ISTANBUL BILGI UNIVERSITY
INSTITUTE OF GRADUATE PROGRAMS
ORGANIZATION STUDIES PHD PROGRAM

ADOPTION OF INTERNET OF THINGS (IoT) CONCEPTS WITHIN CONSUMER, COMMERCIAL, INDUSTRIAL AND INFRASTRUCTURE APPLICATIONS

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İSTANBUL
2023

Adoption Of Internet Of Things (IoT) Concepts Within Consumer, Commercial, Industrial and Infrastructure Applications

Nesnelerin İnterneti Konseptlerinin Tüketici, Ticari, Endüstri ve Altyapı Uygulamalarında Benimsenmesi

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Tezin Onaylandığı Tarih : 17.01.2023
Toplam Sayfa Sayısı : 98

Anahtar Kelimeler (Türkçe)	Anahtar Kelimeler (İngilizce)
1) Nesnelerin İnterneti	1) Internet of things
2) Bağlanabilirlik	2) Connectivity
3) Teknoloji benimseme	3) Technology adoption
4) İnovasyon yayılımı	4) Innovation diffusion
5) Yapay zeka	5) Artificial intelligence

FOREWORD

This dissertation could not have been possible without the encouragement of my dear wife İpek who has supported me along the whole journey relentlessly night in and out. I dedicate this work to her and our daughter Ada hopefully to join our family soon.

I could not thank enough my advisor Prof. Dr. Beril Durmuş, she has always been there when I needed guidance and motivated me all along the way with remarkable patience.

Lastly, I'd like to memorialize Prof. Dr. Selime Sezgin, who has shown both tremendous compassion and mentorship in my PhD endeavour. May her soul rest in peace.

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LIST OF ABBREVIATIONS

AWS	Amazon Web Services
AI	Artificial Intelligence
CIO	Chief Information Officer
C2C	Consumer to Consumer
C2M	Consumer to Machine
DIT	Diffusion of Innovation Theory
DIY	Do it yourself
ECG	Electrocardiogram
FSC	Food Supply Chain
GPS	Global Positioning System
HCI	Human Computer Interaction
IHCI	Implicit Human Computer Interaction
IOT	Internet of Things
M2M	Machine to Machine
RFID	Radio Frequency Identification
SDN	Software Defined Networking
SCM	Supply Chain Management
TAM	Technology Acceptance Model

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ABSTRACT

Internet of things (IoT) can be defined as the interconnectivity of all smart devices with one another using the proper infrastructure thanks to the technological sophistication level achieved as of today. According to many, IoT is evaluated to be the next disruptive technological advancement which will shape our lives in the near future. On top its contributions to individual’s daily life, there are also many barriers hindering the dissemination of the IoT technology as it works on the basis of big data management via cloud systems which also comprises personal information inside. As IoT operates in a systematic manner, there is a variety of applications of the IoT technology in many fields ranging from smart health services, smart manufacturing, connected and autonomous mobility, smart city, smart farming to smart digital payment services. There is a vast amount of research focusing on the factors affecting the IoT technology adoption in single particular scope of implementation however there is no evident case in literature which studies the significant effects on IoT adoption in a holistic perspective by taking multiple fields of exercise.

This research aims to fill this gap by creating a virtual future mise en scene, where the study group is requested to envision the future IoT dominated living space. On this conceptual framework, primary focus of this dissertation is to lay out the parameters having a substantial effect on the IoT adoption in application areas smart health, smart home, connected mobility and smart payment respectively. Latter objective of the thesis study is to bring to surface the differences between the variables acting on the IoT adoption in these focused application areas. In conclusion, implications for marketers and recommendations for future research are also asserted for IoT technology adoption in marketing context.

Keywords: Internet of Things, Connectivity, Technology Adoption, Innovation Diffusion, Artificial Intelligence

ÖZET

Nesnelerin İnterneti (IoT), günümüzde ulaşılan teknolojik gelişmişlik seviyesi sayesinde tüm akıllı cihazların gerekli altyapıyı kullanarak birbirleriyle bağlantı kurması olarak tanımlanabilir. Pek çok çalışmaya göre IoT, yakın gelecekte hayatımızı şekillendirecek bir sonraki yıkıcı teknolojik gelişme olarak değerlendiriliyor. Bireyin günlük yaşamına sağladığı katkıların yanı sıra, IoT teknolojisinin, içinde kişisel bilgilerin de yer aldığı bulut sistemleri üzerinden büyük veri yönetimi esasına göre çalışması nedeniyle yaygınlaşmasının önünde birçok engel de bulunmaktadır. Nesnelerin interneti sistemli bir şekilde çalıştığından, akıllı sağlık hizmetlerinden akıllı üretime, bağlantılı ve otonom mobiliteden akıllı şehir, akıllı çiftçiliğe ve akıllı dijital ödeme hizmetlerine kadar pek çok alanda IoT teknolojisinin çeşitli uygulamaları bulunmaktadır. Belirli bir uygulama kapsamında IoT teknolojisinin benimsenmesini etkileyen faktörlere odaklanan çok sayıda araştırma bulunmaktadır. Ancak literatürde, IoT teknolojisinin benimsenmesi üzerindeki önemli etkileri birden fazla uygualama alanı üzerinde bütünsel bir bakış açısıyla inceleyen bir çalışma bulunmamaktadır. Bu araştırma kapsamında, çalışmaya katılan araştırma grubundan gelecekte IoT teknolojilerinin hakim olduğu bir dünyayı hayal etmelerini sağlayacak sanal bir mizansen oluşturularak, IoT teknolojisinin benimsenmesine etki eden faktörler araştırılmış ve literatürdeki bu boşluğun kapatılması amaçlanmıştır. Bu kavramsal çerçevede, tezin birincil odak noktası sırasıyla akıllı sağlık, akıllı ev, bağlanabilir mobilite, ve akıllı ödeme uygulama alanlarında IoT'nin benimsenmesinde önemli bir etkiye sahip olan parametreleri ortaya koymaktır. Tez çalışmasının ikincil amacı da, odaklanılan uygulama alanlarında IoT'nin benimsenmesine etki eden değişkenler arasındaki farklılıkları ortaya çıkarmaktır. Sonuç olarak pazarlama literatürü çerçevesinde, IoT teknolojisinin benimsenmesi için pazarlamacılar adına çıkarımlar ve gelecekteki araştırmalar için öneriler de ileri sürülmüştür.

Anahtar Kelimeler: Nesnelerin İnterneti, Bağlanabilirlik, Teknoloji Benimseme, İnovasyon Yayılımı, Yapay Zeka

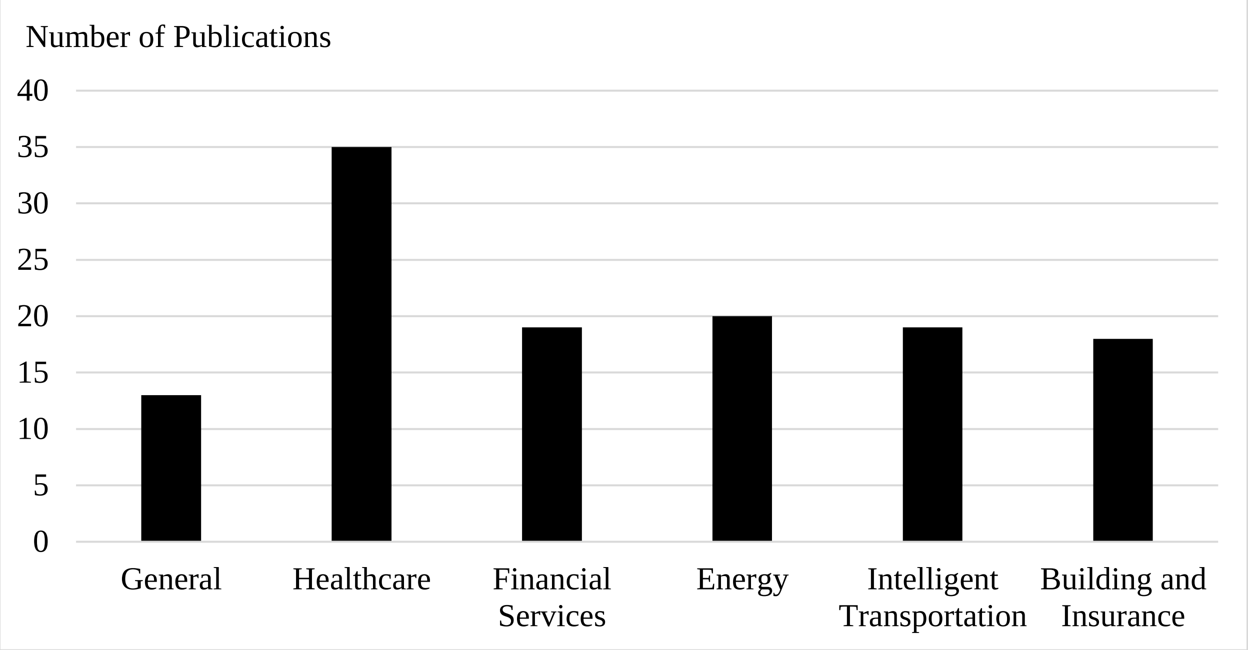
INTRODUCTION

The Internet of Things (IoT) is driving the transformation of the tangible world into an ecosystem in which everyday things contain sensors, actuators, and network connectivity to a broad variety of applications and services. The Internet of Things (IoT) might propel the next stages in the digitalization of our economy and culture. For its customers, it offers a number of advantages ranging from improved speed and precision in environmental sensing to cheaper monitoring of production operations. Incomes for IoT application and service providers are predicted to increase dramatically as the number of connected devices grows. New business frames for both consumers and manufacturers will be prompted by the IoT, shifting the competitive landscape. A company's ability to reap long-term advantages from its usage of the Internet of Things is largely dependent on how creatively and effectively it applies the IoT to the creation of new business models and the discovery of profitable uses for IoT data. (K. Naveed et al., 2018)

Academics and government officials just lately began to recognize the rapidly growing importance and pervasiveness of the Internet of Things. The integration of networks for synchronous data gathering and processing is made possible by the proliferation of sensors, smart devices, and high-speed Internet, which paves the way for rapid decision-making and immediate behavioral reactions to changes. The adoption of IoT-based platforms in production and consumption may be traced back to the administrative efficiency and emotional comfort that the virtual interconnectivity of persons and things provides for network operators, end users, and other third-party players. (D.N. Le et al., 2019)

In Figure 1.1 it is illustrated how articles are distributed amongst various sectors (Thibaud, 2018)

Figure 1.1 Distribution of IoT Related Publication by Industry



Source: M. Thibaud et al. / Decision Support Systems 108 (2018) 79–95

1.1 STATEMENT OF THE PROBLEM

Vast amount of research has been done respectively on different application areas of the IoT such as smart health, smart home, smart payment, connected mobility, smart agriculture, smart manufacturing and smart city. The scope of research on IoT technology has many touchpoints in either of these applicable sectors whereas there is no research in marketing literature consolidating all the different aspects monitored in these areas in one single holistic approach. This dissertation aims to address this gap within the marketing literature serving to the nature of the IoT technology adoption as the system functions in the best way if it comprises as many connected systems and people in it. This paper seeks to understand the effect of different parameters acting on the adoption of the IoT technology and underline the differences on how these parameters are assessed between the applied sectors.

Smart health and smart home sections are considered under consumer applications whereas smart payment and connected mobility are evaluated under commercial application in this paper’s scope. Smart agriculture (farming) and smart manufacturing are listed under industrial applications and smart city refers to the infrastructure application of IoT technologies.

Table 1.1 Area of Application per IoT Technology Employed

IoT Technology	Area of Application
Smart Health	Consumer
Smart Home	Consumer
Smart Payment	Commercial
Connected Mobility	Commercial
Smart Agriculture	Industrial
Smart Manufacturing	Industrial
Smart City	Infrastructure

1.2 AIM OF RESEARCH AND RESEARCH QUESTIONS

The purpose of the research has two folds. Primary aim of the dissertation is to understand the factors affecting the adoption decision of the end user for the corresponding IoT technology. Consolidating the input from various papers focused on different IoT technology areas, a research model has been established addressing all the enablers and challenges revolving around IoT technology adoption. The model also aims to comprise the technology acceptance model parameters as IoT emerges as one of the leading new technologies that snowballed into a global trend in the recent years. Research model and the respective scales to measure IoT technology adoption will be in-depth analysed in the methodology section of the paper however research questions can be annumerated as follows to give a preliminary insight on the content of the research.

- What is the effect of the “cost of the related IoT technology product/service” on the adoption intention of the end user?
- What role does “privacy” play by means of adopting the IoT technology?
- In which way “security” of the IoT technology product/service effects the adoption decision?
- Is “ubiquity” a relevant parameter for IoT technology adoption?
- In terms of technology acceptance model, does “perceived usefulness” plan a role in the IoT technology adoption?
- How does “anxiety” effect the IoT product/service adoption?

- How is “innovativeness” related to IoT technology adoption?
- Is “intrusiveness” a threat for IoT adoption?
- As per innovation diffusion theory how do “relative advantage”, “complexity” and “compatibility” effect the IoT adoption decision?

Latter purpose of the dissertation is to dig out if any relationship exists between these parameters in different applicable areas of the IoT technology such as smart health services, smart home solutions, smart digital payment methods and connected mobility. Smart manufacturing, smart city and smart agriculture may be context of future studies to expand the findings of this research.

1.3 CONCEPTUAL FRAMEWORK

In order to assess the parameters affecting the IoT product/service adoption intention in a holistic manner, a hypothetical world has been depicted for the participants in the survey where a daily routine of an individual in the future is described using various means made available to him by the IoT technology such as connected health services, smart home technologies, easy and connected payment methods and connected mobility solutions. Within this framework, to help the participant visualize this world, a specific video has been created showing different experiences that the individual goes through during the day. This research focuses on this integral concept of the IoT technologies and aims to comprehend the relationship between the IoT technology applications and how they are perceived and intended to be adopted by the end user.

1.4 SIGNIFICANCE AND CONTRIBUTIONS OF THE STUDY

This research will contribute to the marketing literature on new technology adoption and innovation diffusion by adding the specific parameters related to Internet of Things technology products and services. There are many papers published in the area of marketing and as well as in the engineering sense considering different applicable sectors of the Internet of Things. This paper will bring in a new approach where a holistic helicopter view will be employed in assessing the parameters affecting the adoption on this new technology. As IoT is intended to be used in a complicated and complex system where many different systems speak to one another touching the individual’s daily life on many aspects, this study aims to understand the common and labile scales affecting the adoption of this new technology.

2. INTERNET OF THINGS

2.1 DEFINITION

Ashton (2009), a British technological entrepreneur, is credited with finding the phrase "internet of things" (IoT) in 1999. (Gubbi et al., 2013). The goal of the IoT is to bring the conveniences of the traditional internet to the real world, such as continual connectivity, remote control, data exchange, and so on. (Peoples et al., 2013)

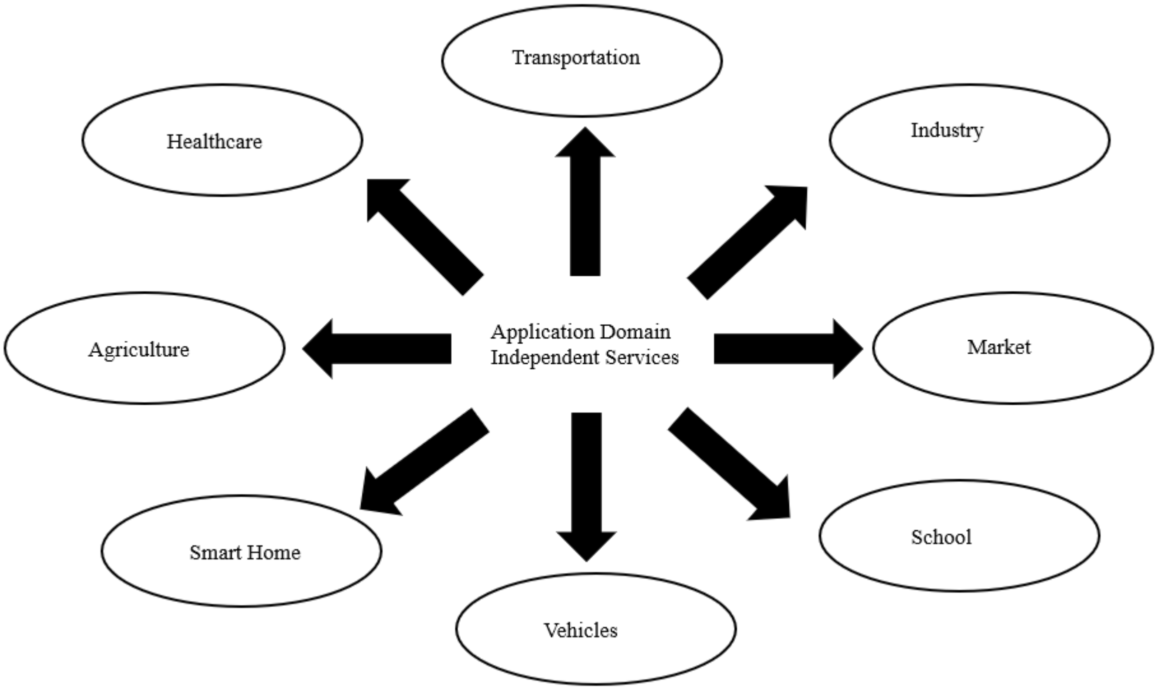
A new technological paradigm, the Internet of Things (IoT) is envisioned as an interoperable worldwide network of machines and gadgets all over the world. It goes by various names, such as the Internet of Everything or the Industrial Internet. The Internet of Things (IoT) is receiving a great deal of interest from several sectors due to its status as one of the most promising emerging technologies. When devices in the IoT are able to exchange data with one another and interact with enterprise-wide platforms like vendor-managed inventory systems, customer support systems, business intelligence tools, and business analytics, the actual potential of the IoT for businesses becomes apparent (Lee, 2015).

Through the IoT, it is possible to connect almost any device, anywhere in the world, at any time (Vermesan et al., 2011). The widespread use of sensors, physical artifacts within electronic devices with the capacity to bridge the gap between the virtual and the physical, is what makes this future a reality (Atzori et al., 2010). Vital signs such as heart rate and temperature can be collected from patients; individual forms of movement can be tracked via global positioning systems in urban areas; power and electricity usage can be monitored using sensors in homes; vehicle routes and driver attitude can be studied using devices installed in vehicles (X. Caron et al., 2016).

Despite its extensive coverage in professional publications, the Internet of Things (IoT) is really rather complex, including a wide range of technology, applications, economic players, and challenges. That's why there are numerous different takes on what the IoT is and what it means in both business and academics. Numerous research have made an effort to map out the IoT and determine its constituent parts (e.g., Al-Fuqaha et al., 2015; Atzori et al., 2010; Borgia, 2014; Lin et al., 2017; Whitmore et al., 2015). Atzori et al. (2010) echoed this sentiment, noting that the IoT is a multifaceted sector that draws on expertise in areas as varied as telecommunications, informatics, and social science. To help with the development of IoT-based services and products, they offered an overview of the key technology, application areas, and problems. Borgia (2014) provided a comprehensive analysis of the technology, applications, and problems associated with the Internet of Things. With questions like "Does the IoT already exist?" and summaries of technologies like cloud computing and wireless technologies, practitioners in the industry (Want, Schilit, & Jenson, 2015) have joined the endeavour to comprehend the IoT (Chae, 2019).

Figure 2.1 illustrates the overall concept of the IoT in which every domain specific application is interacting with domain independent services, whereas in each domain sensors and actuators communicate directly with each other. Over time, the IoT is expected to have significant home and business applications, to contribute to the quality of life and to grow the world's economy (Al-Fuqaha, 2015).

Figure 2.1 Application Domain and Independent Services of IoT



Source: Al-Fuqaha, A., Guizani, M., Mohammadi, M., Aledhari, M., & Ayyash, M. (2015). Internet of Things: A survey on enabling technologies, protocols, and applications.

The concepts behind the Internet of Things have been around for a while. Ubiquitous computing researchers have been debating the advantages and disadvantages of such systems for years.

For instance, Poslad (2009) specifies the following characteristics of a ubicom system:

Five characteristics distinguish iHCI from pure HCI: 1) networked, distributed, transparently accessible; 2) iHCI (implicit human computer interaction), HCI needs to be less obtrusive, more hidden; 3) context awareness (CA) (devices need to be aware of the context in which they are operating); 4) autonomy (need to be able to operate autonomously without human intervention; be self-governed); and 5) artificial intelligence (AI)

With these characteristics in mind, it's easy to understand how the IoT is a current realization of a ubicom. There are several different types of interactions that can take place between devices, including digital "machine-to-machine" (M2M) interactions, consumer-to-machine (C2M) interactions, device-to-physical world contacts, and consumer-to-consumer (C2C) interactions. When analysed via the ubicom lens, we can see how these diverse consumer-device interactions in the smart home have the potential to yield novel user experiences. Internet of Things is characterized by the following characteristics: The network of physical things and gadgets that are programmed to perform certain tasks and can connect wirelessly via the Internet and with one another. Using the Internet to send and receive data that is then saved and structured in a database, "smart products" can interact and communicate with one another, as well as with humans. Connected products can learn about users' environments and behaviors through their interfaces.

When both parties are in a certain mental and environmental state, they can have a conversation. That gives them the freedom to function without human interference. Consumer IoT items linked to one another and to humans via the internet and databases form a whole that is greater than the sum of their parts (Poslad, 2009). The table below illustrates how IoT is managed in the context of key technological developments.

Table 2.1 IoT Context in Major Technology Trends

Technology Trend	**Context**
Big Data	IoT helps us interpret the huge amount of data collected at any place of the world at any given instant. The bigger the size of the data easier it gets for governments, brand, enterprises to build up their work plans and strategies. It also helps them to understand the world from the consumers’ eyes as instant data can be collected with the help of IoT systems.
Cloud	With the availability of cloud computing, data can be stored ubiquitously in a

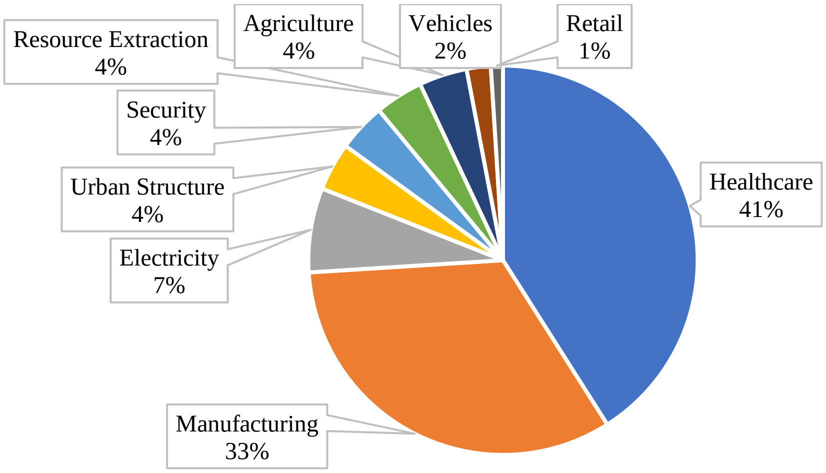
computing	cloud where it can be accesses at will. It also enables the users to share any relevant data with any third party by granting access.
Wearable technology	The consumer can become the centre for data as well via wearing a smart device all day long. Without any notice, this technology can collect data for instance about the vitals of an individual which then can be shared in case of an emergency with a doctor or the smart device can collect everyday knowledge about the consumer activities which can come in handy for companies marketing their products.
Blockchain	The blockchain can be thought of as a distributed ledger in which data is stored in cryptographically secure blocks that are recorded in chronological order. As an example, it's well-suited to the Internet of Things because of the following: Due to blockchain's sequential nature, it can be used to monitor sensor data measurements and stop any unnecessary recording of the same data. Due to the lack of a central point of failure and the requirement of consensus in the chain of blocks for any efforts to update records, blockchain provides a higher level of security. Blockchain technology is widely used for smart contracts. A smart contract is an electronic agreement with predetermined triggers for the execution of predetermined actions, like as the transfer of funds or ownership of property, when certain circumstances are met. On a blockchain, transactions cannot be slowed down by intermediaries.
New interfaces	To access IoT systems, smartphones are the primary interfaces at the moment. Health tracking applications are the standard on wearable devices, and smart thermostats are typically managed from a smartphone. This tendency is being bucked by the introduction of new interfaces like Amazon Alexa and Google Home, which offer improved connectivity with IoT devices and the physical environment.
New interactions	New forms of communication are required in a society full of intelligent gadgets. The prevalence of smart cameras in consumer goods is fueling the rise of visual recognition. In today's image-centric, constantly connected society, our fixation with appearances seems to only increase.

Source: A Marketer's Guide to the Internet of Things, Econsultancy Report, 2018

2.2 GENERAL STATISTICS ON INTERNET OF THINGS USAGE

IoT-based services have contributed significantly to the economic success of corporations. It is expected that the healthcare and industrial sectors would gain the greatest benefits. By 2025, the global economy is projected to grow by between $1.1 and $2.5 trillion per year thanks to healthcare applications and related IoT-based services like mobile health and telecare, which make medical wellness, prevention, diagnosis, treatment, and monitoring services accessible via electronic media. By 2025, experts predict that the IoT will have an annual economic effect of between $2.7 trillion and $6.2 trillion (Al-Fuqaha, 2015). The anticipated market share of leading IoT applications is shown in Figure 2.2.

Figure 2.2 Projected IoT Application Market Share by 2025



Source: Al-Fuqaha, A., Guizani, M., Mohammadi, M., Aledhari, M., & Ayyash, M. (2015). Internet of Things: A survey on enabling technologies, protocols, and applications

Additional research brings on to the table that the IoT landscape is being shaped by many different technologies, approaches, applications, enterprises, and concerns, with varying degrees of appeal. Cloud computing stood up as the most widely adopted component. This is because cloud computing is generally accepted as the backbone infrastructure for the Internet of Things, allowing for the communication of linked devices and the delivery of services based on the Internet of Things to end users. Twitter users often talk about how the Internet of Things (IoT) relates to cloud computing and software-defined networking (SDN). Managing networks for linked heterogeneous objects and devices is a difficult task, but software-defined networking (SDN) has emerged as a promising new option (Nunes, et al., 2014). Technology companies like Microsoft, IBM, and Amazon Web Services (AWS) appear to be aggressively marketing their products and services. Big data looks to be the second most widely used component of the Internet of Things ecosystem. Analytics, data science, deep learning, machine learning, and artificial intelligence were all prominent in the IoT environment, as were other terms and ideas linked to big data management and analytics. The relationship between big data and the IoT has been the subject of previous literature as well (Chae, 2015). Collecting, organizing, and analysing data is essential for any Internet of Things services and applications, making big data-related components highly sought for. It's clear from the statistics worked for IoT technologies that there are four distinct facets of security to consider: cyber, data, criminal, and personal. Prior technical studies have highlighted security and privacy as major concerns for IoT product and service rollouts (Lin et al., 2017). Cybersecurity and data security have been two of the most widely discussed of these four areas. The "wearable" topic was quite popular, placing fourth overall and only behind cloud computing, big data, and security-related issues. Wearable technology like Google Glass, the Smartwatch are among the most often used terms in this context. One of the most often used terms in this context was "nano," maybe because of the growing interest in nanotechnology and its use in fields such as sensing and healthcare (Abbasi et. al., 2017). This suggests that people are talking about nanoparticles as a potential next-generation material for wearable technology. In the IoT ecosystem, the introduction of cryptocurrencies and related technologies (such as blockchains). Bitcoin, cryptocurrency, Ethereum, btc, and eth are some of the most searched terms related to IoT technology.

Creating smart settings is central to the Internet of Things, and two prominent Twitter conversations center around this idea: the "smart city" and the "smart house." Services such as structural health monitoring, waste management, air quality monitoring, noise monitoring, traffic monitoring, city energy consumption, smart parking, smart lighting, and building automation are all part of what is referred to in the literature as urban IT and what constitutes a "smart city" (Ju et.al., 2018). Not only that, but it seems that the Internet of Things will play a significant role in the marketing, manufacturing, and insurance industries as well. In the retail sector, optimism is rising that Internet of Things technology will significantly alter the way supply and demand are managed. Businesses in the retail industry would do well to learn the importance of coordinating product needs with available inventory. Camera networks, smart cards, and location tracking sensors are all examples of Internet of Things (IoT) devices that can improve a retailer's market-sensing (demand-side) and product-tracking (supply-side) capabilities, resulting in more accurate pricing, more timely stock replenishment, and more efficient inventory management (Caro et.al., 2019). Production automation in keeping with "factories of the future" (Pei Breivold, 2019) and "industry 4.0" is another important use case. The objective of the IoT technology is to use smart technologies and cloud computing to fully automate industrial processes and systems (such as production and maintenance).

The following table, based on the Gartner conference in Barcelona, illustrates the Internet of Things technologies that will fuel digital innovation through 2023 (Gartner, 2018).

Table 2.2 IoT Technologies Driving the Future

Trend Number (Sorted according to foreseen importance in the near future)	**Trend**
1	Artificial Intelligence (AI)
2	Social, Legal and Ethical IoT
3	Infonomics and Data Broking
4	The shift from Intelligent Edge to Intelligent Mesh
5	IoT Governance
6	Sensor Innovation
7	Trusted Hardware and Operating System
8	Silicon Chip Innovation
9	New Wireless Networking Technologies for IoT

Source: Gartner, Top IoT technology trends that will drive digital business innovation from 2018 through 2023, 2018.

There are several aspects that need to be addressed by the CIOs (Chief Information Officers) in enterprises that go along with the IoT trends driving the future transformation. For the artificial intelligence (AI) context; in 2023, the AI technology environment will remain convoluted due to the various IT companies' heavy investments in the industry, the coexistence of different AI flavors, and the emergence of novel AI-based goods and services. Despite these challenges, AI will be able to produce useful outcomes in many IoT contexts. Consequently, CIOs need to provide their teams with the knowledge and expertise to make the most of AI in their IoT initiatives.

A myriad of social, legal, and ethical concerns will become increasingly pressing as the IoT develops and is implemented more broadly. Data and inference ownership, algorithmic bias, data privacy, and general data protection regulation compliance are all issues that need to be addressed. For an Internet of Things solution to be widely adopted, it must be both technically sound and socially adoptable. CIOs should consider organizing committees like ethical councils to assess organizational strategies and should train themselves and their employees on the topic. Additionally, CIOs should consider hiring third-party consultants to assess critical algorithms and AI systems to detect any bias in data treatment.

According to a survey conducted by Gartner on IoT initiatives 35% of companies reported selling or preparing to sell data gathered by their goods or services. Information economics (infonomics) goes a step further by considering data as a strategic commodity that should be accounted for in the books. Trading information between IoT devices will be commonplace by 2023. To establish the necessary IT rules in this area and to advise other sections of the company, CIOs need to educate their companies about the threats and benefits associated with data broking (Gartner, 2018).

In the Internet of Things (IoT), the transition from centralized and cloud to edge architectures is well underway. However, this is not the final destination, as edge architecture is destined to grow into a less organized architecture that includes a broad variety of "things" and services connected in a dynamic mesh. Flexibility, intelligence, and responsiveness in IoT systems are all possible thanks to mesh topologies, but they typically come at the expense of increased complexity. CIOs need to anticipate changes to their IT infrastructure, personnel, and funding brought on by mesh architectures.

The importance of a governance structure to ensure proper conduct, regarding to production, storage, usage, and deletion of data pertaining to IoT projects will rise in tandem with the IoT's growth. The term "governance" covers a broad spectrum of activities, from relatively straightforward technical chores like auditing devices and installing new firmware to more involved concerns like exercising authority over devices and making effective use of the data they provide. When it comes to governance, CIOs need to take the lead in training their personnel and, in certain situations, allocating resources to addressing governance head-on.

Through 2023, the sensor industry will be in a state of constant change. In the future, it can be expected to see the introduction of new sensors that can detect a wider variety of situations and events, the price reduction or repackaging of existing sensors to make them more accessible for new applications, and the development of new algorithms that can derive additional information from these sensors. It is the responsibility of the CIOs to assure that their staff is keeping an eye on developments in sensor technology for signs that it might help the company seize new opportunities and innovate in existing ones.

When it comes to the technical aspects of establishing IoT devices, security is always cited as the top worry by Gartner polls. This is due to origin and characteristics of the software and hardware used in IoT projects are sometimes outside the control of the businesses involved. However, in the future it is anticipated further rollout of hardware and software combinations that, when taken together, will provide more trustworthy and secure IoT systems. Chief information officers (CIOs) work together with chief security officers before making any purchases regarding Internet of Things (IoT) devices or embedded operating systems.

Further developments in IoT technology will make it possible for low-cost battery-powered gadgets to have features like speech recognition and data analytics. CIOs should take note of this development since the advent of silicon chips that provide features like integrated AI allowing businesses to develop cutting-edge goods and services.

Cost, power consumption, bandwidth, latency, connection density, operational cost, quality of service, and range are just a few of the competing needs that must be taken into account while designing an IoT system. CIOs will have more options and freedom with the advent of new IoT networking technologies because no particular networking solution optimizes all of these. They should explore at 5G, the next series of low earth orbit satellites, and backscatter networks in particular (Gartner, 2018).

Having looked at the specifics of the technological background of the IoT applications, next section will bring forth the narrowed scope of this dissertation targeting smart health, smart home, connected mobility and smart payment solutions.

2.3 CONSUMER APPLICATIONS

2.3.1 Smart Health

The Internet of Things (IoT) and developments in business analytics today enable it to collect huge quantities of personal health data. The Internet of Things enables healthcare service providers to tailor patient treatment. New Internet of Things (IoT) technologies supply data on a patient's daily habits and health, allowing medical practitioners to impact patients much more often and efficiently (Lee, 2015).

We desire affordable and qualified healthcare services throughout our life and Internet of Things (IoT) can achieve this goal. Greater gadgets employ more patient monitoring for chronic health conditions, and this leads to fewer examinations and pointless consultations, which leads to overall cost savings. IoT technology can help early diagnostics and interventions to improve the identification of the nature of a disease or other concerns based on an evaluation of its symptoms. The Internet of Things (IoT) is anticipated to be the next major technological revolution after the Internet (Karahoca, 2017).

The Internet of Things has a major impact in healthcare, particularly in the areas of chronic illness treatment and prevention. Networking all of a hospital's devices together, an IoT-based healthcare system enables things like Internet-based remote surgery, diagnosis, and tracking (Tarouco et al., 2012). The major contribution of the IoT to health and welfare is the monitoring of people's well-being and life quality through aspects like transparency, comfort, and safety (Atzori et al., 2017).

Numerous wearables built on the Internet of Things are currently available for use in medical settings. "Devices that can be worn or mated with the human skin to continually and closely monitor an individual's actions, without disrupting or affecting the user's motions"; this is the definition of wearable electronics (Haghi et al., 2017). They are known as "IoT-based healthcare wearables" because of the Internet of Things technology that enables them to be used in the healthcare sector (Haghi et al., 2017). Healthcare wearables based on the Internet of Things are devices that can be used at all times to continuously monitor and measure biomechanical and physiological characteristics (Steele et al., 2009). These Internet of Things (IoT) wrist monitors track a wide range of health metrics, including but not limited to sleep quality, heart rate, electrocardiogram (ECG), glucose levels, cardiovascular fitness, brain activity, blood pressure, oxygen saturation, temperature, and pulmonary measurements (Vermesan et al., 2011). You may find them available as rings, bracelets, garments, glasses, and contact lenses.

The research demonstrates for smart health applications that usage barriers such as conventional barriers, and risk aversion are listed as "reasons against" adoption, whereas "reasons for" adoption include widespread availability, relative advantages, compatibility, and convenience. Reasons for and against adopting IoT-based wearables are heavily influenced by the importance placed on "openness to change" (Sivethanu, 2018).

2.3.2 Smart Home

A smart home, as per definition, is a network of interconnected devices that, when controlled by a central hub, may perform a variety of automatic tasks in response to a user's selection from a limited number of predetermined "scenes," such as "home," "away," "bed," and "waking up." Premium options like these are often provided by home automation firms (Hoffmann & Novak, 2015).

Consumer IoT is predicted to grow at a staggering rate. By 2025, McKinsey Global Institute predicts, the Internet of Things will have an annual economic effect of more than $11 trillion (Manyika and Chui 2015). John Chambers, CEO of networking firm Cisco, has called the Internet of Things (IoT) the "second generation" of the Internet and has estimated its economic potential at $19 trillion (King 2015). According to the industry, widespread consumer adoption of IoT smart home devices is inevitable (Acquity Group 2014; Nielsen 2014), with 66 percent of customers planning to purchase at least one smart home gadget over the next five years. However, present adoption rates are low; just 16% of customers possess a single device, and only 4% own two or more (Gartner); only 6% utilize smart home technology (Nielsen), and only 4% own a single device (Acquity).

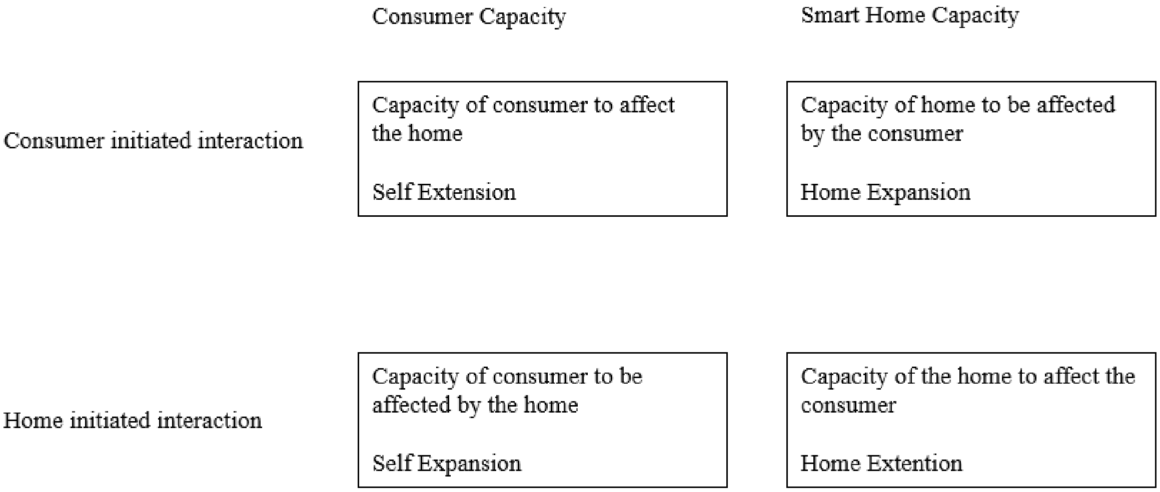
Five years from now, even the most optimistic estimates predict that just 30% of households will have invested in a smart thermostat (one of the most obvious smart home applications).

The delayed adoption rates can be traced back to several obstacles. There are three issues that have been found via research in the industry that are slowing down the adoption of the consumer IoT. Awareness is the first issue. According to Acquity Group, 87% of consumers were unfamiliar with the term "Internet of Things," but this is expected to change in the near future as IoT news becomes more widely covered in the media. Concerns from customers is the second issue. Consumers are concerned about the pricing, security, privacy, and the potential for a loss of control. Consumers are understandably wary of smart home gadgets due to pricing, privacy, and the possibility that they may acquire sentience of their own. Third issue is perhaps the most significant. This relates to the question of value, and it is not obvious that cheaper prices can solve the value equation by themselves. Quite simply, most buyers do not understand the use of a "smart home," and marketers have had difficulty articulating the benefits of these homes to buyers.

Currently, smart home solutions tend to center on high-priced, stand-alone devices like thermostats and light bulbs or carefully chosen "starting kits" and niche applications (turn on lights when I get home). Common customers have a hard time seeing the point in upgrading their present light bulbs, switches, and monitoring devices to more expensive models that don't appear to give much value beyond the novelty element while possibly adding extra technical difficulties into their life. Marketers need to change the focus from use cases to the kind of consumer experiences that will arise from people using smart homes and the possible identities associated with them.

The neorealist school of thought offers a theory of social complexity called "assemblage theory," which describes how a complex whole (one that is more than the sum of its parts) evolves from the ongoing interactions of its diverse constituent pieces (DeLanda 2002, 2006, 2011; Deleuze and Guattari 1987). Here, it might be inquired as to what, if anything, will be different in the smart house compared to what has previously been known and experienced. There is no change to the assembling processes themselves, but the components and their interactions are different. The foundation of a smart house is laid with the same features as a conventional dwelling, but with the addition of high-tech features that can augment or even completely replace older, less-advanced ones. What really sets these modern smart home features apart is the way they communicate with one another and the people living in the home. One notable change is the increased independence afforded to components. A smart thermostat is an interactive participant in our conversations. It might be trying to tell us by its activities that it has greater ideas for the house than we do. The toaster is only one example of a common household item that may play an active role in conversations. If we're not using the toaster as often as other people in the network are, a smart networked toaster will flick its lever furiously to grab our attention (Rebaudengo, Aprile and Hekkert 2012). Secondly, the furniture and lights in our home may now interact with one another in ways that go much beyond the most basic type of positional arrangement seen in the conventional home. The lights can turn on automatically if motion is sensed where none was expected. To improve the watching experience, a television can be equipped with an audio sensor that modifies the room's illumination (intensity and color) to match the show's music. Third, there is a spectrum from "ambient" to "direct" interaction between people and their electronic gadgets. When the wash cycle is complete, the washing machine may softly glow instead of releasing a piercing beep if someone is in the room with it, or it might figure out where the person is in the house and dim the lights there instead. If no one notices, it may emit an alarming chime or send a message through the cell phone if necessary. Fourth, coding can take on a more bottom-up, rather than top-down, and individualistic function. In the below Figure 2.3, consumer experience of the smart home emerges over time from the consumer’s part-whole interactions with the smart home assemblage, as exercised through paired capacities. In this research’s context, it is also aimed to test the consumer interaction and adoption intention of the IoT technology in a holistic sense also comprising smart home applications.

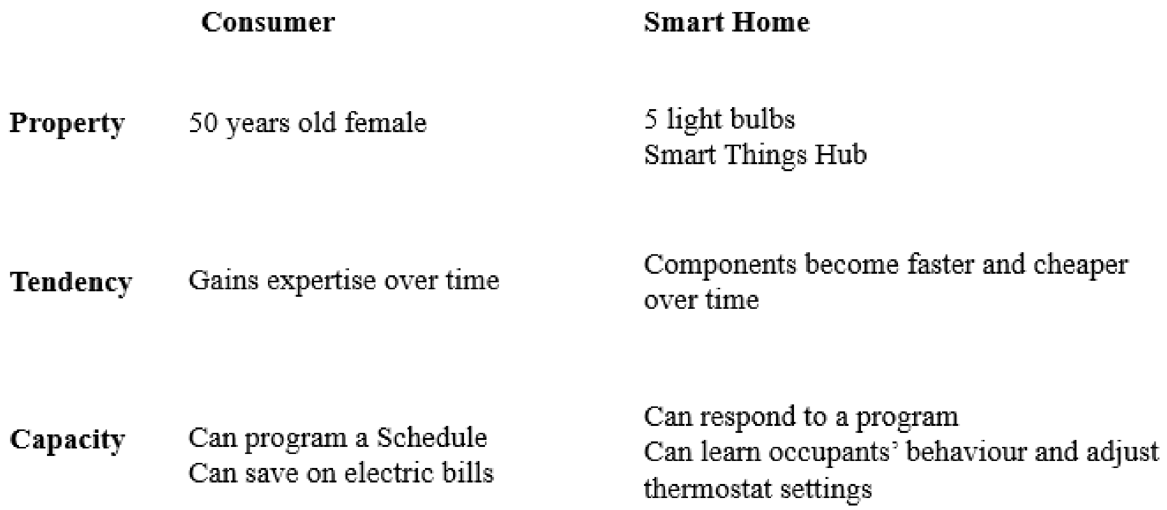
Figure 2.3 Consumer and Smart Home Interaction



	Consumer Capacity	Smart Home Capacity
Consumer initiated interaction	Capacity of consumer to affect the home Self Extension	Capacity of home to be affected by the consumer Home Expansion
Home initiated interaction	Capacity of consumer to be affected by the home Self Expansion	Capacity of the home to affect the consumer Home Extention

Source: Hoffman Donna and Novak Thomas, Emergent Experience and the Connected Consumer in the Smart Home Assemblage and the Internet of Things, 2015

Figure 2.4 Consumer and Smart Home Interaction Evolution Over Time



	Consumer	**Smart Home**
Property	50 years old female	5 light bulbs Smart Things Hub
Tendency	Gains expertise over time	Components become faster and cheaper over time
Capacity	Can program a Schedule Can save on electric bills	Can respond to a program Can learn occupants' behaviour and adjust thermostat settings

Source: Hoffman Donna and Novak Thomas, Emergent Experience and the Connected Consumer in the Smart Home Assemblage and the Internet of Things, 2015

2.4 COMMERCIAL APPLICATIONS

2.4.1 Smart Payment

Every aspect of people's lives is being changed by the exponential growth of the Internet of Things. There's no dispute that the Internet of Things will pave the way for innovative applications across a wide range of industries. Services (such as finance, insurance, transportation, etc.) will undoubtedly take advantage of the speed and autonomy with which these technologies acquire, analyse and share a wide variety of data (Wünderlich, 2013). That will open the door for new kinds of commerce and the development of "smart services" that make use of interconnected objects. There has been a lot of debate recently about how new services, such as related with health, smart banking, and connected homes, are influencing consumers to alter their habits (mobility, ubiquity, connectivity, etc.). The bank, along with other economic players, will benefit from the possibilities presented by linked things under these circumstances. As a matter of fact, the banking sector is investing extensively in technological advances, and it will continue to exploit new technologies to improve the customer experience and strengthen their relationship with this one, as indicated by Capgemini (Accenture, 2014). In light of clients' growing need for real-time banking, connected items represent novel tools that banks may include into their digital strategy (Deloitte, 2018)

Offering items and services at the appropriate time, in the correct packaging, and into the right channel are all vital to creating a positive client engagement, which is why digital technology was developed in the first place (Alf, 2018).

Connected things are definitely an opportunity that banks must embrace in order to remain competitive. Today's consumers anticipate a great deal of innovation from their bank, particularly from the digitally enabled institution that will provide them with the right services for their new connected lifestyle (Petracek, 2018). Below, several IoT-based digital developments are explained that have a direct influence on financial services: mobile banking, crowd funding, virtual currency, high-frequency trading firms, cybercrime, big data, and IT analytics.

Remote banking through mobile device: As more and more services go online, customers want to be able to manage their accounts in the same convenient manner on all of their devices.

Thanks to IoT technology, the individual can log into his bank account from any device with internet connectivity. In addition, the term "biometrics" is used to refer to any and all computerized methods of identifying a specific person by any combination of their physical, biological, and even behavioral features. Information collected from a person's biometric features is one-of-a-kind and irreversible. Any device with a digital interface may be used to view and manage financial accounts. To substitute for physical signatures, "Wet Ink" technology allows for the exact duplication on paper of a physical signature created on any touch screen device. This allows for the use of electronic signatures for a wider variety of financial services and goods. Therefore, the consumer's actual presence is unnecessary. Internet of Things technology enables banks to track the state of the assets they finance in real time, allowing for constant monitoring of collaterals and assets (car, appliance, machinery industry ...). With everyone and everything having a unique digital identifier, it would be possible to apply for loans and transfer ownership digitally without ever having to physically meet with a bank representative.

Mobile banking payment processing with a high number of touchpoints: Previously, the functions of the Internet of Objects were restricted to things like counting steps and tracking heart rate, but now, they have been updated to include the ability to accept payment. Instantaneous transactions are the focus of attention at the moment. As a result of regulatory support, this innovation is now crucial. The increasing popularity of internet connected gadgets can be directly attributed to consumers' growing faith in contactless technology. The security provided by biometrics technology is also satisfactory, making it ideal for the ever expanding ecosystem of internet enabled devices. Incorporating contactless technology into any product increases its desirability to buyers. This means that as time goes on, more and more inventions will be made that allow any item to be used as currency. Levi's and Jacquard by Google, for instance, are working on a garment called the "Commuter Trucker Jacket" that incorporates contactless payment straight into the sleeve. If our jacket has the ability to accept money, just think about the impact on your wallet. A wallet full with items: The wallet is a portable payment and storage device that eliminates the need for a bank account. An associated, pre-funded wallet will instantaneously and automatically control the costs of any gadget or piece of equipment. Digitally signed agreements, or "smart contracts," If residents of Burj Khalifa, the world's tallest building in Dubai, are late on their rent, the building's owner will cut them off from using the elevators.

As a result, in the not too distant future, smart payment contracts will make it feasible to automatically link an action (here, turning off the elevator) to a condition (here, rent not being paid). As a result, financial institutions may now provide product offerings to consumers in a seamless, rapid manner. Financial support from a large number of individuals at once: In order to fund a venture, "crowd-based financing" allows a huge number of people to contribute monetary resources, although relatively tiny ones, using an online platform. As the Internet of Things develops, it will be able to take use of new technologies, terminals, and platforms. Moreover, by collecting and examining the data from the various IoTs, it would be possible to assess the creditworthiness of borrowers and their repayment patterns. Digital currency: In the years to come, blockchain will be a technology to watch. It has the potential to disrupt many parts of the economy, including the banking and insurance industries. Without a need for a controlling authority, it facilitates the transfer and storage of data in an open, safe, and decentralized manner. It resembles a massive database that records all the interactions that have taken place inside it from its inception. The blockchain's three main applications are asset transfer (money, securities, etc.), improved asset and product tracking, and the automated execution of contracts ("smart contracts"). It may be implemented on IoT platforms to address digital difficulties, such as keeping track of the data created by an IoT process through an analytical model, enforcing strict identification criteria to protect data, and settling payments between devices and network users in real time (McKinsey, 2018). Intelligent algorithmic models: the expansion of both data volume and data velocity will continue as a courtesy of the Internet of Things technology. Businesses that can rapidly and effectively utilize this information will be in the best position to create effective algorithms that can maximize profit and target specific areas for intervention. Online crime institutions in the financial sector are responding to the rising demand for the safety of banking transactions by providing novel solutions based on biometrics, a technology that allows individuals to be identified by their distinct physical and behavioral features. Authentication and validation are two crucial phases of the user experience that need various degrees of protection. Continuous technological development provides potent security options predicated on factors like biometrics (Fadoua, 2019). To verify purchases, make payments, or sign up for services, Barclays has created a venous impression recognition system more secure than the fingerprint (Sia, 2018).

2.4.2 Connected Mobility

A major challenge for local governments in a smart city is managing traffic. The Internet of Things (IoT) might bring useful benefits to modern urban areas. Smart sensors and cameras installed in a system give experts with a wealth of information. The data gleaned from their application can inform improvements to the structure of public transportation systems. With the help of systems able to monitor traffic using the aggregation of information picked by smart sensors, smart cities may gain smart parking networks, management of traffic offenses, and vehicle tracking (Zafeiriou, 2020).

Table 2.3 Contemporary IoT technologies in Cities Used for Mobility

Smart City	IoT Technology	Explanation
Bogota	Sensors, smart traffic lights, smart cameras	Cloud database that consolidates all the information using IoT technology
New York	Sensors, traffic surveillance cameras	Traffic monitoring in real time
Luxemburg	Sensors	A system that provides real-time updates on traffic, accidents, and available parking spots
Seoul	Sensors, Artificial Intelligence	IoT and sensor-based parking management system. Automated cab scheduling system

Source: Zafeiriou Ionna, IoT and mobility in smart cities, 2020

The purpose of implementing IoT devices is to give solutions for the general public. The issue of pedestrian accidents must be mentioned whenever the topic of smart city mobility is discussed. Not only do pedestrians often put themselves in danger by crossing the street outside of a crosswalk, but automobiles also often fail to slow down while entering such intersections. When fitted in vehicles, thermal sensors can alert vehicles to a pedestrian crossing. Nanotechnology with the appropriate optomechanical characteristics is used in these sensors (Engin, et al., 2020).

2.5 INDUSTRIAL APPLICATIONS

The Internet of Things has transformed the traditional corporate environment into a digitally sophisticated digital organism. More nimble manufacturing processes and effective stakeholder engagement are two potential outcomes of the Internet of Things' (IoT) goal of connecting any "Thing" over error-free networks (Baldini et al., 2018). In the supply chains for both products and services, the Internet of Things allows a method of exchanging data that is both reliable and safe (Arunachalam et al., 2018; Haddud et al., 2017).

The perceived advantages, the perceived cost, faith in technology, and external pressure can be annumerated as the four most influential elements on a company's inclination to embrace IoT for logistics and supply chain management. The likelihood of adopting new technology is influenced by users' trust in that technology and their estimation of its usefulness. According to previous research findings, many businesses don't feel compelled to use IoT in the absence of external pressure, such as rules or stringent needs from consumers. (Tu, 2017) It's expected that the IoT will provide real gains for commercial enterprises (Borgia, 2014; Madakam et al., 2015; Russo et al., 2015). Due to its transparency, traceability, adaptability, scalability, and flexibility, the Internet of Things has the potential to enhance operational processes, cut costs, and lessen risks (Zhou et al., 2015). There are a lot of obstacles (both technological and societal) in the way of the IoT's development, and they'll need to be dealt with before widespread adoption and spread of the technology can take place (Whitmore et al., 2015). According to Lee and Lee (2015), research on the IoT's societal, behavioural, economic, and administrative implications is still in its infancy. This makes it hard for businesses to make well-informed judgments about IoT adoption and deployment. According to Mishra et al. (2016), research investigating the link between IoT deployment and enhanced business, and logistics performance is few. The digital revolution has affected many areas of business including supply chains as well (Chase, 2016). Supply chain management (SCM) is a top concern for practically every manufacturer, placing it squarely in the middle of the impending "internet of things" (IoT) era (Farahani et al., 2017). A PwC research on the growth of Industry 4.0 found that 35% of the more than 2,000 respondents indicated that their organizations had begun digitizing supply chains and 72% said they expected to have done so over the next five years (Schrauf and Berttram, 2016). One of the main focal points of the SCM research community will be the impact of digitalization on the field (Pflaum et al., 2017). There has been a lot of buzz about the potential impact of digitization on the management and design of global supply chains recently (Klötzer and Pflaum, 2017). It is clear how important it is to think through the consequences of digitizing supply networks. Internet of Things (IoT) technology and big data applications are expected to play a vital role in increasing global agricultural production to feed billions over the coming decades, and this is on top of their influence on industrial and supply chain management. In the data-driven future that experts are imagining, sensors on agricultural equipment, self-driving tractors, drones, GPS imagery, and weather tracking would help farmers not only feed the globe, but also make better use of scarce resources like fossil fuels, water, and arable land (Ray, 2017; Lohr, 2015). There will reportedly be 225 million connected agricultural equipment in use by 2024, up from 13 million in 2014. This increase is attributable, in part, to the global installation of IoT devices, which is expanding at a compound annual growth rate of 20%. (Machina Research, 2016; Meola, 2016). Data from a variety of sources, including sensors on agricultural equipment and plants, satellite photos, and weather tracking, are being utilized in what is being called "agriculture 3.0," according to reports in the popular press (Lohr, 2015). With the use of statistical models and algorithms, formerly unquantifiable enormous amounts of data can now be evaluated in agriculture, allowing farmers to track the progress of their crops in real time and adjust their planting strategies accordingly (Johnston, 2014; Cukier and Mayer-Schoenberger, 2013; Noyes, 2014). The Internet of Things (IoT) has the potential to revolutionize farming by enabling more efficient and profitable operations, as well as more environmentally responsible methods of farming management (Kite-Powell, 2016). It has been shown that the use of smart farming tools, such as GPS mapping and precise yield estimates, may improve both sustainable farming methods and the financial success of a farm (Walter et al., 2017).

2.6 INFRASTRUCTURE APPLICATIONS

Smart city applications can benefit from the rapid progress being made in Internet of Things (IoT) technology. Technologies such as ubiquitous sensing, heterogeneous network architecture, intelligent information processing, urban computing, etc. are all essential parts of an IoT-based smart city. Smart city applications have several challenges, but one of the most important is predicting urban traffic flows, which has implications for urban administration and public safety. Smart Internet of Things (IoT) devices and services are becoming increasingly common, making it easier than ever to collect information on urban traffic. Connected data networks through approved smart devices provide access to a wealth of data types, including user trajectory data and internet access content data, that may be used for secure urban crowd monitoring (Zeng et al., 2021).

With the proliferation of IoT devices, the notion of a "smart city" is starting to look more realistic. Urban infrastructure may be made more effective and reliable by continual IoT research. Problems like gridlock, a dearth of parking spaces, and driver safety may all be alleviated with the help of the Internet of Things (Sangeetha et al., 2022).

The exponential expansion and growth of the Internet of Things (IoT) and cloud-based smart technologies have given additional depth to the concept of constructing smart cities. The goals of the smart city idea are to decrease operational costs, enhance municipal administration, boost efficiency, and boost output. A "smart city" is a concept where infrastructure, buildings, smart transportation network, community security, healthcare, and educational institutions are all methodically monitored and managed (Singh, 2022).

2.7 HOLISTIC PERSPECTIVE CONSIDERING ALL APPLICATIONS AND CONNECTIVITY

Sensors and actuators built into IoT devices and equipment produce massive volumes of data, which is then sent to business intelligence and analytics platforms so that people can use it to make choices. With this information, businesses can better understand and respond to challenges like shifting client preferences and market conditions, which in turn helps boost customer loyalty and happiness. In order to make decisions in real time at the point where data is collected, business analytics tools might be incorporated into Internet of Things devices like wearable health monitoring sensors (Lee, 2015).

Connected devices that can exchange data over the web are what the IoT refers to (Uckelmann et al., 2011). Originally, the term "Internet of Things" was used to describe internet-connected devices that could read and respond to RFID tags. Supply chain management, urban planning, library management, retail tracking, stock control, digital logistics, efficient transportation, home automation, mobile payment, warehouse management, healthcare, are just a few of the many current applications of the Internet of Things (Ding, 2013; Zorzi et al., 2010). There will be significant efficiencies gained by both businesses and customers thanks to the Internet of Things (Uckelmann et al., 2011).

Internet of Things (IoT) technology are employed in smart refrigerators, which can track the amount of food and drink a household consumes without human intervention and automatically restock pantry staples (Sundmaeker et al., 2010). In this setting, IoT technologies will have an impact on user behavior across a variety of domains (Li and Wang, 2013).

Table 2.4 Benefits of IoT Technology Usage in Various Sectors

Sector	**IoT Application Benefits**
Logistics	Facilitating autonomous agent-based local collaboration, increasing scalability, configurability, and extendibility of the production system, and fostering rapid rescheduling and planning in production logistics are all goals of a well-integrated production environment. (Yu and Wang, 2016)
Retailing	Better inventory management, store layout optimization, customer tracking, item location identification, on-shelf availability, real-time in-store promotions, augmented reality, and savvy customer service (Bok, 2016)
Manufacturing	Decentralized supply chains, increased connectivity between industrial processes, smart products, personalized distribution and procurement, and enhanced monitoring and management of physical operations are all on the rise. (Roblek et al., 2016)
Healthcare	Early detection and intervention/prevention through clinical treatment and remote monitoring (Kulkarni and Sathe, 2014)

Energy and utilities	Increased efficiency, smart energy management, (Kyriazis et al., 2013; Moreno et al., 2014; SAP Corporation, 2014; Zheng and Carter, 2015)
Home appliances	Controlling one's energy usage, interacting with one's appliances, recognizing danger, avoiding accidents, easily locating one's belongings, and securing one's home etc. (Khan et al., 2012)
Heavy Equipment	The tracking, tracing, and monitoring of assets (Velandia et al., 2016
Education	There are new educational systems, more autonomous (digital) students, and innovative methods of teaching etc. (Agrawal and Mazumdar, 2015; Selinger et al., 2013)
Insurance	Create one-on-one connections with your customers, customize your product lineup and service levels, and eliminate any middlemen. (Koenig et al., 2016)
Airlines	Improved services for checking bags and making reservations; facilitated airport parking; simplified airport navigation etc. (Alghadeir and Al-Sakran, 2016)

Source: Abubaker Haddud, Arthur DeSouza, Anshuman Khare, Huei Lee, (2017) "Examining potential benefits and challenges associated with the Internet of Things integration in supply chains", Journal of Manufacturing Technology Management, Vol. 28 Issue: 8, pp.1055-1085, https://doi.org/10.1108/ JMTM-05-2017-0094

This research aims to bring in an overarching perspective in understanding the IoT technology adoption of the end consumer considering both the advantages, disadvantages brought forth by this new technology and also the barriers hindering the adoption process examined within the previous literature.

3. TECHNOLOGY ADOPTION MODELS

3.1 TECHNOLOGY ADOPTION MODELS USED IN MARKETING

Although TAM has been widely used in earlier research to explain user acceptance of technologies, it is unclear whether or not it adequately explains the adoption of various technologies.
In order to better comprehend the rapid changes in information technology and to gain a greater

explanatory power, some research have suggested combining TAM with other theories, most notably DIT (Hardgrave, Davis, & Riemenschneider, 2003; Lee et al., 2011; Legris, Ingham, & Collerette, 2003) DIT, in contrast to TAM, captures more nuanced aspects of an invention that are relevant to understanding the reasons for and processes of decision-making behind its uptake by users (Rogers, 1995). Therefore, these traits are considered to be antecedents of TAM, particularly when it comes to understanding why consumers accept new forms of innovation like information technology (Wang et al., 2012). Researcher Somang explains that his work on Uber's tech adoption may be used as a springboard for further investigation in a number of different directions.

To begin, researchers in the future may look at how certain personality traits affect people's willingness to adopt new technologies. With the proliferation of smartphones, mobile apps have become increasingly integral to our everyday lives. Mobile application use is becoming increasingly prevalent as a result of this trend. Some people, however, are still in the early stages of mobile app adoption and are not yet comfortable with the technology. The degree to which people are willing and able to accept new technologies, such as mobile applications, may vary. Therefore, future studies may look at how various people's levels of technological preparedness influence their views on and actions surrounding adoption.

This was recently demonstrated by a group of researchers (Somang et al., 2018). That is why a technology readiness scale is also integrated into the research model by this context.

3.2 TECHNOLOGY ACCEPTANCE MODEL

Models have been proposed for a number of different reasons in the IT/IS literature that explain how innovations are used (Venkatesh et al., 2003). Among them, Davis's (1989) TAM has become the de facto standard (Chau and Hu, 2001; Svendsen et al., 2013).

According to TAM, two factors—how simple and how helpful a system or technology is—play a major role in shaping people's decisions about whether or not to adopt them.

Perceived usefulness, in this context, is the confidence that one has that employing the technology would result in improved performance (Davis et al., 1989). The perceived ease of use of a piece of technology is the extent to which its consumers anticipate minimal learning curves and an effortless experience when using its features. Similarly, TAM suggests that differences in perceived utility might be explained by differences in how easy they are to use. TAM has been used to investigate a wide variety of topics, such as the spread of online banking (Al-Ajam and

Nor, 2013), online shopping (MccloKcy, 2003), mobile financial services (Lee et al., 2012), mobile advertising (Zhang and Mao, 2008), 3G mobile value-added services (Kuo and Yen, 2009), online community participation (Wang et al., 2012), the spread of e-health (Du (Lee et al., 2012). As can be seen from previous literature, TAM is exerted on specific fields of application of IoT technology however there is a gap in literature using TAM in multiple application areas (Lingling, 2014). This research targets to fill in this gap within the literature.

TAM factors may be used to predict customer acceptance in a variety of contexts, even if TAM was first developed to forecast IT system adoption in the workplace. Since IoT systems are a form of emerging IT, TAM may provide a solid groundwork for studying how people are accepting of this new innovation. To explain consumer adoption, TAM only uses two user beliefs (perceived usefulness and perceived ease of use), despite earlier research finding TAM to be a parsimonious and robust model.

However, other elements, such as the opinions of other influential people (social influence), will also affect a user's inclination towards adoption of IoT. (Venkatesh et al., 2012).

In addition, users' intentions to do an action are not enough; they need to have the ability to carry it out as well (perceived behavioral control) in order to actually do it (Ajzen, 2011).

This suggests that the original TAM characteristics may not fully and completely reflect crucial elements impacting consumers' acceptance of IoT. Since this is the case, we contend that the model needs to be solidified by integrating other parameters in order to account for the widespread adoption of IoT devices. For the TAM variables, to reduce the complexity of the research model, perceived usefulness variable has been integrated into the model.

3.3 INNOVATION DIFFUSION MODEL

Everett M. Rogers's studies are the most well-known foundation for IDT. Diffusion is the gradual spread of a new idea throughout a society through many routes of communication. Rogers (2003). Compatibility, relative advantage, trialability, complexity, and observability are the five hallmarks of IDT that have a direct impact on individuals as an outcome of innovation. When anything is deemed more beneficial than the original concept, it is considered an innovation. Not only monetary success, but also social standing, ease of life, and personal fulfillment, all play a role in determining relative advantage.

When an invention is compatible, it is seen as fitting in with the beliefs, norms, and requirements of its potential users. The complexity of a new technology is measured by how challenging it appears to be to implement and utilize. An innovation's trialability indicates how well it lends itself to small-scale testing. The degree to which an innovation's effects may be seen by others is known as its observability. Over the past decade, IDT has been frequently used to investigate IT adoption and usage. Compatibility, perceived usefulness and perceived ease of use for instance, are the major criteria that determine the attitude toward utilizing virtual stores, as shown by Chen et al. (2002). As part of their research, Wu and Wang (2005) looked at the influences that consumers' behavioral intentions have on their adoption of mobile commerce. All criteria except perceived ease of use were found to have a substantial impact on users' behavioral intentions to adopt mobile commerce. Compatibility was the single most important element. For the sake of simplicity in creating the research model as it will be tested against several fields of application of the IoT technology, relative advantage, complexity and compatibility are taken into the model in this research’s scope.

3.4 BARRIERS IN TECHNOLOGY ADOPTION AND DIFFUSION

Applications of smart services, such as in smart homes, smart healthcare, smart grids, smart banking, etc., are expanding rapidly. A smartwatch can now analyze private data related to sports activities and offer individualized training programs, a connected car can analyze how we drive and automatically provide driving history information to insurers, a smart light bulb can detect an intrusion and alert the user and his security company, etc.

Companies providing services will be able to better understand consumer profiles, pinpoint customer lifestyles, and collaborate with third parties to provide customers with relevant and personalized offers thanks to IoT sensors installed in vehicles, houses, and infrastructure items.

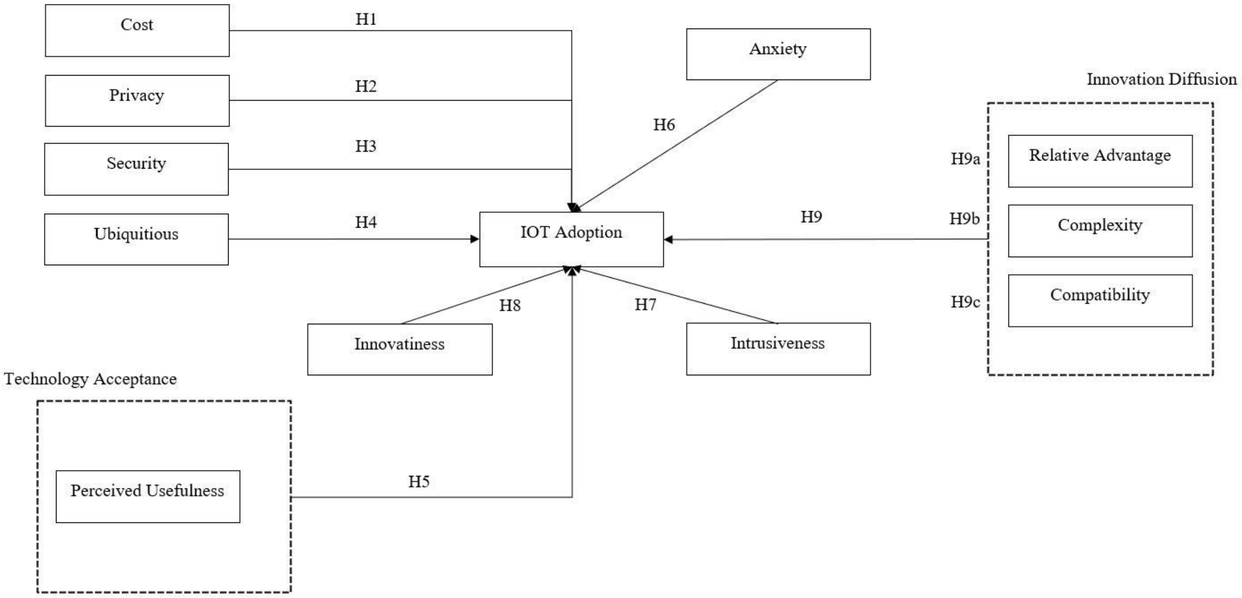
(Mani, 2018) Both innovation adoption and resistance to innovation are recognized as study paradigms in the marketing literature that explain the customer reaction to innovation (Laukkanen, 2016). In the second model, those who oppose change are in the spotlight (e.g., Heidenreich and Handrich, 2015; Kim and Kankanhalli, 2009; Lapointe and Rivard, 2005; Ram, 1989; Ram and Sheth, 1989). Gatignon and Robertson (1989) argue that the same reasons that explain acceptance do not explain the choice to reject an innovation. Although "innovation resistance is not the inverse of innovation acceptance," Ram (1987) argues otherwise. So, getting people to accept a new idea depends on their getting past their first reservations about it. Consequently, both opposition and support for an innovation might exist simultaneously and be accounted for by the same forces throughout its lifespan (Ram, 1987). Research under the resistance paradigm often use the notion of resistance to change to inquire into the causes behind people's aversion to trying anything new. A person's level of resistance to change "is connected with the degree to which individuals consider themselves threatened by change" (Ram, 1987), according to the work of Zaltman and Wallendorf (1983). (Ram, 1987, p. 208). The concept of customer resistance to change has been extensively explored in marketing literature (e.g., Kleijnen et al., 2009; Ram, 1987, 1989; Ram and Sheth, 1989). Consumers' aversion to new products and services is an example of the resistance to innovation (Ram, 1987). There might be consumer pushback "either because it poses prospective alterations from an acceptable status quo or because it disagrees with their belief framework" (Ram and Sheth, 1989, p. 6). Studies done recently have looked on the challenges that come with putting IoT into practice (Shang et al., 2012). Security and privacy concerns, for instance, have been cited as important obstacles for user-focused IoT applications by academics (Hancke et al., 2010; Medaglia and Serbanati, 2010). The architecture of the Internet of Things was comprehensively outlined by Uckelmann et al. (2011). While many studies have looked at IoT from the perspective of organizations and industries, few have tried to comprehend how regular people feel about using these kinds of tools in their daily lives (Schlick et al., 2013, Li and Wang, 2013). Fit to existing and evolving lifestyles, privacy and security, public perceptions, loss of control and apathy, dependability, and cost are some of the social aspects that Balta-Ozkan identifies as impediments to the adoption and dissemination of IoT technology in the smart home setting. (Balta-Ozkan, 2013) In this research context, privacy, security, anxiety and intrusiveness are adopted into the research model under the umbrella of barriers hindering IoT technology adoption.

4. METHODOLOGY

4.1 RESEARCH MODEL

In order to build up an overarching research model which is going to be able to cover majority of the aspects already studied withing the literature, several parameters have been adopted from various sources. First of all, IoT technology adoption is considered as a new form of technology which is subject for adoption of the consumer, so the framework drawn by previous technology adoption theories have been put into use for this study’s scope as well. Perceived usefulness scale is taken from technology acceptance model and supported by the scales laid forth by the innovation diffusion theory such as relative advantage, complexity and compatibility. Some of scales considered both in TAM and IDT are not taken into the study's scope for the sake of simplicity as the model is going to be tested for several constructs of the IoT applications. On top of the technology adoption and innovation models, also variables such as cost, privacy, security and ubiquity specifically taken into account in IoT adoption perspective in previous studies covered in the literature review are also integrated into the research model. Last but not least, in many research papers, barriers impeding the technology adoption such as anxiety and intrusiveness are also considered within the model. Bringing in a holistic perspective of variables adopted from various perspectives, also innovativeness is counted amongst the variables affecting the IoT technology adoption. The value add of this paper to the contemporary marketing literature on IoT is that it combines many of the variables assessed within the IoT adoption research and it also does it in an embracive way by testing it for various application areas of IoT such as smart health, smart home, connected mobility and smart payment. In previous literature, research is focused on either one of these pillars of IoT technology, there is no study found covering all applicable areas in one study. Considering all these aspects, the research model is formulated as follows in Figure 4.1. All of the variables utilized within the research model as well as the questions employed in the data collection method are defined in the next section. Hypothesis statements are formulated based on the previous literature findings. Main purpose of the research is to lay out the differences of how these variables affect the IoT adoption in different application sectors.

Figure 4.1 Research Model



4.2 SCALES AND HYPOTHESIS STATEMENTS

4.2.1 Cost

Cost is simply defined as the money required to acquire something.

In this study’s context it refers to the price to be paid by consumers for IoT product and services. Hoffman and Novak (2015) found out that high price perception is considered to be a barrier in intention of adopting a smart device. Hence the following hypothesis statement is formulated:

H1. Cost has a negative impact on the IoT product/service adoption.

Within the context of the survey, scale for cost is adopted from Hoffman and Novak’s study which is formed as below:

- I think that the fees of the IOT service will be high. [CS1]
- I think the IOT service will be costly. [CS2]
- I think that the IOT service will be expensive. [CS3]

4.2.2 Privacy

Since the advent of the information age, there has been a greater focus on information gathering, processing, and dissemination as a result of the widespread use of IT.

When it comes to collecting and using people's personal information, these tasks involve special ethical concerns (X. Caron, 2016). According to Smith et al. (2011), in today's more interconnected and networked world, consumer privacy is rising to the forefront of worries. The Internet of Things (IoT) has made this problem even more pervasive by making it easier to monitor, communicate, store, and retrieve data on individual users (such as the cloud) (Smith et al., 2011).

If we focus on the former, Thierer (2013) argues that people need to be flexible in how they see their privacy in light of the IoT's new realities. Thierer adds that it will become more challenging to develop and implement set legal privacy rules that are acceptable for different social groupings. Individuals may be involved in their own privacy violations, as Nissenbaum (1998) notes, since they are willing to give up certain personal information in exchange for better, upgraded services. Anonymous communication networks combined with data encryption might be one answer to this privacy problem (Datta and Nandi, 2014; Liu et al., 2014).

However, this might cause the problem that improper users are not penalized for their behaviour (Wang et al., 2014). Considering the aspects above following hypothesis statement is laid forward:

H2. Privacy is negatively associated with the intention to adopt IoT product/service.

In the scope of this research privacy scale has been adopted from the study of Karahoca focusing on the health application of IoT. According to the literature, privacy concern is an important context in adoption of or continuation to use a new technology. If adopters feel that randomly anyone can access their personal data when using IoT products/services, they can reject or give up using it. In this context, privacy refers to the concern of the individual of being exposed to any third party without their will (Karahoca,2017). Following questions are employed to measure privacy variable within the research model:

- It would be risky to disclose my personal information to vendors providing IoT products/services. [PR1]
- There would be too much uncertainty associated with giving my personal information to vendors providing IoT products/services. [PR2]
- There would be high potential for loss associated with disclosing my personal information to vendors providing personal smart IOT technology products. [PR3]

4.2.3 Security

In this study’s context, security refers to the state of mind of the consumer towards adopting the

IoT based technology considering usage safety, safeguard against the misuse or loss of personal data (Claudy et. al.,2015). It is considered to be a major adoption barrier within the literature. Consequently, following hypothesis statement is brought forth:

H3. Security concerns will increase the resistance for IoT product/service adoption.

Additionally, below depicted questions are used in measuring the security scale in the research model:

- I feel that IoT-based products/services are not safe and secure. [ST1]
- I fear that while using IoT-based products/services information will be misused. [ST2]
- I fear that while using IoT-based products/services, my personal data will be lost. [ST3]

4.2.4 Ubiquity

Ubiquity represents the availability of the IoT service/product anytime, anywhere and through any device. (Gupta and Arora, 2017). Former research has shown that ubiquity is a vital enabler for IoT adoption. Hence, following hypothesis statement is formulized:

H4. Ubiquity of the IoT product/services enhances the adoption intention of the product/service.

Ubiquity is a specific term frequently coined with IoT technology within the literature. It has been mentioned several times in various context within the scope of this dissertation.

Following questions are employed to measure the ubiquity scale:

- IoT-based products/services can assist me to be well informed about my need. [UB1]
- IoT-based products/services can allow me to access need anytime. [UB2]
- IoT-based products/services can help me to get information and monitor my need regardless of where I am. [UB3]

4.2.5 Perceived Usefulness

Perceived usefulness is described as the consumer’s tendency to use or not to use the application depending on the extent they believe it will assist them in doing their job better. (Davis, 1989). It’s been laid forward in the technology acceptance model that perceived usefulness is evaluated as an important parameter. Thus, following hypothesis statement is formed.

H5. Perceived usefulness has a positive impact on the IoT product/service adoption.

TAM is examined in detail in the technology adoption literature review in this thesis study and questions to measure this scale has been adopted from the originator of the concept, Davis and adopted according to the IoT context.

- Using IoT-based products/services would enable me to take action related to my need more quickly. [PU1]
- Using IoT-based products/services would improve my deciding performance related to my need. [PU2]
- Using IoT-based products/services would make it easier to take decisions related to my need. [PU3]

4.2.6 Anxiety

Consumers who are not prepared for the new technology may end up building anxiety against it (Parasuraman, 2000). Following hypothesis statement is laid forward:

H6. Anxiety has a negative impact on the IoT product/service adoption.

Anxiety has been brought up as one of the major barriers impeding the IoT adoption. Consumers tend to stick to the technology that they are accompanied with and may feel reluctant or overwhelmed to adopt any additional technology into their lives.

Below questions are employed for the anxiety scale and adopted from Xu. (2016)

- I feel anxious about using new IoT based technologies. [AX1]
- IoT technology is intimidating to me. [AX2]
- I hesitate to use IOT technology for fear of making mistakes I cannot correct. [AX3]

4.2.7 Intrusiveness

In this study’s context, intrusiveness is referred to the state of entering the consumer’s life without granting any permission in advance. (Mani,2017) Based on the literature, smart products could be evaluated as intrusive as they are able to perform actions on their own without seeking any allowance from the user (Hoffman and Novak, 2015). Thus, following hypothesis statement can be built:

H7. Intrusiveness has a negative impact on the IoT product/service adoption.

Scale measures are taken from Mani and Chouk’s study as five questions are integrated into the survey for each construct:

- IoT based products/services are intrusive. [IN1]
- IoT based products/services are irritating. [IN2]
- IoT based products/services are indiscreet. [IN3]
- I am not comfortable with the IoT based products/services. [IN4]
- IoT based products/services are disturbing. [IN5]

4.2.8 Innovativeness

Innovativeness is a pillar of the technology readiness index brought forth by Parasuraman. The term describes an individual’s predisposition to use new technologies (Parasuraman,2000). Innovativeness designates the tendency of the individual to be a technology pioneer and thought leader. This dimension is considered to be a motivating factor in new technology adoption. Hence, the following hypothesis statement is formed:

H8. Innovativeness has a positive impact on the IoT product/service adoption.

As per the questions employed in the questionnaire, they can be listed down as below:

- Other people come to me for advice on new technologies. [INN1]
- In general, I am among the first in my circle of friends to acquire new technology when it appears. [INN2]
- I can usually figure out new high-tech products and services without help from others. [INN3]
- I keep up with the latest technological developments in my areas of interest. [INN4]

4.2.9 Relative Advantage

Relative advantage construct is driven by the innovation diffusion theory meaning that innovation brings greater benefits to potential adopters. Relative advantage is considered to be a strong parameter in technological adoption. (Lee,2011) Accordingly, following hypothesis is formed:

H9a. Relative advantage has a positive impact on the IoT product/service adoption.

Below questions are adopted from Sivethanu’s (2017) work to address relative advantage variable within the model:

- IoT-based products/services have more advantages as compared to other conventional devices. [RA1]

- IoT based devices takes less time and effort for the job. [RA2]
- IoT-based devices offer greater value to manage my job effectively. [RA3]

4.2.10 Complexity

Complexity: Complexity is another dimension of the innovation diffusion theory. It is described as the the degree of an innovation which is perceived as hard to comprehend and use.

Accordingly, following hypothesis statement is formed:

H9b. Complexity has a negative impact on the IoT product/service adoption.

Below measures have been employed in the survey to address complexity variable in the context of the research model, adopted from Mani and Chouk's study (2018).

- Learning to use smart IoT product/services will be easy for me. [CX1]
- Smart IoT product/services will be easy to use. [CX2]
- It is easy to get results that I desire from IoT products/services. [CX3]

4.2.11 Compatibility

Compatibility is the status of an innovation that is perceived as being consistent with the existing values, past experiences and needs of potential adopters (Karahoca, 2017) and is considered to be within the innovation diffusion model. Hence, following hypothesis statement is brought forth:

H9c. Compatibility has a positive impact on the IoT product/service adoption.

Measures for compatibility are taken from Claudy's research, adopted for IoT context as below:

- Using IOT technology would be in line with my own personal values. [CT1]
- Using IOT technology fits the way I view the world. [CT2]
- Using IOT technology would be consistent with the way I think I should live my life. [CT3]

4.2.12 Adoption Intention

Adoption intention is the final stage of the consumer's journey in deciding whether or not to adopt the new technology. It is described as the final decision of the consumer towards a new product or service comprising a new technology.

Following questions are adopted from Sivethanu's study (2017) to be included in the survey for each construct:

- I will use IoT-based technology in the future. [AD1]
- I can see myself using IoT-based technology in the future. [AD2]
- I intend to use IoT-based technology in near future. [AD3]

4.3 HYPOTHETICAL FUTURE WORLD DESCRIPTION

The authenticity of this research is based upon the fact that the model will be tested for more than one field of application of the IoT technology however it also is the major challenge for this dissertation as there is no extensive dissemination of the IoT technology as of this date that the end consumer is able to experience or use in the daily routine. In order to overcome this challenge and to test the model in a holistic manner covering a variety of IoT execution areas, a hypothetical world is formulated to help the survey participants to visualize a future world where IoT technology has already taken over the daily routine of our lives and has already become the major technological trend shaping how the world operates. To build up this hypothetical future world mise en scene, a video has been created using a video editing tool, portraying a full daily routine of an individual where it is shown how smart health, smart home, connected mobility and smart payment technologies that are considered to be the sub fields of application of the IoT ecosystem shape the everyday activities of the consumer. In Annex-B, several screenshots of the respective video are enclosed. In this video, the future individual starts off the day by looking outside of his window in which he can also see the activities planned for the day. He possesses a house equipped with smart devices which are connected to each other and can also interact with the house and the individual. The hypothetical future individual then goes out for the morning run wearing his smart health watch tracking his vitals and sending over to a data cloud where they can be shared with his doctor when deemed necessary. The future person then goes to work in a plant where each process is run autonomously, and data is analysed and actions are planned based on the artificial intelligence backed up system. He then leaves work and goes home by using a shared vehicle service which utilizes a driverless car that is able to interact with its environment thanks to the smart city infrastructure making the full autonomous drive possible. Cost of the journey is automatically withdrawn from the individual's account as the system is able to detect that the journey is over and the individual has arrived at home.

4.4 DATA COLLECTION TOOL

The participants for this research were requested to watch the video mentioned in the above section which was embedded in the survey form before answering the questions prepared for each construct of IoT application. Online survey methodology is employed to collect data that is going to be relevant for the analysis of the variables affecting the IoT adoption as mentioned in the research model. To collect the data, Google Forms link is distributed to participants who took the survey online. For questions addressing the variables, 5 point Likert scale is utilized.

4.5 SAMPLE DESIGN AND PROFILE

200 participants took part in the survey in a time period of seven months between 01.2021 and 07.2021. 42.5% of the participants were female and 57.5% were male. As per the education level of the survey takers, 96.5% have an education level of bachelor’s degree or above. Only 3.5% of the correspondents are high school graduates. In terms of income level interpretation of the participants, it can be said that sample is homogenously distributed. Correspondents having a monthly income greater than 12.000 TL comprises 30.5% of the sample size. Participants that have a monthly income between 8001 and 12000TL are 23% of the total survey takers. 27% of the survey takers declared a monthly income between 5001 and 8000 TL. A minor portion of the correspondents have a monthly income less than 3000 TL. It is important to mention that the income level of participants should be evaluated in accordance with the inflation level by the time the research has been made as it has a direct effect on the purchasing power of the individual for a technological product or service. To understand the tendency of the sample survey takers towards technological products or improvements, two exploratory questions were included in the questionnaire. %98 of the correspondents answered as “Yes” to the question “Are you interested in technological improvement?”. It can be interpreted that the sample has already a close relationship with the technological products and improvements concerning them. Although the participants are closely acquainted with the technological products or services, 55% of the correspondents declared that they do not possess a technological device that uses a IoT technology as instance a robot vacuum cleaner. Survey results comprised from the input of the 200 participants

in the online survey are articulated in the next section.

5. RESEARCH FINDINGS

For all the variables mentioned in the research model, reliability analysis has been conducted for each field of application (Smart Health, Smart Home, Connected Mobility and Smart Payment) and for all variables Cronbach α values are found to be above the minimum threshold of 0.70 which is depicted in Table 5.1.

Table 5.1 Cronbach α Values for Each Variable in IoT Field of Applications

Variable	Smart Health	Smart Home	Smart Payment	Connected Mobility
Cost	0.877	0.899	0.947	0.965
Privacy	0.903	0.912	0.909	0.937
Security	0.814	0.856	0.882	0.824
Ubiquity	0.846	0.897	0.915	0.920
Intrusiveness	0.810	0.840	0.898	0.904
Perceived Usefulness	0.881	0.908	0.899	0.933
Anxiety	0.816	0.815	0.823	0.867
Relative Advantage	0.813	0.909	0.877	0.911
Complexity	0.798	0.882	0.905	0.892
Compatibility	0.878	0.899	0.936	0.939
Adoption Intention	0.911	0.922	0.955	0.906
Innovativeness			0.712	

As a latter step, confirmatory factor analysis (CFA) was employed for the variables to understand if they are fit to represent the constructs. CFA is run using IBM SPSS Amos software. Questions to assess each variable have been determined and for all variables, correlations between each of them have been checked using CFA. With the reliability analysis, all variables were already assessed to be reliable, on top of this finding, with the CFA approach it is aimed to confirm the reliability of the variables checking the fit measures. All the fit measures are included in the bottom of the CFA tables for each construct, which are smart health, smart home, connected mobility and smart payment.

On top of Cronbach α values, composite reliability (CR) value in the CFA analysis is analysed as well as it is an indicator to assess internal consistency. CR is advised to be above the limit of 0.70 value to affirm reliability (Nunnally & Bernstein, 1994). In the scope of this research, reliability of the constructs is both tested using Cronbach α values and CR values driven from the CFA analysis.

Primary condition is that CFA loadings should be above the minimum threshold of 0.50 to assess construct validity (Anderson and Gerbing, 1988; Amin et al., 2014). Following condition is that CR figures have to be above 0.70 (Nunnally & Bernstein, 1994). As an additional step, the average variance extracted (AVE) figures are calculated as well. AVE figures are used to determine if the constructs can be validated or not. According to previous research it is expected that AVE figures should be 0.5 or above (Fornell and Larcker, 1981).

Once the CFA is confirmed for each construct, as final step, path analysis is employed to test the research model against each construct and to conclude which variable effects the IoT adoption in what extent. Research findings for each IoT applied sector are analyzed respectively in the following section. In the conclusion section, overall assessment and comparisons between findings in different field of applications are articulated.

5.1 SMART HEALTH

Confirmatory factor analysis is run for each of the constructs. Looking at the results for "Smart Health" field of application in Table 5.2, it can be seen that each variable has a Cronbach α value greater than the lower threshold 0.70. On top of Cronbach's reliability, construct reliability (CR) and average variance extracted values have been calculated for each construct. CR values range from 0.745 to 0.921 which are at the acceptable level according to the referenced norms mentioned in the introduction to the research findings section.

Looking at the AVE figures, they range from 0.517 to 0.796 except "Intrusiveness" which has an AVE value of 0.49 which is very close to the minimum threshold value of 0.50 according to Fornell and Larcker. (Candemir,2018)

Analysing the model fit values, Comparative Fit Index (CFI) can be seen as 0.904 which shows that the model has a good fit. Tucker-Lewis Index (TLI) and Normed Fit Index (NFI) are 0.886 and 0.820 respectively. Root mean square error of estimation (RMSEA) value is 0.067 which is below the recommended 0.08 level proving the good fit of the model. Significance value falls under $p<0.01$ for all variables. Lastly, looking at the CFA loadings, it can be observed that they range from 0.734 to 0.913 except intrusiveness and innovativeness measures that fall under the 0.50 threshold. Apart from these measures all loadings are above the 0.50 limit.

Table 5.2 Confirmatory Factor Analysis Results for Smart Health

	CFA	**t**
Cost (α=0.877; CR=0.881; AVE=0.714)		
CS_Health_3	0.907	a
CS_Health_2	0.734	12.11**
CS_Health_1	0.884	15.009**
Privacy (α=0.903; CR=0.908; AVE=0.769)		
PR_Health_3	0.764	a
PR_Health_2	0.906	14.048**
PR_Health_1	0.95	14.702**
Security (α=0.814; CR=0.763; AVE=0.519)		
ST_Health_3	0.649	a
ST_Health_2	0.743	12.556**
ST_Health_1	0.764	9.665**
Ubiquity (α=0.846; CR=0.800; AVE=0.574)		
UB_Health_3	0.744	a
UB_Health_2	0.649	12.786**
UB_Health_1	0.865	12.419**
Intrusiveness (α=0.810; CR=0.814; AVE=0.490)		
IN_Health_1	0.393	a
IN_Health_2	0.895	5.306**
IN_Health_3	0.455	5.455**
IN_Health_4	0.729	5.282**
IN_Health_5	0.868	5.513**
Perceived Usefulness (α=0.881; CR=0.886; AVE=0.724)		

	CFA	**t**
PU_Health_3	0.913	a
PU_Health_2	0.899	18.945**
PU_Health_1	0.728	12.76**
Anxiety (α=0.816; CR=0.826; AVE=0.617)		
AX_Health_3	0.627	a
AX_Health_2	0.884	9.755**
AX_Health_1	0.822	9.329**
Relative Advantage (α=0.813; CR=0.826; AVE=0.617)		
RA_Health_1	0.625	a
RA_Health_2	0.851	9.466**
RA_Health_3	0.857	9.507**
Complexity (α=0.798; CR=0.759; AVE=0.517)		
CX_Health_1	0.591	a
CX_Health_2	0.71	9.311**
CX_Health_3	0.835	8.255**
Compatibility (α=0.878; CR=0.880; AVE=0.711)		
CT_Health_1	0.86	a
CT_Health_2	0.889	16.197**
CT_Health_3	0.777	13.102**
Adoption Intention (α=0.911; CR=0.921; AVE=0.796)		
AD_Health_1	0.977	a
AD_Health_2	0.924	26.105**
AD_Health_3	0.762	15.367**
Innovativeness (α=0.712; CR=0.745; AVE=0.517)		
INN_4	0.374	a
INN_3	0.858	4.847**
INN_1	0.822	4.881**

χ2(593)=1129.042 p=0.000; NFI=0.820; CFI=0.904; TLI=0.886; RMSEA=0.067

Note. α = Cronbach’s Reliability; CR= Construct Reliability; AVE=Average Variance Extracted

p*< .05. ** *p*< .01. * *p*< .001

CFI=Comparative Fit Index; RMSEA=Root Mean Square Error Approximation; TLI=Tucker-Lewis Index; NFI=Normed Fit Index

As the CFA is confirmed for “Smart Health” area of use for IoT technology, path analysis is run to test the research model in scope of “Smart Health” and to reveal which of the variables have significant relationship with IoT adoption in the context of “Smart Health”.

Path analysis results for “Smart Health” construct are depicted in the Table 5.3.

Table 5.3 Path Analysis Results for Smart Health

			Beta	**SE**	**t**
IOT_Adoption	<---	Anxiety	-0.474	0.089	-5.346***
IOT_Adoption	<---	Innovativeness	0.487	0.173	2.809**
IOT_Adoption	<---	Perceived_Usefulness	0.363	0.054	6.713***
IOT_Adoption	<---	Intrusiveness	-0.546	0.166	-3.281**
IOT_Adoption	<---	Compatibility	0.15	0.053	2.841**
IOT_Adoption	<---	Security	0.109	0.047	2.316*
ST_Health_3	<---	Security	1		
ST_Health_2	<---	Security	1.138	0.115	9.858***
ST_Health_1	<---	Security	0.721	0.083	8.716***
AX_Health_3	<---	Anxiety	1		
AX_Health_2	<---	Anxiety	1.541	0.177	8.694***
AX_Health_1	<---	Anxiety	1.477	0.169	8.732***
AD_Health_1	<---	IOT_Adoption	1		
AD_Health_2	<---	IOT_Adoption	0.979	0.048	20.361***
AD_Health_3	<---	IOT_Adoption	0.841	0.067	12.594***
INN_4	<---	Innovativeness	1		

			Beta	**SE**	**t**
INN_3	<---	Innovativeness	2.746	0.598	4.593***
INN_1	<---	Innovativeness	2.797	0.628	4.452***
PU_Health_3	<---	Perceived_Usefulness	1		
PU_Health_2	<---	Perceived_Usefulness	0.974	0.059	16.404***
PU_Health_1	<---	Perceived_Usefulness	0.738	0.061	12.058***
CT_Health_1	<---	Compatibility	1		
CT_Health_2	<---	Compatibility	1.088	0.079	13.709***
CT_Health_3	<---	Compatibility	0.917	0.075	12.274***
IN_Health_1	<---	Intrusiveness	1		
IN_Health_2	<---	Intrusiveness	2.321	0.515	4.506***
IN_Health_3	<---	Intrusiveness	1.416	0.297	4.769***
IN_Health_4	<---	Intrusiveness	2.005	0.462	4.343***
IN_Health_5	<---	Intrusiveness	2.392	0.53	4.517***

$\chi 2(597)=1443.29$. p=0.000; GFI=0.69; AGFI=0.6115; NFI=0.722; CFI=0.772; TLI=0.740; RMSEA=0.126

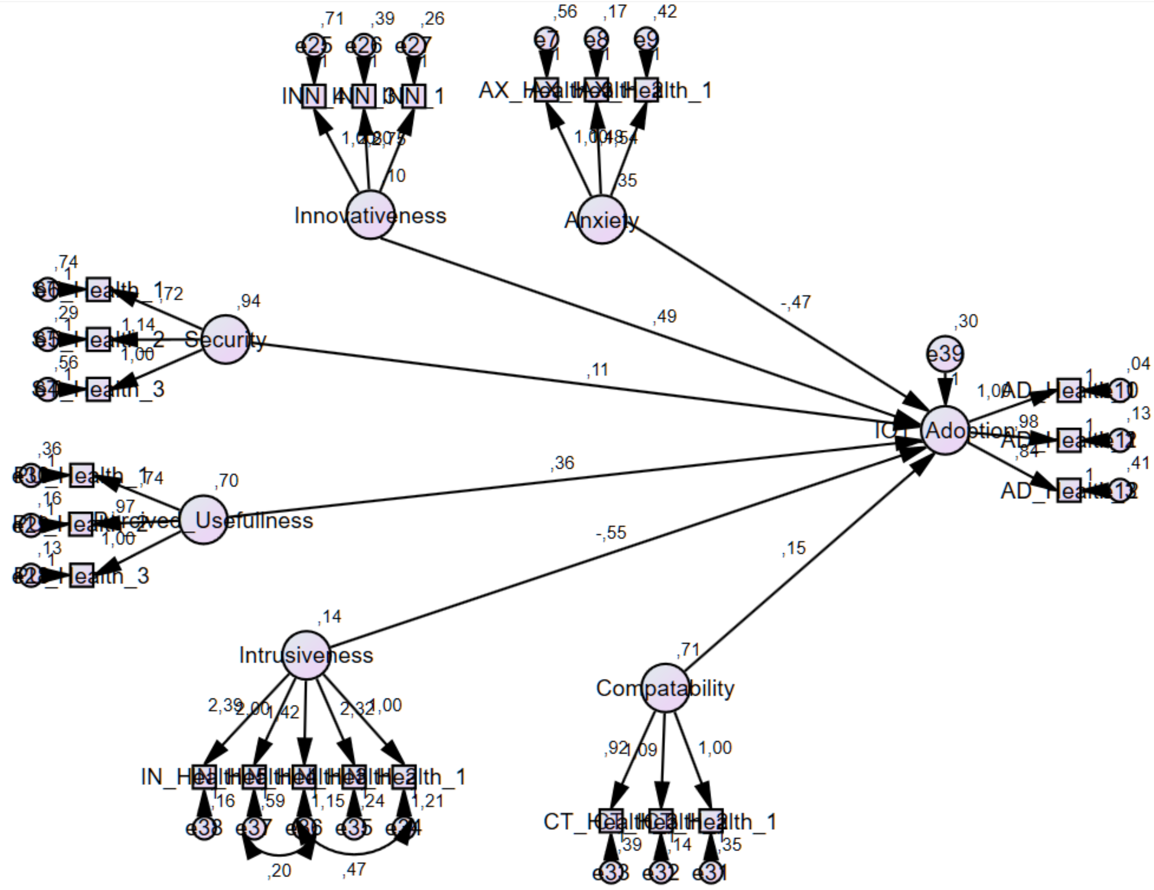
$*p< .05$. $** p< .01$. $*** p< .001$

CFI=Comparative Fit Index; RMSEA=Root Mean Square Error Approximation; TLI=Tucker-Lewis Index; NFI=Normed Fit Index; GFI=Goodness of Fit; AGFI= Adjusted Goodness of Fit

Looking at the model fit indexes, it can be seen that CFI is 0.772 close to the threshold for moderate fit. NFI and TLI are 0.772 and 0.740 respectively. RMSEA value can be read as 0.126 and GFI value is 0.69. Interpreting the path analysis results for “Smart Health” context, it can be articulated that anxiety, innovativeness, perceived usefulness, intrusiveness, compatibility and security have significant effect on the IoT adoption decision of the consumer. Amongst these variables, it can be seen that innovativeness have the strongest relationship with IoT adoption in positive sense whereas anxiety has the strongest link to the IoT adoption in negative perception.

Summary of the causal relationship between IoT adoption and the research model variables in “Smart Health” context is depicted in the figure below.

Figure 5.1 Path Diagram of Smart Health



5.2 SMART HOME

Looking at the results for “Smart Home” field of application in Table 5.4, it can be seen that each variable has a Cronbach α value greater than the lower threshold 0.70. On top of Cronbach’s reliability, construct reliability (CR) and average variance extracted values have been calculated for each construct. CR values range from 0.745 to 0.925 which are at the acceptable. Looking at the AVE figures, they range from 0.518 to 0.790 which are also within the acceptable range. Analysing the model fit values, Comparative Fit Index (CFI) can be seen as 0.873 which shows that the model has a moderate fit. Tucker-Lewis Index (TLI) and Normed Fit Index (NFI) are 0.851 and 0.804 respectively which also add up for the moderate fit of the model in smart home scope. Root mean square error of estimation (RMSEA) value is 0.084 which is not majorly above the recommended 0.08 level proving the good fit of the model. Significance value falls under p<0.01 for all variables. Lastly, looking at the CFA loadings, it can be observed that they range from 0.531 to 0.956 except intrusiveness and innovativeness measures that fall under the 0.50 threshold. Apart from these measures all loadings are above the 0.50 limit.

Table 5.4 Confirmatory Factor Analysis Results for Smart Home

	CFA	**t**
Cost (α=0.899; CR=0.901; AVE=0.753)		
CS_Home_3	0.922	a
CS_Home_2	0.794	14.383**
CS_Home_1	0.883	16.878**
Privacy (α=0.912; CR=0.918; AVE=0.790)		
PR_Home_3	0.815	a
PR_Home_2	0.918	16.160**
PR_Home_1	0.929	16.436**
Security (α=0.856; CR=0.866; AVE=0.684)		
ST_Home_3	0.862	a
ST_Home_2	0.867	16.263**
ST_Home_1	0.747	12.655**
Ubiquity (α=0.897; CR=0.901; AVE=0.751)		
UB_Home_3	0.866	a
UB_Home_2	0.896	17.105**
UB_Home_1	0.837	15.197**
Intrusiveness (α=0.84; CR=0.851; AVE=0.555)		
IN_Home_1	0.393	a
IN_Home_2	0.869	5.667**
IN_Home_3	0.531	6.492**
IN_Home_4	0.896	5.705**
IN_Home_5	0.883	5.687**

Perceived Usefulness (α=0.908; CR=0.912; AVE=0.775)		
PU_Home_3	0.956	a
PU_Home_2	0.864	19.580**
PU_Home_1	0.816	17.041**
Anxiety (α=0.815; CR=0.819; AVE=0.601)		
AX_Home_3	0.745	a
AX_Home_2	0.784	11.261**
AX_Home_1	0.796	11.468**
Relative Advantage (α=0.909; CR=0.912; AVE=0.776)		
RA_Home_1	0.839	a
RA_Home_2	0.895	16.173**
RA_Home_3	0.907	16.500**
Complexity (α=0.882; CR=0.856; AVE=0.668)		
CX_Home_1	0.708	a
CX_Home_2	0.783	13.957**
CX_Home_3	0.943	11.741**
Compatibility (α=0.899; CR=0.903; AVE=0.756)		
CT_Home_1	0.83	a
CT_Home_2	0.882	15.293**
CT_Home_3	0.894	15.590**
Adoption Intention (α=0.922; CR=0.925; AVE=0.805)		
AD_Home_1	0.915	a
AD_Home_2	0.923	20.764**
AD_Home_3	0.852	17.469**
Innovativeness (α=0.712; CR=0.745; AVE=0.518)		
INN_4	0.378	a
INN_3	0.854	4.887**
INN_1	0.825	4.921**

χ2(597)=1443.29. p=0.000; NFI=0.804; CFI=0.873; TLI=0.851; RMSEA=0.084

Note. a = Cronbach's Reliability; CR= Construct Reliability; AVE=Average Variance Extracted

*p< .05. ** p< .01. *** p< .001

CFI=Comparative Fit Index; RMSEA=Root Mean Square Error Approximation; TLI=Tucker-

Lewis Index; NFI=Normed Fit Index

As the CFA is confirmed for “Smart Home” area of use for IoT technology, path analysis is executed to test the research model in scope of “Smart Home” and to understand which of the variables have significant relationship with IoT adoption in the context of “Smart Home”.
Path analysis results for “Smart Home” construct are depicted in the Table 5.5.

Table 5.5 Path Analysis Results for Smart Home

			Beta	**SE**	**t**
IOT_Adoption	<---	Relative_Advantage	0.451	0.064	7.085***
IOT_Adoption	<---	Anxiety	-0.393	0.073	-5.419***
IOT_Adoption	<---	Innovativeness	0.398	0.16	2.481*
IOT_Adoption	<---	Ubiquitious	0.203	0.056	3.604***
AX_Home_3	<---	Anxiety	1		
AX_Home_2	<---	Anxiety	1.035	0.109	9.476***
AX_Home_1	<---	Anxiety	1.277	0.134	9.555***
AD_Home_1	<---	IOT_Adoption	1		
AD_Home_2	<---	IOT_Adoption	0.963	0.055	17.375***
AD_Home_3	<---	IOT_Adoption	0.958	0.065	14.82***
RA_Home_1	<---	Relative_Advantage	1		
RA_Home_2	<---	Relative_Advantage	1.154	0.074	15.521***
RA_Home_3	<---	Relative_Advantage	1.055	0.068	15.432***
UB_Home_3	<---	Ubiquitious	1		
UB_Home_2	<---	Ubiquitious	1.116	0.069	16.261***
UB_Home_1	<---	Ubiquitious	0.864	0.064	13.551***
INN_4	<---	Innovativeness	1		
INN_3	<---	Innovativeness	2.685	0.573	4.685***
INN_1	<---	Innovativeness	2.701	0.593	4.553***

$\chi 2(86)=335.481$. p=0.000; GFI=0.813; AGFI=0.739; NFI=0.841; CFI=0.876; TLI=0.848; RMSEA=0.121

p*< .05. ** *p*< .01. * *p*< .001

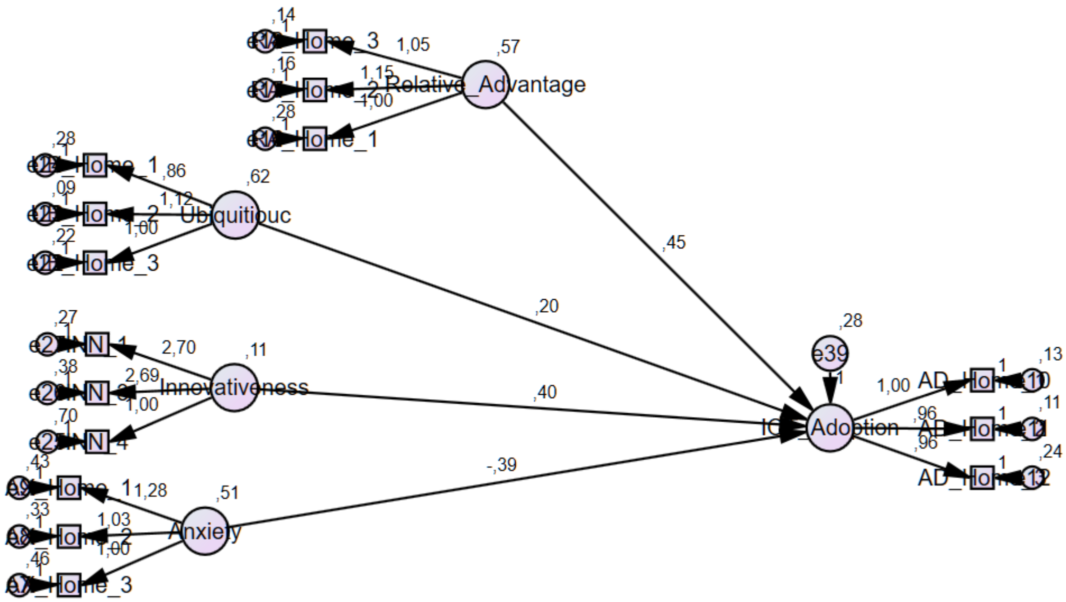
CFI=Comparative Fit Index; RMSEA=Root Mean Square Error Approximation; TLI=Tucker-

Lewis Index; NFI=Normed Fit Index; GFI=Goodness of Fit; AGFI= Adjusted Goodness of Fit

Looking at the model fit indexes, it can be seen that CFI is 0.876 close to the threshold for good fit and can be interpreted as moderate fit. NFI and TLI are 0.841 and 0.848 respectively. RMSEA value can be read as 0.121 and GFI value is 0.813 which is an indication of moderate fit of the model. Interpreting the path analysis results for “Smart Home” context, it can be stated that relative advantage, anxiety, innovativeness and ubiquity have significant effect on the IoT adoption decision of the consumer. Amongst these variables, it can be seen that relative advantage has the strongest relationship with IoT adoption in positive sense whereas anxiety has the strongest link to the IoT adoption in negative context.

Summary of the causal relationship between IoT adoption and the research model variables in “Smart Home” frame is depicted in the figure below.

Figure 5.2 Path Diagram for Smart Home



5.3 CONNECTED MOBILITY

Analysing the results for “Connected Mobility” field of application in Table 5.6, it can be seen that each variable has a Cronbach α value greater than the lower threshold 0.70. CR values range from

0.743 to 0.965 which are at the acceptable level according to the referenced norms mentioned in the introduction to the research findings section. Looking at the AVE figures, they range from 0.516 to 0.903 which are all above the minimum recommended level of 0.50. Looking into the model fit values, Comparative Fit Index (CFI) can be seen as 0.897 which shows that the model has a good fit. Tucker-Lewis Index (TLI) and Normed Fit Index (NFI) are 0.879 and 0.835 respectively. Root mean square error of estimation (RMSEA) value is 0.082 which is at the recommended 0.08 level proving the good fit of the model. Significance value falls under $p<0.01$ for all variables. Lastly, looking at the CFA loadings, it can be observed that they range from 0.650 to 0.979 except innovativeness measure that fall under the 0.50 threshold. Apart from that value, all loadings are above the 0.50 limit.

Table 5.6 Confirmatory Factor Analysis Results for Connected Mobility

	CFA	**t**
Cost (α=0.965; CR=0.965; AVE=0.903)		
CS_Mobility_3	0.952	a
CS_Mobility_2	0.931	26.977**
CS_Mobility_1	0.966	31.515**
Privacy (α=0.937; CR=0.937; AVE=0.833)		
PR_Mobility_3	0.881	a
PR_Mobility_2	0.927	19.927**
PR_Mobility_1	0.929	19.989**
Security (α=0.824; CR=0.843; AVE=0.648)		
ST_Mobility_3	0.9	a
ST_Mobility_2	0.876	17.659**
ST_Mobility_1	0.606	9.62**
Ubiquity (α=0.92; CR=0.913; AVE=0.779)		
UB_Mobility_3	0.836	a
UB_Mobility_2	0.88	15.982**
UB_Mobility_1	0.929	17.586**
Intrusiveness (α=0.90; CR=0.892; AVE=0.627)		
IN_Mobility_1	0.665	a
IN_Mobility_2	0.856	10.678**

	CFA	**t**
IN_Mobility_3	0.65	15.848**
IN_Mobility_4	0.859	10.707**
IN_Mobility_5	0.894	11.06**
Perceived Usefulness (α=0.933; CR=0.933; AVE=0.824)		
PU_Mobility_3	0.979	a
PU_Mobility_2	0.936	30.47**
PU_Mobility_1	0.799	17.552**
Anxiety (α=0.867; CR=0.868; AVE=0.688)		
AX_Mobility_3	0.77	a
AX_Mobility_2	0.911	13.877**
AX_Mobility_1	0.801	11.973**
Relative Advantage (α=0.911; CR=0.912; AVE=0.777)		
RA_Mobility_1	0.871	a
RA_Mobility_2	0.836	15.61**
RA_Mobility_3	0.934	19.347**
Complexity (α=0.892; CR=0.902; AVE=0.756)		
CX_Mobility_1	0.86	a
CX_Mobility_2	0.939	17.911**
CX_Mobility_3	0.803	14.103**
Compatibility (α=0.939; CR=0.940; AVE=0.839)		
CT_Mobility_1	0.879	a
CT_Mobility_2	0.932	20.175**
CT_Mobility_3	0.936	20.38**
Adoption Intention (α=0.906; CR=0.908; AVE=0.767)		
AD_Mobility_1	0.829	a
AD_Mobility_2	0.893	15.73**

	CFA	t
AD_Mobility_3	0.903	15.985**
Innovativeness (α=0.712; CR=0.743; AVE=0.516)		
INN_4	0.364	a
INN_3	0.834	4.703**
INN_1	0.849	4.682**

$\chi 2(598)=1403.089$. p=0.000; NFI=0.835; CFI=0.897; TLI=0.879; RMSEA=0.082

Note. a = Cronbach's Reliability; CR= Construct Reliability; AVE=Average Variance Extracted

p*< .05. ** *p*< .01. * *p*< .001

CFI=Comparative Fit Index; RMSEA=Root Mean Square Error Approximation; TLI=Tucker-Lewis Index; NFI=Normed Fit Index

As the CFA is confirmed for "Connected Mobility" area of use for IoT technology, path analysis is run to test the research model in scope of "Connected Mobility" and to reveal which of the variables have significant relationship with IoT adoption in this context.

Path analysis results for "Connected Mobility" construct are depicted in the Table 5.7.

Table 5.7 Path Analysis Results for Connected Mobility

			Beta	SE	t
IOT_Adoption	<---	Compatibility	0.4	0.05	7.985***
IOT_Adoption	<---	Cost	0.044	0.036	1.229*
IOT_Adoption	<---	Privacy	-0.119	0.039	-3.041*
IOT_Adoption	<---	Ubiquitious	0.466	0.064	7.245***
IOT_Adoption	<---	Perceived_Usefulness	-0.048	0.039	-1.246*
CS_Mobility_3	<---	Cost	1		
CS_Mobility_2	<---	Cost	1.021	0.038	27.013***
CS_Mobility_1	<---	Cost	1.056	0.034	31.439***
AD_Mobility_1	<---	IOT_Adoption	1		
AD_Mobility_2	<---	IOT_Adoption	1.069	0.08	13.400***
AD_Mobility_3	<---	IOT_Adoption	1.232	0.09	13.683***
PR_Mobility_3	<---	Privacy	1		
PR_Mobility_2	<---	Privacy	1.072	0.056	19.295***
PR_Mobility_1	<---	Privacy	1.089	0.055	19.663***
UB_Mobility_3	<---	Ubiquitious	1		

			Beta	**SE**	**t**
UB_Mobility_2	<---	Ubiquitious	1.092	0.097	11.216***
UB_Mobility_1	<---	Ubiquitious	1.37	0.152	9.003***
PU_Mobility_3	<---	Perceived_Usefulness	1		
PU_Mobility_2	<---	Perceived_Usefulness	1.046	0.039	26.771***
PU_Mobility_1	<---	Perceived_Usefulness	0.857	0.05	17.073***
CT_Mobility_1	<---	Compatibility	1		
CT_Mobility_2	<---	Compatibility	1.026	0.052	19.576***
CT_Mobility_3	<---	Compatibility	1.033	0.052	19.946***

$\chi 2$(125)=685.340. p=0.000; GFI=0.763; AGFI=0.676; NFI=0.832; CFI=0.858; TLI=0.826; RMSEA=0.150

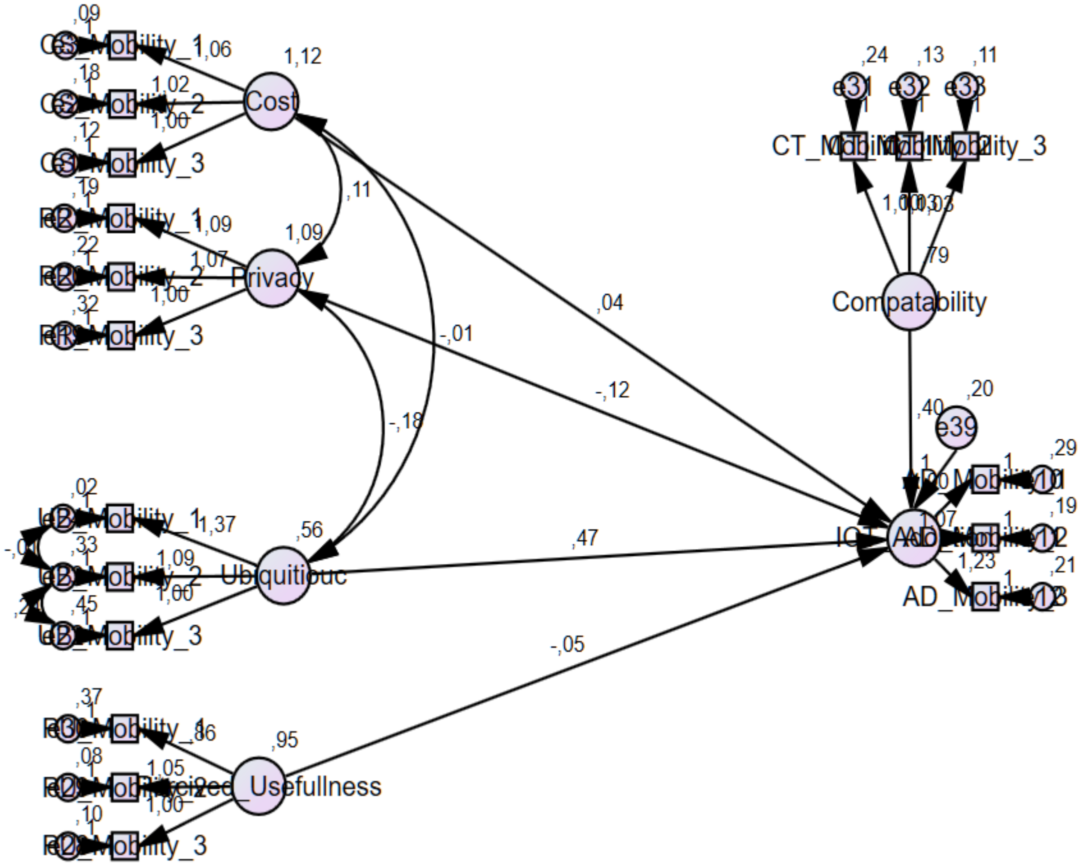
p*< .05. ** *p*< .01. * *p*< .001

CFI=Comparative Fit Index; RMSEA=Root Mean Square Error Approximation; TLI=Tucker-Lewis Index; NFI=Normed Fit Index; GFI=Goodness of Fit; AGFI= Adjusted Goodness of Fit

Looking at the model fit indexes, it can be seen that CFI is 0.858 indicating a moderate fit of the model. NFI and TLI are 0.832 and 0.826 respectively. RMSEA value can be read as 0.150 and GFI value is 0.763. Interpreting the path analysis results for “Connected Mobility” scope, it can be interpreted that compatibility, cost, privacy, ubiquity and perceived usefulness have significant effect on the IoT adoption decision of the consumer. Amongst these variables, it can be seen that ubiquity has the strongest relationship with IoT adoption in positive sense whereas privacy has the strongest link to the IoT adoption in negative perception.

Summary of the causal relationship between IoT adoption and the research model variables in “Connected Mobility” context is depicted in the figure below.

Figure 5.3 Path Diagram for Connected Mobility



5.4 SMART PAYMENT

Looking at the results for "Smart Payment" field of application in Table 5.8, it can be seen that each variable has a Cronbach α value greater than the lower threshold 0.70. CR values range from 0.744 to 0.956 which are at the acceptable level. Looking at the AVE figures, they range from 0.517 to 0.877 which are also within the acceptable range. Analysing the model fit values, Comparative Fit Index (CFI) can be seen as 0.911 which shows that the model has a good fit. Tucker-Lewis Index (TLI) and Normed Fit Index (NFI) are 0.895 and 0.846 respectively which show that the model has a moderate fit in smart payment concept. Root mean square error of estimation (RMSEA) value is 0.075 which is at the desired level of <0.08. Significance value falls under p<0.01 for all variables. Lastly, looking at the CFA loadings, it can be observed that they range from 0.578 to 0.971 except intrusiveness measure which is under the 0.50 threshold. Apart from that measure all loadings are above the 0.50 limit.

Table 5.8 Confirmatory Factor Analysis Results for Smart Payment

	CFA	**t**
Cost (α=0.947; CR=0.948; AVE=0.858)		
CS_Payment_3	0.919	a
CS_Payment_2	0.904	21.154**
CS_Payment_1	0.954	24.125**
Privacy (α=0.909; CR=0.911; AVE=0.774)		
PR_Payment_3	0.824	a
PR_Payment_2	0.919	16.48**
PR_Payment_1	0.894	15.791**
Security (α=0.884; CR=0.719; AVE=0.648)		
ST_Payment_3	0.832	a
ST_Payment_2	0.86	15.216**
ST_Payment_1	0.851	14.953**
Ubiquity (α=0.942; CR=0.844; AVE=0.779)		
UB_Payment_3	0.872	a
UB_Payment_2	0.971	20.488**
UB_Payment_1	0.909	17.547**
Intrusiveness (α=0.898; CR=0.897; AVE=0.638)		
IN_Payment_1	0.813	a
IN_Payment_2	0.86	14.608**
IN_Payment_3	0.578	10.034**
IN_Payment_4	0.849	14.325**
IN_Payment_5	0.858	14.577**
Perceived Usefulness (α=0.899; CR=0.906; AVE=0.765)		
PU_Payment_3	0.928	a
PU_Payment_2	0.927	23.273**
PU_Payment_1	0.757	14.33**
Anxiety (α=0.823; CR=0.831; AVE=0.623)		
AX_Payment_3	0.786	a
AX_Payment_2	0.866	13.557**

	CFA	**t**
AX_Payment_1	0.708	10.558**
Relative Advantage (α=0.877; CR=0.879; AVE=0.709)		
RA_Payment_1	0.767	a
RA_Payment_2	0.812	12.21**
RA_Payment_3	0.938	14.269**
Complexity (α=0.905; CR=0.875; AVE=0.703)		
CX_Payment_1	0.727	a
CX_Payment_2	0.81	17.29**
CX_Payment_3	0.961	12.877**
Compatibility (α=0.936; CR=0.938; AVE=0.834)		
CT_Payment_1	0.864	a
CT_Payment_2	0.92	18.825**
CT_Payment_3	0.953	20.15**
Adoption Intention (α=0.955; CR=0.956; AVE=0.877)		
AD_Payment_1	0.95	a
AD_Payment_2	0.953	28.795**
AD_Payment_3	0.907	23.85**
Innovativeness (α=0.712; CR=0.744; AVE=0.517)		
INN_4	0.368	a
INN_3	0.849	4.731**
INN_1	0.833	4.756**

$\chi 2(596)=1258.542$, p=0.000; NFI=0.846; CFI=0.911; TLI=0.895; RMSEA=0.075

Note. a = Cronbach's Reliability; CR= Construct Reliability; AVE=Average Variance Extracted

*p< .05, ** p< .01, *** p< .001

CFI=Comparative Fit Index; RMSEA=Root Mean Square Error Approximation; TLI=Tucker-Lewis Index; NFI=Normed Fit Index

As the CFA is confirmed for "Smart Payment" area of use for IoT technology, path analysis is executed to test the research model in scope of "Smart Payment" and to understand which of the variables have significant relationship with IoT adoption in the related context.

Path analysis results for "Smart Home" construct are depicted in the Table 5.9.

Table 5.9 Path Analysis Results for Smart Payment

			Beta	**SE**	**t**
IOT_Adoption	<---	Compatibility	0.364	0.046	7.839***
IOT_Adoption	<---	Intrusiveness	-0.25	0.041	-6.115***
IOT_Adoption	<---	Perceived_Usefulness	0.299	0.041	7.338***
AD_Payment_1	<---	IOT_Adoption	1		
AD_Payment_2	<---	IOT_Adoption	1.074	0.048	22.466***
AD_Payment_3	<---	IOT_Adoption	1.048	0.071	14.745***
PU_Payment_3	<---	Perceived_Usefulness	1		
PU_Payment_2	<---	Perceived_Usefulness	0.984	0.05	19.831***
PU_Payment_1	<---	Perceived_Usefulness	0.772	0.057	13.461***
CT_Payment_1	<---	Compatibility	1		
CT_Payment_2	<---	Compatibility	1.048	0.056	18.736***
CT_Payment_3	<---	Compatibility	1.103	0.056	19.771***
IN_Payment_1	<---	Intrusiveness	1		
IN_Payment_2	<---	Intrusiveness	0.875	0.065	13.474***
IN_Payment_3	<---	Intrusiveness	0.737	0.074	9.991***
IN_Payment_4	<---	Intrusiveness	0.982	0.074	13.264***
IN_Payment_5	<---	Intrusiveness	0.984	0.071	13.891***

$\chi 2(72)$=298.925, p=0.000; GFI=0.829; AGFI=0.751; NFI=0.890; CFI=0.914; TLI=0.891; RMSEA=0.126

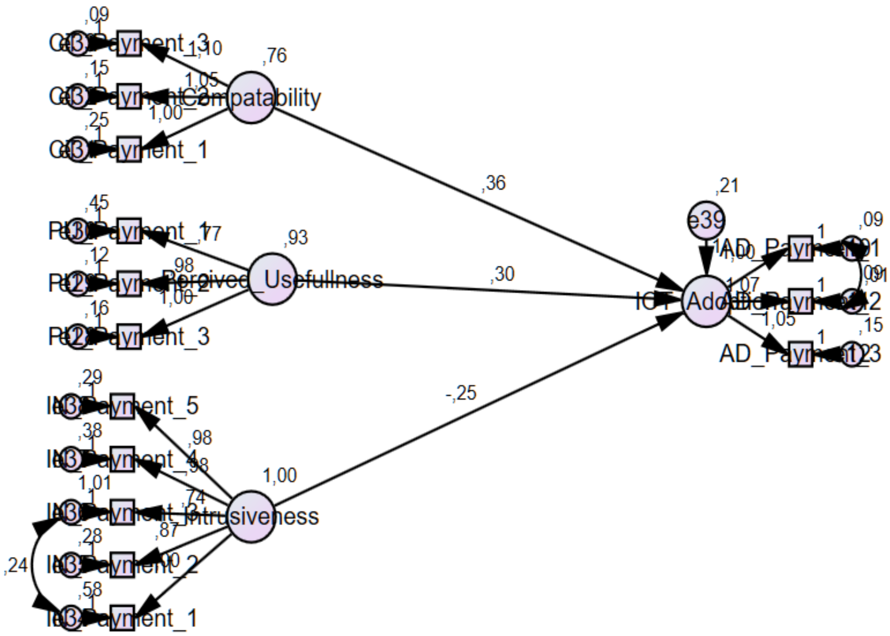
p*< .05, ** *p*< .01, * *p*< .001

CFI=Comparative Fit Index; RMSEA=Root Mean Square Error Approximation; TLI=Tucker-Lewis Index; NFI=Normed Fit Index; GFI=Goodness of Fit; AGFI= Adjusted Goodness of Fit

Looking at the model fit indexes, it can be seen that CFI is 0.914 which is an indication of good fit model. NFI and TLI are 0.890 and 0.891 respectively. RMSEA value can be read as 0.126 and GFI value is 0.829 which can be interpreted as moderate fit of the model. Commenting on the path analysis results for “Smart Payment” context, it can be stated that compatibility, intrusiveness and perceived usefulness have significant effect on the IoT adoption decision of the consumer. Amongst these variables, it can be seen that compatibility has the strongest relationship with IoT adoption in positive sense whereas intrusiveness has the strongest link to the IoT adoption in negative context.

Summary of the causal relationship between IoT adoption and the research model variables in "Smart Payment" frame is depicted in the figure below.

Figure 5.4 Path Diagram for Smart Payment



CONCLUSION

In the above section, research model has been tested for each of the field of application in the IoT technology and the results are demonstrated. As mentioned in the introductory part, this study's primary focus is to underline the different factors affecting the IoT adoption decision for various IoT technology employed sectors. Consolidating the path analysis results from each construct constitutes the following summary table of the factors having a significant impact on IoT adoption. For smart health application area, the results show that security, perceived usefulness from TAM, anxiety, intrusiveness, innovativeness and compatibility have significant effect on IoT adoption of the consumer. For smart home construct, variables having an important causal effect to the IoT adoption are smaller in size compared to smart health. Ubiquity, anxiety, innovativeness and relative advantage are evaluated as significant factor affecting IoT adoption.

Table 6.1 Path Analysis Overall Assessment for Field of Applications of IoT Technology

Variable	**Hypothesis**	**Smart Health**	**Smart Home**	**Connected Mobility**	**Smart Payment**
Cost	H1			☑	
Privacy	H2			☑	
Security	H3	☑			
Ubiquity	H4		☑	☑	
Perceived Usefulness	H5	☑		☑	☑
Anxiety	H6	☑	☑		
Intrusiveness	H7	☑			☑
Innovativeness	H8	☑	☑		
Relative Advantage	H9a		☑		
Complexity	H9b				
Compatibility	H9c	☑		☑	☑

When the research model is tested for connected mobility construct, it resulted that cost, privacy, ubiquity, perceived usefulness and compatibility are found to be the signification variables acting on IoT adoption. Lastly for smart payment, perceived usefulness, intrusiveness and compatibility have a strong relationship with IoT adoption. As driven from the summary table, all of the variables within the research model except complexity are assessed to have significant effect on IoT adoption in an implementation area of the IoT technology taken into consideration in the scope of this dissertation. Perceived usefulness is significantly affecting the IoT adoption in three of the four application areas and come forth as one of the fundamental variables in assessing IoT adoption in different fields. Also compatibility adopted from IDT has substantial effect on IoT adoption in three fields as well. Both for perceived usefulness and compatibility, IoT adoption decision seems to be not effected within the smart home scope. It can be interpreted that the smart home area of IoT application is already the pioneering area of IoT penetration and dissemination and the participants may be already familiar with the usefulness and compatibility of the IoT products and services which may have led to insignificant relationship of the variables with IoT adoption. Looking closely at the barriers impeding the IoT adoption, both anxiety and intrusiveness have significant on the IoT adoption in two of the four IoT sectors. Smart health is the common field of application where they have a causal relationship with the adoption intention. Anxiety seems to play an important role in adoption decision in smart home construct whereas intrusiveness in smart payment. For connected mobility, the results show that the participants see no effect coming from IoT adoption barriers such as anxiety and intrusiveness, however privacy still acts as a significant element impeding IoT adoption in connected mobility. Examining cost, privacy and security, these variables have an important causal relationship with IoT adoption in one of the four IoT sectors. Cost and privacy are evaluated to have a significant role in connected mobility whereas security has a notable influence on IoT adoption in smart health context. Ubiquity being adopted into the model as it is a commonly considered variable within the IoT adoption literature is resulted to significantly impact IoT adoption in smart home and connected mobility constructs only.

Concluding all the figures, hypothesis statements formed according to the research model are concluded as follows:

H1. Cost has a negative impact on the IoT product/service adoption statement is confirmed in connected mobility field of application.

H2. Privacy is negatively associated with the intention to adopt IoT product/service is confirmed within connected mobility context.

H3. Security concerns will increase the resistance for IoT product/service adoption is confirmed in the smart health area of IoT technology implementation.

H4. Ubiquity of the IoT product/services enhances the adoption intention of the product/service is confirmed for smart home and connected mobility constructs.

H5. Perceived usefulness has a positive impact on the IoT product/service adoption is confirmed within all areas except smart home.

H6. Anxiety has a negative impact on the IoT product/service adoption is confirmed within the scope of smart health and smart home.

H7. Intrusiveness has a negative impact on the IoT product/service adoption is confirmed for smart health and smart payment constructs.

H8. Innovativeness has a positive impact on the IoT product/service adoption is confirmed within smart health and smart home contexture.

H9a. Relative advantage has a positive impact on the IoT product/service adoption is confirmed within smart home construct only.

H9b. Complexity has a negative impact on the IoT product/service adoption is refuted as there is no significant impact found on any of the application areas.

H9c. Compatibility has a positive impact on the IoT product/service adoption is confirmed for all constructs except smart home.

6.1 IMPLICATIONS

According to research conducted by Donna L. Hoffman and Thomas P. Novak, the market for Internet of Things (IoT) hardware is currently highly fragmented due to vendors' historical emphasis on niche use cases. Some buyers may decide that the benefits outweigh the added expense and effort involved in upgrading to a smart refrigerator, linked toothbrush, or intelligent thermostat. However, each one falls short of fulfilling the promise of a more interconnected existence on its own. When taken by themselves, they are only tools. Marketers need to "see the smart home as a complicated dynamic system," argue Hoffman and Novak. Marketers should focus on communicating the value proposition inherent in experience; current approaches may actually be underselling the smart home" if they want to see widespread uptake. This means that developers must provide solutions to actual consumer problems, such as, for example, automating tasks that consumers find time-consuming. marketing analysis of the type required to identify such issues. (Downes, 2018) Consumers will be able to design their own one-of-a-kind IoT experiences by putting together collections of diverse smart gadgets. (Hoffman & Novak, 2018)

Findings in this research advocated the statements mentioned above, showing that different variables come into effect for each different application of IoT technology and diversity of smart devices and system approach to the IoT technology are going to amplify the value additions of the

IoT technology into the consumer’s lives. Further implications for marketers can be to adopt robust security procedures before governments enforce them; incorporate smart technology in established goods and brands to ease the transition; converge on a common set of standards; put measures in place to lessen consumers' concerns about the protection of their personal data. Drive the technological shift without being overly invasive; people need room to adapt.

Instead of zeroing down on one use case, embrace the overall and systematic value addition of the IoT systems.

Rather than coming up with gimmicks, focus on solving actual issues and creating practical use cases. Focus on the bits that are coming out of people's own lives.

The outcomes of this study may also encourage marketers to modify their advertisement content to better appeal to audiences in each specific IoT use case.

6.2 LIMITATIONS AND FUTURE RESEARCH

Describing a IoT dominated hypothetical world and using it as basis to have the survey participants picture themselves in that world and assess different aspects affecting the IoT adoption intention is a differentiation point of this research amongst other research exerted on the IoT technology adoption in marketing literature scope as well as a limitation as the participants had to answer the survey questions without having real physical experience with the products and services in focus. It is a challenge for the correspondents to relatively compare the future technologies described with the contemporary technology they have available at hand.

Analysing the demographics of the sample, it shows that the education level is rather higher than the average education level in Turkey and the tendency to use new technology is also high. This might have showed a positive bias towards adopting a new technology, such as an IoT product or service. Thus, the sample size can be enlarged for any future study which will aim to address similar research scope. Another limitation is that the study has been made in Turkey. If the exercise has been done on other countries with different maturity levels towards new technology adoption, it might show more comprehensive results regarding the effects of the variables listed in the research model on IoT adoption. It’s been mentioned several times in the dissertation that there are many IoT fields of applications as the connectivity between things grow larger by the day. In this research’s scope, smart health, smart home, connected mobility and smart payment constructs are analysed per IoT adoption however the extent of the research can be amplified by integrating other IoT area of practices. As the IoT maturity is not yet at it’s peak, this study can be repeated in a future point of time when the usage of IoT products and services are majorly common within the population. It would pave the way to a clearer picture in understanding the variables affecting IoT adoption.

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8. ANNEXES

ANNEX-A SURVEY QUESTIONS

Demographic Questions:

Yaşınız
Cinsiyetiniz
Eğitim Durumunuz
Gelir Seviyeniz

Questions to analyse tendency to a new technology:

Teknolojik gelişmelere ilgi duyar mısınız?

Evinizde “nesnelerin interneti” teknolojisini kullanan herhangi bir ürün var mı? (Örnek olarak akıllı süpürge,uzaktan kontrol edebildiğiniz çamaşır makinası vb.)

Questions to analyse technology readiness

Arkadaş çevrem içerisinde yeni bir teknolojik ürün çıktığında ilk alan kişi genelde ben olurum.

Yeni bir teknolojik ürün veya hizmeti genelde başkalarından yardım almadan anlayabilirim.

Yeni bir teknolojik ürün çıktığında arkadaşlarımdan daha önce bu ürünü almaya ve denemeye çalışırım.

İlgi alanım içerisindeki son teknolojik gelişmeleri takip ederim.

Survey questions below are repeated for each of the four constructs. The phrase “IoT” is replaced by the specific application area, as instance as “smart health device or service” for first construct. Same logic is applied for following constructs. Full content can be examined via accessing the link:https://docs.google.com/forms/d/1kjZwpIe4XZG2kEd77S3sqXmXQSvJyZ7tl6LWsJDqY/edit.

Table A.1 Survey Questions and References

Measure	**Indicator**	**Turkish Translation**	**Reference**
Perceived Cost	CS1	IOT ürün ve hizmetlerinin ücretlerinin yüksek olacağını düşünüyorum.	Mani&Chouk(2018)
Perceived Cost	CS2	IOT ürün ve hizmetlerinin maliyetlerinin yüksek olacağını düşünüyorum.	Mani&Chouk(2018)
Perceived Cost	CS3	IOT bazlı hizmetlerin pahalı olacağını düşünüyorum.	Mani&Chouk(2018)
Relative Advantage	RA1	IoT teknolojisine sahip ürün veya hizmetler geleneksel cihazlara kıyasla daha fazla avantaja sahiptir.	Sivathanu(2017)- Background: Claudy et al. (2015), Westaby (2005b), Westaby et al. (2010), AnilGupta and Neelika Arora (2017)
Relative Advantage	RA2	IoT bazlı cihazlar işimi halletmem için daha az zaman ve efor harcamamı sağlar.	Sivathanu(2017)- Background: Claudy et al. (2015), Westaby (2005b), Westaby et al. (2010), AnilGupta and Neelika Arora (2017)
Relative Advantage	RA3	IoT teknolojisine sahip ürünlerin katkısı sayesinde işimi verimli bir şekilde yönetebilirim.	Sivathanu(2017)- Background: Claudy et al. (2015), Westaby (2005b), Westaby et al. (2010), AnilGupta and Neelika Arora (2017)
Compatibility	CT1	IoT teknolojisini kullanıyor olmam kişisel değerlerimle örtüşür.	Claudy(2015)

Compatibility	CT2	IoT teknolojisini kullanmam dünya görüşümle uyumlu bir hareket olur.	Claudy(2015)
Compatibility	CT3	IoT bazlı ürünleri kullanmam hayatımı yaşamak istediğim tarza uygun olur.	Claudy(2015)
Complexity	CX1	IoT teknolojisini öğrenmek benim için kolay olacaktır.	Mani&Chouk(2018)
Complexity	CX2	IoT teknolojisine sahip ürün veya hizmetlerin kullanımı kolay olacaktır.	Mani&Chouk(2018)
Complexity	CX3	IoT bazlı ürünlerden istediğim sonuçları almak kolaydır.	Mani&Chouk(2018)
Anxious	AX1	IoT teknolojisine sahip ürün veya hizmetleri kullanmak konusunda endişeliyim.	Xu (2016)
Anxious	AX2	IoT teknolojisi benim için korkutucu.	Xu (2016)
Anxious	AX3	Düzeltemeyebileceğim hatalar yapma ihtimalimden dolayı IoT ürünlerini kullanmakta tereddüt ederim.	Xu (2016)
Intrusiveness	IN1	IoT bazlı ürün veya hizmetler hayatıma karışabilir.	Mani&Chouk(2017) Background: Herault and Belvaux (2014)
Intrusiveness	IN2	IoT teknolojisi benim için sinir bozucudur.	Mani&Chouk(2017) Background: Herault and Belvaux (2014)
Intrusiveness	IN3	IoT bazlı hizmetler hayatıma izin vermediğim oranda müdahil olabilir.	Mani&Chouk(2017) Background: Herault and Belvaux (2014)

Intrusiveness	IN4	IoT teknolojisine sahip ürün veya hizmetleri kullanmak için kendimi rahat hissetmiyorum.	Mani&Chouk(2017) Background: Herault and Belvaux (2014)
Intrusiveness	IN5	IoT ürünleri rahatsız edicidir.	Mani&Chouk(2017) Background: Herault and Belvaux (2014)
Security	ST1	IoT bazlı ürünlerin güvenli olmadığını hissediyorum.	Sivathanu(2017)- Background: Claudy et al. (2015), Westaby (2005b), Westaby et al. (2010), AnilGupta and Neelika Arora (2017)
Security	ST2	IoT teknolojisini kullanırken bilgilerimin suistimal edilebileceğinden korkuyorum.	Sivathanu(2017)- Background: Claudy et al. (2015), Westaby (2005b), Westaby et al. (2010), AnilGupta and Neelika Arora (2017)
Security	ST3	IoT teknolojisine sahip ürün veya hizmetleri kullanırken kişisel bilgilerimin kaybolmasından korkuyorum.	Sivathanu(2017)- Background: Claudy et al. (2015), Westaby (2005b), Westaby et al. (2010), AnilGupta and Neelika Arora (2017)
Perceived usefulness	PU1	IoT teknolojisine sahip ürün veya hizmetler ihtiyacıma göre gereken aksiyonu daha hızlı almamı sağlayacaktır.	Davis (1989)
Perceived usefulness	PU2	IoT ürünleri ihtiyacım için gerekli olan kararı verme	Davis (1989)

		performansımı iyileştirir.	
Perceived usefulness	PU3	IoT teknolojisine sahip ürün veya hizmetler ihtiyacım için gerekli olan kararı almamı kolaylaştırır.	Davis (1989)
Ubiquity	UB1	IoT bazlı hizmetler ihtiyacım hakkında bilgi sahibi olmam için bana yardımcı olur.	Sivathanu(2017)- Background: Claudy et al. (2015), Westaby (2005b), Westaby et al. (2010), AnilGupta and Neelika Arora (2017)
Ubiquity	UB2	IoT teknolojisine sahip ürün veya hizmetler ne zaman olursa olsun ihtiyacım olan şeye ulaşmamı sağlar.	Sivathanu(2017)- Background: Claudy et al. (2015), Westaby (2005b), Westaby et al. (2010), AnilGupta and Neelika Arora (2017)
Ubiquity	UB3	IoT bazlı ürünler nerede olursam olayım ihtiyacım hakkında bilgi almamı ve takip edebilmemi sağlar.	Sivathanu(2017)- Background: Claudy et al. (2015), Westaby (2005b), Westaby et al. (2010), AnilGupta and Neelika Arora (2017)
Perceived Privacy	PR1	IoT hizmet sağlayıcılarına kişisel bilgilerimi vermem çok riskli olurdu.	Karahoca (2017)
Perceived Privacy	PR2	IoT hizmet sağlayıcılarına kişisel bilgilerimi vermem durumunda aklımda birçok soru işareti ve belirsizlik	Karahoca (2017)

		olurdu.	
Perceived Privacy	PR3	IoT hizmet sağlayıcılarına kişisel bilgilerimi vermem durumunda bilgilerimin kaybolma ihtimali oldukça yüksek olurdu.	Karahoca (2017)
Adoption Intention	AD1	IoT bazlı ürünleri veya hizmetleri gelecekte kullanacağım.	Sivathanu(2017) - Background: Fishbein and Ajzen (1980), AnilGupta and Neelika Arora (2017)
Adoption Intention	AD2	Gelecekte kendimi IoT teknolojisini kullanırken görebiliyorum.	Sivathanu(2017) - Background: Fishbein and Ajzen (1980), AnilGupta and Neelika Arora (2017)
Adoption Intention	AD3	Yakın gelecekte IoT teknolojisini kullanmaya niyetliyim.	Sivathanu(2017) - Background: Fishbein and Ajzen (1980), AnilGupta and Neelika Arora (2017)

ANNEX-B VIDEO TO ILLUSTRATE THE HYPOTHETICAL WORLD

A video has been created using the video creation tool “climpchamp” and an AI tool to create virtual sound over the video, which describes a future hypothetical world to help the survey takers visualize a day in which people are surrounded by various IoT technologies and they actively use them during their routine. Whole video can be watched via accessing the link, it is also embedded in the survey link: https://www.youtube.com/watch?v=g5agYzu88Eg
Below are the screenshots showing illustrations depicting various application areas of IoT technologies in the video.

Figure B.1 Survey Video - Hypothetical World Introduction

2035 yılında yepyeni bir dünyaya uyandığınızı hayal edin!

Figure B.2 Survey Video – Start of the Day Via Smart Window

Future IOT World

Güne akıllı pencerenizden bakarak başlıyorsunuz.
Günlük takviminizi takip edebiliyorsunuz.

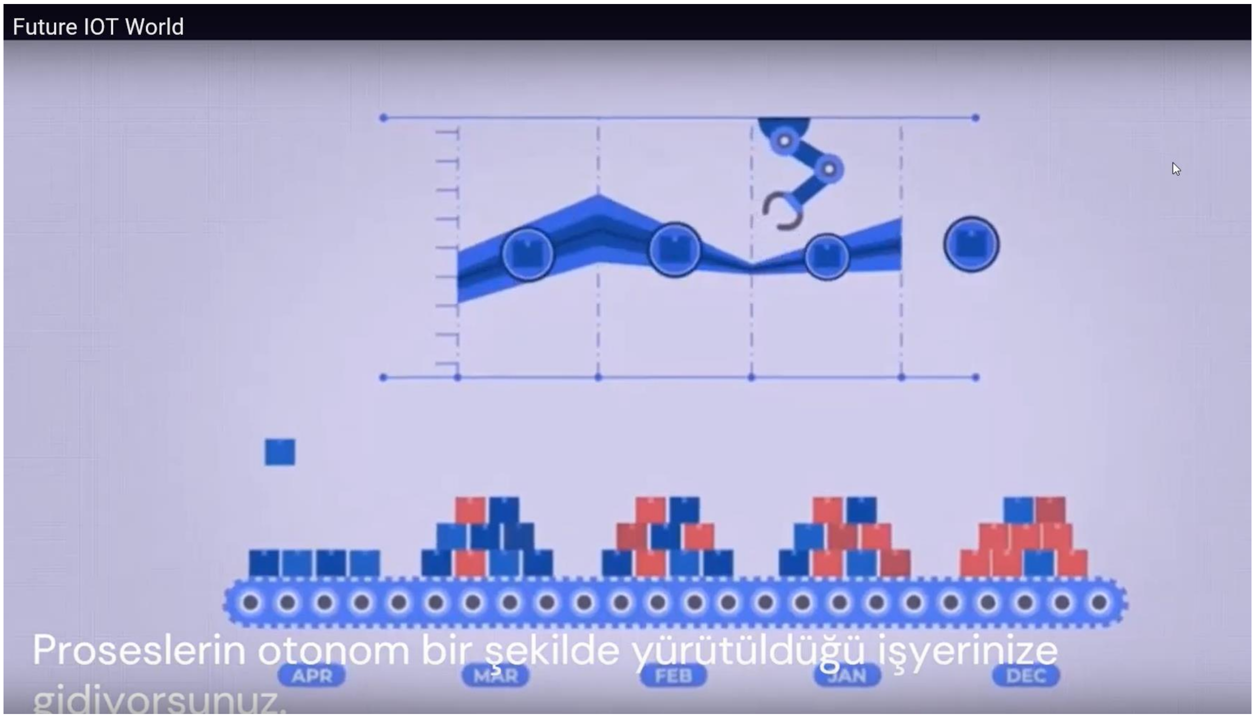
Figure B.3 Survey Video – Smart Home Devices Illustration

Akıllı cihazlarla dolu bir eve sahipsiniz. Televizyonunuz,bilgisayarınız,buzdolabınız ve ekmek kızartıcınız bile akıllı ve hepsi birbirine bağlı.

Figure B.4 Survey Video – Smart Health Application

Tüm verileriniz data cloud'a gönderiliyor ve doktorunuzla anlık olarak paylaşılabiliyor.

Figure B.5 Survey Video – Smart Manufacturing Illustration



Proseslerin otonom bir şekilde yürütüldüğü işyerinize gidiyorsunuz.

Figure B.6 Survey Video – Connected Mobility Depiction

İşten çıkıyorsunuz, telefonunuzdan araç paylaşım uygulamasını açıp evinize gitmek için aracınızı çağrıyorsunuz.

Figure B.7 Survey Video – Smart Payment Description

Yolculuğunuz sonrası evinize ulaşıyorsunuz.
Seyahatinizin ücreti cloud'da bulunan dijital hesabınızdan otomatik olarak çekiliyor ve fatura hesabınıza gönderiliyor.

FigureB.8 Survey Video – Smart City Depiction

Altyapı dahil her şeyin birbiriyle bağlı olduğu akıllı bir şehirde yaşıyorsunuz.

Figure B.9 Survey Video – Closing Scene Showing Connectivity of Things

Nesnelerin interneti herkesin ve her şeyin birbiri ile bağlı olduğu bir platform oluşturuyor.

ANNEX-C ETHICS BOARD APPROVAL

Ethics Board Approval is available in the printed version of this dissertation.