific soundness of a construct will require multiple items. Typically, three or more items for each dimension provide useful statistical information about shared variance (Taber 2018). Hence this study used three items to measure most of the variables. The majority of the items were measured by a 5-point Likert scale, i.e., Strongly disagree; Disagree; Neither agree nor disagree; Agree; Strongly agree. The following sections present details of the measuring items of each study.

5.4.1 Measurement of items of constructs

Considering an initial review of unstructured interviews conducted to compile a list of relevant factors as well as supervisory review of questionnaire design, it was evident that respondents may either not be aware or fully understand the term IoT devices and hence the term was replaced with a more familiar term (Smart Devices) suggested by participants of the interview.

Table 5. 1 Measurement items of constructs (Table of items)

Construct	Item	Label	Source
Psychological factors			
Innovativeness	I like to experiment with new high- tech products in the market.	I1	Baudier, Ammi, and Deboeuf-Rouchon, (2020)
	Among my peers, I am usually the first to try out new high-tech products.	I2	
	If I heard about a new high-tech product, I would look for ways to experiment with it.	I3	
Self-efficacy	I will be able to use smart devices if I have just the built-in help facility for assistance	S1	Heidenreich and Handrich (2015)
	I will be able to use smart devices if I see someone else using it before I try them myself	S2	
	I will be able to use smart devices if someone showed me how to do it first	S3	
Positive Self-Image	On the whole, I am satisfied with myself.	P1	Expected self-presentation Adapted and revised based on the scales used in Kim et al. (2012); Escalas and Bettman (2003); Krasnova et al. (2010)
	I feel that I have a number of good qualities.	P2	
	I take a positive attitude toward myself	P3	
Attitude	I think using smart devices is a nice idea.	A1	Davis (1989); Park et al. (2017); Park and Kim, (2014); Kwon, Park, and Kim (2014)

	I think using smart devices is/will be beneficial to me	A2	
	I have positive feelings toward the idea of using Smart devices at home.	A3	
Intention to buy/use	How likely are you to interconnect smart devices you own into a network to optimise their use?	IB1	New scale adapted from interoperability to signify intention to buy/use
	I am willing to buy smart devices in the future.	IB2	Davis (1989); Sinaga (2019); Venkatesh, Thong, and Xu (2012)
	How likely are you to buy a smart device in the near future?	IB3	
Perceived Ease of Use	Using the smart device is clear and easy to understand.	PE1	Venkatesh (2000)
	Using smart device does not require a lot of my effort.	PE2	
	I find it easy to get the smart device to do what I want it to do.	PE3	
Perceived Usefulness	I find smart devices useful in my daily life.	PU1	Venkatesh et al. (2003)
	Using smart devices helps me accomplish tasks more quickly.	PU2	
	Using smart devices improves my chances of achieving things	PU3	
Perceived features of IoT devices			
Compatibility	Using smart devices is/will be compatible with my lifestyle	C1	Moore and Benbasat (1991); Islam and Rahman (2016); Bradford and Florin (2003)
	Smart devices will complement existing devices in my home	C2	
	Smart devices fit into my home lifestyle	C3	
Mobility	I find it very convenient that smart devices can be accessed anywhere at any time.	M1	Yang and Lee (2018); Yang (2018); Park and

			Ohm (2014); Hill and Roldan (2005)
	It is a big advantage that smart devices can be used while moving from place to place.	M2	
	Mobility is an outstanding advantage of smart devices.	M3	
Automation	It is a great feature of smart devices that they do many things on their own without human intervention	AU1	Augusto and Nugent (2006); Luor et al. (2015); Yang (2018)
	It is convenient that smart devices provide auto-adjust function	AU2	
	I can control every electrical apparatus of smart home through simple operation.	AU3	
Perceived Cost	I think smart devices could be too expensive	PC1	Shin (2010); Kim and Shin (2015); Kim, Kaufmann and Stegemann (2014)
	The additional convenience of smart devices does not justify the extra cost	PC2	
	I think I would not be able to afford smart devices	PC3	
Social Influence	People who are important to me think that I should use smart devices	SI1	Venkatesh, Thong and Xu (2012)
	People whose opinions I value prefer that I use smart devices	SI2	
	People who influence my behaviour think that I should use smart devices	SI3	
Hedonic Motivation	Using smart devices would be fun	H1	Venkatesh, Thong and Xu (2012); Afonso (2019)
	Using smart devices would be very entertaining	H2	
	Using smart devices would be enjoyable	H3	
Perceived Risks			
Privacy Risk	If I use a smart device, I will lose control over the privacy of my personal data.	PR1	Featherman and Pavlou (2003);

	My personal information will be less confidential if I use a smart device.	PR2	
	I fear to use smart home devices due to loss of my personal data and privacy.	PR3	
Security Risk	I suspect that security systems built into smart devices are not strong enough to process my information securely.	SR1	Stojkoska and Trivodaliev (2017); Cheng, Lam and Yeung (2006) Pal et. al. (2018)
	There is a big chance that internet hackers may take control of my information if I use a smart device.	SR2	
	I find it risky to disclose my personal information with smart home devices.	SR3	
Physical Risk	I am concerned about potential physical risks because smart devices may not be completely safe (may cause fire, flooding, electrical shock, etc.)	PHR1	Stone and Grønhaug (1993) Yang, Lee and Zo (2017)
	I do not like smart devices as they could cause damage due to malfunctions or misuse.	PHR2	
	I am afraid that smart devices will cause some problems at my home.	PHR3	
Trust in IoT Providers	Smart devices providers are trustworthy.	IoT1	Nunkoo and Ramkissoon (2012); Chen (2006); Kim et al. (2008); McCole (2002); Wu, Wu and Chen (2005).
	Smart devices providers are reliable.	IoT2	
	Smart devices providers have integrity.	IoT3	

5.4.2 Moderators in the study:

Gender, age, level of income and level of education have been shown to be of significant importance in influencing the intention to new technologies. These have been studied in a varied categories in previous studies. (See Table 9 for a full range of studies including demographic factors in previous studies).

5.4.2a Gender

A generic classification of male and female with an additional option of prefer not to say included in this study allowing the respondents the autonomy to make the choice of revealing their identified gender. A review of studies including gender (Yang et al. 2017; Yang, Lee and Zo 2017; Shin, Park, and Lee, 2018; Nikou 2019; Wu, Wu and Chang 2016; Rauschnabel, Brem and Vens, 2015; Coskun, Kaner and Bostan, 2018; Mennicken, Vermeulen and Huang, 2014) revealed that prefer not to say was not discussed in any of the data analysis, however, it may not necessarily mean that the respondents weren't given the option to choose. In order to adhere to ethical approval guidelines, this study included the three gender categories.

5.4.2b Age

Age has been classified as 20's, 30's to 60's in (Shin, Park and Lee, 2018) whereas Pal et al. (2018) used a more narrow but older population and classified the age groups as 55-64, 65-74 and 75 and above whereas Baudier, Ammi, and Deboeuf-Rouchon, (2020) used groups of 17-20, 21-25, >25 as age groups. Studies involving a more generalised population (Afonso, 2019) tend to classify the age groups as 18-24, 25-34, 35- 44 and 45-54 years old or as used by Cannizzarro et al. (2020) who classified these groups in 5 categories, 18–24, 25–34, 35–49, 50–64 65+. This study used 4 categories 18 years to 29 years, 30 years to 44 years, 45 years to 59 years and above 60 years old to classify the age of the respondents, considering the categories used in the UK census summary (Gov.uk, 2021). The study excludes the responses from an underage population of less than 18 years old but included a wider group of 60 years and above.

5.4.2c Level of income

As broad as 2 categories of low-income and high-income groups according to Shin, Park, and Lee (2018) and a wide classification of 5 groups of income level according to Pliatsikas and Economides (2022) i.e. 0–5000, 5001–10,000, 10,001–15,000, 5,001–20,000, 20,001 and above euros, there is a significant variance in the way this variable has been studied in previous research. Income level is a sensitive question, and direct monetary measurements are likely to result in nonresponse (Tourangeau and Yan, 2007). To address this problem, the respondents were asked to select from an income bracket rather than asking direct measurement question. The income brackets included Below £15,000, £15,000 to £30,000 and £30,000 and above.

5.4.2d Level of education

The variable of education has been categorised ranging from very specific to very broad groups. Where Shin, Park, and Lee (2018) and Afonso (2019) provided only 2 options i.e., Low and High level and Bachelors and Masters classification respectively to the respondents, Cannizzaro et al. (2020) includes three broad categories with a wide range of qualification level i.e. ISCED 0-2 including Pre-primary education, Primary Education and GCSE/Vocational GCSE or equivalent (incl. O-levels), ISCED 3–4 including A-level/Vocational A-level or equivalent (incl. AS-level), Higher Diplomas below degree level/as gateways to degree and ISCED 5–6 including Undergraduate degree and Postgraduate degree (Master and PhD) alongside Pliatsikas and Economides (2022) who categorises the level of education in Primary, Secondary, Higher, Masters and PhD.

However, this study aimed to measure the impact of level of education of adults in four categories of Bachelors, Masters, Professional and Doctorate qualifications. An open text option of other qualifications which may be lower than Bachelors was also provided to the respondents.

Based on the constructs and moderators above, a questionnaire was designed (Appendix 3).

5.5 Reliability and validity

Reliability refers to the consistency between a variable and what it intended to measure, while validity describes the degree to which the measurements can correctly represent the concept of study (Hair Jr et al., 2014). Stated differently, validity pertains to how well the notion is described by the measurements, whereas reliability defines how a variable is assessed. Prior to evaluating validity, the construct reliability needs to be met (Hair Jr et al., 2014).

Cronbach's alpha test is commonly used to evaluate survey reliability through measuring internal consistency. It indicates the degree in which the survey's participants would respond to the same questions in the same way or closely each time.

Reliability in statistics is the measure of overall consistency. Questionnaire is said to have a high reliability if it produces similar results under consistent conditions. It is the characteristic of a set of test scores that relates to the amount of random error from the measurement process that might be embedded in the scores. Scores that are highly reliable are accurate, reproducible, and consistent from one testing occasion to another. That is, if the testing process were repeated with a group of test takers, essentially the same results would be obtained.

Construct reliability and construct validity were thus examined in this study using CFA. Value of Cronbach alpha for each bucket was computed along with the overall validity of the tool and is summarized in the table 13.

Interpretation of Cronbach's alpha:

Cronbach's alpha is a measure of internal consistency, that is, how closely related a set of items are as a group. It is considered to be a measure of scale reliability.

$$\alpha = \frac{n}{n-1}\left(1 - \frac{\sum s^2\,(X_i)}{s^2(Y)}\right)$$

Some of the factors were grouped and includes sub-variables such as psychological variables which included innovativeness, self-efficacy and positive self-image, perceived attributes, which included PEOU and PU, perceived features of IoT devices which included compatibility, mobility and automation and perceived risks which included privacy, security, and physical risk. The Cronbach alpha value for the overall factor was calculated as shown in Table 12.

Table 5. 2 Cronbach alpha values of all factors

Factors	Variables	Cronbach alpha	Number of items
Innovativeness	I1	0.81	3
	I2		
	I3		
Self-efficacy	S1	0.75	3
	S2		
	S3		
Positive Self image	P1	0.84	3
	P2		
	P3		
Attitude	A1	0. 92	3
	A2		
	A3		
Intention to buy/use	IB1	0.72	3
	IB2		
	IB3		
Perceived Ease of Use	PE1	0.70	3
	PE2		
	PE3		
PU -Perceived Usefulness	PU1	0.88	3
	PU2		
	PU3		
Compatibility	C1	0.92	3
	C2		
	C3		
Mobility	M1	0.86	3
	M2		
	M3		
Automation	AU1	0.79	3
	AU2		
	AU3		
Perceived Cost	PC1	0.72	3

	PC2		
	PC3		
Social Influence	SI1	0.92	3
	SI2		
	SI3		
Hedonic Motivation	H1	0.91	3
	H2		
	H3		
Factor – Privacy risk	PR1	0.85	3
	PR2		
	PR3		
Factor – Security risk	SR1	0.78	3
	SR2		
	SR3		
Factor – Physical risk	PHR1	0.82	3
	PHR2		
	PHR3		
Factor – Trust in IoT providers	IoT1	0.83	3
	IoT2		
	IoT3		
Total number of factors = 17			Total number of items = 51

Table 5. 3 Cronbach alpha measures

Cronbach's alpha	**Internal consistency**
$\alpha \geq 0.9$	Excellent
$0.7 \leq \alpha < 0.9$	Good
$0.5 \leq \alpha < 0.7$	Poor

The Cronbach alpha values of each framework's dimension of factors were analysed to consider their reliability based on the theoretical model. The values should meet the minimum accepted criteria, that is, above 0.6, in order to confirm the model consistency and reliability AlHogail (2015). Results indicate that Cronbach's alpha values ranged between 0.70 and 0.92, which is greater than the approved threshold. Compatibility, attitude, hedonic motivation and social influence had the alpha values > 0.9, whereas as perceived ease of use had the least alpha value of 0.70, however it was still considered good for internal consistency as per the criteria used in the table 5.3 for approved threshold and hence it was considered acceptable. All the other factor's alpha values were good being in the $0.7 \leq \alpha < 0.9$ range. This reflects a good internal consistency and reliability. Consequently, the questionnaire was considered to be composed of a set of consistent variables for capturing the meaning of the range of factors. The questionnaire tool was tested and validated using Cronbach alpha.

5.6 Data Collection Method

5.6.1 Pilot study – process

Ethical approval was obtained in accordance with the established procedures of University of Central Lancashire prior to the pilot study taking place. This research was effectively conducted following the ethical principles underlying the Declaration of Helsinki and the University Code of Conduct for Research, (University of Central Lancashire, 2022).

Academics were identified as one of the leading groups of innovators whose learning is constantly developed based on continuous learning, skills to learn new technology for effective learning. The characteristics of academics' match to those of early adopters in several ways such as being considered as leaders of the community and being well educated. Not only are academics considered pioneers in their own subject area, but they can also be considered creative when it comes to adopting new teaching and learning technologies and hence, they represent an important group of adopters (Loogma, Kruusvall and Umarik, 2012). Various studies (Aldunate and Nussbaum, 2013; Abdullah and Ward, 2016) confirmed this selection to be of acceptable criteria. Loogma, Kruusvall and Umarik (2012) and Almaiah et al. (2022) identified the impact of innovativeness as a key characteristic of academics affecting their acceptance of e-learning whereas Tobbin and Adjei (2012) identified academics to be in good employment giving them affordability to buy new devices. According to Rogers (1962), early adopters are individuals who have the highest degree of opinion leadership among the adopter categories.

The profession of academics as the major stratification variable was used to develop a list of contacts in various well-known universities in the UK like University of Bolton, Oldham University, John Moore's University, Manchester College, Sheffield Hallam University, Lancaster University, Blackpool College etc. An informal contact was made receiving positive response for the data collection process. Over the course of four weeks, key contacts from these universities were contacted to reach out to the identified sampling frame. Professional network of LinkedIn as well as various Post Graduation Research groups comprising of academics from across the country were used to maximise the initial reach out for the required sample. An approximate total of 100 academics were contacted using multiple channels with an expected response rate of 10%. The pilot study gathered responses from 11 participants which roughly met the expected response rate. Based on the evaluation of this pilot study and the average completion time of the main study (8 minutes), collected questionnaires that had been completed in less than three minutes were to be excluded from the dataset. However, none of the participants in the pilot study took less than 3 minutes and hence no data was removed on this basis.

By applying the above-stated criteria in the data screening process, 11 completed questionnaires were entered into the preliminary pilot data analysis.

5.6.2 Pilot study – results

Table 5. 4 Socio-demographic profile of pilot study respondents

Demographic characteristic	Type	Frequency n=11	Percentage
Gender	Male	7	63.64%
	Female	3	27.27%
	Prefer not to say	1	9.09%
Age	Below 30 years	0	0.00%
	30- 50 years	5	45.45%
	Above 50 years	6	54.55%
Personal income	Less than or equal to £15,000	0	0.00%
	£15,001 - £30,000	4	40.00%
	More than £30,000	6	60.00%

Highest level of formal education	Bachelor	2	18.18%
	Master	4	36.36%
	Doctorate	3	27.27%
	Professional qualification	2	18.18%
	Other	0	0.00%

The pilot data suggested that as there were no restrictions added to the questionnaire on Qualtrics for the respondents to be within the UK and hence an additional question was added to establish the confirmation of respondent's living status within the United Kingdom, further classifying the region of residence within the United Kingdom. Review of sampling frame and sample choice required a change of the sample from academics to a more generalisable sample, which meant several substantive changes were required. The replaced question of confirmation of being an academic to living status of the respondent enabled to represent a wider sample to generalise the findings of this study. Considering the change in the sample composition, where academics were classified into three main categories of age i.e., below 30 years, 30 – 50 years and over 50 years, it would lead to masses of data losing their variability in these categories. Henceforth, the categories of age were revised to include a younger population representation i.e., 18-29 years, 30 – 44 years, 45 – 59 years and over 60 years. (Kelly et al. 2018). Other demographic questions related to gender and income level were not changed confirming the original justification of choice of the questions.

5.6.3 Final data collection process

Following the above pilot study, a questionnaire-based online survey was carried out to collect data for the study using the Qualtrics. A brief introduction was included on the first page of the questionnaire, introducing the objective of the study, and providing instructions to the respondents, a declaration about data use and contact information about the researcher. Participants were also provided with the participation information sheet (Appendix 4) as a partial requirement of the ethical approval guidelines of the University.

Respondents were given three options to access the online survey, i.e., link on social media, anonymous link and QR code. The respondents were free to choose from any of these methods to access and complete the survey. The author did not have direct access to the respondents, which preserved their anonymity. 125 responses were initially received for the research study of which 2 respondents were outside the UK and 1 completed by person under 18 years of age and thereby were excluded from the data.

A further attempt to collect more data was made to increase the sample size and ensure representativeness of sample to the population, along with ensuring the reliability and validity of findings of this study. An additional 80 responses were obtained within the limited time frame of the study leading to a total sample size of n=207 which was achieved after deliberate efforts undertaken for the study. The researcher argues data saturation at this point due to resource constraints and future implications of a larger sample size would ensure further development of knowledge in this area.

5.6.4 Final data collection preliminary data analysis

With help of online data collection tool data was collected. After the preprocessing of the captured data response of 207 respondents were captured. Based on preliminary data analysis it was found that data of one location was highly concentrated while for majority of areas we were unable to get data as shown in Table 16. Considering the obtained data further data analysis was carried out. Analysis started with exploratory data analysis which consists of frequency table, charts, central tendency, and dispersion measures. Further keeping the objective of the study in mind, advance statistical tools, and techniques like Confirmatory Factor Analysis (CFA) followed by the Structural Equation modelling (SEM) was carried out to get results and answers of defined study aims.

Table 5. 5 Socio-demographic profile of respondents

Demographic characteristic	Type	Frequency N = 207	Percentage
Gender	Male	77	37%
	Female	128	62%
	Prefer not to say	02	1%
Age	18- 29 years	77	37%
	30 - 44 years	75	36%
	45 - 59 years	48	23%
	60+ years	7	3%
Personal income	Less than or equal to £15,000	89	43%
	£15,001 - £30,000	43	21%
	More than £30,000	75	36%
Highest level of formal education	Bachelor	70	34%
	Master	73	35%
	Doctorate	19	9%
	Professional qualification	12	6%
	Other	33	16%

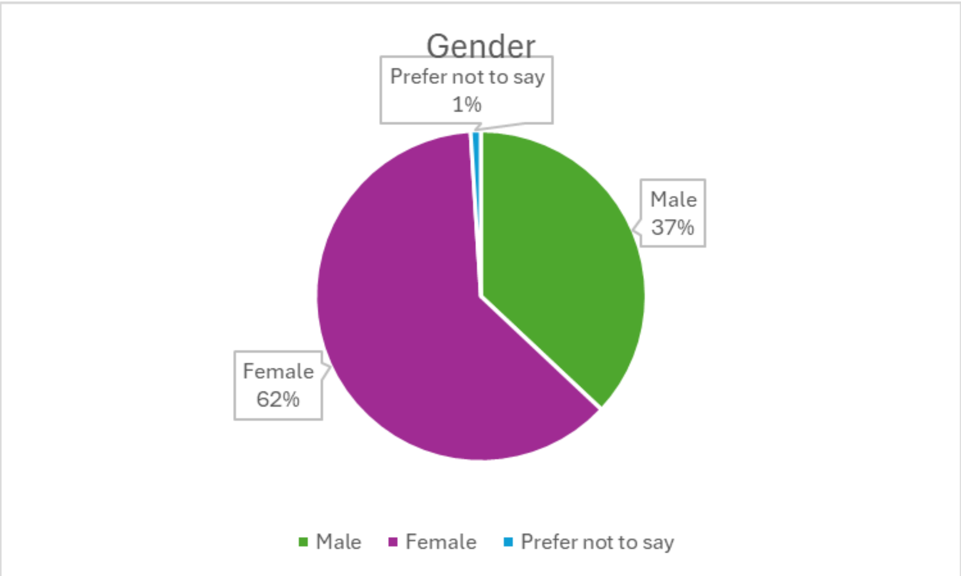

Figure 5. 1 Pictorial presentation of the demographic data - gender

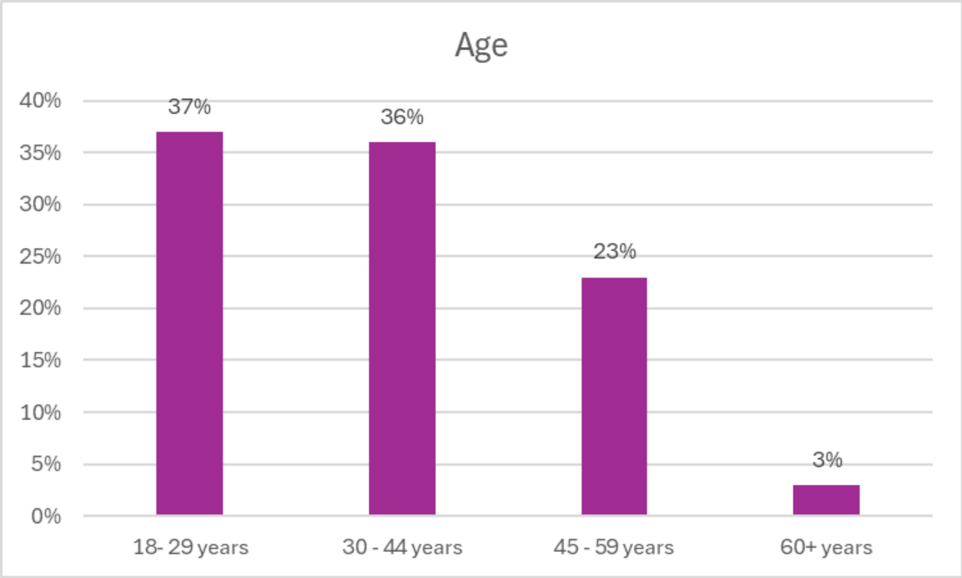

Figure 5. 2 Pictorial presentation of the demographic data - age

Figure 5. 3 Pictorial presentation of the demographic data – personal income

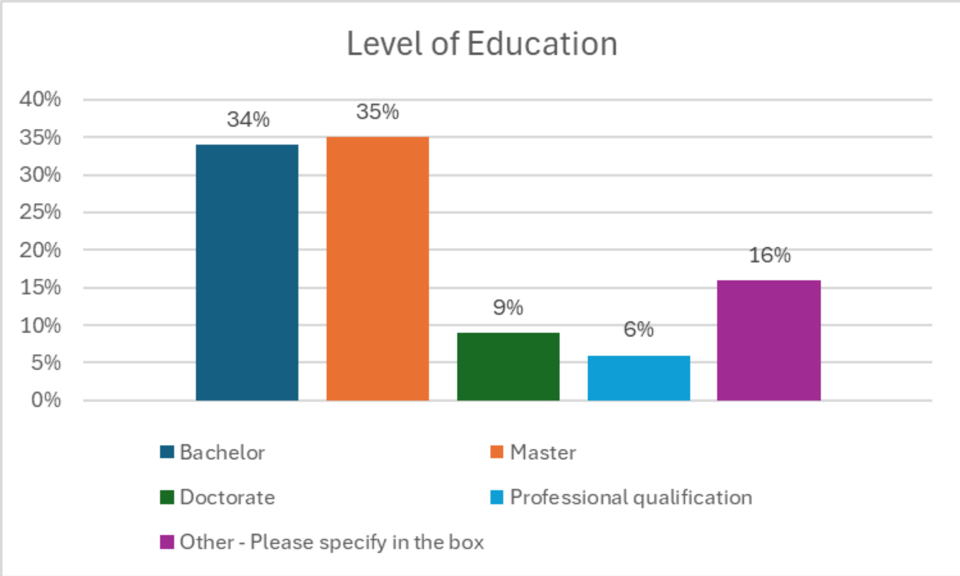

Figure 5. 4 Pictorial presentation of the demographic data – level of education

5.7 Data Analysis Method and Techniques

This research used Qualtrics, DSMT with the inbuilt functions of preliminary data analysis as well as downloadable comma separated value (csv) files available to export to other sophisticated software for further statistical analysis. Originally SPSS software was downloaded for preliminary analysis of the data. However, review of the number of constructs and objective of studying relationship between multiple variables, a more advanced software R was also downloaded for undertaking the advanced level statistical techniques. (Rosseel, 2012)

5.7.1 Data analysis approach

Educational and social science researchers make use of different kinds of research methods and strategies. Some of them are inductive in nature. For example, the well-known triangulation strategy of constructive replication is designed to establish the generalizability of empirical relationships. It is, therefore, a strategy of enumerative induction. Other methods are hypothetico-deductive in nature. Structural equation modelling, for example, conforms to the hypothetico-deductive strategy of testing certain classes of latent variable models in terms of their empirical adequacy. Hair Jr et al. (2014).

Multivariate analysis is widely used in addressing practical and theoretical research questions (Hair Jr et al., 2014). A number of widely used multivariate techniques, such as multiple regression, factor analysis, multivariate analysis of variance, and discriminant analysis, expanded the explanatory ability of surveys (Hair Jr et al., 2014). However, these techniques have a common limitation in statistical efficiency in that they can examine only one relationship at a time and the relationship between only one independent variable and many dependent variables (Hair Jr et al., 2014). Structural equation modelling offers a number of advantages when compared with techniques such as those mentioned above in terms of (a) making it possible to examine a series of dependence relationships simultaneously; (b) it being particularly useful in testing dependence relationships of multiple equations; and (c) allowing for assessing measurement properties and testing theoretical relationships. This study employed structural equation modelling as the data analysis technique and followed the process suggested by (Hair Jr et al., 2014) and by (Gaskin, 2016). R lavaan and SPSS were used for the statistical analysis of the main hypotheses and moderation effects.

The following section presents the strategy of data analysis of the study. Three of the latent variables, i.e., psychological variables, perceived risk, and perceived features of IoT devices which comprised of a set of observed variables. A 'latent variable' in a statistical model is a random variable that is unmeasured (although not necessarily unmeasurable) which may be included in a study to help measure model features of interest that are not directly measurable (Sprites, 2015). Each of the variables were analysed separately using individual models. This research adopted two steps in the analysis, i.e. reliability and validity tests using confirmatory factor analysis, and hypothesis tests using structural equation modelling (Hair Jr et al., 2014).

5.8 Ethical implications

Every researcher needs to apply a set of behavioural standards known as ethics (Cooper & Schindler, 2008; Edwards & Mauthner, 2002). Diener and Crandall (1978, p. 14) define ethics as "expressions of our values and a guide for achieving them" although any ethical course of action is dependent upon the contradictory criteria that is applied (Israel & Hay, 2006). UK consumers are an integral part of this empirical research and hence each participant was advised that participation is voluntary and that withdrawal from the research is possible at any time with no consequences (Gregory, 2003). Furthermore, subjective ethical decisions were used in this IoT devices research and consistently applied across all stages of the ethics continuum i.e. research design, data collection, data processing and storage and finally data analysis and reporting as identified by Saunders, Lewis and Thornhill (2012).

Stage 1 Research design

More general ethical issues of confidentiality, privacy, deception and objectivity were found important when considering ethics in research instrument design and access, in order to use of consumer survey as a research instrument (Zikmund, Babin, Carr & Griffin, 2013). The ethical issues were evaluated and addressed effectively as part of the research design phase (Creswell and Clark, 2017) although ethical issues may arise spontaneously throughout the research or thereafter (Oliver, 2010). The research design fully addressed the two key ethical aspects of social research which are providing participant anonymity and participants suffer no harm (Bryman and Bell, 2011; O'Leary, 2004).

Stage 2 Data collection

a) Semi-structured interviews:

Purposeful sampling was used with each interviewee selected from existing contacts as improved access is achieved when the researcher is known to the individual (Easterby Smith et al., 2012) which established an existing level of credibility and provided a much stronger foundation in the belief of anonymity and confidentiality (Bryman, 1988). In addition, assurances of anonymity and confidentiality are also provided to each interviewee as part of negotiating access as this further assisted in securing consent (Gregory, 2003).

b) Questionnaires:

The use of a questionnaire as a research instrument minimised ethical problems compared to other research instruments (Dale, Arber & Proctor, 1988) and is designed to ensure anonymity of the participants as far as is practical and reasonable (Quinlan, 2011). The questionnaire administration ensured that participants were made aware that participation is voluntary, provide participant anonymity and that only summary data would be published as shown in the research purpose section of the questionnaire which is provided as Appendix 3.

Furthermore, the questionnaire introduction established a balance between the amount of time required to complete the survey against the willingness of participants to provide their time to complete the questionnaire (Bordens & Abbott, 2010) which demonstrated the subjective ethical process and how compromise occurs between ethical ideals and real-world problems.

When considering ethics in research instrument administration and data collection the use of LinkedIn and Facebook as methods of data collection raises specific ethical technology usage issues (Bryman & Bell, 2011). Each participant was provided with a clear definition of participation in plain English using terms that are easily understood i.e. smart devices instead of IoT devices as informed consent is a key ethical issue (Fisher, 2010). This ensured that each participant was made aware of what was required of them before they made a decision on participation.

The level of information that is provided is a subjective assessment and is both sufficient and satisfactory for the purpose (Allmark, 2002). The information provided is what a participant would want to know (Israel and Hay, 2006) without providing too much information that may result in boredom or information overload (Bordens and Abbott, 2010; Miller & Brewer, 2003).

The questionnaire and interviews were designed and administered to ensure that they are not regarded as intrusive and do not invade the privacy of any participant (Bulmer, 1979) although the definitions of intrusive and privacy are subjective terms. Furthermore, semi-structured interviews enabled the avoidance of over-zealous questioning in the interviews as the interviewer followed a set structure of questions mainly the raking order of factors. No participant were forced for a response at any time and no demeaning questions were asked, in order to avoid interviewee stress (Sekaran & Bougie, 2013).

Stage 3 Data processing and storage

When considering the ethics in data processing and storage, all the research data including excel csv files as well as interview notes were kept in a secure environment on researcher's password protected laptop giving access to only those who are meant to have access to it. Qualtrics software a Digital Survey Management Tool (DSMT) was used to conduct the survey, and hence the survey responses, along with excel csv file are also stored on a password protected institution login on Qualtrics.

Stage 4 Data analysis

Rational interpretation was used within the data analysis to produce the findings that minimises any bias (Huberman & Miles, 2002). In addition, no fabrication of any research data was undertaken, falsification of the research results or misrepresentation of the research findings (Israel & Hay, 2006).

5.9 Methodological limitations

Despite a rigorous theoretical underpinning in the research design and execution, this research also faced some methodological limitations. Extra data was collected due to the addition of an extra question in the questionnaire. This could have been avoided by reviewing the questions against the conceptual framework. Technically one can argue the willingness to interconnect the smart devices into a network for optimal use could study the usage willingness of the respondent and mapped against the behavioural intention to buy/use smart devices. This could mean the conceptual framework originally proposed would change and add an extra variable for usage. However, one element of willingness to interconnect may not be sufficient to study the overall actual usage of these smart devices and hence the additional data has not been used in this study.

Although it is possible to claim that using a qualitative method lowers the level of validity and reliability, quantitative and reductionist approaches have historically dominated studies of technology acceptance. The fact that the factors under investigation in this study have comparable methodological limitations is an extremely significant finding. The majority of studies on technology adoption rely heavily on survey-based quantitative approaches (see for example Davis, Bagozzi and Warshaw, 1992).

These studies have been helpful in identifying relevant factors for additional research, but at this point in the discussion, deeper understanding is needed that can't be obtained using factor analysis or ordinary least squares regression. The research design was partially developed to include a wide range of factors that affect the acceptance of technology. However, several factors were excluded from the scope of this study due to significant reasons as discussed in chapter 3 and hence obtaining a true hierarchy and an overall comprehensive model proved to be a challenge.

One of the key methodological limitations of this study included the significant reduction of measurement items for a number of constructs. For example, Davis 1989 used six items to measure the construct of PEOU whereas Venkatesh (2003) used 4 items to measure the same construct in an organisational setting. Due to the nature and scope of this research, every construct in the study was measured using three items based on Model of Technology Adoption in households (Brown and Venkatesh, 2005) which limited the undertaking of some statistical analysis. The number of items depends on the abilities to approximate and estimate a continuous dimension, and the ability to differentiate items meaningfully. A minimum of three items are necessary for statistically meaningful estimation of latent factor scores (Alhija, 2010) whereas two doesn't permit identification of a unique solution in factor analysis – there's no indication of how to weigh two items as measures of any common factor(s). More items is generally better for the sake of approximating and estimating a continuous latent dimension to add overly duplicative items, because that could encourage inattentive responding and thus engender both arbitrary noise and (more) systematic bias (Ozaki, 2024). Less items were chosen for the sake of reducing respondent fatigue which could be a source of inattentive responding, noise, and bias, participant's time and concentration as people may not like to think that hard for that long. The researcher faced a few complexities by removing some items from the questionnaire which may be the partial cause of weak explanatory cause for some of the constructs.

Despite the reduction in number of factors and reduced number of items to study each of the construct studied in this research, the final number of factors studied reached to 17 and total number of items leading to 50 items along with other questions on ownership, interconnectivity, and demographics details of the respondents. This lead to the technical challenge of fitting a holistic perspective into the software. Use of multiple software and programmes helped to encounter this challenge for effective visual presentation of the research data.

5.10 Conclusion

This chapter established and justified a pragmatist philosophy as this research explored the factors that affect the acceptance of IoT devices within a smart home environment. The rationale for the use of sequential mixed methods research was then provided and justified as this research explores and interprets consumer behaviour perspectives using empirical UK consumer data (Hussey & Hussey, 1997; Saunders et al., 2012). Other research strategy options were then identified along with rationale for why these are unsuitable for this research. A full description of the design and administration of the research instruments i.e. Questionnaire and semi-structured interviews was then provided as this increases the validity and reliability of the research findings (Flick, 2011). The data collection processes into two parts i.e pilot study and final data collection process, were explained and justified. The chapter also included discussion of research ethics that apply to the various aspects of this research. The chapter concluded with the identification of a number of methodology limitations. The next chapter describes clearly the numerical data analysis that is undertaken on the quantitative questionnaire data and the content analysis that is undertaken on the qualitative interview data. The chapter goes on to identify the data validity and data reliability that applies to the analysis that is undertaken on empirical data obtained.

CHAPTER 6 DATA ANALYSIS AND FINDINGS

6.1 Introduction

This study addresses the research question "How do various factors influence the behaviour of adopters in the UK in relation to the acceptance of IoT devices within a smart home environment?", as outlined in the first chapter of the thesis followed by the design of the survey using a questionnaire as outline in Chapter 5. This chapter summarises the data analysis and findings with focus on the research objective to organise and analyse the data acquired from the data collection activities.

The following sub-sections present discussions on the results and findings of the study.

6.2 Contextual analysis

6.2.1 Ownership of IoT devices

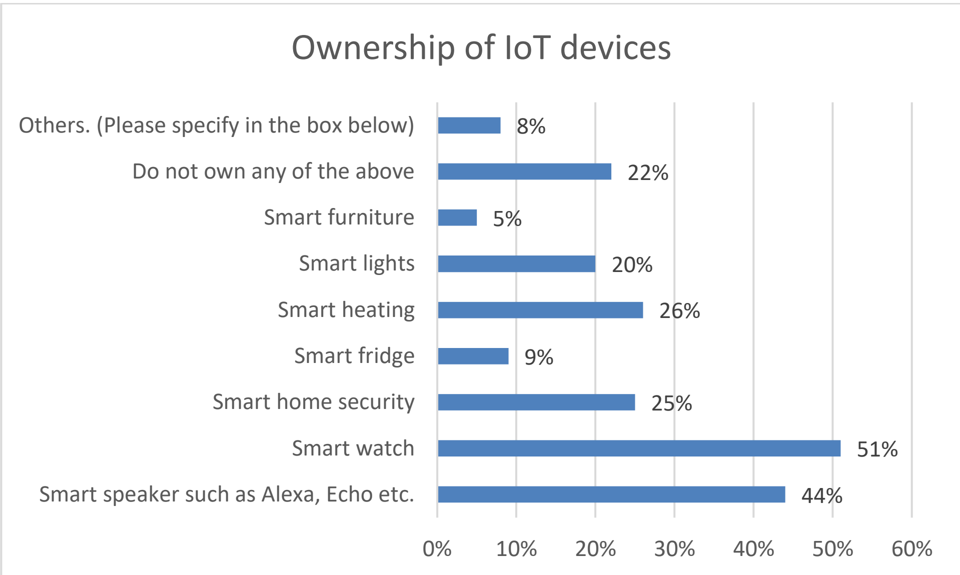

Figure 6. 1 Ownership of smart devices results

The questionnaire collected data regarding potential consumers and existing owners of smart devices which indicated maximum ownership of smart devices that of smart speakers and smart watches falling in the category of wearable devices (Wu, Wu, and Chang, 2016) with the least ownership of smart furniture as low as 5%. This also matches with the figure 1 data (Government Office for Science, 2021) depicting a high level of ownership of smart speakers in UK households. Data also suggested a range of other devices owned by the respondents i.e., smart dishwasher, smart vacuum cleaner and smart dryers indicating acceptance of white goods within the Large Domestic Appliances (LDA) sector. Other devices owned by the respondents included smart plugs and smart phones, however smart phones are considered as more of an interface device and were not found to be significant in influencing the objectives of this study. 22% of the respondents indicated that they do not own any of the smart devices listed in the question, equating to 46 out of 207 respondents who still have not accepted this technology. Although a majority of the respondents can be regarded as adopters of these technologies, nearly a quarter of the sample exhibited a reluctance in ownership of such IoT devices and hence their further responses on other variables of the study would be considered significant in understanding their behavioural influences.

6.3 Descriptive statistics of items of constructs

Descriptive statistics plays an important role in the exploration of any data and to understand the distribution and scatteredness of dataset with which one is dealing at the time. Here two major and widely used measures i.e., mean, variance and standard deviation was computed and is presented in Table 6.2.

Table 6. 1 Mean and standard deviation of measurement items of constructs

Factor	No		Mean	Standard deviation	Variance
Intention to buy/use	1.	How likely are you to interconnect smart devices you own, into a network to optimise their use?	3.33	1.35	1.82
	2.	How likely are you to buy a smart device in the near future?	3.67	1.27	1.63
	3.	I am willing to buy smart devices in the future.	4.07	0.93	0.86

Innovativeness	4.	I like to experiment with new high- tech products in the market.	3.571	1.203	1.446
	5.	Among my peers, I am usually the first to try out new high-tech products.	2.683	1.180	1.393
	6.	If I heard about a new high-tech product, I would look for ways to experiment with it.	3.136	1.340	1.795
Self-efficacy	7.	I will be able to use smart devices if I have just the built-in help facility for assistance.	3.610	0.993	0.986
	8.	I will be able to use smart devices if I see someone else using it before I try them myself.	3.620	1.121	1.256
	9.	I will be able to use smart devices if someone showed me how to do it first.	3.829	1.253	1.569
Positive self-image	10.	On the whole, I am satisfied with myself.	4.274	0.837	0.700
	11.	I feel that I have a number of good qualities.	4.293	0.803	0.644
	12.	I take a positive attitude toward myself.	4.179	1.069	1.142
Attitude	13.	I think using smart devices is a nice idea.	3.890	0.894	0.800
	14.	I think using smart devices is/will be beneficial to me.	3.968	0.929	0.863
	15.	I have positive feelings toward the idea of using smart devices at home.	3.773	1.070	1.144
Perceived Ease of Use (PEOU)	16.	I expect smart devices to be easy to use.	4.183	0.854	0.729
	17.	Using smart device does not require a lot of my effort.	3.870	0.995	0.990
	18.	I find it easy to get the smart device to do what I want it to do.	3.864	0.922	0.851
Perceived Usefulness (PU)	19.	I find smart devices useful in my daily life.	4.045	0.945	0.893
	20.	Using smart devices helps me accomplish tasks more quickly.	3.857	1.032	1.064

	21.	Using smart devices improves my chances of achieving things.	3.656	1.075	1.155
Compatibility	22.	Smart devices will complement existing devices in my home.	3.660	1.021	1.042
	23.	Smart devices fit with my home lifestyle.	3.627	1.106	1.222
	24.	Using smart devices are/will be compatible with my lifestyle.	3.771	1.085	1.178
Mobility	25.	I find it very convenient that smart devices can be accessed anywhere at any time.	4.203	0.806	0.649
	26.	It is a big advantage that smart devices can be used while moving from place to place.	4.281	0.854	0.730
	27.	Mobility is an outstanding advantage of smart devices.	4.126	0.954	0.911
Automation	28.	It is a great feature of the smart devices that they do many things on their own without human intervention.	3.579	1.204	1.451
	29.	It is convenient that smart devices provide auto-adjust function.	3.671	1.034	1.070
	30.	I can control every electrical apparatus of smart home through simple operation.	3.316	1.279	1.635
Perceived high cost	31.	I think smart devices could be too expensive.	4.093	0.929	0.864
	32.	The additional convenience of smart devices does not justify the extra cost.	3.480	1.034	1.070
	33.	I think I would not be able to afford smart devices.	2.899	1.167	1.361
Social Influence	34.	People who are important to me think that I should use smart devices.	3.027	1.093	1.194
	35.	People whose opinions that I value prefer that I use smart devices.	2.987	1.068	1.141

	36.	People who influence my behaviour think that I should use smart devices.	2.993	1.126	1.268
Hedonic Motivation	37.	Using smart devices are/would be fun.	3.867	0.910	0.828
	38.	Using smart devices are/would be very entertaining.	3.785	0.956	0.913
	39.	Using smart devices are/would be enjoyable.	3.750	0.968	0.937
Privacy risk	40.	If I use a smart device, I will lose control over the privacy of my personal data.	3.673	1.090	1.188
	41.	My personal information will be less confidential if I use a smart device.	3.640	1.160	1.346
	42.	I fear to use smart home devices due to loss of my personal data and privacy.	3.280	1.270	1.612
Security risk	43.	I suspect that security systems built into smart devices are not strong enough to process my information securely.	3.527	1.139	1.298
	44.	There is a big chance that internet hackers may take control of my information if I use a smart device.	3.593	1.153	1.330
	45.	I find it risky to disclose my personal information with smart home devices.	3.550	1.249	1.560
Physical risk	46.	I am concerned about potential physical risks because smart devices may not be completely safe (may cause fire, flooding, electrical shock, etc.)	2.980	1.144	1.308
	47.	I do not like smart devices as they could cause damage due to malfunctions or misuse.	2.860	1.159	1.343
	48.	I am afraid that smart devices will cause some problems at my home.	2.793	1.149	1.319
	49.	Smart devices providers are trustworthy.	2.822	1.167	1.361

Trust in IoT Providers	50.	Smart devices providers are reliable.	3.250	1.094	1.196
	51.	Smart devices providers have integrity	2.823	1.179	1.390

The above items measuring 17 different constructs were rated from 1 to 5 on a five-point Likert scale, where one indicated strongly disagree and 5 indicate strongly agree for each of the item.

6.4 Correlation between factors

Correlation is meant for exploring the degree of relationship between two variables inconsideration. Correlation coefficient is the measure to quantify such degree of relationship of the variables. Generally, two correlation coefficients are used in applications, namely: Pearson's Product Moment Correlation Coefficient and Spearman's Rank Correlation Coefficient. This study primarily considers the applications of Pearson's Simple Linear Correlation in exploring the relationship between variables.

In 1896, correlation coefficient was first formulated and explored by Karl Pearson (Hauke and Kossowski, 2011), with the concepts of correlation by Francis Galton and the relative contribution by Auguste Bravais (Denis, 2001). Hauke and Kossowski (2011) do endorse that the Pearson's Product Moment Correlation Coefficient (usually denoted r) is a scale to measure the strength of linear association between variables. As it measures the degree of linear association of variables, interval or ratio variables should be in consideration with a condition that the variables considered should fall in normal distribution.

Pearson's mathematical formulation to quantify the degree of relationship (R) between variables, namely, X and Y, can be given as:

$$R = \frac{n(\sum XY) - (\sum X).(\sum Y)}{\sqrt{n(\sum X^2) - (\sum X)^2}\ \sqrt{n(\sum Y^2) - (\sum Y)^2}}$$

Where,

ΣX = Sum of observations of variable X ΣY = Sum of observations of variable Y

ΣXY = Sum of product of respective observations of variable XY,

$(\Sigma X)^2$ = square of the sum of variable X $(\Sigma Y)^2$ = square of the sum of variable Y

ΣX^2 = sum of squared values of the variable X ΣY^2 = sum of squared values of the variable Y n= number of observations,

Pearson correlation analysis was conducted to measure the linearity between two metric variables. A Pearson correlation (r) measures the amount of variation in one variable that is explained by a linear relationship with another variable (Aljandali, 2016). If two variables are perfectly linearly related, the correlation is 1. The value 0 shows no linearity between two variables and the value -1 defines the perfect descending correlation.

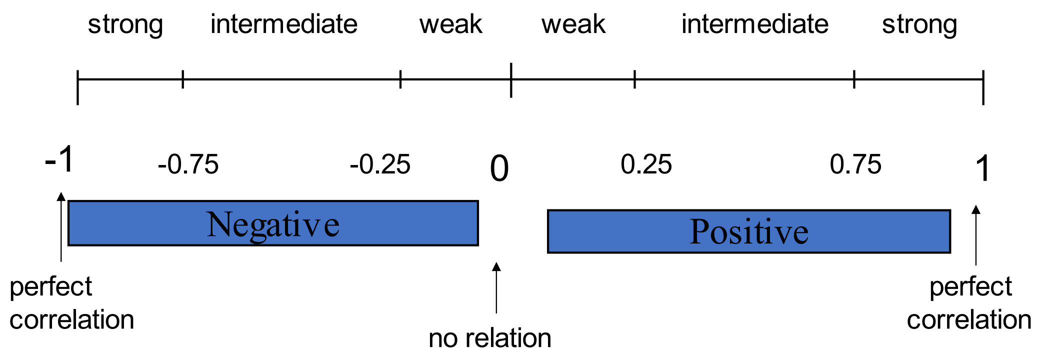

Figure 6. 2 Nature and strength of correlation

A total of 136 possible combinations of correlation values, 36 values showed a negative correlation in different factors whilst 99 positive correlation values were observed. In terms of the strength of the relationship using the scale in the figure above 30 relations were found to be weak negative, 6 intermediate negative relations whereas 42 weak positive, 56 intermediate positive and 1 strong positive relationship were observed. One relationship was found as neutral with an r=0.

The table 6.2 below shows the calculated values of r of all the 17 factors with respect to other factors to know the linear relationship between the factors under study. The correlation values suggested that Innovativeness, self-efficacy and positive self-image had low positive or low negative corelation with that of other factors, while factors such as attitude, intention to buy/use, PEOU, PU, compatibility and mobility, had weak or intermediate positive correlation with each other. On the other hand, factors such as privacy, security, and physical risks, were negatively correlated with majority of the factors except self-efficacy but interestingly all three internally had intermediate or strong correlation with each other. social influence had a positive relation with all factors except with that of security risk at a very weak r=-0.01. Perceived costs was seen negatively correlated to innovativeness, self-image, perceived usefulness, compatibility and intention to buy. Hedonic motivation, and trust in IoT providers had similar kind of relation as that was observed in psychological variables i.e., these factors had weak negative or positive correlation with other factors.

It was noteworthy to see self-efficacy did not have any negative corelation with any of the other factors showing the confidence in own skills leading to positive association with other factors.

Security risk and privacy risk were highly correlated with r=0.77 indicating a strong relationship between the two categories of perceived risks. Where respondents fear the risk of loss of their personal information which went in line with their fear of risk of being hacked. Another strong correlated pair of factors was that of innovativeness to that of intention to buy/use with r=0.70, indicating innovative people often have a strong inclination to try new technologies. The highest negative correlation was found between trust in IoT providers and security risk as well as trust in IoT providers and privacy risk with r= -0.35 and r=-0.33 respectively, indicating the fear of losing personal information often leads to breakdown of trust in IoT providers. Table 6.3 shows the bivariate correlation analysis of all variables. The significant correlation (r> .500) are shown in dark green cells in the table. The greatest positive correlation among all given variables was the correlation between privacy and security risk (r=0.77) and the greatest negative corelation was found between security risk and Trust in IoT providers (r=-0.35).

Table 6. 2 Correlation between factors

Correlation Heatmap

Variables	Innovativeness	Selfefficacy	Selfimage	Attitude	PEOU	PU	Compatibility	Mobility	Automation	Perceivedcost	Socialinfluence	Hedonicmotivation	Privacyrisk	Securityrisk	Physicalrisk	IoT	Intentiontobuy
Intentiontobuy	0.69	0.13	0.11	0.59	0.40	0.59	0.69	0.43	0.45	-0.13	0.35	0.40	-0.23	-0.20	-0.10	0.39	1.00
IoT	0.30	0.13	0.17	0.53	0.34	0.42	0.52	0.28	0.43	0.13	0.31	0.40	-0.33	-0.35	-0.13	1.00	0.39
Physicalrisk	-0.11	0.08	0.09	-0.12	-0.15	-0.07	-0.20	-0.12	-0.03	0.22	0.18	-0.04	0.41	0.54	1.00	-0.13	-0.10
Securityrisk	-0.09	0.08	-0.00	-0.28	-0.16	-0.15	-0.27	-0.04	-0.19	0.22	-0.01	-0.17	0.77	1.00	0.54	-0.35	-0.20
Privacyrisk	-0.10	0.07	0.04	-0.28	-0.18	-0.16	-0.30	-0.03	-0.23	0.11	0.03	-0.17	1.00	0.77	0.41	-0.33	-0.23
Hedonicmotivation	0.34	0.08	0.14	0.68	0.42	0.61	0.61	0.54	0.60	0.18	0.48	1.00	-0.17	-0.17	-0.04	0.40	0.40
Socialinfluence	0.33	0.23	0.15	0.45	0.19	0.47	0.45	0.31	0.41	0.09	1.00	0.48	0.03	-0.01	0.18	0.31	0.35
Perceivedcost	-0.13	0.18	-0.02	0.09	0.01	-0.01	-0.05	0.03	0.07	1.00	0.09	0.18	0.11	0.22	0.22	0.13	-0.13
Automation	0.39	0.03	0.07	0.58	0.47	0.52	0.63	0.50	1.00	0.07	0.41	0.60	-0.23	-0.19	-0.03	0.43	0.45
Mobility	0.38	0.19	0.15	0.55	0.41	0.51	0.61	1.00	0.50	0.03	0.31	0.54	-0.03	-0.04	-0.12	0.28	0.43
Compatibility	0.56	0.09	0.09	0.74	0.50	0.71	1.00	0.61	0.63	-0.05	0.45	0.61	-0.30	-0.27	-0.20	0.52	0.69
PU	0.55	0.12	0.17	0.68	0.47	1.00	0.71	0.51	0.52	-0.01	0.47	0.61	-0.16	-0.15	-0.07	0.42	0.59
PEOU	0.31	0.08	0.17	0.47	1.00	0.47	0.50	0.41	0.47	0.01	0.19	0.42	-0.18	-0.16	-0.15	0.34	0.40
Attitude	0.44	0.12	0.21	1.00	0.47	0.68	0.74	0.55	0.58	0.09	0.45	0.68	-0.28	-0.28	-0.12	0.53	0.59
Selfimage	0.16	0.04	1.00	0.21	0.17	0.17	0.09	0.15	0.07	-0.02	0.15	0.14	0.04	-0.00	0.09	0.17	0.11
Selfefficacy	0.11	1.00	0.04	0.12	0.08	0.12	0.09	0.19	0.03	0.18	0.23	0.08	0.07	0.08	0.08	0.13	0.13
Innovativeness	1.00	0.11	0.16	0.44	0.31	0.55	0.56	0.38	0.39	-0.13	0.33	0.34	-0.10	-0.09	-0.11	0.30	0.69

Correlation: 1.0, 0.5, 0.0, -0.5, -1.0

6.5 Chi-square tests

The following contingency tables (tables 6.4-6.7) were extracted from the data received from the sample of 207 respondents. Each of the factor coding lead to an overall response code for the associated variable in the Chi-square tests. The following hypothesis were developed to measure the relationship between each of the four socio-demographic variables and other identified factors that influence the decision to buy smart devices derived from the proposed conceptual framework.

H_0: socio demographical parameters and factors that influence the decision to buy smart devices are independent.

H_1: socio demographical parameters and factors that influence the decision to buy smart devices are dependent.

6.5.1 Chi-square test results

Table 6. 3 Degree of freedom and p-values of associated relationships between demographic variables and other factors

	Chi-square P-values with respect to				
Factor number	Factor title	Gender	Age group	Income	Qualification
F1	Innovativeness	0.2074	0.06697	0.05497	0.5487
F2	Self-efficacy	0.3498	0.4153	0.05047	0.9685
F3	Positive Self-image	0.1529	0.3768	0.08296	0.3778
F4	Attitude	0.2489	0.0005	0.05547	0.05547
F5	Intention to buy/use	0.4593	0.002499	0.3853	0.4433
F6	Perceived Ease of Use	0.006	0.008496	0.1764	0.7141
F7	Perceived Usefulness	0.1244	0.003998	0.2224	0.01699
F8	Compatibility	0.2584	0.009995	0.7796	0.002499
F9	Mobility	0.07696	0.01899	0.2194	0.8406
F10	Automation	0.4638	0.03148	0.2484	0.01349
F11	Perceived Cost	0.4533	0.02749	0.1049	0.000
F12	Social Influence	0.1034	0.5062	0.07396	0.3163
F13	Hedonic Motivation	0.008496	0.01049	0.1034	0.09345
F14	Privacy Risk	0.1134	0.7806	0.4838	0.08746
F15	Security Risk	0.1364	0.1454	0.06697	0.2659
F16	Physical Risk	0.1544	0.005497	0.1904	0.2784
F17	Trust in IoT Providers	0.3543	0.01849	0.5747	0.05597

From the above table 6.4 it is observed that p-value for different socio-demographic variables as against all the factors. Only two of the relationships of gender with perceived ease of use and hedonic motivation have p<0.05 and all other factors show p>0.05, hence it can be concluded that PEOU and gender are not independent as well as hedonic motivation and gender are not independent whereas all other factors show no relationship with gender.

Age has a combination of values with 11 factors with p value of <0.01 indicating the rejection of null hypothesis of no relationship between age and these factors at 5% level of significance. Age vs innovativeness, self-efficacy, self-image, social influence, privacy risk and security risk all have p>0.05 so we accept the null hypothesis and reject the alternate hypothesis that age as a socio-demographic variable and these factors that influence the decision to buy smart devices are dependent.

Level of education perceived usefulness, compatibility, automation and perceived costs with a p value of <0.05 leading to the conclusion that these factors and level of education are not independent.

Level of income is the only socio-demographic variable in relation to all other factors with a p value of >0.05 accepting the null hypothesis and rejecting the alternative hypothesis that there is a relationship between income and all the 17 factors.

All the other relationships as studied in the table 6.4 above have p values of more than 0.05 and hence, the null hypothesis may be accepted that these socio-demographic variables and factors that influence the decision to buy smart devices are independent. Thus, on the basis of this test result one can conclude that the alternate hypothesis be accepted that these attributes are not associated with each other.

Due to existence of three or more independent groups and Individual impact analysis using Kruskal Wallis tests (Kruskal and Wallis, 1952) were also undertaken in order to make inferences about the impact of socio-demographic variables on each of the 17 factors investigated in this study.

6.5.2 Non-parametric test results

Two broad categories are considered for inference under hypothesis testing in which all inferential tests are classified. It is all based on the assumption of normality, data follows normal distribution. This is verified by the help of the Q-Q plot and Shapiro test of normality. If it is found that data is normally distributed then one can apply parametric test under which we have t tests, z tests and F test. While if normality assumption is violated then alternative tests to t tests, z tests and F tests, are called non- parametric tests. Considering that the data for this study was mostly based on Likert scale lead to it being non-Gaussian an alternate nonparametric test was considered as T-tests are considered unreliable for this categorical data.

Kruskal Wallis is one such non- parametric test that is known as the alternative to the t-test (Kruskal and Wallis, 1952). Here median is compared instead of mean. Due to the data being categorical data, median was considered as a suitable measure of central tendency to compare between two or more than two groups. Hence the study used the P values. The following table 20 lists the P values of all the 17 factors with respect to the 4 socio-demographic variables used in this study.

Table 6. 4 P values according to Kruskal Wallis test for socio-demographic variables

	P-values with respect to				
Factor number	Factor title	Gender	Age group	Income	Qualification
F1	Innovativeness	0.26	0.10	0.00	0.63
F2	Self-efficacy	0.51	0.18	0.35	0.58
F3	Positive Self-image	0.30	0.11	0.31	0.41
F4	Attitude	0.40	0.09	0.10	0.22
F5	Intention to buy/use	0.12	0.05	0.08	0.30
F6	Perceived Ease of Use	0.07	0.14	0.04	0.23
F7	Perceived Usefulness	0.28	0.02	0.01	0.65
F8	Compatibility	0.56	0.12	0.26	0.12
F9	Mobility	0.29	0.15	0.46	0.31
F10	Automation	0.98	0.02	0.00	0.04
F11	Perceived Cost	0.71	0.37	0.26	0.10
F12	Social Influence	0.21	0.10	0.02	0.22
F13	Hedonic Motivation	0.27	0.01	0.00	0.54
F14	Privacy Risk	0.97	0.76	0.38	0.76
F15	Security Risk	0.28	0.46	0.19	0.41
F16	Physical Risk	0.74	0.01	0.04	0.34
F17	Trust in IoT Providers	0.51	0.40	0.73	0.10

The above test was successful in identifying the specific variable from the range of perceived risks that could potentially be affected as indicated from the previous chi-square results. From the above table 6.6, age ($p<0.05$) proved to have significance with regards to physical risk. In line with the results from chi-square tests that signified no significant relationship between psychological variables and gender, the Kruskal Wallis tests (Kruskal and Wallis, 1952) proved this conclusion reliable. Gender was found to have no significance with any of the other 16 factors, however age and income level were found to have significant relationship with a number of factors. Level of education/qualifications only had a significant relationship with automation and had no significant relationship with any of the other 14 factors.

6.6 Moderation analysis

Moderation analysis is when the link between two constructs is not constant but rather depends on the values of a third variable, known as a moderator variable. A relationship between two constructs in a model can be altered in strength or even direction by the moderator variable (or construct). For instance, previous studies have demonstrated that the relationship between effort expectancy of using a technology and intention to use varies depending on the experience of customers according to UTAUT (Venkatesh et. al 2003). When the level of a third variable, known as a moderator variable, that interacts with the independent factors determines how the independent variables affect a dependent variable, this is known as moderation. (Edward, 2007). The literature review for this study found significant moderators including age, gender, experience, voluntariness etc. to be of significant value adding to the moderating effect on several relationships between factors affecting the acceptance of technology. As discussed in chapter 4 of developing a conceptual framework and hypothesis development, 4 of the socio-demographic variables i.e. age, gender, level of income and level of education were hypothesised to have a moderating impact on the three main factors adapted from TAM (Davis, 1989) i.e. PEOU, PU and Intention to buy/use. Since these variables' data was collected in categories of intervals i.e. income brackets rather than exact income amount, the data lead to be categorical in nature and an alternate statistical measure proved to be eminent in making reliable conclusions about the impact of moderators on relationship between the factors identified in the hypothesis 13A to 13C. A moderation analysis was performed for better accuracy and estimation of effect of these independent variables using PLS path model analysis.

The moderation analysis tells us that the effects of independent variables depend on subgroups of categorical variables. If there is any interaction between two independent variables or not.

In the table 6.7 below it was observed that there is differing results with regards to the moderation effect of socio-demographic variables to that of relationship between the three key factors of Perceived Ease of Use, Perceived Usefulness and Intention to buy from the underlying theory of TAM (Davis, 1989)

Table 6. 5 Moderation analysis results

Dependent Variable: Intention to buy
Type: OLS linear regression

MODEL FIT:
$F(9,133) = 5.55$, $p = 0.00$
$R^2 = 0.27$ Adj. $R^2 = 0.22$

Standard errors: OLS

	Est.	S.E.	t val.	p
(Intercept)	13.70	5.68	2.41	0.02
PEOU	-0.10	0.47	-0.21	0.84
Gender	1.23	2.15	0.57	0.57
Age	-1.67	1.62	-1.03	0.30
Income	-0.88	1.90	-0.46	0.64
Education	-1.92	0.85	-2.25	0.03
PEOU: Gender	-0.05	0.18	-0.29	0.77
PEOU: Age	0.10	0.14	0.73	0.47
PEOU: Income	0.06	0.15	0.37	0.71
PEOU: Education	0.14	0.07	1.98	0.05

Dependent Variable: Intention to buy
Type: OLS linear regression

MODEL FIT:
$F(9,134) = 12.10$, $p = 0.00$
$R^2 = 0.45$ Adj. $R^2 = 0.41$

Standard errors: OLS

	Est.	S.E.	t val.	p
(Intercept)	12.37	3.64	3.40	0.00
PU	-0.04	0.31	-0.13	0.89
Gender	-0.92	1.64	-0.56	0.58
Age	-1.55	1.00	-1.55	0.12
Income	0.22	1.23	0.18	0.86
Education	-1.38	0.57	-2.41	0.02
PU: Gender	0.14	0.14	0.97	0.34
PU: Age	0.09	0.09	1.02	0.31
PU: Income	-0.02	0.10	-0.16	0.87
PU: Education	0.10	0.05	2.14	0.03

Dependent Variable: PU
Type: OLS linear regression

MODEL FIT:
$F(9,135) = 5.46$, $p = 0.00$
$R^2 = 0.27$ Adj. $R^2 = 0.22$

Standard errors: OLS

	Est.	S.E.	t val.	p
(Intercept)	6.19	5.41	1.14	0.25
PEOU	0.51	0.45	1.14	0.26
Gender	2.15	2.04	1.05	0.29
Age	-2.68	1.54	-1.73	0.09
Income	1.51	1.80	0.84	0.40
Education	-0.84	0.81	-1.04	0.30
PEOU: Gender	-0.17	0.17	-0.96	0.34
PEOU: Age	0.23	0.13	1.79	0.07
PEOU: Income	-0.17	0.15	-1.16	0.25
PEOU: Education	0.06	0.07	0.95	0.34

Based on the above statistics and p values of each of the moderator, the following hypothesis can be reviewed:

At 5% level of significance, the sample results approved two of the proposed moderation hypothesis as the overall p values of each of the moderator to that of respective factor is <0.05.

A group of socio-demographic variables considered as moderators for this study namely gender, age, income level and education were studied to identify their impact on three different relationships within the model. Overall socio-demographic characteristics were found to be having no significant impact on the relationship between perceived ease of use and perceived usefulness indicating gender, age, income and education of consumers do not influence consumers perception of how easy IoT devices are to use and its impact on whether they perceive these IoT devices as useful in their lives.

However, these socio-demographic variable did indicate have a moderating impact on their decision-making of intention to buy/use these IoT devices depending on their perception of ease of use and usefulness of IoT devices. It was noteworthy from the results that although the overall group of variables demonstrated a moderating impact some demographic variables had higher p values in the analysis as high as 0.87 that of income level. However, the combined p value of the overall group of socio-demographic variables lead to the acceptance of the overall moderation hypothesis.

One of the most significant moderator variables in the group was that of education level. The results as shown in Table 6.7 indicate that education moderates the relationship between PEOU and intention to buy/use as well as between PU and intention to buy/use. It is seen that for those respondents who possess higher level of education, the influence of perceived ease of use and perceived usefulness on intention to buy is higher as compared to those who are less qualified. One plausible reason for this could be that higher level of education might have been the user of the facility for a long time and their experience might be positive.

6.6.1 Moderation hypothesis review

Table 6. 6 Moderation hypothesis review

Stated hypothesis	**Review at p<0.05**
H13A: Sociodemographic characteristics (e. g., gender, age, education, income) moderates the impact of perceived ease of use on perceived usefulness of IoT devices.	Rejected
H13B: Sociodemographic characteristics (e. g., gender, age, education, income) moderates the impact of perceived ease of use on intention to buy/use IoT devices.	Accepted
H13C: Sociodemographic characteristics (e. g., gender, age, education, income) moderates the impact of perceived usefulness on intention to buy/use IoT devices.	Accepted

6.7 Structural Equation Modelling

A multivariate statistical analytic method called structural equation modelling is employed to examine structural relationships. This method examines the structural link between measured variables and latent constructs by combining two statistical methods: Confirmatory Factor Analysis (CFA) and path analysis. This study favours this approach since it estimates numerous and connected dependencies in a single investigation. Endogenous and exogenous variables are the two types of variables employed in this analysis. These variables are the same as both the independent and dependent variables.

SEM is a technique that tests the models using multiple regression and component analysis to determine how well the connection models match the data. Its foundation is factor analysis and multiple regression techniques, which evaluate the proposed links within the models and look at their goodness-of-fit (GOF) or goodness-of-fit indices (GFI). SEM models are characterised as causal models that researchers use to confirm, modify, and evaluate causal linkages between the variables under study (Cohen, Manion and Morrison, 2011).

Cohen, Manion and Morrison, (2011) identified SEM as a powerful tool for statistically based research that uses intervals and ratio data. Byrne (2010) clarified that SEM can also be used successfully in non-experimental research areas. The R software package can be used to perform SEM and import Excel CSV files. Pallant (2013) claims that factor analysis and multiple regression techniques are used in SEM, allowing for the evaluation and testing of the overall model fit of the data on R software (Rosseel, 2012).

Blunch (2012) states that SEM is used to map the theory of the system under study and then analyse the empirical evidence to confirm presumptions. The reasons behind popularity of SEM according to Schumacker and Lomax (2010), are because on one hand researchers are becoming more adept at using multiple observed variables in their studies, they are using more sophisticated modelling and statistical testing of complex datasets; whereas on the other hand SEM has been able to analyse more complex theoretical SEM models over the past 30 years; enabling the ease of use of SEM software programmes. Lastly one of the key features of SEM is that measurement error is taken into account when evaluating the validity and reliability scores of SEM measurements.

Blunch (2012) asserts that one benefit of using latent variables in SEM is that, in contrast to other scientific fields with measurable units, such as weight, length, and height, concepts in SEM are diffuse and require indirect measurement in the form of indicators (items) in a questionnaire. Kline (2015) argues that SEM should be viewed as a family of related techniques rather than a single statistical strategy since it also includes covariance structure modelling and analysis.

Tabachnick and Fidell (2013) state that a model is identified if there is a single numerical solution for each of its parameters. They further recommend that only identified models be further examined and estimated.

6.8 Confirmatory Factor Analysis

Factor analysis is a multivariate technique which is generally preferred as data reduction technique and is widely known and used in many different disciplines. This is used when latent variable is present in the study and is measured with help of other measurable variables. This method has two broad approaches.

1. Exploratory Factor Analysis (EFA)
2. Confirmatory Factor Analysis (CFA)

Confirmatory Factor Analysis (CFA) and Exploratory Factor Analysis (EFA) are two common techniques used in scale development and scale adaptation studies. If the relationship among the items is not known it is recommended to use EFA, but if the relationship is tested and the factors and related items are known, CFA is recommended to be used (Orcan, 2018).

The use of EFA is advocated during the early stages of scale development to avoid misspecification of the number of factors and to maximize the convergent and discriminant validity of the items constituting each factor (Bartholomew, Ntoumanis and Thogerson-Ntouman, 2010).

Confirmatory Factor Analysis (CFA) is the method used to measure latent variables (Hoyle 1995; 2011; Kline 2010; Byrne 2013). Among related variables, it extracts the latent construct from other variables and explains the most variance.

By estimating latent variables based on correlated fluctuations of the dataset (e.g., association, causal relationship), confirmatory factor analysis can reduce the dimensions of the data, standardise the scale of many indicators, and account for the correlations present in the dataset (Byrne 2013). It is therefore important to consider the rationale for the hypothesising of a latent variable. According to the theory of technology acceptance, attitudes, and intentions to purchase or use are latent factors. With the use of CFA, theorists such as Venkatesh, Thong, and Xu (2012) were successfully able to contribute the UTAUT2 model of technology acceptance.

In this study Confirmatory Factor Analysis is used as to measure psychological variables, perceived features of IoT, perceived risks and questions related to all three factors were asked and response corresponding to questions was recorded on a five-point Likert scale. This technique basically helps us to transform multiple variables into factors with fewer dimensions with loosing minimum information from the original data.

Detailed factor loading of each of the factor and their respective items were estimated to find the correlation between each item and its related factor, using the confirmatory factor analysis as shown in the table 6.9 below.

Table 6. 7 Detailed factor loading table

	Factors	Variables	Cronbach alpha (α)	Loading Value
Psychological Variables	Innovativeness	I1	0.81	1.000
		I2		0.973
		I3		1.129
	Self-efficacy	S1	0.75	1.000
		S2		1.604
		S3		1.720
	Positive Self image	P1	0.84	1.000
		P2		0.786
		P3		1.133
	Attitude	A1	0.92	1.000
		A2		1.066
		A3		1.127
	Intention to buy/use	IB1	0.72	1.000
		IB2		1.305
		IB3		1.123
Perceived attributes	Perceived Ease of Use	PE1	0.70	1.000
		PE2		1.806
		PE3		1.9
	PU -Perceived Usefulness	PU1	0.88	1.000
		PU2		1.111
		PU3		1.103
Perceived features of IoT	Compatibility	C1	0.92	1.000
		C2		1.128
		C3		1.144
	Mobility	M1	0.86	1.000
		M2		1.186
		M3		1.201
	Automation	AU1	0.79	1.000
		AU2		0.868
		AU3		0.861
	Perceived Cost	PC1	0.72	1.000
		PC2		1.549
		PC3		1.972
	Social Influence	SI1	0.92	1.000
		SI2		1.055
		SI3		1.010
	Hedonic Motivation	H1	0.91	1.000
		H2		1.159
		H3		1.103

Perceived Risks	Factor – Privacy risk	PR1	0.85	1.000
		PR2		1.048
		PR3		1.281
	Factor – Security risk	SR1	0.78	1.000
		SR2		1.044
		SR3		1.378
	Factor – Physical risk	PR1	0.82	1.000
		PR2		1.346
		PR3		1.223
	Factor – Trust in IoT providers	IoT1	0.83	1.000
		IoT2		0.761
		IoT3		0.80

Factor loading < 0.40 is deemed to be of low significance and not contributing to the overall construct. None of the values in the factors analysis items were <0.40 and hence it was necessary to include them in the measurement of the model.

For a newly developed items, the factor loading for every item should exceed 0.5. For any established items, the factor loading for every item should be 0.6 or higher (Awang, 2014). All other items carried factor loading >0.5 and hence were approved for the next stage of the analysis.

6.9 Path analysis

In order to quantify the correlations between many factors, path analysis was created (Wright, 1921). Before there were latent variables, this was the original name for SEM, and it was very effective in testing and developing the structure hypothesis with both indirect and direct causal effects. Recently, though, the two effects have been used interchangeably. The relationships between variables' causes can be explained through path analysis. Assuming that a variable can have an impact on an outcome both directly and indirectly through another variable, mediation is a common function of path analysis.

6.10 Criteria for model fit indices

SEM evaluation is based on the fit indices (p value and standard error) for the test of a single path coefficient and the overall model fit. Model fit indices appear to have a wide range of applications, according to the literature. The more fit indices that are used to a SEM, the more likely it is that a miss-specified model would be rejected, which implies that a higher percentage of acceptable models will also be rejected. Furthermore, this suggests combining at least two fit indices (Hu and Bentler 1999). While some indices offer recommended cut-off values, none are perfect for every situation (Fan, Thompson, and Wang, 1999; Chen et al. 2009; Kline 2010; Hoyle 2011). Discussed below is an overview of some of the possible fit indices that can be used to assess the reliability of models.

6.10.1 Chi-square test

Chi-square (χ^2) tests the hypothesis that there is a discrepancy between model-implied covariance matrix and the original covariance matrix. Therefore, the non-significant discrepancy is preferred. For optimal fitting of the chosen SEM, the χ^2 test would be ideal with $p > 0.05$ (Bentler and Bonett 1980; Mulaik et al. 1989; Hu and Bentler 1999). One should not be overly concerned regarding the χ^2 test because it is very sensitive to the sample size and not comparable among different SEMs (Bentler and Bonett 1980; Joreskog and Sorbom 1993; Hu and Bentler 1999).

6.10.2 Root Mean Square Error of Approximation (RMSEA) and Standardised Root Mean-square Residual (SRMR)

RMSEA is a “badness of fit” index, where 0 indicates the perfect fit and higher values indicate the lack of fit (Brown and Cudeck 1993; Hu and Bentler 1999; Chen et al. 2008). It is useful for detecting model misspecification and less sensitive to sample size than the χ^2 test. The acceptable RMSEA should be less than 0.06 (Browne and Cudeck 1993; Hu and Bentler 1999; Fan, Thompson, and Wang, 1999). SRMR is similar to RMSEA and should be less than 0.09 for a good model fit (Hu and Bentler 1999).

6.10.3 Comparative Fit Index (CFI)

CFI represents the amount of variance that has been accounted for in a covariance matrix. It ranges from 0.0 to 1.0. A higher CFI value indicates a better model fit. In practice, the CFI should be close to 0.95 or higher (Hu and Bentler 1999). CFI is less affected by sample size than the χ^2 test (Fan, Thompson, and Wang, 1999; Tabachnick and Fidell 2001).

6.10.4 Tucker-Lewis Index (TLI)

TLI is a Non-Normed Fit Index (NNFI) that partly overcomes the disadvantages of Normed Fit Index (NFI) and also proposes a fit index independent of sample size (Bentler and Bonett 1980; Bentler 1990). A TLI of >0.90 is considered acceptable (Hu and Bentler 1999).

6.10.5 Akaike information criterion (AIC) and Bayesian information criterion (BIC)

AIC and BIC are two relative measures from the perspectives of model selection rather than the null hypothesis test. AIC offers a relative estimation of the information lost when the given model is used to generate data (Akaike 1974; Kline 2010; Hoyle 2011). BIC is an estimation of how parsimonious a model is among several candidate models (Schwarz 1978; Kline 2010; Hoyle 2011). AIC and BIC are not useful in testing the null hypothesis but are useful for selecting the model with the least over fitting (Burnham and Anderson 2004; Johnson and Omland 2004).

In order to analyse the data received to review the multiple relationships identified in the proposed model, an overall model using SEM was extracted using R software, lavaan package (Rosseel, 2012) and model fits indices were assessed using the criteria for RMSEA, SRMR, CFI and TLI as discussed above. AIC and BIC have not been used in this study. The models are shown and discussed below.

6.11 Explanation of Composite Reliability and AVE

Composite reliability measures the internal consistency of indicator variables that load on a latent variable. A composite reliability value greater than 0.7 indicates that the indicator variables share variance and are consistently measuring the same construct.

Some of the criteria use to interpret composite reliability values:

0.6–0.7: An acceptable level of reliability
0.8 or greater: A very good level of reliability
0.95 or higher: Not necessarily good, as it could indicate redundancy

In exploratory research, a composite reliability value between 0.60 and 0.70 is acceptable. In more advanced stages, the value should be higher than 0.70

Average Variance Extracted (AVE) is a metric used to assess the amount of variance in a construct compared to the amount of variance due to measurement error. It's commonly used to validate constructs in structural equation models. Here are some ways to interpret AVE:

- Convergent validity

An AVE of at least 0.5 is considered acceptable, meaning that the latent construct explains at least 50% of the indicator variance. An AVE above 0.7 is considered very good and AVE above 0.5 is considered acceptable.

- Discriminant validity

The positive square root of the AVE for each latent variable should be higher than the highest correlation with any other latent variable. This is known as the Fornell–Larcker criterion.

- Explanation of variance

AVE can be used to explain how much variation in items can be explained by a construct. For example, if the AVE for four items measuring perceived quality of information in Wikipedia is 0.658, then 65.8% of the variation in perceived quality is explained by those items.

6.12 Structural model

Following the CFA, a comprehensive structural model was then developed considering the extent and scale of the number of variables measured in this study. Several relationships were studied using Rstudio to develop the model. This was done in two stage, firstly an overall relationship model with all the proposed relationships was developed and assessed using the fit measures. Following the assessment of criteria followed by the model a revised model of significant parameters was developed.

6.12.1 Overall relationship model

The comprehensive model and its output from the R software has been presented in the figure 6.19 below.

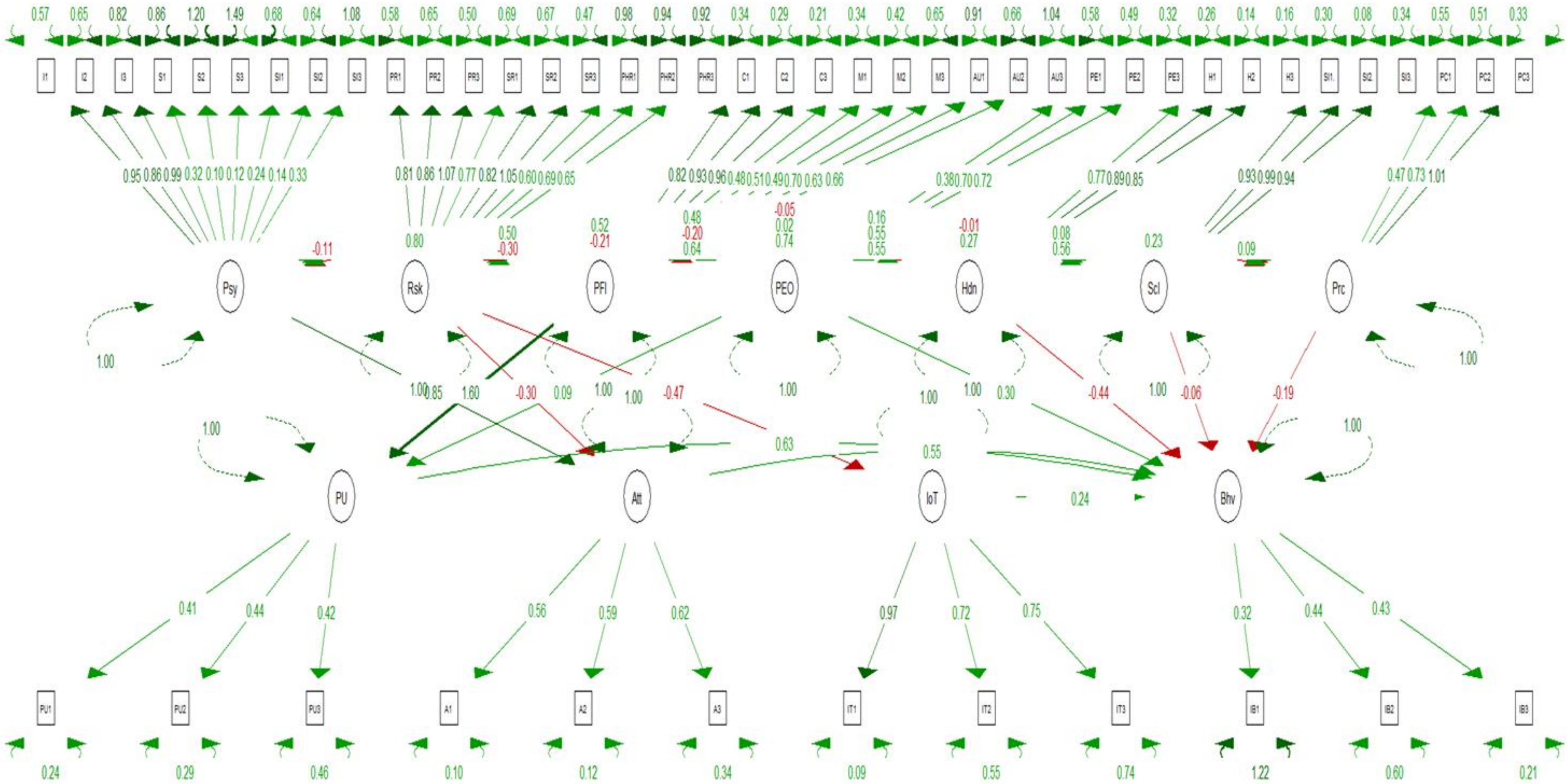

Figure 6. 3 Path diagram with all the constructs before deletion

Table 6. 8 Overall relationships table

Sr. No	lhs op rhs		Standard estimate β	P value	Critical ratio
Construct and items relationship					
1	Psychological variables =~	I1	0.953	0	9.985
2	Psychological variables =~	I2	0.858	0	9.013
3	Psychological variables =~	I3	0.991	0	9.173
4	Psychological variables =~	S1	0.315	0	3.492
5	Psychological variables =~	S2	0.095	0.359	0.917
6	Psychological variables =~	S3	0.115	0.322	0.990
7	Psychological variables =~	P1	0.242	0.002	3.034
8	Psychological variables =~	P2	0.142	0.063	1.860
9	Psychological variables =~	P3	0.334	0.001	3.311
10	Perceived Risk =~	PR1	0.808	0	9.281
11	Perceived Risk =~	PR2	0.862	0	9.336
12	Perceived Risk =~	PR3	1.068	0	11.301
13	Perceived Risk =~	SR1	0.770	0	8.459
14	Perceived Risk =~	SR2	0.822	0	8.924
15	Perceived Risk =~	SR3	1.054	0	11.429
16	Perceived Risk =~	PHR1	0.595	0	6.012
17	Perceived Risk =~	PHR2	0.690	0	6.929
18	Perceived Risk =~	PHR3	0.648	0	6.618
19	PFOIoT =~	C1	0.815	0	11.021
20	PFOIoT =~	C2	0.926	0	12.210
21	PFOIoT =~	C3	0.959	0	13.071
22	PFOIoT =~	M1	0.483	0	7.946
23	PFOIoT =~	M2	0.512	0	7.644
24	PFOIoT =~	M3	0.490	0	6.175
25	PFOIoT =~	AU1	0.703	0	7.213
26	PFOIoT =~	AU2	0.626	0	7.492
27	PFOIoT =~	AU3	0.658	0	6.482
28	Attitude =~	A1	0.556	0	11.614
29	Attitude =~	A2	0.594	0	11.618
30	Attitude =~	A3	0.617	0	10.140
31	PEOU =~	PE1	0.378	0	4.693
32	PEOU =~	PE2	0.698	0	7.925
33	PEOU =~	PE3	0.716	0	8.871
34	Perceived usefulness =~	PU1	0.405	0	8.323
35	Perceived usefulness =~	PU2	0.440	0	8.324
36	Perceived usefulness =~	PU3	0.422	0	7.750
37	Social influence =~	SI1	0.930	0	11.985

38	Social influence =~ SI2	0.988	0	14.425
39	Social influence =~ SI3	0.940	0	11.736
40	Hedonic Motivation =~ H1	0.767	0	11.361
41	Hedonic Motivation =~ H2	0.892	0	13.385
42	Hedonic Motivation =~ H3	0.846	0	13.046
43	Trust in IoT providers =~ IoT1	0.975	0	12.084
44	Trust in IoT providers =~ IoT2	0.724	0	9.071
45	Trust in IoT providers =~ IoT3	0.746	0	8.472
46	Perceived Cost =~ PC1	0.472	0	5.858
47	Perceived Cost =~ PC2	0.731	0	7.833
48	Perceived Cost =~ PC3	1.009	0	9.448
49	Intention to buy/use =~ IB1	0.321	0	4.770
50	Intention to buy/use =~ IB2	0.444	0	6.431
51	Intention to buy/use =~ IB3	0.427	0	6.490
Relationship between factors				
52	Attitude ~ Psychological variables	0.853	0	5.945
53	Attitude ~ Perceived Risk	-0.297	0.007	-2.675
54	Perceived usefulness ~ PEOU	0.091	0.639	0.469
55	Perceived usefulness ~ PFOIoT	1.597	0	5.838
56	Trust in IoT providers ~ Perceived Risk	-0.473	0	-4.351
57	Intention to buy/use ~ Attitude	0.545	0	3.813
58	Intention to buy/use ~ PEOU	0.296	0.175	1.358
59	Intention to buy/use ~ Perceived usefulness	0.629	0	3.853
60	Intention to buy/use ~ Social Influence	-0.062	0.712	-0.369
61	Intention to buy/use ~ Hedonic Motivation	-0.440	0.070	-1.813
62	Intention to buy/use ~ Trust	0.243	0.053	1.938
63	Intention to buy/use ~ Perceived Cost	-0.191	0.210	-1.253

Chisq 2663.427, df 1191.000, p value 0, cfi 0.684, tli 0.662, srmr 0.124, rmsea 0.098

It is noted in the above table 6.8 that only a few of the standard estimates are under 0.30 and majority of the items have a p value of <0.05 or 0. The overall fit measures of the model using the cfi and tli values did not meet the acceptable range and hence the items with p values of >0.05 were deleted in line with Schumacker and Lomax (2010) who proposed that in an instance where the model is unfit, non-significant routes should be added to the model using the modification indices in accordance with the empirical literature now in existence be eliminated from the model in order to arrive at the optimal final model that would statistically and practically fit the data and have meaningful theoretical implications.

The amalgamation of methodological progressions and enhancements to various software facets in SEM has led to its widespread acceptance among scholars and enabled its utilisation in many research domains across the globe (Khine, 2013). Additionally, Schumacker and Lomax (2010) claimed that in order to define and assess the theoretical components in the hypothesised model, SEM uses a variety of models to examine the hypothesised correlations between observed variables.

Utilising a hypothesis testing methodology, SEM conceptualises the theory being studied in order to investigate the causal and structural linkages (Byrne, 2010). Byrne (2010) states that in order to ascertain whether the data is consistent, a statistical test is conducted on the proposed model. The model is approved if it passes the Goodness Of Fit (GOF) test. The model and its relationships are disregarded if the GOF is insufficient.

6.12.2 Significant parameters

A revised model was prepared after removing variables that were not significantly contributing to the overall model. Any items with p values of >0.05 and standard estimates of <0.30 were removed such as S2, S3, and P2 by RStudio package. It is imperative to note that although P1 had a standard estimate of <0.30, due to meeting the criteria for the p values and critical ratio, this item was deemed significant for the next stage of the model development.

A model was run to obtain the significant parameters from the overall model where by two of the items for self-efficacy P2 and P3 along with one item of self-image S2 were removed from the overall model. A new revised model was developed using the significant parameters as shown in the figure 6.21 below.

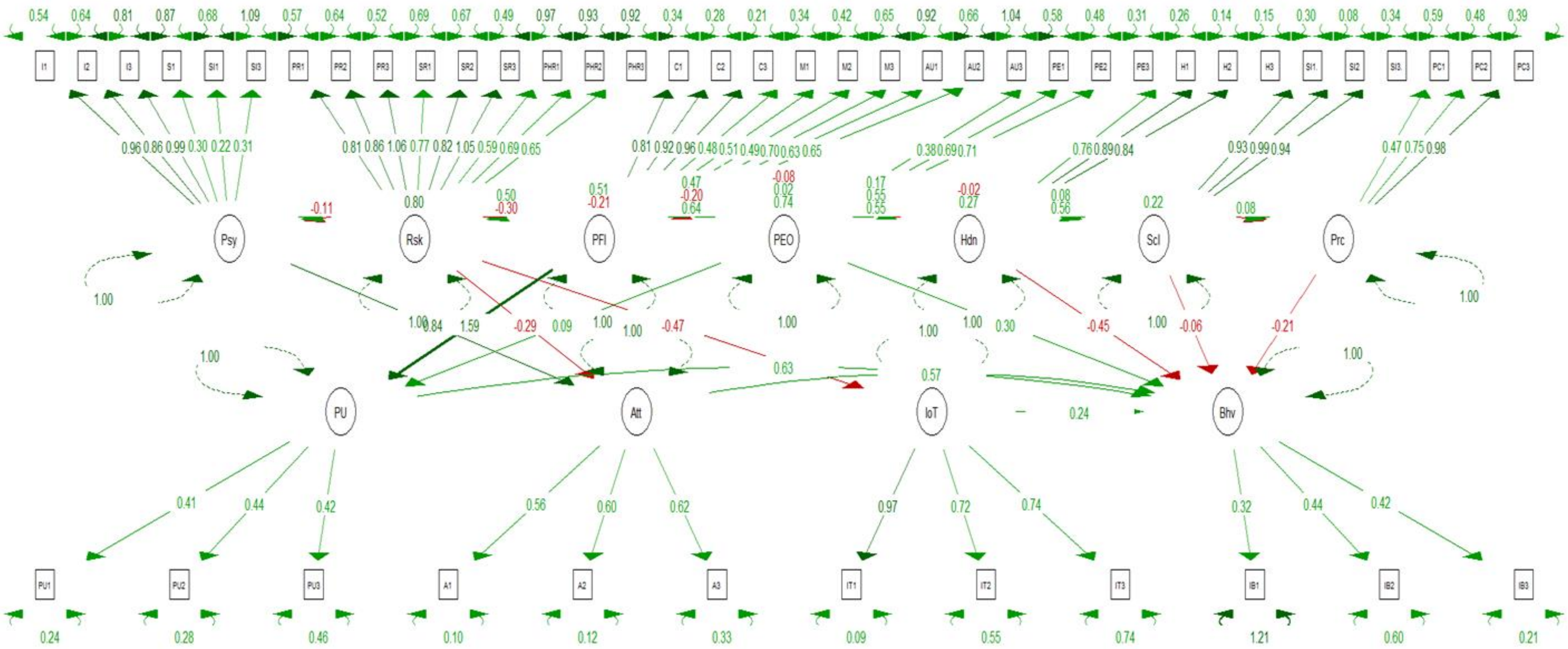

Figure 6. 4 Revised structural model

Table 6. 9 Revised Overall relationships table with significant parameters

Sr. No	lhs op rhs	Standard estimate β	P value P
Construct and items relationship			
1	Psychological variables =~ I1	0.965	0
2	Psychological variables =~ I2	0.862	0
3	Psychological variables =~ I3	0.991	0
4	Psychological variables =~ S1	0.297	0.001
5	Psychological variables =~ P1	0.219	0.006
6	Psychological variables =~ P3	0.307	0.002
7	Perceived Risk =~ PR1	0.806	0
8	Perceived Risk =~ PR2	0.860	0
9	Perceived Risk =~ PR3	1.061	0
10	Perceived Risk =~ SR1	0.767	0
11	Perceived Risk =~ SR2	0.819	0
12	Perceived Risk =~ SR3	1.046	0
13	Perceived Risk =~ PHR1	0.593	0
14	Perceived Risk =~ PHR2	0.689	0
15	Perceived Risk =~ PHR3	0.645	0
16	PFOIoT =~ C1	0.813	0
17	PFOIoT =~ C2	0.923	0
18	PFOIoT =~ C3	0.955	0
19	PFOIoT =~ M1	0.483	0
20	PFOIoT =~ M2	0.511	0
21	PFOIoT =~ M3	0.490	0
22	PFOIoT =~ AU1	0.705	0
23	PFOIoT =~ AU2	0.628	0
24	PFOIoT =~ AU3	0.653	0
25	Attitude =~ A1	0.556	0
26	Attitude =~ A2	0.598	0
27	Attitude =~ A3	0.619	0
28	PEOU =~ PE1	0.379	0
29	PEOU =~ PE2	0.695	0
30	PEOU =~ PE3	0.713	0
31	Perceived usefulness =~ PU1	0.405	0
32	Perceived usefulness =~ PU2	0.440	0
33	Perceived usefulness =~ PU3	0.421	0
34	Social Influence =~ SI1	0.926	0
35	Social Influence =~ SI2	0.985	0
36	Social Influence =~ SI3	0.936	0
37	Hedonic Motivation =~ H1	0.764	0

38	Hedonic Motivation =~ H2	0.889	0
39	Hedonic Motivation =~ H3	0.843	0
40	Trust in IoT providers =~ IoT1	0.970	0
41	Trust in IoT providers =~ IoT2	0.721	0
42	Trust in IoT providers =~ IoT3	0.743	0
43	Perceived Cost =~ PC1	0.467	0
44	Perceived Cost =~ PC2	0.746	0
45	Perceived Cost =~ PC3	0.977	0
46	Intention to buy/use =~ IB1	0.317	0
47	Intention to buy/use =~ IB2	0.439	0
48	Intention to buy/use =~ IB3	0.422	0
Relationship between factors			
49	Attitude ~ Psychological variables	0.839	0
50	Attitude ~ Perceived Risk	-0.294	0.008
51	Perceived usefulness ~ PEOU	0.088	0.647
52	Perceived usefulness ~ PFOIoT	1.591	0
53	Trust in IoT providers ~ Risk	-0.474	0
54	Intention to buy/use ~ Attitude	0.569	0
55	Intention to buy/use ~ PEOU	0.301	0.170
56	Intention to buy/use ~ Perceived usefulness	0.629	0
57	Intention to buy/use ~ Social Influence	-0.063	0.710
58	Intention to buy/use ~ Hedonic Motivation	-0.445	0.067
59	Intention to buy/use ~ Trust in IoT providers	0.241	0.056
60	Intention to buy/use ~ Perceived Cost	-0.209	0.180

Chisq 2227.079, df 1047.00, p value 0, cfi 0.730, tli 0.709, srmr 0.124, rmsea 0.093

6.13 Model impact

Although the revisions were made to lead to an ideal reliable model, the removal of 5 items with standard estimates <0.30 did not prove to cause any significant different in the fit indices of the overall model. The fit indices of both the models have been compared in the table 43 below.

Table 6. 10 Comparative table of GFI of overall models

	Chi-square	Df	P value	Cfi	Tli	srmr	Rmsea
Acceptable Criteria	-	-	p>0.05	>0.90	>0.90	<0.09	<0.09
All parameters	2663.427	1191	0.000	0.684	0.662	0.124	0.098
Significant parameters	2227.079	1047	0.000	0.730	0.709	0.124	0.093
Impact	-436.348	-144	-	+0.025	+0.047	-	-0.005

Where cfi and tli do not vary much with the sample size, srmr and rmsea are larger with smaller sample sizes (Kenny, 2020). The results of overall model indicated large values of srmr = 0.124 and rmsea = 0.098. Removal of insignificant parameters and items with p value greater than 0.05 lead to a minor impact in the value of rmsea reducing it to 0.093 and fitting in the acceptable criteria. The values of cfi and tli also showed a positive movement towards acceptable criteria whereas srmr did not have any impact due to the removal of items of P2, P3, and S2 which may be due to a smaller sample size. The study would possibly see a difference in these fit indices if a larger sample size was recruited.

The minute difference in values of srmr and rmsea that of +0.047 brought the fit indices closer to the acceptable range of rmsea < 0.09 as well as the difference in cfi and tli values of +0.025 and +0.047 brought the fit indices closer to the acceptable range of cfi, tli >0.90 however, three of these values although closer to the acceptability criteria may need further data to establish the reliability of the model in totality. The p value of the overall model was estimated as 0 by SEM whereas the acceptable criteria being p>0.05 failed to meet the mark. The acceptable range of cfi value > 0.90 and tli value > 0.90 and srmr <0.09 were also not met by the overall model. However, the model could be accepted solely on the basis of the only acceptable fit measure of rmsea <0.09 (See table 6.13).

6.14 Composite reliability and AVE for both models

Table 6. 11 Composite reliability and AVE

	Composite Reliability		Average variance Extract (AVE)	
Factor	**Original model**	**Revised model**	**Original model**	**Revised model**
Psychological variables	0.546	0.682	0.269	0.384
Risk	0.882	0.881	0.491	0.489
Social Influence	0.920	0.920	0.790	0.790
Hedonic Motivation	0.922	0.922	0.789	0.789
Perceived Cost	0.776	0.764	0.560	0.542
PFoIoT	0.848	0.847	0.481	0.480
PU	0.849	0.848	0.761	0.670
PEOU	0.692	0.692	0.453	0.452
Attitude	0.916	0.915	0.779	0.777
Intention to buy	0.674	0.675	0.462	0.462
Trust	0.836	0.835	0.643	0.642
CR - 0.6–0.7: An acceptable level of reliability				
0.8 or greater: A very good level of reliability				
0.95 or higher: Not necessarily good, as it could indicate redundancy				
AVE - >0.50 considered good				

All the indicator variables of all the factors excluding psychological variables share variance and are consistent in measuring the construct. However, due to a lower composite reliability of psychological variables with a CR of 0.549 does not indicate great reliability in the consistency of indicator variables such as innovativeness, self-efficacy and self-image in measuring the latent variable of psychological variables. This was reversed due to removing the insignificant items from the overall model leading to an improved composite reliability of 0.682 for psychological variables.

The highest explaining factor include 79% of the variation in social influence is explained by the items measuring social influence whereas only 26.90% of the variation in psychological variables is explained by the items measuring innovativeness, self-efficacy and self-image. The values of AVE did not show any significant difference after the revised model.

Whilst the item's reliability was assessed previously in chapter 4 on methodology, where statistical findings indicated that all latent constructs have Cronbach alpha (α) value above the cut-off point of 0.60 ranging between 0.70 for PEOU and 0.92 for social influence AlHogail (2015). Likewise, Composite Reliability (CR) and Average Variance Extracted (AVE) are tested as shown in Table 6.10 in order to ensure an adequate level of scales reliability. Composite validity for all latent constructs existed within their respective level of 0.70 except that of the psychological variables. Excluding the psychological variables, Table 40 indicates that while the highest value of CV (0.922) was noticed for hedonic motivation and CV (0.920) for social influence, the minimum value was exhibited by Intention to buy (0.674). Moreover, the AVE value of the factors ranged from 0.453 (PEOU) to 0.790 (SI) of which 5 of the values were all under the cut-off value of .50 (Hair Jr. et al. 2010).

6.15 Review of hypothesis

The review of hypothesis used a multistage process considering the statistical analysis using Structural equation modelling, where p values, cfi, tli, srmr as well as rmsea values were calculated for the overall model. A preliminary model as well as revised model were prepared after excluding insignificant items from the review to enable this study to review the series of hypothesis proposed in chapter 3 of this thesis.

According to Keene (2020) fit refers to the ability of a model to reproduce the data (i.e., usually the variance-covariance matrix). A good-fitting model is one that is reasonably consistent with the data and so does not necessarily require re-specification. There is considerable debate as to what is meant by 'reasonably consistent with the data.' Also, a good-fitting measurement model is required before interpreting the causal paths of the structural model. Fit indexes are a topic of significant debate. According to some researchers (Barrett, 2007), fit indices do not offer anything to the analysis; the chi square alone needs to be understood. The issue is that fit indices give academics the opportunity to argue that a model that is miss-specified is nonetheless good. Cutoffs for a fit index, according to some (Hayduk et al. 2007), can be deceptive and misused. While most analysts agree that fit indices are useful, they advise against relying too heavily on cutoffs.

In light of the above discussion, it is vital that the parameter estimates must be carefully examined to determine if one has a reasonable model. Since the original overall model depicted the low level of acceptance of Goodness of Fit Indices, it deemed to fail for approval of the overall model. However, 5 of the 12 hypothesis could have been approved based on the p values and critical ratios stipulated in table 6.8, including impact of psychological variables to attitude, perceived risks to trust in IoT providers, perceived features of IoT devices to perceived usefulness, the relationships between factors such as perceived risks on attitude and PEOU on perceived usefulness. The hypothesis related to the 4 direct relationships of perceived ease of use, social influence, hedonic motivation, perceived cost on the intention to buy/use IoT devices would have been rejected (See table 6.18). However, after exclusion of 3 items of scale measurement of psychological variables, this changed the status of approval of the stipulated hypothesis in chapter 4. This re-specification of the model lead to acceptance of 6 hypothesis as seen in the table 6.12 below, a detailed discussion on hypothesis results and its implications will be done in the next chapter 7.

6.15.1 Path coefficient for the overall revised model

Although the overall model may exhibit the necessity of further data and analysis, it was beneficial to see the significance of relationships studied in the model. Values of critical ratio, standard deviation and p values enable the discussion of significance of each of the relationships studied in the overall model. Below is a table indicating these values of 12 such relationships studied in this research model.

Table 6. 12 Path coefficient for the overall revised model

Path	Standard estimate	P value	Critical ratio	Significance
Attitude ~ Psychological variables	0.839	0.000	5.926	Significant
Attitude ~ Perceived Risk	-0.294	0.008	-2.665	Significant
Perceived usefulness ~ PEOU	0.088	0.647	0.458	
Perceived usefulness ~ PFOIoT	1.591	0.000	5.856	Significant
Trust in IoT providers ~ Risk	-0.474	0.000	-4.366	Significant
Intention to buy/use ~ Attitude	0.569	0.000	3.877	Significant
Intention to buy/use ~ PEOU	0.301	0.170	1.374	
Intention to buy/use ~ Perceived usefulness	0.629	0.000	5.926	Significant
Intention to buy/use ~ Social Influence	-0.063	0.710	-0.372	
Intention to buy/use ~ Hedonic Motivation	-0.445	0.067	-1.828	
Intention to buy/use ~ Trust in IoT providers	0.241	0.056	1.915	
Intention to buy/use ~ Perceived Cost	-0.209	0.180	-1.340	

The significance of each of the relationship is dependent on the criteria of p values less than 0.05 ($p<0.05$) and critical value of more than 1.96 ($CR>1.96$) have lead to the significance of the relationship. 6 of the relationships showed significance to the overall model with highest critical ratio of 5.926 of impact of psychological variables on attitude and impact of perceived usefulness on intention to buy.

These critical ratios and p values were used to review the approval and or rejection of hypothesis as shown in table 6.145 below.

6.15.2 Path co-efficient for group of variables

Where a construct is measured through multiple variables, for examples psychological variables included innovativeness, self-efficacy, positive self-image, perceived risks included privacy, security and physical risks whereas perceived features of IoT devices included compatibility, mobility and automation. It was important to undertake the standard estimates of each of the contributing variable in order to address their significance to the overall construct in the sub models and thereby the impact of the overall construct in the model relationship to the latent variable.

Table 6. 13 Path coefficient for latent variables

Path	Standard estimate
Psychological variables =~PSY	0.583
PV = ~ I	1.000
PV = ~ PS	0.083
PV = ~ SI	0.175
Perceived Risks=~RSK	0.574
Risk = ~ PR	1.000
Risk= ~ SR	1.165
Risk = ~ PHR	0.614
PFOIoT= ~ PFIoT	0.754
PFOIoT = ~ C	1.000
PFOIoT = ~ M	0.537
PFOIoT = ~ AU	0.798

Table 6. 14 Hypothesis review

Proposed hypothesis	Approved/ Rejected
H1 – Psychological factors have an impact on attitude towards IoT devices.	Approved
H2 Positive Attitude has a positive impact on intention to buy/use IoT devices.	Approved
H3 Perceived Ease of Use (PEOU) positively affects the intention to buy/use smart IoT devices.	*Rejected*
H4 Perceived Usefulness (PU) positively affects the intention to buy/use IoT devices.	Approved
H5 Perceived ease of use has a positive impact on perceived usefulness of IoT devices.	*Rejected*
H6 Perceived features of IoT devices have an impact on perceived usefulness of IoT devices.	Approved
H7 Perceived high cost has a negative impact on the intention to buy/use smart IoT devices.	*Rejected*
H8 Social Influence has a positive impact on intention to buy/use IoT devices.	*Rejected*
H9 Hedonic motivation/perceived fun has a positive impact on intention to buy/use IoT devices.	*Rejected*
H10 Perceived risks associated with IoT devices negatively influences the attitude towards IoT devices.	Approved
H11 Perceived risk has a negative impact on trust in IoT devices.	Approved
H12 Trust in IoT devices providers is positively associated with intention to buy/use IoT devices.	*Rejected*

Both hypothesis affecting attitude were approved where psychological variables such as innovativeness, self-efficacy and positive self-image positively impacted the attitude towards IoT devices. On the other hand, perceived risks such as privacy risk, security risk and physical risk had a negative impact on attitude towards IoT devices. The impact of perceived risks on trust in IoT providers was also found to be significant and thereby leading to acceptance of the hypothesis.

1 out 2 hypothesis affecting perceived usefulness approved – perceived features of IoT devices such as compatibility, mobility and automation were found to be significant in their impact of perceived usefulness. Whereas perceived ease of use of these IoT devices did not significantly impact on the perceived usefulness of the IoT devices.

2 out of the 6 hypothesis proposed to have an impact on intention to buy/use were accepted which included attitude and perceived usefulness at $p<0.05$ showing a significant impact whereas factors such as perceived ease of use, perceived cost, hedonic motivation and social influence did not show a significant impact on intention to buy. Trust in IoT providers could be acceptable at $p<0.056$ and only missed the mark by a negligible figure of +0.002. and hence the hypothesis can arguably be accepted considering other test results.

6.16 Summary

This chapter intended to summarise the data analysis and findings with the focus to achieving the research objective to organise and analyse the data acquired from the data collection activities. The data analysis commenced with a contextual analysis of ownership status of research respondents with a 78% of the respondents owning a smart device whereas 22% of these respondents declared no ownership of any smart device. The descriptive statistics of all measurement items and factors indicated the highest mean average of Positive self-image, followed by mobility and the lowest mean average for innovativeness followed by second least Physical risk. It was then followed by a bi-variate correlation analysis between all factors with highest correlation between security and privacy risk r=0.77 and Compatibility and attitude=0.74. Negative correlation was found between Security risk and Trust in IoT providers -0.35. The data signified the role of level of education as a socio-demographic variable moderating relationships between PEOU, PU and Intention to buy/use IoT devices. The overall model was analysed using confirmatory factor analysis and structural equation modelling, which provided the path co-efficient to review the hypothesis. Some significant findings were sought with the effective use of appropriate data analysis techniques which will enable the discussion of these findings in comparison to findings from previous literature in the next chapter 7.

CHAPTER 7 DISCUSSION

7.1 Introduction

This chapter includes findings from the data analysis techniques applied in the previous chapter along with the interpretation. This chapter reviews research aims, objectives and the alignment of findings against these aims and objectives, leading from the testing of model with respect to the goodness of fit and performance as discussed in the previous chapter.

7.2 Findings

7.2.1 Descriptive statistics findings

The descriptive statistics as evident in table 6.2 indicated an average spread of the data from 2.68 to 4.29 indicating either neutral or positive opinions of the respondents with regards to each of the items of the 17 factors. The lowest mean score of 2.64 went to one of the items measuring innovativeness which also had items on the lower scale such as 2.68. Respondents showed a lower self-perception of their innovativeness to use IoT devices when asked "Among my peers, I am usually the first to try out new high-tech products.", indicating that respondents may not be the first ones to buy the technology and may wait for reviews and adaptability in the market before buying such IoT devices in line with San Martin and Herrero, (2012). One other low mean score was that for perceived risks associated with IoT devices with a mean score of 2.79 which was contrary to the findings of Jose and Malikan (2015). Considering the nature of IoT devices in a smart home environment which come with numerous health and safety guidelines, respondents did not strongly feel in agreement that these devices could cause physical harm due to abuse or malfunction, instead privacy and security risks scored a higher mean average indicating the perceived risk of losing personal information and hacker's threat.

The highest mean score of 4.29 was depicted is a positive self-image perceived by the respondents when asked about possessing good qualities, indicating a good state of self-awareness and contentment in the respondents (Wang, McGill and Klobas, 2020).

Second close to the highest was a mean score of 4.28 went to one of the items measuring mobility feature of IoT devices which was highly rated by the respondents as one of the best advantages of IoT devices in agreement with previous studies (Park et al. 2014; Yang et al. 2017 and Kim and Moon, 2023) The ability to use IoT devices from anywhere in the world and whilst moving from place to place is considered a key feature of these devices where one can set the room temperature to the optimum level before setting from work or any other destination for home. Likewise other smart devices offering similar features such as smart home security and smart lights providing additional home security whilst being away from home.

On the other hand, where social influence is considered as one of the most important variables affecting the buyer intention in previous studies (Alolayan, 2014; Baabdullah, 2018), these descriptive statistics indicated that the respondents neither agreed to disagreed on the influence of their peers, friends and family or other influential people’s views as significant in influencing their decision to buy/use IoT devices. The items measuring social influence scored a 3 on an average. Similarly, respondents exhibited a lower level of trust in IoT providers with an average score of 3 indicating the requirement of additional measures to be taken by IoT providers in building the trust of prospective buyers of IoT devices (Cannizzaro et.al., 2020).

The findings displayed acceptable variability within the data set as the standard deviation fell between 0.73 and 1.35. Thus, it shows that the respondents have different point of view regarding the studied variables.

7.2.2 Moderation analysis findings

The model studied moderation impact of four socio-demographic variables such as gender, age, level of income and level of education on three of the relationships proposed in the model. These relationships included impact of perceived ease of use on perceived usefulness, impact of perceived ease of use on intention to buy/use and lastly impact of perceived usefulness on intention to buy/use. The results in previous chapter as discussed in table 6.7 and table 6.8, suggested the approval of 2 moderation hypothesis (H13B and H13C) whereas rejection of one hypothesis (H13A)

Perceived ease of use and perceived usefulness (H13A)

With an overall statistically significant p value at 0.00, approximately 27% of the variance in "Perceived Usefulness" is explained by the predictors of PEOU with $R^2 = 0.27$, Adjusted $R^2 = 0.22$. The coefficient for PEOU is not significant (b=0.51,p=0.26b = 0.51, p = 0.26b=0.51,p=0.26), indicating that PEOU does not directly influence PU in this model contradicting previous findings as per TAM (Davis, 1989). The interactions of gender, income and education do not indicate the moderation effect on relationship between PEOU and PU, with gender, p=0.34, income p = 0.25b = -0.17, and education p = 0.34. None of the interaction terms between PEOU and sociodemographic characteristics (gender, age, income, and education) significantly influenced perceived usefulness (all p-values > 0.05) negatively comparing to the findings from Venkatesh, Thong and Xu, (2012). With a p value of 0.07 a marginal significant may be questioned concluded as there is a trend that age might moderate the effect of PEOU on PU with older individuals potentially valuing ease of use more.

The results suggested limited moderation effects for PEOU on PU. There appeared a marginal indication that age might moderate the relationship, warranting further investigation. Otherwise, the interactions did not significantly alter the relationship between PEOU and PU specially that of gender, level of income and level of education. A weak trend where older users may value ease of use more when assessing usefulness (Chen et. al, 2023). However, this finding did not meet the threshold for significance at 5% level and was insufficient to support the hypothesis.

Overall, this hypothesis of moderation impact of socio-demographic variables moderating the relationship between perceived ease of use and perceived usefulness has been rejected by the sample data. It will be insightful to apply the same model to larger sample and different geographic location to see the impact of the moderators.

The results indicate that sociodemographic factors do not meaningfully moderate the relationship between PEOU and PU. This may suggest that users perceive the usefulness of IoT devices in a way that is largely independent of ease of use across demographic groups. The weak trend for age as a potential moderator warrants further exploration, possibly with larger sample sizes or in different contexts (Coskun, Kaner and Bostan, 2018; Pal et. al. 2018).

Perceived ease of use, perceived usefulness and intention to buy/use IoT devices

The interaction term PEOU × level of education was statistically significant (b=0.14,p=0.05b = 0.14, p = 0.05b=0.14,p=0.05). This indicated that education moderates the relationship between PEOU and intention to buy/use IoT devices (H13B). Specifically, for individuals with higher education, the effect of PEOU on intention to buy/use is stronger (Baudier, Ammi and Deboeuf-Rouchon, 2020). None of the other interaction terms involving PEOU (gender, age, income) showed significance, suggesting these factors do not moderate the relationship. (Wu, Wu and Chang, 2014).

This finding highlights that education is an important moderating factor. Educated consumers may place more emphasis on ease of use when forming intentions to accept the IoT devices (Shin, Park and Lee, 2018). This could be due to their heightened expectations for usability or greater reliance on ease of use as a deciding factor in technology acceptance. Gender, age, and income, in contrast, did not appear to affect how PEOU influenced behavioural intention. This suggests that the usability-related aspects of IoT devices are evaluated consistently across these groups. Additionally, education moderates the relationship between PU and intention to buy/use IoT devices. Similar to the findings in H13B, individuals with higher education show a stronger positive relationship between PU and intention to buy/use. The other sociodemographic variables (gender, age, income) did not significantly moderate this relationship, as their respective interaction terms had p-values > 0.05. This result suggested that higher-educated consumers are more likely to consider the usefulness of IoT devices when forming their buying intentions (Shin, Park and Lee, 2018). They may better recognize or value the practical benefits offered by these devices. The non-significance of gender, age, and income as moderators indicates that the perceived usefulness of IoT devices influences buying intentions in a largely uniform manner across these demographic groups.

Education acts as a consistent moderator, in both the relationships between PEOU and intention to buy/use as well as PU and intention to buy/use IoT devices. Level of education consistently moderated the relationships between PEOU/PU and intention to buy with $p<0.05$. Higher education levels amplify the effects of cognitive evaluations, suggesting that more educated individuals may be more influenced by considerations of usefulness and ease of use when deciding to adopt IoT devices (Baudier, Ammi and Deboeuf-Rouchon, 2020).

PEOU does not demonstrate significant direct effects on the intention to buy. This indicates that these constructs may work indirectly or require certain conditions (e.g., high education levels) to influence behavioural intentions. Except for education (and a marginal effect of age), demographic variables like gender and income do not play a substantial moderating role in this dataset challenging the historical finds from Nikou, 2019 and Rauschnabel, Brem and Vens (2015) as well as Venkatesh, Thong and Xu, 2012). This suggests that these factors may not critically shape technology acceptance behaviours in this context. The findings reinforce the importance of considering moderating variables like education in technology acceptance models. Marketers and designers targeting more educated consumers should emphasize ease of use and usefulness to improve technology acceptance rates.

7.2.3 Model findings and hypothesis

Six hypothesis were accepted from a total of twelve hypothesis along with two of the moderation hypothesis from a total of three as discussed in 7.2.2 above, leading to a total of eight hypothesis accepted out of fifteen hypothesis proposed in this paper.

This study exhibited a significant variance from findings from the original literature review, from which the list of factors was chosen. One of the criteria of selection of the factor was its significance and impact on the dependant value. However, the results of this study indicated a number of hypotheses to be untrue significantly questioning the relevance of findings from previous studies to the chosen sample. Another possibility of difference may be imparted to the technology in question that of IoT devices, where earlier studies focussed on technology in banking (Richad et al. 2019), technology in education (Dintoe, 2018) or technology in work environments

Venkatesh (2003), this study focussed on the technology of a home setting. Due to the complexities of studying and unravelling differences in consumer psychology, it may not come as a surprise that the findings of this study are applicable to the consumers of IoT devices of the current era.

A number of studies unanimously identified innovativeness as having a positive impact on the adoption behaviour (Bartels and Reinders, 2011; Alagoz and Hekimoglu, 2012; Baudier, Ammi, and Deboeuf-Rouchon, 2020; Wang et al. 2019) in the context of online food ordering, acceptance of smart homes by students and acceptance of Green Building Technologies (GBTS) in the construction market etc, the results of this study agree with previous literature where it accepts the impact of innovativeness on attitude towards IoT devices. Evidence to approve the positive impact of self-efficacy on attitude towards IoT devices disagrees with the negative relationship found by (Ozturk et al., 2016) however approves the findings from Abdullah and Ward (2016) for e-learning acceptance whilst Coeurderoy, Guilmot and Vas (2014) classed self-efficacy as having a direct influence on the speed of technological adoption. Where products are more external facing allowing buyers to showcase their image to the outer world in case of adoption of electric cars (Barbarossa et. al. 2015), self-image proved to play a positive role, the same can be claimed that devices within a home setting enables the platform of showcasing an individual's possessions may be one of the factors that may have influenced the results of this study. Previous studies have studied the enhancement of self-image of potential buyers using new technologies (Wang McGill and Klobas, 2020) whereas there was limited literature studying the impact of positive self-image, how one felt about themselves affected the formation of attitude, this study concludes that positive self-image had an impact on attitude towards IoT devices.

This study intended to reinstate the role of attitude influencing the behavioural intention towards IoT devices using numerous earlier research that discovered a favourable association between attitude and intention to buy new technologies (Cheong and Park 2005; Hsiao, 2013; Hussein, Oon and Fikry, 2017). The research findings approved this hypothesis and both the impact of psychological variables on attitude as well as received risks on attitude were found to have an impact on attitude. Additionally the role of attitude proved to have a positive impact on intention to buy/use IoT devices which negates the removal of this factor from the original TAM (Davis 1989) and hence should be considered significant in the studies of technology acceptance of IoT devices.

The analysis of the path coefficients in the given structural equation model (SEM) reveals key insights into the relationships among psychological, risk-related, and behavioral constructs influencing attitudes, perceptions, and intentions regarding acceptance of IoT devices within a smart home environment. This helped interpret the standardized estimates, considering their magnitude, direction, and significance.
The following findings from the data provide an insight into the consumer behaviour related to acceptance of IoT devices within the smart home environment based on the data analysis in the previous chapter 6.

1. Attitude Formation

One of the most important research aims of this study was to reinstate the role of attitude in the technology acceptance theories. It was evident from the findings that a strong positive coefficient (0.839) indicated that psychological variables significantly enhance attitudes toward IoT devices (Rogers, 1962). This suggests that users with high innovativeness, self-efficacy, and positive self-image are more likely to form favourable attitudes. This aligns with theories emphasizing the role of individual traits in technology acceptance (Rogers, 1962; Ajzen, 1991)

Where psychological variables have a positive relationship with attitude, perceived risks such as security, privacy and physical risks associated with using IoT devices showed a negative impact on formation of this attitude Gebhart (2020). The moderate negative coefficient (-0.294) shows that perceived risks diminish positive attitudes. While not as strong as the psychological variables, this inverse relationship underscores the importance of addressing privacy, security, and physical risks to foster favourable attitudes.

Psychological Variables (Innovativeness, Self-Efficacy, Positive Self-Image) → Attitude	Perceived Risk (Privacy, Security, Physical) → Attitude
Estimate: 0.839	Estimate: -0.294
p=0	p=0.01

The impact of perceived risks such as privacy risk, security risk and physical risks on attitude was supported by the results with a p value of 0.01 and a standard estimate of -0.294 showing the impact of these perceived risk as a crucial factor for potential buyers of IoT devices. The results match with that of previous studies of Chou and Yutami (2014) who also showed that perceived risk, of which privacy and safety concerns are significant antecedents, negatively affected attitudes toward smart meter adoption (Eastlick, Lotz and Warrington, 2006; Kim, 2008). The perceived risks increase user reluctance of interacting with a device (Gefen, Karahanna and Straub, 2003) or disclosing personal information (Dinev and Hart, 2006). Studies by Boucher and Hackett (2017) and Maheshwari (2017) discussing hacking situations where Google Home and Amazon Echo devices heard a voice order from a TV show instead of their owner and carried it out add substantial credit to the findings to the results of this study. Physical risks have not been researched extensively as not many incidents have been report in line with Jose and Malekian (2015) who stated that a basic gadget like a fluorescent lamp connected to a IoT home assistant might injure occupants physically (e.g., shatter glass, start a fire, or poison them with mercury) and hence this type of risk was not perceived negatively by potential buyers.

2. Perceived Usefulness

Two of the factors perceived ease of use and perceived features of IoT devices such as compatibility, mobility and automation were studied to assess their impact on perceived usefulness. The hypothesis originated from the understanding that if a consumer finds a technology easy to be used, this should have an impact on whether they feel it is useful for them. Similarly, IoT devices offer specific features of automation to consumers life, offering an easy but useful way to doing some of the daily chores of life. The hypothesis aimed to study if these functionalities have an impact on how useful these are for consumers. Results indicated a weak positive coefficient (0.088) suggesting that perceived ease of use (PEOU) has a minimal influence on perceived usefulness (PU). This may imply that ease of use is not the primary driver of perceived utility in IoT devices, possibly due to their inherently complex functionalities (Afonso, 2019). The perceived features of IoT devices such as compatibility, mobility and automation were found to be significant factors affecting buying behaviour of new technologies in previous studies (Park et. al., Salimon, Gorondutse and Abdullah, 2018). Where compatibility was found having a moderating and mediating role in influencing a user's perceptions of such technology (Islam and Rahman, 2016; Ozturk et al. 2016), mobility was found to be directly related to the functionality of mobile devices because it can enhance the service access points of users (Yang et al. 2017; Park et al. 2014). Luor et al. (2015) showed that the automation function is positively related to residents' perceived usefulness of IoT devices. This falls in line with the results of this study with a remarkably strong positive coefficient (1.591) indicated that perceived features of IoT devices strongly influence perceived usefulness. Compatibility, mobility, and automation appear to be critical factors that significantly enhance users' perceptions of the utility of IoT devices.

Perceived Ease of Use → Perceived Usefulness	Perceived Features (Compatibility, Mobility, Automation) → Perceived Usefulness
Estimate: 0.088	Estimate: 1.591
p=0.647	p=0

3. Perceived risks and trust in IoT Providers

The impact of perceived risk on trust in IoT providers, as indicated by the negative coefficient of -0.474, highlights a significant inverse relationship between these two constructs. This result suggests that as consumers perceive higher levels of risk—whether stemming from privacy concerns, security vulnerabilities, or potential physical risks—their trust in IoT providers decreases substantially. Trust is a critical factor in technology adoption, and these findings underscore how negative perceptions about risk erode confidence in the companies providing IoT solutions. This erosion of trust can create significant barriers to adoption, as users may feel apprehensive about the safety and reliability of IoT devices. For IoT providers, addressing these concerns through transparent communication, robust security measures, and assurance of privacy protection is vital for building and maintaining consumer trust. This negative relationship serves as a reminder that mitigating perceived risk is not merely a technical challenge but also a fundamental trust-building exercise for organizations operating in the IoT space.

Risk → Trust in IoT Providers
Estimate: -0.474
p= 0

4. Intention to Buy/Use IoT Devices

The model hypothesized the impact of a number of factors such as attitude, PEOU, PU, social influence, trust in IoT providers to have a positive impact on consumer's intention to buy/use IoT devices in a smart home environment.

Strong contribution towards intention to buy/use

The results of the study indicated strong positive coefficient of 0.569 between attitude and intention to buy/use, indicating that favorable attitudes significantly drive intentions to buy or use IoT devices. This result aligns with the theory of planned behavior (Ajzen, 1991), where attitude is a primary determinant of behavioral intentions.

A strong positive coefficient of 0.629 for perceived usefulness and intention to buy/use IoT devices, shows that perceived usefulness is a significant driver of intention, reinforcing the idea that users adopt IoT devices based on their practical benefits and utility. (Davis, 1989)

Attitude → Intention to Buy/Use	Perceived Usefulness → Intention to Buy/Use
Estimate: 0.569	Estimate: 0.629
p = 0	p=0

Moderate contribution towards intention to buy/use

Literature review found that a few studies concluded that PEOU directly affected the behavioural intention to use along with PU (Moore and Benbasat 1991, Thompson et al. 1991; Venkatesh and Davis 1996; Chin and Gopal 1995; Venkatesh 1999). This study found the relationship of PEOU on intention to buy/use along with trust in IoT providers both indicated a positive yet moderate relationship with intention to buy, suggesting the needs of consumers in terms of simplicity in the functionality and operations of IoT devices when considering IoT technology acceptance. The harder the devices functions, they reduce the intention to buy/use. In this fast-changing world consumers expect easy life which smart devices offer, yet if the devices are complex to use, it may add unnecessary stress reducing the willingness to buy or use these products. (Gupta, Manrai and Goel, 2019). Further research in the usage behaviour of consumers would enable to study this phenomenon in greater depth, identifying the exact functionalities and their usage within the households. On the other hand, trust may be perceived as a very personal matter, trust in IoT providers which is affected by a number of elements of perceived risks such as privacy and security risks, influences the intentions to buy technology products. This study marginally failed to approve the hypothesis of a positive impact of trust on intention to buy with a p=0.056, which would be an implication for future research with a larger sample size. However, in light of a critical ratio of 1.915 very much near the mark of 1.96, it may be argued that trust is rated highly by the potential buyers of IoT devices agreeing with the findings of Luor et al. (2015) who concluded that perceptions of trust and attitudes toward smart home services are positively correlated and that of Mashal and Shuhaiber (2018) who also studied the impact of trust on behavioural intention and found it significant influencer. Where providers such as Google and Amazon offer IoT devices Alexa and Echo, the intention of buying and using these smart speakers is often related to how comfortable are consumers with the companies. The moderate positive coefficient (0.241) suggests that trust in IoT providers plays a role in shaping intentions (Petrovskaya and Haleem, 2020), though its influence is weaker compared to attitude and perceived usefulness. This highlights the importance of trust-building strategies for IoT providers.

Perceived Ease of Use → Intention to Buy/Use	Trust in IoT Providers → Intention to Buy/Use
Estimate: 0.301	Estimate: 0.241
p= 0.170	P=0.056

Negative contributors towards intention to buy/use

This study hypothesised perceived costs as negatively affecting intention buy/use whereas two of the factors positively affecting the intention to buy/use IoT devices, i.e. social influence studied as subjective norms in earlier studies (Venkatesh, 2000; Venkatesh and Bala, 2008) as well as hedonic motivation studied as perceived fun, perceived enjoyment (Venkatesh and Bala, 2008). Whilst perceived cost with a standard estimate of -0.209 was found to be significant inverse association, both social influence and hedonic motivation which were expected to positively impact consumer's intention to buy/use IoT devices, found contrary findings suggesting an inverse relation to intention to buy with standard estimate of social influence (-0.063) and hedonic motivation (-0.445). The relationship between social influence and intention to buy/use IoT devices shows a negative but weak and statistically non-significant effect, as indicated by an estimate of -0.063. This finding suggests that the opinions or behaviours of peers, family, or society at large do not play a major role in shaping an individual's intention to adopt IoT devices. Although a low significance and the hypothesis rejected at 5% significance level, this result contrasts with traditional models of technology acceptance, such as the Unified Theory of Acceptance and Use of Technology (UTAUT)(Venkatesh et. al, 2003), TRA (Fishbein and Ajzen 1975), TPB (Ajzen, 1985), TAM2(Venkatesh, 2000), CTAM-TPB (Taylor and Todd, 1995), MPCU (Triandis, 1979), and IDT (Rogers, 1962), where social influence often emerged as a positive determinant of behavioural intention. This finding also contradicts with some of the significant empirical studies such as Gruzd, Staves and Wilk (2012); Wang, (2017); Mashal and Shuhaiber (2018); Afonso (2019) that class social influence as having a positive impact on behavioural intention, yet falls in line with Alalwan (2017) who found this impact to be neutral in Jordanian banking customers and Pal et al (2018) who also found that social influence had a neutral impact in the smart homes for elderly population studies.

The adoption of IoT devices may be perceived as a personal or utilitarian decision, where individuals rely more on their personal needs, preferences, and evaluations rather than external pressures or social expectations. Unlike more socially visible technologies like smartphones or wearable devices (Park 2020), IoT adoption could be less influenced by peer behaviour due to its focus on functionality over status or trendiness. In contexts where IoT technology is well-established or familiar, individuals may already have sufficient knowledge or experience, reducing the weight of external opinions in their decision-making. This contrasts with emerging technologies, where social influence tends to play a larger role in adoption.

The weak negative relationship might indicate that for some demographic groups, social influence slightly detracts from intention, perhaps due to scepticism or conflicting opinions about the usefulness or safety of IoT devices. This could particularly apply in cases where IoT technologies face criticism or lack social consensus on their value.

The negative coefficient (-0.445) for the relationship between hedonic motivation and intention to buy/use IoT devices is remarkable and contrary to previous studies (Venkatesh and Bala, 2008; Venkatesh, Thong, and Xu, 2012) where consumers accepted technology out of entertainment or fun. The impact of fun element of acceptance of IoT devices was found to be significant in recent empirical studies Mashal and Shuhaiber (2018), the results of this study with a negative standard estimate value of -0.445 fall more in line with the findings of Vejacka (2015) who found that perceived enjoyment is not a significant factor in accepting contactless payment method and contradicting the findings of Abdullah and Ward, (2016); Kahlert, Constantinides and Vries, (2017); Mashal and Shuhaiber (2018) who found it as the most influential factor.

Hedonic motivation, which reflects the enjoyment or pleasure derived from using a technology, is typically seen as a positive driver of adoption (Li and Hsu, 2016; Alalwan et. al. 2018; Baabdullah, 2018 and Afonso, 2019). However, the significant negative effect in this context suggests that higher levels of hedonic motivation may actively decrease individuals' intention to buy or use IoT devices (Vejacka, 2015). One of the possible explanations for this could be a mismatch between the type of product and consumer expectations of enjoyment from these products. IoT devices are often associated with utility, functionality, and automation rather than entertainment or enjoyment. Consumers who prioritize hedonic experiences may find IoT devices less appealing because these technologies primarily address functional needs (e.g., home automation, energy efficiency) rather than providing enjoyment or entertainment. This mismatch may lead to a lower intention to adopt IoT devices. As discussed above with a weak coefficient between perceived ease of use and perceived usefulness one can argue that perceived complexity may be one of the factors affecting the **h**edonic motivation which may be inversely related to technology acceptance if individuals perceive IoT devices as complex or requiring effort to set up and use. For consumers seeking effortless enjoyment, the initial learning curve or technical challenges of IoT devices may detract from their motivation to buy or use such devices. Since a majority of the respondents (78%) owned some of the IoT devices, their experience of using these devices may have had an impact on the relationship between hedonic motivation and their intention to buy/use these devices in future. If consumers approach IoT devices expecting pleasurable or entertaining experiences (e.g., enhanced interactivity, smart entertainment systems) and these expectations are unmet, this could lead to dissatisfaction and reduced intention to adopt. Negative experiences or unmet expectations may contribute to this significant negative association.

Social Influence → Intention to Buy/Use	Hedonic Motivation → Intention to Buy/Use	Perceived costs → Intention to Buy/Use
Estimate: -0.063	Estimate: -0.445	Estimate: -0.209
p=0.710	p=0.067	p=0.180

One of the negative hypotheses of this study claiming an inverse relationship with the intention to buy/use IoT devices was proposed in line with Alolayan (2014) who found that cost is the most significant issue in determining users' intention to purchase smart homes' devices, such as smart fridge as well as smart washing machine (Kim and Moon, 2023). However, sample results of this study failed to approve this hypothesis there is significant fulfilment. Standard estimates found that only 20.9% of the variance in intention to buy/use IoT devices is explained by variance in the perceived cost factor contradicting Alolayan (2014). Perceived cost encompasses both monetary aspects, such as the upfront price of the devices and ongoing subscription fees, and non-monetary elements, such as the time, effort, or potential trade-offs required to adopt and use IoT technology effectively. Consumers often perceive IoT devices as premium products, with high initial investments for smart devices like home assistants, security systems, or thermostats. These upfront costs, combined with potential recurring expenses for maintenance, updates, or additional services (e.g., cloud storage or smart hubs), may discourage price-sensitive consumers from committing to purchase. (Seymour et. al 2024). The negative path coefficient suggests that consumers may perceive the value offered by IoT devices as not sufficiently justifying their cost. When consumers question the return on investment, particularly for non-essential IoT devices, their intention to buy/use diminishes. This is especially pertinent for IoT technologies targeting convenience or luxury markets, where utility may not be immediately apparent.

7.3 Review of research question

A strenuous study of nearly 250 research articles and other academic and non-academic sources enabled this study to attempt answering the research question:

How do various factors influence the behaviour of adopters in the UK in relation to the acceptance of IoT devices within a smart home environment?

The methodical process to address this research question was the identification of factors before studying the behaviour of these factors in influencing the buying decisions of prospective consumers of IoT devices. This was accomplished through achieving the first three research aims. The second most important element of the research question was the identification of a suitable study population where adopters in the UK were identified as a potential group of individuals who owned one or more of the smart devices within their household. The final element of the research question consisted of IoT devices within a smart home environment, which included defining the scope of this research study, focusing on IoT devices within a home environment. This did not include smart devices used in businesses or elsewhere in the lives of adopters. The achievement of the overall research question can be reviewed after discussing the research aims and objectives designed to answer this research question.

7.4 Review of Research Aims

The following research aims were developed from preliminary review of existing literature, which will be reviewed in light of the data analysed in chapter 6:

7.4.1 Effect of factors on attitude towards IoT devices

To identify the effect of relevant factors on attitudes of consumer's toward IoT devices.

Two of the most significant factors found in the literature review of consumer behaviour theories, technology acceptance theories as well as empirical studies using these theories were that of psychological variables including innovativeness (Bartels and Reinders, 2011; Alagoz and Hekimoglu, 2012; Baudier, Ammi, and Deboeuf-Rouchon,2020; Wang et al., 2019), self-efficacy (Alalwan, Dwivedi and Rana, 2017; Sharma et al., 2016) and positive self-image (Barbarossa et al. 2015; Wang, McGill and Klobas, 2020) as well as perceived risks including privacy (Eastlick, Lotz and Warrington, 2006; Kim, 2008), security (Balta-Ozkan et al., 2014; Yang et al., 2016) and physical risks (Jose and Malekian, 2015). This study aimed to identify the effect of these factors on attitudes of adopters towards IoT devices with the premise that attitude formation plays a significant role in making the intention to buy/use IoT devices (Ajzen, 1985; Aboelmaged and Gebba, 2013; Yang and Lee, 2018). When consumers like a product they are more likely to buy the product. This attitude formation is reliant on individual characteristics of innovativeness to trial new technological product/service, self-efficacy which is an individual's confidence in their own skills to use a new technology as well as positive self-image which is their positive belief about themselves. With privacy and security concerns surrounding the favourability towards technological products, perceived risks also played an important role. Perceived risks proved to be of higher significance than psychological variables in the overall ranking of the factors as discussed in research aim 3 discussions.

7.4.2 Effect of attitude on buying intentions

To examine the effect of consumer's attitudes toward IoT devices on their buying intentions.

This research aim, not only proposed to examine the effect of attitudes towards IoT devices, but it also included to examine the direct and indirect effect of nearly 16 factors on the overall behavioural intention of adopters. This included examining the effect 7 factors directly influencing the intention to buy/use which included perceived cost, hedonic motivation, social influence, trust in IoT providers, perceived usefulness, perceived ease of use and attitude. The 6 factors influencing intention to buy/use through attitudes of buyers included innovativeness, self-efficacy, positive self-image, privacy risk, security risk and physical risk as discussed in research aim one review. The final 3 factors influencing intention to buy/use through perceived usefulness included the perceived features of IoT devices including compatibility, mobility, and automation. List of references of each of the chosen factor is listed in the table 9.

7.4.3 Hierarchy of factors

To develop a ranking order of factors influencing the acceptance of IoT devices by consumers.

In order to rank the studied factors into a hierarchy, a ranking system was developed based on the p values of each factor directly impacting the intention to buy/use. The factors such as psychological variables, perceived risks and perceived features of IoT devices were latent variables and hence had an indirect impact on intention to buy/use through attitude, and perceived usefulness. The p values of both attitude and perceived usefulness combine the effect of these variables on to the intention to buy/use. however other factors such as PEOU, social influence, hedonic motivation, trust and perceived costs had a direct impact on intention to buy/use. Based on the p values of each of the factor, following table 48 is created to address the research aim of developing a hierarchy of factors based on importance of each factor.

Table 7. 1 Ranking of factors based on p values of overall model

Factor	p values (overall)	p values (revised)
Intention to buy/use ~ Perceived Usefulness	0	0
Intention to buy/use ~ Attitude	0	0
Intention to buy/use ~ Trust	0.053	0.056
Intention to buy/use ~ Hedonic Motivation	0.070	0.067
Intention to buy/use ~ PEOU	0.175	0.170
Intention to buy/use ~ Perceived Cost	0.210	0.180
Intention to buy/use ~ Social Influence	0.712	0.710

Although some of the above p values are >0.05, which signifies that the factor does not have significance on the overall model, but the ranking identifies an order in which they may be considered relevant. In this scenario, critical ratios were also deemed suitable to establish a ranking order of factors affecting the latent variables such as intention to buy/use, attitude and perceived usefulness.

Table 7. 2 Ranking of factors of IB based on critical ratios of overall model and revised model after variation

Path	Critical ratio Overall model	Critical ratio Revised model
Intention to buy/use ~ Perceived usefulness	3.853	5.926
Intention to buy/use ~ Attitude	3.813	3.877
Intention to buy/use ~ Trust	1.938	1.915
Intention to buy/use ~ PEOU	1.358	1.374
Intention to buy/use ~ Social Influence	-0.369	-0.372
Intention to buy/use ~ Perceived Cost	-1.253	-1.340
Intention to buy/use ~ Hedonic Motivation	-1.813	-1.828

It was interesting to find the ranking order using p values as compared to using critical ratios did not show a significant variation in the higher order ranking of variables. The order of ranking of the last two variables changed patterns social influence was the least important factor according to the p values, hedonic motivation was ranked the last as per critical ratio values. From both the above tables (See table 7.1 and table 7.2), it was found the perceived usefulness is the most significant factor impacting the intention to buy/use with the least p value of 0.0 and the highest critical ratio of 5.926, followed by attitude with p=0 and critical ratio of 3.877. Social influence is the least important factor impacting the intention to buy/use with the highest p value of 0.712 (p=0.710 after variation), however according to the critical ratios it performed better than the hedonic motivation and hedonic motivation was rated the least important factor with the lowest critical ratio of -1.813 (-1.828 after variation). It is imperative to reflect that the variation made to the items exclusion to receive the final p values for the relationship between factors and intention to buy/use has no impact on the ranking of these variables.

A similar comparison can be made between factors having a direct impact on attitude viz psychological variables and perceived risks. In terms of ranking of the factors, both these factors have p>0.05 and whereas critical ratio of PV – A is lower than the benchmark of 1.96 to be accepted for ranking whereas perceived risk exhibited a higher critical ratio of 2.14 putting it higher in the order of ranking of the factors. The impact of psychological variables on attitude is more significant than the impact of perceived risk on attitude according to the p values before variation.

Table 7. 3 Ranking of factors affecting attitude

Factor	p values before variation	P values After variation	Critical ratio Revised model
Attitude ~ Psychological variables	0.0	0.0	5.926
Attitude ~ Perceived Risk	0.007	0.008	-2.665

However, when the p values from model after variations are compared, there is a significant difference in the p values of both the factors making the impact of perceived risk (p= 0.032, p<0.05) higher than the impact of psychological variables (p=0.076, p>0.05) on attitude.

The final comparison between factors having a direct impact on perceived usefulness, viz perceived features of IoT devices and perceived ease of use, signifies that overall perceived features of IoT devices with p=0 ($p<0.05$) is highly significant in terms of its direct impact on perceived usefulness of IoT devices. It also exceeded in terms of ranking in comparison to perceived ease of use of IoT devices' impact on perceived usefulness. In contrast the critical ratio of PEOU to PU was lower than the 1.96 benchmark as opposed to a 4.62 ratio of PFIoT to PU.

Table 7. 4 Ranking of factors affecting perceived usefulness

Factor	p values	Critical ratios
Perceived Usefulness ~ PFOIoT	0.000	5.856
Perceived Usefulness ~ PEOU	0.000	0.458

Taking a wholistic view of all the factors and their overall significance in the model of IoT technology acceptance as seen in table 7.5.

Table 7. 5 Overall comparison of all factors

Path	P value Revised model	Critical ratio Revised model	Standard estimate
Attitude ~ Psychological variables	0	5.926	0.839
Perceived usefulness ~ PFOIoT	0	5.856	1.591
Intention to buy/use ~ Perceived usefulness	0	5.926	0.629
Intention to buy/use ~ Attitude	0	3.877	0.569
Intention to buy/use ~ Trust	0.056	1.915	0.241
Intention to buy/use ~ PEOU	0.170	1.374	0.301
Perceived usefulness ~ PEOU	0.647	0.458	0.088
Intention to buy/use ~ Social Influence	0.710	-0.372	-0.063
Intention to buy/use ~ Perceived Cost	0.180	-1.340	-0.209
Intention to buy/use ~ Hedonic Motivation	0.067	-1.828	-0.445
Attitude ~ Perceived Risk	0	-2.665	-0.294
Trust in IoT providers ~ Perceived Risk	0	-4.366	-0.474

One can conclude that psychological variables, perceived usefulness and perceived features of IoT devices that of compatibility, mobility and automation with the least p value and highest critical ratio are found to be of the highest order followed by attitude, whereas trust in IoT providers, perceived risk and hedonic motivation ranked the least significant in the order.

Table 7. 6 Variation in ranking order of factors

Factor	P values	Factor	Critical ratio	
Intention to buy/use ~ PEOU	0.170	Intention to buy/use ~ Perceived Cost	-1.340	4th
Intention to buy/use ~ Perceived Cost	0.180	Intention to buy/use ~ Hedonic Motivation	-1.828	3rd
Perceived usefulness ~ PEOU	0.647	Attitude ~ Perceived Risk	-2.665	2nd
Intention to buy/use ~ Social Influence	0.710	Trust in IoT providers ~ Perceived Risk	-4.366	1st least

The ranking order of the 4 least important factors showed alterations in the position it occupied in the overall comparison. These included factors of perceived cost which rated the 4th least important according to critical ratio whereas third least important according to the p values. (See table 7.6)

7.4.4 Technology Acceptance Model of Internet Of Things devices (TAM-IOT)

To build a model of the factors influencing consumer's acceptance of IoT devices.

This research aimed to develop a real time model of factors influencing a set of consumers i.e., the adopter's acceptance of IoT devices. With the vast literature review in consumer behaviour and psychology as well as technology acceptance, it was nearly impossible to create a holistic model of technology acceptance of IoT devices. With nearly 51 identified factors, this study included one third of the factors to ensure the feasibility of achieving the research aims of this study in the most efficient manner. The researcher believes there are numerous undiscovered elements of human psychology which pull the triggers to making the intention to buy/use a new product or for that matter a new technology and hence the final product of this thesis, i.e., the Technology Acceptance Model of Internet Of Things (TAM-IOT) is limited to the selected factors of this study.

7.5 Review of Research Objectives:

This research aimed to achieve the following research objectives, in order to answer the above research question and research aims:

RO1: Identify the research population of adopters using criteria developed in the literature.

From academics to a general population, from stratified sampling to convenience sampling, this research objective was finally achieved after rigorous evaluation of literature in innovation, consumer behaviour and technology acceptance theories as well as the current state of ownership of smart devices within the UK. There was a vast difference in the populations studied in the previous research papers ranging from older population (Golant, 2017) to millennials (Richad et al. 2019), from teachers (Aldunate and Nussbaum, 2013) to retailers (Kahlert, 2017), from banking professionals to educators (Dintoe, 2018). This study identified a general target population not confining to a specific category of user since belonging to a particular group minimized the generalizability of the results of this study. Also, since IoT devices have now become a part of living of a common man, it was argued to enable all an equal chance of providing their opinion on their acceptance of this technology.

RO2: Apply data collection methods.

The literature review not only supported the study in identifying a research population, but it also provided an evaluation of various qualitative (Gruzd, 2012; Seitebeland and Dintoe, 2019) and quantitative approaches adapted to study the consumer behaviour of acceptance new products and services. Where quantitative approaches provided statistically proven results for the selected study populations, qualitative papers provided a deeper understanding of reasons for acceptance of various technologies of its times. A quantitative approach was found suitable to achieve the aims of this research, whereby a questionnaire was developed using validated items to measure 17 different constructs/factors influencing the acceptance of IoT devices. This was executed using DSMT, Qualtrics.

RO3: Organise and analyse the data acquired from the data collection activities.

A series of tables, charts, figures, and models were prepared in order to organise the vast data collected from the questionnaire. A range of statistical techniques were then applied to significant elements of the data. Firstly, to ensure that the questionnaire items were reliable to measure each of the construct, Cronbach alpha was executed. Secondly the data was organised in frequency and relative frequency tables and charts for visual presentation. Techniques such as descriptive statistics, t-tests, Kruskal Wallis tests, correlation test, chi-square tests, structural equation modeling including confirmatory factor analysis were undertaken to review the hypothesis and develop a comprehensive model of IoT technology acceptance.

RO4: Present findings and conclusions of the research in the form of thesis.

A completed thesis was developed as a part of this research and amendments made as a requirement of the process.

7.6 Summary

This chapter reviewed the research question, aims and objectives of this study in light of the data collected for the study. The researcher fulfilled the set aims and objectives to the best possible empirical evidence and use of the most effective statistical techniques. With new generations to come and newer technologies of the robotic world and industry 4.0 and beyond, the factors studied in this research are not an exhaustive list of factors that affect and continue to affect the consumer's buying behaviour. However perceived usefulness and attitude were found to be the most significant factors affecting the intention to buy/use IoT devices. One of the noteworthy findings of this research included the negative impact of social influence and hedonic motivation on intention to buy/use IoT devices contrary to previous findings. With human mind and psychology in question, no researcher can give the answer to this research question in totality as to **how do various factors influence the behaviour of consumers in the UK in relation to the acceptance of IoT devices within a smart home environment**, specially this being a quantitative study, the reason behind the choices of opinions on the Likert scale could not be explored in further detail. Nevertheless, this study provides a snapshot of behavioural dynamics between selected factors and acceptance of selected IoT devices with a smart home environment. The next chapter being the final chapter of this thesis will include a summary of implications of these findings from a theoretical and practical perspective, contribution to literature of technology acceptance, limitations and future research opportunities.

CHAPTER 8 CONCLUSION

8.1 Introduction

The final chapter in the thesis includes theoretical ad practical implications from this research study along with identification of contribution to the knowledge in the subject area of technology acceptance, limitations of the study and implications for future research. Previous chapter provided an insight into the interpretations of data analysis of descriptive statistics of respondents average scores for statements measuring their opinions on factors influencing the intentions to buy/use IoT devices. Several hypotheses of relationships between these factors were either approved or rejected as supported by the sample data results. This chapter intends to dwell further into these findings and their implications on the overall theory of technology acceptance as well as practical implications on business, developers, providers of IoT devices as well as the ultimate users of IoT devices.

8.2 Theoretical implications

The significant negative relationship between hedonic motivation and intention to buy/use IoT devices challenges traditional assumptions in technology adoption literature. While hedonic motivation is often a strong predictor of adoption for entertainment-focused technologies (e.g., gaming or streaming services), its role in functional, utility-driven technologies like IoT may differ. This finding underscores the importance of considering the unique characteristics and value propositions of specific technologies when assessing the role of hedonic motivation in consumer behaviour.

Although social influence plays a less significant role according to the data from the sample of this study, one of the theoretical implications for future research could explore whether this finding holds across different cultural or geographic contexts, as social influence may have a more pronounced effect in collectivist societies where social norms are stronger.

8.3 Practical/managerial implications

The current study aimed to identify a range of the major predictors of technology acceptance. The findings of this study will help marketers in framing strategies for understanding the driving factors for consumers to purchase smart IoT devices.

8.3.1 Addressing consumer’s self-awareness

Innovativeness, self-efficacy and positive self-image being crucial factors in the formation of attitude towards IoT devices, Marketing experts should be able to offer suitable products matching consumer’s needs of identified features of IoT devices, encourage business to promote the key features of these smart IoT devices leading to the enhancement of a positive self-image for the consumers. Consumer-oriented strategies emphasizing consumers' self-image are likely to drive sales of IoT devices. Understanding the impact of psychological variables will also equip the consumers with self-awareness to make better informed buyer choices. It will provide them with more autonomy in terms of managing their expectations in relation to technological innovations. This consumer awareness will in turn encourage a more responsible buying behaviour in the consumers.

8.3.2 Role of Social Influence v/s utilitarian benefits

Considering the ranking order of social influence on the consumers of today’s age, where previous studies identified a powerful source of peer groups and their influence on consumer’s buying decision, the findings of this study indicate that today’s consumer is willing to make their own decisions not only on the basis of recommendations of influential people in their lives but based on their own intellect. First and foremost, the device’s usefulness being the strongest positive predictor (SE=0.629) and ability to provide compatibility, mobility, and automation rates higher in the eyes of potential consumers than any other factors influencing their buying decision. If the technology is able to provide these features to make the lives of consumers easy, there is a high likelihood of these devices being accepted in the lives of consumers.

Marketing campaigns that rely heavily on leveraging social norms or peer recommendations may have limited effectiveness in driving IoT acceptance. Instead, focusing on individual benefits and addressing specific consumer issues may yield better results. The findings of this research indicate that social influence plays a minimal role in shaping intention to adopt IoT devices, which highlights the unique nature of IoT technology adoption, which appears to be driven more by functional considerations than by social or emotional factors. For managers, this suggests a need to prioritize utilitarian benefits and address issues with functional features. Developers can use TAM to facilitate the acceptance of technology by understanding the degree to which technology is useful and easy to operate by consumers, they can design consumer-oriented IoT products (Davis, 1989). Given the confusion observed in the use of some smart technologies, like thermostats, consumers can thenuse the guidance provided by the providers to understand how these devices function. Reading manuals, seeking demonstrations, or consulting with vendors can help them fully utilize their devices' capabilities and avoid underutilization.

8.3.3 Trust in IoT Providers

Trust in IoT providers ranked in one of the top factors of the list in the hierarchy of factors influencing the intention to buy/use/ use IoT devices indicating a significant amount of effort to be put in by the IoT providers. Trust has played a significant role in consumer satisfaction for decades of business history and this study focussed on the elements of trustworthiness, reliability as well as integrity of IoT providers.

Technology adoption has been found to be significantly influenced by trust (Gefen 2003). Because it can address two crucial IoT technological conditions—the concerns of vulnerability and uncertainty—trust plays a crucial part in the acceptance of Internet of Things devices. Additionally, it has been demonstrated that the acceptance of IoT favourably relates to the degree of trust that customers have (Khan 2016). Understanding trust-related variables is necessary to increase customer trust towards the adoption of IoT technologies. Theoretically, because of the dynamic nature of IoT environments, resource constraints, and the expense of security needs, this relationship is complicated (Koien, 2011).

Some of the implications to address the issue of trust thereby ensuring that the trust factor gains its due significance include specific recommendations for IoT providers. Even though security and privacy are among the top concerns for earning the trust of customers, they are still difficult problems in IoT technology. Subsequently, the product must seem beneficial to users with apparent advantages, features, and capabilities that prioritise the user experience in order to increase consumer confidence in IoT acceptance and expand the market.

IoT technology also needs to meet standards, be dependable and trustworthy, and adhere to certain user criteria and expectations in order to gain users' trust. In general, device performance and reliability—even in a harsh environment—are crucial to ensuring consumer trust in IoT devices.

According to Falcone and Sapienza (2018), users may not give high trust levels for a variety of reasons, including worry that a task will not be completed to their satisfaction or at all, or that harm may be done. Therefore, in order for an IoT device to be trusted and approved by consumers, it needs to include a number of features, like encryption and usefulness. Developers designing the devices should focus on sought after features of IoT devices, privacy and security measures built into the devices rather than an additional buy to make the devices more protected. Consumers should be mindful of privacy and security risks associated with IoT and smart home devices. They can mitigate these risks by understanding device permissions, opting for reputable brands with strong data security measures, and regularly updating device software to protect against vulnerabilities.

An assurance of maintaining the privacy and security of personal information, protection against hackers and identity threats as well as ethical use of data will enable the IoT providers to gain the trust of potential consumers leading to a trustworthy acceptance of IoT devices.

8.3.4 Level of education of consumers

Bearing in mind the moderating role of level of education in this model, IoT manufacturers should prioritize ease of use and emphasize practical benefits, particularly for products targeting educated audiences. The marketing focus needs to be steered towards educated consumers as their level of education plays a key role in moderating the impact of perceived usefulness and perceived ease of use on their intention to buy. Instead of generalising the advertising campaigns to a generic wider population, advertising campaigns can highlight features that resonate with educated consumers, such as efficiency and compatibility, to maximize their perceived usefulness and ease of use.

8.3.5 Hedonic motivation

While hedonic motivation has a significant and negative impact on intention to buy/use IoT devices, IoT providers should be cautious about overemphasizing hedonic aspects in marketing or product design unless their devices are explicitly intended for entertainment purposes. Misaligned messaging could result in unmet expectations and decreased consumer interest. It may be more effective to focus on communicating the functional and practical benefits of IoT devices rather than trying to position them as sources of enjoyment. Simplifying setup processes and improving usability can help mitigate the negative perception that IoT devices are complex or effort-intensive, which may appeal to consumers who value both hedonic and utilitarian motivations.

8.3.6 Perceived costs

With a negative correlation and impact on intention to buy/use IoT devices, perceived costs play an important role in influencing a consumer's decision to use IoT devices. In order to overcome this barrier, IoT providers should consider strategies to make their products more affordable, such as offering payment plans, subscription models, or bundling options. Transparent pricing and cost breakdowns can also alleviate concerns and demonstrate the long-term value of investing in IoT devices.

Companies should focus on effectively communicating the benefits of IoT devices in terms of cost savings, efficiency, or enhanced quality of life. For example, emphasizing how smart energy systems can reduce electricity bills or how security systems provide peace of mind can help justify the perceived costs.

Although level of income did not moderate the consumer behaviour towards IoT devices, a negative impact of perceived costs indicated the price sensitivity towards these devices. IoT providers might benefit from offering entry-level or budget-friendly products tailored to price-sensitive segments. This approach can help increase accessibility and reduce the perception that IoT devices are exclusively for high-income or luxury markets.

Simplifying device setup, offering robust customer support, and designing intuitive user interfaces can reduce the perceived time and effort associated with adopting IoT devices. Providing clear guides, tutorials, or customer service channels can help alleviate these non-monetary costs.

While IoT technology offers significant potential benefits, perceived costs—both monetary and non-monetary—can create substantial barriers to adoption. Addressing these concerns through cost-reduction strategies, effective value communication, and user-friendly design will be essential for IoT providers aiming to expand their market penetration and consumer base.

In conclusion, this research highlights the multifaceted factors influencing IoT device acceptance. While practical utility and favorable attitudes are critical, addressing costs, risks and trust issues remains essential. The unexpected findings on hedonic motivation and social influence invite additional research to refine theoretical frameworks and practical strategies while for researchers, these findings open the door for further exploration of the nuanced dynamics of IoT acceptance as discussed in future research section in 8.7 later.

8.4 Contribution

8.4.1 Theoretical Contribution

Empirical contributions IoT devices technology is a relatively new and evolving phenomenon for the UK and the majority of western European countries (Diniz et al., 2011). This thesis contributes to contemporary research as it provides a perspective of UK consumer perceptions of IoT devices based upon an empirical study conducted in the UK in 2023-24. Adoption of IoT devices is dependent upon the widespread technology adoption by UK consumers as a first step in the process although consumer-oriented technology has become widely adopted and an integral part of, and embedded in today's society (Drucker, 2011).

The key empirical contributions are summarised are under with a detailed explanation.

a) Role of attitude which has been overlooked in the recent technology adoption models such as TAM and its extensions, was found to be a significant contributing factor towards intention to buy/use IoT devices in line with TRA and TPB. The key factors affecting the formation of attitude include psychological variables such as innovativeness, self-efficacy and positive self-image. Theoretical models like the Technology Acceptance Model (TAM) and its extensions (TAM2, TAM3, UTAUT, and UTAUT2) have increasingly shifted their focus toward utilitarian factors such as perceived usefulness and perceived ease of use, often at the expense of considering the component of attitude. These models have prioritized direct predictors of behavioural intention while bypassing the role of attitude as a mediator or independent construct. However, the findings of this study underscore the significant influence of attitude on intention to buy or use IoT devices, thereby reaffirming the relevance of foundational theories such as the Theory of Reasoned Action (TRA) and the Theory of Planned Behaviour (TPB), which suggested attitude as a central determinant of behavioural intention.

   The significant role of attitude in this study suggests that recent technology adoption models should reconsider its exclusion or marginalization. While TAM and its extensions have focused on direct utilitarian predictors, the reintroduction of attitude as an independent or mediating variable can provide a more comprehensive understanding of consumer decision-making. Attitude captures the evaluative and affective dimensions of consumer behaviour that utilitarian factors alone may overlook.

The findings align with TRA and TPB, which emphasize attitude as a critical antecedent of behavioural intention. This underscores the enduring relevance of these foundational theories and their potential utility in studying emerging technologies such as IoT. Future theoretical advancements could explore how the constructs of TRA and TPB—such as attitude, subjective norms, and perceived behavioural control—interact with the utilitarian dimensions emphasized in TAM-based models.

b) The impact of perceived ease of use on perceived usefulness as found in TAM has been challenged by the results of this study, which concluded that perceived features of IoT devices such as compatibility, mobility and automation are more relevant when perceiving the usefulness of these devices compared to how easy consumers perceive the operation of these devices to be. This could also be an indication of the embedding of technology in today's society leading to a higher level of self-efficacy when it comes to new devices.

c) Perceived usefulness remains a significant contributor of intention to buy/use IoT devices in line with previous studies which was studied as relative advantage having an impact on attitude as per TPB, performance expectancy in UTAUT and UTAUT2 and utilitarian outcomes as per MATH.

d) Theoretical models such as UTAUT and UTAUT2, along with earlier frameworks like the Theory of Reasoned Action (TRA), the Theory of Planned Behaviour (TPB), and extensions of the Technology Acceptance Model (TAM2, TAM3), have consistently emphasized the positive role of social influence in shaping behavioural intentions. Social influence, studied as subjective norms (TRA, TPB, TAM extensions) or normative beliefs (Model of Adoption of Technology in Households, MATH), is predicated on the assumption that individuals' behaviours are heavily influenced by the opinions and behaviours of others, particularly in the context of adopting new technologies. However, the findings of this study challenge these established theories by demonstrating a weak and non-significant relationship (standard estimate: -0.063) between social influence and the intention to buy or use IoT devices.

This negation of the theoretical assumption can be attributed to the specific characteristics of IoT devices and their market dynamics. Unlike other consumer technologies where adoption may be visibly influenced by peer behaviour (e.g., smartphones or social media platforms), IoT devices are often perceived as utilitarian tools designed to fulfil specific functional needs (e.g., home automation, energy efficiency, or security). Consequently, individual decision-making in this context may rely more on personal evaluations of utility, ease of use, and perceived cost than on social conformity or peer endorsement.

Additionally, IoT devices often operate in private or semi-private contexts, such as homes or personal spaces, which limits the visibility of their adoption and diminishes the impact of normative social pressures. This finding suggests a contextual variability in the role of social influence, underscoring the need to refine existing models to account for technology-specific factors. The results encourage future theoretical work to explore how the visibility, social desirability, and utility of different technologies moderate the influence of social norms on adoption intentions

e) Hedonic motivation, defined as the enjoyment or pleasure derived from using a technology, has been a central construct in models such as UTAUT2, where it is posited to positively influence behavioural intentions, particularly in the context of consumer technologies. Theoretical frameworks like TAM extensions and MATH also highlight the importance of hedonic attributes, such as entertainment value and aesthetic appeal, in driving adoption. However, the results of this study reveal a significant negative relationship (standard estimate: -0.445) between hedonic motivation and the intention to buy or use IoT devices, contradicting the positive impact proposed by these theories.

This unexpected finding suggests that the role of hedonic motivation may be context-dependent and less relevant for utilitarian technologies like IoT devices, which prioritize functionality and efficiency over entertainment or pleasure. Unlike technologies designed primarily for enjoyment, such as gaming consoles or streaming platforms, IoT devices are often adopted for their practical benefits, such as automation, energy savings, or security enhancements. When consumers focus on these utilitarian aspects, excessive emphasis on hedonic features may lead to perceptions of frivolity or misalignment with their expectations, thereby diminishing adoption intentions.

Moreover, the negative relationship between hedonic motivation and intention to adopt IoT devices could also reflect the complexity and learning curve associated with these technologies. For some consumers, the effort required to set up and use IoT devices may overshadow any perceived enjoyment, leading to frustration or dissatisfaction. This finding calls into question the universality of hedonic motivation as a driver of technology adoption and highlights the need for more nuanced theoretical models that consider the interplay between hedonic and utilitarian factors. Other factors such as perceived ease of use, perceived costs have remained consistent within the model but with differing importance.

f) Level of education is an important moderator of perceived usefulness and perceived ease of use impacting the intention to buy/use IoT devices. Other moderators such as age, gender which were significant moderators in UTAUT and UTAUT2, and age and level of income in MATH, were found to be insignificant as per this study. The majority of UK consumers now perceive technology generally, and smart phones specifically, are regarded as easy to use and useful independent of age, gender or level of income which is contrary to previous research findings (Carow & Staten, 1999; Koenig-Lewis et al., 2010; Riquelme & Rios, 2010; and Rouibah, 2009).

g) The amount of literature available focusing on technology acceptance is vast and often complex. Prevalence of several models developed and tested in different environments was beneficial on one hand but lead to confusion on the other. This research aimed to <u>build a model</u> of technology acceptance specifically for the new and upcoming AI/IoT technology, thereby strengthening the conceptual knowledge of existing technology adoption theories. With empirical evidence, this research contributed to the development of a technology acceptance model for Internet of Things (TAM-IOT) extending the significance of factors from historical theories as well as added factors of perceived costs, social influence and hedonic motivation as negatively affecting the intention to buy/use whereas attitude, perceived ease of use, perceived usefulness, trust in IoT providers as positively affecting this intention.

h) A wide range of factors have been studied in the past leading to chaotic abundance of positions in the field of technology adoption (Park et al. 2017). This research not only studied the impact of various historical and new factors on attitude toward IoT devices but also aimed to create a <u>hierarchy of factors</u>. The proposed model organised nearly 17 factors into categories leading to a more cohesive understanding of technology acceptance, including 7 of the factors directly impact the intention to buy/use IoT devices. This hierarchy found perceived usefulness, attitude and trust in IoT providers as the most significant in the hierarchy of factors contributing to the intention to buy/use IoT devices. Social Influence remained one of the lowest in the ranking of factors influencing the intention to buy/use IoT devices, indicating a negative impact in consumer behaviour towards the IoT technology.

i) Literature review suggested that technology acceptance model developed by a pioneering researcher Davis in 1989 and extension to this model focused on technology acceptance in organizational settings whereas technology not being confined to workspaces in the current day and age and transitioning into consumer's home space showcased the involvement of technology in all spheres of human lives. Although the MATH model aimed to focus on the technology adoption within households, The focus of the study was the then new technology of a Personal Computer which is significantly different to today's technology as discussed earlier in peculiarity of IoT devices. Technology such as IoT devices has now become the way of life, and it was important to identify why and how the adopters permit the use of such IoT devices in their personal life. The resulting model of this research is a unique model with applicability in the home environment.

8.4.2 Practical and Methodological contribution

This thesis contributes to theory development of consumer behaviour, consumer purchase behaviour and technology acceptance through the use of TAM with additional features added from empirical studies and exploratory research findings. Research findings are then included within the existing body of knowledge including a methodical contribution based upon a mixed methods approach. However, IoT devices are still an upcoming phenomenon (Baiyere et. al 2020) and, as a result, the existing theoretical and methodological body of knowledge on this phenomenon continues to emerge. In addition, this research has implications for the theoretical understanding of how consumers currently assess the evolving IoT devices phenomenon. although the TAM was originally developed to assess technology adoption in a business environment, TAM has been widely used to assess technology adoption in both a consumer and a business environment (Yousafzai et al., 2007). Whilst the original TAM is easy to apply in different environments with predictive results, it does not provide sufficient depth of understanding of the drivers of consumer behaviour that lead to technology acceptance without the inclusion of additional constructs such as perceived risks and trust in IoT providers which adds to the theoretical assessment of UK consumer perceptions of intention to buy/use IoT devices providing empirical evidence.

Quantitative methods of assessment have been mainly used in previous technology acceptance research (Amoroso & Magnier-Watanabe, 2012; Arvidsson, 2014; Liebana Cabanillas et al., 2014; Rouibah, 2009; Shin, 2009; Shin et al., 2014; Swilley, 2010). This research extended the application of theory through the use of a mixed method research (Saunders, Lewis and Thornhill, 2012). Semi-structured interviews used as a preliminary data collection method to collate qualitative data for identifying relevant factors for the study followed by a questionnaire used to gather quantitative data. The use of two separate research instruments produces rich and intricate data that may not have been obtained from the use of a single research instrument (Bryman, 1992; Hussey & Hussey, 1997). The use of mixed methods approach provides a new theoretical perspective for exploring UK consumer perceptions of IoT devices as compared to the predominant use of quantitative methods in previous research using TAM and derivatives according to Yousafzai et al. (2007). The use of multiple research methods is a valuable approach to exploring consumer perspectives of the acceptance of IoT devices with firstly semi structured interviews that provided strong foundations for exploring further quantitative data through the use of questionnaire.

The demographic uniqueness of UK adopters was accounted for in this research leading to the development of UK specific model and providing grounds for future research on applicability of this model in other geographical areas and thereby a comparison between countries will also be possible. With partial validity of the overall model, it can be suggested that the groundwork for a future applicable model has been laid by this study, which will provide an insightful journey into the understanding of other factors affecting the acceptance of technology within the UK and worldwide.

This research intended to examine the role of perceived risk on privacy and security on consumer's mindsets and their attitude. An in-depth analysis of consumer's perception of these risks and expectations from the IoT providers enabled the development of practical and theoretical implications, which includes the parameters of provisions to ensure privacy and security of consumers of IoT devices aiding the providers to target the consumers to access a wider scale of the market than prevalent.

The rate at which the technology has developed leading to palm top computers in terms of smart devices we have, validated the need for a modern theory to understand the behaviour of these consumers. This study provides the understanding of these behaviours which has challenged the significant findings from previous models and that require further research.

8.5 Limitations of the study

Though this research study has highlighted different concepts and aspects relating to the implication and use of IoT devices within a smart home environment within the UK, there are certain limitations which hampered the outcome of the study.

1. The proposed model included measuring the relationship of psychological variables on attitude formation, two studying the relationship of perceived risks on attitude and thirdly the impact of perceived features of IoT devices. Each of the latent variables are subject to numerous issues. The selection of innovativeness, self-efficacy and personal self-image as factors affecting the latent variable underwent a critical analysis and selection process out of the pool of other variables such as ethics, beliefs, lifestyle etc. indicating there are no issues with misinterpretation of the questions asked (passing the Cronbach alpha measures) or the conceptual framework. On the other hand, developing an attitude is a long-term process whereas this study focussed on the current attitude towards the IoT devices, which may be owned or not by the respondents. The measurement items of attitude ranged from 3 to 5 items in previous studies (Davis, 1985) along with other complexities where there might be significant divergence between those publicly declared and privately held attitudes indicating attitudes can only be inferred. Together these conditions influenced the impact of these variables contributing to the overall path between the two variables. There are numerous problems in eliciting psychological variables, which may restrict the fit statistics arising from the study of this sample. This study focussed on measuring these complex variables using self-ratings, which may reflect an individual's feelings at the

moment in time however data collected using a time-series with many measurement points may indicate different results

2. One of these limitations of the study could be the complexities of measuring features such as compatibility, mobility, and automation of IoT devices. Considering the relative newness of these devices, the respondents were limited to a very small number of items to determine their perception about these complex features, where they may still be uncovering the potential functions, their devices could perform.

3. Although the number of items used to measure the variables PEOU and PU was minimised to 3 items due to a larger number of variables in this study, whereas both of these variables were studied using 10 items in TAM (Davis, 1985), this model proves that some acceptable fit indices could be achieved with the lower number of items too. However, it would be advisable to increase the number of items for measuring these variables for more effective results.
4. A significant number of factors were not included in this study as listed in chapter 3 such as individual's beliefs, which could have a significant impact on the behavioural intention of accepting IoT devices, limiting the scope of this research to only the selected factors of the study. Factors not studied in this research due to resource limitations need to be explored further, to develop an integrated model of technology acceptance of IoT devices.
5. Although the use of IoT devices within the smart home environment is relatively new in the UK, the users may not be accustomed to using this technology. Their habit is being ignored from the study's conceptual model. Nevertheless, as time passes and people within the UK and worldwide get habituated with this technology, future research studies can easily identify their buying habits and intention (Venkatesh et al. 2012).
6. Due to the research being quantitative nature using a positivist approach, respondent could only choose an option from the 5-point Likert scale rather than the reasons behind their choice, this can be explored further using an

interpretivist methodological approach with smaller sample groups to add more qualitative data to this research area.

7. This research's aims were confined to measuring the intention to buy/use or use selected IoT devices within a smart home environment. The study did not investigate the actual usage of these devices. Intention to buy/use may not always result in actual usage of these devices and hence behavioural intention may be different to actual usage behaviour. Subsequent usage behaviour can be one of the key components for future research.
8. By the application of the convenience sampling technique, the study focused only upon the customers of two major areas of United Kingdom; however a fully representative sample of UK is questionable and thus, the perspectives of the customers in the other geographical areas with a fair representation could not be evaluated which might have a negative impact over the generalisability of the research outcome. Similar studies can be carried out with wider samples from other areas of the UK and the world.

9. Although, the sample chosen for this study's purpose attempted to be representative of all ages, gender, level of education and level of income, it is also a notable limitation as the outcomes generated are mainly associated with the perspectives of these people who could complete the survey online and not of other population segments who could not access this survey and hence their views could not be included in this study. No investigation has been made upon the technology acceptance of the people belonging to other income groups, genders, different educational backgrounds and ages and technological experiences. Thus, the generalisability of the outcomes is affected.

10. Furthermore, the study does not follow a longitudinal design; instead, it is based on cross-sectional data and information and hence the usability and validity of these outcomes over the long-term technological acceptance of these devices may be questioned. Although as time passes on, consumers' likes, preferences, awareness, and views regarding the use and applicability of

technology might vary significantly, which needs to be kept in mind when doing this specific analysis (Bhattacherjee 2012).

11. Moreover, this study focussed on selected IoT devices within a smart home environment and ignored the buyer’s intention to buy/use or use other significant smart devices that are evolving within the smart home environment. Nonetheless these devices are also being innovated in other spheres of a consumer’s life and hence further studies can be undertaken to investigate user’s behavioural intentions towards these new and upcoming smart devices.

To summarise, this study may have used too small number of measures to capture the multidimensional variables and hence the unreliability reflects the complexity of these variables for e.g., measurement of attitude, psychological variables or IoT features such as automation. With these variables being personal or subjective opinions, better measurement would lead to better understanding of the respondent’s opinions.

8.6 Future research opportunities

Technology is believed to be easy to use by UK consumers who find IoT devices is easy to use. In addition, technology is widely adopted by a large number of UK consumers irrespective of age, gender and educational qualifications. This is in contrast to previous research that identifies these demographic characteristics are key influences of perceived ease of use and thereby the intention to buy/use (Agarwal & Prasad, 1999; Kim et al., 2010; Phan & Daim, 2011; Shin, 2009). Widespread UK adoption of consumer-based technology (IDC, 2020; Ling, 2004) and self-service technology (Bolton & Saxena-Iyer, 2009; Curran & Meuter, 2005) may explain why these individual consumer characteristics are no longer an influence on intention to buy/use IoT devices. The significant moderation impact of education is worth noting in this research. Investigating why education consistently moderates these relationships while other sociodemographic variables do not would be a vital area for future research.

Future research can use the same research methods and questions with other UK consumers to explore perceived ease of use of IoT devices to establish if these research findings are consistent with the wider UK consumer population. As a limited number of demographic questions are used to explore the impact on intention to buy/use IoT devices, future research can also explore UK consumer perceptions of using of IoT devices through the inclusion of alternative demographic characteristics such as ethnic origin, marital status etc. that may be more appropriate for exploring UK consumer perceptions of the IoT devices acceptance. This study can provide the foundations for exploring other potential moderators, such as digital literacy, technological familiarity, prior IoT device experience, or cultural factors, to better understand the dynamics of technology adoption.

Since this research was totally focussed on a sample of respondents from the UK, in addition, future research can further explore this change in UK consumer perception of buying of technology within the affective human psychology response framework in order to ascertain if these research findings apply in a broader context within the UK but also across other geographical areas and countries.

Ownership of smart devices ranging from smart speakers to smart furniture was one of the key questions asked to study the perceptions of consumers. 73% of questionnaire respondents indicated owning a smart device whilst 22% of the respondents noted no ownership of smart devices. As new IoT devices enter into the market, future research can explore the ownership rates to establish if these research findings are consistent with the wider UK consumer population in future times. In addition, future research can explore technology acceptance of other technological devices generally but also with specific IoT devices within and outside the home settings, which would provide further consumer perspectives of the IoT devices buying behaviour.

A follow up study to assess the conversion of intention to buy into actual behaviour may be undertaken in future. The dependant variable being intention to buy/use IoT devices could be extended by a longitudinal study to assess the actual behaviour of respondents, focussing on the peculiar functionalities of IoT devices and how they are effective is meeting the consumer expectations of these devices.

To address the limitations of this study, which might have resulted from a lower sample size, a comparable investigation with a bigger sample size can be conducted in order to further establish the model based on additional data.

This research studied the impact of a series of relationships between various factors such as perceived risks and psychological variables on formation of attitude, the same factor's impact can be studied directly on intention to buy/use IoT devices. Hence a range of diverse relationships can be studied including the 17 factors highlighted in this study.

It is noteworthy that the aims of this research focussed on IoT devices within the home environment. It may be argued that consumer behaviour related to devices used outside this smart home environment may be significantly differ to the findings of this study. Hence future study can be extended to IoT devices outside the smart home environment such as driverless cars etc.

The negative relationship between perceived cost and intention to adopt IoT devices aligns with findings in broader technology adoption literature, where cost-related concerns frequently emerge as significant barriers. However, future research could delve deeper into specific cost dimensions (e.g., hardware cost vs. service fees) to better understand their respective impacts. Additionally, exploring how cost perceptions vary across demographic groups, such as income levels or geographic regions, could provide more nuanced insights for targeted strategies.

8.7 Conclusion

This study used a combination of elements from historic models in order to develop a Technology Acceptance Model for Internet Of Things devices (TAM-IOT) by studying several interconnected relationships between these factors.

Considering the status of ownership of IoT devices within the UK, this research focussed on acceptance of these devices by consumers who either already own one or more IoT devices within their home or may be prospective buyer/users of these devices. A further classified studies based on behaviours of categories of adopters such as early adopters, early majority, late majority and the laggards remain under the scope of future research.

With increased threat and over privacy and security risks associated with IoT devices, and consumer's attitude towards IoT devices affected by this perceived risk, this study provided several suggestions for the marketers, providers as well as the consumers of these IoT devices to develop, convey awareness and follow usage guidance in effective use of these devices. This would lead to development of a healthy relationship between the businesses and consumers as well as enhancement of consumer's trust in IoT providers.

An in-depth review of literature review found existence of ample of studies undertaken to understand the acceptance of smart home devices (Magara, et. al., 2024; Kraemer and Flechais, 2018) using selected factors, however this study provided a greater coverage of these factors examining IoT devices (San-Martín and Herrero, 2012). Thus, this study fulfilled its aim to study how various factors influence the behavioural intention of consumers in the UK in relation to the acceptance of IoT devices within a smart home environment.

Although the study is a step closer to finding answers to the inquisitiveness of technology acceptance, consumer behaviour towards new technologies in new context prevails to remain in future times to come, with the development of new technologies in new context, the research journey is bound to be ongoing to add new knowledge to the field of technology acceptance.

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APPENDICES

Appendix 1 – IoT definitions

Since the definition of the IoT is still evolving because technology and the ideas behind it change themselves over time, the definitions that follow provide illustrative concept definitions rather than tightly worded definitions.

A non-exhaustive list of definitions about the IoT.

#	Definition	Source
1	The Internet of Things (IoT) refers to a distributed network connecting physical objects that are capable of sensing or acting on their environment and able to communicate with each other, other machines or computers. The data these devices report can be collected and analysed in order to reveal insights and suggest actions that will produce cost savings, increase efficiency or improve products and services.	European Parliament (May 2015). The Internet of Things: Opportunities and challenges. WEB
2	The Internet of Things (IoT) is the network of physical objects or "things" embedded with electronics, software, sensors, actuators, and connectivity to enable objects to exchange data with the manufacturer, operator, and/or other connected devices.	Internet Engineering Task Force (IETF) (Jan 2022). The Internet of Things at the IETF. WEB
3	A global infrastructure for the information society, enabling advanced services by interconnecting (physical and virtual) things based on existing and evolving interoperable information and communication technologies.	International Telecommunication Union (ITU) (Jun 2012). Recommendation ITU-T Y.2060: Overview of the Internet of Things. WEB
4	The Internet of Things (IoT) describes physical objects (or groups of such objects) that are embedded with sensors, processing ability, software, and other technologies that connect and exchange data with other devices and systems over the Internet or other communications networks.	Wikipedia (Jan 2022). Internet of Things. WEB
5	The Internet of Things (IoT) is the network of devices such as vehicles and home appliances that contain electronics, software, actuators, and connectivity which allows these things to connect, interact and exchange data.	Wikipedia (Jan 2019). Internet of Things. WEB

A non-exhaustive list of definitions about the IoT.

#	Definition	Source
6	The Internet of Things (IoT) describes the network of physical objects — "things" — that are embedded with sensors, software, and other technologies for the purpose of connecting and exchanging data with other devices and systems over the internet. These devices range from ordinary household objects to sophisticated industrial tools.	Oracle (Nov 2020). What Is the Internet of Things (IoT)? WEB
7	A dynamic global network infrastructure with self-configuring capabilities based on standard and interoperable communication protocols where physical and virtual "things" have identities, physical attributes, and virtual personalities and use intelligent interfaces, and are seamlessly integrated into the information network.	European Research Cluster on IoT (IERC) (2014). Internet of Things. WEB
8	The Internet of Things (IoT) are connected objects and devices (aka "things") that are equipped with sensors, software, and other technologies that allow them to transmit and receive data – to and from other things.	System Analysis Program Development (SAP) (2016). What is the Internet of Things (IoT)? WEB
9	Internet of Things is an integrated part of Future Internet and could be defined as a dynamic global network infrastructure with self configuring capabilities based on standard and interoperable communication protocols where physical and virtual "things" have identities, physical attributes, and virtual personalities and use intelligent interfaces, and are seamlessly integrated into the information network. In the loT, "things" are expected to become active participants in business, information and social processes where they are enabled to interact and communicate among themselves and with the environment by exchanging data and information "sensed" about the environment, while reacting autonomously to the "real/physical world" events and influencing it by running processes that trigger actions and create services with or without direct human intervention. Interfaces in the form of services facilitate interactions with these "smart things" over the Internet, query and change their	Cluster of European Research Projects on the Internet of Things (CERP-IoT) (2009). Internet of Things: Strategic Research Roadmap. WEB

A non-exhaustive list of definitions about the IoT.

#	Definition	Source
	state and any information associated with them, taking into account security and privacy issues.	
10	The network of devices that contain the hardware, software, firmware, and actuators which allow the devices to connect, interact, and freely exchange data and information.	National Institute of Standards and Technology (NIST) (Feb 2020). Glossary, Ref. NIST SP 800-172. WEB
11	The Internet of Things, or IoT, is a system of interrelated computing devices, mechanical and digital machines, objects, animals or people that are provided with unique identifiers (UIDs) and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction.	Alexander S. Gillis, IoTAgenda (Jan 2021). What is Internet of Things (IoT)? WEB
12	The Internet of Things (IoT) is the network of physical objects accessed through the Internet, as defined by technology analysts and visionaries. These objects contain embedded technology to interact with internal states or the external environment. In other words, when objects can sense and communicate, it changes how and where decisions are made, and who makes them.	Cisco (Jun 2014). The Internet of Things (IoT): An Overview. WEB
13	A network of items — each embedded with sensors — which are connected to the Internet.	R. Minerva for IEEE IoT Magazine (Nov 2015). Towards a definition of the Internet of Things (IoT). WEB
14	Internet of Things refers to the networking capability that allows information to be sent to and received from objects and devices (such as fixtures and kitchen appliances) using the Internet.	Merriam-Webster (Sep 2017). Internet of Things. WEB
15	The Internet of Things (IoT) is the network of physical objects that contain embedded technology to communicate and sense or interact with their internal states or the external environment.	Gartner Glossary (Dec 2019). Internet of Things (IoT). WEB
16	In a nutshell, the Internet of Things is the concept of connecting any device (so long as it has an on/off switch) to the Internet and to other connected devices. The IoT is a giant network of connected	Jen Clark, IBM (Nov 2016). What is the Internet of Things (IoT)? WEB

A non-exhaustive list of definitions about the IoT.

#	Definition	Source
	things and people — all of which collect and share data about the way they are used and about the environment around them.	
17	The Internet of Things (IoT) is a set of tools, techniques and resources that make ordinary inanimate objects come alive, develop sensory and communications capacities to enhance their core function or purpose, and through cognitive computing processes, establish an understanding of their context and ecosystem that bestows a primitive rationality.	Anthony Behan, IBM (Nov 2016). No really, what is the Internet of Things? WEB
18	Devices of all sorts [...] equipped with sensors and actuators, connected to the Internet, allowing them to monitor their status or the environment, to receive orders or even to take autonomous action based on available information.	European Commission (EC) (Dec 2015). Monitoring the Digital Economy and Society. WEB
19	The interconnection via the Internet of computing devices embedded in everyday objects, enabling them to send and receive data.	Office of Communications (Ofcom) (Mar 2016). Internet of Things (IoT). WEB
20	The IoT is a suite of technologies and applications that equip devices and locations to generate all kinds of information — and to connect those devices and locations for instant data analysis and, ideally, "smart" action. Conceptually, the IoT implies physical objects being able to utilize the Internet backbone to communicate data about their condition, position, or other attributes.	Smart buildings: How IoT technology aims to add value for real estate companies (Apr 2016). Surabhi Kejriwal and Saurabh Mahajan, Smart buildings: How IoT technology aims to add value for real estate companies, Deloitte University Press. WEB
21	An infrastructure of interconnected objects, people, systems and information resources together with intelligent services to allow them to process information of the physical and the virtual world and react.	ISO/IEC JTC 1 WG5 AHG1 (Jul 2014). Internet of Things (IoT). WEB
22	The Internet of Things (IoT) is a system of interrelated devices connected to a network and/or to one another, exchanging data without necessarily requiring human-to-machine interaction. In other words, IoT is a collection of electronic devices that	Congress.gov (Feb 2020). The Internet of Things (IoT): An Overview. WEB

A non-exhaustive list of definitions about the IoT.

#	Definition	Source
	can share information among themselves. Examples include smart factories, smart home devices, medical monitoring devices, wearable fitness trackers, smart city infrastructures, and vehicular telematics.	
23	The concept to allow Internet-based communications to happen between physical objects, sensors, and controllers. The network of physical objects — devices, vehicles, buildings, and other items that are embedded with electronics, software, sensors, and network connectivity, which enables these objects to collect and exchange data.	Analog Devices (2016). IoT DEFINITIONS. WEB
24	Sensors and actuators embedded in physical objects are linked through wired and wireless networks, often using the same Internet Protocol (IP) that connects the Internet.	IoT Analytics, McKinsey (Dec 2014). Why the Internet of Things is called Internet of Things: Definition, history, disambiguation. WEB
25	The Internet of Things is a paradigm where everyday objects can be equipped with identifying, sensing, networking and processing capabilities that will allow them to communicate with one another and with other devices and services over the Internet to accomplish some objective. Ultimately, IoT devices will be ubiquitous, context-aware and will enable ambient intelligence.	Andrew Whitmore, Anurag Agarwal and Li Da Xu (2015). The Internet of Things — A survey of topics and trends. WEB
26	Internet of Things (IoT) is a global network and service infrastructure of variable density and connectivity with self-configuring capabilities based on standard and interoperable protocols and formats which consists of heterogeneous things that have identities, physical and virtual attributes, and are seamlessly and securely integrated into the Internet.	S. Tarkoma and A. Katasonov (Sep 2011). Internet of Things Strategic Research Agenda (IoT–SRA). WEB
27	Objects with computing devices in them that are able to connect to each other and exchange data using the internet.	Cambridge Dictionary (Jul 2016). The Internet of Things. WEB
28	The Internet of Things (IoT) is a cyber-physical ecosystem of interconnected sensors and actuators, which enable intelligent decision making.	European Union Agency for Cybersecurity (ENISA) (Jun 2018). Internet of Things (IoT). WEB

A non-exhaustive list of definitions about the IoT.

#	Definition	Source
29	A network which can collect information from the physical world or control the physical world objects through various deployed devices with capability of perception, computation, execution and communication, and support communications between human and things or between things by transmitting, classifying and processing information.	China Communication Standards Association (CCSA) (2011). Communication standard technical report. WEB
30	The Internet of Things (IoT) refers to a vast number of "things" that are connected to the internet so they can share data with other things — IoT applications, connected devices, industrial machines and more. Internet-connected devices use built-in sensors to collect data and, in some cases, act on it. IoT connected devices and machines can improve how we work and live. Real-world Internet of Things examples range from a smart home that automatically adjusts heating and lighting to a smart factory that monitors industrial machines to look for problems, then automatically adjusts to avoid failures.	SAS (Jan 2022). What is The Internet of Things (IoT). WEB
31	IoT is a network of networks of uniquely identifiable endpoints (or "things") that communicate without human interaction using IP connectivity — whether locally or globally. The IoT brings meaning to the concept of ubiquitous connectivity for businesses, governments, and consumers with its innate management, monitoring, and analytics. With uniquely identifiable endpoints integrated throughout networks, operational and location data, as well as other such data, it is managed and monitored by the intelligent or traditional embedded system that has been enhanced and made part of IoT solutions and applications for businesses, governments, and consumers. IoT is composed of technology-based connected solutions that allow businesses and governments to gain insights that help transform how they engage with customers, deliver products/services, and run operations.	D. Lund, C, MacGillivray, V. Turner and M. Morales for International Data Corporation (IDC) (May 2014). Worldwide and Regional Internet of Things (IoT). WEB
32	IoT is simply the point in time when more things or objects were connected to the Internet than people.	D. Evans (2011). Cisco IBSG. WEB

A non-exhaustive list of definitions about the IoT.

#	Definition	Source
33	Put very simply, the IoT is when everyday products such as refrigerators, watches, cars, speakers and coffee machines that are connected to internet and to one another through a network, speak to each other. The IoT is about information technology that can gather its own information and do things with it, often using artificial intelligence (AI) which can analyse the information, identify patterns and respond quickly or even predict scenarios.	M. White, P. Mennie and R. Chudzynski for PricewaterhouseCoopers (PwC) (Oct 2020). Regulating the Internet of Things in the UAE. WEB
34	The "Internet of Things" is the ubiquitous connection of people, things and machines. This connection is intended to produce a variety of new goods and services. Products, means of transport or tools are expected to "negotiate" within a virtual marketplace regarding which production elements could best accomplish the next production step. This would create a seamless link between the virtual world and the physical objects within the real world.	D. Wegener of Siemens for PricewaterhouseCoopers (PwC) (Dec 2014). Industry 4.0 — Opportunities and Challenges of the Industrial Internet. WEB
35	The Internet of Things (IoT) is the intelligent connectivity of smart devices by which objects can sense one another and communicate, thus changing how, where and by whom decisions about our physical world are made.	B. Barnes, Cisco (May 2015). MC2 Conference. WEB
36	The term IoT describes a network of objects in your home or office that have sensors and software that enables them to communicate with each other using the internet. They are usually traditional, everyday objects such as vacuum cleaners, air conditioners and thermostats, TV sets, and refrigerators.	Alliance for Internet of Things Innovations (AIOTI) (Jan 2022). The Internet of Things and Its Revolutionary Power. WEB
37	Broadly speaking, the IoT is an expansion of the global infrastructure through existing and evolving interoperable information and communication technologies. It incorporates the interconnection of physical and virtual systems to enable new and autonomous capabilities.	National Security Telecommunications Advisory Committee (NSTAC) (Nov 2014). Industrial Internet Scoping Report. WEB
38	The Internet of Things is a plethora of technologies and their applications that provide means to access and control all kinds of ubiquitous and uniquely identifiable devices, facilities, and assets. These include equipment that has inherent intelligence,	Honbo Zhou (Mar 2013). The Internet of Things in the Cloud: A Middleware Perspective. WEB

A non-exhaustive list of definitions about the IoT.

#	Definition	Source
	such as transducers, sensors, actuators, remote mobile devices, industrial controllers, HVAC (heating, ventilation, and air-conditioning) controllers, home gadgets, surveillance cameras, and others, as well as externally enabled things or objects, such as all kinds of assets tagged with RFID, humans, animals, or vehicles that carry smart gadgets, and so forth. Communications are via all sorts of long-and short-range wired or wireless devices in different kinds of networking environments such as Intranet, extranet, and Internet that are supported by technologies such as cloud computing, SaaS, and SOA and have adequate privacy and security measures, based on regulated data formats and transmission standards. The immediate goal is to achieve pervasive M2M connectivity and grand integration and to provide secure, fast (real time), and personalized functionalities and services such as (remote) monitoring, sensing, tracking, locating, alerting, scheduling, controlling, protecting, logging, auditing, planning, maintenance, upgrading, data mining, trending, reporting, decision support, dashboard, back office applications, and others. The ultimate goal is to build a universally connected world that is highly productive, energy efficient, secure, and environment friendly.	
39	At the most simplistic level IoT relates to the connection of a variety of devices to the Internet and the Machine-to-Machine (M2M) interfaces used between these devices.	Organization for the Advancement of Structured Information Standards (OASIS) (Jul 2014). Impact of the Internet of Things. WEB
40	A development of the Internet in which everyday objects have network connectivity, allowing them to send and receive data. A state in which physical objects (things) having embedded technology to sense and communicate, being connected via an identifier such as a micro-chip/SIM. This will serve the communication among those things, closing the gap between the real and the virtual world and creating smarter processes and structures that can	Belimo (Jul 2017). Internet of Things (IoT) Glossary of Terms. WEB

A non-exhaustive list of definitions about the IoT.

#	Definition	Source
	support us without needing our attention. It can be compared with the digital connection on the internet.	
41	The Internet of Things describes the coordination of multiple machines, devices and appliances connected to the Internet through multiple networks.	GSMA (Sep 2016). What is the Internet of Things (IoT)? WEB
42	The Internet of Things (IoT) can be defined as a set of smart things/objects such as home devices, mobile, laptop, etc., addressed by a unique addressing scheme and connected to the Internet through a unified framework this framework may be cloud computing.	Z. H. Ali, H. A. Ali and M. M. Badawy for International Journal of Computer Applications (IJCA) (Oct 2015). Internet of Things (IoT): Definitions, Challenges and Recent Research Directions. WEB
43	The Internet of Things links the objects of the real world with the virtual world, thus enabling anytime, anyplace connectivity for anything and not only for anyone. It refers to a world where physical objects and beings, as well as virtual data and environments, all interact with each other in the same space and time.	Cluster of European Research Projects on the Internet of Things (CERP-IoT) (Mar 2010). Vision and Challenges for Realising the Internet of Things. WEB
44	The Internet of Things connects devices such as everyday consumer objects and industrial equipment onto the network, enabling information gathering and management of these devices via software to increase efficiency, enable new services, or achieve other health, safety, or environmental benefits.	Goldman Sachs (Sep 2014). The Internet of Things: Making sense of the next mega-trend. WEB
45	The Internet of Things (IoT) is a computing concept that describes the idea of everyday physical objects being connected to the internet and being able to identify themselves to other devices and send and receive data.	Techopedia (Nov 2020). Internet of Things (IoT). WEB
46	The Internet of Things refers to the ever-growing network of physical objects that feature an IP address for internet connectivity, and the communication that occurs between these objects and other Internet-enabled devices and systems.	Webopedia (May 2021). IoT — Internet of Things. WEB
47	The Internet of Things represents the idea that ordinary objects — from thermostats and shoes to	Center for Data Innovation (Dec 2014). How Can

A non-exhaustive list of definitions about the IoT.

#	Definition	Source
	cars and lamp posts — will be embedded with sensors and connected to the Internet.	Policymakers Help Build the Internet of Things? WEB
48	The Internet of Things, commonly abbreviated "IoT," is an umbrella term that refers to anything connected to the Internet. It includes traditional computing devices, such as laptops, tablets, and smartphones, but also includes a growing list of other devices that have recently become Internet enabled. Examples include home appliances, automobiles, wearable electronics, security cameras, and many other things.	TechTerms.com (Jan 2015). Internet of Things. WEB
49	From a technical perspective, Internet of Things is the network which can achieve interconnection of all things anywhere, anytime with complete awareness, reliable transmission, accurate control, intelligent processing and other characteristics by the supportive technologies, such as micro-sensors, RFID, wireless sensor network technology, intelligent embedded technologies, Inter net technologies, integrated intelligent processing technology, nanotechnology.	X.-Y. Chen and Z.-G. Jin (2012). Research on Key Technology and Applications for Internet of Things. WEB
50	The Internet of Things, or "IoT" for short, is about extending the power of the internet beyond computers and smartphones to a whole range of other things, processes, and environments. […] The Internet of Things means taking all the things in the world and connecting them to the internet.	Calum McClelland, IoT For All (May 2019). What is the Internet of Things, or IoT? A Simple Explanation. WEB
51	A network of everyday devices, appliances, and other objects equipped with computer chips and sensors that can collect and transmit data through the internet.	Dictionary.com (Mar 2016). Internet of Things. WEB
52	Internet of Things (IoT) is an intermediate term used to refer to the interconnection of physical components with the ability to connect and exchange data, without human interaction, due to the integration of software and electronic components. Examples of these components include home appliances, vehicles, and computing devices.	BCS (Aug 2018). Internet of Things: Definition, application and challenges. WEB

A non-exhaustive list of definitions about the IoT.

#	Definition	Source
53	A network of objects that are fitted with microchips and connected to the internet, enabling them to interact with each other and to be controlled remotely.	Collins Dictionary (Sep 2019). The Internet of Things. WEB
54	The Internet of Things (IoT) refers to the growing network of physical objects that have an IP address in order to connect to the web and the communication that occurs between these objects and other devices enabled for the Internet and other systems.	Arimetrics (Jan 2021). What is IoT — Internet of Things. WEB
55	IoT is simply the network of interconnected things/devices which are embedded with sensors, software, network connectivity and necessary electronics that enables them to collect and exchange data making them responsive. More than a concept Internet of Things is essentially an architectural framework which allows integration and data exchange between the physical world and computer systems over existing network infrastructure.	Internet of Things Wiki (IoT Wiki) (Dec 2015). Understanding Internet of Things. WEB
56	The Internet of Things represents a vision in which the Internet extends into the real world embracing everyday objects. Physical items are no longer disconnected from the virtual world, but can be controlled remotely and can act as physical access points to Internet services. An Internet of Things makes computing truly ubiquitous.	F. Mattern and C. Floerkemeier (2010). From the Internet of Computers to the Internet of Things. WEB
57	A world where physical objects are seamlessly integrated into the information network, and where the physical objects can become active participants in business processes. Services are available to interact with these 'smart objects' over the Internet, query their state and any information associated with them, taking into account security and privacy issues.	R.H. Weber and R. Weber (2010). Internet of Things: Legal Perspectives. WEB
58	An evolving convergent Internet of Things and services that is available anywhere, anytime as part of an all pervasive, omnipresent, socio-economic fabric, made up of converged services, shared data and an advanced wireless and fixed infrastructure	UK Future Internet Strategy Group (UK FISG) (2011). Future Internet Report. WEB

A non-exhaustive list of definitions about the IoT.

#	Definition	Source
	linking people and machines to provide advanced services to business and citizens.	
59	The Internet of Things (IoT) consists of things that are connected to the Internet, anytime, anywhere. In its most technical sense, it consists of integrating sensors and devices into everyday objects that are connected to the Internet over fixed and wireless networks.	Internet Protocol for Smart Object Alliance (IPSO) (2008). Report. WEB
60	The Internet of Things could be conceptually defined as a dynamic global network infrastructure with self-configuring capabilities based on standard and interoperable communication protocols where physical and virtual 'things' have identities, physical attributes and virtual personalities, use intelligent interfaces and are seamlessly integrated into the information network.	V. Ovidiu and P. Friess (May 2011). Internet of Things — Global Technological and Societal Trends. WEB
61	A global network infrastructure, linking physical and virtual objects using cloud computing, data capture and network communications. It allows devices to communicate with each other, access information on the Internet, store and retrieve data, and interact with users, creating smart, pervasive and always connected environments.	C. Doukas (Feb 2012). Arduino, Sensors, and the Cloud. WEB
62	Internet of Things (IoT) is a concept where components are connected via a computer network and where one or more of those components interact with the physical world.	Industry IoT Consortium (IIC) (Oct 2020). The Industrial Internet of Things Vocabulary. WEB
63	The term Internet of Things generally refers to scenarios where network connectivity and computing capability extends to objects, sensors and everyday items not normally considered computers, allowing these devices to generate, exchange and consume data with minimal human intervention.	K. Rose, S. Eldridge, L. Chapin (Oct 2015). The Internet of Things (IoT): An Overview. WEB
64	Although there is no single definition for the Internet of Things, competing visions agree that it relates to the integration of the physical world with the virtual world — with any object having the potential to be connected to the Internet via short-range wireless technologies, such as radio frequency identification	J. Winter and R. Ono (Dec 2015). Algorithmic Discrimination: Big Data Analytics and the Future of the Internet. WEB

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#	Definition	Source
	(RFID), near field communication (NFC), or wireless sensor networks (WSNs). This merging of the physical and virtual worlds is intended to increase instrumentation, tracking, and measurement of both natural and social processes.	
65	The concept of Internet of Things (IoT) [...] is that every object in the Internet infrastructure is interconnected into a global dynamic expanding network.	M.S. Farasha, M. Turkanovićb, S. Kumaric and M. Hölbl (May 2015). An efficient user authentication and key agreement scheme for heterogeneous wireless sensor network tailored for the Internet of Things environment. WEB
66	We define the Internet of Things as sensors and actuators connected by networks to computing systems. These systems can monitor or manage the health and actions of connected objects and machines. Connected sensors can also monitor the natural world, people, and animals.	J. Manyika, M. Chui, P. Bisson, J. Woetzel, R. Dobbs, J. Bughin and D. Aharon for McKinsey (Jun 2015). The Internet of Things: Mapping The Value Beyond the Hype. WEB
67	An IoT is a network that connects uniquely identifiable "Things" to the Internet. The "Things" have sensing/actuation and potential programmability capabilities. Through the exploitation of unique identification and sensing, information about the "Thing" can be collected and the state of the "Thing" can be changed from anywhere, anytime, by anything.	R. Minerva, A. Biru and D. Rotondi (Sep 2015). Towards a definition of the Internet of Things (IoT). WEB
68	IoT envisions a self-configuring, adaptive, complex network that interconnects "things" to the Internet through the use of standard communication protocols. The interconnected things have physical or virtual representation in the digital world, sensing/actuation capability, a programmability feature, and are uniquely identifiable. The representation contains information, including the thing's identity; status; location; or any other business, social, or privately relevant information. The things offer services, with or without human	T. Samad, IEEE (Jan 2016). Control Systems and the Internet of Things. WEB

A non-exhaustive list of definitions about the IoT.

#	Definition	Source
	intervention, through the exploitation of unique identification, data capture and communication, and actuation capability. The service is exploited through the use of intelligent interfaces and is made available anywhere, anytime, and for anything taking security into consideration.	
69	The main idea behind the IoT is to bridge the gap between the physical world of humans and the virtual world of electronics via smart objects. These smart objects allow the interactions between humans and their environment by providing, processing, and delivering any sort of information or command. Sensors and actuators will be integrated in buildings, vehicles, and common environments and can tell us about them, their state, or their surroundings.	A. Makhoul, C. Guyeux, M. Hakem and J. M. Bahi (Feb 2016). Using an Epidemiological Approach to Maximize Data Survival in the Internet of Things. WEB
70	We must first define what we mean by 'things.' It could be very simple objects or complex objects. Things do not need to be connected directly to the public Internet, but they must be connectable via a network (which could be a LAN, PAN, body area network, etc.). The IoT is the network of physical objects that contain embedded technology to communicate and interact with the external environment. The IoT encompasses hardware (the 'things' themselves), embedded software (software running on, and enabling, the connected capabilities of the things), connectivity/communications services, and information services associated with the things (including services based on analysis of usage patterns and sensor or actuator data). An IoT solution is a product (or set of products) combined with a service either a one-to-one or a one-to-many relation. Meaning one service is combined with one (set of) product(s), or one service is combined with multiple (sets of) products.	F. Jammes, Association for Computing Machinery (ACM) (Feb 2016). Internet of Things in Energy Efficiency. WEB
71	At the very high level of abstraction, the Internet of Things (IoT) can be modeled as the hyper-scale, hyper-complex cyber-physical system.	K. A. Delic (Feb 2016). On Resilience of IoT Systems. WEB
72	The Internet of Things (IoT) paradigm is based on intelligent and self-configuring nodes (things)	A. Botta (Mar 2016). Integration of Cloud

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#	Definition	Source
	interconnected in a dynamic and global network infrastructure.	Computing and Internet of Things: a Survey. WEB
73	The Internet of Things (IoT) [...] is connecting everyday objects to the Internet and facilitating machine-to-human and machine-to-machine communication with the physical world.	Y. Qin (Apr 2016). When things matter: A survey on data-centric Internet of Things. WEB
74	Whilst the definition of 'Internet of Things' is elusive in general, the use of the term refers to the use of sensors and data communications technology built into physical objects in order to track, coordinate or control the functioning of those objects based on data over the network or the Internet.	C. O. Fjader, Editor A. J. Masys (2016). Exploring the Security Landscape: Non-Traditional Security Challenges > National Security in a Hyper-Connected World: Global Interdependence and National Security. WEB
75	The Internet of Things is a new paradigm in which every device is digitally connected, regardless of their function, and can communicate with other devices and people over communication protocols.	F. Silva and C. Analide, Editors J. Machado and A. Abelha (2016). Applying Business Intelligence to Clinical and Healthcare Organizations > Sensorization to Promote the well-being of people and the betterment of health organizations. WEB
76	The Internet of Things is a term used to describe the ever-growing number of devices connecting to a network, including televisions and appliances.	J. Minnick and L. Friedrichsen (2016). Web Design with HTML and CSS3: Comprehensive. WEB
77	The Internet of Things (IoT) envisions a world where smart objects connected to the Internet, share their data, exchange their services and cooperate together to provide value-added services that none of these objects could provide individually.	A. Yachir, Y. Amirat, A. Chibani and N. Badache (Dec 2015). Event-Aware Framework for Dynamic Services Discovery and Selection in the Context of Ambient Intelligence and Internet of Things > IEEE Transactions on Automation Science and Engineering. WEB

A non-exhaustive list of definitions about the IoT.

#	Definition	Source
78	Although many standardization groups such as IEEE, ITU, 3GPP, and IETF have presented various definitions, in its broadest sense, Internet of the Things means technology through which additional values can be provided to users by linking things or devices to the Internet.	Dong-Woo Lee (2016). A Study on Actual Cases and Meanings for Internet of Things > International Journal of Software Engineering and Its Applications. WEB
79	The Internet of Things (IoT) is the interconnection of everyday computerized devices linked through the Internet that enables them to send and receive data.	E. Havemann, Allot (Sep 2018). What is the Internet of Things? WEB
80	The Internet of Things is a system made up of physical devices connected by the internet and capable of accumulating and sharing data across a network.	Phoenix Internet (Jun 2019). Everything You Need to Know About the Internet of Things (IoT). WEB
81	The Internet of Things, or IoT for short, is a network of physical internet-connected devices that can collect and share data across a network. Simply put, IoT is a term used to describe objects connected to the internet.	HubSpot (Sep 2018). The Ultimate Guide to the Internet of Things (IoT). WEB
82	Internet of Things (IoT) is the digital interconnection of objects in different areas — home, industry, city, etc. — that allows us to integrally monitor the state of objects based on the collected data analysis.	ACCIÓ (Oct 2019). The Internet of Things (IoT) in Catalonia. WEB
83	"Internet of Things" (IoT) refers to networks of objects that communicate with other objects and with computers through the Internet. "Things" may include virtually any object for which remote communication, data collection, or control might be useful, such as vehicles, appliances, medical devices, electric grids, transportation infrastructure, manufacturing equipment, or building systems.	E. A. Fischer (Oct 2015). The Internet of Things: Frequently Asked Questions. WEB
84	The IoT is an intelligent network which connects all things to the Internet for the purpose of exchanging information and communicating through the information sensing devices in accordance with agreed protocols.	S. Chen, H. Xu, D. Liu, B. Hu and H. Wang (Aug 2014). A Vision of IoT: Applications, Challenges, and Opportunities With China Perspective. WEB
85	Internet of Things (IoT) is a world-wide network of interconnected objects uniquely addressable based	D. A. Hendricks (Aug 2015). The Trouble with the Internet of Things. WEB

A non-exhaustive list of definitions about the IoT.

#	Definition	Source
	on standard communication protocols whose point of convergence is the Internet.	
86	Internet of Things (IoT) is a paradigm with a notion of enabling the things (physical entities, e.g,: human, car, animal, mirror, bulb, plant, etc.) to communicate with each other, to transfer and receive the information (read-only data), through the use of underlying network (wired or wireless), supporting technologies (e.g., ZigBee, Bluetooth, Wi-Fi, etc.), required sensors, actuators and computing devices, and finally respond back in a way that requires least or negligible human intervention.	P. Matta and B. Pant (2019). Internet-of-things: Genesis, Challenges And Applications. WEB
87	The Internet of Things, or IoT, is defined as a network of devices that are autonomously able to sense, monitor, or interact with the surrounding environment, in addition to collect and exchange data.	Communications and Information Technology Commission (CITC) (Feb 2021). Internet of Things. WEB
88	The Internet of Things (IoT) is the concept of many objects, smart devices, machines, consumers, patients and services being increasingly able to be connected to solve problems in new and more effective ways.	GS1 (Oct 2016). GS1 and the Internet of Things. WEB
89	The Internet of Things refers to a type of network to connect anything with the Internet based on stipulated protocols through information sensing equipments to conduct information exchange and communications in order to achieve smart recognitions, positioning, tracing, monitoring, and administration.	K. K. Patel and S. M. Patel (2016). Internet of Things-IoT: Definition, Characteristics, Architecture, Enabling Technologies, Application and Future Challenges. WEB
90	Internet of Things (IoT) is denned as 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.	J. Gubbi, S. Marusic, A. S. Rao, Y. W. Law and M. Palaniswami (Aug 2013). A pilot study of urban noise monitoring architecture using wireless sensor networks. WEB
91	The Internet of Things (IoT) is defined as a paradigm in which objects equipped with sensors,	P. Sethi and S. R. Sarangi (Aug 2016). Internet of Things: Architectures,

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#	Definition	Source
	actuators, and processors communicate with each other to serve a meaningful purpose.	Protocols, and Applications. WEB
92	The Internet of Things (IoT) is a paradigm where a network of physical objects and infrastructure interact with each other, often autonomously. IoT connects people and things seamlessly forming a symbiotic relationship. In pervasive presence of IoT, services are provided as commodity.	N. D. Patel and H. D. Patil, International Journal of Management Technology and Engineering (IJAMTES) (Jan 2019). Defining Internet of Things: A Survey. WEB
93	The Internet of Things (IoT) is an interconnected system of distinctively address able physical items with various degrees of processing, sensing, and actuation capabilities that share the capability to interoperate and communicate through the Internet as their joint platform.	M. H. Miraz, M. Ali, P. S. Excell, R. Picking (Sep 2017). A Review on Internet of Things (IoT), Internet of Everything (IoE) and Internet of Nano Things (IoNT). WEB
94	The Internet of Things (IoT) refers to physical devices that are connected to the internet, collecting and sharing data. It is the global network of infrastructure, vehicles, wearable devices, home appliances, medical technologies and other objects that are embedded with electronics, software, sensors and actuators, enabling these 'things' to share and exchange data to perform their functions more efficiently and effectively.	State of New South Wales (NSW) (Oct 2019). Internet of Things (IoT) Policy Guidance. WEB
95	Internet of Things is simply an interaction between the physical and digital worlds. The digital world interacts with the physical world using a plethora of sensors and actuators.	O. Vermesan et al. (2011). Internet of Things Strategic Research Roadmap. WEB
96	Internet of Things is defined as a paradigm in which computing and networking capabilities are embedded in any kind of conceivable object.	I. Peña-López, ITU (2005). ITU Internet Report 2005: The Internet of Things. WEB
97	The Internet of Things refers to the networking of physical objects through the use of embedded sensors, actuators, and other devices that can collect or transmit information about the objects.	H. Bauer, M. Patel and J. Veira for McKinsey (Dec 2014). The Internet of Things: Sizing up the opportunity. WEB
98	The Internet of Things refers to the use of sensors, actuators, and data communications technology built into physical objects — from roadways to	J. Manyika, M. Chui, J. Bughin, R. Dobbs, P. Bisson and A. Marrs for McKinsey

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#	Definition	Source
	pacemakers — that enable those objects to be tracked, coordinated, or controlled across a data network or the Internet.	(May 2013). Disruptive technologies: Advances that will transform life, business, and the global economy. WEB
99	Embedded sensors and actuators in machines and other physical objects that are being adopted for data collection, remote monitoring, decision making and process optimization in everything from manufacturing to infrastructure to health care.	R. Dobbs, J. Manyika and J. Woetzel (2015). No Ordinary Disruption: The Four Global Forces Breaking All the Trends. WEB
100	The Internet of Things (IoT) refers to the technologies and devices that sense information and communicate it to the Internet or other networks and, in some cases, act on that information. [...] The term "Internet of Things" (IoT) is generally defined as the concept of connecting and interacting through a network with a broad array of "smart" devices, such as fitness trackers, cameras, door locks, thermostats, vehicles, or jet engines.	United States Government Accountability Office (GAO) (May 2017). Internet of Things: Status and implications of an increasingly connected world. WEB
101	In short, the Internet of Things refers to the rapidly growing network of connected objects that are able to collect and exchange data in real time using embedded sensors. Thermostats, cars, lights, refrigerators, and more appliances can all be connected to the IoT.	A. Meola for Business Insider (Jan 2022). A look at examples of IoT devices and their business applications in 2022. WEB
102	Internet of Things (IoT) is a network of physical objects or people called "things" that are embedded with software, electronics, network, and sensors that allow these objects to collect and exchange data.	J. Smith for Guru99 (Dec 2021). Top 78 IoT Interview Questions and Answers. WEB
103	The Internet of Things, or IoT, refers to the set of devices and systems that interconnect real-world sensors and actuators to the Internet. This includes many different systems, including Internet connected cars, wearable devices, smart meters and smart objects, home automation systems and lighting controls, smartphones, and wireless sensor networks.	P. Fremantle for WSO2 (Oct 2015). A Reference Architecture for the Internet of Things. WEB

A non-exhaustive list of definitions about the IoT.

#	Definition	Source
104	IoT refers to a world-wide network of interconnected objects uniquely addressable, based on standard communication protocols.	L. Atzori, A. Iera and G. Morabito (Oct 2010). The Internet of Things: A survey. WEB
105	The IoT is a decentralized network of objects, applications, and services that can sense, log, interpret, communicate, process, and act on a variety of information or control devices in the physical world.	National Security Telecommunications Advisory Committee (NSTAC) (Nov 2014). NSTAC Report to the President on the Internet of Things. WEB
106	The Internet of Things in the physical world is basically a network of digitally enabled communicating devices, products and services.	P. Tadejko (Sep 2015). Application of Internet of Things in Logistics — Current Challenges. WEB
107	Internet of Things (IoT) is an open and comprehensive network of intelligent objects that has the capacity to auto-organize, share information, data and resources, reacting and acting in face of situations and changes in the environment.	S. Madakam, R. Ramaswamy and S. Tripath for National Institute of Industrial Engineering (NITIE) (May 2015). Internet of Things (IoT): A Literature Review. WEB
108	Internet of Things (IoT) is a global network, which allows the communication between human-to-human, human-to-things and things-to-things, which is anything in the world by providing unique identity to each and every object.	R. Aggarwal and M. Lal Das (Aug 2012). RFID security in the context of "Internet of Things". WEB
109	The Internet of Things (IoT) is the connection of devices within everyday objects via the internet, enabling them to share data.	Oxford Dictionary (Jan 2022). Internet of Things. WEB
110	Based on infrastructure, the Internet of Things (IoT) is a dynamic global network infrastructure of physical and virtual objects having unique identities, which are embedded with software, sensors, actuators, electronic and network connectivity to facilitate intelligent applications by collecting and exchanging data. Based on existing technology, the Internet of Things (IoT) is a new revolution to the internet due to the advancement in sensor networks,	Government College of Engineering (2020). Definition of IoT (Internet of Things):. WEB

A non-exhaustive list of definitions about the IoT.

#	Definition	Source
	mobile devices, wireless communication, networking and cloud technologies.	
111	The Internet of Things (IoT) refers to a type of network to connect anything with the Internet based on stipulated protocols through information sensing equipments to conduct information exchange and communications in order to achieve smart recognitions, positioning, tracing, monitoring, and administration.	International Journal of Engineering Science and Computing (IJESC) (May 2016). Internet of Things — IoT: Definition, Characteristics, Architecture, Enabling Technologies, Application and Future Challenges. WEB
112	The Internet of Things (IoT) is a name for the aggregate collection of network-enabled devices, excluding traditional computers like laptops and servers.	Investopedia (Dec 2021). The Internet of Things (IoT). WEB
113	The Internet of Things (IoT) refers to a system of interrelated, internet-connected objects that are able to collect and transfer data over a wireless network without human intervention.	Aeris (Jan 2021). What is IoT? Defining the Internet of Things (IoT). WEB
114	The IoT can be described as an extension of the internet and other network connections to different sensors and devices — or "things" — affording even simple objects, such as lightbulbs, locks, and vents with a higher degree of computing and analytical capabilities.	Trend Micro (Jan 2021). Internet of Things (IoT). WEB
115	The Internet of Things, or IoT, refers to the billions of physical devices around the world that are now connected to the internet, all collecting and sharing data.	ZDNET (Feb 2020). What is the IoT? Everything you need to know about the Internet of Things right now. WEB
116	Simply, the Internet of Things is made up of devices — from simple sensors to smartphones and wearables — connected together.	Matthew Evans, TechUK (Feb 2018). What is the Internet of Things? WIRED explains. WEB
117	In the simplest terms, the Internet of Things (IoT) is how we describe the digitally connected universe of everyday physical devices. These devices are embedded with internet connectivity, sensors and	Built In (May 2019). IoT: The Internet of Things. WEB

A non-exhaustive list of definitions about the IoT.

#	Definition	Source
	other hardware that allow communication and control via the web.	
118	The Internet of Things, commonly abbreviated as IoT, refers to the connection of devices (other than typical fare such as computers and smartphones) to the Internet. Cars, kitchen appliances, and even heart monitors can all be connected through the IoT.	A. Meola for Business Insider (Jan 2022). What is the Internet of Things? What IoT means and how it works. WEB
119	The Internet of Things (IoT) is a network of connected devices with 1) unique identifiers in the form of an IP address which 2) have embedded technologies or are equipped with technologies that enable them to sense, gather data and communicate about the environment in which they reside and/or themselves.	i-SCOOP (Sep 2021). Making sense of IoT (Internet of Things) — the IoT business guide. WEB
120	The Internet of Things is a technology that allows us to add a device to an inert object (for example: vehicles, plant electronic systems, roofs, lighting, etc.) that can measure environmental parameters, generate associated data and transmit them through a communications network.	Ferrovial (May 2020). Internet of Things. WEB
121	The Internet of Things (IoT) is a framework which connects the physical world with the digital world. In simple terms, the Internet of Things is a giant network in which every day devices are connected to other connected devices and to the internet.	Study.com (Dec 2021). Application in Internet of Things: Definition and Purpose. WEB
122	Simply put, Internet of Things (IoT) is the concept of basically connecting any device with an on and off switch to the Internet (and/or to each other). This includes everything from cellphones, coffee makers, washing machines, headphones, lamps, wearable devices and almost anything else you can think of. This also applies to components of machines, for example a jet engine of an airplane or the drill of an oil rig.	J. Morgan for Forbes (May 2014). A Simple Explanation Of 'The Internet of Things'. WEB
123	On the most general level, the Internet of Things is about using sensors and digital technologies to make previously unintelligent things (from door locks and kitchen appliances to entire buildings and cities) able	IoT Rapid-Proto Labs (IoTLabs) (Oct 2017). Internet of Things: Best Practices in Technology, Development

A non-exhaustive list of definitions about the IoT.

#	Definition	Source
	to compute and communicate — typically wirelessly.	Methods and Product Design. WEB
124	The Internet of Things is a network of physical objects or devices that communicate and interact with each other via an internet connection. [...] In short, we can define the Internet of Things as a systems of systems that have (at least) the following properties: sensing and actuation, connectivity, intelligence, heterogeneity, dynamicity, scalability, and security.	The Economist Intelligence Unit (2020). The Internet of Things: Applications for Business. WEB
125	The phrase "Internet of Things" has arisen to reflect the growing number of smart, connected products and highlight the new opportunities they can represent.	M. E. Porter and J. E. Heppelmann for Harvard Business Publishing (HBP) (Nov 2014). How Smart, Connected Products Are Transforming Competition. WEB
126	The Internet of Things is a lot like it sounds. The IoT is a growing system of billions of devices — or things — worldwide that connect to the internet and to each other through wireless networks.	K. Chivers for Norton (Apr 2019). What is the Internet of Things? How the IoT works, and more. WEB
127	From a system-level perspective, the Internet of Things can be looked at as a highly dynamic and radically distributed networked system, composed of a very large number of smart objects producing and consuming information.	D. Miorandi, S. Sicari, F. De Pellegrini and I. Chlamtac for Ad Hoc Networks Journal (Apr 2012). Internet of Things: Vision, applications and research challenges. WEB
128	Internet of Things (IoT) is defined as wireless or fixed, two-way communication between geographically distributed remote devices and sensors through a centralized platform.	IDB Invest, GSMA and Frost and Sullivan (2019). Prepare for the Internet of Things Disruption. WEB
129	The term "IoT" describes the use of sensors or other electronic devices that collect data about the physical world and transmit their information, via the internet.	J. P. Farmer for City of New York (Mar 2021). IoT Strategy: The New York City Internet of Things Strategy. WEB

A non-exhaustive list of definitions about the IoT.

#	Definition	Source
130	The Internet of Things (IoT) describes the phenomenon of everyday devices connecting to the Internet through tiny embedded sensors and computing power.	Accenture (2014). The Internet of Things: The Future of Consumer Adoption. WEB
131	Internet of Things (IoT) refers to an emerging paradigm consisting of a continuum of uniquely addressable things communicating with each other to form worldwide dynamic networks.	E. Borgia (Dec 2014). The Internet of Things vision: Key features, applications and open issues. WEB
132	Internet of Things (IoT) is not the result of a single technology, but it is the combination of several complementary development technologies that provide capabilities, which help to bridge the gap between the virtual and the physical world.	F. Mattern and C. Floerkemeier (2010). From the Internet of Computers to the Internet of Things. WEB
133	Simply stated, IoT is the connectivity that enables connected devices to interoperate. IoT connects the world's physical systems such as power meters, vehicles, containers, pipelines, wind-farm turbines, vending machines, personal accessories, and much more.	International Chamber of Commerce (ICC) (2016). ICC Policy Primer on the Internet Of Everything. WEB
134	Internet of Things (IoT) is a network of items, embedded with sensors and actuators.	S. König, S. Schiebeck, S. Schauer, M. Latzenhofer, P. Mayer and G. Fitzpatrick (May 2017). Deliverable 3: Internet of Things Risk Analysis and Assessment. WEB
135	The IoT is an environment that gathers information from multiple devices (computers, vehicles, smart phones, traffic lights, social media and anything with a sensor or actuator) and applications – anything from a social media app like Twitter to an e-commerce platform, from a manufacturing system to a traffic control system.	G. Heydon and F. Zeichner (Oct 2015). Enabling the Internet of Things for Australia. WEB
136	Internet of Things [...] is the vast network of devices connected to the Internet, including smart phones and tablets and almost anything with a sensor on it — cars, machines in production plants, jet engines,	M. Muntjir, M. Rahul and H. A. Alhumyani (Jun 2017). An Analysis of Internet of Things (IoT): Novel Architectures, Modern Applications, Security Aspects and Future

A non-exhaustive list of definitions about the IoT.

#	Definition	Source
	oil drills, wearable devices, and more. These "things" collect and exchange data.	Scope with Latest Case Studies. WEB
137	A global network infrastructure, linking physical and virtual objects through the exploitation of data capture and communication capabilities. This infrastructure includes existing and evolving Internet and network developments. It will offer specific object-identification, sensor and connection capability as the basis for the development of independent cooperative services and applications. These will be characterised by a high degree of autonomous data capture, event transfer, network connectivity and interoperability.	Coordination and Support Action for Global RFID-Related Activities and Standardization (CASAGRAS) (Feb 2009). CASAGRAS and The Internet of Things: Definition and Vision Statement Agreed. WEB
138	The Internet of Things (IoT) is a world where physical objects are seamlessly integrated into the information network, and where the physical objects can become active participants in business processes. Services are available to interact with these 'smart objects' over the Internet, query and change their state and any information associated with them, taking into account security and privacy issues.	Future Internet (May 2009). Research. WEB
139	The Internet of Things (IoT) is the network formed by things/objects having identities, virtual personalities operating in smart spaces using intelligent interfaces to connect and communicate with the users, social and environmental contexts.	European Technology Platform on Smart Systems Integration (ETP EPoSS) (2008). Internet of Things in 2020: Roadmap for the Future.

Appendix 2 Constructs used in previous studies

1. **Innovativeness**

Study	**Constructs**	**Cross reference**
Sinaga 2019	PI1 I like to experiment with new and innovative products. PI2 Among my friends, I am usually the first to explore new technologies. PI3 If I heard about new technology, I would look for ways to experiment with it.	Agarwal and Prasad, 1998; Girod, Mayer, and Nägele 2017

2. **Self-efficacy**

Study	**Constructs**	**Cross reference**
Heidenrich, 2015	I am fully capable of using the app. I am confident in my ability to use the app. Using the app is well within the scope of my abilities.	Meuter et al., 2005
Luarn and Li, 2005	I could conduct my banking transactions using the mobile banking systems... PSE1 ... if I had just the built-in help facility for assistance. PSE2 ... if I had seen someone else using it before trying it myself. PSE3 ... if someone showed me how to do it first	Compeau and Higgins (1995)

3. **Positive Self-image**

Study	Constructs	Cross reference
Wang, 2018	Image1 People who use smart home devices have a more prestigious image than people who do not. Image2 People who use smart home devices have a high profile.	Moore and Benbasat, 1991

	Image3 Use of a smart home device presents a positive image to other people. Image4 Having a smart home device would be a status symbol.	
Mijin 2017	Using EMR system improves my image within the hospital. Because of my use of EMR system, others in my hospital see me as a more valuable employee.	Moore and Benbasat, 1991
Chouk and Mani 2019	I identify with the typical smart service user I fit in with the typical image of a smart service user The image of the typical smart service user reflects the kind of person I am	Anton et al., 2013; Kleijnen et al., 2005
Rosenberg, M. (1965)	1. On the whole, I am satisfied with myself. 2. At times I think I am no good at all. 3. I feel that I have a number of good qualities. 4. I am able to do things as well as most other people. 5. I feel I do not have much to be proud of. 6. I certainly feel useless at times. 7. I feel that I'm a person of worth, at least on an equal plane with others. 8. I wish I could have more respect for myself. 9. All in all, I am inclined to feel that I am a failure. 10. I take a positive attitude toward myself.	Baumeister, R. F., Campbell, J. D., Krueger, J. I., and Vohs, K. D. (2003) Ciarrochi, J., Heaven, P. C. L., and Fiona, D. (2007). Gray-Little, B., Williams, V.S.L., and Hancock, T. D. (1997).

4. Attitude

Study	**Constructs**	**Cross reference**
Park et al. 2017	AT1: I think using IoT technologies in a smart home environment is a nice idea. AT2: I think using IoT technologies in a smart home environment is beneficial to me.	Park and Kim, 2014; Kwon, Park and Kim, 2014

	AT3: I have positive feelings toward IoT technologies in a smart home environment.	
Davis 1986	All things considered, my using electronic mail in my job is: (place X mark on each of the five scales) **Good Neutral Bad** **Wise Neutral Foolish** **Favourable Neutral Unfavourable** **Beneficial Neutral Harmful** **Positive Neutral Negative**	
Wu, Wu and Chang 2016	ATT1 Using a smartwatch would be a positive decision. ATT2 Using a smartwatch would be a smart decision to make. ATT3 I have a positive impression toward using a smartwatch for work. ATT4 I would feel excited to purchase a smartwatch. ATT5 I would be happy to use a smartwatch.	Mao and Palvia 2006; Davis 1986; Moore and Benbasat 1991; Wang et al. 2009
Yang, Lee and Zo 2017	It would be a wonderful idea to employ smart home services. I would have positive feelings toward smart home services. It is better for me to employ smart home services, as opposed to other services.	Bhattacherjee, 2000
Nunkoo and Ramkissoon 2012	Using the Internet to make travel purchases is a good idea. My general opinion regarding the e-purchasing of travel products is positive. Using the Internet to purchase tourism products seems an intelligent idea to me	Morosan, 2012; Wang and Qualls, 2007; Schneberger, Amoroso, and Durfee, 2007

5. **Intention to buy/use**

Study	Constructs	Cross reference
Flyden 2018	Intention to adopt Using smart home services is worthwhile I intend to use smart home services in the future I predict I would use smart home services in the future	Yang, Lee and Zo, 2017

Lu 2019	I intend to use the IoT in the future. IoT-BI1 I will try to use the IoT in my daily life. IoT-BI2 I will plan to use the IoT frequently. IoT-BI3	Venkatesh, 2000
Sinaga 2019	IA1 I plan to adopt Philips Hue. IA2 I am willing to adopt Philips Hue. IA3 I will not hesitate to purchase Philips Hue. IA4 I would recommend others to adopt Philips Hue when they plan to adopt smart home.	Venkatesh et al. 2003

6. Perceived Ease of Use

Study	**Constructs**	**Cross reference**
Flyden 2018	Perceived ease of Use It is easy to use smart home products and services It is easy to get smart home products and services to do what I want it to do It is convenient to access smart home products and services	Lee et al., 2007; Delone and McLean, 1992; Davis, 1989
Lu 2019	Using the Internet is clear and easy to understand. I-PEOU1 Using the Internet does not require a lot of my effort. I-PEOU2 I find the Internet to be easy to use. I-PEOU3 I find it easy to get the Internet to do what I want it to do. I-PEOU4	Venkatesh,2000
Sinaga 2019	EE1 I think Philips Hue is easy to learn. EE2 I think Philips Hue is easy to install at home. EE3 I believe Philips Hue is easy to use. EE4 I believe it is easy for me to be skilful using Philips Hue.	Venkatesh et al. 2003
Wang, McGill and Klobas 2018	EE1 Smart home devices are easy to use EE2 Smart home devices are easy to find in the marketplace EE3 It will be quick for me to learn how to use smart home devices	Venkatesh et al. 2003

	EE4 It will be easy for me to learn how to use smart home devices EE5 Operation of smart home devices is clear and understandable	

7. Perceived Usefulness

Study	Constructs	Cross reference
Flyden 2018	I find smart home products and services useful in my daily life. Using smart home products and services helps me accomplish things more quickly. Using smart home products and services improves my chances of achieving things I find important	Lee et al., 2007
Lu 2019	Using the Internet improves my performance in my personal and work-related tasks. I-PU1 Using the Internet in my personal and work-related tasks increases my productivity. I-PU2 Using the Internet enhances my effectiveness in my personal and work-related tasks. I-PU3 I find the Internet to be useful in my personal and work-related tasks. I-PU4	Venkatesh,2000
Sinaga 2019	PE1 I believe Philips Hue will be useful in my daily life. PE2 I believe Philips Hue will increase my chances of achieving important tasks. PE3 I believe Philips Hue will help to accomplish my jobs more quickly. PE4 I believe Philips Hue will increase the productivity to control my home lighting system.	Venkatesh et al. 2003

8. Compatibility

Study	Constructs	Cross reference
Islam and Rahman (2016),	Compatibility 1 .* Using a PWS is compatible with all aspects of my	Moore and Benbasat, 1991

Bradford and Florin (2003)	work. 2. Using a PWS is completely compatible with my current situation. 3.* I think that using a PWS fits well with the way I like to work. 4.* Using a PWS fits into my work style.	

9. Mobility

Study	**Constructs**	**Cross reference**
Yang, Lee and Zo, 2017	MO1 It is convenient to access smart home services anywhere at any time. MO2 It is convenient to use smart home services while moving from place to place or doing anything else. MO3 Mobility is an outstanding advantage of smart home services.	Park and Ohm, 2014; Hill and Roldan, 2005

10. Automation

Study	**Constructs**	**Cross reference**
Yang, Lee and Zo, 2017	It is convenient that smart home services help the residents proactively without human intervention. It is convenient that smart home services provide auto-adjusted control. I can control every electrical apparatus of smart home services through simple operation.	Augusto and Nugent, 2006; Luor et al., 2015
Yang and Lee, 2018	It is convenient that VPA devices help the users proactively without human intervention AT2 It is convenient that VPA devices provide auto-adjusted control	Augusto and Nugent 2006, Luor et al. 2015

11. Perceived Cost

Study	**Constructs**	**Cross reference**

Flyden 2018	The smart home products and services are reasonably priced	Lee et al., 2007
Pal et al. 2018	The cost of investing into the various smart home products for healthcare are too expensive I need to pay a much lower price for doctor consultation than I have to do for subscribing to smart home services Purchasing and maintaining a smart home is a burden for me	Islam and Rahman, 2016
Park et al. 2017	COS1: Using IoT technologies in a smart home environment is expensive overall COS2: Installing and operating IoT technologies in a smart home environment are a burden to me COS3: There is a financial barrier to maintaining and repairing IoT technologies in a smart home environment	Shin, 2010; Kim and Shin, 2015; Kim, Kaufmann and Stegemann, 2014
Mashal and Shuhaiber 2018	COS1 I think smart home devices could be expensive COS2 I think I would not able to afford smart home devices COS3 Subscribing smart home devices could be expensive	Park et al. 2017

12. Social Influence

Study	**Constructs**	**Cross reference**
Sinaga 2019	SI1 People who are important to me might suggest using Philips Hue. SI2 People who influence my behavior might suggest using Philips Hue. SI3 Friends, family and colleagues think that I should use Philips Hue. SI4 Many people around me use Philips Hue. SI5 The mass media including social media, influence me to use Philips Hue. SI6 I see many ads about Philips Hue.	Venkatesh et al. 2003; Bhattacherjee, 2000

Venkatesh, Thong and Xu 2012	SI1. People who are important to me think that I should use mobile Internet. SI2. People who influence my behavior think that I should use mobile Internet. SI3. People whose opinions that I value prefer that I use mobile Internet	

13. Hedonic Motivation

Study	Constructs	Cross reference
Venkatesh, Thong and Xu 2012	HM1 Using mobile Internet is fun HM 2 Using mobile Internet is enjoyable HM 3 Using mobile Internet is very entertaining	
Afonso 2019	Using a smart speaker would be funny Using a Smart Speaker would be enjoyable Using mobile Internet is very entertaining Using a Smart Speaker would be a lot of fun	Venkatesh, Thong and Xu 2012

14. Perceived Risk

Study	Constructs	Cross reference
Sinaga 2019	PR1 I will feel less autonomy since I let Philips Hue control things around me. PR2 I will feel risky to share my information and daily data to Philips Hue. PR3 I am afraid that Philips Hue will not fully function as expected. PR4 I am afraid that Philips Hue will cause some problems at my home	New scales, adapted from Wilson et al. (2017) and Balta-Ozkan et al. (2013)

15. Privacy risk

Study	Constructs	Cross reference

Barbosa, Zhang and Wang 2020	PriR1 If I use a smart home device, I would lose control over the privacy of my personal data. PriR2 My personal information will be less confidential if I use a smart home device.	Featherman and Pavlou, 2003; Li, et al. 2018

16. Security risk

Study	**Constructs**	**Cross reference**
Pal et al. 2018	I fear to use smart home service due to loss of my personal data and privacy The internet offers a secure medium through which sensitive personal information can be send confidentially I find it risky to disclose my personal details and health information to smart home service providers	Stojkoska and Trivodaliev, 2017; Cheng, Lam and Yeung, 2006
Barbosa, Zhang and Wang 2020	SR1 The security systems built into smart home devices are not strong enough to protect my information. SR2 Internet hackers (criminals) might take control of my information if I use a smart home device.	Featherman and Pavlou, 2003

17. Physical risk

Study	**Constructs**	**Cross reference**
Yang, Lee and Zo, 2017	PHR1 Smart home services could lead to some uncomfortable physical side effects due to malfunctions or misuse (smart oven, smart door-lock, smart healthcare, etc.). PHR2 Because smart home services may not be completely safe, I concern about potential physical risks	Stone and Grønhaug, 1993

18. Trust

Study	**Constructs**	**Cross reference**

Sinaga 2019	T1 I trust Philips. T2 I believe Philips has great quality products. T3 I trust Philips Hue. T4 Philips Hue seems secure. T5 Philips Hue is created to help the users.	Pappas, 2016
Nunkoo and Ramkissoon 2012	13. Online sites for tourism purchases are trustworthy. 14. Online sites for tourism purchases are reliable. 15. Tourism online sites have integrity	Chen, 2006; Kim et al., 2008; McCole, 2002; Wu and Chan, 2006
Alalwan et al. 2018	TR1 I believe that Mobile banking is trustworthy. TR2 I trust in Mobile banking. TR3 I do not doubt the honesty of Mobile banking. TR4 I feel assured that legal and technological structures adequately protect me from problems on Mobile banking. TR5 Even if not monitored, I would trust Mobile banking to do the job right. TR6 Mobile banking has the ability to fulfil its task.	Gefen, Karahanna and Straub 2003
Yang, Lee and Zo, 2017	TR1 I think smart home services providers are reliable. TR2 I think smart home services providers keep promises and commitments. TR3 I think smart home services providers keep customers' best interests in mind TR4 I feel confidence in brand of smart home service providers.	Li and Hsu 2014; Ballester, 2004

Appendix 3 Questionnaire

Section A – About yourself			
1	Do you live in the UK	Yes = 1 No = 2	
2	Please select the geographical area where you currently live	• North East England • North West England • Yorkshire and Humber • East Midlands • West Midlands • East of England • London • South East England • South West England • Scotland • Wales • Northern Ireland	
3	Do you work in a UK based College, University or Higher Education Institution?	Yes = 1 No = 2	

Section B Smart home devices ownership/ buy			
1	Do you own any of the following devices?	Smart speakers ☐ Smart watch ☐ Smart home security (for example, a doorbell) ☐ Smart fridge ☐ Smart heating ☐ Smart lights ☐ Smart furniture ☐ Other smart devices (please specify) ☐ None ☐	
2	How likely are you to interconnect smart devices you own into a network to optimise their use?	Very unlikely: 1 / Unlikely: 2 / Undecided: 3 / Likely: 4 / Very likely: 5	

3	How likely are you to buy a smart device in the near future?	Very unlikely	Unlikely	Undecided	Likely	Very likely		
		1	2	3	4	5		
Section C <u>Construct statements</u>								
Factor - Innovativeness								
1	I like to experiment with new high- tech products in the market	Strongly Disagree	Disagree	Neither disagree nor agree	Agree	Strongly Agree		
		1	2	3	4	5		
2	Among my peers, I am usually the first to try out new high-tech products	Strongly Disagree	Disagree	Neither disagree nor agree	Agree	Strongly Agree		
		1	2	3	4	5		
3	If I heard about a new high-tech product, I would look for ways to experiment with it	Strongly Disagree	Disagree	Neither disagree nor agree	Agree	Strongly Agree		
		1	2	3	4	5		
Factor – Self efficacy								
4	I will be able to use smart devices if I have just the built-in help facility for assistance	Strongly Disagree	Disagree	Neither disagree nor agree	Agree	Strongly Agree		
		1	2	3	4	5		
5	I will be able to use smart devices if I see someone else using it before I try them myself	Strongly Disagree	Disagree	Neither disagree nor agree	Agree	Strongly Agree		
		1	2	3	4	5		
6	I will be able to use smart devices if someone showed me how to do it first	Strongly Disagree	Disagree	Neither disagree nor agree	Agree	Strongly Agree		
		1	2	3	4	5		
Factor – Positive Self image								

7	On the whole, I am satisfied with myself.	Strongly Disagree	Disagree	Neither disagree nor agree	Agree	Strongly Agree	
		1	2	3	4	5	
8	I feel that I have a number of good qualities.	Strongly Disagree	Disagree	Neither disagree nor agree	Agree	Strongly Agree	
		1	2	3	4	5	
9	I take a positive attitude toward myself	Strongly Disagree	Disagree	Neither disagree nor agree	Agree	Strongly Agree	
		1	2	3	4	5	
Factor - Attitude							
10	I think using smart devices is a nice idea	Strongly Disagree	Disagree	Neither disagree nor agree	Agree	Strongly Agree	
		1	2	3	4	5	
11	I think using smart devices is/will be beneficial to me	Strongly Disagree	Disagree	Neither disagree nor agree	Agree	Strongly Agree	
		1	2	3	4	5	
12	I have positive feelings toward the idea of using Smart devices at home	Strongly Disagree	Disagree	Neither disagree nor agree	Agree	Strongly Agree	
		1	2	3	4	5	
Factor – intention to buy/use							
13	I am willing to buy smart devices in the future.	Strongly Disagree	Disagree	Neither disagree nor agree	Agree	Strongly Agree	
		1	2	3	4	5	

Perceived attributes							
PEOU – Perceived Ease of Use							
14	Using the smart device is clear and easy to understand.	Strongly Disagree	Disagree	Neither disagree nor agree	Agree	Strongly Agree	
		1	2	3	4	5	
15	Using smart device does not require a lot of my effort.	Strongly Disagree	Disagree	Neither disagree nor agree	Agree	Strongly Agree	
		1	2	3	4	5	
16	I find it easy to get the smart device to do what I want it to do.	Strongly Disagree	Disagree	Neither disagree nor agree	Agree	Strongly Agree	
		1	2	3	4	5	
PU -Perceived Usefulness							
17	I find smart devices useful in my daily life.	Strongly Disagree	Disagree	Neither disagree nor agree	Agree	Strongly Agree	
		1	2	3	4	5	
18	Using smart devices helps me accomplish tasks more quickly.	Strongly Disagree	Disagree	Neither disagree nor agree	Agree	Strongly Agree	
		1	2	3	4	5	
19	Using smart devices improves my chances of achieving things	Strongly Disagree	Disagree	Neither disagree nor agree	Agree	Strongly Agree	
		1	2	3	4	5	
Perceived features of IoT devices							
Factor - Compatibility							
20	Using smart devices is/will be	Strongly Disagree	Disagree	Neither disagree	Agree	Strongly Agree	

	compatible with my lifestyle	 1	 2	e nor agree 3	 4	 5		
21	Smart devices will complement existing devices in my home	Strongly Disagree 1	Disagree 2	Neither disagree nor agree 3	Agree 4	Strongly Agree 5		
22	Smart devices fit into my home lifestyle	Strongly Disagree 1	Disagree 2	Neither disagree nor agree 3	Agree 4	Strongly Agree 5		
Factor - Mobility								
23	I find it very convenient that smart devices can be accessed anywhere at any time.	Strongly Disagree 1	Disagree 2	Neither disagree nor agree 3	Agree 4	Strongly Agree 5		
24	It is a big advantage that smart devices can be used while moving from place to place.	Strongly Disagree 1	Disagree 2	Neither disagree nor agree 3	Agree 4	Strongly Agree 5		
25	Mobility is an outstanding advantage of smart devices.	Strongly Disagree 1	Disagree 2	Neither disagree nor agree 3	Agree 4	Strongly Agree 5		
Factor - Automation								
26	It is a great feature of smart devices that they do many things on their own without human intervention	Strongly Disagree 1	Disagree 2	Neither disagree nor agree 3	Agree 4	Strongly Agree 5		
27	It is convenient that smart devices provide auto-adjust function	Strongly Disagree	Disagree	Neither disagree nor agree	Agree	Strongly Agree		

		1	2	3	4	5		
28	I can control every electrical apparatus of smart home through simple operation.	Strongly Disagree	Disagree	Neither disagree nor agree	Agree	Strongly Agree		
		1	2	3	4	5		
Factor – Perceived cost								
29	I think smart devices could be too expensive	Strongly Disagree	Disagree	Neither disagree nor agree	Agree	Strongly Agree		
		1	2	3	4	5		
30	The additional convenience of smart devices does not justify the extra cost	Strongly Disagree	Disagree	Neither disagree nor agree	Agree	Strongly Agree		
		1	2	3	4	5		
31	I think I would not be able to afford smart devices	Strongly Disagree	Disagree	Neither disagree nor agree	Agree	Strongly Agree		
		1	2	3	4	5		
Factor – Social Influence								
32	People who are important to me think that I should use smart devices	Strongly Disagree	Disagree	Neither disagree nor agree	Agree	Strongly Agree		
		1	2	3	4	5		
33	People whose opinions I value prefer that I use smart devices	Strongly Disagree	Disagree	Neither disagree nor agree	Agree	Strongly Agree		
		1	2	3	4	5		
34	People who influence my behaviour think that I should use smart devices	Strongly Disagree	Disagree	Neither disagree nor agree	Agree	Strongly Agree		
		1	2	3	4	5		
Factor – Hedonic Motivation								

35	Using smart devices would be fun		Strongly Disagree	Disagree	Neither disagree nor agree	Agree	Strongly Agree		
			1	2	3	4	5		
36	Using smart devices would be very entertaining		Strongly Disagree	Disagree	Neither disagree nor agree	Agree	Strongly Agree		
			1	2	3	4	5		
37	Using smart devices would be enjoyable		Strongly Disagree	Disagree	Neither disagree nor agree	Agree	Strongly Agree		
			1	2	3	4	5		
Perceived Risks									
Factor – Privacy risk									
38	If I use a smart device, I will lose control over the privacy of my personal data.		Strongly Disagree	Disagree	Neither disagree nor agree	Agree	Strongly Agree		
			1	2	3	4	5		
39	My personal information will be less confidential if I use a smart device.		Strongly Disagree	Disagree	Neither disagree nor agree	Agree	Strongly Agree		
			1	2	3	4	5		
40	I fear to use smart home devices due to loss of my personal data and privacy		Strongly Disagree	Disagree	Neither disagree nor agree	Agree	Strongly Agree		
			1	2	3	4	5		
Factor – Security risk									
41	I suspect that security systems built into smart devices are not strong enough to process my information securely.		Strongly Disagree	Disagree	Neither disagree nor agree	Agree	Strongly Agree		
			1	2	3	4	5		

42	There is a big chance that internet hackers may take control of my information if I use a smart device	Strongly Disagree	Disagree	Neither disagree nor agree	Agree	Strongly Agree	
		1	2	3	4	5	
43	I find it risky to disclose my personal information with smart home devices.	Strongly Disagree	Disagree	Neither disagree nor agree	Agree	Strongly Agree	
		1	2	3	4	5	
Factor – Physical risk							
44	I am concerned about potential physical risks because smart devices may not be completely safe (may cause fire, flooding, electrical shock, etc.)	Strongly Disagree	Disagree	Neither disagree nor agree	Agree	Strongly Agree	
		1	2	3	4	5	
45	I do not like smart devices as they could cause damage due to malfunctions or misuse	Strongly Disagree	Disagree	Neither disagree nor agree	Agree	Strongly Agree	
		1	2	3	4	5	
46	I am afraid that smart devices will cause some problems at my home.	Strongly Disagree	Disagree	Neither disagree nor agree	Agree	Strongly Agree	
		1	2	3	4	5	
Factor – Trust in IoT providers							
47	Smart devices providers:	Strongly Disagree	Disagree	Neither disagree nor agree	Agree	Strongly Agree	
	Are trustworthy	1	2	3	4	5	
	Are reliable	1	2	3	4	5	
	Have integrity	1	2	3	4	5	

Item	***Description***	***Response code***	***Response***
		Section D <u>Socio-demographic details – moderators</u>	
1	What is your gender?	Male = 0 Female = 1 Other = 2	
2	What is your age?	18- 29 = 0 30 – 44 years = 1 45 – 59 years = 2 60+ years = 3	
3	Which of the following best describes your personal income last year?	Below £15,000 = 0 £15, 001 to £30, 000 = 1 Above £30, 000 = 2	
4.	What is your highest level of formal education?	Bachelors = 0 Masters = 1 Doctorate = 2 Professional qualification = 3 Others (please specify) = 4	

Thank you for taking part in this research.

University of Central Lancashire
UCLan

Evaluation of factors influencing the acceptance of IoT Devices in a smart home environment by early adopters

Information Sheet

Version 1,20

February 2023

You are being invited to participate in a research study. Before you decide if you wish to take part, it is important that you understand why the research is being done and what it will involve. Please take time to read the following information carefully and if you would like more information or if there is anything that you do not understand, please contact us using the contact information below. Please also feel free to discuss with others if you wish.
Thank you for reading this.

What is the purpose of the study?

The study is being completed by Rizwana Patel, as part of PhD, at the University of Central Lancashire and is being completed under the supervision of Andrei Kuznetsov and Olga Kvasova.
The aim of this study is to evaluate the factors that influence the behaviour of early adopters in the UK in relation to the acceptance of smart devices within a home environment.

Why have I been invited to take part?

This research has identified academics working in Universities, Higher education institutions and colleges within the UK as the target adopters of innovative technology and hence you have been chosen to take part in this survey.

What will happen if I take part?

The study involves taking part in an online survey, which will be completed anonymously. The survey asks 47 questions on acceptance of smart devices, and should take approximately 15 minutes to complete, depending on how much information you choose to share. Before you complete the survey, you will be asked to read and consent to a series of statements before proceeding.
If you are interested in taking part, please download a copy of the participant information sheet and retain this for your records before starting the survey.

Do I have to take part?

No, it is entirely up to you if you want to take part or not. Participation in the study is voluntary. If you do decide to take part, all questions are optional so you may omit any questions. You will be able to withdraw at any point for any reason before submitting your answers by closing the survey browser.

How will my data be used?

We will not collect or process any personal data. All data you provide will be completely anonymous, which means that no-one could use any reasonable means to identify you from the data.

The answers that you provide will only be accessible to the research team at UCLan. The data will be used in results, written up to form part of thesis for PhD. Some results may also be used for academic publications, conference presentations.
The answers you provide will be held securely and will be password encrypted and stored in a password-protected electronic file on the UCLan's secure servers.
The responses will be kept for 7 years. and then destroyed, in line with University policy.

Are there any risks in taking part?

There are no perceived risks or disadvantages involved.

Are there any benefits from taking part?

There are no anticipated direct benefits to you. However, we hope that the collective responses may lead to a better understanding about acceptance of smart devices.

What will happen to the results of the study?

The results of the study will be written for a PhD degree.

What will happen if I want to stop taking part?

As this study is completely anonymous it is not possible to withdraw your data once you have submitted your responses. When you select "Complete Survey" at the bottom of the last page, the data will be submitted. Up until this point, you can stop at any time and data provided to that point will not be saved.

Who has reviewed this study?

The study has been reviewed and approved by the BAHSS2 Ethics Review Panel at the University of Central Lancashire Project reference number BAHSS2 01021.

What if I am unhappy or if there is a problem?

If you are unhappy, or if there is a problem, please feel free to let us know by contacting Rizwana Patel on rpatel64@uclan.ac.uk and we will try to help. If you remain unhappy or have a complaint which you feel you cannot come to us with, then please contact the Ethics, Integrity and Governance Unit at UCLan via OfficerforEthics@uclan.ac.uk.

Who can I contact if I have further questions?

Andrei Kuznetsov – School of Business and Enterprise, UCLan, Preston, PR1 2HE. akuznetsov@uclan.ac.uk
Olga Kvasova – International Business and Management, UCLan Cyprus Ltd. okvasova@uclan.ac.uk

Consent

I confirm that I have read and understood the information provided on the information page of this survey, for Evaluation of factors influencing the acceptance of IoT Devices in a smart home environment by early adopters.
Yes No
I understand that my participation is voluntary and I am free to stop at any time, until I submit the survey by clicking on the 'Submit' button on the last page of the survey.
Yes No

I understand that the answers I provide are completely anonymous and I can therefore not be identified in any way.

Yes No

I agree to take part in this study

Yes No

I confirm that I am over 18 years of age

Yes No

Appendix 5 Constructs and distribution of respondents

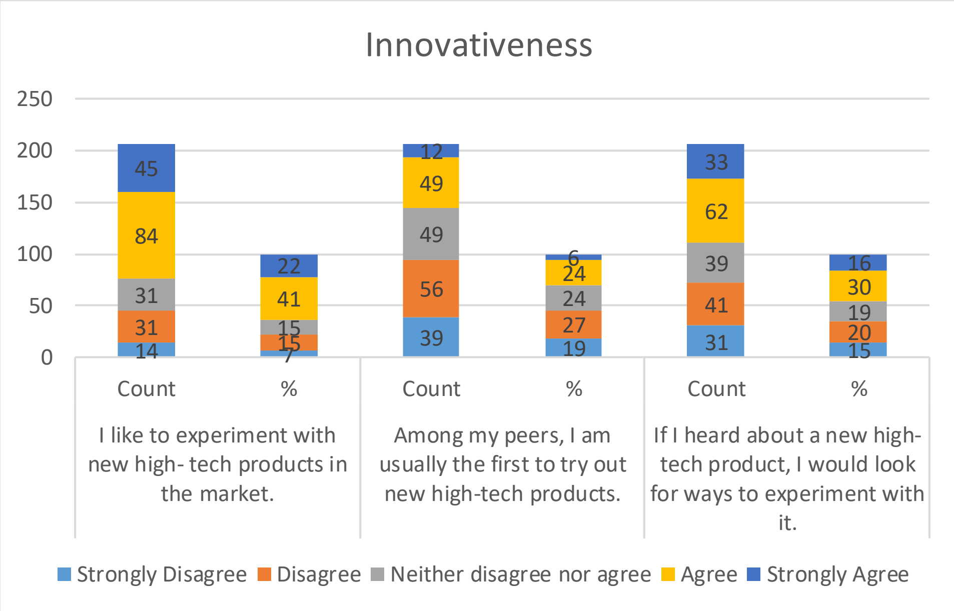
5.1. Innovativeness, Self-efficacy and Positive Self-Image

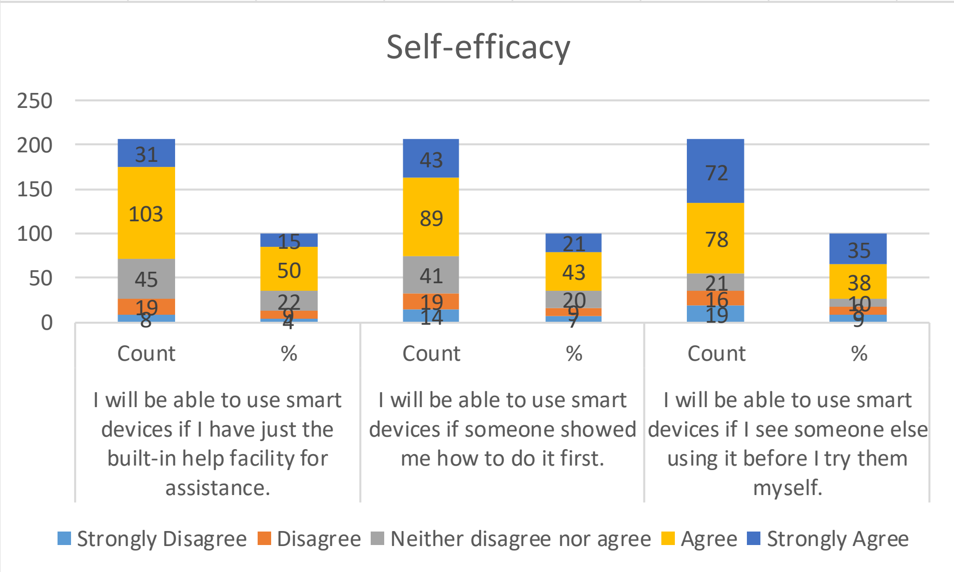
Table A5. 1 Item scores for innovativeness, self-efficacy and positive self-image

Innovativeness		1		2		3	
		I like to experiment with new high-tech products in the market.		Among my peers, I am usually the first to try out new high-tech products.		If I heard about a new high-tech product, I would look for ways to experiment with it.	
		Count	%	Count	%	Count	%
	Strongly Disagree	13	11	19	16	23	19
	Disagree	17	14	37	30	30	25
	Neither disagree nor agree	23	19	27	22	19	16
	Agree	44	36	31	25	33	27
	Strongly Agree	25	20	8	7	17	14
	Total	122	100	122	100	122	100

Self efficacy		1		2		3	
		I will be able to use smart devices if I have just the built-in help facility for assistance.		I will be able to use smart devices if someone showed me how to do it first.		I will be able to use smart devices if I see someone else using it before I try them myself.	
		Count	%	Count	%	Count	%
	Strongly Disagree	9	8	13	10	16	13
	Disagree	16	13	11	9	9	8
	Neither disagree nor agree	31	26	14	12	9	8
	Agree	45	37	53	44	42	35
	Strongly Agree	20	17	31	26	45	37
	Total	122	100	122	100	122	100

Positive Self image		1		2		3	
		I like to experiment with new high-tech products in the market.		Among my peers, I am usually the first to try out new high-tech products.		If I heard about a new high-tech product, I would look for ways to experiment with it.	
		Count	%	Count	%	Count	%
	Strongly Disagree	2	1	2	1	6	5
	Disagree	3	3	3	3	9	8
	Neither disagree nor agree	17	14	13	10	14	12
	Agree	58	47	55	45	45	37
	Strongly Agree	42	35	50	41	47	38
	Total	122	100	122	100	122	100





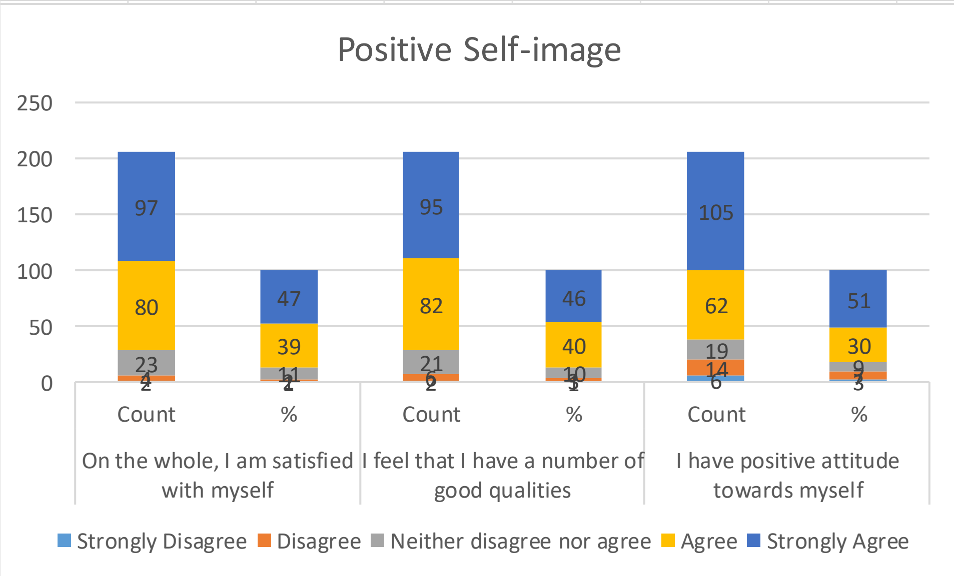


Figure A5. 1 Item scores for innovativeness, self-efficacy and positive self-image

5.2 Attitude and Intention to buy/use

Table A5. 2 Item scores for attitude and intention to buy/use

Attitude		1		2		3		intention to buy		1		2			
		I think using smart devices is a nice idea.		I think using smart devices is/will be beneficial to me.		I have positive feelings toward the idea of using smart devices at home.				I am willing to buy smart devices in the future.		How likely are you to buy a smart device in the near future?		How likely are you to interconnect smart devices you own, into a network to optimise their use?	
		Count	%	Count	%	Count	%			Count	%	Count	%	Count	%
	Strongly Disagree	2	1	2	1	5	4		Strongly Disagree	3	3	9	8	17	14
	Disagree	0	0	3	3	6	5		Disagree	8	7	13	10	16	13
	Neither disagree nor agree	27	22	22	18	38	31		Neither disagree nor agree	14	12	11	9	28	23
	Agree	74	60	69	56	50	41		Agree	58	47	52	42	33	27
	Strongly Agree	20	17	27	22	23	19		Strongly Agree	39	32	38	31	28	23
	Total	122	100	122	100	122	100		Total	122	100	122	100	122	100

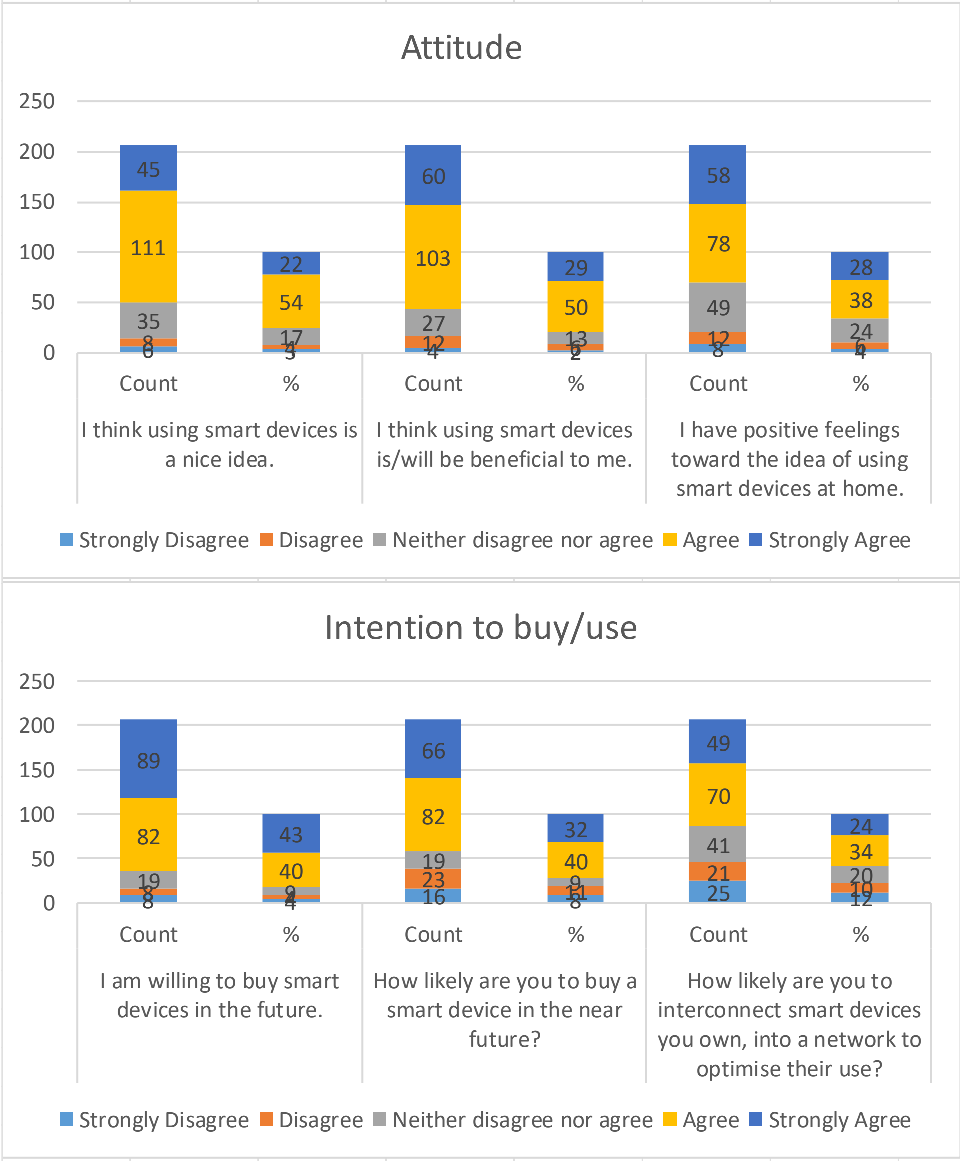


Figure A5. 2 Item scores for attitude and intention to buy/use

5.3 Perceived Ease of Use and Perceived Usefulness

Table A5. 3 Item scores for Perceived Ease of Use and Perceived Usefulness

Perceived Ease of Use		1		2		3	
		I expect smart devices to be easy to use.		Using smart device does not require a lot of my effort.		I find it easy to get the smart device to do what I want it to do.	
		Count	%	Count	%	Count	%
	Strongly Disagree	0	0	2	1	2	1
	Disagree	6	5	16	13	8	6
	Neither disagree nor agree	20	17	25	21	27	22
	Agree	56	46	48	40	61	50
	Strongly Agree	39	32	31	26	25	21
	Total	122	100	122	100	122	100

Perceived Usefulness		1		2		3	
		I find smart devices useful in my daily life.		Using smart devices helps me accomplish tasks more quickly.		Using smart devices improves my chances of achieving things.	
		Count	%	Count	%	Count	%
	Strongly Disagree	2	1	3	3	2	1
	Disagree	6	5	6	5	14	12
	Neither disagree nor agree	19	15	28	23	41	33
	Agree	63	51	61	50	42	35
	Strongly Agree	33	27	23	19	23	19
	Total	122	100	122	100	122	100

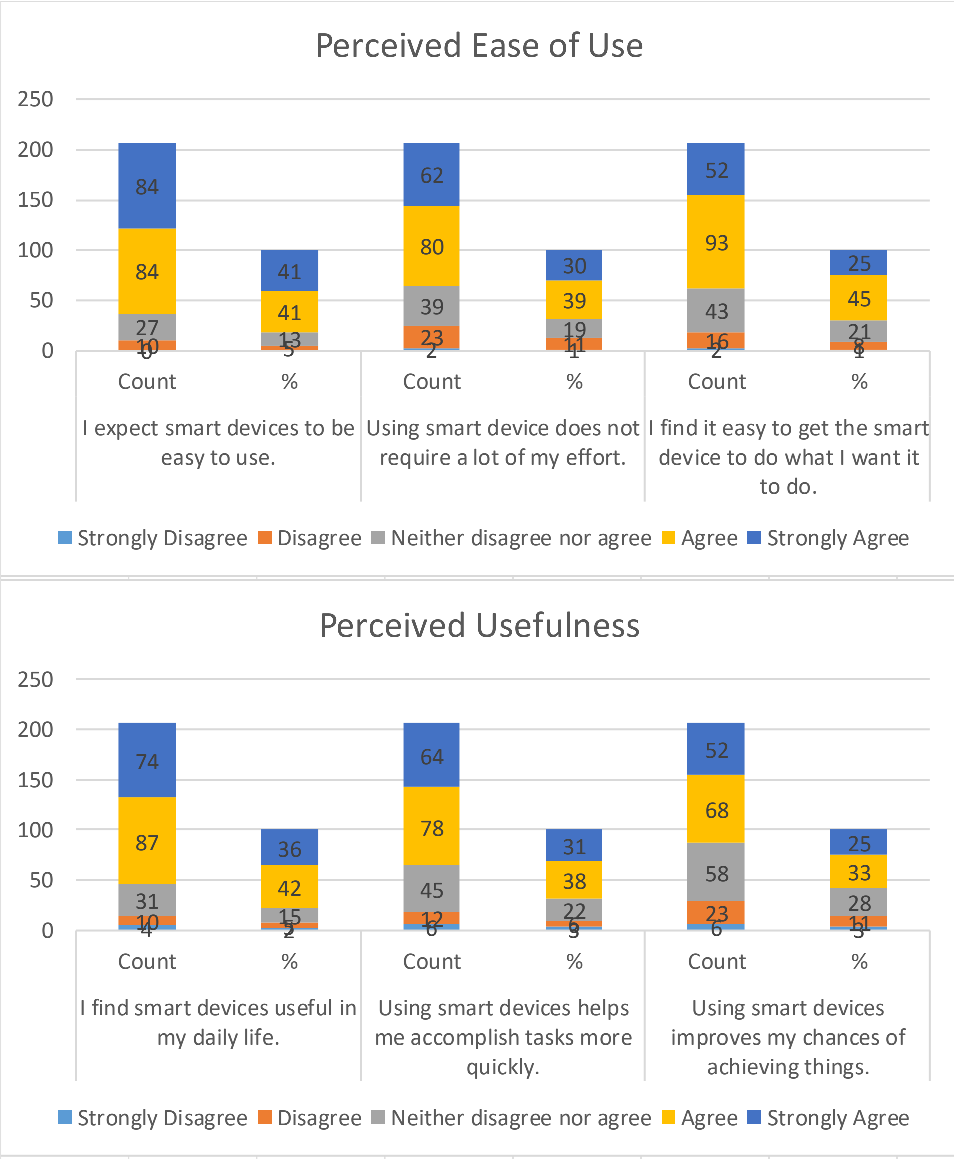


Figure A5. 3 Item scores for Perceived Ease of Use and Perceived Usefulness

5.4 Compatibility, Mobility and Automation

Table A5. 4 Item scores for compatibility, mobility and automation

Compatibility		1		2		3	
		Smart devices will complement existing devices in my home.		Smart devices fit with my home lifestyle.		Using smart devices are/will be compatible with my lifestyle.	
		Count	%	Count	%	Count	%
	Strongly Disgree	3	3	6	5	5	4
	Disagree	13	10	13	10	14	12
	Neither disagree nor agree	33	27	34	28	27	22
	Agree	48	40	44	36	48	40
	Strongly Agree	25	21	25	21	28	23
	Total	122	100	122	100	122	100

Mobility		1		2		3	
		I find it very convenient that smart devices can be accessed anywhere at any time.		It is a big advantage that smart devices can be used while moving from place to place.		Mobility is an outstanding advantage of smart devices.	
		Count	%	Count	%	Count	%
	Strongly Disagree	2	1	3	3	2	1
	Disagree	2	1	2	1	2	1
	Neither disagree nor agree	17	14	13	10	28	23
	Agree	55	45	47	38	39	32
	Strongly Agree	47	38	58	47	52	42
	Total	122	100	122	100	122	100

Automation		1		2		3	
		It is a great feature of the smart devices that they do many things on their own without human intervention.		It is convenient that smart devices provide auto-adjust function.		I can control every electrical apparatus of smart home through simple operation.	
		Count	%	Count	%	Count	%
	Strongly Disagree	8	6	5	4	17	14
	Disagree	16	13	11	9	14	12
	Neither disagree nor agree	25	21	41	33	39	32
	Agree	44	36	45	37	30	24
	Strongly Agree	30	24	20	17	22	18
	Total	122	100	122	100	122	100

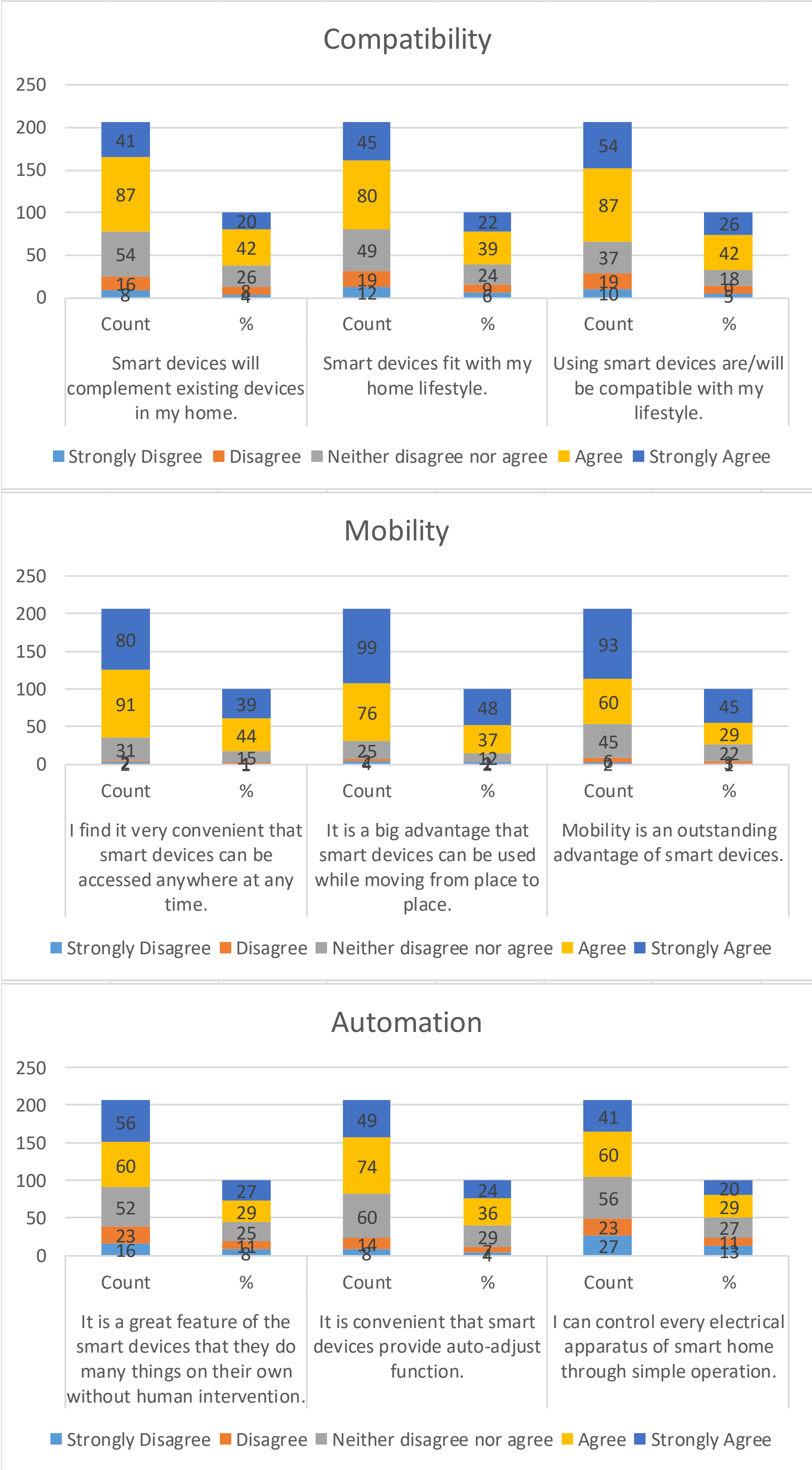


Figure A5. 4 Item scores for compatibility, mobility and automation

5.5 Perceived Cost, Social Influence and Hedonic Motivation

Table A5. 5 Item scores for perceived cost, social Influence and Hedonic motivation

Perceived cost	1		2		3	
	I think smart devices could be too expensive.		The additional convenience of smart devices does not justify the extra cost.		I think I would not be able to afford smart devices.	
	Count	%	Count	%	Count	%
Strongly Disgree	3	3	3	3	14	12
Disagree	8	6	20	17	38	31
Neither disagree nor agree	16	13	28	23	25	21
Agree	59	49	50	41	36	29
Strongly Agree	36	29	20	17	9	8
Total	122	100	122	100	122	100

Social Influence	1		2		3	
	People who are important to me think that I should use smart devices.		People whose opinions that I value prefer that I use smart devices.		People who influence my behaviour think that I should use smart devices.	
	Count	%	Count	%	Count	%
Strongly Disgree	14	12	19	15	17	14
Disagree	11	9	11	9	11	9
Neither disagree nor agree	67	55	66	54	66	54
Agree	22	18	20	17	20	17
Strongly Agree	8	6	6	5	8	6
Total	122	100	122	100	122	100

Hedonic Motivation	1		2		3	
	Using smart devices are/would be fun.		Using smart devices are/would be very entertaining.		37 Using smart devices are/would be enjoyable.	
	Count	%	Count	%	Count	%
Strongly Disgree	2	1	3	3	5	4
Disagree	0	0	5	4	3	3
Neither disagree nor agree	33	27	30	24	38	31
Agree	69	56	69	56	58	47
Strongly Agree	19	15	16	13	19	15
Total	122	100	122	100	122	100

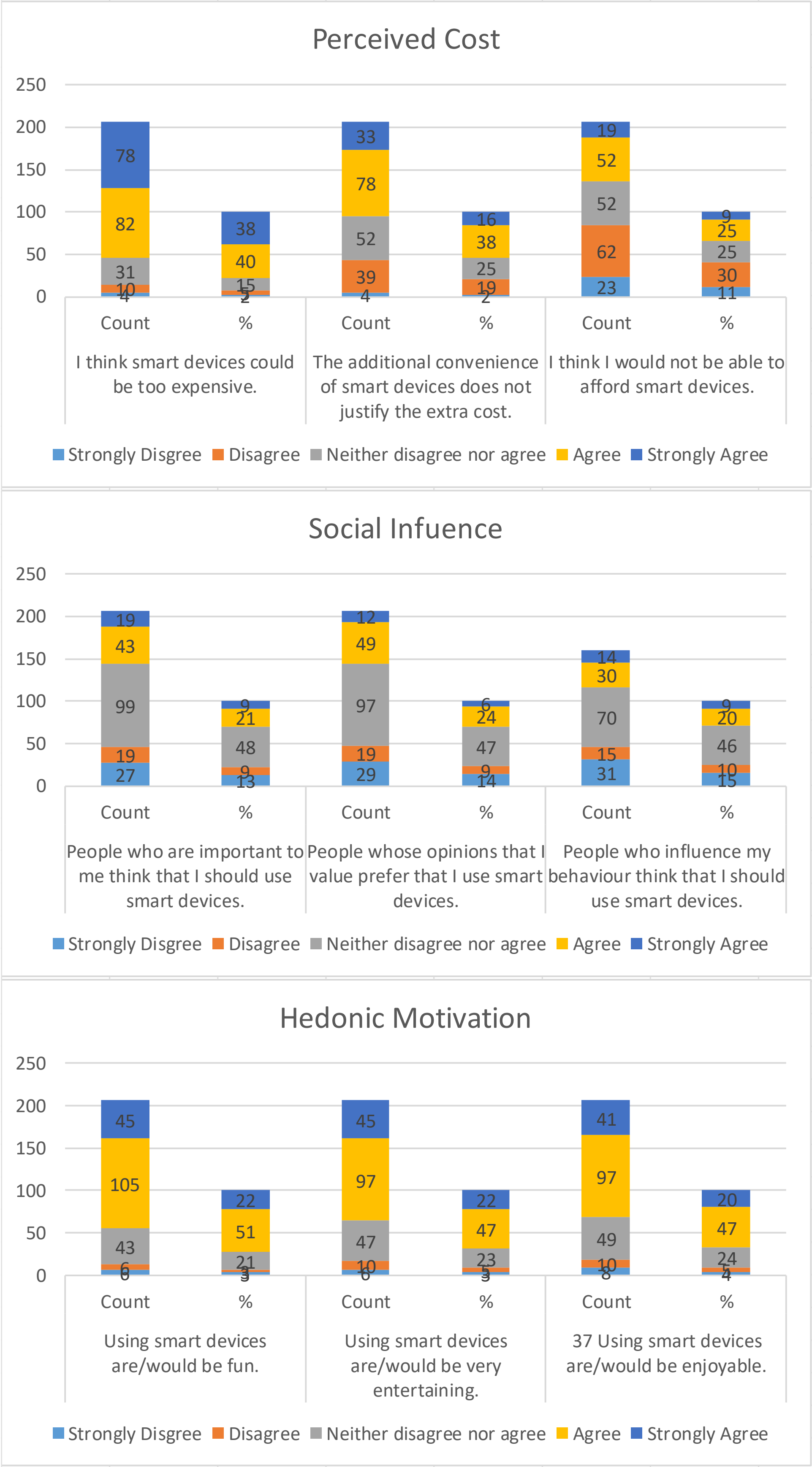


Figure A5. 5 Item scores for perceived cost, social Influence and Hedonic motivation

5.6 Privacy Risk, Security Risk and Physical Risk

Table A5. 6 Item scores for privacy, security and physical risk

Privacy risk	1		2		3	
	If I use a smart device, I will lose control over the privacy of my personal data.		My personal information will be less confidential if I use a smart device.		I fear to use smart home devices due to loss of my personal data and privacy.	
	Count	%	Count	%	Count	%
Strongly Disagree	3	3	9	8	9	8
Disagree	19	15	13	10	30	24
Neither disagree nor agree	28	23	20	17	22	18
Agree	42	35	52	42	36	29
Strongly Agree	30	24	28	23	25	21
Total	122	100	122	100	122	100

Security risk	1		2		3	
	I suspect that security systems built into smart devices are not strong enough to process my information securely.		There is a big chance that internet hackers may take control of my information if I use a smart device.		I find it risky to disclose my personal information with smart home devices.	
	Count	%	Count	%	Count	%
Strongly Disagree	8	6	6	5	13	10
Disagree	19	15	19	15	23	19
Neither disagree nor agree	19	15	25	21	20	17
Agree	55	45	50	41	44	36
Strongly Agree	22	18	22	18	22	18
Total	122	100	122	100	122	100

Physical risk	1		2		3	
	I am concerned about potential physical risks because smart devices may not be completely safe (may cause fire, flooding, electrical shock, etc.)		I do not like smart devices as they could cause damage due to malfunctions or misuse.		I am afraid that smart devices will cause some problems at my home.	
	Count	%	Count	%	Count	%
Strongly Disagree	14	12	22	18	22	18
Disagree	36	29	33	27	33	27
Neither disagree nor agree	33	27	36	29	31	26
Agree	30	24	28	23	33	27
Strongly Agree	9	8	3	3	3	3
Total	122	100	122	100	122	100

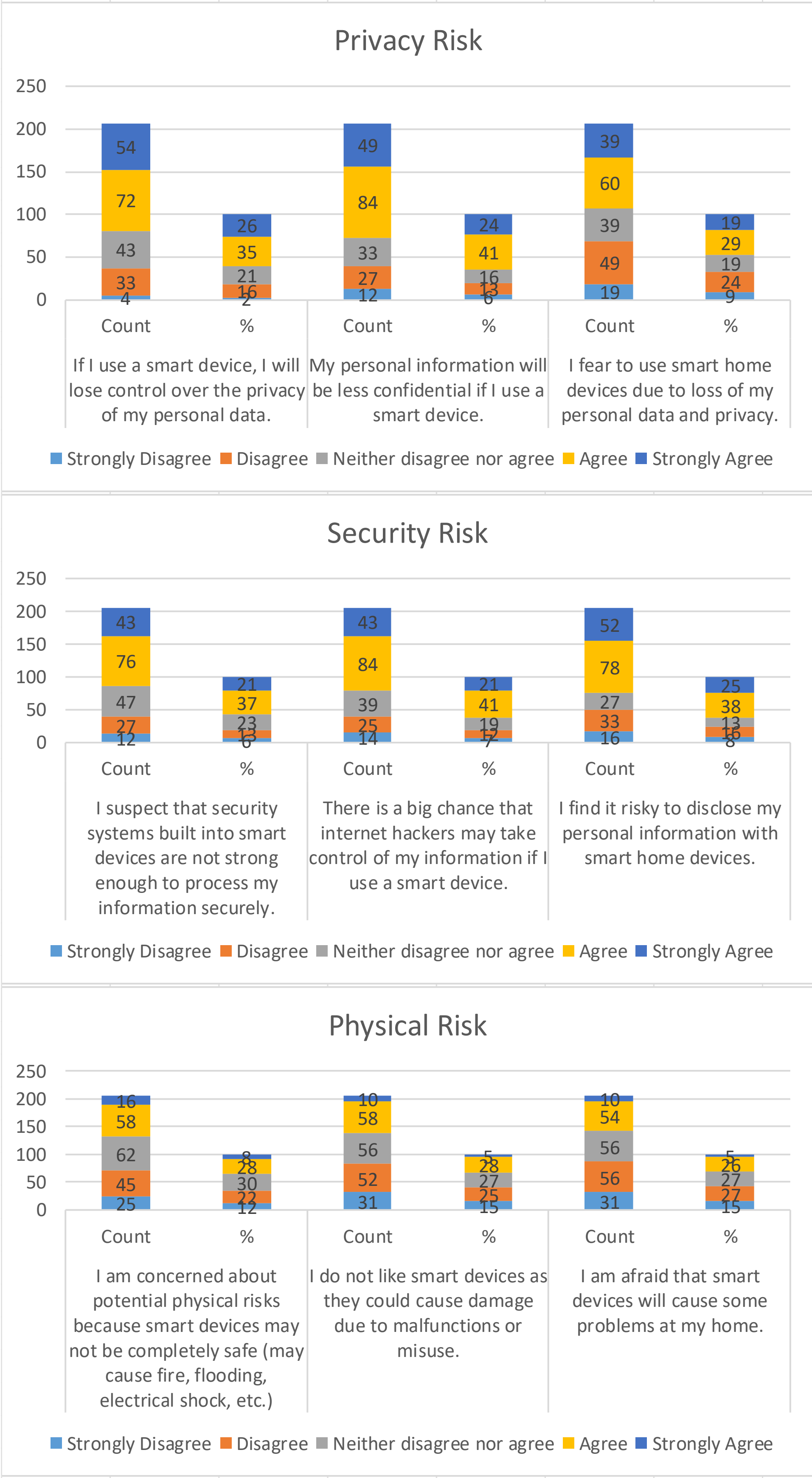


Figure A5. 6 Item scores for privacy, security and physical risk

5.7 Trust in IoT Providers

Table A5. 7 Item scores for trust in IoT Providers

		1		2		3	
Trust in IoT providers		Smart devices providers: - are trustworthy		Smart devices providers: - are reliable		Smart devices providers: - have integrity	
		Count	%	Count	%	Count	%
	Strongly Disagree	14	12	8	6	16	13
	Disagree	23	19	19	15	31	26
	Neither disagree nor agree	45	37	39	32	42	35
	Agree	31	26	47	38	23	19
	Strongly Agree	8	6	9	8	9	8
	Total	122	100	122	100	122	100

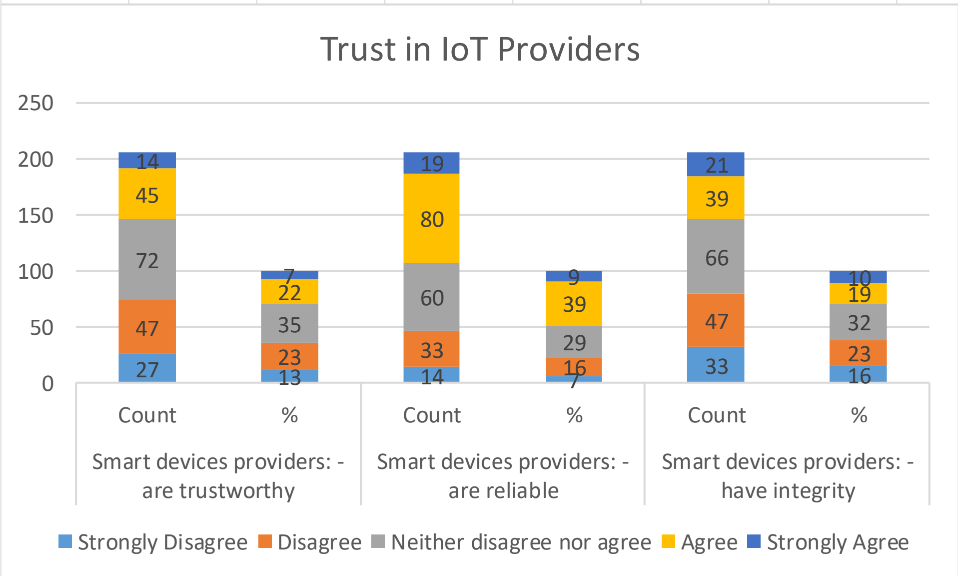


Figure A5. 7 Item scores for trust in IoT Providers

Appendix 6 Social media advert

Appendix 7 Overview of smart home literature

Year	Research Focus	Study/Source(s)
2013	Adoption of Smart Metering: Study on UK consumers' attitudes toward smart meters and their willingness to adopt the technology.	Balta-Ozkan, N., Davidson, R., Bicket, M. and Whitmarsh, L. (2013) Social Barriers to the Adoption of Smart Homes. Energy Policy, 63, 363-374. http://dx.doi.org/10.1016/j.enpol.2013.08.043
2013	Diffusion of Smart Energy Technologies: Study exploring how diffusion theory applies to the uptake of smart energy devices, including IoT devices in UK homes.	Strengers, Y. (2013). Smart Energy Technologies in Everyday Life: Smart Utopia? (1st ed.) Palgrave Macmillan. https://www.palgrave.com/gp/book/9781137267047
2014	Key factors influencing user acceptance of the smart fridge.	Alolayan, B. (2014) 'Do I really have to accept smart fridges? An empirical study', ACHI 2014, The Seventh International Conference on Advances in Computer-Human Interactions.
2015	Acceptance of Smart Home Devices: Study examining key factors influencing the acceptance of IoT smart devices in homes.	Wilson, C., Hargreaves, T. & Hauxwell-Baldwin, R. Smart homes and their users: a systematic analysis and key challenges. Pers Ubiquit Comput 19, 463–476 (2015). https://doi.org/10.1007/s00779-014-0813-0
2016	Smart wearable devices	Yang, H., Yu, J., Zo, H. and Choi, M. (2016) 'User acceptance of wearable devices: An extended perspective of perceived value', Telemat. Inform.33, 256–269.
2017	Smart home in Korea	Yang, H., Lee, H. and Zo, H. (2017) 'User acceptance of smart home services: an extension of the theory of planned behavior', Wembley: Emerald Publishing Limited (Industrial management and#43; data systems, 117), 117(1), pp. 68–89. Available at: doi: 10.1108/IMDS-01-2016-0017.
2017	Smart home environment	E. Park, Y. Cho, J. Han and S. J. Kwon, "Comprehensive Approaches to User Acceptance of Internet of Things in a Smart Home Environment," in IEEE Internet of Things Journal, vol. 4, no. 6, pp. 2342-2350, Dec. 2017, doi: 10.1109/JIOT.2017.2750765.
2017	User Adoption of Smart Home Technologies	Wilson, C., Hargreaves, T. and Hauxwell-Baldwin, R. (2017) Benefits and Risks of Smart Home Technologies. Energy Policy, 103, 72-83. https://doi.org/10.1016/j.enpol.2016.12.047
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