ATTITUDES OF CITIZENS TOWARDS IOT-BASED SMART CITY APPLICATIONS AND USE: DEVELOPMENT OF AN ADOPTION MODEL USING STRUCTURAL EQUATION MODELING

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ABSTRACT

ATTITUDES OF CITIZENS TOWARDS IOT-BASED SMART CITY APPLICATIONS AND USE: DEVELOPMENT OF AN ADOPTION MODEL USING STRUCTURAL EQUATION MODELING

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Citizen-centric smart city services aim to make the public sector more efficient, create more public value and improve quality of life (QoL) for all citizens. However, before any technology enters the market, the factors making the adoption easier should be investigated. Here, the researcher aims to explore the citizens' motivations to use smart city services, from end-users' perspective. The proposed research model, Smart City Services Acceptance Model (SCSAM), built over the human, technology, and institutions dimensions of smart city concept. Based on the sequential explanatory mixed method design adopted here, first, the researcher statistically validated the proposed model and tested the hypotheses with online survey data of 640 respondents (359 males, 281 females) by using Structural Equation Modeling (SEM). Then, two different qualitative data sets were analyzed: the first data set was the answers given to the open-ended question in the questionnaire, and the second was semi-structured interviews designed according to the analysis results of quantitative data. Finally, valuable and strong findings were obtained regarding the adoption of IoT-based smart city services by collectively evaluating the results of quantitative and qualitative analysis applied to different types of data sources under mixed method design. This is one of the very few studies in the literature investigating the acceptance of IoT-based smart city services. Additionally, SCSAM is the only acceptance model in the literature based on the human, technology, and institutional dimensions of smart city concept. The findings obtained here will help local administrations and service providers to develop better strategies to accelerate technological transformation and improve the QoL in urban.

Keywords: Smart city, Internet of things, Structural equation modeling, Quality of life, Technology acceptance

ÖZ

KENT SAKİNLERİNİN IOT TABANLI AKILLI ŞEHİR UYGULAMALARINA VE BU UYGULAMALARIN KULLANIMINA KARŞI TUTUMU: YAPISAL EŞİTLİK MODELİ KULLANARAK BİR KABUL MODELİ GELİŞTİRİLMESİ

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Vatandaş merkezli akıllı şehir hizmetleriyle, kamu sektörünün daha verimli hale gelmesi, daha fazla kamusal değer yaratılması ve tüm vatandaşlar için yaşam kalitesinin artırılması hedeflenmektedir. Ancak, herhangi bir teknoloji pazara girmeden önce, benimsemeyi kolaylaştıran faktörler araştırılmalıdır. Bu çalışmada, vatandaşların nesnelerin interneti tabanlı akıllı şehir hizmetlerini kullanma motivasyonlarının son kullanıcı bakış açısıyla anlaşılması amaçlanmaktadır. Burada önerilen ve Akıllı Şehir Hizmetleri Kabul Modeli (SCSAM) olarak adlandırılan araştırma modeli, akıllı şehir kavramının insan, teknoloji ve kurum boyutları üzerine inşa edilmiştir. Benimsenen sıralı açıklayıcı karma yöntem tasarımına uygun olarak, önce, önerilen model istatistiksel olarak doğrulandı ve hipotezler, 640 yanıtlayıcının (359 erkek ve 281 kadın) katılımı ile elde edilen çevrimiçi anket verilerinin kullanıldığı Yapısal Eşitlik Modellemesi ile test edildi. Daha sonra, ilki ankette sorulan açık uçlu soruya verilen cevaplardan, ikincisi ise nicel verilerin analiz sonuçlarına göre tasarlanmış yarı yapılandırılmış görüşmelerden elde edilen iki farklı nitel veri seti analiz edildi. Son aşamada, farklı veri kaynaklarına uygulanan nicel ve nitel analizlerin sonuçları toplu olarak değerlendirilerek, nesnelerin interneti tabanlı akıllı şehir hizmetlerinin benimsenmesine ilişkin değerli ve güçlü bulgular elde edildi. Bu doktora çalışması, literatürde nesnelerin interneti tabanlı akıllı şehir hizmetlerinin kabulünü araştıran çok az sayıdaki çalışmalardan biridir. Ayrıca, SCSAM, akıllı şehir kavramının insan, teknoloji ve kurumsal boyutlarına dayanan tamamen orijinal bir kabul modelidir. Bu çalışmada elde edilen bulgular, kent merkezlerindeki teknolojik dönüşümün hızlandırılması ve yaşam kalitesinin iyileştirilmesi adına ilgili tarafların etkin stratejiler geliştirmesine yardımcı olacaktır.

Anahtar Sözcükler: Akıllı şehir, Nesnelerin İnterneti, Yapısal eşitlik modellemesi, Yaşam kalitesi, Teknoloji kabulü

Dedicated to my family.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

4G	Fourth Generation Mobile Network
5G	Fifth Generation Mobile Network
AGFI	Adjusted Goodness of Fit Index
AMOS	Analysis of a Moment Structures
ANFIS	Adaptive-Network based Fuzzy Inference Systems
AVE	Average Variance Extracted
CFA	Confirmatory Factor Analysis
CFI	Comparative Fit Index
CMIN	Chi-Square Goodness of Fit Index
COS	Perceived Cost
df	Degree of Freedom
DOI	Diffusion of Innovation
DTPB	Decomposed Theory of Planned Behavior
EFA	Exploratory Factor Analysis
e-GovQual	A Scale for Assessing e-Government Service Quality
ENISA	European Union Agency for Cybersecurity
EU	European Union
fsQCA	Fuzzy Set Qualitative Comparative Analysis
GDP	Gross Domestic Product
GFI	Goodness of Fit Index
ICT	Information and Communication Technologies
IDC	International Data Corporation
IDT	Innovation Diffusion Theory
IEC	International Electro-technical Commission
IOT	Internet of Things
IS	Information Systems
ISO	International Organization for Standardization
IT	Information Technology
KMO	Kaiser-Meyer-Olkin
MADM	Multiple Attribute Decision-Making
MAXQDA	Software Package for Qualitative Data Analysis
METU	Middle East Technical University
MIS	Management Information Systems
PC	Privacy Concern
PCA	Principal Component Analysis

PEOU	Perceived Ease of Use
PI	Personal Innovativeness
PLS	Partial Least Squares
PLS-SEM	Partial Least Squares Structural Equation Modeling
PT	Perceived Trust
PU	Perceived Usefulness
QOE	Quality of Experience
QOL	Quality of Life
QOLS	Quality of Life Scale
QOS	Quality of Service
QUAL	Qualitative
QUAN	Quantitative
RFID	Radio Frequency Identification
RMSEA	Root Mean Square Error of Approximation
SCSAM	Smart City Services Acceptance Model
SEM	Structural Equation Modeling
SERVEQUAL	A Scale for Measuring Consumer Perceptions of Service Quality
SI	Social Influence
SPSS	Statistical Package for The Social Sciences
SRMR	Standardized Root Mean Square Residuals
SWH	Smart Wearable Healthcare
TAM	Technology Acceptance Model
TOE	Technology Organization and Environment
TPB	Theory of Planned Behavior
TRA	Theory of Reasoned Action
UN	United Nations
UTAUT	Unified Theory of Acceptance and Use of Technology
VAM	Value-based Adoption Model
WebQual	Website Quality Instrument
WHOQOL	World Health Organization Quality of Life
WSN-SHHS	Wireless Sensor Network based Smart Home Healthcare Systems

CHAPTER 1

INTRODUCTION

1.1. Chapter Overview

This part of the study starts with some introductory information about the general concepts in the scope. Then, in the third part, the main objectives of the study are given. After explaining why the study is important for the literature and what kind of beneficial outcomes it has for interested parties, research questions are defined. The limitations of the study are summarized in the sixth chapter. Finally, this chapter ends with the structure of the thesis and a chapter summary.

1.2. Introduction

Low-power sensors, wireless networks and mobile-based applications have been used more broadly than ever owing to decreasing cost of technology and increasing digital services (Lea, 2017). Thereupon, in the past decade, smart health, smart home, even smart city concepts, together with the Internet of Things (IoT) phenomenon, have appeared and smart services deployed in these concepts have become widespread. On the other hand, the continual population increase in urbans makes a paradigm shift inevitable for the local administration. Urbans has become digital thanks to the smart city services offered to citizens, thereby this technological evolution has started to speed up cities' economic development and contribute to the development of the whole country's economy (Dubbeldeman & Ward, 2015). Therefore, smart city transformation has the potential to improve the gross domestic product (GDP) in a country all (Beaudry & Green, 2002; Foster & Rosenzweig, 2010). Although the concept of smart city has become more popular recent years, there is still no smart city definition universally accepted. Nevertheless, one can define smart city as the city that uses information and communication technologies (ICT) and data in order for making daily routines more efficient, more sensitive and more sustainable (Faller, 2015). Contrary to popular belief, equipping a city with ICT is not enough to make it smart (Neirotti et al., 2014). Because, the smart city concept has two more pillars as human and institution, other than technology

(Nam & Pardo, 2011), and 6 main characteristics: people, life, environment, governance, economy and mobility (Giffinger et al., 2007).

Actually, the revolution of smart city has accelerated with the rise of IoT. This game-changing technology could be defined as a network of smart and connected objects communicating in real time over IP-based communication protocols (Al-Fuqaha et al., 2015). In IoT concept, physical objects are equipped with sensors and connectivity equipment to collect, exchange, analyze data and take appropriate actions. Architecturally, IoT consists of multiple layers: application, connection and device layers (Bandyopadhyay et al., 2013). IoT-based services offered in everyday-life (e.g. smart home, smart transportation, mobile payments etc.) are located in the application layer where end users interact directly (Gubbi et al., 2013).

Smart city initiatives based on the Internet and IoT intend to automate processes, reduce costs, increase efficiency and performance in the services offered, but the ultimate aim is to improve socio-economic well-being, transparency and quality of life (QoL) through human-centric and sustainable approaches in urban areas (Aldama-Nalda et al., 2012; Xie et al., 2008). So, success for smart city initiatives can be defined as improving city administration to supply the current requirements and wants of citizens and improving their QoL through smart services (Dubbeldeman & Ward, 2015).

Highly digitized structure of cities getting smart, based on huge amounts of digital data and huge number of objects connected to Internet and each other, bring out many challenging issues such as security, privacy, and interoperability. Such challenges not only strengthen the concerns of end-users but also affect negatively the success rate of initiatives aiming to make the cities smarter and improve the QoL (Bestepe & Ozkan, 2019). Since the success of smart city investments highly depends on whether the end-users adopt them in daily activities or not, before any technology enters the market and becomes widespread, the factors, that make it easier for people to adapt it to their daily routines, need to be explored. In fact, researching the adoption of a new technology can provide critical information for the design and production phase of that technology. Since user demand and attitude play an important role today (Hamdi-Kidar & Vellera, 2013), practices to understand the behavior of potential users should be integrated into the development processes of innovation. Unless smart services offered are used appropriately by citizens, it will be very unlikely for smart city initiatives to succeed and achieve objectives. Therefore, factors that affect the people's will to accept IoT- based smart services in urban areas and facilitate continuous use of these services should be explored (Yeh, 2017). In this way, more human-centric smart services can be developed according to the needs of citizens. Better understanding of user behavior by service providers and developers will be beneficial for accelerating the diffusion of technology, as well. So, the adoption of such smart services is a critical matter for the city administration and service providers (Woetzel et al., 2018). This situation has prompted many researchers to analyze the factors that accelerate or hinder the adoption of new technologies. However, despite the size of smart city economy, little work has been done on factors that facilitate the adoption of smart city services, and such urban services based on IoT technology is not analyzed comprehensively in the literature so far (Bestepe & Ozkan, 2019). Based on this point, the current study addresses the user experience of smart city technologies in Turkey's metropolitan areas.

1.3. The Purpose of the Study

This study mainly aims to explore the user motivations with an adoption model developed. The focus of current study is to understand acceptance process of IoT-based technologies offered in cities from the end-user perspective. Here, the researcher developed an original acceptance model to evaluate the factors that motivate city residents to adopt the IoT-based services in urban areas and how usage intention impacts on QoL expectancy. The proposed acceptance model, so-called Smart City Services Acceptance Model (SCSAM), could fill the gap in the technology acceptance literature for the IoT-based smart city services. In that regard, SCSAM examined the major determinants affecting the city residents' usage intention of such technologies offered to increase the life quality in urban areas. With the proposed model, it was also examined whether the demographic characteristics of smart city residents, that is, those who potentially adopt the services offered, cause a difference in their usage intentions.

1.4. The Importance of the Study

Although there are many well-known models and important theories on acceptance, they may not be compatible for every concept. To explain the adoption process for smart city services, when considering the smart city context, which is a multi-dimensional structure, an original adoption model should be developed with appropriate and original factors and relationships between the factors to cover the major aspects of smart cities. Therefore, the SCSAM is built on the human, technology, and institution dimensions of smart city context. Under human dimension, SCSAM has the constructs of personal innovativeness, social influence and perceived cost effecting the usage decision. The perceived trust and its antecedent privacy concerns, and quality of service (QoS) are examined under the institution and technology dimensions of smart city concept, respectively. The main dependent variable of the model is QoL expectancy depending on the citizens' usage intention on such services. The researcher tested developed hypotheses, and thus the proposed model, by structural equation modeling (SEM) carried out after "confirmatory factor analysis" (CFA).

As far as is known, this study is the only research in the literature that comprehensively investigates the acceptance of IoT-based smart city services from end-user's perspective. Therefore, it will significantly contribute to the academic literature. In addition, SCSAM is the only acceptance model in the literature built over the human, technology and institutional dimensions of smart city context, and this originality and being custom fit to smart city concept has improved the model's success in explaining the adoption process of smart city services. The major findings of this study will help local governments and service providers to develop better strategies for smart and sustainable city transformation and prompt them to focus on social, technological, and institutional aspects of smart city initiatives in a holistic manner.

1.5. Research Questions

The two major research questions that the current PhD study tried to answer are listed below:

Research Question 1: Which determinants influence Turkish citizens' usage intention on IoT-based services offered in urban areas?

This research question’s focus is to determine the drivers that influence the acceptance process of such technologies and services, from end users’ perspective.

Research Question 2: Do the demographics have any effect on the usage decision of city residents on IoT-based smart city services?

This research question focuses on whether the demographics of potential adopters cause any difference in their usage intention such services offered.

1.6. Thesis Structure

The current study is organized in the subsequent chapters and the rest of this study is presented as follows: Chapter 2 explains the smart city in detail by giving the dimensions and features of the concept as well as IoT-based smart city applications and main challenges. Chapter 3 gives the results of the systematic review of literature and presents a theoretical background for the research by explaining the construction process of research hypotheses. In Chapter 4, research method is explained. Chapter 5 reveals the empirical results of analyses. Finally, in Chapter 6, main results are discussed, and conclusions are given, for practitioners and researchers studying on smart cities.

1.7. Chapter Summary

Initially, this first chapter of the study provided some introductory and general knowledge about thesis scope. After the purpose of the study was given, the gap in the literature that this thesis would fill were defined. Author also mentioned how the findings could help the city administrations and technology companies, that think to invest smart cities in Turkey or even in the world. Finally, after having explained the limitations of the study, the overall structure of the thesis was given.

CHAPTER 2

CONCEPT OF SMART CITY

2.1. Chapter Overview

Second chapter starts with definitions of smart city referenced from different sources and some samples of smart city solutions commonly used in smart cities all over the world. Then, in fourth part, author outlines how smart cities emerged and why smart city concept is needed. After describing three dimensions of smart city, six main characteristics of this concept are explained in detail. This chapter ends with the explanation of IoT-based technologies offered in urban areas, in the seventh part and, primary challenges relevant to the cities that are getting smarter, in the eighth part.

2.2. Definition

According to the United Nations (UN), almost 60% of the world's population lives in urban areas, and authorities expect that this rate will likely approach 70% in the next 30 years (United Nations, 2019). Another figure that makes this situation even more dramatic is that urban areas make up only 2 percent of the world's land (United Nations, 2019). As a result of this situation, cities that produce more than 60% of greenhouse gas emissions also consume about 78% of the world's energy, again according to the UN. Therefore, this situation stands as a real risk to the nations of the world and makes result-oriented initiatives for a solution inevitable. At this point, in our world where resources are increasingly scarce, cities see technology and advanced networks as a solution to better manage these scarce resources. In fact, the emergence of the smart cities is largely related to this orientation. The results of a study conducted by Emarketer.com in 2019, given in Figure 1, reveal that approximately 65% of US internet users somehow are willing to live in smarter cities. Considering that this concept is still immature, it will not be surprising that the rate of tendency living in a smart city might increase in the future. This increase in population and urbanization rate and scarce resources will increase the tendency towards smart cities more and more. Smart city solutions use mostly IoT-based devices such as connected sensors, cameras, and meters to collect and analyze data and use this data to increase the life quality by improving infrastructure, public services and more.

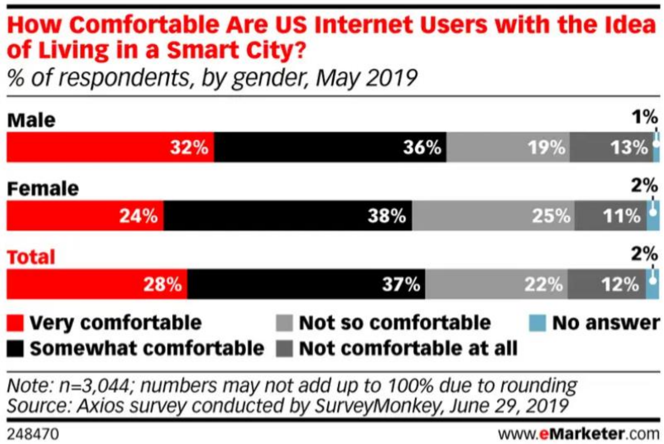


Figure 1: Rate of US Internet users who are friendly to living in smart cities

So, what entirely is meant by smart city? There is still no universally accepted definition of smart cities, which is a very broad concept and has unclear boundaries. The concept is popularly known, but since it is used in different shapes and conditions all over the world, it is possible to come across a wide variety of smart city definitions. Here are some of them:

- **Smart Cities Council**: "A smart city is one that has digital technology embedded across all city functions."

- **IEEE Smart Cities**: "A smart city brings together technology, government and society to enable the following characteristics: smart cities, a smart economy, smart mobility, a smart environment, smart people, smart living, smart governance."

- **European Commission**: "A smart city is a place where traditional networks and services are made more efficient with the use of digital and telecommunication technologies for the benefit of its inhabitants and business. A smart city goes beyond the use of information and communication technologies (ICT) for better resource use and less emissions. It means smarter urban transport networks, upgraded water supply and waste disposal facilities and more efficient ways to light and heat buildings. It also means a more interactive and responsive city administration, safer public spaces and meeting the needs of an ageing population."

- **British Government**: "The concept is not static, there is no absolute definition of a smart city, no end point, but rather a process, or series of steps, by which cities become more livable and resilient and, hence, able to respond quicker to new challenges."

- **Business Dictionary**: “A developed urban area that creates sustainable economic development and high quality of life by excelling in multiple key areas; economy, mobility, environment, people, living, and government. Excelling in these key areas can be done so through strong human capital, social capital, and/or ICT infrastructure.”

Technology is the most common word of all smart city definitions, but simply equipping a city with technological devices and networking capabilities is not enough to make it smart (Neirotti et al., 2014). Smart cities should not be thought of as a concept consisting of technology only, as it will be explained in the following sections, it is a very large and multidimensional context.

2.3. Some Examples of Smart Services

Smart city solutions aim to make daily life easier and safer by eliminating issues about the traffic and the environment and ensuring the safety of city residents and their goods. Some smart city solutions are briefly described below:

Smart cards: Smart cards have a strategic importance as they are one of the most effective tools for citizens to access smart city services. City residents welcome the idea of combining all services as much as possible and offering them on a single card (Belanche-Gracia et al., 2015). Citizens, who can effectively benefit from many public services with a single smart card, have a great comfort in daily city life. In addition, the collection and processing of smart card data in accordance with privacy principles can provide very valuable contributions to city administrations. In short, smart cards not only make city life better for residents and visitors, but also provide valuable information for improving services.

Smart transportation: As the number of vehicles connected to each other and to the Internet in traffic, especially in public transportation, is increased, the benefits of these smart transportation systems have started to be noticed. It is obvious that the increase in the interaction of vehicles with users and the instant evaluation of location data and shortening the travel time and/or route and thus making the journey more comfortable and enjoyable will increase the adoption rate of smart transportation solutions.

Smart meters: Smart meters are a very good example of smart city applications because they are IoT-based and a complete public service. These smart meters installed in buildings and facilities, together with the smart networks they are connected to, allow service providers to effectively manage the energy flow according to instant data. On the other hand, it makes it easier for subscribers to effectively track their own consumption and thus save energy.

Smart grids: To conserve resources and save energy, just smart meters will not be enough, smart grids are also needed. For example, in a smart city, households can contribute to energy production thanks to household energy storage units and solar panels.

In this way, the energy produced during the hours when the demand is not intense can be stored and used during the peak hours or sold to the smart grid. Thus, it can be ensured that both the subscriber saves money, and the energy grid effectively manages the peak demand times.

Waste management: Increasing urbanization has made waste management one of the biggest problems of local governments. Disposing of waste with traditional methods is both costly and inefficient. However, garbage bins equipped with sensors could enable the instantaneous amount of garbage to be monitored and service providers with this knowledge to collect and dispose of garbage in the most optimal way. In fact, the level of smartness of the garbage cans can be at a level that can provide information about the amount of waste available for recycling in the content of the garbage. This type of smart city solutions can help efficiently plan the recycling process of garbage, thereby saving scarce resources.

Air quality monitoring: Air pollution, which has become one of the most important problems of cities, or low air quality, is very important because it directly affects health and QoL. Citizens can be exposed to dust, dirt and even chemicals in the air at home, at work and outside, in short, at any time of the day. Since this may cause serious risks especially for children, the elderly and patients, air quality monitoring is a necessity. It is possible to detect all kinds of harmful substances, reducing the air quality, contained in the air, and to present them as instant information with smart solutions. By sending this information to an indicator in the environment or to smart devices (phone, tablet, etc.) of the people, the damages of the unsafe levels of air quality can be reduced.

2.4. How Smart City Concept Emerged

The Internet continues to change the way people and even objects communicate and share information, around the world. Although internet access opportunities and infrastructures differ regionally, in many parts of the world, the digital population is increasing significantly. As a result, the Internet is increasingly becoming an essential element of daily life. While the number of internet users worldwide was 4.13 billion in 2019, this figure reached 4.66 billion in 2020 (J. Johnson, 2021). These data show us that more than half of the world's population has access to internet connection. Similarly, the number of mobile users has been increasing rapidly, too. The number of people using mobile devices, which reached 6.95 billion worldwide in 2020, is estimated to reach 7.41 billion by 2024 (O’Dea, 2020). With the upgrade of mobile communications to 5G, humanity will experience a much faster and smoother communication infrastructure that will deeply affect almost all practices in daily life.

With the decrease in ICT costs as well as high-speed Internet and other technological developments, the use of low-power sensors and IoT devices has become widespread, and this has reshaped the daily life routines in urban areas (Lea, 2017). When 5G comes into our lives, a much denser network will surround cities, with huge number of IoT devices equipped with 5G antennas that require less power, and smaller 5G base stations located at shorter ranges and operating at higher frequencies. This network infrastructure will make it possible to transfer data from billions of devices up to 20 times faster than 4G, with almost no latency. In this way, transferring huge amounts of data from almost any industry such as banking, healthcare, public sector, etc. in real time will be much easier, and this much data received from millions of low-power sensors and IoT devices will become rapidly available to be processed. This might increase the ability of local governments to intelligently manage problems such as traffic congestion, air pollution, power consumption, and more.

As urbanization increases, it becomes a necessity for our cities to become smarter and acquire new capabilities. Politicians, city managers, even scientists should find new ways to manage complexity, increase productivity, and improve life quality by reducing the costs to overcome adverse effects of rapid urbanization. The ability of cities to provide the instantaneous data about traffic, environmental pollution, parking lots, usage of natural resources and power, to residents, visitors and all other stakeholders can significantly contribute to improving the economic and environmental condition of the city. In smart cities where mobile applications, low power sensors and IoT devices are used together with fast enough Internet, local governments will be able to provide services much more effectively, economically, and efficiently.

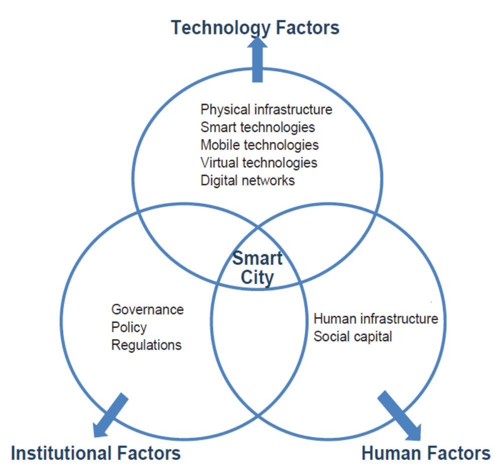
A smart city can minimize the unfavorable effects of urbanization on daily life, the environment, and the economy. As more and more people realize the advantages that a smart city can provide and its effects on city life, the diffusion of smart cities is getting increased in both developed and developing countries. The Worldwide Smart City Spending Guide, published by International Data Corporation (IDC), estimates that, in 2020, around $130 billion could be spent on smart city projects, up one-fifth from 2019. While these smart city initiatives aim for a more enjoyable, healthy, and quality living environment in cities, they also support the cities to be more resilient and environmentally friendly with a sustainable economic growth.

Life on earth faces many changes, and accordingly risks and challenges due to the increased urbanization, industrialization, and globalization. Some of these challenges could be handled more efficiently with the help of more feasible solutions provided under smart city context. Climate change is one of the most critical threats causing possible irreversible effects on human life over the world. Although the two-way relationship between them requires more research, urbanization and global warming are largely interrelated (Simon, 2007). Effects of climate change are prominent in most parts that are crucial to the community, such as healthcare, farming, food safety, supply of clean water and energy, transportation, and so on. Also, it is most probably that these risk will be more devastating effect in near future, due to the extreme atmospheric conditions and huge forest fires, increased air pollution, and contagious disease spreading via insects, vermin, food, and supplies (Reidmiller et al., 2018). The main objective that smart city initiatives want to achieve is to make the cities more resilient and sustainable, and this aim, which directly relates to global warming, mostly refers how to develop better solutions to reduce the effects of climate change in cities, consequently in the world.

With economic progress and rapid growth of urban population, resources are consumed much faster and therefore the depleted resources make the life more difficult by reducing people's purchasing power. This situation can be better managed with the more efficient daily life practices offered by smart cities, by using resources more efficiently, by reducing waste and by recycling wastes to the economy more effectively. Some other problems caused by increased world and urban population are suburbs, polluted air and water, shortages of energy and water, heavy traffic, insufficient wastewater and drainage treatment capacity and insufficient disposal capacity for trash produced by urban areas and industrial plants. Inversely, the countries with lower birthrates and facing the problem of aging populations need to provide more feasible mobility options in urban life for older residents. All these problems indicate how crucial smart cities for the life quality and solution of population-based problems in urban.

2.5. The Dimensions of Smart City

In reality, equipping a city with technology is not enough to make the city capable of fixing tough problems caused by urbanization (Neirotti et al., 2014). Along with technology, human and institution dimensions should be studied carefully. While the sociability, creativity, diversity, and education of people are relevant to human dimension, infrastructures of hardware and software constitute the technology dimension, and administration, governance and policy matters constitute the institution dimension as illustrated in Figure 2 (Nam & Pardo, 2011).



Source: (Nam & Pardo, 2011)

Figure 2: Three main pillars of smart city concept

Considering the three dimensions of the smart city concept, it can be said that in order for a city to be smart, it should spend money on human capital as well as technological substructure in a way that stimulate sustainable development while increasing the quality of life (Caragliu et al., 2011).

2.5.1. Technology Dimension

From the perspective of technology, there are similar terms used instead of smart city in the literature such as digital city, smart city, virtual city, hybrid city and ubiquitous city. Many innovative developments such as cloud-based technologies, mobile communication and big data have contributed to the emergence of smart cities. But the main driving force of smart cities is the IoT technology supported by low-power wireless sensors. From this perspective, technology might seem to be the key dimension to make a city smarter and significantly transform daily life in urban areas. However, technology alone will never be enough to create a smart city. Technology for smart city may be a prerequisite, but, a complete smart city cannot be achieved without especially the adaptation of citizens, and the participation, cooperation and desire of public sector, private companies, non-profit organizations and even universities (Nam & Pardo, 2011). The smart city, according to Washburn et al., is the composition of smart computing solutions implemented on critical equipment and applications; and they define the smart computing as the integrated solution based on hardware, software, and communication devices in order for providing instant data used in people's decision making processes (Washburn & Sindhu, 2010). Technological dimension of smart city concept mainly includes network devices (fiber optic or wireless connection equipment), service points (kiosks or similar smart devices), and service-based information technologies. A smart city is also expected to provide interoperable and Internet-based e-government services, to enable connectivity from anywhere for citizens and businesses (Anthopoulos & Fitsilis, 2010).

2.5.2. Human Dimension

Technology alone is not enough to make a city smart, as mentioned several times so far. Smart city initiatives are expected to strengthen the connection between all stakeholders of city life (governmental services, businesses, visitors and citizens), help build collective skills and capacities, and offer specific services that facilitate cities to achieve their goals (Nam & Pardo, 2011). That is why any smart city initiative that does not consider the human dimension and not address the city residents appropriately is incomplete and risky to be successful. Most of the smart solutions are ultimately for either human use or human benefit. Therefore, the human dimension should be appropriately evaluated and developed along with technology in smart city concept. Smart people refers to the city residents who are the main element of social capital and the focal point of city life, with high awareness and creativity, participatory, able to establish quality social relations with their environment, learning lifelong, and integrating information technologies into their lives (Meijer & Bolívar, 2016). Apart from these, it is possible to associate the concept of smart people with communal and racial plurality, elasticity, multinationality, freedom of thought and attendance actively in public living (Nam & Pardo, 2011). Collective intelligence and social learning are also among the most important smart human features (Coe et al., 2001).

2.5.3. Institution Dimension

Support from government and policy provides the basis for the design and implementation of smart city initiatives. However, institutional factors are not limited to supportive policies, the government's position should improve the relation between public bodies and all other stakeholders. Always seen as a critical element of smart cities in almost all frameworks, smart governance should deliver more than regulation. A well-established administrative environment is not only a critical requirement, but also a supportive factor for all other smart city elements (Yigitcanlar & Velibeyoglu, 2008). An appropriate and supportive administrative environment is crucial for the success of smart city ventures and requires transparent and joint administration, activities supporting strategic management as well as participatory, social, and collaborative approach under the organizational dimension (Odendaal, 2003). Real-time dynamic connectivity between residents, groups and business world is also critical to driving development, change, and improvement in the smart city. Smarter governments integrate service delivery, establish bureaus supporting many services, and deliver mostly required operations from web-based applications. In fact, smart government basically refers to offering services and operations by putting people at the center.

Since removing legal and regulatory barriers is important, the proper existence of institutional components can be considered as prerequisite for the success of smart city initiatives. In addition, e-governance is one of the keys to a smarter city goal, as it is citizen-oriented at its core. Citizen-driven approach in e-government applications facilitates the participation of citizens in the processes and makes decision and implementation processes transparent (Paskaleva, 2009).

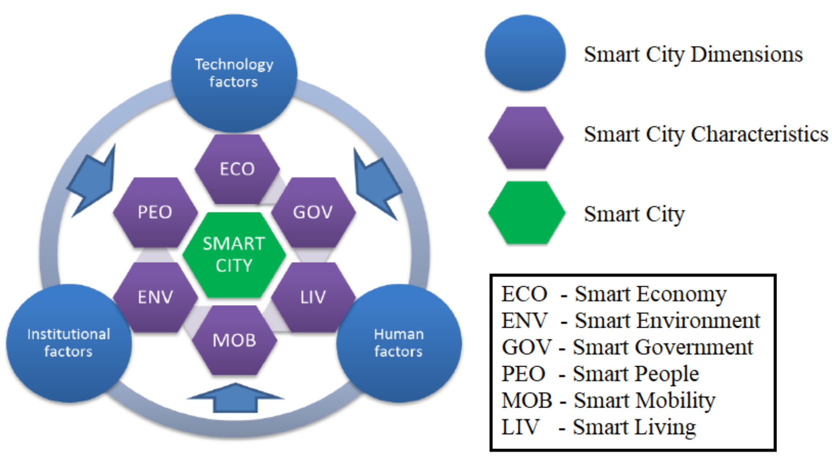
In short, a good harmony between all dimensions, technology, institution, and human should be ensured for the success of the initiatives. A smart city initiative can be implemented in some way, but active and efficient participation of all stakeholders is essential for success.

2.6. Smart City Characteristics

European Smart Cities Research Group working on the issue of smart cities in Vienna University of Technology, developed the European Smart City Model in cooperation with different partners from public and private sectors. This model is presented in a report published by the Directorate General for Internal Policies of European Parliament (Manville et al., 2014). This report provides some background information and advice on smart cities in Europe as well as explain the existing mechanisms towards improved life quality of city residents. Additionally, six smart city characteristics were defined in this report, as listed below:

- “Smart Governance”
- “Smart Economy”
- “Smart Mobility”
- “Smart Environment”
- “Smart People”
- “Smart Living”

These characteristics provide a strong baseline to evaluate current condition of smart cities. These six features, which can be considered as 6 key strategic areas where local governments need to act to become a smart city, have connection between 3 dimensions of smart city as shown in Figure 3. Each characteristic is relevant to some components that smart city initiatives should cover. For example, a smart city initiative based on smart governance should contain some components under smart city dimensions towards transparency, accountability, collaboration, and participatory approach in order to involve all stakeholders and ensure the citizens' participation properly.



Source: Mapping Smart cities in the EU (Manville et al., 2014)

Figure 3: Relation between Smart City dimensions and characteristics

The goal of becoming a smart city requires a holistic approach, a strategy and action plan that covers all six indicators. For a smart city initiative, understanding the linkages between smart city dimensions and characteristics, and configuring the project over this structure is quite critical to achieve the pre-defined objectives. Smart city transformation can be facilitated with the smart cooperation of all relevant stakeholders from the local administration, non-public companies, and universities, especially the citizens, that is, residents of the city. Concrete and smart solutions that will be put forward by creating different sub-categories under these six main headings will become the main drivers pushing the cities forward in the way of getting smarter. It is only possible to transform the smart city concept into a collective benefit only by creating added value and people-centered approaches.

As always stated, although the term "smart" refers to technology, it is not possible for smart city strategies to be confined to pure technology. Actually, smartness means methodological smartness as much as technology and applying useful and effective solutions correctly. To overcome city life challenges and seize development opportunities, appropriate solutions must be created, adapted, or replicated in the different categories under these six smart city characteristics. Therefore, considering the needs of all actors, especially citizens, is crucial to the smart city goal.

2.6.1. Smart People

The smartness of a city is related to how much it improves the lives of its citizens with that technology rather than the amount of technology it uses. The rapid development in technologies such as sensor technologies, big data, broadband internet, cloud computing and artificial intelligence has accelerated the transformation of living spaces into smart cities. However, most of the time, amid this technology intensity, the most important element of any city, the citizens themselves, are not taken into consideration as much as necessary. Of course, primary aim of technologies utilized in smarter cities is to advance the life quality, but only improving environment with technology without improving people will not get us to the goal. Smart people, in an inclusive society that enables creativity and encourages innovation, are the individuals who can use technology effectively in business and daily life, and have the necessary e-skills (Manville et al., 2014).

2.6.2. Smart Government

The smart city is not a simple concept and an easily accessible goal, but the result of the efforts of many stakeholders who need to work together towards a common goal. Among these stakeholders, government is an important factor that can combine many roles. City governments must determine the right strategies and make informed choices to solve the challenges posed by rapid urbanization and increasing urban population in the most effective way. The smart government should set a clear direction in line with the smart city goal and put forward the smart city vision. Creating laws and regulations to preserve the benefits of city residents while cities are transforming into smarter living areas is also considered under the smart government component. A local government that enables companies and start-ups that can produce smart solutions to emerge and develop, that facilitates new ventures and that shares data is very important to achieve the smart city target (Dubbeldeman & Ward, 2015).

2.6.3. Smart Environment

Climate change is a serious problem threatening humanity, and one of the factors affecting the growth of this problem is urbans. As mentioned previously, urban areas make up almost 2 percent of the world's land (United Nations, 2019). However, according to the UN, almost 60% of the world's population lives in urban areas, and one expect that this rate will likely approach 70% in the next 30 years (United Nations, 2019). As a result of this situation, cities, that produce almost two third of greenhouse gas emissions, use up almost 80% of the energy on the world, as well, again according to the data of UN. So, it is possible to talk about many negative effects of urbanization on the environment such as the destruction of the natural environment, high energy consumption, harmful emissions released into the atmosphere and large amounts of waste.

Even worse, these numbers are expected to continue to increase in the coming years as cities grow. Due to the risks posed by this trend, protecting the basic elements of our environment is very important in terms of human health and therefore QoL, one of the most important goals of smart cities. An environment in which clean air can be breathable, provided healthy source of drinking water, and the harmful effects of waste and noise are reduced, is a pre-condition for the welfare in urban areas (Aletà et al., 2017). Under the smart environment component, smart city initiatives aimed at solving existing or potential environmental problems, coordinating the relationship between human and environment and ensuring a sustainable economic and social development should be supported and implemented (Manville et al., 2014).

2.6.4. Smart Living

In a real smart city, the smart life concept aims to improve the daily lives of residents with technology-supported solutions. The solutions providing a smarter living can cover technologies and services that help citizens monitor their health, improve energy use, stay connected with their homes, and receive customized services. New approaches to data processing and smart living enable citizens to make better choices in their own lives. The smart life concept clearly takes its place in life with smart homes. A smart home resident can connect to his home via portable equipment such as mobile phones, notebooks, and tablets, and can monitor and control the usage, safety, and efficiency of any equipment in the home in real time. In this way, lights, heating, television, and other everyday appliances can be operated remotely and relevant areas of the house can be monitored for security. Sensor-equipped smart homes also provide a quality home care environment, especially for elderly citizens, allowing them to feel safe and protect their independence. Additionally, with smart home systems, behavioral conditions of people such as eating, sleeping or moving, as well as physical indicators of breathing and heart rate can be monitored instantly, analyzed and the symptoms of the problem can be reported to the concerned (caregivers, doctors, etc.) (Deloitte, 2017).

2.6.5. *Smart Economy*

The fact that urbanization and economic development are interrelated and that urban areas are seen as the driving force of economic development have caused central and local governments to see urbanization as a development tool. The creation of smart economies should be seen as a natural outcome of smart cities pushed by technological development and assisted by academia, focusing on science, industry, business, cultural heritage, architecture, and planning. In smart economies under the smart city concept, creativity is valued, and new ideas are welcomed. In this way, it offers a variety of economic opportunities to its citizens by providing a balanced and sustainable economic growth. By this means, smart cities with smart economies can also attract quality labor force that can increase its prosperity. A resourceful and highly productive urban having a strong and smart economy component could also become ready more rapidly to manage risks and benefit from opportunities coming with the globalized economies (Vinod Kumar & Dahiya, 2017).

2.6.6. *Smart Mobility*

When looking at a city from above, nothing but a world in motion will be seen, and this mobility is indispensable for cities. Because the provision of goods and services, which are the basis of economic life, is provided by this mobility. However, this dynamic world also reveals annoying consequences such as noise, pollution, and traffic congestion. Although mobility is necessary and important for people, safe, quality, and affordable transportation is often not possible in cities. Under the mobility component, it is indispensable for smart cities to shorten travel times, increase availability and accessibility, and provide quality and safe transportation with innovative smart city solutions. The prediction that, smart city residents and visitors will soon be able to benefit from multimodal, affordable, and multiple mobility options is extremely rational. In addition, it seems highly likely that under the smart city concept, having traditional cars will be replaced by shared electric and autonomous vehicles, as well (Hannon et al., 2016).

2.7. IoT-Based Smart City

IoT, is a technology in which objects, especially devices used in daily routines, equipped with microprocessors, transmitters and receivers enabling them to speak with each other and with people (Atzori et al., 2010). 1999 is the year when the term IoT was first heard by people. Kevin Ashton used IoT term for the first time in a presentation of his work on sensors. Although the concept of IoT first emerged in 1999 and the Internet towards the 1970s, the existence of devices in communication with each other dates back to the invention of the electromagnetic telegraph, that is, in the 1830s. The first device that could be called IoT was a design by several Carnegie Melon University students in the 1980s that allowed a campus vending machine to report current product status via a network (Scammells, 2020). A toaster, a small household appliance, was connected to the Internet by John Romkey in 1990. One year after that, in 1991, several academics from the British Cambridge University set up a camera system to monitor the coffee machine. This coffee monitoring system was designed to send the coffee machine image to a computer screen three times a minute. These early examples are considered as the first IoT trials that managed to transact online with an approach that was ahead of their time. Later, in 2000, the first refrigerator in the world accessible over internet was introduced by LG Electronics. It had the capability to make online and automatic food purchase possible. The first international conference in the IoT field was held in Switzerland in 2008. And today there are thought to be almost 30 billion devices with Internet connection, and that number is expected to exceed 100 billion by 2030 (Scammells, 2020).

IoT, as a disruptive technology, has begun to change routines in many areas such as healthcare, manufacturing, automation, transportation, and communications, as expected, and its prevalence is rapidly increasing in applications such as smart recognition, positioning, tracking, monitoring and management. There are also many researches and studies on the use of IoT solutions in areas such as sensor based control, networking, and analytics of big data. But smart city is the main application area that IoT could emerge, with the help of some other technologies such as cloud computing, big data, and mobile communication. Considering what it can offer, it is not difficult to understand why IoT technology is the major technology stimulating the smart cities. IoT-based integrated solutions have tangible capabilities and great potential, to make the cities smarter and a community life more sustainable. A smart solution that can connect life and people with devices in homes, vehicles, streets, and many public places can provide many opportunities for both citizens and administrators and increase the life quality considerably in urban areas, as illustrated in Figure 4. One can see these services as such:

- Smart houses with almost all functions of which can be controlled by a device with Internet connection.
- Smart parking systems giving you an idea about where you can park your car before leaving home or work.
- Smart surveillance systems where you can see instantaneous environmental condition or weather condition at any point.
- Smart traffic systems where you can learn the vehicle traffic for a location or a specific route.
- Smart energy systems and smart grids that will enable you to increase energy efficiency.

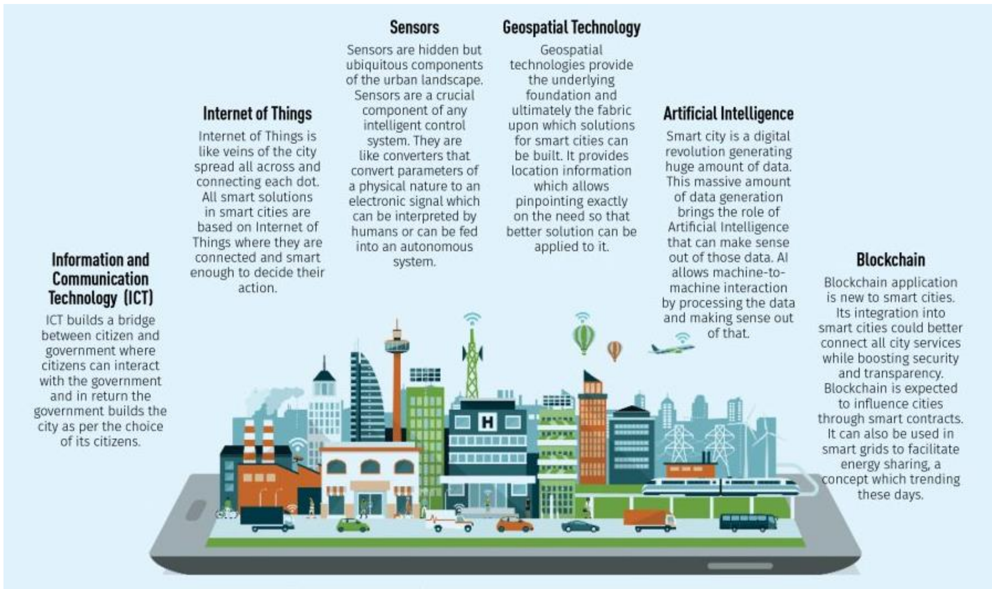
Source: (Talha, 2019)

Figure 4: IoT-enabled smart city services

If the smart city concept will continue to develop and grow, it will be thanks to IoT technology that can connect all objects, including people. With these and more IoT can offer, it will continue to be the main driving force of the smart city concept together with the low-power wireless sensors. The coexistence of smart city and IoT has the potential to increase life quality by radically changing the way local governments do their business. However, in order to carry out this transformation more effectively and efficiently, the change should be planned strategically and the challenges brought by this change should be managed properly (Muratore, 2019).

2.8. Challenges of Smart Cities

Smart city projects such as smart lighting, smart transportation systems and smart metering (for water and natural gas), aim to provide cost-effective and innovative solutions to the challenges faced by municipalities. Such smart city solutions are based on sensor-centric data collection and data analysis and include many new technologies as shown in Figure 5. The cumulative effect of using such new technologies and innovations together will be even stronger, both positively and negatively. The benefits provided by smart city concept bring many challenges, as well. These challenges, explained below, make it difficult for the smart city concept to become widespread and for end users to safely access smart city services.



Source: (Choudhary, 2018)

Figure 5: Some technologies used for making a city smart

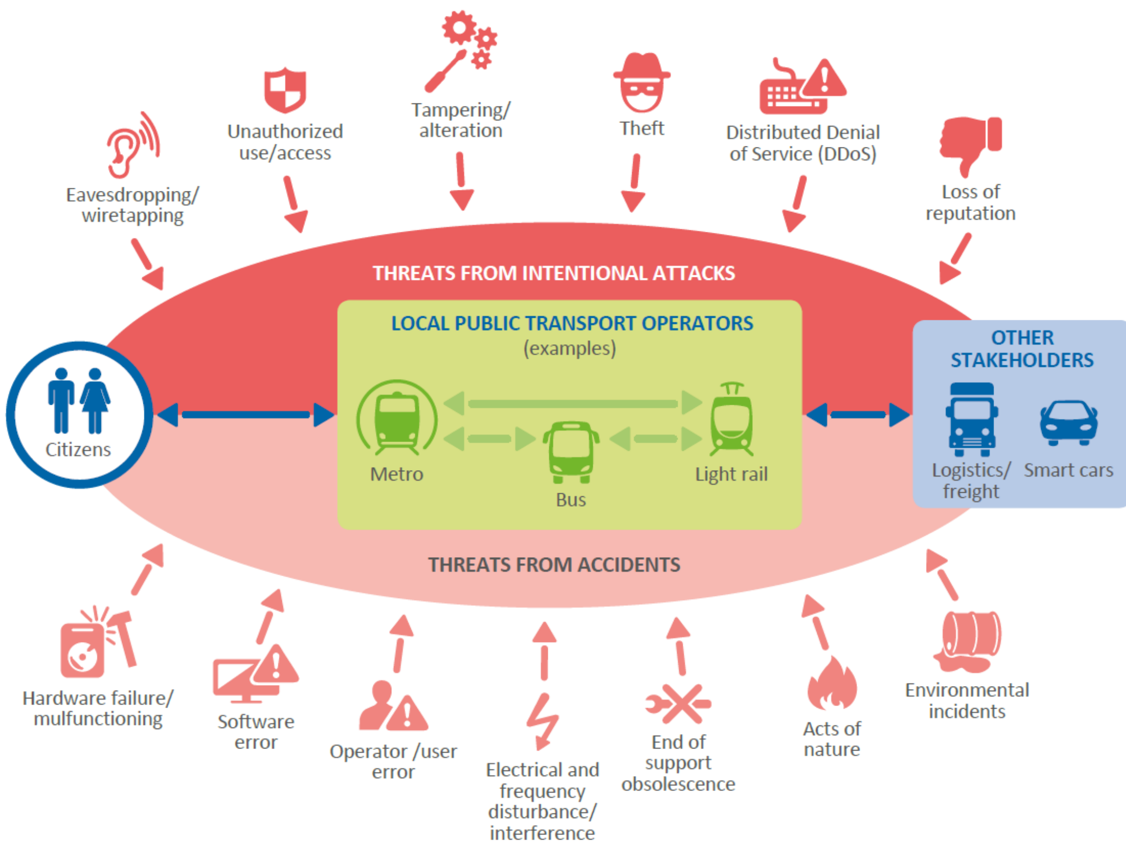
Infrastructure: In terms of smart cities, technologies such as IoT, artificial intelligence, deep learning and big data are technological capabilities that need to be developed and integrated into more applications on smart city. Many smart city applications use sensor technology to collect information and provide services. Sensors collect data on everything from traffic density to crime rates, parking capacity to air quality. These sensors are often costly to install and maintain. In addition, the result is an infrastructure that gets more complex day by day. Where and how will these sensors and other necessary equipment be mounted? How will their energies be provided? Would it be more feasible to connect to the grid or to use solar energy or batteries? Or what to do in case of a power outage? The most accurate answers to these questions should be found and the system life cycle should be carried out in the most feasible way.

All cities have existing infrastructure for communication, energy, water, and transportation systems and modifying decades of infrastructure in urban areas is a challenge in itself. Although broadband wireless service has become widespread in major cities, there are still areas where access is limited. Because such activities aimed at developing technological capacity and renovating the infrastructure are costly in terms of both financial and labor force. At this point, it would be wise for developers and technology companies to turn to hardware that is easy to install and operate to make smart cities progress with more solid steps. It can accelerate smart city adaptation if universities, entrepreneurs, and industry partners carry out some research and development studies on new technologies with plans focused on the smart city concept. On the other hand, the technological development needs the presence of qualified human resources who have developed their skills in these technologies and decision-making processes. The existence of a very robust and state-of-the-art surveillance system can be meaningful by the presence of a human resource that can use the data provided by the system to make smart decisions on time. Another approach may be to ensure that some of the decisions are made by artificial intelligence applications and to include the human factor in the process only at very critical points. In any case, it is necessary to have the appropriate technological infrastructure together with sufficient human resources.

Digital Security: The main challenging issues about smart cities are generally characterized by highly digitized structure of IoT-based services, huge data volume stored in digital environments and huge number of devices and objects interconnected each other and connected to the Internet (Dubbeldeman & Ward, 2015). By this means, security and privacy appear as the major barriers in front of the pervasive usage of such technologies by end users. Destroying a city in traditional ways can be quite difficult, but a smart city can easily be overturned by an effective cyberattack. As the world becomes more connected day by day, the importance of cyber risks increases proportionally. Therefore, smart cities must be ready for such attacks.

The information technology infrastructure of cities, which are the backbones of modern civilization, is different from other organizations. The government, local administration, and private sector all must work together to ensure the proper functioning of the city as a whole. Because, all city residents, government offices and businesses can be victims of cyber attackers who exploit the security vulnerabilities of smart cities. The cyber threats shown in Figure 6 are mostly related to smart transportation systems, but these threats are more or less applicable to most services in smart cities. If these increasing risks are not managed well and necessary precautions are not taken against threats, then smart buildings, facilities and systems of public institutions, highways, and road networks, in short, all services operating on technological infrastructure may stop.

Smart city systems and infrastructures should be designed, installed, operated, and terminated in accordance with security principles and considering the cyber risks at every stage from design to termination, with a system development lifecycle approach. Many things might be done very well from security point of view for the smart city management. For example, a multilateral and inclusive security management system may be established, managerial and operational roles and responsibilities properly shared, financial, and human resources adequately planned, and many more things done right. However, smart cities still have an extremely complex infrastructure, many unexplored vulnerabilities and extremely large attack surface. Therefore, digital security for smart cities must always be at the top of the agenda.



Source: Cyber security for Smart Cities, ENISA, December 2015

Figure 6: Cyber threats associated with smart city transportation systems

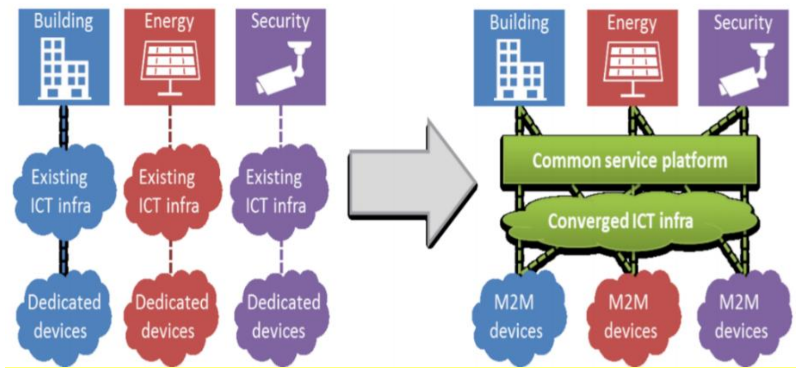
Legislation and Policies: Although the smart city concept is very popular recent times and everyone encounters many smart applications in cities, it is difficult to say that it has still reached a sufficient level of adoption. The still inadequate regulatory frameworks for smart cities could be an important cause of the low diffusion and acceptance level. Ensuring national and international standardization and establishing the necessary legislation is vital because systems that are not designed in accordance with a specific standard or framework may become inoperable with new technologies due to rapidly developing and changing conditions. The overall success of the smart city concept depends on the harmony and coordination of many different systems working together, in short, on the principle of interoperability. Otherwise high-cost investments that are realized with the aim of creating smart cities may turn into waste and problem due to the lack of standardization and regulation (Weber & Zarko, 2019).

Large amounts of data must flow seamlessly for smart cities to function. However, those who collect this large amount of data will have an important responsibility to protect this data and use it appropriately. What data will be collected, how it will be used, stored, and shared should be regulated by laws, regulations, and instructions. Data-driven innovation mostly contradicts with personal privacy, and this is a familiar challenge of the information age we are in. In the simplest form, smart parking systems or surveillance cameras must collect a lot of personal data of citizens for smart cities to operate. Protecting privacy under these conditions is a really challenging responsibility. Smart cities must have laws and regulations that determine how cyber security is provided and how citizens' privacy will be protected. The data of city residents should be secured with these laws, and the citizens' trust in smart city services should be ensured with the necessary IT, system and compliance audits (Sears, 2019).

Funding and Business Models: Finding investors to finance smart city projects is not always easy. Therefore, business models to attract financiers need to be put forward and limited budgets of cities need to be supported. Technology risk is one of the main obstacles that make it difficult to finance smart city projects. A project in which a particular technology is used for the first time may reduce investor confidence as it carries risks in terms of integration and usability. It can also be difficult to get funding for a smart city project where it is difficult to generate financial returns from the project. A comprehensive strategic plan that focuses on the strengths of a smart city project and reveals its investment suitability can contribute to addressing such challenges. In addition, the fact that strategic planning includes a solid business model and has a creative approach to financing resources can make the project attractive for investors.

It is also very important to choose the most suitable one for the project among different financing options for smart city investments. To determine the most effective way to fund an initiative for smart cities, one should anticipate possible cash flows, who will use the service, and who will bear the associated risks, as well as financing options. Oftentimes, the public sector pays for the installation and operation of the service to gain savings or higher efficiency. Sometimes the revenues to support a smart city project can come from selling the generated value to other third parties. The four most effective digital revenue models to date are; using advertising revenue, selling data, "all you can eat" subscription or pay-as-you-go user charges, and all these option could be used for the business model of smart city initiatives (Skowron & Flyn, 2018). Funding smart city initiatives, providing exciting new opportunities for governments, citizens, and businesses, can be a difficult and complex process. To manage this challenge well and increase the probability of success of smart city initiatives; a good understanding of all possible options, a good analysis of the advantages and disadvantages of each; and determination of strategies that best suit the current situation are needed.

Interoperability: Smart city services require complex infrastructures by their nature, where many different equipment and applications are used together, so interoperability is a major challenge for urban innovation. The fact that many IoT-based equipment supplied from different manufacturers are used independently in different smart city applications and the lack of any interoperability principles for this equipment is an important risk that will reduce the expected benefit from smart city applications. In an ideal smart city environment, applications should work together in a seamless and integrated manner, and data should be shared seamlessly at any level of the urban infrastructure, is illustrated in Figure 7. For example, to reduce traffic congestion, all data from public transport vehicles, smart parking lots and smart cameras need to be synchronized and evaluated together. So, one could define interoperability for smart cities as having a single standards-based network, independent from vendors and technologies, to manage and control the vast number of urban applications, such as street lighting, public parking spaces, electricity distribution system, solid waste collection, video surveillance, emergency support services, and much more (Minetti, 2019). In other words, a supplier's smart lighting system should not only work with bulbs from the same supplier. However, many smart solutions using IoT devices work with cloud infrastructure, mostly controlled by specific vendors, and communication is also based on proprietary protocols. This lack of interoperability provides very limited capabilities for third parties and severely limits market growth and technology diffusion (Ahlgren et al., 2016). In addition, dependence on specific vendors' services may result in dysfunction of the device and system if that particular service is temporarily or permanently unavailable for any reason.



Source: Telecom Regulatory Authority of India

Figure 7: Convenience provided by interoperability

Lack of Confidence or Reluctance Shown by Citizens: As always stated, smart city does not mean an urban area equipped with advanced technological device only, it is a living area where the smarter ways of doing daily routines are offered to citizens. People can become smart citizens of smart cities when the use of technology enables more efficient and effective use of available resources and time. While many studies of smart cities focus on technological equipment used and funds invested, they can ignore the direct or indirect effects of these technologies on the lives and behavior of citizens (Woetzel & Kuznetsova, 2018). Smart solutions offered in smart cities are very important for citizens and city administration as they have the potential to save time, energy, and cost, but understanding what affects an individual's choice to use or not use these smart solutions is just as important as the technology used and the money invested. Because the citizens living in the urban areas are the direct users of smart city services, and the success of the investments made to improve the living environment, increase the quality of life, and make the city smarter directly depends on citizens' decision to adopt these new and smart services. So, the acceptance of such services and technologies is a critical matter for urban administration and has a great importance for the success of smart city concepts. In this regard, citizens' opinions and perspectives should be considered when planning, implementing, and managing smart city services. QoS, complexity, extra costs and operational issues are some of the problems negatively affecting the end users' intention to use smart services.

2.9. Chapter Summary

This chapter started with the smart city definitions proposed different organizations such as Smart City Council, IEEE, and European Commission. After giving some samples of smart city solutions commonly used in smart cities all over the world, author outlined how smart cities emerged and why smart city concept is needed, in fourth part. Three dimensions and six main characteristics of smart city concept were explained in detail, in fifth and sixth parts, respectively. Then the author explained the IoT-based smart city concept in seventh part. Finally, this chapter ended with the description of primary challenges of smart cities.

CHAPTER 3

LITERATURE REVIEW AND THEORETICAL MODEL

3.1. Chapter Overview

This chapter starts with explanation of the strategy applied during the systematic literature review and the main results of this systematic review. After giving some descriptive review statistics, the studies obtained by literature review are outlined by organizing under three subsections such as smart city acceptance, IoT acceptance and other services. Then, some important and prominent acceptance theories that form the basis of many technology acceptance studies in the literature are explained. Finally, the chapter ends with the description of hypothesis development and model construction process.

3.2. Systematic Review Strategy

Initially, the literature was searched to find the acceptance studies relevant to IoT technology and smart cities. Published journal papers in Web of Science, IEEE Xplore, ScienceDirect (Elsevier) and Emerald online libraries in last ten years were reviewed. The studies obtained in the literature review were examined in three groups. Additionally, the important acceptance theories in the literature are explained in this section. The proposed research model and hypotheses are developed based on this reviewed literature.

The literature was systematically reviewed based on 3-stage Kitchenham methodology: planning, conducting and reporting (Kitchenham, 2004). In the planning phase, research criteria and search databases were defined. Then the researcher conducted keyword searches in specified databases and reported review results in a systematic manner. The defined search keywords were as follows:

- “Smart City” **or** “Internet of Things”

and

- Technology **or** Service

and

- Acceptance **or** Adoption

To confine the search scope, only the journal papers written in English and published in between January 2008 – March 2018 in Web of Science, IEEE Xplore, ScienceDirect (Elsevier) and Emerald online libraries were covered. In this initial literature review, the articles in press, conference proceedings, textbooks, unpublished papers, and academic thesis were excluded from the scope. At the very beginning, the search resulted 397 papers. After eliminating irrelevant and duplicated papers, the number of papers reduced to 237.

3.3. Main Results of Systematic Review

Tree shape classification of literature review results is given in Figure 8. Seventy-two out of 237 refined papers are relevant to user acceptance of some new technologies, mostly IoT-based. Thirty-four papers in this group have a model-based approach for user acceptance or adoption of IoT-based technologies and smart services. Among these 34 journal papers; 14 studies are analyzing the adoption of general IoT-based services including wearable sensors, RFID (Radio Frequency Identification) sensors and so on. While 7 papers are about user acceptance of smart healthcare services, another 7 studies are analyzing the adoption of smart home and smart building applications from end-user's perspective. The remaining 6 papers are directly studying the acceptance of smart city services with a model-based approach.

According to the review results the number of academic studies on adoption of smart services have been increasing dramatically in last three years as shown in Figure 9. This result indicates that the research topic on the acceptance of smart services is getting popular in academic world recently. As seen from Figure 10, adoption and acceptance matters are quite popular especially in Asian countries. When looking at the research methodologies of the reviewed studies, most of the model-based adoption studies (31 out of 34) have used questionnaires to get the user intentions. Just three of them have conducted expert interviews or focus group technique while analyzing acceptance issue. While the questionnaires in 13 studies are online, 5 studies have employed both online and paper-based surveys (58% online in sum), five papers (16%) have conducted only paper-based surveys. In 8 studies (26%), there is no specification about survey methodology. Average number of respondents in surveys is 373. The maximum and minimum number of sample size are 1091 and 76, respectively.

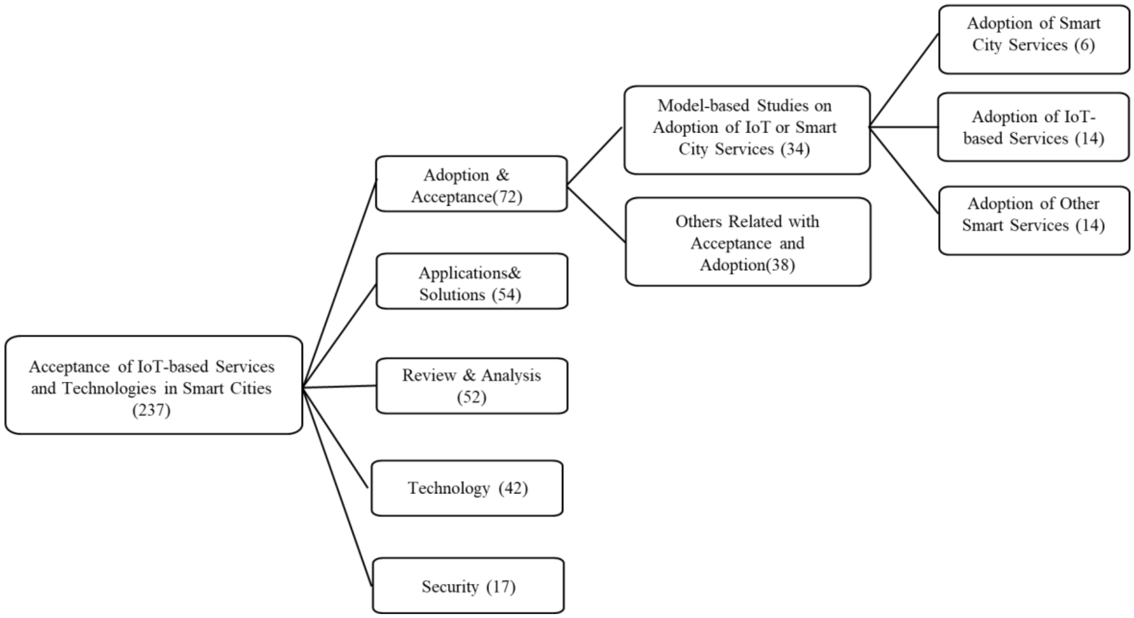


Figure 8: Classification of reviewed papers

In the reviewed papers, different statistical techniques seem to be used such as First-Generation Multiple Regression Analysis, Kruskal-Wallis H Test and Back Propagation Neural Network Analysis. However, most studies (74% - 23 out of 31) employed SEM in order to test the hypothesis and validate the models statistically. Smart-Partial Least Square (PLS) is the most preferred statistical tool (29% - 9 out of 31). The other popular tools are AMOS and LISREL. 11 studies (35%) have no statement about statistical tool used.

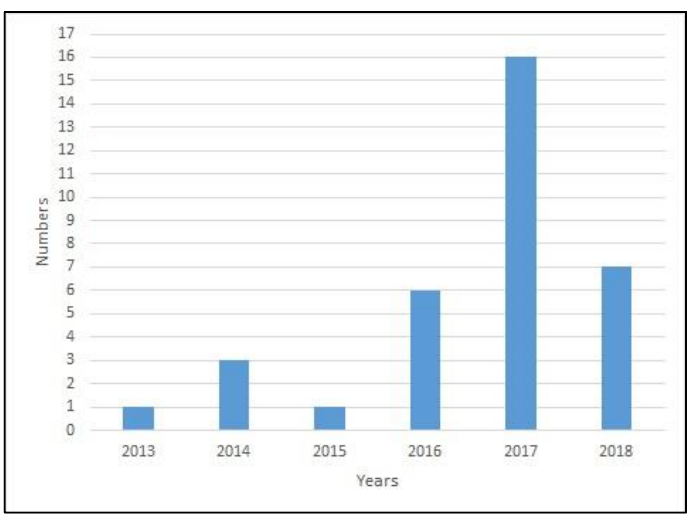


Figure 9: Distribution of papers over years

Note: In 2018, only the first quarter of the year was covered.

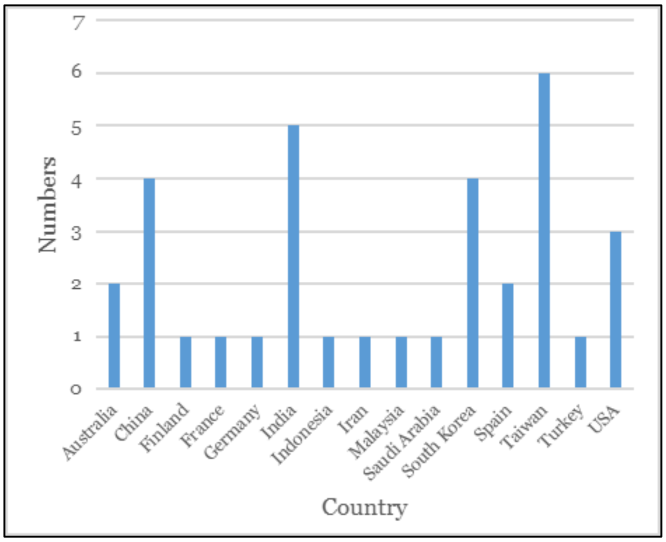


Figure 10: Distribution of papers by countries

The literature review showed that many different adoption factors were utilized in the literature relevant to the studied technology and preferred model. Some different named adoption factors seem different at first glance, but many of them have similar, even same, meaning. By considering this matter, review results revealed that 50 different adoption factors used in the literature for IoT-based smart services. The most used ones (4 or more times) are listed in Table 1.

The mostly preferred factors are perceived usefulness (PU) and perceived ease of use (PEOU) which were introduced by Davis (Davis, 1989). This is an expected finding because Davis's Technology Acceptance Model (TAM) has a broad usage area in the literature because of its simplicity and representativeness. However, many researchers have sometimes employed TAM factors in different names such as benefit, effort expectancy, etc. as shown in Table 1. Social influence or subjective norm (SN) is another commonly used factor primarily introduced by Theory of Reasoned Action model (A. Fishbein & Ajzen, 1975; Ajzen, 1991). Interestingly, the privacy concern is the third most preferred factor. When considering the increased information security threats and user awareness on privacy risks recently, this result seems quite reasonable. The other common factors are cost, attitude, trust, perceived behavioral control and perceived enjoyment.

Table 1: Most used acceptance factors in reviewed literature

Factors	Frequency
Perceived Usefulness/Perceived Advantage/Performance Expectancy/Benefits/Utility	24
Perceived Ease of Use/Effort Expectancy/Complexity/Technicality/System	19
Privacy Concerns/Data Sharing Type	13
Social Influence/Subjective Norm/External Pressure/Perceived Critical Mass/Coolness/Image	12
Cost/Price/Fee	9
Attitude/Affordance	9
Trust/Perceived Trustworthiness/Content	8
Perceived Behavioral Control/Self-efficacy/Technology Anxiety	8
Perceived Enjoyment/Hedonic/Playfulness/ Pleasure	7
Perceived Adaptiveness/Compatibility	6
Technology Level/Technological Innovativeness/Innovation and Creativity of Service/Used Device	6
Innovation and Creativity of User/Personal Innovativeness	4
Technology Readiness/Facilitating Conditions	4

In most studies, researchers have also evaluated the demographics of respondents while analyzing the acceptance of IoT-based services (74.2%). In just 8 of 31 studies (25.8%), there is no statement about the demographic features of the users. The most used demographics in the reviewed studies are listed in Table 2.

Table 2: Most used demographic features in reviewed literature

Feature	**Frequency**
Gender	20
Age	20
Education	17
Income	7
Use Experience	5

3.3.1. Acceptance of Smart City Services

Yeh surveyed the citizens in Taiwanese cities for the acceptance and usage of information and communication technologies (ICT) based smart city services (Yeh, 2017). In this study, the author proposes a framework based on Innovation Diffusion Theory (IDT) and incorporating the allegations in Unified Theory of Acceptance and Use of Technology (UTAUT). Proposed framework includes 8 constructs: innovation concept, personal innovativeness, city engagement, service quality, perceived privacy, trust, quality of life and acceptance. The citizens' gender, age, education level and how often they use ICT-based smart city services are utilized as the control variables in the model. According to their findings, citizens tend to use and accept ICT-based smart city services if the design of services is innovative, user privacy is protected, and service quality is high. City engagement of end users is the only factor not affecting smart city adoption. This study also reveals that Taiwanese with innovative approach adopt ICT-based services offered in smart cities faster than those who are more closed to innovation and technology. The early adopters of the smart city services also motivate the people in their sphere of influence to use the services. Another result is that the demographic characteristics does not affect much the attitudes of citizens against smart city services (Yeh, 2017).

In one of six studies on acceptance of smart city services, the factors driving the citizen's intention to use a mobile application in an e-government system in Indonesia were examined from the acceptance point of view (Susanto et al., 2017). In this study, Susanto et al. initially performed a preliminary open-ended questions survey to explore the factors motivating the citizens to use the specific mobile e-government application. The determined factors were compared to some well-known technology acceptance models such as Technology Acceptance Model (TAM), Diffusion of Innovation (DOI), UTAUT, Theory of Reasoned Action (TRA), Theory of Planned Behavior (TPB), and Decomposed Theory of Planned Behavior (DTPB). According to the results of this comparison the authors decided to use the DTPB model with a new construct. They collected data from the citizens in 7 sub-districts of Surabaya city. The results show that the most significant determinants of user's intention to use the mobile e-government application is attitude and there are only two factors influencing the attitude positively: perceived ease of use and perceived usefulness.

Chatterjee and Kar sought to examine the adoption process of information technology (IT)-based services delivered in India's smart cities from an end-users' point of view (Chatterjee & Kar, 2017). Proposed framework includes nine constructs: overall innovation and creativity, personal creativity and innovativeness, resident engagement, service quality, perceived privacy, perceived security, perceived trust, user experience and quality of life. The user demographics and usage patterns are their control variables. The findings show that IT-enabled services have substantial and effective impact on citizens' living standard, even if varied demographics do not affect much the adoption. In addition, the innovative and new digital services would have behavioral, technological, and social impact on the citizens' lives. Good functionality, quality, active participation of the citizens and user-centric focused attention are also important factors from end users' perspective, as well. Increased trust level against the usage of IT-driven services also positively influences the usage rate and improves the overall utilization (Chatterjee & Kar, 2017).

Leao and Izadpahani studied to determine the causes for non-attendance and motivators of attendance to urban sensing project called “2Loud?” (Leao & Izadpahani, 2016). The authors examined the effect of totally four motivational factors: concern and belief as subjective factors, technology and time as means factors on behavioral intention to use. The findings indicate that attendees have a statistically significant positive approach towards participation if having enough time and tolerable belief and concern, and reaching to technology, compared to non-attendees. However, the results reveal that just technology and time are the prominent determinants of participation intention (Leao & Izadpahani, 2016).

Belanche-Gracia et al. proposed a theoretical model for the citizens’ intention to use smartcards continuously in Zaragoza in Spain (Belanche-Gracia et al., 2015). Security and privacy, functional benefits (i.e., usefulness and ease-of-use) and frequency of using the services offered are seen as critical enablers of intention to use in their model. The authors also consider socio-demographic variables (gender, age, and level of education) and the system used for payment to complete their proposed framework. By this way, they studied two models: with and without control variables. The results of this research on smartcard in Spain show that perceived ease of use and security are primary antecedents of continuance intentions. Ease of use appears as a critical determinant for continuous usage of such city cards via improving security perception, privacy, and usefulness. Unexpectedly, the impacts of privacy on sense of usefulness and continuance intentions are both non-significant. However, the effects of security on perceived usefulness and continuance intentions are positive and significant. On the other hand, the influence of socio-demographic variables is found to be not significant, so that smartcard service should target a wide-range of users. How often a person interacts with the services offered by local governments has a significant impact on that person's perception of the usefulness of the smart card, as well (Belanche-Gracia et al., 2015).

Ylipulli et al. analyzed the acceptance of two smart city services, wi-fi provided by local government and interactive screens publicly available, through multi-level adoption model (Ylipulli et al., 2014). Their findings reveal that appropriation is a long process and the adoption of such technologies might be slow-going because of some variables such as unfamiliarity, questionable utility, and short time availability. The results of this study also indicate that the acceptance of a new service in a smart city is a complicated process and requires long-term and in-depth multidisciplinary studies to be understood. The authors also state that different demographic groups may experience smart city services indifferent ways; for example, the creativity and joyfulness of a service could be more interesting feature for young people than elders (Ylipulli et al., 2014).

3.3.2. Acceptance of IoT-Based Services

Mital et al. examined the adoption of IoT in India by comparing three important adoption theories in the literature (Mital et al., 2017): TAM, TRA and TPB. The study reports that usefulness and ease of use from TAM, and social influence and attitude from TRA are important determinants for the acceptance of smart devices. However, the impact of perceived behavioral control appears as non-significant for the intention to use IoT-based services. This study revealed that the 3 well-known theories evaluated were able to model the individuals' use intention on IoT-based services with approximately the same levels of fit, only that perceived behavioral control from the critical factors of TPB did not have a significant effect. The overall results revealed that TMA, TRA and TPB, separately, did not have sufficient capability to explain the use intention on such services in India (Mital et al., 2017).

Hsu and Lin applied the value-based adoption model (VAM) to analyze the effects of benefits and sacrifices on the user's intention to use the IoT services (Hsu & Lin, 2018). In the VAM model, perceived usefulness and perceived joyfulness are considered as benefits, and privacy risk and perceived costs are considered as sacrifices. The findings revealed that perceived usefulness and perceived joyfulness are effective variables, with the moderation of perceived value, in predicting behavioral intention. In addition, privacy risk is also found to be a factor that significantly affects the acceptance of IoT-based services (Hsu & Lin, 2018). In another study, Hsu and Lin tried to develop a conceptual framework considering the network externalities and privacy to understand the motivations driving the continued use of IoT services. Their model determines the intention to use over benefit, privacy concern and attitude. Attitude has a mediation role for the impact of perceived benefits and concern for information privacy. Their findings reveal that network externalities have an important role in affecting the acceptance, since end users have a perception that it is advantageous to use such systems, however concerns on privacy do not have such strong impact on acceptance (Hsu & Lin, 2016). Gao and Bai aimed to develop a model of variables predicting the end users' adoption of IoT-based services (Gao & Bai, 2014). The IoT acceptance model proposed by the authors is based on TAM and there are three variables on technology (ease of use, usefulness, and trust), one variable on social situation (subjective norm), and two variables on features of end users (behavioral control and joyfulness) in their model. Their findings show that all factors other than trust have significant role in predicting the user behavioral intention. In addition, perceived ease of use and trust have impact on perceived usefulness (Gao & Bai, 2014).

The behavioral intention to use IoT-based services in mobile commerce by consumers is critical because integrated information according to time, location, and context could provide more effective shopping experience. Tsai et al. examined the behavioral intention to use the store applications by using TAM as the framework and incentive theory to model the external variables. The results of their study reveal that convenience, information, fun, and interactive motivations, called as external factors, indirectly affect consumers' behavioral intentions with the mediation of usefulness perceived by consumers. When looking at the impact on ease of use, just interactive motivation is important among the convenience, promotion, information, fun and interactive motivations, since it indirectly affects behavioral intention over ease of use (Tsai et al., 2017). Singh et al. studied the adoption of IoT-based technologies in the corporate sector in India and tried to identify factors influencing its adoption rate. They adopted TAM in their study and used five organizational constructs as perceived usefulness, perceived ease of use, internal organization variables, external organization variables and behavioral intention to use. They applied a questionnaire to executives and business leaders in IT companies and their results are in line with original TAM and also show that the maturity level of the organization and external conducive environment also positively affect the adoption (Singh et al., 2017).

In another study, Mani and Chouk examined the factors that explain consumer resistance to smart products and developed a conceptual framework with seven key variables: usefulness, novelty, cost, intrusiveness, concerns on privacy, dependence and perceived behavioral control (Mani & Chouk, 2017). They tested the hypotheses by SEM and the findings show that six of the variables (other than dependence) appear as effective on end users' reluctance to smart services (Mani & Chouk, 2017). Tu tried to understand the main factors as incentives and concerns influencing the acceptance of IoT-based technologies in the management of supply chain. The author’s Grounded Theory based qualitative analysis reveals that cost and benefit sense, ambiguity on reliability and the external driving factors are the main issues for the adoption of IoT in logistics. The author adopted Technology, Organization and Environment (TOE) framework as a quantitative research model and used PLS-SEM to analyze the data. The results show that perceived usefulness and cost as well as extrinsic pressure are important predictors for the IoT adoption. Trust on technology appears as non-significant determinant, but have an indirect influence on IoT adoption intention through perceived benefits (Mengru Tu, 2018).

Yildirim and Ali-Eldin analyzed the factors influencing individual’s behavioral intention to use an IoT wearable device at the workplace (Yildirim & Ali-Eldin, 2018). The results of this study show that perceived usefulness have strong significant positive relationship with behavioral intention and no statistically significant relationship between privacy concerns and behavioral intention. Also, the perceived risk cannot significantly predict behavioral intention. Besides, trust and ethical concerns are found to have statistically significant but rather weak positive relationship with behavioral intention. The authors used the PLS path modelling, and the Adaptive-Network based Fuzzy Inference Systems (ANFIS) approaches to test the reliability and validity of the proposed model and relationships. The findings state that the predictability of their proposed model increased after applying the ANFIS model (Yildirim & Ali-Eldin, 2018). Shin represented an approach for evaluating the Quality of Experience (QoE) for IoT applications (D.-H. Shin, 2017). Shin’s study made a conceptualization the quality notion for IoT from a theoretical point of view and founded a connection between technical quality and evaluation perceived by end-users. The results approve that the QoE model is a worthy extension of user experience in IoT concept as it provide effectual measuring of heuristics and quality in point of IoT-based applications (D.-H. Shin, 2017). Roy et al. investigated the customer acceptance of smart technologies in retail sector. They used symmetrical PLS path modelling and asymmetrical Fuzzy Set Qualitative Comparative Analysis (fsQCA) to analyze the collected data. The findings explain how store reputation, adaptiveness, superior functionality, usefulness, ease of use and readiness of technology affect the consumer attitude and behavioral intentions towards smart retail technology. Their results imply that technology readiness does not have direct impact on end users' attitude but indirect impact over characteristics of innovation. They also revealed that retailers have to put the simplicity on center for smart services (Roy et al., 2018).

3.3.3. Acceptance of Other Smart Services

Saidi et al. studied the adoption of IoT technology for smart buildings and used SEM to measure the relationship between research variables (Saeidi et al., 2017). Their study states that the ease of use and trust in perceived usefulness is effective on the acceptance of IoT-based smart service in building. Together with other dimensions such as understanding the benefits, appreciation of pleasure, social influence and understanding of behavior control will ultimately shape the acceptance of such IoT-based services (Saeidi et al., 2017). Kim et al. analyzed the factors affecting the consumers to accept smart home services and developed an acceptance model based on VAM by using both negative and positive variables on the same measure, different from TAM (Y. Kim et al., 2017). Their study shows that perceived benefit and sacrifice are both effective on perceived value. But the effect of perceived benefit on perceived value is considerably stronger than the perceived sacrifice (Y. Kim et al., 2017). Similarly, Park et al. introduced an adoption model for IoT-based smart home services by integrating five motivating factors: enjoyment, compatibility, connectedness, control, and cost. The results of this study show that consumers' attitude against IoT-based services is the strongest determinant of their use intention. Also, the influence of usefulness on use intention is higher than that of ease of use. On the other hand, the effect of usefulness on attitude is lower than that of perceived ease of use. Among the extrinsic incentives, cost and compatibility show remarkable influence on intention to use. Moreover, both connectedness and compatibility are two significant extrinsic determinants when embedded to original form of TAM (E. Park et al., 2017).

Dong et al. tried to explain how end users' cognitive and affect experiences moderate the relation between usefulness and psychological perception factors (Dong et al., 2017). The findings of their study reveal that it is not sufficient to improve the level of influence and enhance the performance of IoT-based services to make end users use such applications, in place of this, making IoT-based services easier to use is more important. In addition, they state that ease of use, usefulness, and privacy risk are three major determinants of intention to use, and external factors has a significant positive influence on perceived usefulness. Their results showed that TAM could be used for the acceptance analysis of smart home services (Dong et al., 2017). Bao et al. extended TAM by covering extra factors such as compatibility, subjective norm, secureness of home environment, security risk on technology, and cost, perceived by end users. Due to this proposed model, they aimed to explore the predictors of adoption of smart home systems based on mobile technology in China. The results of their study show that compatibility, subjective norm, and usefulness, considerably affect the end users' intention to accept smart home based on mobile technology. Subjective norm, perceived secureness of home environment, and ease of use directly and positively affect the usefulness, as well (Bao et al., 2014).

The term "guest technologies" refers to services that facilitate the guest experience, such as smart TVs, wake-up and reminder systems, thermostats, and internet connectivity. Netflix through Smart TV's, ambient intelligence devices like Amazon Echo and Google Home are some of the ICT-based guest technologies that customers adopted earlier than hotels. Beldona et al. compared the hotel's technology with home through three items: technology level, quality, innovativeness (outdated or futuristic) (Beldona et al., 2018). Their results reveal that there is not any remarkable difference between relative standing of hotel technology compared to home and technology satisfaction. However, the relationship between technology satisfaction and overall satisfaction is significantly different. Main finding of this study is that the hotel technologies should be greater than the technologies at home in order to get the customer satisfaction (Beldona et al., 2018).

Papa et al. examined the acceptance of IoT-based smart wearable healthcare (SWH) devices involving the use of metering devices, biometrics, sensors, actuators, and Radio Frequency Identification (RFID) in order to gather, visualize and process the healthcare data (Papa et al., 2018). In their theoretical model they added two external variables, intrusiveness and comfort, to the original TAM variables (i.e., perceived usefulness (PU) and perceived ease of use (PEOU)). Based on their findings, intrusiveness introduces non-significant impact on PU and PEOU. Similarly, comfort has non-significant effect directly on attitude against acceptance but has a remarkably strong negative effect on PEOU. This implies that comfort of wearables is a remarkable sign of successful acceptance of SWH technologies and comfort should be considered very carefully together with usefulness and ease of use (Papa et al., 2018).

As the implementation of healthcare services provided over internet, covering IoT-based solutions, calls for sizeable investment, e-loyalty of patients is necessary not to waste the resources. Martinez-Caro et al. studied e-loyalty of patients and examined the indirect impacts of personal innovativeness and self-efficacy on e-loyalty via the satisfaction and usefulness simultaneously (Martínez-Caro et al., 2018). Their theoretical model shows that usefulness is the mediator for the relation between self-efficacy and personal innovativeness on satisfaction. In addition, satisfaction is the mediator for the relation between e-loyalty and usefulness (Martínez-Caro et al., 2018).

UTAUT model that has four independent constructs as performance expectancy (like TAM's usefulness), effort expectancy (like TAM's ease of use), subjective norm and facilitating conditions and one dependent construct as behavioral intention. Pal et al. tried to determine the core variables influencing the aged people's adoption of smart home services for healthcare by developing a theoretical model based on extended form of UTAUT (Pal, Funilkul, Vanijja, et al., 2018). They combined the original constructs of

UTAUT with four extrinsic variables: expert advice to explain the user behavior, perceived cost and trust, and technology anxiety. According to the results of their study, performance expectancy has an impact on behavioral intention, however the effect of effort expectancy is far greater than performance expectancy. Perceived trust and expert advice are other important constructs. Their study also reveals that the effect of subjective norm and facilitating conditions are not significant, while technology anxiety and perceived cost are major factors affecting the behavioral intention in a negative way (Pal, Funilkul, Vanijja, et al., 2018).

Karahoca et al. investigated the important variables influencing users' intention to accept IoT-based healthcare technologies in Turkey (Karahoca et al., 2017). They developed an integrated model based on IDT and TAM together with privacy calculus theory, protection motivation theory and technological innovativeness. According to their results, ease of use, image, and perceived advantage have noticeable impact on intention to accept IoT-based healthcare services. Their study also states that trialability and compatibility are more effective on ease of use for females, while perceived advantage has more impact on perceived ease of use for males. Image, perceived vulnerability and privacy risk are more effective on males than females (Karahoca et al., 2017). Alaid and Zhou studied the main drivers and obstacles of patients' acceptance of wireless sensor network-based smart home healthcare systems (WSN-SHHS) (A. Alaiad & L. Zhou, 2017). The results of their study has not only confirmed the original UTAUT variables' validity (i.e., subjective norm, effort and performance expectancies, and facilitating condition) but also revealed several new factors of the adoption of WSN-SHHS as expectancy on life quality, cost concerns, privacy concerns, and isolation concerns of human (A. Alaiad & L. Zhou, 2017). Yee-Loong Chong et al. proposed a model to predict the adoption of RFID by healthcare workers by integrating variables from psychology, health informatics and management information systems (MIS) theory (Yee-Loong Chong et al., 2015). Their study extended UTAUT model with personality factors (extraversion, agreeableness, openness to experience, conscientiousness, and neuroticism) and demographics (gender and age). Their findings show that the strongest drive to adopt RFID is personality factors and the predictive power of other MIS adoption models can be improved by incorporating personality variables (Yee-Loong Chong et al., 2015).

Marakhimov and Joo examined the usage of wearable healthcare technologies when health and privacy concerns exist (Marakhimov & Joo, 2017). Their model was based on coping theory and coping model of user adaptation. According to their results, while health and privacy concerns impact the consumers' challenge assessments positively, they impact the consumers' threat assessments negatively. Also, assessments on challenge and threat impact positively end users' problem-focused and emotion-focused coping efforts, that impact positively the prolonged usage of wearable healthcare technologies. There are some other studies analyzing the end user acceptance of IoT-based smart healthcare services with different models such as conjoint analysis and hybrid modified Multiple Attribute Decision-Making (MADM) model (S. Kim & Kim, 2017; Liu et al., 2017).

3.4. Important Theories in the Literature

Understanding the needs of individuals and acceptance motivations is very important for any businesses and this understanding would be helpful to innovate new technologies and services adopted by end users more easily. So, the researchers are studying to realize the factors effecting acceptance or rejection decision of users for new technologies and services (Taherdoost, 2018). Each technology acceptance theory or model, well known and still valid in the relevant literature, can provide valuable insights for the design of the model that is planned to be developed in this research. Therefore, it is not only beneficial but also necessary to carefully study the relevant theories and models. Because the theoretical concepts derived from these theories will help to construct a strong base for establishing a suitable research model, and thus obtaining more satisfactory results regarding the adoption of technology will be probable. In this context, compatible with the objective of this research, this section will review and scrutinize five well-known theories or models proposed to elucidate adoption of new technologies and summarized in Table 3 below.

Table 3: Features and constructs of major acceptance theories

Theory	Focus	Constructs
"Theory of Reasoned Action" (TRA) (Fishbein & Ajzen, 1975)	• based on social psychology • one of the essential and powerful theories on human behavior	• "attitude toward behavior" (ATB) • "subjective norm" (SN)
Technology Acceptance Model" (TAM) (Davis, 1989)	• principally developed to determine adoption and usage of information technology	• "perceived usefulness" (PU) • "perceived ease of use" (PEOU)
"Theory of Planned Behavior" (TPB) (Ajzen, 1991)	• extends TRA by adding the construct of perceived behavioral control (PBC)	• "attitude toward behavior" (ATB) • "subjective norm" (SN) • "perceived behavioral control" (PBC)
"Diffusion of Innovation Theory" (DOI) (Rogers, 1983)	• based on sociology • used to study many new technologies on agriculture, organization etc.	• "relative advantage" • "compatibility" • "complexity" • "trialability" • "observability"
"Unified Theory of Acceptance and Use of Technology" (UTAUT) (Venkatesh et al., 2003, 2016)	• integrates elements of prominent models • adds four moderation variables (i.e., age, gender, experience, and voluntariness to use)	• "performance expectancy" • "effort expectancy" • "social influence" • "facilitating conditions"

3.4.1. Theory of Reasoned Action

TRA, adapted for use in many fields, is one of the essential and powerful theories on human behavior and forms the backbone of studies associate with attitude-behavior relationships. This theory is based on social psychology and states that behavioral intention towards using a technology or service is based on potential users' attitude against the behavior and the social influence relevant to that behavior, as shown in Figure 11 (Fishbein & Ajzen, 1975). Attitude towards the behavior arises from user's appraisal of this specific action and is weighed by the behavioral beliefs about the consequences and features of that particular behavior (Madden et al., 1992). In other words, attitude towards behavior occurs when the possible consequences of decisions and actions are considered before making any decision about whether to engage in a particular behavior or not. One's beliefs are also effective at this point. According to this theory, the intention of an individual to do a particular behavior or not is the main predictor of that behavior to be taken by that individual. So, if someone believes that positive results will occur when he/she performs a certain behavior, he/she will have a positive attitude towards that behavior, and vice versa. An individual's action is often affected by beliefs and actions of important people in the individual's social environment. With this regard, subjective norm is the user's sense of what others think about his/her behavior (Leach et al., 2006). More simply, it is the pressure exerted by the social environment on individual to do a particular behavior or not. Therefore, in a person's decision to perform a certain behavior, what the individuals around that person will think, whether they will agree or not, and how important these other individuals are to the decision maker have a significant effect. This effect is largely the reason why people consult others before making any decisions. Behavioral intention is a person's willingness to do a behavior and the main factor shaping actual behavior. TRA is a prominent model applied to determine the human behavior in many different areas (Ajzen & Fishbein, 1980). In the literature, especially IT-based fields, this model is frequently used in studies conducted to predict how new technologies will be met by users. Many known technology acceptance models contain the effects of TRA as well as the theoretical approaches on which they are based.

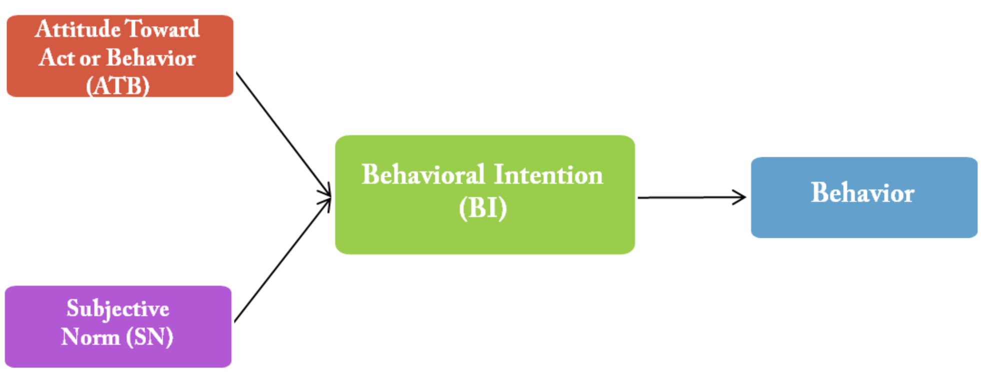


Figure 11: Theory of Reasoned Action model

3.4.2. Technology Acceptance Model

TAM, shown in the simplest form in Figure 12, is an adapted form of TRA by Davis and primarily developed to predict information technology acceptance and usage (Davis, 1989). TAM states that a person's behavioral intention to utilize an IT product or service is dependent on usefulness (perceived usefulness) and ease of use (perceived ease of use) of that technology sensed by the person (Davis, 1989). Perceived usefulness is the level of perceived positive effect of utilizing a specific technology on user' performance on doing a job. Similarly, perceived ease of use is the easiness perceived by a person (being effortless) of utilizing a specific technology.

Perceived usefulness and perceived ease of use were theorized by Davis (1989) as the primary determinants of the use of a technological product or service (Davis, 1989). In the ten years afterwards, TAM has become a robust and powerful model for predicting user acceptance and explaining system use, with studies in the literature (Venkatesh & Davis, 2000). In this robust form, TAM also theorized that some external factors such as technical features and training affect the intention of use through the two main factors of the model, perceived usefulness, and ease of use. Additionally, TAM hypothesizes that a system or technology that is perceived more easily can be perceived as more beneficial when all other factors are the same (Venkatesh & Davis, 2000).

In addition to their theoretical value, TAM factors also have great practical value for both technology suppliers who want to shape their designs through user feedback and information systems managers who want to evaluate new and innovative offers. There are some assumptions in TAM as well as in many models and theories. For example, TAM assumes that users are voluntarily using a new technology (Davis, 1989). In addition, given sufficient time and information about an action, it is accepted that the behavioral intention of the person will be very similar to his or her actual behavior. That is, it assumes that a person's behavior depends on his own will and that he can take the action he wants to take freely and without being subject to any restrictions (Ajzen & Fishbein, 1980). However, there may be many obstacles to acting freely in practical life, such as time, lack of skills, environmental and institutional limits, and habits (Bagozzi, 1992).

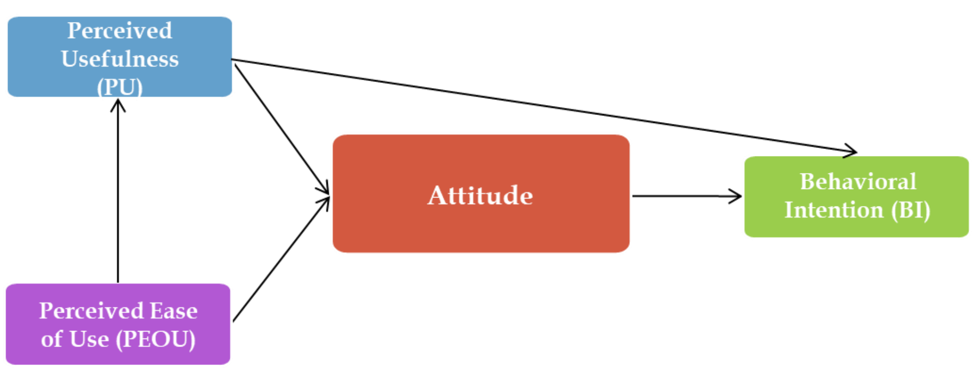


Figure 12: Technology Acceptance Model

3.4.3. Theory of Planned Behavior

TPB is the expanded form of TRA with the addition of "perceived behavioral control" as shown in Figure 13. "Perceived behavioral control" is the sensed control of an individual over performing a specific action. TPB briefly states that "perceived behavioral control" shapes the behavioral intention to use and actual behavior together with attitude towards behavior and social influence (Ajzen, 1991). In general, if an individual's attitude toward a behavior is positive, perceived behavior control is high, and the subjective norm is also in a positive direction, the intention of the person to perform that behavior will also be strong. One of the main reasons why TPB emerged as a variation of TRA is that TRA's performance is low regarding behaviors where people's behavioral control is not high enough in real life. Ajzen (1991) emphasizes exactly this point and states that TPB has a structure suitable for situations where there are obstacles for an individual to take action freely (Ajzen, 1991). TPB is a theory that accepts that behavior can only be deliberate and planned, and thanks to perceived behavioral control factor it contains, it is considered more general and more appropriate to practical situations than TRA (Chau & Hu, 2002).

According to Ajzen and Driver, human behavior is shaped based on three types of beliefs, behavioral, normative and control (Ajzen & Driver, 1991). Behavioral beliefs, which are relevant to the possible outcomes of the behavior and the assessment of these outcomes, cause a favorable or unfavorable attitude toward the action in question. Normative beliefs, on the other hand, imply to the perceived behavioral expectations of person or group of persons who are in the social environment of the person such as partner, family and friends and can be influential in the person's decisions. As a result of these beliefs, the subjective norm, which is the reason for the concept called social pressure, emerges. Finally, control beliefs are related to the presence of variables that can facilitate performing an action and the perception of how strong these factors are. These beliefs are the source of perceived behavioral control and show how much of an individual is in control of any behavior. As a result, according to TPB, attitude, subjective norm and perceived behavioral control affect a person's intention to do a certain action and increase or decrease the likelihood of that action being performed by the person.

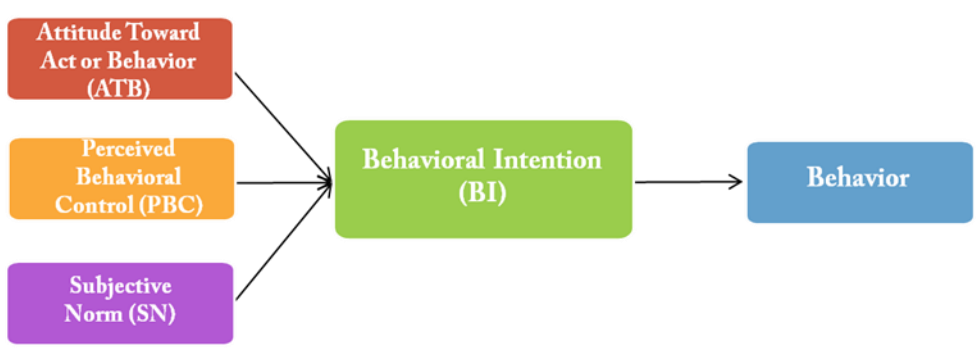


Figure 13: Theory of Planned Behavior model

3.4.4. Diffusion of Innovation Theory

DOI Theory is a very old theory on social science and developed in 1962 (Rogers, 1962). According to DOI, in a social medium, adoption of an innovation does not happen all together, some people adopt an innovation earlier than the others and they have some different characteristics than people who adopt an innovation later. According to DOI, diffusion of an innovation takes 5 steps (Rogers, 1995). The first stage is when the potential user of the innovation becomes aware of that innovation and reaches the first information. This first knowledge occurs when the potential user encounters the innovation and obtains data about the functions of the innovation. In the second stage, the potential user or individual develops an attitude towards innovation. This positive or negative attitude determines whether the individual is persuaded or not. If the individual's attitude towards innovation is positive, adoption takes place at the next stage. This third stage is followed by the implementation of the innovation in question by the individual. If the attitude of the individual is negative, the rejection of the implementation of the innovation, which is the last phase, i.e., the fifth stage, occurs.

In DOI theory, there are 5 primary variables affecting the acceptance of an innovation: “relative advantage”, “compatibility”, “complexity”, “trialability” and “observability”, as shown in Figure 14. “Relative advantage” is the level to which a new technology is seen as preferable than what is replaced. “Compatibility” refers to the accordance level of the innovation with the values, experiences, and wants of potential users. “Complexity” means the difficulty level of learning or utilization the innovation by end users. “Trialability” is based on how possible to test or experiment the innovation before an engagement to adoption. “Observability” is about how tangible outcomes the innovation provide (Rogers, 1983).

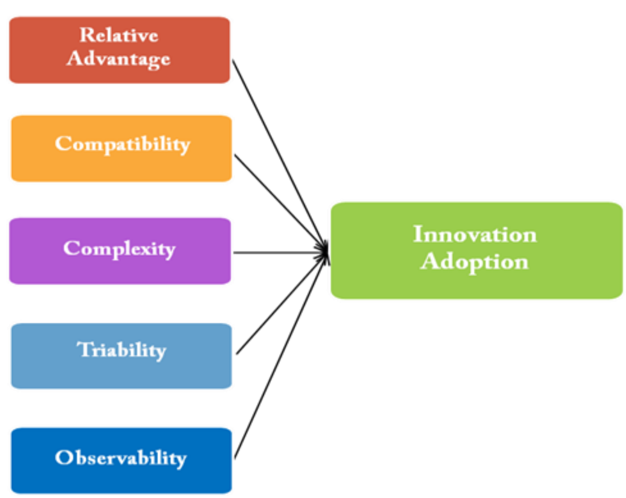


Figure 14: Diffusion of Innovation Theory

3.4.5. Unified Theory of Acceptance and Use of Technology

Venkatesh et al. synthesized prominent models of adoption into UTAUT that defines 4 primary variables (i.e., "performance expectancy", "effort expectancy", "social influence", and "facilitating conditions") and 4 moderation variables (i.e., "age", "gender", "experience", and "voluntariness to use") influencing the behavioral intention to utilize a technological product or system essentially in organizational context as shown in Figure 15 (Venkatesh et al., 2003). According to UTAUT, social norm, and, performance and effort expectancies influence the behavioral intention to use a technological service, while behavioral intention and facilitating conditions predict the use of that service (Venkatesh et al., 2003, 2016).

The theoretical perspective of UTAUT is very valuable, as UTAUT summarizes the evolution of adoption factors over time used in many models in the literature to determine the intentions and behaviors of individuals (Venkatesh et al., 2003). It is noteworthy that demographic features are used in the model to moderate relations between structures. For example, it is seen that the age factor, which does not receive much attention in technology acceptance studies, affects almost all relationships in the UTAUT model. In addition, according to Levy (1988), gender is also an effective moderator, and this is compatible with the outcomes of researches on social psychology (Levy, 1988).

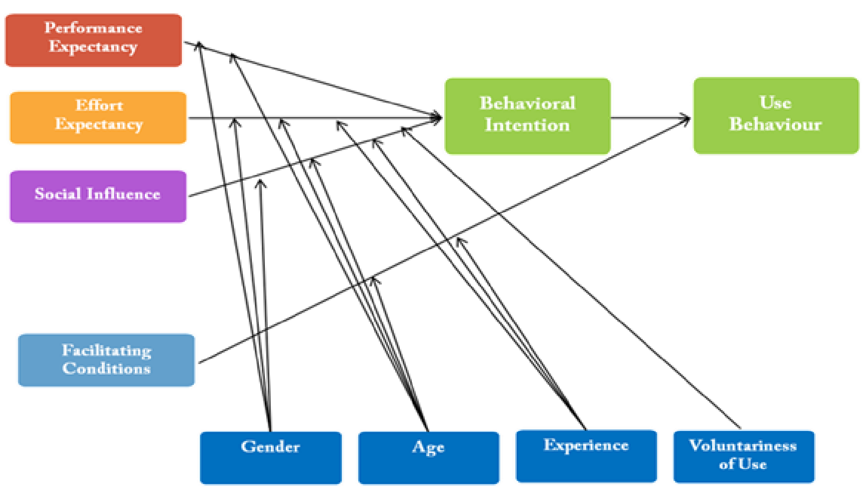


Figure 15: Unified Theory of Acceptance and Use of Technology model

3.5. Hypothesis Development and Model Construction

The proposed model SCSAM and hypotheses are developed from the relevant literature. Understanding the needs of individuals and acceptance process is essential to any business, and this understanding will help to develop new technologies and services that are more easily adopted by end users. Therefore, researchers have developed many theories explained previously to understand the variables affecting users' decision to accept or reject new technologies. TRA, based on social psychology, is one of the most fundamental theories of human behavior. This theory states that behavioral intention to use a technology depends on potential users' attitude toward the behavior and the subjective norm relevant to that behavior (Fishbein & Ajzen, 1975). TAM, probably the most widely used model in the literature, is an adapted form of TRA and primarily developed to predict information technology adoption. TAM states that a user's behavioral intention to use a technological system or product is dependent on "usefulness" and "ease of use" of the technology (Davis, 1989). Ajzen developed the TPB by adding "perceived behavioral control" to TRA (Ajzen, 1991). DOI Theory is a very old social science theory and developed by Rogers in 1962. Venkatesh et al. (2003) has developed the unified acceptance and technology theory (UTAUT), which identifies 4 primary construct variables and 4 mediation variables previously explained (Venkatesh et al., 2003, 2016). However, all these well-known and important theories may not be compatible for every concept.

To explain the adoption process for smart city services, while considering the smart city context, which is a multi-dimensional structure, an original adoption model should be developed with appropriate and original factors and relationships to cover technology, human and institutional aspects. Smart city initiatives that do not focus on people and miss the characteristics of citizens have little chance of success. Despite all risky and uncertain situations related to innovation, citizens with high personal innovativeness (PI) are more prone to adopt an innovation into their daily life routines (Rogers, 1983). These individuals are more likely to follow technological developments to take advantage of a new technology at home and at work (van Raaij & Schepers, 2008). PI is originally defined by Rogers and Shoemaker as an observable factor in adoption process (Rogers & Shoemaker, 1974). From a technological point of view, PI can be explained as the willingness of end users to try and use a new technological product or service (Agarwal & Prasad, 1999; Okumus et al., 2018) and it is considered an important dimension of the end-users' e-skills (Martínez-Caro et al., 2018). From information systems perspective, PI can shape individuals' perceptions about systems and their approach to innovation (Dabholkar & Bagozzi, 2002). Previous studies have discussed the influence of PI on adoption and use of a smart city service (Chatterjee & Kar, 2017; Yeh, 2017). Yeh (2017) reported that citizens who have higher PI accept and use smart city services relatively sooner than the others who have lower innovativeness. Similarly, the study of Chatterjee and Kar (2017) showed that the level of PI of citizens significantly affect the acceptance of smart city services. Based on these literatures, the following hypothesis about PI considered under human dimension is developed:

Hypothesis 1: "Personal innovativeness" (PI) has a positive impact on users' intention to use IoT-based smart city services.

There are many motivators and de-motivators to use a new technology or service, but the cost may be more prominent factor in underdeveloped or developing countries. In the simplest sense, a new technology is expected to be cost-effective to succeed and achieve wide utilization. Previous studies on information-oriented services define cost as concerns about the costs of purchasing, using and repairing a particular system or service (Park et al., 2017; D. D. H. Shin, 2009). Cost can also be defined as the price that users think is appropriate for the service they receive using smart systems (Pal, Funilkul, Charoenkitkarn, et al., 2018). Since TAM has some shortcomings with end users who have to make their own self-assessments on the pros and cons of using an innovation (Y. Kim et al., 2017), the VAM model has emerged that examines technology acceptance through perceived benefits (“usefulness” and “enjoyment”) and perceived sacrifices (“technicality” and “perceived fee”). A survey study examining the variables influencing the acceptance of a new technology has shown that cost is one of the biggest concerns, especially for older users (Peek et al., 2014). Another very recent study reveals that users' intentions to use smart wearables are influenced by five factors: satisfaction, pleasure, usefulness, flow status and cost (Park, 2020). Similarly, in many adoption studies, cost has been identified as a factor affecting end users' attitudes and intentions to use smart services and technologies (Ma et al., 2016; Nikou, 2019; Peek et al., 2014; Rajaee et al., 2019; Revels et al., 2010). However, the cost investigated in this study is the cost that the end user will have to bear to access the service, which is reflected directly to the end user during the use of the services. Indirect or hidden costs of these smart city services are not covered by the definition of cost here. Based on all this information, the following hypothesis about cost considered under human dimension is developed:

Hypothesis 2: “Perceived cost” (COS) negatively affects users’ intention to use IoT-based smart city services.

When a technology is not yet widespread, its users may not have sufficient information about the usability of this technology. In such cases, society can play a critical role in encouraging or hampering the adoption of a new technology (Walldén & Mäkinen, 2014) as the users may be affected by the people in their social environment. Important people in users' life could have an influence on the decision that individual makes (Hsu & Lu, 2004). Therefore, the impact of social influence (SI) or subjective norm should also be evaluated to understand the process of adopting a new service or technology. In its simplest form, SI is the degree to which an individual's actions are influenced by the actions and beliefs of people he or she deems important (Alaiad & Zhou, 2017; Venkatesh et al., 2003). TRA states that behavioral intention to use a technology depends on the attitude of potential users toward the action and the SI relevant to the action (Fishbein & Ajzen, 1975). Gao and Bai (2014) defined SI as a user’s perception on whether other important people approve that he/she should do the behavior. Many previous studies in the literature have confirmed the positive relationship between SI and intention to use (Gao & Bai, 2014; García-Maroto et al., 2020; Maity et al., 2019; Sener et al., 2019). In one of these studies, analyzing the attitudes of end users toward self-driving vehicles, it was seen that SI is among the factors that have the strongest relationship with intention to use (Sener et al., 2019). Based on the literature reviewed here, the following hypothesis about SI considered under human dimension is developed:

Hypothesis 3: “Social Influence” (SI) positively affects the intention to use IoT-based smart city services.

It is important to meet QoS criteria in almost every business. Providing better qualified service to customers is an important tactic for the presence and success of an organization (Parasuraman et al., 1985). In addition, QoS plays an important role in forming user perception toward technology (Khudri & Sultana, 2015; Sharma, 2015). Therefore, QoS has been used as a factor that affect citizens' intention to use in acceptance models for smart city services (Chatterjee & Kar, 2017; Yeh, 2017). There are many QoS factors that can be used to evaluate technological products and services in different industries and countries. Parasuraman et al. (1985) proposed a multi-item measure for the estimation of service quality perceived by end users (five-dimensional SERVEQUAL) as a model with five dimensions such as such “tangibles”, “assurance”, “responsiveness”, “reliability”, and “empathy”. SERVEQUAL is commonly utilized in service marketing, however, many researchers have criticized this model for not giving enough weight to the customer perspective (Cronin & Taylor, 1992; Finn & Charles, 1991). Many other QoS models (WebQual, e-GovQual, etc.) used in various industries have adapted the dimensions of the original SERVQUAL model to the need of the study (Sharma, 2015). On the other hand, ISO/IEC 9126 (2001) defines QoS for a software product with six elements: “functionality”, “reliability”, “usability”, “efficiency”, “maintainability”, and “portability”. However, the quality factors used here largely depend on the type of user. For example, it is not convenient for end users to evaluate the maintainability and portability that are suitable for maintenance staff (Bevan, 1999). From end user perspective, perceived quality of a service is mainly the result of functionality, reliability, usability and efficiency (Bevan, 1999; Horan et al., 2006). QoS from end-users’ perspective is an important determinant of user satisfaction and eventually adoption (Wang & Liao, 2008). Trust is sometimes seen as a critical QoS parameter that should be considered in service requests (Buyya et al., 2008). It is also important for government e-services to create a trusted service perception among citizens and to establish a trusted system for QoS management (Belanche et al., 2012; Corbitt et al., 2003; Pinem et al., 2018).

Hypothesis 4: Quality of service (QoS) of IoT-based smart city services positively affects citizens' intention to use.

Hypothesis 5: The quality of IoT-based smart city services positively influences end users’ trust in responsible parties.

Privacy can be seen as one of the cognition-based trust antecedents related to end users’ observations and perceptions regarding the characteristics of responsible entities (D. J. Kim et al., 2008). Yeh (2017) has defined privacy as the ability to control how individuals' personal information is obtained and used. Collecting, managing, monitoring and analyzing personal data in smart systems may raise privacy concern (PC) and negatively affect perceived trust (PT), one of the key determinants in adopting a new technology (Yeh, 2017). In this sense, including privacy in acceptance models is quite reasonable, considering recently increased user awareness of information security threats and privacy risks. IoT-based services in smart cities perform many digitized operations that require users' private data. Therefore, citizens may be worried about personal data security, and of course, such PC can negatively affect end users' intention to accept smart city services (Chatterjee & Kar, 2017). Even technologies that were initially adopted due to their perceived usefulness may ultimately be denied due to the perceived high risks, particularly with respect to privacy (Miltgen et al., 2013). Several prior studies in the literature showed that PC is a determinant for users' intention to use smart technologies and services (Kazancoglu & Aydin, 2018; J. Kim et al., 2017; Yang et al., 2018). In many other studies, the effect of PC on intention to use were analyzed through trust (Chatterjee & Kar, 2017; Punyatoya, 2019; Yeh, 2017). Given the recently increasing level of awareness of privacy risks, it seems reasonable to include PC under institution dimension in the acceptance model, and so the following hypothesis is developed based on relevant literatures:

Hypothesis 6: Privacy concerns (PC) negatively affect PT.

Smart services usually need personal data to perform their functions, and so users accept a certain level of risk, when using these services, assuming that responsible institutions and service providers take the necessary actions (Pal, Funilkul, Charoenkitkarn, et al., 2018). Low trust toward a new service negatively affects the user's behavioral intention to use this service (Yildirim & Ali-Eldin, 2018). From information perspective, trust, can be defined as the perception or belief that users' personal data are safe, carefully protected and anonymously processed (Pal, Funilkul, Charoenkitkarn, et al., 2018). If citizens frequently use a smart service or see that others are using it safely, a sense of trust develops in their minds, and such increased trust level makes it easier for them to adopt these services (Chatterjee & Kar, 2017). In many acceptance studies on new technologies and services, PT appeared as an important predictor for end users' intention to use (Belanche et al., 2012; Dutot et al., 2019; Hansen et al., 2018; Huijts et al., 2014; Miltgen et al., 2013). Huijts et al. (2014), in their study, showed that trust is a direct predictor of intention to use an innovation. Belanche et al. (2012) stated that trust positively influences behavioral intentions since it reduces uncertainty and increases the expectation of satisfaction. Hansen et al. (2018) also revealed that PT is an important factor for models examining intention to use social technologies. Several prior studies also showed that increased level of trust had positive effect on the usage of smart city technologies (Chatterjee & Kar, 2017; Yeh, 2017). Based on the literature reviewed here, the following hypothesis about PT considered under institution dimension is developed:

Hypothesis 7: Perceived trust (PT) has a positive effect on users' intention to use IoT-based smart city services.

"Behavioral intention to use" is an extent of the probability that an individual will perform a certain use behavior (Ajzen & Fishbein, 1980). In the simplest form, it is the desire to use. Motivations, such as achieving better living conditions and improving QoL, can affect people's intention to use a new technology. Smart city services ultimately aim to improve citizens' QoL. Defining the QoL, the elements, that are structured hierarchically and form the QoL, should be determined and their relationships should be properly defined (Zinam, 1989). In the literature, it is possible to come across many models and tools that define the factors of QoL from different perspectives. In the 1970s, an American psychologist

John Flanagan proposed a model called the “Quality of Life Scale” (QOLS), originally a 15-item tool that measures 5 conceptual QoL areas: “material and physical well-being”, “relationships with other people”, “social, community and civic activities”, “personal development and fulfillment”, and “recreation” (Flanagan, 1978). Later, in 1991, the “World Health Organization Quality of Life” (WHOQOL) project was initiated whose main objective was to develop a comparable and cross-cultural QoL assessment tool. The analogues of WHOQOL have been used in numerous studies in healthcare field to evaluate the individuals’ QoL (Berkowsky et al., 2017; Bong et al., 2019; Burckhardt & Anderson, 2003; Chan, 2015; Siegel & Dorner, 2017). Another instrument for assessing the QoL is the Quality-of-Life Indicators, a multi-dimensional (8+1) model developed by the European Union (EU) based on academic studies and practical applications. The first 8 dimensions of this model (i.e., “material living conditions”, “productive or main activity”, “health”, “education”, “leisure and social interactions”, “economic and physical safety”, “governance and basic rights”, “natural and living environment”) relate to the ability of citizens to ensure QoL according to their own criteria. The final dimension of the model (i.e., +1), “overall life experience”, expresses the person's perception of QoL (i.e., life satisfaction, emotions, meaning of life). From end users’ perspective, expectancy on QoL expresses the perception on how technology and services can improve the QoL and living environments. When technological advances and innovative services are used correctly and in place, they can improve the overall QoL of end users (Chatterjee & Kar, 2017; van der Graaf & Veeckman, 2014; Yeh, 2017). In other words, making the world smarter with information and technology is the key to improve the QoL and social progress. In line with this notion, smart city concept aims to create sustainable socio-economic prosperity and ultimately improve the living environment for citizens (Atkinson & Castro, 2008; Bestepe & Ozkan, 2019; Neirotti et al., 2014; Yeh, 2017). Based on all these literatures, the following hypothesis is developed:

Hypothesis 8: Intention to Use (ItoU) IoT-based smart city services positively affects users’ expectancy on QoL and living standards.

According to DOI theory, demographics are critical variables affecting users' intention to use an innovation. There are many technology acceptance studies examining the impact of demographics, especially gender, age and education, in the literature (Belanche et al., 2015, 2016; Chatterjee & Kar, 2017; Karahoca et al., 2017; D.-H. Shin, 2017; Yeh, 2017; Ylipulli et al., 2014). As the smart city services could be used as a driver to reintegrate all citizens into society, the acceptance of such services by all demographic groups should be examined more carefully. Therefore, in SCSAM, the researcher used demographic features to better explain the adoption of IoT-based smart city services by end users: the level of education of participants as the control variable and, gender, age, and frequency of use as the grouping variables. In the current study, based on the hypotheses developed here from the relevant literature, the researcher proposed the research model SCSAM depicted in Figure 16. In this research, the researcher is not interested in, for example, the specified cost of a smart city service, the researcher would like to analyze the perception of end-users on the cost of IoT-based smart city services. Similarly, the study does not aim to measure the service quality of a specific technology, just aim to understand how end-users perceive QoS or satisfy from the service quality of smart city applications generally. All the model constructs, such as personal innovativeness, trust, privacy, and quality of life, are based on intentions, perceptions, expectancy, or concerns. As these intangibles are difficult to measure directly, the researcher constructed the model, SCSAM, with latent variables.

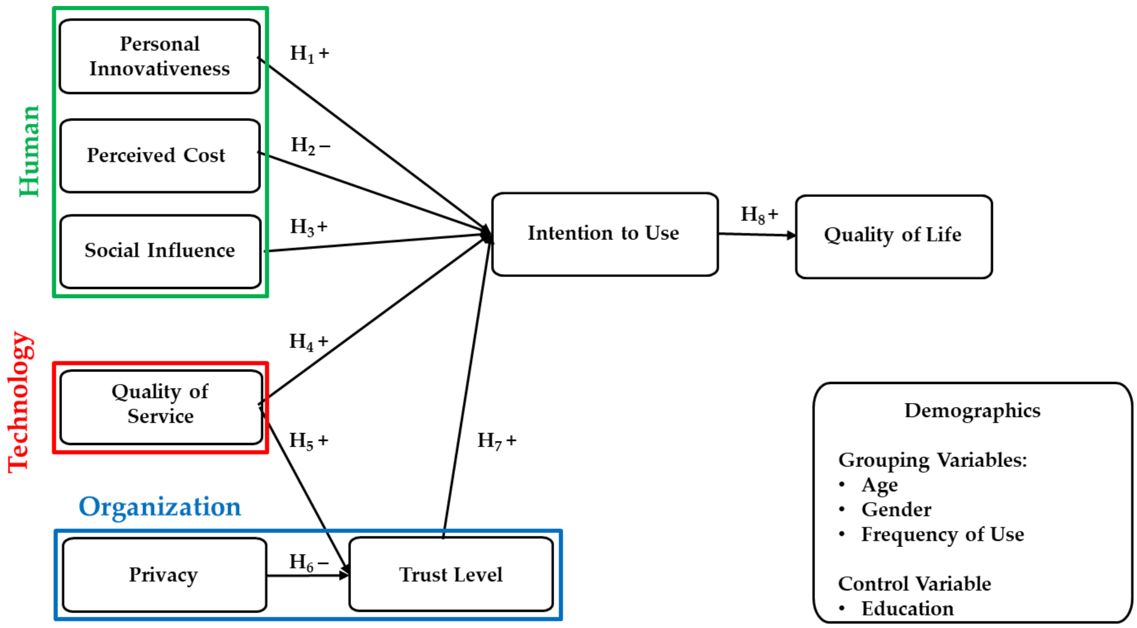


Figure 16: Proposed acceptance model SCSAM

3.6. Chapter Summary

In this chapter, firstly, the explanation of systematic review strategy and the results of this review were given. The resultant studies of literature review on smart city acceptance, IoT acceptance and acceptance of other services were outlined separately. The descriptive review statistics of literature review were also given. By explaining the important and prominent acceptance theories commonly used in the literature, the base for the model development were obtained. Finally, hypothesis development and model construction process, conducted based on the detailed literature review, were explained.

CHAPTER 4

METHODOLOGY

4.1. Chapter Overview

Fourth chapter starts with an introduction part which outlines the overall study step by step from methodological point of view. After the research paradigm and philosophical assumptions of the study are explained, the mixed method approach is described with main aspects. Then sequential explanatory design, which is the adopted form of mixed methods design, is explained in detail. This chapter ends with the description of quantitative and qualitative phases of the study, which are given in the sixth and seventh parts, respectively.

4.2. Introduction

The main purpose of this study is to explore the user motivations from the end-user perspective with an adoption model developed. It is important to carry out the research process systematically in line with the research purpose. In that regard, the research design and methodology are presented in this chapter. The researcher conducted the study in nine steps as outlined in Figure 17. The first two steps, the systematic literature review and model development, were explained in the previous chapter. During systematic review of the literature, the author examined the smart city concept and relevant acceptance studies in the literature. Afterwards, the research model was constructed based on the results of literature review and smart city concept. Then, firstly, philosophical assumptions or philosophical paradigm was defined, and accordingly the research methodology and proper methods were selected in the third step, the design step. According to the sequential explanatory mixed method design, adopted here, quantitative and qualitative phases were conducted, respectively. In step 4, the researcher carried out a pilot study by implementing homogeneous convenience sampling to check the semantics, reliability, and item correlations for quantitative phase. After ensuring the feasibility of the online cross-sectional survey, in step 5, the survey was applied to Turkish citizens, who are mainly living in Istanbul, Ankara and Izmir, and over than 18 years old. Since many similar studies in the literature have been carried out for people over the age of 18, and considering that urban residents under the age of 18 may be restricted in the use of some smart city services, only Turkish citizens over the age of 18 have been determined as the target audience. According to the quantitative results obtained by exploratory and confirmatory factor analysis and SEM in step 6, the qualitative data was collected via semi-structured interviews, in step 7. Afterwards, two different types of qualitative data were analyzed separately by using qualitative data analysis techniques in MAXQDA Plus program in step 8. The qualitative analysis techniques were applied to both the answers to open-ended question asked in the cross-sectional survey and the speech recordings obtained from semi-structured interviews, respectively. And at the final step, the findings of quantitative and qualitative results were reported as well as the the results of triangulation of both findings, together with the discussion section.

Step 1	**Literature Review**	• Examining the smart city concept and relevant acceptance studies • Reviewing the relevant literature systematically and prominent acceptance theories
Step 2	**Model Development**	• Roughly designing the research model based on the results of literature review • Determining the constructs of research model
Step 3	**Design**	• Thinking about the research philosophy and theoretical perspective • Determining the research method (Explanatory Sequential Mixed Method)
Step 4	**Pilot Study**	• Checking the feasibility of quantitative part • Checking the semantics, reliability and item correlations
Step 5	**Quantitative Data Collection**	• Applying online cross sectional questionnaire
Step 6	**Quantitative Analysis**	• EFA, CFA and SEM analyses by SPSS and AMOS
Step 7	**Qualitative Data Collection**	• Carrying out semi-structured interviews based on the quantitative results
Step 8	**Qualitative Analysis**	• Coding the data, reviewing the code and combining the codes into themes MAXQDA Plus
Step 9	**Reporting**	• Findings of quantitative and qualitative results • Triangulation of the quantitative and qualitative findings

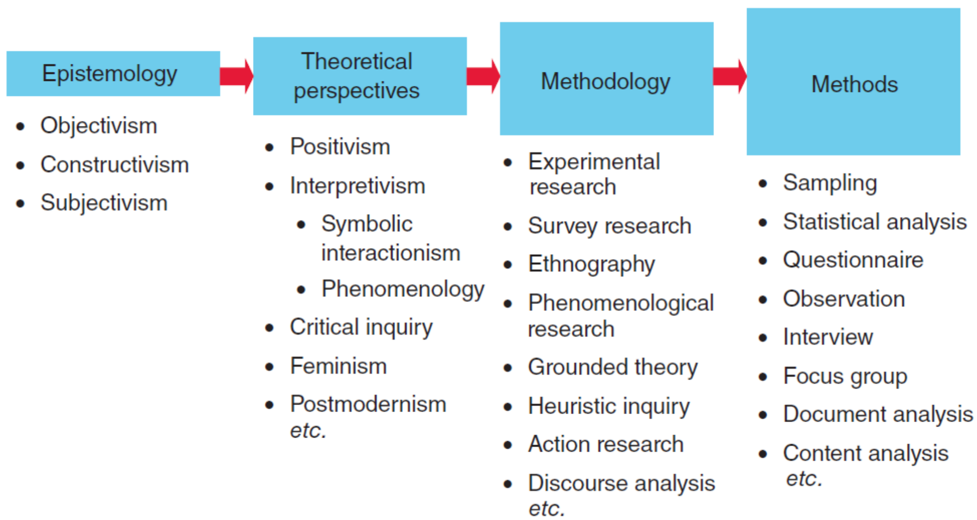
Figure 17: Main steps of the study

Steps 3,4,5 and 7 are explained in this chapter in following sections.

4.3. Research Paradigm

According to Crotty (1998), when designing a study, a researcher should start by thinking about the philosophy of research, examine philosophical assumptions such as epistemology and ontology, and adopt a certain stance against the nature of knowledge (Crotty, 1998). The research paradigm or worldview adopted by the researcher affects every step of the research process, from determining the research problem to the analysis and interpretation of the data (R. B. Johnson & Onwuegbuzie, 2004; Mertens, 2014).

Creswell (1998) defined the research paradigm as "the set of basic assumptions or benefits that drive a research process" (Creswell, 1998). The belief or epistemology, which will form the basis of the entire research process, will also help determine the theoretical perspective (e.g., post-positivism, interpretation, or pragmatism). The connection between the theoretical perspective of the research, utilized methodology and methods, and the researcher's epistemological point of view is shown in Figure 18, that is, the theoretical perspective chosen will shape the research methodology (e.g. grounded theory, ethnography or mixed methods), which can actually be defined as a strategy or action plan (Crotty, 1998). The specified methodology or research strategy includes research methods and procedures for data collection, analysis and interpretation (e.g. surveys or interviews).



Source: (Gray, 2017)

Figure 18: The connection between epistemology and used methods

There have always been efforts to form a common ground between epistemology and theoretical perspectives, in social sciences (Rescher, 1977). Positivism is a theoretical stance tightly linked to objectivism and argues that reality exists in the external world, that is outside of the researcher, and must be studied with a rigorous and scientific approach (Gray, 2017). According to positivism, which is mostly associated with quantitative approaches, scientific research should be based on observable and measurable facts instead of subjective experiences. Positivism and post-positivism, based on objectivist epistemology, use mostly quantitative methodologies including experimental research survey and some designs of Grounded Theory (Bryman, 2007). Conversely, constructivism refuses this perspective, based on human knowledge, and argues that there is no truth and meaning in the external world, but they are constituted through the interaction of the subject with the world. The meaning is not explored but constructed, so even if the subjects are related to the same phenomenon, they can construct their own meanings in different ways. Therefore, there may be multiple, contradictory but equally valid realities. Like the relation between positivism and objectivism, interpretivism is a theoretical perspective linked to constructivism. Constructivism, usually linked with qualitative techniques, has a varied assumption set (Denzin, 2012).

In 1988, Howe proposes the application of pragmatism as a response to the connection between method and epistemology (Howe, 1988). Pragmatism is based on many ideas that used different approaches and valued both objective and subjective knowledge. According to pragmatism, the knowledge value of a thought can be measured by its practical value. From the point of epistemology and ethics, this theory evaluates the value of human thought and knowledge in terms of its practical life. In addition, the concept of pragmatism sees qualitative and quantitative methods compatible with each other and thinks that they can be used together (Howe, 1988). Therefore, some researchers think that pragmatism is proper for the researches on management and organizations and also provide an epistemological reasoning for mixed methods (Onwuegbuzie et al., 2009). Tashakkori and Teddlie (2003) associated pragmatism and mixed method study on the aspects listed below (Tashakkori & Teddlie, 2003):

- It is possible to use qualitative and quantitative techniques together in the same study.
- The research question is more critical than the method, and the philosophical world view underlying the method, and it should be of primary importance.
- For researchers, the feeling that there is no alternative but positivism and constructivism should be abandoned.
- There is no need to use metaphysical concepts such as truth and reality.
- Methodological choices should be made by the guidance of a practical and applied research philosophy.

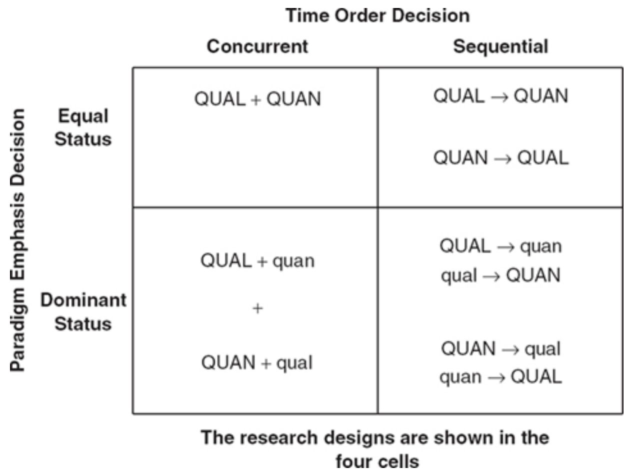
Pragmatism is compatible with positivism in the view that there is an external reality, but a pragmatist also argues that there must be an absolute reality or truth (Creswell, 2013; Tashakkori & Teddlie, 1998). Thus, a researcher adopting a pragmatist approach can be both subjective and objective in terms of his epistemological position. Many authors in the literature see pragmatism as the most appropriate stance for mixed method design (Tashakkori & Teddlie, 2003). So, as a result, the adoption of pragmatism was preferred in the current study, as it is consistent with the use of both quantitative and qualitative methods.

4.4. Mixed Methods

The most fundamental and simplest difference between qualitative and quantitative study is the data type, that is, if the data is in numerical form, it is called as "quantitative", otherwise it is called as "qualitative". Quantitative research evaluates the problem with numerical data that can be statistically analyzed. If it is aimed to generalize the results while measuring variables such as attitude, opinion and behavior, the quantitative research method that requires a larger sample size is preferred (Creswell, 2015). In quantitative research, much more structured data collection methods are used than qualitative research (Smith, 1983). For example, structured surveys can be applied to respondents online, in paper form, via kiosk-like devices, even face-to-face or phone calls. Apart from that, longitudinal studies and systematic observations are some other data collection methods used in quantitative research.

Qualitative study, which is a type of research whose primary purpose is to explore the underlying causes, ideas and motivations, typically requires a smaller sample size than quantitative analysis (Patton, 1990). The qualitative sample size is typically smaller compared to quantitative research but should be large enough to explain the phenomenon under investigation. According to Glaser and Strauss (1967), if additional perspectives or information are not obtained when more participants are added to the study, it means that saturation has been reached, and ideal sample number of qualitative studies should be the number at this saturation point (Glaser & Strauss, 1967). For phenomenological studies, sample size is suggested as 5–25 by Creswell (1998) and at least six by Morse (1994), however the number of participants required should ultimately depend on when saturation is reached (Creswell, 1998; Morse, 1994). Qualitative analysis, especially in mixed design, is used to reveal trends in behavior, thinking and opinions and to explain the problem in more detail, provides insights into the problem and helps develop hypotheses for quantitative research (Creswell & Clark, 2017).

When quantitative or qualitative methods alone are not sufficient to capture the details and provide a satisfactory explanation to the research problem, mixed methods might be preferred, because using quantitative and qualitative methods together can provide more complete and powerful analysis thanks to the strengths of both methods (Greene et al., 1989; Tashakkori & Teddlie, 1998). Considering that quantitative research method is used much more frequently in technology adoption and information systems (IS) fields and, it is clear that the benefits of the mixed method approach are not sufficiently used in this field. One can define mixed methods as procedures that require gathering, analyzing and combining both quantitative and qualitative data in the same study to better understand the problem and find more reliable answers to research questions (Tashakkori & Teddlie, 2003). In addition to being practical and intuitive, mixed methods have the main advantage that the strengths of a method used can support the disabilities of other one. Also, using multiple data sources and methods makes it possible to gain more evidence and a deeper understanding of a problem. In this way, it provides results that can be evaluated together and obtained from different points of view regarding the underlying cause of the problem (Creswell & Clark, 2017). In the literature, there are dozens of different designs on mixed methods (Tashakkori & Teddlie, 2003) and nine of them are as presented in the matrix in Figure 19. This matrix shows which phase, i.e., qualitative (Qual) or quantitative (Quan), is performed at which stage, and which phase is dominant. Capital letters in the matrix below indicate dominance, while the "+" sign means concurrent, and "→" means sequential.



Source: (R. B. Johnson & Onwuegbuzie, 2004)

Figure 19: Matrix of mixed methods design

On the other hand, Creswell et al. (2003) identified six most frequently used mixed method designs (Creswell, 2003), three of which are sequential and the other three are concurrent design, as given below:

1. “sequential explanatory design (QUAN → qual)”
2. “sequential exploratory design (QUAL → quan)”
3. “sequential transformative design” (moving between phases with no clear priority)
4. “concurrent triangulation strategy (QUAN + QUAL)”
5. “concurrent nested strategy” (quantitative in qualitative, or oppositely)
6. “concurrent transformative strategy” (concurrent phases with no clear priority)

Then, Creswell and Clark (2006) advanced a classification including four main mixed method designs, each with different variants (Creswell & Clark, 2006). The 4 primary mixed methods designs are:

- “Triangulation Design”
- “Embedded Design”
- “Explanatory Design”
- “Exploratory Design”

Triangulation Design is very well-known mixed methods approach among the researchers and is used very common. The aim of using this design is to gather diverse but complementing data on the same subject and resolve the research question ideally (Morse, 1991) by combining quantitative methods (large sample size but generalizable results) and qualitative methods (few participants but in-depth understanding) with their strengths (Patton, 1990). Triangulation Design is also referred to as "concurrent triangulation design" because it has a single phase where researchers apply qualitative and quantitative methods in the same time period and equally weighted. There are four variants of this design: “the convergence model”, “the data transformation model”, “the validating quantitative data model”, and “the multilevel model” (Creswell & Clark, 2006). The first two models differ at the timing that the researcher tries to combine the two types of data (while interpretation or analysis), the third one is employed to enhance findings of a questionnaire, and the fourth is employed to study different levels of analysis (Creswell & Clark, 2006).

Embedded Design is a mixed method in which another dataset, which has an auxiliary role, is used to support the main data type of the study (Creswell et al., 2003). This design is generally suitable for studies where a single dataset is not enough and there are diverse research questions that require different data types. Embedded Design is the mixing of a data type within the work framed by another data type at the design stage (Caracelli & Greene, 1993). This design, in which quantitative and qualitative data are analyzed together to explain diverse research problems in the study, can be carried out in one or two stages (Hanson et al., 2005). Although there are many variants of Embedded Design, the experimental model and the correlation model are the most common.

In two-phase Exploratory Design, which is also called as the Exploratory Sequential Design, the quantitative method is developed or supported using the results of qualitative method in the first-phase (Greene et al., 1989). This design is used in situations that require exploration, such as the absence of measures or instruments, unknown variables, lack of guiding framework or theory. Since qualitative analysis is done at the first stage, exploratory design is the most appropriate approach to discover a phenomenon (Creswell et al., 2003). This design initiates with qualitative phase to explore a phenomenon, later moves on to the quantitative phase. Since it starts with qualitative analysis, more weight is usually assigned to qualitative data. Two common variants of this design are the “instrument development model” and the “taxonomy development model”, and both begin with a qualitative stage and end with a quantitative stage, but the difference is the weights of the two methods, and how the researcher connects the two phases (Creswell & Clark, 2006).

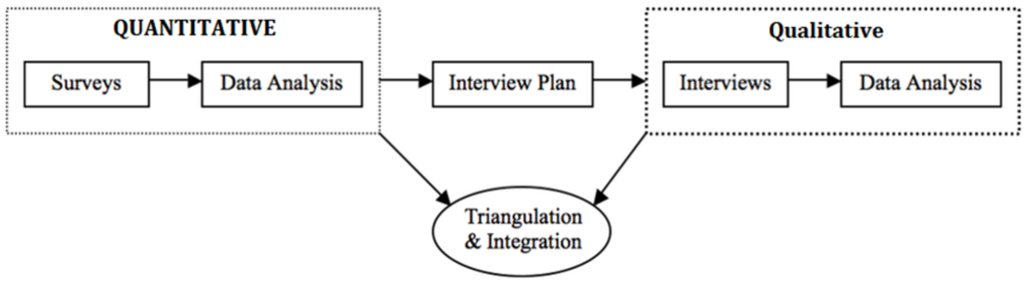
The fourth and the last type of mixed methods design is Explanatory Design. Similar to Exploratory Design, it has two sequential steps and is used in situations where the results of the first phase (here, it is quantitative) are intended to help construct or support the second phase (here, it is qualitative) (Creswell & Clark, 2006). Since the Explanatory Design is used in this research, this approach is described in detail in the next section.

In a study, the researcher must adopt a research design that best meets research requisites. According to the adopted design, the purpose of the mixed method is either to reveal different insights by examining the same phenomenon from different angles with different methods, or to use the other method to improve and verify the structures used in a method, or both (Creswell & Clark, 2017). The mixed method approach is not the method in which quantitative and qualitative studies are conducted separately (Wu, 2012), contrarily, it is necessary to establish a link between the two phases and integrate the findings in some way (Tashakkori & Creswell, 2007). So, the mixed method designs are generally not easy to implement, even if they are popular and easy looking. During the implementation of the method, various methodological difficulties can challenge researchers, such as whether the quantitative or qualitative phase will be prioritized or weighted, at which stages the qualitative and quantitative analyses will be linked, and how to integrate the results more accurately and effectively (Creswell et al., 2003; Morgan, 1998).

Integration of quantitative and qualitative data sets, i.e. data triangulation, might be the most critical part of the mixed methodology (Creswell & Clark, 2017). As a simplest definition, triangulation is the utilization of more than one methodologies or datasets together, and it is used to add exactness, deepness, complexity, and richness to a study (Creswell & Clark, 2017). However, while implementing triangulation, a researcher does not necessarily aim to cross-validate or cross-check dataset from different sources or methods and approving it is right or not, but rather to seize the same phenomenon from diverse perspectives. The primary aim is to obtain better understanding on researched problem from diverse viewpoints and reinforce the researcher's perspectives from different aspects (Creswell & Clark, 2017). Actually, using multiple methods to collect and analyze data on the same phenomenon contribute to assure the research validity. According to Merriam and Tisdell, a researcher could triangulate more than one data collection methods, data sources, investigators or theories to strengthen the internal validity of the study (Merriam & Tisdell, 2015).

4.5. Sequential Explanatory Design

Sequential Explanatory Mixed Methods Design, adopted in this study, is a very straightforward design and illustrated in Figure 20 below (Wu, 2012). According to this design, which is very popular among researchers, two consecutive phases, quantitative and qualitative, are implemented respectively. In the first phase, quantitative data is collected and analyzed, then, the qualitative phase is built and applied based on the quantitative results that need to be explained in more detail (Creswell et al., 2003; Tashakkori & Teddlie, 1998). Therefore, in this type of design, the qualitative stage mostly depends on quantitative results. Thanks to the different but connected phases, it is aimed to reveal different inferences that support or explain each other better by evaluating the same phenomenon with different methods and perspectives. A researcher usually prefers this design when he or she needs qualitative data to explain significant or insignificant but valuable findings, outliers, or unexpected results of quantitative analysis (Morse, 1991). This design can also be used when groups based on quantitative results are to be created and groups are required to be handled next trough qualitative study (Morgan, 1998; Tashakkori & Teddlie, 1998) or when qualitative stage participants need to be determined by purposeful sampling from quantitative participants characteristics (Creswell et al., 2003). Since this design starts with quantitative analysis, the quantitative phase is more dominant in overall analysis. Although there is a qualitative part after the quantitative part in both versions of Explanatory Design ("follow-up explanation model" and "participant selection model"), the difference is in the way the two phases are connected. While the follow-up explanation model concentrate on the findings to be analyzed in more detail, the participant selection model focuses on the selection of appropriate participants (Creswell & Clark, 2006).



Source: (Wu, 2012).

Figure 20: Explanatory sequential mixed methods design

According to Creswell and Clark (2017), the strengths and weaknesses of the explanatory design are given below (Creswell & Clark, 2017):

Strengths:

- There is no need for a research team to carry out the design, because the two stages are not concurrent and just one data type is gathered at each phase, so its implementation is quite easy.
- Reporting results for similar reasons is two-step and therefore easy. It is also more convenient for readers to understand the results.
- It can be used comfortably in both multi-stage research and single mixed method studies.
- It appeals to quantitative researchers due to the dominance of the quantitative phase.

Weaknesses:

- It takes a long time to implement and complete the two phases. The qualitative part could require more time than the quantitative part, even if the number of participants may be limited.
- In both stages, it should be decided whether to use the same individuals, different individuals from the same sample, or the same population but different individuals from a different sample.

- Until the first findings are obtained, it may not be determined how the participants will be selected for the second stage, so there may be difficulties in obtaining the approval of the Ethics Committee.

4.6. Quantitative Phase of the Study

After the cross-sectional survey methodology was decided to collect the data, a structured questionnaire was prepared in the study. An online questionnaire based on a 5-point Likert scale between 1 ("strongly disagree") and 5 ("strongly agree") was applied to test the hypotheses and quantitatively validate the proposed SCSAM model. In the literature, the five-point Likert-type scale is accepted as the most appropriate scale in making the answer levels easily determinable and reducing the bias in the answers (Allen & Seaman, 2007; Krosnick & Presser, 2010; Schrum et al., 2020). The survey is composed of 4 parts. In the first part, preliminary information was given to the participants on issues such as volunteerism, the purpose of the study and data privacy. In the second part, information on demographic features of the participants, such as age, gender, education level, total household income, living city and their use of smart city services, were collected by asking 6 demographic questions to the participants. In the third part, 36 closed-ended questions about the model were asked. The model constructs and their items, which were taken from relevant literature, adapted to the smart city concept. In the last part, 1 open-ended question was asked to the participants in order to enable them to describe the variables that influence the usage of smart city services positively or negatively in their own words. Since this research was limited with only Turkish citizens in Turkey, a professional translator, who is familiar with the field of informatics, translated the main questionnaire used in this study into Turkish.

The smart city concept covers a wide range from e-Gov applications to traffic flowing with autonomous vehicles. So, it would be very challenging for the people to evaluate smart city services as a whole. Therefore, in this study, the acceptance of only IoT-based smart city services was examined. In order to increase the participants' awareness of relevant technologies and services, IoT-based smart city services were explained in the first part of the questionnaire with the illustrative images. Questions for the demographics were also in the first section. Items to explore the acceptance of IoT-based smart city services were surveyed in the second part.

4.6.1. Focus Group Reviews

After defining the items initially for each construct, the construct validity and items were tested by focus group technique. The experts in the focus group were chosen from academicians and researchers studying on technology acceptance. The opinions of academicians and researchers experienced on technology adoption and information systems were consulted and the construct validity was tried to be ensured. The table given in Appendix A was sent to ten experts in excel file format and they were asked to evaluate items appropriateness for the research framework. Seven of them responded to the researcher's request. The main points retrieved from expert reviews are listed below:

- The items of Innovation Concept and QoS are confused with each other.
- The problematic items are mostly belonged to Innovation Concept, QoS and QoL.
- The items of Perceived Trust and Security might be confused with each other.
- The explanations of some items are either very long or unnecessary.

4.6.2. Pilot Study

Based on the experts' comments and recommendations, some constructs and items were revised. The author decided to modify problematic items criticized by most of the experts consulted before the pilot study. After obtaining the approval of "Human Research Ethics Committee" of Middle East Technical University (METU) (Appendix B), a pilot study was carried out by applying homogeneous convenience sampling. The questionnaire used in this pilot study is given in Appendix C. For the pilot study, 55 people with different demographics were conveniently sampled to represent the target population of the main survey as graphically depicted in Figure 21.

The reliability statistics of the pilot study is summarized in Table 4 below. As seen from this table, all Cronbach's alpha values are above 0.7 and that implies that all constructs are satisfying reliability criteria. Based on the feedback from the focus group and the pilot study, some minor changes on items, mostly in wording, were made. Thus, the model structures and items were finalized and the questionnaire to be applied to the target population in the next step was obtained. Constructs and items of main survey and finalized version of main questionnaire are given in Appendix D and E, respectively.

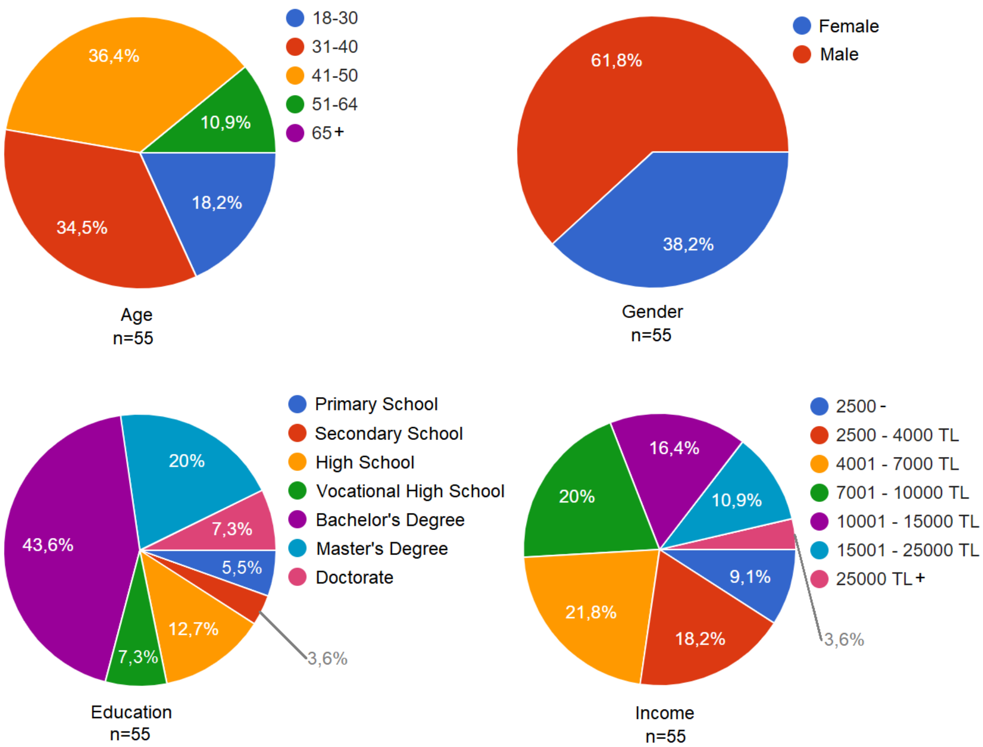


Figure 21: Demographics of respondents in pilot study

Table 4: Cronbach's Alfa values of model constructs in pilot study

	Number of Items	Cronbach's Alfa
Quality in Use	7	0.874
Social Norm	4	0.886
Personal Innovativeness	4	0.825
Cost	4	0.902
Privacy Concerns	4	0.931
Trust Level	6	0.836
Intention to Use	4	0.947
Quality of Life	3	0.964
Total	36	

4.6.3. Sample Size

There are several rules-of-thumb in the literature for evaluating the adequate sample size for SEM analysis. A simple and widely accepted rule of thumb is 10x as the lower bound for an adequate sample size, where x represents the number of observed variables. There are some others, such as 50+3x, 50+5x or 50+8x. Additionally, if the data are not perfectly well-behaved, then increasing sample size as 15 cases per measured variable in SEM would be reasonable (Bentler & Chou, 2016). The a-priori sample size calculator for SEM, that the researcher used, gave the minimum sample size to 444 when the expected effect size was 0.2, the required level of statistical power was 0.8, the number of latent variables was 8, the number of observed variables was 36, and the probability level was 0.05 (Soper, 2020). So, the researcher aimed to achieve 500 respondents with 50% response rate at least.

4.6.4. Main Survey

The author preferred online questionnaire technique and used Google Forms to conduct main survey to simplify the data preparation and analysis. The welcome page of the online survey is presented in Figure 22. At the very beginning of the questionnaire, participants were informed that participation in the survey is entirely voluntary, the data to be collected will be kept strictly secret and will be processed by only the researchers for purely scientific incentives. In addition, before starting the survey, all participants were informed that the survey is mainly aimed at understanding the factors that impact the usage of smart city services by city residents, either positively or negatively, and that it will take approximately 15 minutes. All the participants started answering the questions after this information was given to them and they agreed to participate in the survey of their own free will.

The online survey was distributed randomly to nearly 1000 Turkish citizens, who are over 18 years old and mainly living in Istanbul, Ankara and Izmir, the largest cities of Turkey. Since these cities have been equipped with many IoT-based smart city services for years, all respondents are users of these services or familiar with them at least. In order to ensure the probability sampling, the people, who came to several big shopping centers, supermarkets and hospitals or applied to the information desks there, were asked to participate the questionnaire. The link of online survey was sent to individuals via mobile phone or email, according to their preferences. Two weeks after the survey was sent, a follow-up message was sent to potential respondents over the same channel they initially preferred, to increase response rate. Additionally, some samples of IoT-based smart city services and relevant technologies were illustrated with images in the questionnaire, to increase the respondents’ awareness of the concept. Also, the researcher added an intriguing image to each question in the survey relevant to the content of the question. In this way, the researcher aimed to raise participants' interest in the survey, and, as a result, to improve response rate.


Nesnelerin İnterneti (IoT) Tabanlı Akıllı Şehir Hizmetleri İçin Son Kullanıcı Anketi

* Gerekli

1- Ankete katılım tamamen gönüllülük esasına dayanmakta olup vereceğiniz bilgilerin tamamı gizli tutulacak ve sadece araştırmacılar tarafından tamamen bilimsel amaçlarla analiz edilecektir.

2- Bu anket; Akıllı Şehir Hizmetlerinin vatandaşlar tarafından kullanılmasını olumlu ya da olumsuz etkileyen unsurların anlaşılmasına yöneliktir ve yaklaşık 15 dakika sürmektedir.

3- Söz konusu Akıllı Şehir Hizmetlerinin bazı örnekleri aşağıda görsellerle açıklanmıştır.

4- Her türlü soru, görüş, öneri veya yorumunuzu 505 319 64 18 numaralı telefona veya fbestepe@gmail.com adresine gönderebilirsiniz.

5- Yukarıdaki açıklamaları okuduysanız ve ankete katılmayı kabul ediyorsanız lütfen soruları cevaplamaya başlayınız ve anket bitince gönder tuşuna basmayı unutmayınız.

Figure 22: Initial view of online questionnaire on Google Forms

The researcher obtained 643 responses to the online questionnaire conducted between 8 January and 8 February 2020. The individuals who accepted to join the survey were free to answer the questions on demographics and submit their responses, however the online survey tool Google Forms was configured to not allow submissions with missing data at the questions asked to measure the acceptance of smart city services. So, in the dataset, there was not any submission discarded because of missing data. However, there were three variables with missing values all less than 5% missing, so the researcher replaced missing values with median for ordinal scaled variables and mean for continuous scaled variables. After removing three unengaged responses, a total of 640 valid responses were obtained, that satisfy the criteria in the literature for minimum sample size and sufficient response rate, for SEM analysis. The demographic features of these 640 respondents are outlined in Table 5.

Table 5: Demographic features of main survey respondents

Gender			**Education Level**			**Age**	
	n	%		n	%		
Female	281	43.9	**High school or below**	122	19.1	Mean ±Std	38.0 ±9.6
Male	359	56.1	**Undergraduate and graduate**	363	56.7	Min	18
			Postgraduate	155	24.2	Max	70

4.6.5. Quantitative Analysis Approach

The researcher employed a three-step approach to analyze the empirical data. First, Cronbach's α values were obtained and "exploratory factor analysis" (EFA) was fulfilled to analyze the internal reliability of items and constructs. Then, by CFA, measurement model was tested in terms of reliability and validity (discriminant and convergent validity). Finally, after obtaining satisfactory goodness of fit for measurement model, the researcher analyzed the structural model to test hypotheses and get the path coefficients. For all these analyses the SPSS™ Statistics 25 and AMOS™ 24 tools were used. AMOS™ is a very user-friendly and widely used tool to carry out SEM analysis. As the data set had almost no missing data and satisfied the normal distribution assumptions substantially based on skewness and kurtosis, AMOS™ is an appropriate tool for this study. In addition, the sufficiently large sample size gave the researcher the opportunity to use AMOS™ safely.

4.7. Qualitative Phase of the Study

A qualitative stage was planned to be carried out after the quantitative stage in accordance with the sequential explanatory mixed method design. In this qualitative phase, researcher collected data via semi-structured interviews. Semi-structured interviews make it possible for the participants to explain their opinions on the research subject in their own words and for the researcher somehow to obtain the hidden but relevant information out of their minds. Because people may have information in their minds that cannot be obtained through structured surveys or observations, and one of the ways to access this information is through this sort of interviews (Patton, 2005). Qualitative research, which is not the opposite of quantitative analysis, but a different philosophy, which can be summarized as collecting and statistically analyzing numerical data, involves the collection and analysis of non-numerical data (e.g. audio, video or text) to explore the concepts, ideas or experiences (Creswell & Clark, 2017). In this way, it may be possible to gather in-depth information about the research topic or to reach new ideas for research. The main purpose of performing a qualitative phase here is to understand the quantitative outcomes better and in depth with the help of qualitative data.

4.7.1. Qualitative Design

During the first part of the study, the researcher analyzed the quantitative data to achieve the statistically significant results. In this qualitative phase, the quantitative results were tried to be explored in more depth with several individuals. Firstly, the researcher decided to analyze the direct effects of independent variables on dependent variables in SCSAM as well as the effect of citizens' demographics on technology acceptance. Thus, the researcher determined what quantitative results needed further and deeper explanation by a qualitative approach.

Purposeful sampling is the selection of participants deliberately among the individuals who know the phenomenon or primary concept under investigation (Creswell & Clark, 2017), and in qualitative research, it can be used to select individuals who can supply the needed data to explore the main topic (Palinkas et al., 2015). Among the strategies for purposeful sampling, the researcher used "maximal variation sampling", in which a variety of people are expected to have diverse viewpoints on the subject under study, in this research. The main idea is that if the respondents are selected purposefully in diverse profiles, a good study will be obtained in which the views will reflect different perspectives and examine all aspects of the phenomenon (Palinkas et al., 2015). The criteria for maximizing differences depend on the study and the strategy chosen. In this research, the maximal variation sampling was applied strategy based on gender, education level and total income to differentiate participants at the highest level.

4.7.2. Semi-Structured Interviews

There are many ways researchers can collect qualitative data, such as "open-ended interviews" (e.g., "one-on-one interviews", "phone calls", "online e-mail interviews", "focus groups"), "open-ended observations", documents, text messages, blogs, wikis, twitter, and audio-visual materials (e.g., videos, photos, sounds). Some types of qualitative data may be determined before a study initiates, while others arise in the course of the process. Here in this study, the researcher decided to have two different forms of qualitative data, both of which were determined initially. The first form is the responses obtained from the participants to open-ended question in the survey. One of the most basic ways to obtain qualitative data is to ask participants open-ended questions without predetermined categories or scales (Creswell & Clark, 2017). The second form is data obtained from the semi-structured interviews.

For the semi-structured interviews, an interview protocol was prepared as presented in Figure 23 in order to help the researcher to control the flow of dialog with the interviewee and to conduct the interviews in harmony with each other. It was not deemed necessary to organize an observation protocol, since the meetings were planned to be held with the video-conference method and to record both audio and video with the consent of the participants.

DD/MM/YY

1. Interviewer information

(Name, Surname)

The interviewer was the Author.

2. Interviewees' information

(Age, Gender, Education Level, Total Income, Usage Experience of Smart City Services)

The interviewees, chosen among the main survey respondents who accepted to participate semi-structured interviews.

3. Instructions for the interviewer

Introductory speech, a brief summary of the research, obtaining consent for recording.

4. The open-ended questions

The pre-defined questions based on the quantitative findings.

Some probing questions when needed.

5. Final and overall remarks about the topic under research

6. Final speech

Thank you statement for the cooperation and participation.

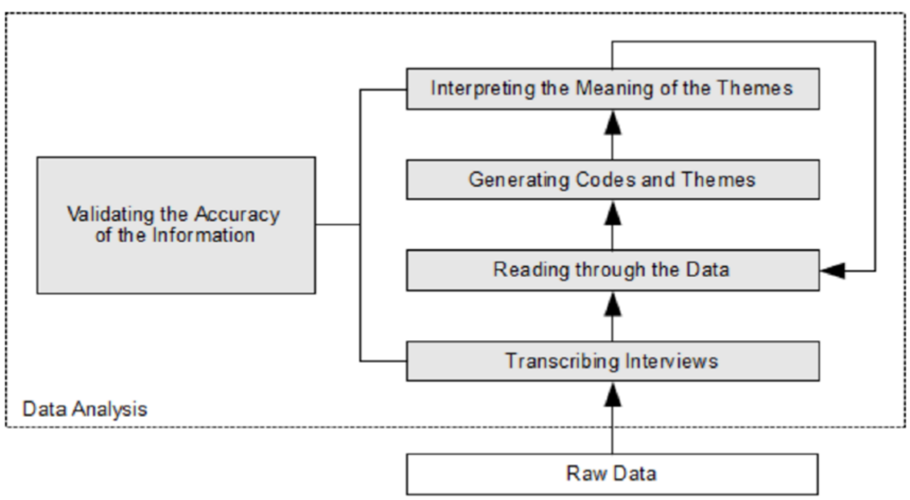
Figure 23: Interview protocol

As the researchers have to get the permission of the authorized boards, the approval of Human Research Ethics Committee of METU (Appendix F) for the questionnaire including the open-ended question was obtained in November 2019. After determining the open-ended questions as given in Appendix G, the researcher also got the approval of Human Research Ethics Committee of METU for one-on-one semi-structured interviews in November 2020, as well. Such boards and ethics committees have been set up to protect the rights of participating individuals and to assess the potential risks and harms of the research to these individuals. Researchers should not provide study outcomes if consent of participants has not been obtained before data collection begins. In this study, after 10 participants determined for semi-structured interviews were fully informed about the study, their voluntary approvals were obtained for participation.

The interviews were conducted over the Zoom videoconferencing platform (Zoom) due to the Covid-19 outbreak, except for one participant who stated that he/she could not use the Zoom. Archibald et al. (2019) recommend Zoom's applicability as a qualitative data collection tool due to its relative easiness, low costs, data security and management features (Archibald et al., 2019). Despite some potential technical difficulties, interviews via Zoom were generally found to be quite satisfactory by interviewees compared to other interviewing tools such as face-to-face, phone and other video conferencing applications (Archibald et al., 2019). During the interviews over the Zoom, audio and video recordings were made with the knowledge of the participants, and the researcher informed the participants that the recordings would be kept in secure folders and would remain confidential.

4.7.3. Qualitative Analysis Approach

Process of qualitative analysis is depicted in Figure 24. The process starts with the transcription of raw data such as audio or video recordings and notes etc. Later, the transcribed data is read several times to ensure accuracy of the information and spelling errors are corrected. Then, the researcher creates the codes and themes and interprets their meanings. Reading and interpretation process continues cyclically till all the statements are assigned with codes and themes.



Source: (Creswell, 2003)

Figure 24: Flow diagram of qualitative analysis process

The qualitative data encoding process can be explained as the definition of data segments under more general idea, situation, theme or categories (Creswell et al., 2007). A priori coding is not recommended because it starts with pre-defined codes and is therefore restrictive (Creswell et al., 2007). For this reason, open coding approach was adopted at this stage of the study.

In addition to the content analysis, the data were reviewed and compared repeatedly in accordance with the constant comparison method (Leech & Onwuegbuzie, 2007). Memo-writing is the writing out of all kinds of information by interviewer during the interview, in addition to the interview content. The memo-writing technique might be conducted by re-listening or analyzing the interview recordings after interview. Anecdotal information, new ideas, possible new questions, possible results and emerging patterns were recorded by memo-writing (Charmaz, 2008). Code is actually the context of a statement (i.e. word, line, sentence, or paragraph) included in the interview transcripts. These codes make up the themes. The researcher used MAXQDA Plus™ software, a powerful qualitative data analysis tool, to evaluate and interpret semi-structured interview recordings. While coding with this software, coding methods such as first coding, sentence coding and line by line coding were used (Charmaz, 2008).

First, the answers corresponding to the main and sub-questions of the research were transcribed. Each interview record was carefully transcribed, and spelling errors were corrected, by listening repeatedly, and finalized with the confirmations of the interviewees. After the first stage codes were obtained, a code book containing the important words, patterns, and themes in the interview records was created using the inductive reasoning method (Creswell & Clark, 2017).

Since the reliability and validity of the qualitative study is an issue that is always questioned with suspicion, it is possible to find studies that suggest solutions with this issue in the literature (Burns, 2000; Lincoln & Guba, 1985; Recker, 2013). Practical guidelines for qualitative study and interview protocols could contribute to the validity of the qualitative study (Creswell & Clark, 2017). In addition, using more than one technique such as note taking, coding (Recker, 2013) and contextual analysis (Mishler, 1991) methods also contribute to qualitative reliability, since it allows cross checking of answers.

To enhance the trustworthiness of the qualitative data, four conditions-criteria were proposed: "credibility", "transferability", "dependability", and "conformability" (Lincoln & Guba, 1985; Recker, 2013). In a qualitative study, when the same observations and data are presented to individuals other than researchers, it can be said that the dependability requirement is met if they achieve the same or at least similar results. This requirement, which can also be expressed as inter-rater reliability, is actually the consistency of judgments regarding the data (Creswell & Clark, 2017). In this study, codes and themes were reviewed by 2 independent researchers. Independent and experienced researchers were asked to review the codebook and encode a participant transcript that was submitted to each. When the encoded transcripts from 2 independent researchers were compared and discussed, it was seen that the coding structures were sufficiently like that of the author.

Credibility, which is related to the internal validity of research results, is related to whether the researcher can present sufficient evidence from different sources in qualitative data analysis. Triangulating and keeping clear notes on the codes and themes identified throughout the research are approaches that will help ensure credibility. In this study, in addition to the interview contents, the notes taken regarding the interview environment, the interviewee's state and attitude during the interview, and context analysis were analyzed by triangulation. By this way, the credibility of the qualitative data was tried to be achieved.

For qualitative data, confirmability is a rule relevant to that qualitative outcomes can be independently confirmed by individuals in a situation to validate the outcomes, such as interviewed individuals. Although this verification is mainly done through the outlines of interviews, it can also be done by examining qualitative analysis results or other inferences from qualitative data. In this study, the researcher shared the transcription and findings with a total of two interviewees, a female and a male randomly selected from among 5 female and 5 male interviewees (interviewee 5 and interviewee 9), and they were requested to confirm that the codes and themes, that the researcher developed, were valid (Corbin & Strauss, 2014). Both participants provided feedback to verify whether the codes obtained from their interviews reflect their perspectives and are appropriate.

4.8. Chapter Summary

In this chapter, firstly, a brief introduction was given to outline the overall methodology thoroughly applied during study. Then the philosophy of the research was explained from epistemological point of view. General aspects of mixed methods and, sequential explanatory design, which is mixed methodology adopted in this study, were explained in detail in fourth and fifth parts, respectively. Later, quantitative analysis, which is the first stage of sequential explanatory mixed methods design, was outlined. And finally, Chapter 4 ended with the description of qualitative analysis, the latter stage of the methodology.

CHAPTER 5

RESULTS

5.1. Chapter Overview

In this chapter, the results of both quantitative and qualitative analyses are given in second and third parts, respectively. The results of quantitative phase are outlined under three main subsections: EFA, CFA and structural model. There are two sub-sections under part three, explaining the findings of qualitative analyses, conducted over two different qualitative datasets.

5.2. Quantitative Analysis

Quantitative method can be defined as the objective measurement, and statistical and numerical analysis of data collected through instruments such as voting, query and survey (Muijs, 2011). The main purpose of quantitative research is to explain a particular phenomenon with the inferences obtained from the numerical data collected and to generalize the findings for the main population (Babbie, 2010; Muijs, 2011). In this section, the stages of quantitative analysis applied to the main survey data are explained step by step.

5.2.1. Exploratory Factor Analysis

The researcher started quantitative analysis by checking normality of the data. The sample size of the research was highly large enough and main survey dataset satisfied the normal distribution assumptions according to skewness and kurtosis values. It is difficult find an official rule for the normality check based on skewness and kurtosis. Mostly, the skewness and kurtosis values outside the range of -2 and +2 are considered as an indicator of “non-normal univariate distribution” (George & Mallery, 2010). However, there are other studies in the literature claiming that data is assumed as normal if skewness is between -2 to +2 and kurtosis is between -7 to +7 (Byrne, 2010; Hair et al., 2010). Additionally, in order to assess multivariate normality which is required in factor analyses, Curran et al. (1996) suggest the same moderate normality thresholds of 2.0 for skewness and 7.0 for kurtosis (Curran et al., 1996). Based on these studies mentioned, none of the items in the data set had skewness and kurtosis issue, and so normality condition was satisfied for the dataset.

The dataset had almost no missing data, so in the next step of the quantitative analysis, construct reliabilities were tested. The Cronbach's α value, which is an internal consistency measure and considered "acceptable" of 0.70 or above, was higher than 0.80 for all the constructs, as listed in Table 6. These results suggest that the items in each construct are closely related and have relatively high internal consistency. Only the items of SI produced too high Cronbach's α value (0.98) implying some redundancy, but the researcher did not see it as a major problem at this stage.

Table 6: Construct reliabilities

Construct	**Cronbach's Alpha**
Personal Innovativeness – PI	0.84
Perceived Cost – COS	0.87
Social Influence – SI	0.98
Quality of Service (Usability) – QoS	0.84
Privacy Concern – PC	0.93
Perceived Trust – PT	0,84
Intention to Use – ItoU	0.93
Quality of Life – QoL	0.93

During the "Exploratory Factor Analysis" (EFA), first, the appropriateness and adequacy of the sampling data were tested by KMO ("Kaiser-Meyer-Olkin") test and obtained KMO measure of sampling adequacy as 0.882, which implies the sufficiency of the sampling data. In the "Principal Component Analysis" (PCA) in EFA, the researcher used 8 components as defined in the initial construction of the theoretical model and achieved 72.15% explained total variance. Additionally, in EFA, a very good structured and clear Pattern Matrix was obtained by using PCA as extraction method and Promax with Kaiser Normalization as a rotation method. This pattern matrix was completely matching with the theoretical design of the model with 8 components. The factor loadings of all the items in the pattern matrix were above 0.70 for their own constructs as listed below in Table 7. There was not any item in pattern matrix having a cross-loading greater than 0.40. These results imply that all items load more highly on their own construct than on others.

Table 7: Factor loadings and composite reliabilities

Construct	Item	Factor Loading
Personal Innovativeness	PI1	0.765
	PI2	0.884
	PI3	0.835
	PI4	0.776
Perceived Cost	COS1	0.893
	COS2	0.793
	COS3	0.894
	COS4	0.802
Social Influence	SI1	0.892
	SI2	0.923
	SI3	0.898
Quality of Service	QoS4	0.852
	QoS5	0.812
	QoS6	0.901
Privacy Concerns	PC1	0.867
	PC2	0.944
	PC3	0.899
	PC4	0.904
Perceived Trust	PT4	0.891
	PT5	0.953
	PT6	0.742
Intention to Use	ItoU2	0.847
	ItoU3	0.910
	ItoU4	0.898
Quality of Life	QoL1	0.713
	QoL2	0.948
	QoL3	0.910

5.2.2. Confirmatory Factor Analysis

Based on the results of CFA over the measurement model, in order to meet the required convergent and discriminant validity and overcome the high cross-loading problem, some items of QoS (items 1, 2, 3 and 7), PT (item 1, 2 and 3) and ItoU (item 1) were removed from the dataset. Therefore, QoS, consisting of functionality, reliability, usability, and efficiency dimensions, has essentially turned into QoS-usability. As shown in the same Table 8, the average variance extracted (AVE) values all exceed 0.5 threshold value.

These results, together with the proper factor loadings, indicate that measurement model has adequate convergent validity. Additionally, all inter-construct correlations are smaller than the square root of corresponding AVE, the diagonal entries of the matrix given in Table 8. In Table 9, together with the factor loadings in the measurement model, the composite reliability values, indicator of internal consistency, calculated for each construct are given, and as it can be seen, all composite reliability values were greater than the 0.70 cutoff. This fact means that each construct is more strongly related to its own than to others. In other words, constructs in the measurement model are different, and this means that all constructs have sufficient discriminant validity. The results of multi-collinearity check are summarized in Table 10. And as seen from Table 11, all fit indices indicate that the measurement model fits the data perfectly. All these results show that convergent validity and discriminant validity are provided, no problem of multi-collinearity exists, and SEM analysis could be conducted safely.

Table 8: Correlation matrix and reliability analysis by AVE*

	1- PT	**2- PC**	**3- COS**	**4- PI**	**5- ItoU**	**6- SI**	**7- QoL**	**8- QoS**	**AVE**
1- Perceived Trust (PT)	**0.79**								**0.62**
2- Privacy Concerns (PC)	-0.39	**0.88**							**0.77**
3- Perceived Cost (COS)	-0.22	0.39	**0.80**						**0.64**
4- Personal Innovativeness (PI)	0.30	-0.06	0.03	**0.74**					**0.55**
5- Intention to Use (ItoU)	0.52	-0.08	-0.16	0.44	**0.91**				**0.83**
6- Social Influence (SI)	0.36	0.00	-0.06	0.40	0.54	**0.91**			**0.82**
7- Quality of Life (QoL)	0.42	-0.04	-0.14	0.36	0.72	0.56	**0.91**		**0.82**
8- Quality of Service (QoS)	0.39	-0.07	-0.12	0.55	0.48	0.58	0.54	**0.81**	**0.65**

* The diagonals are the square roots of AVE.

Table 9: Measurement model factor loadings and composite reliabilities

Measurement Model		
Factor Loadings		Composite Reliability
PT4	0.752	0.83
PT5	0.735	
PT6	0.863	
PC1	0.857	0.93
PC2	0.935	
PC3	0.829	
PC4	0.877	
COS1	0.843	0.87
COS2	0.637	
COS3	0.912	
COS4	0.775	
PI1	0.773	0.83
PI2	0.708	
PI3	0.764	
PI4	0.707	
ItoU2	0.913	0.94
ItoU3	0.928	
ItoU4	0.897	
SI1	0.856	0.93
SI2	0.950	
SI3	0.910	
QoL1	0.827	0.93
QoL2	0.938	
QoL3	0.943	
QoS4	0.710	0.85
QoS5	0.823	
QoS6	0.872	

Table 10: Summarized results of multi-collinearity check

Multi-collinearity Check (Gaskin, 2021)	
Convergent Validity	Discriminant Validity
No cross-loading higher than 0.4	√AVE > All inter-factor correlations (Table 8)
AVE > 0.5 (Table 8)	No cross-correlations larger than 0.8 (Table 8)
Composite reliabilities > 0.7 (Table 9)	
All factor loadings > 0.6 (Table 9)	

Table 11: Fit indices of measurement model

Fit Indices	Estimates Measurement Model	Recommended Criteria
CMIN ($\chi2$)	619.95	-
df	288	-
$\chi2$/df	2.15	Between 1 and 3
GFI	0.93	>0.90
AGFI	0.91	>0.80
CFI	0.97	>0.95
RMSEA	0.043	<0.060
SRMR	0.037	<0.080

As the author plans to explore the differences between age, gender, and frequency of use groups over structural model with multi-group analysis in AMOS, the measurement model invariances tests were also conducted at this stage. Invariances tests, if satisfied, reveal that there are no significant differences between groups on measurement model, and the differences between groups are not because of the model parameters. In other words, if the invariance tests are met and the results of the multi-group analysis reveal a difference between the groups, then the researcher can safely conclude that the differences between the groups are not due to the model parameters, but that the groups differ significantly from each other (Gaskin, 2021). Therefore, the configural invariance (based on model fit indices) and metric invariance (Chi-square difference test) of the measurement model on the grouping variables were tested and the results are summarized in Table 12. According to the results of the invariance tests, the measurement model met the configural invariance for all grouping variables. However, metric invariance tests for all grouping variables failed. This result emerged as an issue that should be considered when evaluating the results of multi-group analysis.

Table 12: The results of configural and metric invariance tests

Grouping Variable	Configural Invariance Test		Metric Invariance Test			
	Model Fit Indices	Test Result	Chi-square	Degrees of freedom (df)	p Value	Test Result
Gender (Male vs. Female)	CFI = 0.963 SRMR = 0.043 RMSEA = 0.036	Satisfied	1050.8* 1159.6**	576* 603**	<0.001	Failed
Age (⩾ 40 vs < 40)	CFI = 0.964 SRMR = 0.051 RMSEA = 0.035	Satisfied	1038.3* 1092.2**	576* 603**	0.002	Failed
Frequency of Use (High Use vs Low Use)	CFI = 0.960 SRMR = 0.039 RMSEA = 0.037	Satisfied	1068.8* 1173.1**	576* 603**	<0.001	Failed

* : unconstrained model
** : constrained model

5.2.3. Structural Model

The structural model transformed from the measurement model was tested with the same set of fit indices that are listed in Table 13. Model fit indices and required thresholds indicate that the structural model also fits perfectly with data as for the measurement model. The regression weights of perfectly fitted model are given in Table 14. According to the results of SEM analysis, shown in Figure 25, all hypothesized relationships, except for the COS, in the proposed research model SCSAM are significantly accepted. Additionally, standardized residuals could be evaluated as another diagnostic tool of model-fit within the AMOS™. Essentially, residuals refer to individual differences between observed data and data estimated by a model. That is, a better fit model produces smaller residuals. Standardized residuals can be positive or negative and do not depend on the measurement scale, as they are standardized. Typically, standardized residuals with an absolute value of less than 2.5 do not imply any problem. However, standardized residuals higher than 4 imply a potentially unacceptable level of error. In such a case, deleting the relevant item from model could be an appropriate response. In the standardized residual covariance matrix of the model, there is no value greater than 4 and almost all values are less than 2.5. When considered with other model fit parameters, this result indicates that the model perfectly fits into the dataset.

As shown in Table 14 and illustrated in Figure 25, PI (β=0.13, $p<0.01$), SI (β=0.35, $p<0.001$), QoS-usability (β=0.13, $p<0.05$) and PT (β=0.26, $p<0.001$) have positive significant impact on intention to use IoT-based smart city services. However, COS (β=-

0.06, p>0.05) has no significant effect on citizens' intention to use. On the other side, QoS-usability positively (β=0.38, $p<0.001$) but PC (β=-0.36, $p<0.001$) negatively affect PT, as hypothesized initially. Finally, ItoU (β=0.95, $p<0.001$) has very high significant positive impact on citizens' expectancy on QoL. R^2 values show that the model explained 31%, 43% and 47% of the variance in PT, ItoU and QoL, respectively. Based on these results, one has seen that all hypotheses developed and tested in this study are supported by the proposed SCSAM model, except for COS→ItoU.

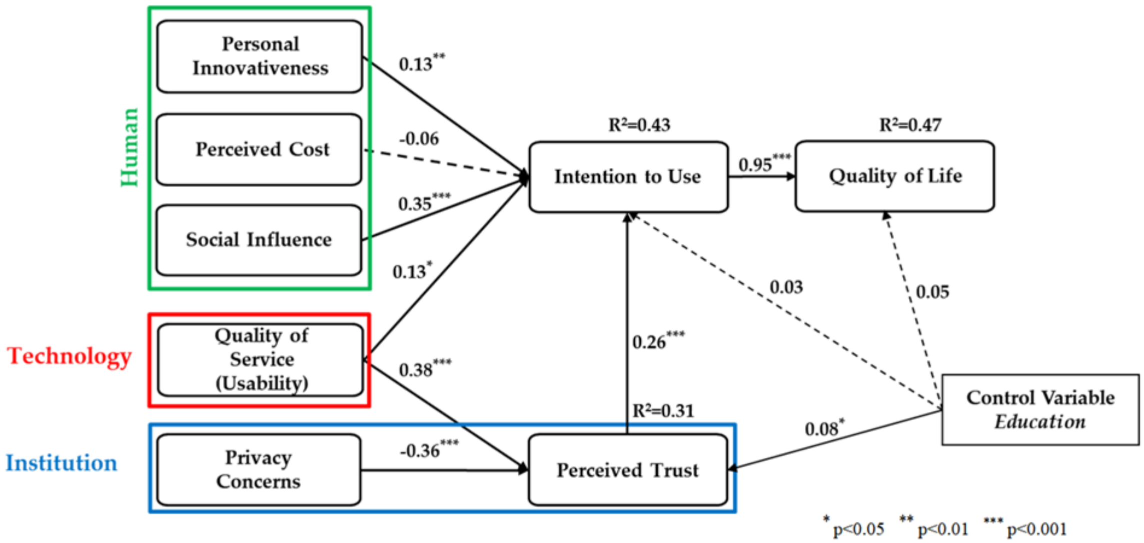


Figure 25: The path analysis for SCSAM

Table 13: Fit indices of structural model

	Estimates	
Fit Indices	**Structural Model**	**Recommended Criteria**
CMIN (χ2)	708.46	-
df	316	-
χ2/df	2.24	Between 1 and 3
GFI	0.93	>0.90
AGFI	0.91	>0.80
CFI	0.97	>0.95
RMSEA	0.044	<0.060
SRMR	0.046	<0.080

Table 14: Path regression weights for structural model

Path			Standardized Regression Weights	Regression Weights (RW)	Standard Error (SE)	Critical Ratio (RW/SE)	p Value
PT	←	PC	**-0.36**	-0.26	0.033	-7.824	**<0.001**
PT	←	QoS	**0.38**	0.41	0.054	7.623	**<0.001**
ItoU	←	PI	**0.13**	0.12	0.037	3.218	**0.001**
ItoU	←	COS	-0.06	-0.05	0.024	-1.912	0.056
ItoU	←	SI	**0.35**	0.35	0.041	8.584	**<0.001**
ItoU	←	QoS	**0.13**	0.15	0.06	2.513	**0.012**
ItoU	←	TL	**0.26**	0.28	0.046	6.17	**<0.001**
QoL	←	ItoU	**0.95**	0.91	0.056	16.145	**<0.001**
QoL	←	Education	0.05	0.02	0.015	1.423	0.155
ItoU	←	Education	0.03	0.01	0.016	0.784	0.433
PT	←	Education	**0.08**	0.04	0.017	2.09	**0.037**

Additionally, PI, SI, QoS-usability, and PT have indirect impact on QoL through the mediation of ItoU, as listed in Table 15. Similarly, QoS-usability and PC indirectly impact on intention to use through the mediation of PT. The results showed only COS does not have any indirect effect on QoL.

Table 15: Indirect effects

Indirect Effect					Estimate	Lower	Upper	p
SI	→	ItoU	→	QoL	0.32	0.23	0.43	**0.001**
PI	→	ItoU	→	QoL	0.11	0.04	0.18	**0.012**
COS	→	ItoU	→	QoL	-0.05	-0.09	-0.01	0.054
PT	→	ItoU	→	QoL	0.25	0.17	0.37	**<0.001**
QoS	→	ItoU	→	QoL	0.15	0.02	0.29	**0.040**
QoS	→	PT	→	ItoU	0.12	0.08	0.18	**<0.001**
PC	→	PT	→	ItoU	-0.07	-0.10	-0.05	**<0.001**

The effect of demographics such as age (senior or junior), gender (female or male) and frequency of use (high use or low use) on the proposed model was tested with AMOS multi-group analysis. The cut-off points are defined as "40" for age (≥40 and <40) and "at least once a week" for frequency of use. Table 16 and Table 17 show the results of chi-square tests on these grouping variables and the results of multi-group analysis, respectively. The analysis to estimate the effects of gender, age and frequency of use on intention to use resulted that neither gender groups nor age groups differ at the model level. Although the groups of frequency of use appeared different at the model level and just the path PI→ItoU had significantly different regression weights between the groups, one should consider that the measurement model metric invariance was not satisfied for the frequency of use, so the difference might not be based on the grouping variable. Additionally, the researcher observed that the education level of the participants, as a control variable, had a significant effect only on PT. However, there was no difference between the groups of age, gender, and frequency of use in terms of the effect of education level on PT.

Table 16: Chi-square tests on the grouping variables

Grouping Variable	$\Delta\chi^2$	Δdf	p Value
Age	17.66	11	0.090
Gender	15.16	11	0.175
Frequency of Use	25.98	11	0.007

Table 17: The results of multigroup analysis

Multigroup Variable	Groups	Significantly Different Path	Standardized Path Co-efficient	p Value
Gender	Female (n=281)	QoS → ItoU	0.039	0.018
	Male (n=359)		0.225	
Age	Senior (n=271)	PT → ItoU	0.205	0.049
	Junior (n=369)		0.299	
	Senior (n=271)	PC → PT	-0.435	0.008
	Junior (n=369)		-0.295	
Frequency of Use	High Use (n=472)	PI → ItoU	0.202	0.029
	Low Use (n=168)		0.022	

5.3. Qualitative Analysis

Quantitative research generally aims to explore the relation between the independent variable and the dependent or outcome variables in a population. However, to get a better picture of a phenomenon, the researcher also needs different types of data that are difficult to measure and reduce to numerical values (Babbie, 2010). Therefore, qualitative analysis carried out with qualitative data focuses on meanings and contains a sensitivity to context rather than obtaining universal generalizations. In other words, qualitative analysis seeks an answer to the "why" and "how" of human behavior. In this respect, quantitative analysis and qualitative analysis cannot be defined as the opposite of each other; they are just different approaches, and when used together, they can provide stronger analysis and useful information (Creswell & Clark, 2017).

5.3.1. Answers to Open Ended Question in Survey

At the end of the questionnaire, the researcher asked an open-ended question requesting the respondents to explain the matters they think were influential in their decision to use or not use these smart city services but were not adequately covered in the survey. 52 out of 643 respondents answered this open-ended question. In the first part of qualitative analysis, the researcher coded and analyzed these unstructured answers via MAXQDA™ 2020 Plus.

Respondents who answered the open-ended question mostly commented on the drawbacks or deficiencies of the IoT-based smart city services (67 out of 94 coded comments in 52 analyzed documents) as presented in Table 18 and Figure 26. Only 11 coded comments are on the benefits of the smart services. The researcher noticed that the respondents focused mostly on how these services save their time (6/11) and make life easier (4/11), as the main benefits of IoT-based smart city services. It is obvious that the respondents used the open-ended question to express their complaints about such services. Accessibility issues and inadequate prevalence (24/94), and deficiencies in QoS (21/94) seem to be the main complaints. Functionality (9/21) and usability (6/21) are the factors of QoS about which the respondents mostly mentioned in negative comments. Other critical issues that respondents cited as the drawbacks of smart services are low levels of trust in these services (7/67), security and privacy concerns (6/67), and the digital divide (5/67). There were also 8 coded comments stating that more training and/or advertising is needed to popularize such services.

As seen from the Table 19, just 19 (36.5%) out of 52 respondents answered to the open-ended question are female and this rate is lower than the rate of females in total respondents (43.9%). Females mostly complain of accessibility problems and insufficient prevalence of smart service; more than a third of all coded comments (12/34) of females are on this topic, and half of the negative comments (12/24) on this issue also belong to female respondents. Another remarkable finding is that females are not happy with reliability of such services (4/5 coded comments on this issue) and have a trust problem about them (4/7 of coded comments on this issue) when compared to males. Correspondingly, they worry about their security and privacy while using smart services (3/6 of coded comments on security and privacy concerns). In addition, the respondents, who answered open-ended question and think that they have to use such services due to lack of alternative, are all female respondents (3/3). Like females, male respondents mostly complain of accessibility problems and insufficient prevalence of smart service (12/60). On the other hand, unlike women, male respondents cited more about functionality (7/60) and usability (5/60) issues and the digital divide (4/60) as the drawbacks of smart systems. In addition, males also focused on training and advertising needs (7/60), as well as the benefits of IoT-based smart city services (10/60), in their comments, and they highlighted the time-saving benefit (5/10) of such services mostly.

Table 18: Code frequencies for the responses to open-ended question

Codes			**Frequency**		
Drawbacks			**67**		
	Accessibility/Diffusion			**24**	
	QoS			**21**	
		Functionality			9
		Usability			6
		Reliability			5
		Efficiency			1
	Low Trust			**7**	
	Security/Privacy Concerns			**6**	
	Digital Divide			**5**	
	Obligation			**3**	
	Interoperability/Integration			**1**	
Benefits			**11**		
	Time Saving (Efficiency)			**6**	
	Easiness (Usability)			**4**	
	Usefulness (Functionality)			**1**	
Training - Advertising Need			**8**		
Supporting			**6**		
Not Necessary			**1**		
QoL			**1**		
Total			**94**		

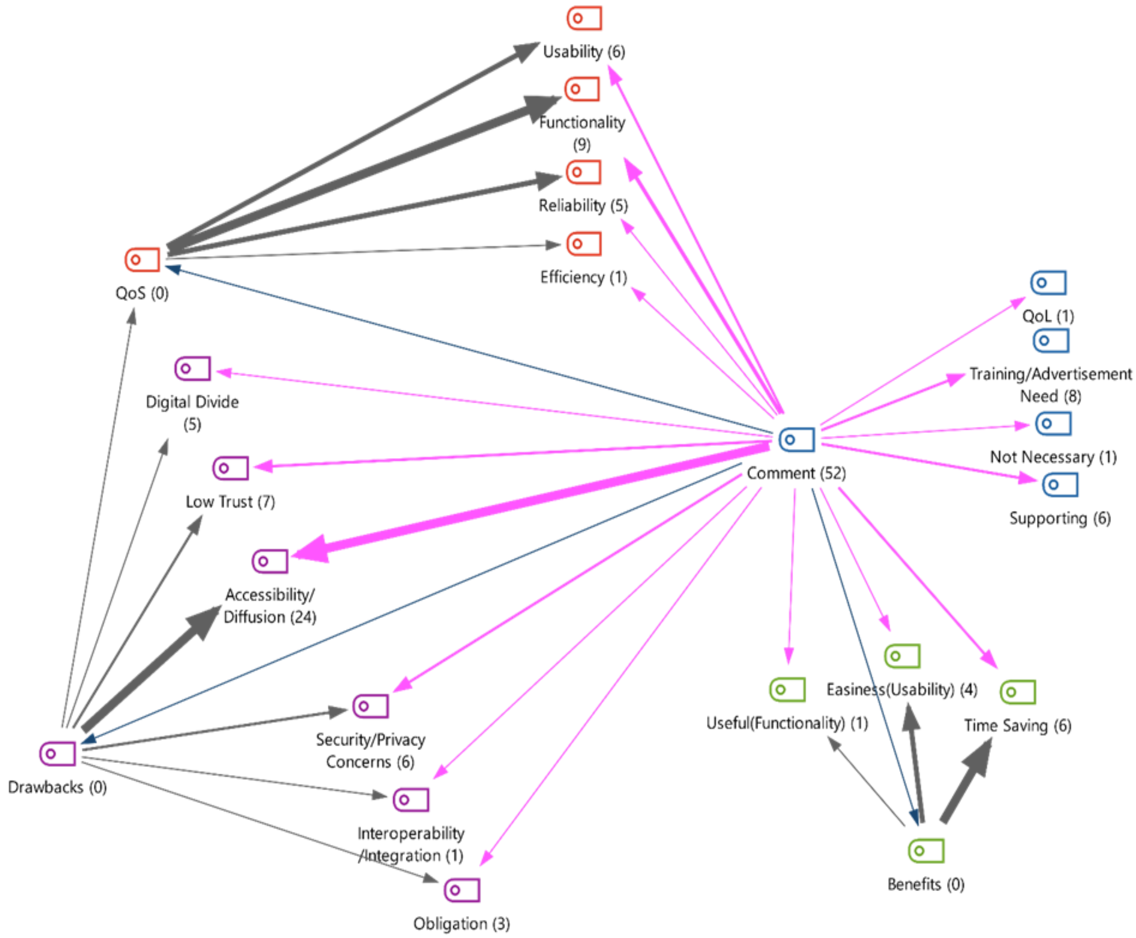


Figure 26: Illustration of code frequencies for the responses to open-ended question

Table 19: Code frequencies based on gender

Codes and Sub-codes			Males	Females	Total
Drawbacks	Accessibility/Diffusion		12	12	24
	QoS	Functionality	7	2	9
		Usability	5	1	6
		Reliability	1	4	5
		Efficiency	0	1	1
	Low Trust		3	4	7
	Security/Privacy Concerns		3	3	6
	Digital Divide		4	1	5
	Obligation		0	3	3
	Interoperability/Integration		0	1	1
Benefits		Time Saving (Efficiency)	5	1	6
		Easy (Usability)	4	0	4
		Useful (Functionality)	1	0	1
Training - Advertising Need			7	1	8
Supporting			6	0	6
QoL			1	0	1
Not Necessary			1	0	1
Total			60	34	94
Number of Respondents Answered			33 (63.5%)	19 (36.5%)	52
Number of Total Respondents			359 (56.1%)	281 (43.9%)	640

In Table 20 given below, it is also observed that undergraduate and graduate respondents answered the open-ended question more (63.5%), compared to their overall ratio (56.7%). In contrast, respondents with high school or below education levels were less willing to answer this open-ended question. However, accessibility issues and insufficient prevalence of smart services are emerging as the most complained issue by participants of all education levels (3/14, 16/61, 5/19). Furthermore, participants who are still students or graduated from a university highlighted the issues about QoS (15/61) and the low level of trust associated with security and privacy concerns (9/61). They also mentioned about the need for training and advertising (5/61), as well as how such systems save time (5/61) and how easy they are to use (3/61). Interestingly, the digital divide is the matter mostly mentioned by respondents with education level of post-graduate (MSc or PhD) (2/5 of coded comments on this topic) or, high school or below (2/5 of coded comments on this topic).

Table 20: Code frequencies based on education level

Codes and Sub-codes			High School or Below	Under-graduate and Graduate	Post-graduate	Total
Drawbacks	Accessibility/Diffusion		3	16	5	24
	QoS	Functionality	1	6	2	9
		Usability	1	4	1	6
		Reliability	0	5	0	5
		Efficiency	1	0	0	1
	Low Trust		0	5	2	7
	Security/Privacy Concerns		1	4	1	6
	Digital Divide		2	1	2	5
	Obligation		1	0	2	3
	Interoperability/Integration		1	0	0	1
Benefits		Time Saving (Efficiency)	0	5	1	6
		Easy (Usability)	0	3	1	4
		Useful (Functionality)	0	1	0	1
Training - Advertising Need			1	5	2	8
Supporting			2	4	0	6
QoL			0	1	0	1
Not Necessary			0	1	0	1
Total			14	61	19	94
Number of Respondents Answered			7 (13.5%)	33 (63.5%)	12 (23.0%)	52
Number of Total Respondents			122 (19.1%)	363 (56.7%)	155 (24.2%)	640

5.3.2. Semi-Structured Interviews

The code frequencies obtained from the qualitative analysis of the semi-structured interviews are given in Figure 27 and Table 21 below. This illustration shows that QoL, sub-elements of QoS (i.e., efficiency, functionality, and usability), security and privacy concerns, and intention to use are the most popular and highlighted topics by the interviewees. All these topics are the factors of SCSAM model that are proved as effective in quantitative analysis and tried to be supported by qualitative phase. However, there are some factors such as digital divide (or technophobia), the need for education or advertising, and accessibility issues, that are not directly examined in the interviews but are frequently mentioned by the interviewees. This result is also consistent with the results of qualitative analysis applied to the responses to the open-ended questionnaire, as these factors are mentioned mostly by the survey respondents as well.

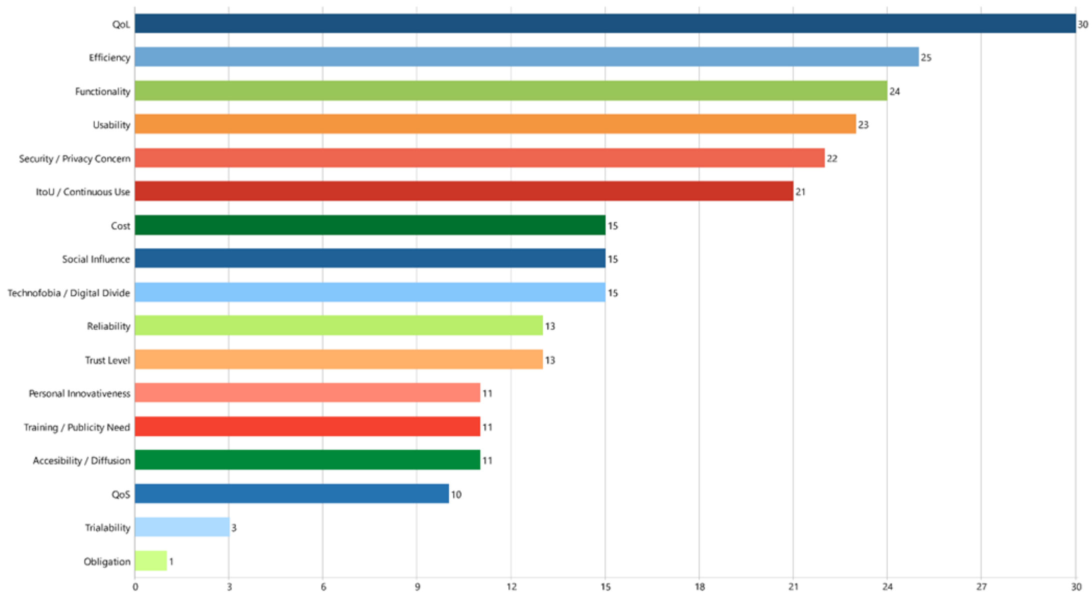


Figure 27: Code frequencies for the semi-structured interviews

Table 21: Code frequencies for the semi-structured interviews

Code	Coded Sections	Documents
QoL	30	10
Efficiency	25	9
Functionality	24	10
Usability	23	8
Security / Privacy Concern	22	10
ItoU / Continuous Use	21	10
Social Influence	15	10
Cost	15	10
Technophobia / Digital Divide	15	7
Trust Level	13	8
Reliability	13	8
Accessibility / Diffusion	11	8
Training / Publicity Need	11	6
Personal Innovativeness	11	10
QoS	10	10
Trialability	3	3
Obligation	1	1

As illustrated in Table 22, consistent with the results of the quantitative analysis, except for one interviewee with the lowest income level, all interviewees said that if the cost increase remains reasonable, the cost would not affect their use intentions much, and they could pay some extra fee for the use of IoT-based smart city services, considering the efficiency and functionality of such systems. While three participants (all males) thought that privacy concerns do not affect their intention to use such systems, according to two participants (one male and one female), personal innovativeness does not affect the usage decisions of end users. Consistent with the SCSAM results, all other factors were evaluated by the interviewees as influential in the intention to use smart services. In addition, all the participants stated that using such services positively affects the quality of life, again supporting the model results.

Table 22: Effectiveness of factors according to the interviewees.

Interviewee	QoS	SI	PI	Cost	PC	PT
1	Effective	Effective	Effective	Ineffective	Effective	Effective
2	Effective	Effective	Effective	Effective	Effective	Effective
3	Effective	Effective	Effective	Ineffective	Effective	Effective
4	Effective	Effective	Effective	Ineffective	Ineffective	Effective
5	Effective	Effective	Effective	Ineffective	Effective	Effective
6	Effective	Effective	Effective	Ineffective	Effective	Effective
7	Effective	Effective	Ineffective	Ineffective	Ineffective	Effective
8	Effective	Effective	Effective	Ineffective	Effective	Effective
9	Effective	Effective	Ineffective	Ineffective	Effective	Effective
10	Effective	Effective	Effective	Ineffective	Ineffective	Effective

The analysis of the interview data according to gender is presented below in Figure 28, which shows the distribution of the codes between male and female interviewees. This illustration introduces some remarkable results. First, while male interviewees highlight mostly the efficiency (16/25) and functionality (17/24) of smart services as QoS indicators, clearly female respondents give weight to usability (14/23) of such services. Additionally, female interviewees seem to attach more importance not only social influence (9/15) but also the matters relevant to accessibility (7/11) and training need (7/11) than male interviewees.

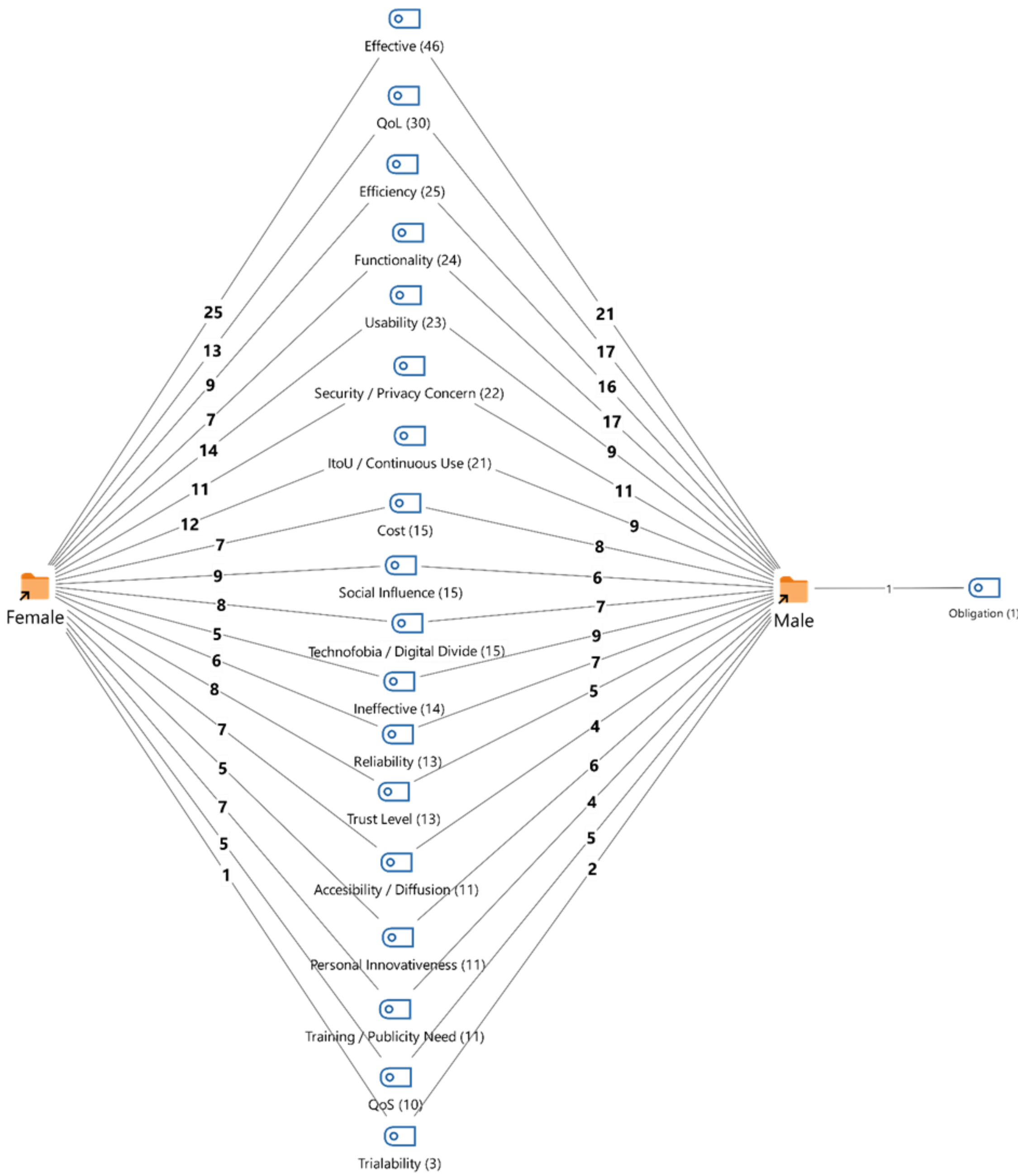


Figure 28: Code frequencies based on gender for semi-structured interviews

Based on the results of quantitative analysis, social influence appeared as the strongest factor affecting citizens' intention to use of smart city services. Social influence or social norm, in its simplest form, is the degree of influence on user' behavior by the beliefs and actions of important people in the social circle of individual (Alaiad & Zhou, 2017; Venkatesh et al., 2003). There were many interviewees who talked about how effective the advice and comments from their social circles regarding the use of smart city services were. In addition, even one interviewee who stated that the most important factor was his own opinion, said that the opinions of the people around him about a system he never used would be effective.

> ***"Let me be frank, I decide more based on what I see. I prefer to buy from these systems, even though it takes a few liras more commission, than waiting in line for hours. But the positive comments of a friend about a new system I have never used leave a positive impression on me." – Interviewee 8***
>
> *"Açık söyleyeyim, ben daha çok kendi gördüğüme göre karar veririm. Saatlerce kuyruk beklemektense birkaç lira daha fazla komisyon almasına rağmen bu sistemlerden almayı yeğliyorum. Ama hiç kullanmadığım yeni bir sistemle ilgili bir arkadaşımın olumlu görüşleri bende olumlu izlenim bırakır."*

> ***"…Positive feedbacks I have received have positive effects, and negative ones have negative effects. I mean, maybe it is because I have a character who is very affected by this, but it is important to be encouraged. If someone close to me uses it and is mentioned about it, I am intrigued, and it certainly affects me." – Interviewee 9***
>
> *"…Aldığım olumlu geri dönüşler olumlu etkiler, olumsuzlar da olumsuz etkiler muhakkak. Yani ben belki de bundan çok etkilenen bir yapım olduğu için söylüyorum ama teşvik edilmek önemli bu konuda. Yakınlarımdan birinin bunu kullanması ve bunun bahsinin geçmesi benim ilgimi çeker ve beni etkiler kesinlikle.*

> ***"...I am a person who works with references. In other words, I would recommend a service I use to someone, if there is a service that I use and gain speed, that is, a smart city application or something like that. I definitely tell it to my social circle, and I am not insensitive to such a notification from my environment, I definitely try it." – Interviewee 10***
>
> *"…ben referanslı çalışan bir insanım. Yani ben kullandığım bir servisi birilerine tavsiye ederim, faydalandığım ve hız kazandıran bir servis varsa yani bir akıllı şehir uygulaması olur ya da buna benzer bir şey olur, bunu mutlaka çevreme anlatırım ve çevremden bu tarz gelen bir bildirme karşı da duyarsız olmam, mutlaka denerim."*

SCSAM revealed that perceived trust is the second strongest factor influencing the acceptance of smart services by city residents. Meanwhile, the quantitative analysis findings showed that privacy concerns significantly affected the trust level of end users. Among the interviewees, there were those who stated that they did not worry about the risks related to privacy because they saw the risks related to privacy as inevitable. Interviewees who held this view generally stated that privacy is important, but they have to take these risks to take advantage of such services. It is seen that the interviewees generally think that trust is critical, but that the service providers have somehow taken the necessary precautions or that the risk will not be too high.

"Frankly, I do not know what action the service providers take in this regard. I think it is probably largely safe." – Interviewee 1

"Bu konuda servis sağlayıcılar nasıl bir önlem alıyorlar bilmiyorum açıkçası. Muhtemelen büyük oranda güvenlidir diye düşünüyorum."

"... I am using the application, but I think that the necessary security measures are probably being taken. Sometimes I comment on my own. I trust the private sector a little more. In my opinion, I am in favor of enabling technology companies in such transactions. I have more confidence in private companies, compared to local governments, let me say that." – Interviewee 3

"...uygulamayı kullanıyorum ama gerekli güvenlik önlemleri alınıyordur diye *düşünüyorum. Bazen de kendi kendime yorum yapıyorum. Özel sektöre biraz daha güveniyorum. Bence bu tarz işlemlerde teknoloji firmalarına imkan verilmesi, olanak sunulması taraftarıyım. Özel firmalara güvenim daha fazla, yerel yönetimlere kıyasla, öyle söyleyeyim."*

"I am undecided as to whether it is protected or not. It is probably protected." – Interviewee 5

"Korunup korunmadığı noktasında kararsızım. Korunuyordur büyük ihtimalle."

"...since everything electronic is obtainable, I think that anyone who wants to do such a thing can definitely get it. ... I think they can be infiltrated if desired, but that does not change my decision to use them. Why this does not change my mind, I do not think someone with such a talent can spare time for that. But my personal data can certainly be accessed if desired. I take this risk as I do not find the probability very high… as technology evolves in this way, I think there will be huge problems about protecting people's personal data in the future. Because people do not go to the buffet anymore, they buy everything from new applications emerged, even the two bread they will buy from the buffet. He enters his information there, everything there. In the future, these smart cities will also experience that, and as these applications increase, I think there will be more information security gaps. So, I think people should definitely pay attention to

under what conditions they use them, what they take into account, and what information they enter. This can cause problems for people." – Interviewee 7

"...elektronik olan her şey ele geçirilebilir olduğu için eğer böyle bir şey yapmak isteyen kişinin kesinlikle ele geçirebileceğini düşünüyorum ben. ... istenilirse bunlara sızılabileceğini düşünüyorum ama bu benim onları kullanma kararımı değiştirmez. Neden değiştirmez, öyle bir yeteneği olan birinin ona vakit ayırabileceğini düşünmüyorum. Ama istenirse kesinlikle benim kişisel verilerime erişilebilir. Olasılığı çok yüksek bulmadığım için bu riski alıyorum…bu şekilde teknoloji evrildikçe ilerde insanların kişisel verilerinin korunması hakkında çok büyük problemler olacağını düşünüyorum ben. Çünkü insanlar artık büfeye gitmiyor, büfeden alacağı iki tane ekmeği bile yeni uygulamalar çıktı oralardan söylüyor. Oraya bilgilerini giriyor, oraya her şeyini falan. İlerde bu akıllı şehirlerde de yaşanacak, bu uygulamalar arttıkça ben daha çok bilgi güvenlik açıklarının yaşanacağını düşünüyorum. O yüzden insanların kesinlikle bunları kullanırken ne şartlar altında kullandıkları, neyi göze aldıkları ve hangi bilgilerini girdiklerine dikkat etmesi gerektiğini düşünüyorum. İnsanların başına sıkıntılar getirebilir bu."

Another factor, which has impact on citizens' intention to use IoT-based smart services in urban areas, was personal innovativeness. Personal innovativeness is defined as the willingness of end users to try and use a new technology in the literature (Agarwal & Prasad, 1999; Okumus et al., 2018) and is considered an important dimension of the e-skills of end users (Martínez-Caro et al., 2018). Despite the risky and uncertain situations associated with innovation, those, who are more likely to adopt new technologies and services in their daily lives, are the citizens with high personal innovativeness (Rogers, 1983). The interviewees who participated in the semi-structured interviews mostly made comments that supported the findings of the structural model on personal innovativeness.

"If you do not use other technological devices a lot, I think you will hesitate to use them. That is why I think that people who make a habit of using technological tools use them more." – Interviewee 1

"Eğer diğer teknolojik cihazları çok kullanmıyorsanız bunları da kullanmaktan çekinirsiniz bence. O yüzden teknolojik aletleri kullanmayı biraz alışkanlık haline getiren insanlar daha çok kullanıyordur diye düşünüyorum."

"I think curious people and people who are interested in research can learn and use it faster. Being curious has an effect. Those who are not very tech-savvy also use it, but they learn late and can start using the application later. I think those who are curious can interact more quickly and actively. It also influences learning quickly." – Interviewee 6

"Bence araştırmaya ilgili ve meraklı insanlar daha çabuk öğrenip hızlıca kullanabilir. Meraklı olmanın etkisi var. Teknolojiye çok yatkın olmayanlar da yine kullanır ama daha geç bir süre de öğrenirler ve uygulamayı daha geç kullanmaya başlayabilirler. Meraklı olanlar daha hızlı ve aktif bir şekilde etkileşime geçebilir bence. Çabuk öğrenmeye de etkisi olur bunun."

"Technology makes life easier, but the risks are high. We try to use all technological tools that are as useful as we can. People need to be prone to technology to be able to use them. Because my impressions are that I see people having a hard time in natural gas and water counters. So, they are mixing up the menus. Kiosks can also have problems, so people have difficulty using them." – Interviewee 8

"Teknoloji hayatı kolaylaştırır ama riskleri fazladır. Elimizden geldiği kadar yararlı olan bütün teknolojik aletleri kullanmaya çalışıyoruz. İnsanların teknolojiye yatkın olması gerekir bunları kullanabilmek için. Çünkü benim izlenimlerim doğal gaz ve su bankomatlarında insanların çok zorlandığını görüyorum. Yani menüleri karıştırıyorlar. Bankomatlarda da sorun olabiliyor, dolayısıyla insanlar zorlanıyorlar kullanırken."

"I do not think that a person who does not understand technology at all can benefit from these services alone. Let me put it this way, I do not believe that our fathers can easily benefit from these technologies. I mean, they are retired people, literate at a certain level, but I do not think they can benefit from these applications like we do without the help of someone. I mean, I am not one hundred percent addicted to technology, I use technology, but I can use such an application wherever it is released in the world, in any language. Because I have an above-intermediate level of technology predisposition." – Interviewee 10

"Hiç teknolojiden anlamayan bir insanın tek başına buradan faydalanabileceğini düşünmüyorum. Şöyle söyleyeyim babalarımızın bu teknolojilerden fazlasıyla rahat bir şekilde faydalanabileceğine inanmıyorum. Yani onlar da emekli insanlar, okur yazarlar belli bir seviyede ama bu uygulamalardan birinin yardımı olmaksızın bizler gibi faydalanabileceğini zannetmiyorum. Yani ben yüzde yüz teknoloji bağımlısı değilim, teknolojiyi kullanıyorum ama dünyanın neresinde çıkarsa çıksın, hangi dilde çıkarsa çıksın böyle bir uygulamayı kullanabilirim. Çünkü orta seviyenin üstü bir teknoloji yatkınlığım var."

QoS-usability appeared as another strong factor which has positive significant impact on use intention of citizens such services. In fact, the factors related to service quality were the issues that individuals cared most and frequently mentioned in the interviews. Especially efficiency, functionality, and usability were the topics that were emphasized mostly by the interviewees.

> ***"…usefull in terms of time, I think time is very important for all of us in this period. If you can handle your job in a shorter time, when you use them, then you take advantage of these opportunities. Otherwise, your job will take longer. I mostly prefer these transactions because I can complete my transactions in a shorter time to better utilize the time." – Interviewee 3***
>
> *"Bence zaman açısından, zaman hepimiz için bu dönemde çok önemli. Siz bunları kullandığınız zaman daha kısa sürede halledebiliyorsanız, bu olanaklardan faydalanırsanız. Öbür türlü işiniz daha çok uzayacak. Ben en çok yani vaktin daha iyi değerlendirilmesi adına daha kısa sürede işlemlerimi halledebildiğim için bu işlemleri tercih ediyorum."*

> ***"First of all, it saves time. Time is very important now, especially for working people... It affects a lot in terms of time." – Interviewee 9***
>
> *"Bir kere en basitinden zaman kazandırıyor. Zaman çok önemli artık, özellikle çalışan insanlar için... Zaman açısından çok etkiler."*

> ***"In traffic, I no longer use my own knowledge, but the shortcut it gives me in terms of duration and intensity when I open the navigation. In other words, it does not only give the shortest path in km, it gives the most feasible route for the moment." – Interviewee 10***
>
> *"Ben trafikte artık kendi bilgimi değil navigasyonu açtığımda bana süre ve yoğunluk olarak verdiği kestirmeyi kullanıyorum. Yani sadece km olarak en kısa yolu vermiyor, o an için en feasible rotayı veriyor."*

As a remarkable result of quantitative analysis, cost was found only factor that had no significant effect on citizens' intention to use smart city services. Except for one interviewee with the lowest income level, all interviewees said that if the cost increase remains reasonable, the cost will not affect their use intentions much and that they may pay extra for efficiency and functionality provided with IoT-based smart city services.

> ***"I can pay a little more money, for example, not to wait in line, but of course it should not be a very high amount. In other words, I think that an extra cost of at most 20% would probably be reasonable. So obviously I don't want to pay too much extra, but if I can do it without waiting in line, a reasonable difference can be paid." – Interviewee 1***

"Bir miktar daha fazla para ödeyebilirim, mesela sıra beklememek için ama tabi o çok yüksek bir miktar olmamalı. Yani en fazla %20'lik bir ekstra maliyet herhalde makul olabilir diye düşünüyorum. Yani çok fazla ekstra bir miktar ödemek istemem açıkçası ama sıra beklemeden de halledebiliyorsam da makul bir fark ödenebilir."

"(Paying extra fee) adverse effects of course. Because if I have time and if it gets more money from me for that service, I say I won't pay that extra money, I'll use the alternative way, if I have time." – Interviewee 2

"(Ekstra ücret ödemek) olumsuz etkiler elbette. Çünkü eğer benim zamanım varsa ve benden o servis için daha fazla para alıyorsa o ekstra parayı vermeyim alternatif yolu kullanayım derim, zamanım varsa tabi."

"If it is not over my budget, I will pay for it. But if it is over my budget, of course I would not use it. There may be an additional charge for such services." – Interviewee 6

"Bütçemi çok aşmıyorsa ben veririm ücretini. Ama bütçemi aşıyorsa elbette ki kullanmam. Ek bir ücret ödenebilir bence bu tür servisler için."

"Depends on how much easier it will make my work and how much time it will save me. First, I take a look, I definitely go through a trial process, I use it, I apply it. I see if it benefits me as much as necessary, is it worth the fee I give? I do an analysis, then either continue to use or quit. I say it really makes my life easier, it's worth the price I pay, so I'll keep using it or say it's definitely not worth the amount I'm going to pay, I don't need to use it." – Interviewee 7

"İşlerimi ne kadar kolaylaştıracağına ve bana ne kadar zamandan tasarruf ettireceğine bağlı. Önce bir bakarım, kesinlikle bir deneme sürecinden geçiririm, kullanırım, uygularım. Bakarım bana gerektiği kadar fayda sağlıyor mu, verdiğim ücrete değiyor mu. Bir analizi yaparım, ondan sonra ya devam ederim ya da bırakırım. Derim bu gerçekten benim hayatımı kolaylaştırıyor, ödeyeceğim ücrete değer, o yüzden ben bunu kullanmaya devam ederim veya derim ki bu kesinlikle ödeyeceğim miktara değmez, kullanmasam da olur."

QoS-usability positively, but privacy concerns negatively affect citizens' perceived trust. Buyya et al. (2008) stated that trust is sometimes seen as a critical QoS parameter that should be considered in service requests (Buyya et al., 2008). Especially for e-government services, it is also important to create a trusted service perception among citizens and to establish a trusted system for QoS management (Belanche et al., 2012; Corbitt et al., 2003; Pinem et al., 2018). Privacy is one of the most significant antecedents of trust related to end users' observations and perceptions regarding the characteristics of responsible entities (D. J. Kim et al., 2008). According to Yeh (2017), privacy is the ability to control how individuals' personal information is obtained and used (Yeh, 2017). It is quite obvious that collecting, managing, monitoring and analyzing personal data in smart systems more or less raise privacy concern and negatively affect perceived trust, one of the key determinants in adopting a new technology (Yeh, 2017). Most of the interviewees made comments supporting the findings of the study on trust and privacy.

> ***"...can I do it, can I use it, is it something easy to use, what kind of device is it, for example, I would like to have a preliminary knowledge. So, if I don't have enough information, I might be worried." – Interviewee 1***
>
> *"…yapabilir miyim, kullanabilir miyim, kolay kullanılır bir şey mi, nasıl bir cihazdır mesela ön bir bilgim olsun isterim. Yeterli bilgim yoksa endişe yaşayabilirim yani."*

> ***"I do not know much about it, but I do not trust much. The privacy of my data is very important, and I do not think it is very hidden. So, I think someone can steal it somehow. I did not make my bank credit card contactless; I could not do it because I did not trust. If I trust the service providers, if I know that the information will not be stolen, of course I will. Risks related to the privacy of personal data also have a huge impact." – Interviewee 2***
>
> *"Çok bilgim yok ama bu konuda pek güvenmiyorum. Verilerimin gizliliği çok önemli ve ben çok gizlendiğini düşünmüyorum. Yani illa ki birileri bir şekilde çalabilir diye düşünüyorum. Ben banka kredi kartımı temassız yapmadım, güvenmediğim için yapamadım. Servisi sunanlara güvensem, bilgilerin çalınmayacağını bilsem elbette ki yaparım. Kişisel verilerin gizliliği ile ilgili risklerin çok büyük etkisi olur hem de."*

> ***"The information requested from me sometimes makes me nervous, about where and how my data will be used… For example, when I was buying AnkaraKart, the desk clerk asked me for information such as my ID number, phone and address, that made me nervous." – Interviewee 9***
>
> *"Benden talep edilen bilgiler bazen beni tedirgin edebiliyor, verilerimin nerede ve nasıl kullanılacağı noktasında… Mesela geçenlerde AnkaraKart alırken bankodaki görevlinin benden kimlik numaram, telefonum ve adresim gibi bilgileri istemesi beni tedirgin etti."*

And as a final remark relevant to the model constructs, intention to use IoT-based smart city services had highly significant positive impact on citizens' expectancy on life quality. From end users' perspective, expectancy on QoL expresses the perception on how technology and services can improve the QoL and living environments. When technological advances and innovative services are used correctly and in place, they can improve the overall QoL of end users (Chatterjee & Kar, 2017; van der Graaf & Veeckman, 2014; Yeh, 2017). All interviewees had the idea that the usage of smart city services more or less helps to improve the life quality in urban areas.

> ***"If we want to live a better quality of life, I think we should benefit from technology as much as possible, all people, everyone." – Interviewee 3***
>
> *"Daha kaliteli yaşamak istiyorsak zaten teknolojiden mümkün olduğunca fazla faydalanmamız gerektiğini düşünüyorum, bütün insanların, herkesin."*

> ***"…daily life is now very intertwined with technology. Especially transportation-related services directly affect the quality of life." – Interviewee 6***
>
> *"…günlük hayat teknoloji ile çok iç içe artık. Özellikle ulaşım ile ilgili servisler yaşam kalitesine doğrudan etki eder."*

> ***"... it simply saves time. Time is very important now, especially for working people. It affects a lot in terms of time. As I said, if there was no uneasiness in terms of reliability, I mean for myself, I would use it much, much more. ...I think it affects the quality of life a lot, in a positive way." – Interviewee 9***
>
> *"…en basitinden zaman kazandırıyor. Zaman çok önemli artık, özellikle çalışan insanlar için. Zaman açısından çok etkiler. Dediğim gibi güvenilirlik açısından herhangi bir tedirginlik olmamış olsa yani şahsım için söylüyorum çok çok daha fazla kullanırım. …Bence yaşam kalitesini çok fazla etkiler, olumlu anlamda."*

> ***"…it both saves time because of these smart cities and also eliminates stress." – Interviewee 10***
>
> *"…hem zaman kazandırıyor işte bu akıllı şehirlerden dolayı, hem de stresi ortadan kaldırıyor."*

In the literature, many researchers examined the impact of demographics, especially gender, age and education, on the acceptance of technology (Belanche et al., 2015, 2016; Chatterjee & Kar, 2017; Karahoca et al., 2017; D.-H. Shin, 2017; Yeh, 2017; Ylipulli et al., 2014). In this study, the demographics were also examined, and the features such as age, gender and frequency of use were utilized as grouping variable. The findings showed that the difference between the groups based on demographics was not significant. While some of the studies in the literature have found that demographic characteristics have significant effects on end-user behaviors, there are also studies in which demographics do not have a significant effect. This result is discussed in the Discussion, the next chapter. There were interviewees stated their ideas in both directions about the effectiveness of age and education on the usage behaviors and decisions of citizens.

> ***"This is what happens in the elderly, they also want to use it, they consult the young people to help them. If there are relatives around them to help, they also want to use it a lot." – Interviewee 4***
>
> *"Yaşlılarda şöyle bir şey oluyor, onlar da kullanmak istiyorlar, gençlere danışıyorlar yardımcı olmaları için. Etrafında yardımcı olacak yakınları filan varsa onlar da çok kullanmak istiyor."*

> ***"…my mother was 57 years old, born in 1963, for example, she cannot use WhatsApp. But my aunt, who is 6-7 years older than him, can use WhatsApp." – Interviewee 5***
>
> *"…annem 1963 doğumlu 57 yaşında mesela whatsapp kullanamıyor. Ama ondan 6-7 yaş büyük olan yengem whatsapp kullanabiliyor."*

> ***"I see so many people over the age of 65 using these systems that I think they definitely learn when they really need it and when it provides conveniences, both in terms of price and opportunity." – Interviewee 7***
>
> *"Ben 65 yaş üstü bu sistemleri kullanan o kadar fazla görüyorum ki gerçekten lazım olduğunda ve kolaylıklar sağladığında gerek fiyat olarak gerek imkan olarak kesinlikle öğrendiklerini düşünüyorum."*

During the semi-structured interviews, the participants mentioned about some factors as enablers or disablers for the acceptance of IoT-based services other than the model constructs. The most remarkable one was accessibility issue and not high enough diffusion of such services in urban areas.

> ***"It is also not common enough, it's very rare. These need to be made more widespread. It should become more common, whether on the main streets or in certain neighborhoods." – Interviewee 8***

“Ayrıca yeterince yaygın da değil, çok az yerde karşınıza çıkıyor. Bunlar daha yaygın hale getirilmesi lazım. Noktasal olarak ana caddelerde olsun, belli mahallelerde olsun daha yaygın hale gelmeli.”

"First of all, you know that something has a penetration rate in the market, that is availability, so I need to encounter that application once in order to use it first." – Interviewee 10

“Öncelikle hani bir şeyin pazarda bir penetrasyon oranı vardır ya yani bulunabilirlik, o yüzden bir kere o uygulamayla karşılaşmam gerekiyor öncelikle kullanmam için.”

Another critical matter was training need to use such systems properly, especially for disadvantaged groups. In addition, the interviewees generally think that individuals who have some knowledge or high awareness about the use of smart city technologies and services will be more courageous and willing, to try and even adapt such services to their lives.

“I wish if there are tutorial videos or officials who explain and teach at the devices at the beginning... If I can watch someone's action, if I see it twice, for example, I can do the third one myself. It would be very logical if such videos were published. " – Interviewee 2

“Öğretici videolar veya başlangıçta cihazların başında anlatan ve öğreten yetkililer olsa. Birinin yaptığı işlemi izleyebilsem, 2 kere görsem mesela üçüncüye ben de yapabilirim. Böyle videolar yayınlansa çok mantıklı olur.”

“So, if there are educational videos or something, I think people can get rid of their fears by watching them, they can feel a little self-confident. I think these will have a positive effect, there may be educational videos or something.” – Interview 3

“Yani o yüzden bunun eğitici videolar falan olursa bence insanlar izleyerek o korkularını falan atabilir, biraz kendilerine güvenleri gelebilir. Bunlar olumlu etki yapar diye düşünüyorum, eğitici videolar falan olabilir.”

“Because these are the systems that he/she can learn in 5-10 minutes, even when you show it to a person who has nothing to do with technology.” – Interviewee 7

"Çünkü teknoloji ile alakası olmayan bir insana bile gösterdiğinizde 5 – 10 dakikada kesinlikle öğrenebileceği (sistemler)"

Digital divide is the other issue that the interviewees emphasized during the interviews. While some of the interviewees thought that disadvantaged groups would have significant difficulties to use such systems, others thought that they could use them if they want or need enough. Nevertheless, most interviewees stated that some extra actions are needed to lessen the digital divide about the usage of smart city services.

"…not everyone may have the same desire, especially the older group may not be very enthusiastic." – Interviewee 1

"…herkes aynı istekte olmayabilir, özellikle yaşlı grup çok istekli olmayabilir."

"…it needs to be a method that people over a certain age can learn more easily." – Interviewee 2

"…belli bir yaşın üzerindekilerin daha kolay öğrenebileceği bir yöntem olması gerekiyor."

"For me, people aged 45-50 seem to be more afraid of technology in general, but there is something else that is nothing about reading (educational status) or anything, but with culture. I have a university graduate friend like me, I say, for example, you can use this application. "I can't do it." He/she may approach it so that what if I am doing something wrong." – Interviewee 3

"Teknolojiden genelde bana göre 45-50 yaş üstü biraz daha korkuyor gibi ama şöyle de bir şey var bunun okumayla (eğitim durumu ile) falan da alakası yok, kültürle falan. Benim gibi üniversite mezunu arkadaşım var diyorum ki mesela şu uygulamayı kullanabilirsin. Ben onu yapamam. Yanlış bir şey yaparım şeklinde yaklaşabiliyor."

"Obviously, a suggestion for the elderly to use such systems more, now came to my mind, the age of user might be entered in the system first of all, for example, not as personal information, but when the user say that 65 years old or over, the user can be offered live help." – Interviewee 10

"Açıkçası yaşlıların bu tür sistemleri daha çok kullanması için şöyle bir öneri, şimdi aklıma geldi, sistemde öncelikle kaç yaşında olunduğu girilebilir, mesela

kişisel bilgi olarak değil de 65 yaş veya üstü dendiğinde canlı yardım almak ister misiniz seçimi sunulabilir.”

5.3.3. Observations Supporting Qualitative Analysis

As mentioned in previous chapter, ensuring the reliability and validity of the qualitative study is a critical issue for the researcher (Burns, 2000; Recker, 2013). Transferability is a condition to be met to enhance the trustworthiness of the qualitative data, together with the credibility, dependability, and conformability (Lincoln & Guba, 1985; Recker, 2013). In this study, to ensure the transferability as recommended in the literature(Recker, 2013), observational data was collected by taking notes while observing citizens using the smart city services. To collect observation data, interactive kiosks for smart cards in 3 different metro stations were observed between the hours of departure to work (08.15 - 09.00), between 12.00 - 14.00 during the day and return from work (17.30 - 19.00). The compiled version of the notes taken by the researcher during the observations are listed below:

- There were at least 3 smart kiosks at the stations.
- Of the smart kiosks, only 1 smart kiosk in 1 station was out of use.
- There was not much crowd and queue at the smart kiosks even during peak hours.
- Although mostly young and middle-aged citizens used it, the elderly also used the smart kiosks.
- Only one senior citizen requested help from the security guard, but everyone else observed was able to do their own transaction without the need for help.
- Usage times were generally close to each other, but older citizens seemed to need a little more time than younger citizens.
- Smart kiosks where transactions can be made with credit cards were used more.

The use of vending machines with credit card payment options, and interactive kiosks with credit card payment options to load water and natural gas credits have also been observed in similar time periods. As most of the notes are similar to those listed above, a few different observations obtained about these smart services are collectively presented below:

- The smart city service with the highest out-of-service rate was vending machines with credit card payment options.
- It was observed that the service quality decreased as the transaction became more detailed in smart kiosks. For example, it has been observed that citizens

experienced more confusion and difficulty at the kiosks that serve to different types of smart cards at the same time, such as with chip and with magnetic stripe.

- Smart kiosks, which charged an extra transaction fee, were preferred by citizens, especially by young and middle-aged ones, although there was a manned counter nearby with free transactions.

5.4. Chapter Summary

In this chapter, the results of both quantitative and qualitative analyses together with the main findings of the study were given. Quantitative results were outlined under the subsections of EFA, CFA and structural model. In qualitative part, the findings obtained from analyses applied to two different sets of qualitative data were explained. The qualitative results provided first were obtained from the qualitative analysis applied to the answers to the open-ended questions asked at the end of the main questionnaire, and secondly, from the qualitative analysis applied to the semi-structured interview data.

CHAPTER 6

DISCUSSION

Adopting a new technology is a complex process that requires long-term and in-depth multidisciplinary work, especially in urban areas (Ylipulli et al., 2014). If new technologies and smart environments are not designed and presented to narrow the digital divide, they can deepen the problem while aiming to serve as the driver of increased quality of life in urban areas (Sipior et al., 2011). Cooperation and coordination in local between public administration and service providers is crucial for smart city initiatives to understand citizens' needs and serve them better. The Smart City concept can be seen as an important area of opportunity for underdeveloped and developing countries such as Bangladesh, India, and Pakistan. In such countries, where health, education, transportation, and many similar services cannot be provided in a quality and sufficient manner, the increase in smart city investments can help to take quick steps in problematic areas and reduce the gap. Singapore, Hong Kong, Taiwan, and the Netherlands are at the top of the list in terms of smart city prevalence. However, the capital of Bangladesh, which is among the underdeveloped countries, has a population density of about 75 percent more than Hong Kong, and such situations cause the urban problems of developing countries to reach much more dramatic dimensions (Sourav et al., 2020). For this reason, it is important that the literacy rate in developing countries reaches levels that make it possible to adequately understand and use technology properly, and to increase the rate of technology adoption. Therefore, technology that will be used correctly without ignoring the institutional and human dimensions for developing countries can play an important role in becoming a smart city.

The most important challenges to smart city transformation in developing countries are the lack of a clear strategy and bias towards operational management and innovation (Vu & Hartley, 2018). The proliferation of smart cities in developed or developing countries will increase convergence and interaction between urban stakeholders and ensure a sustainable improvement of the quality of life of citizens. Including the social development, economic policy and financial situation of the state for smart city development in developing countries; technological literacy and citizens' willingness to participate in smart city development are important (Tan & Taeihagh, 2020).

In many cities in Turkey, as a developing country (Boyle, 2021), thanks to the innovative approaches in recent years, IoT-based services have been implemented by municipalities and private enterprises. In addition, for the period 2020-2023, Turkish authorities prepared a strategy and action plan aimed at improving smart city maturity with a common understanding in cities by developing a common smart city vision and roadmap. These action plans also aim to provide equity among all citizens in accessing smart city services, because techno-disadvantaged individuals, who have the least access to technology, are among the citizens likely to benefit most from the smart environments (Sipior et al., 2011). With the help of these planned approaches and the Turkish people's interest in technology, in urban areas, there is a rapid development in terms of the use of technology in daily life routines.

In this study, the researcher aimed to analyze the main factors affecting the acceptance of IoT-based smart city services quantitatively and qualitatively. Based on the sequential explanatory mixed methods design, at the first phase of the analysis, the hypotheses were tested via SCSAM, the proposed model. Afterwards, at the second phase of the analysis, the researcher analyzed two different sets of qualitative data: first set of data is obtained from the answers to open-ended question at the end of the questionnaire, and the second is the semi-structured interviews configured based on the results of quantitative analysis. In quantitative analysis, all hypothesized relationships, except for COS→ItoU, are supported by the quantitative data. The results reveal that PI, SI, QoS-usability, and PT are the significant predictors of end users’ intention to use IoT-based technologies. However, COS has no effect on ItoU.

Comparing the antecedents of ItoU, SI and PT emerge as the most powerful predictors with path coefficients 0.35 and 0.26, respectively. In line with these results, all the interviewees evaluated SI and PT as influential to their intention to use smart systems. As the Turkish people mostly exhibits collectivist society characteristics (Hofstede et al., 2010), it is an expected result that the participants in this study will be more vulnerable to social effects and more sensitive to the triggers in their social networks (Kongsompong et al., 2009). In addition, many previous studies in different regions have revealed that SI has a strong significant impact on end users' intention to use new technologies and services (Gao & Bai, 2014; García-Maroto et al., 2020; Mital et al., 2017; Sener et al., 2019; Venkatesh et al., 2003). Similarly, in collectivist societies, a relationship of trust with one person must be established before doing business with that person (Hofstede et al., 2010). The fact that PT is the second strongest factor supports this judgement and shows that Turkish citizens should trust the parties before using a new technology. Several previous studies have used trust in different ways in their models, as a mediator or a factor that directly affects adoption (Belanche et al., 2012; Chatterjee & Kar, 2017; Dutot et al., 2019; Huijts et al., 2014; Miltgen et al., 2013; Yeh, 2017). The study of Belanche et al. (2012) reveals that trust is a factor that reduces uncertainty and increases the expectation of satisfaction and therefore positively affects behavioral intentions. Although Gao and Bai (2014) have not obtained sufficient evidence that trust plays an important role in predicting intention to use IoT technologies, Hansen et al. (2018) state that PT strongly affects intention to use especially in social technologies. In line with the results obtained here, Yeh (2017) and Chatterjee and Kar (2017) also showed how increased level of trust would impact positively the adoption of smart city services from end users’ perspective.

This study also showed that personal innovation has not only a positive significant and direct effect on intention to use, but also an indirect effect on QoL expectation. According to the findings here, in line with the results of Rogers (1983), Turkish citizens with high PI are more prone to adopt new technologies and services in their daily lives. In many studies, PI is considered an important dimension of the end-users' e-skills (Martínez-Caro et al., 2018) and it is seen as a factor shaping the individuals' approach to innovation (Dabholkar & Bagozzi, 2002; Okumus et al., 2018). Similar to this study, several previous studies have discussed the influence of PI on acceptance of innovative smart city services (Chatterjee & Kar, 2017; Yeh, 2017). Yeh (2017) reported that PI has a direct significant effect on intention to use, and consequently the citizens with higher level of PI adopt the smart city services easier and faster. This result and the findings of Chatterjee and Kar (2017) fully support what is reported here. Supporting this finding, the researcher saw that in qualitative analysis, the interviewees often talk about how personal innovativeness can facilitate the use of such systems. They also noted that technophobia is a factor that increases the digital divide and slows the prevalence of IoT-based smart city services. According to the findings of qualitative analysis, encouraging people to use such services through education and advertising seems necessary for the majority to accept smart service.

Perceptions about QoS are based on post-consumption assessment of service performance, unlike other adoption factors such as personal innovation and SI based on pre-determined beliefs and attitudes. Parasuraman et al. (1985) believe that providing high QoS to end users is vital to the continued existence and success of a business organization. Similarly, many researchers think that QoS is very important for the adoption and continuous use of technology, and their studies show that QoS affects significantly the adoption of e-Gov services and smart city services by citizens (Chatterjee & Kar, 2017; Safeena & Kammani, 2013; Sharma, 2015; Yeh, 2017). In line with their results, the model proposed here reveals that QoS from end users’ perspective (QoS-usability) has a significant impact not only on intention to use, but also on PT. Trust can be associated with QoS and should be considered as a factor to be considered in service requests (Buyya et al., 2008). In addition, for e-Gov services, to create a trusted service perception among citizens and to establish a trusted QoS management system are also quite critical (Belanche et al., 2012; Corbitt et al., 2003; Pinem et al., 2018). In addition, the sub-components of QoS from end user perspective, such as functionality, usability, and efficiency, are mostly mentioned factors by participants in the responses to both open-ended question and semi-structured interviews. For example, the deficiencies in QoS seem to be the main source of complaints, together with accessibility issues and inadequate prevalence. Especially in negative comments obtained from open-ended question, functionality and usability are the factors of QoS about which the respondents mostly mentioned. Also, the male interviewees highlighted mostly the efficiency and functionality of smart services as QoS indicators in semi-structured interviews. On the other hand, the female respondents give weight to usability of such services clearly in their answers.

As an expected result, this study also confirmed the strong but negative relation between the citizens' PC and PT. Kim et al. (2008) defined privacy as one of the cognition-based trust antecedents and related to the characteristics of responsible entities. Collecting and processing personal data in smart systems may raise PC and negatively affect PT. Miltgen et al. (2013) stated that high perceived risks especially regarding privacy may negatively affect the acceptance of technologies even if they were adopted initially. Several prior studies in the literature showed that privacy is a determinant for users' intention to use smart technologies and services (Kazancoglu & Aydin, 2018; J. Kim et al., 2017; Miltgen et al., 2013; Yang et al., 2018). Similar to the model proposed here, many studies have analyzed the impact of PC on ItoU through trust and they confirmed the significant indirect relation between PC and ItoU, supporting the findings here (Chatterjee & Kar, 2017; Punyatoya, 2019; Yeh, 2017). In qualitative analysis, even if three interviewees (all males) thought that privacy concerns do not affect their intention to use such systems, nobody mentioned perceived trust as ineffective on intention to use of smart services. In addition, security, and privacy concerns together with low level of trust in these services are mostly mentioned issues cited as the drawbacks of smart services by the respondents.

Contradicting to several prior studies (Ma et al., 2016; Nikou, 2019; Park et al., 2017), cost has neither direct effect on intention to use nor indirect effect on QoL. Although this finding seems unexpected, it is consistent with some other studies in the literature (Hsu & Lin, 2018; Karahoca et al., 2017; Roostika, 2012). One possible explanation for the ineffectiveness of COS in estimating intention to use may be that the IoT-based smart city services are relatively new, so municipalities and service providers have a competitive pricing policy, and citizens need to pay very little or no extra fees to use these services. Additionally, one of the possible reasons why the cost does not have a significant effect on the intention to use may be that the indirect and/or hidden costs incurred in providing smart city services to the citizens are not included in the cost construct in the model. Already, supporting this finding, almost all interviewees in the semi-structured interviews say that if the cost increase is not excessive, the cost will not affect their use intentions much, and they can pay some extra fee for the use of IoT-based smart city services, considering the efficiency and functionality of such systems. Just one of the interviewees, who is in the lowest income level, stated that the cost is important, and he/she does not want to pay any extra money for smart systems. However, after smart city services become more common, future studies may be needed to better understand the impact of cost.

According to the results listed in Tables 16 and 17, the demographics of the citizens (i.e., age, gender, and frequency of use as the grouping variables, and the level of education as the control variable) do not contribute significantly to the dependent variables of the model. Just the frequency of use seems to make a difference at the model level, however, there is no significant difference between high use and low use groups for the path coefficients, except for the PI→ItoU relationship. In those who use smart city services more frequently, PI has a stronger positive effect on ItoU. On the other hand, the researcher noticed that age and gender groups do not make any difference at the model level. Nevertheless, multi-group analysis reveals that QoS-usability is a stronger predictor of intention to use for males than for females. Similarly, PC has a stronger negative impact on PT for the senior citizens. Also, the positive impact of PT on ItoU is stronger for junior users than for senior users. However, when evaluating these differences between groups, it should be considered that the measurement model metric invariance tests for all grouping variables failed even if the configuration invariance tests were met. Thus, these path weight differences may not be due to differences between groups. Finally, the study reveals that the education level of citizens, as a control variable, has significant but relatively low impact on PT, but has no significant impact on intention to use and QoL expectancy. These results may contradict some studies in the literature (Belanche et al., 2016; Karahoca et al., 2017; Ylipulli et al., 2014) but are consistent with many prior studies (Belanche et al., 2015; Chatterjee & Kar, 2017; D.-H. Shin, 2017; Yeh, 2017). The lack of significance of demographics on model variables can be explained by the fact that developing technologies are becoming easier to use for different groups of people (D.-H. Shin, 2017). Another reason for insignificance of demographics may be that the initial design of IoT-based smart city services enables these services to be used by a wide range of citizens, regardless of age, gender or education level (Belanche et al., 2015). The qualitative analyses did not indicate much remarkable results based on demographics as well. Nevertheless, the researcher noticed that female respondents answered to the open-ended question less than males. In semi-structured interviews, some differences between males and females in approaches to smart services were significant. While male interviewees mostly focus on the efficiency and functionality of smart services as QoS indicators, clearly female respondents highlight the usability of such services. Additionally, female interviewees seem to attach more importance not only social influence but also the matters relevant to accessibility and training need than male interviewees.

CHAPTER 7

CONCLUSION

This sequential explanatory mixed method study aims to analyze the main factors affecting the acceptance of IoT-based smart city services with a proposed model SCSAM. Initially, a comprehensive literature review was conducted, and in quantitative phase, hypotheses were developed according to the results of this review and based on the multidimensional nature of the smart city concept. The SCSAM built over human, technology, and institutions dimensions of smart city concept, consists of 27 measured variables and 8 latent variables. After the focus group review and pilot study, the main survey, questioning intention to use IoT-based smart city services, was applied to Turkish citizens with different demographics and 640 valid responses were received. In the qualitative phase, the researcher conducted semi-structured interviews with 10 participants determined by maximal variation sampling based on gender, education level and total income to differentiate participants at the highest level.

In this study, the researcher tried to understand the factors affecting the adoption of smart city services that are based on IoT technology and that will contribute to urban sustainability, and the effect of the intention to use these services on the expectation of quality of life. Due to the wide scope of the smart city concept, the adoption of some IoT-based smart services in Turkey has been examined. According to the results of SEM analysis, all hypothesized relationships, except for COS→ItoU, are supported by the data. Practically, the proposed model introduces that social influences and perceived trust are the major factors effecting the successful adoption of smart city services mostly considered under smart mobility (transportation) and smart living characteristics. In collectivist societies like in Turkey (Hofstede et al., 2010), the effect of social influence on the behavior of end users is expected to be so significant. On the other hand, the increased risks and awareness on information security and privacy in recent years has also increased the concerns about the protection of personal data, as well. Therefore, perceived trust, to which the participants attach great importance, became the second strongest determinant of use intention. In addition, both personal innovativeness and QoS-usability have some positive effect on Turkish citizens' use intentions toward such smart city services. The results also show that the cost has no significant effect on intention to use. As another expected result, privacy concerns and QoS-usability have a strong impact on citizens' perceived trust. The findings of this study also revealed that the use of IoT-based smart city services by Turkish citizens has an important and positive effect on their living standards and QoL expectations. In addition, it has been determined that Turkish citizens can more easily accept smart city services that are perceived as easy to use (QoS-usability) and reliable. In addition, end users who are positively influenced by their social environment and have more personal innovativeness are more likely to use such services in Turkey. Interestingly, this study revealed that demographics did not contribute much, except for a few relationships. And finally, all the results of the quantitative analysis are fully consistent with the qualitative findings.

Theoretical Implications

As far as is known, this study is the only research adopted mixed method design in the literature that comprehensively investigates IoT-based smart city services from end-user's perspective. Therefore, it will also make significant contribution to the academic literature. In addition, SCSAM is the only acceptance model in the literature built over the human, technology, and institutional dimensions of smart city context, and this original feature improved the model's success in explaining the adoption process of smart city services.

Practical Implications

It would not be wrong to think of the concept of smart city as the composition of sustainable-oriented initiatives in theory, since an unsustainable smart city application cannot be smart either (Yigitcanlar et al., 2019). Of course, it is not possible to say that all smart city initiatives directly increase the quality of life or solve all sustainability problems of the city, but it is also very clear that well-planned smart city solutions will contribute significantly to the quality of urban life and sustainability (Wey, 2019). In this context, the findings of current study will help local governments and service providers to develop better strategies to achieve the objective of smart and sustainable cities and prompt them to focus on social, technological, and institutional aspects of smart city initiatives in a holistic manner.

Future Works

The model proposed here can provide a strong foundation for future studies that will examine the adoption of smart city services. Studies to be conducted especially for disabled citizens and the elderly may reveal useful findings regarding the effects of digital divide in the acceptance of smart city services. In addition, possible studies on more specific groups such as individuals under the age of 18 may yield interesting and important results, because the rate of use of smart city services by the young population is increasing day by day and their practices of using these services may differ from other demographic groups.

Longitudinal studies have the potential to provide a unique understanding of the phenomenon that is not possible with other forms of research. The benefit of this type of research is that it allows researchers to look at changes over time. In addition to these important advantages of longitudinal research, there are also some disadvantages that should be considered. For example, longitudinal studies require a tremendous amount of time and are often quite expensive. In addition, the possibility of participants being excluded from the study sometimes and quitting the study for different reasons may come to the fore. However, a longitudinal study that will provide a better understanding of the time-dependent variation of the smart city services acceptance process will be beneficial in terms of validating the SCSAM and strengthening the model findings. Since the survey data used here were collected prior to the Covid-19 pandemic, a longitudinal study with quantitative data to be collected in near future can provide valuable information and insights into the impact of pandemic conditions on smart city services adoption.

Cross-cultural studies are research designs that compare human behavior from two or more countries, ethnic groups, and/or cultures. Cross-cultural research most commonly involves comparing some cultural traits (or the relationships between traits) in a sample of society. Keeping in mind that cultures change over time, the focus and time span of cross-cultural comparisons should be carefully determined. As a possible future study, after appropriate customization of the questionnaire used here, the model SCSAM proposed in this study can be applied to individuals from different cultures to investigate the impact of cultural differences on smart city acceptance.

Limitations

The smart city concept covers a wide range from e-Gov applications to traffic flowing with autonomous vehicles. Therefore, in this study, the acceptance of only IoT-based smart city services was examined, since it will be very challenging for the participants to evaluate all smart city services. Additionally, in this study, the researcher selected survey participants randomly as much as possible, however only Turkish citizens older than 18 years old are included in the research. Therefore, caution should be exercised applying the same questionnaire to participants from different cultures and living standards. Actually, covering the citizens younger than 18 years old could reveal some interesting findings since the younger individuals have been using such services more and more and they are more familiar with technology than older people. As another limitation, the results of multi-group analysis should be evaluated carefully by considering the failed metric invariance test on measurement model. Notwithstanding only frequency of use groups differ at model level and only a few paths for grouped variables have significant path level differences, it should be considered that these few differences may not be due to differences in demographic groups.

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APPENDICES

APPENDIX A

Initial Constructs and Items Reviewed by Experts

Construct	**Reference**	**Item No**	**Item in English** (directly taken from relevant literature)	**Item in Turkish** (directly translated from reference and just adjusted to smart city questionnaire)	**Supportive Information in Turkish** (translated from reference and adjusted with extra explanation)	**Your Comments and Corrective Feedbacks**	**Please Choose the Proper Construct from Combo Box for Each Item**
Innovation Concept	(Yeh 2017)	**1**	**“Voluntariness** : The degree to which citizens' use of the services is voluntary or of free will.”	Akıllı Şehir Servislerini gönüllü olarak ya da özgür iırademle kullanırım.	Akıllı Şehir Servislerinin kullanılması ile ilgili bir zorunluluğunuz olup olmadığını (sunulan servisin başka bir alternatifi olmaması vb.) değerlendiriniz.		
		2	**“Relative advantage:** The degree to which the services is considered as being better than the idea it replaced.”	Akıllı Şehir Servisleri **yerini aldıkları hizmetlerden** daha iyidir.	Akıllı Şehir Servislerini yerini aldıkları **daha eski ve teknolojik olmayan uygulamalarla** kıyaslayarak cevaplayınız.		
		3	**“Complexity-Ease of Use**: The degree to which the services are easy to learn and use.”	Akıllı Şehir Servislerini öğrenmek ve kullanmak kolaydır.			
	(Chatterjee and Kar 2017)	**4**	**“Visibility**: The services provided to the residents are visible and the residents are aware.”	Kullanıcılara sunulan Akıllı Şehir Servisleri görünür niteliktedir ve vatandaşlar bu servislerin farkındadır.			

		5	**“Compatibility**: The IT **services** provided to the residents are **compatible**, i.e. the services are being consistent with the residents’ values, needs, prior experience, etc.”	Sunulan Akıllı Şehir Servisleri vatandaşların değerleri, ihtiyaçları, önceki tecrübeleri vb. ile uyumlu ve bağıntılıdır.	Akıllı Şehir Servislerinin; değerleriniz, ihtiyaçlarınız, geçmiş tecrübeleriniz, yaşam tarzınız vb. ile ne kadar uyumlu olduğunu değerlendiriniz.		
		6	**“Image**: Usage of IT-enabled services enhances the status of the residence than those using the older manual/paper-based processes.”	Eski, otomatik olmayan kağıt tabanlı servisler yerine Akıllı Şehir Servislerini kullanmak, kişilerin statüsünü (prestij ve imajını) yükseltir.	Teknolojik olmayan ve daha eski uygulamalar yerine Akıllı Şehir Servislerini kullanmanın daha prestijli olup olmadığını ve kişilerin imaj ve itibarına olumlu katkı yapıp yapmadığını değerlendiriniz.		
		7	**“Trialability**: The services can be tested with limited resource as and when required to be tested.”	Akıllı Şehir Servisleri kısıtlı özelliklerle ve kısıtlı şartlarda da olsa gerektiğinde test edilebilir.	Akıllı Şehir Servislerini tüm fonksiyonlarıyla olmasa bile deneme ve test etme imkanı olup olmadığını değerlendiriniz.		
Quality of Service	(Chatterjee and Kar 2017)	**8**	**“Functionality:** The functionalities are adequately designed to meet the needs of the residents with full satisfaction.”	Akıllı Şehir Servisleri ihtiyaç duyulan hizmeti uygun ve doğru şekilde sunmakta ve işlevleri beklentilerimi karşılamaktadır.			
		9	**“Reliability:** The system is reliable and it maintains the performance as per the requirements.”	Akıllı Şehir Servisleri uygun şartlarda doğru hizmeti kesintisiz şekilde verebilmektedir.			
		10	**“Efficiency:** The IT-enabled services are efficient and user friendly to the residents of smart city.”	Akıllı Şehir Servisleri kullanıcılar için verimli ve kullanıcı dostudur.	Akıllı Şehir Servislerinin gerektirdiği kaynak ve efora göre sunduğu performansı (verimlilik) ve kullanıcı uyumluluğunu (kullanıcı dostu) değerlendiriniz.		
		11	**“Maintainability:** The systems are well maintained providing good-quality services to the residents.”	Akıllı Şehir Servislerinin bakımı ve idamesi kullanıcılara kaliteli hizmet sunacak şekilde yapılmaktadır.	Akıllı Şehir Servislerine ihtiyaca uygun şekilde güncelleme, yenileme, iyileştirme ve arıza giderme işlemi (bakım ve idame) yapılıp yapılmadığını değerlendiriniz.		

	(Yeh 2017)	**12**	**"Usability:** Bearing the effort needed for use and individual assessment of such usage."	Akıllı Şehir Servislerini kullanmak fazla efor/emek gerektirmez.			
		13	**"Portability:** The ability to be transferred from one environment and another."	Akıllı Şehir Servisleri bir ortamdan diğerine (cep telefonu, bilgisayar, akıllı banko vb.) taşınabilir.	Akıllı Şehir Servislerinin farklı platform ve cihazlardan (cep telefonu, bilgisayar, smart banko vb.) erişilebilir olup olmadığını değerlendiriniz.		
Social Norm	(Hsu and Lin 2016)	**14**	"My family/friends frequently use IoT services."	Ailem/Arkadaşl arım Akıllı Şehir Servislerini sıklıkla kullanırlar.			
		15	"Most people in my community frequently use IoT services."	Çevremdeki çoğu insan Akıllı Şehir Servislerini sıklıkla kullanır.			
	(Pal et al. 2018)	**16**	"People who are important to me will support my use of smart homes for healthcare."	Benim için önemli insanlar Akıllı Şehir Servislerini kullanmamı destekleyecekle rdir.			
	(Mital et al. 2017)	**17**	"Your decision to use smart devices is because the media encourages use of smart devices."	Akıllı Şehir Servislerini kullanma kararınız medyanın akıllı servisleri kullanmayı özendirmesinde ndir.	Akıllı Şehir Servislerinin kullanımının yazılı ve görsel medyada (sosyal medya dahil) teşvik edilmesinin, bu servisleri kullanma kararınızda ne kadar etkili olacağını değerlendiriniz.		
Personal Innovativeness	(Martínez-Caro et al. 2018)	**18**	"If I hear of new technology-based tools, I look for ways to experiment with them."	Yeni teknoloji tabanlı bir cihazdan haberdar olduğumda, onu denemek için yollar ararım.	Yeni ve teknolojik bir cihazı gördüğünüzde ya da duyduğunuzda onu denemeye ne kadar istekli olduğunuzu değerlendiriniz.		
	(Karahoca, Karahoca, and Aksoez 2018)	**19**	"In general, I am among the first in my circle of friends to acquire new technology when it appears."	Yeni bir teknolojiyi arkadaş çevremde ilk edinenlerden biri genellikle ben olurum.			
		20	"I enjoy the challenge of figuring out high tech gadgets."	Yüksek teknoloji cihazlarla ilgili zorlukları çözmeye çalışmaktan hoşlanırım.	Yeni ve yüksek teknolojili cihazlarla uğraşmaktan ve onları kurcalamaktan hoşlanıp hoşlanmadığınızı değerlendiriniz.		

		21	“I keep up with the latest technological developments in my areas of interest.”	İlgi duyduğum alanlarda yeni teknolojileri ve gelişmeleri takip ederim.			
Cost	(Hsu and Lin 2018)	**22**	“The fee that I have to pay for the use of IoT services is too high.”	Akıllı Şehir Servislerini kullanmak için ödemek zorunda kaldığım ücretleri çok yüksek buluyorum.			
		23	“The fee that I have to pay for the use of IoT services is not reasonable.”	Akıllı Şehir Servislerini kullanmak için ödemek zorunda kaldığım ücretleri makul bulmuyorum.			
		24	“I am not pleased with the fee that I have to pay for the use of IoT services.”	Akıllı Şehir Servislerini kullanmak için ödemek zorunda kaldığım ücretlerden memnun değilim.			
	(Alaiad and Zhou 2017)	**25**	“Cost-benefit analysis is very important for me when I adopt the WSN-based home healthcare systems.”	Akıllı Şehir Servislerini benimserken fayda-maliyet analizi benim için çok önemlidir.	Akıllı Şehir Servislerinin faydasına kıyasla maliyetinin sizin için ne kadar önemli olduğunu değerlendiriniz.		
Privacy Concern	(Hsu and Lin 2018)	**26**	“There is a considerable privacy risk involved in using IoT services.”	Akıllı Şehir Servislerinin kullanımında ciddi bir mahremiyet riski bulunmaktadır.	Akıllı Şehir Servislerinde kişisel verilerin kullanılmasının mahremiyet (gizlilik) açısından ciddi bir risk teşkil edip etmediğini değerlendiriniz.		
		27	“There is too much uncertainty associated with using IoT services.”	Akıllı Şehir Servislerinin kullanımıyla alakalı çok fazla belirsizlik var.	Akıllı Şehir Servislerinde toplanan kişisel verilerin nasıl kullanılacağı, saklanacağı ve paylaşılacağına dair belirsizlikler olup olmadığını değerlendiriniz.		
	(Dong et al. 2017)	**28**	“My personal information will be stolen as a result of IoT systems.”	Akıllı Şehir Servislerinin sonucu olarak kişisel bilgilerim çalınabilir.	Akıllı Şehir Servislerinde toplanan kişisel verilerinizin çalınıp çalınamayacağını değerlendiriniz.		

		29	“Using IoT systems will enable others to use my personal information.”	Akıllı Şehir Servislerinin kullanılması başkalarının (3. taraf kişi ve firmaların) kişisel verilerimi kullanmasına olanak tanır.			
Security	(Chatterjee and Kar 2017)	**30**	“Residents are well protected from any security threat.”	Akıllı Şehir Servislerinin kullanıcıları, tüm güvenlik tehditlerinden (siber tehditlerden) iyi şekilde korunmaktadır.			
	(Belanche, Casalo-Arino, and Perez-Rueda 2015)	**31**	“I think the smartcard service has mechanisms to ensure the safe transmission of its users’ information.”	Akıllı Şehir Servislerinin, kullanıcı verilerinin güvenli şekilde iletilmesini sağlayacak mekanizmalara sahip olduğunu düşünüyorum.			
		32	“I feel safe using the smartcard for making transactions.”	Akıllı Şehir Servislerinde işlem yaparken kendimi güvende hissederim.	Akıllı Şehir Servislerinde işlem yaparken siber tehditlere dair bir güvenlik endişesi taşıyıp taşımadığınızı değerlendiriniz.		
Trust	(Gao and Bai 2014)	**33**	“The ETC device/system is trustworthy.”	Akıllı Şehir Servisleri (genel olarak) güvenilirdir.			
		34	“The ETC service provider keeps my best interests in mind.”	Servis sağlayıcılar (devlet kurumları, belediyeler, özel firmalar vb.) Akıllı Şehir Servislerinde benim en iyi çıkarlarımı dikkate alırlar.	Servis sağlayıcıların, Akıllı Şehir Servislerini, sizin yarar ve çıkarlarınızı gözeterek tesis edip etmediklerini değerlendiriniz.		
		35	“The ETC service provider keeps promises and commitments.”	Servis sağlayıcılar (devlet kurumları, belediyeler, özel firmalar vb.) Akıllı Şehir Servislerinde verdikleri söz ve taahhütleri (güvenlik, performans, işlevsellik vb.)			

				yerine getirmektedir.			
		36	“The ETC device/system provides reliable information.”	Akıllı Şehir Servisleri güvenilir bilgi sunar.	Akıllı Şehir Servislerinde sunulan veri ve bilgileri ne kadar güvenilir bulduğunuzu değerlendiriniz.		
Intention to Use	(Dong et al. 2017)	**37**	“I will recommend others to use the IOT systems.”	Akıllı Şehir Servislerini kullanmayı başkalarına tavsiye edeceğim.			
		38	“I will frequently use the IOT systems.”	Akıllı Şehir Servislerini sıklıkla kullanacağım.			
	(Gao and Bai 2014)	**39**	“I am willing to use ETC in the near future.”	Akıllı Şehir Servislerini yakın zamanda kullanmaya hevesliyim.			
	(Alaiad and Zhou 2017)	**40**	“Given the chance, I plan to use WSN-based home healthcare systems in the near future.”	İmkanım olursa Akıllı Şehir Servislerini yakın zamanda kullanmayı planlıyorum.			
Quality of Life	(Alaiad and Zhou 2017)	**41**	“Overall, I think the overall quality of my life would be improved by using WSN-based home healthcare systems.”	Akıllı Şehir Servislerini kullanmanın genel yaşam kalitemi artıracağını düşünüyorum.			
		42	“I think that WSN-based home healthcare systems fit my lifestyle.”	Akıllı Şehir Servislerini kullanmanın yaşam tarzıma uygun olduğunu düşünüyorum.	Akıllı Şehir Servislerini kullanmanın hedeflediğiniz kaliteli yaşam tarzıyla uyumlu olup olmadığını değerlendiriniz.		
	(Chatterjee and Kar 2017)	**43**	“Perceived ability to do things by citizens themselves enhancing self-reliance.”	Vatandaşların bir şeyleri kendi başlarına yaptıklarında yetenekli olduklarını hissetmeleri onların özgüvenlerini artırır.	İnsanların işlerini Akıllı Şehir Servisleriyle kendi başlarına ve pratik şekilde halledebilmelerinin, özgüvenlerine olumlu etkisi olup olmayacağını değerlendiriniz.		

APPENDIX B

Ethical Approval for the Main Survey Before Pilot Study

UYGULAMALI ETİK ARAŞTIRMA MERKEZİ
APPLIED ETHICS RESEARCH CENTER

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21 KASIM 2019

Konu: Değerlendirme Sonucu

Gönderen: ODTÜ İnsan Araştırmaları Etik Kurulu (İAEK)

İlgi: İnsan Araştırmaları Etik Kurulu Başvurusu

Sayın Prof.Dr. Sevgi ÖZKAN YILDIRIM

Danışmanlığını yaptığınız **Fırat BEŞTEPE'nin "Kent Sakinlerinin Akıllı Şehir Uygulamalarına ve Bu Uygulamaların Kullanımına Karşı Tutumu: Yapısal Eşitlik Modeli Kullanarak Bir Kabul Modeli Geliştirilmesi"** başlıklı araştırması İnsan Araştırmaları Etik Kurulu tarafından uygun görülmüş ve **405 ODTU 2019** protokol numarası ile onaylanmıştır.

Saygılarımızla bilgilerinize sunarız.

Prof. Dr. Tülin GENÇÖZ

Başkan

Prof. Dr. Tolga CAN

Üye

Doç.Dr. Pınar KAYGAN

Üye

Dr. Öğr. Üyesi Ali Emre TURGUT

Üye

Dr. Öğr. Üyesi Şerife SEVİNÇ

Üye

Dr. Öğr. Üyesi Müge GÜNDÜZ

Üye

Dr. Öğr. Üyesi Süreyya Özcan KABASAKAL

Üye

APPENDIX C

Questionnaire Used in the Pilot Study

Yaşınız	( ) 18 - 30 ( ) 31 - 40 ( ) 41 - 50 ( ) 51 - 64 ( ) 65 veya daha büyük
Cinsiyetiniz	( )Kadın ( )Erkek
Eğitim Durumunuz	( )İlkokul ( )Ortaokul ( )Lise ( )Ön Lisans ( )Lisans ( )Yüksek Lisans ( )Doktora
Toplam Hane Geliriniz	( )2500 TL'den Az ( )2501 – 4000 TL Arası ( )4001 – 7000 TL Arası ( )7001 – 10000 TL Arası ( )10001 – 15000 TL Arası ( )15001 – 25000 TL Arası ( )25000 TL'den Fazla
Yandaki Akıllı Şehir Servislerinden hangisini/hangilerini kullandınız? (Birden fazla servis işaretleyebilirsiniz!)	( ) Toplu taşıma kartına (AnkaraKart, İstanbulKart vb.) akıllı bankoları (smart banko) kullanarak kredi kartı ile bakiye yüklemek ( ) Metro, otobüs, vapur ve taksi gibi ulaşım araçlarında kredi kartı ile ödeme yapmak ( ) Öğrenci kartı ya da yaşlı kartını akıllı bankoları (smart banko) kullanarak vizelemek/süre uzatmak ( ) Su ve doğalgaz kartlarına akıllı bankolardan kredi kartı ile bakiye yüklemek ( ) Akıllı Durak ekranlarından veya cep telefonundan metro, otobüs, vapur ve taksi gibi ulaşım araçlarının gelişini takip etmek ( ) Otomatik makinelerden (otomat - vending machine) kredi kartı ile ürün almak ( ) Belirli lokasyonlar için sensör ve kamera verilerini (güvenlik, anlık trafik, yol ve hava durumu vb.) cep telefonundan takip etmek ( ) Daha önce bunlara benzer herhangi bir servisi kullanmadım

	Lütfen aşağıda verilen durumlardan düşüncelerinizi en iyi şekilde ifade eden bir cevabı işaretleyiniz.	**Katılmıyorum**	**Kesinlikli Katılmıyorum**	**Karasızım**	**Katılıyorum**	**Kesinlikle Katılıyorum**
1	Akıllı Şehir Servislerinin işlevleri ve sunduğu hizmetler beklentilerimi karşılamaktadır.					
2	Akıllı Şehir Servisleri yerini aldıkları (daha eski ve teknolojik olmayan) hizmetlerden daha iyidir.					
3	Akıllı Şehir Servisleri uygun şartlarda doğru hizmeti kesintisiz şekilde verebilmektedir.					
4	Akıllı Şehir Servislerini kullanmak fazla efor/emek gerektirmez.					
5	Akıllı Şehir Servislerini öğrenmek benim için kolaydır.					
6	Akıllı Şehir Servislerini kullanmak kolaydır.					
7	Akıllı Şehir Servisleri kullanıcılar için daha verimlidir.					
8	Ailem, akrabalarım ve arkadaşlarım kısaca önemsediğim insanlar Akıllı Şehir Servislerini kullanmamı önerir/destekler.					
9	Ailem, akrabalarım ve arkadaşlarım kısaca önemsediğim insanlar Akıllı Şehir Servislerini kullanmamı yararlı bulur.					
10	Ailem, akrabalarım ve arkadaşlarım kısaca önemsediğim insanlar Akıllı Şehir Servislerini kullanmamın iyi bir fikir olduğunu düşünür.					
11	Tanıdığım insanların çoğu Akıllı Şehir Servislerini kullanır.					
12	Yeni teknoloji tabanlı bir cihazdan haberdar olduğumda, onu denemek için yollar ararım.					
13	Yeni bir teknolojiyi arkadaş çevremde ilk edinenlerden biri genellikle ben olurum.					
14	Yüksek teknoloji cihazlarla ilgili zorlukları çözmeye çalışmaktan hoşlanırım.					
15	İlgi duyduğum alanlarda en yeni teknolojik gelişmeleri takip ederim.					
16	Akıllı Şehir Servislerini kullanmak için ödemek zorunda kaldığım ücretleri çok yüksek buluyorum.					
17	Akıllı Şehir Servislerini kullanmak için ödemek zorunda kaldığım ücretleri makul bulmuyorum.					
18	Akıllı Şehir Servislerini kullanmak için ödemek zorunda kaldığım ücretlerden memnun değilim.					

19	Akıllı Şehir Servislerini kullanmak genel olarak pahalıdır.					
20	Akıllı Şehir Servislerinde kişisel verilerin kullanımına dair riskler bulunmaktadır.					
21	Akıllı Şehir Servislerini kullandığımda kişisel bilgilerim çalınabilir.					
22	Akıllı Şehir Servislerinin kullanımı başkalarının kişisel verilerimi kullanmasına olanak tanır.					
23	Birileri Akıllı Şehir Servislerini kullanarak benim kişisel verilerimi çalabilir.					
24	Akıllı Şehir Servislerinin kullanıcıları, siber güvenlik tehditlerinden iyi şekilde korunmaktadır.					
25	Akıllı Şehir Servislerinde işlem yaparken kendimi güvende hissederim.					
26	Akıllı Şehir Servisleri genel olarak güvenilirdir.					
27	Devlet kurumları, belediyeler, özel firmalar vb. servis sağlayıcılar Akıllı Şehir Servislerinde benim en iyi çıkarlarımı gözetir ve dikkate alırlar.					
28	Devlet kurumları, belediyeler, özel firmalar vb. servis sağlayıcılar Akıllı Şehir Servislerinde verdikleri söz ve taahhütleri yerine getirmektedirler.					
29	Akıllı Şehir Servislerinde sunulan bilgiler güvenilirdir.					
30	Akıllı Şehir Servislerini kullanmayı başkalarına tavsiye edeceğim.					
31	Akıllı Şehir Servislerini sıklıkla kullanacağım/kullanmaya devam edeceğim.					
32	Akıllı Şehir Servislerini yakın zamanda kullanmak/kullanmaya devam etmek istiyorum.					
33	İmkanım olursa Akıllı Şehir Servislerini yakın zamanda kullanmayı/kullanmaya devam etmeyi planlıyorum.					
34	Akıllı Şehir Servislerini kullanmanın genel yaşam kalitemi artıracağını düşünüyorum.					
35	Akıllı Şehir Servislerini kullanarak işlerimi halletmek zaman kazanmama yardımcı olur.					
36	Akıllı Şehir Servislerini kullanmak işlerimi daha kolay halletmeme yardımcı olur.					

APPENDIX D

Main Survey Constructs and Items

Construct	Adjusted item	Reference
Quality of service	QoS1: The functions of the Smart City Services meet my expectations.	(Chatterjee and Kar 2017)
	QoS2: Smart City Services are better than the services they replaced.	(Yeh 2017)
	QoS3: Smart City Services can provide the right service without interruption as per the requirements.	(Chatterjee and Kar 2017)
	QoS4: Using Smart City Services does not require much effort.	(Yeh 2017)
	QoS5: Learning Smart City Services is easy for me.	(Gao and Bai 2014)
	QoS6: Smart City Services are easy to use.	(Park et al. 2017)
	QoS7: Smart City Services are more efficient for users.	(Chatterjee and Kar 2017)
Social influence	SI1: People who are important to me would recommend using Smart City Services.	(Gao and Bai 2014)
	SI2: People who are important to me find it useful to use Smart City Services.	
	SI3: People who are important to me think it is a good idea to use Smart City Services.	
	SI4: Most people I know use Smart City Services.	(Hsu and Lin 2016)
Personal innovativeness	PI1: When I hear of a new technology-based device, I look for ways to try it.	(Martinez-Caro et al. 2018)
	PI2: In general, I am among the first in my circle of friends to acquire new technology when it appears.	(Karahoca et al. 2017)
	PI3: I enjoy the challenge of figuring out high-tech devices.	
	PI4: I keep up with the latest technological developments in my areas of interest.	
Cost	COS1: The fee that I must pay to use Smart City Services is very high.	(Hsu and Lin 2018)
	COS2: The fee that I must pay to use Smart City Services is not reasonable.	
	COS3: I am not pleased with the fee I must pay to use Smart City Services.	
	COS4: Using Smart City Services is expensive overall.	(Park et al. 2017)
Privacy concerns	PC1: There is a considerable privacy risk involved in using Smart City Services.	(Hsu and Lin 2018)
	PC2: My personal information can be stolen when I use Smart City Services.	(Dong et al. 2017)
	PC3: Using Smart City Services will enable others to use my personal information.	
	PC4: Someone can use Smart City Services to steal my personal information.	
Trust level	PT1: Users of Smart City Services are well protected from cyber security threats.	(Chatterjee and Kar 2017)
	PT2: I feel safe when using in Smart City Services.	(Belanche et al. 2015)
	PT3: Smart City Services are generally trustworthy.	(Gao and Bai 2014)
	PT4: Service providers (public institutions, municipalities, private companies, etc.) keep my best interests in mind in Smart City Services.	
	PT5: Service providers (public institutions, municipalities, private companies, etc.) keep their promises and commitments in Smart City Services.	
	PT6: The information provided in Smart City Services is reliable.	
Intention to use	ItoU1: I will recommend others to use the Smart City Services.	(Dong et al. 2017)
	ItoU2: I will frequently use the Smart City Services.	
	ItoU3: I am willing to use the Smart City Services soon.	(Gao and Bai 2014)
	ItoU4: Given the chance, I plan to use the Smart City Services soon.	(Alaiad and Zhou 2017)
Quality of life	QoL1: Overall, I think the overall quality of my life would be improved by using Smart City Services.	(Alaiad and Zhou 2017)
	QoL2: Using Smart City Services helps me save time.	(Samsudeen and Mohamed 2019)
	QoL3: Using Smart City Services helps me to save my expense and effort.	(Tarhini et al. 2013)

APPENDIX E

Finalized Version of Main Questionnaire

Yaşınız	
Cinsiyetiniz	( )Kadın ( )Erkek
Eğitim Durumunuz	( )İlkokul ( )Ortaokul ( )Lise ( )Ön Lisans ( )Lisans ( )Yüksek Lisans ( )Doktora
Toplam Hane Geliriniz	( )2500 TL'den Az ( )2501 – 4000 TL Arası ( )4001 – 7000 TL Arası ( )7001 – 10000 TL Arası ( )10001 – 15000 TL Arası ( )15001 – 25000 TL Arası ( )25000 TL'den Fazla
Yaşamakta Olduğunuz Şehir	( )Ankara ( )İstanbul ( )İzmir ( )Diğer
Yandaki Akıllı Şehir Servislerinden hangisini/hangilerini kullandınız? (Birden fazla servis işaretleyebilirsiniz!)	( ) Toplu taşıma kartına (AnkaraKart, İstanbulKart vb.) akıllı bankoları (smart banko) kullanarak kredi kartı ile bakiye yüklemek ( ) Metro, otobüs, vapur ve taksi gibi ulaşım araçlarında kredi kartı ile ödeme yapmak ( ) Öğrenci kartı ya da yaşlı kartını akıllı bankoları (smart banko) kullanarak vizelemek/süre uzatmak ( ) Su ve doğalgaz kartlarına akıllı bankolardan kredi kartı ile bakiye yüklemek ( ) Akıllı Durak ekranlarından veya cep telefonundan metro, otobüs, vapur ve taksi gibi ulaşım araçlarının gelişini takip etmek ( ) Otomatik makinelerden (otomat - vending machine) kredi kartı ile ürün almak ( ) Belirli lokasyonlar için sensör ve kamera verilerini (güvenlik, anlık trafik, yol ve hava durumu vb.) cep telefonundan takip etmek ( ) Daha önce bunlara benzer herhangi bir servisi kullanmadım

Lütfen aşağıda verilen durumlardan düşüncelerinizi en iyi şekilde ifade eden bir cevabı işaretleyiniz.	Katılmıyorum	Kesinlikli Katılmıyorum	Karasızım	Katılıyorum	Kesinlikle Katılıyorum
1. Akıllı Şehir Servislerinin işlevleri ve sundukları hizmetler beklentilerimi karşılamaktadır.					
2. Akıllı Şehir Servisleri yerini aldıkları (daha eski ve teknolojik olmayan) hizmetlerden daha iyidir.					
3. Akıllı Şehir Servisleri uygun şartlarda doğru hizmeti kesintisiz şekilde verebilmektedir					
4. Akıllı Şehir Servislerini kullanmak fazla efor/emek gerektirmez.					
5. Akıllı Şehir Servislerini öğrenmek benim için kolaydır.					
6. Akıllı Şehir Servislerini kullanmak kolaydır.					
7. Akıllı Şehir Servisleri kullanıcılar için daha verimlidir.					
8. Ailem, akrabalarım ve arkadaşlarım (önemsediğim insanlar) Akıllı Şehir Servislerini kullanmamı desteklerler (önerirler).					
9. Ailem, akrabalarım ve arkadaşlarım (önemsediğim insanlar) Akıllı Şehir Servislerini kullanmamı yararlı bulurlar.					
10. Ailem, akrabalarım ve arkadaşlarım (önemsediğim insanlar) Akıllı Şehir Servislerini kullanmamın iyi bir fikir olduğunu düşünürler.					
11. Tanıdığım insanların çoğu Akıllı Şehir Servislerini kullanırlar.					
12. Yeni teknoloji tabanlı bir cihazdan haberdar olduğumda, onu denemek için yollar ararım. (Açıklama: Yeni ve teknolojik bir cihazı gördüğünüzde ya da duyduğunuzda onu denemeye ne kadar istekli olduğunuzu değerlendiriniz.)					
13. Yeni bir teknolojiyi arkadaş çevremde ilk edinenlerden biri genellikle ben olurum.					
14. Yüksek teknoloji cihazlarla ilgili zorlukları çözmeye çalışmaktan hoşlanırım. (Açıklama: Yeni ve yüksek teknolojili cihazlarla uğraşmaktan ve onları kurcalamaktan hoşlanıp hoşlanmadığınızı değerlendiriniz.)					

15. İlgi duyduğum alanlarda en yeni teknolojik gelişmeleri takip ederim.					
16. Akıllı Şehir Servislerini kullanmak için ödemek zorunda kaldığım ücretleri çok yüksek buluyorum.					
17. Akıllı Şehir Servislerini kullanmak için ödemek zorunda kaldığım ücretleri makul bulmuyorum.					
18. Akıllı Şehir Servislerini kullanmak için ödemek zorunda kaldığım ücretlerden memnun değilim.					
19. Akıllı Şehir Servislerini kullanmak genel olarak pahalıdır.					
20. Akıllı Şehir Servislerinde kişisel verilerin kullanımına dair riskler bulunmaktadır.					
21. Akıllı Şehir Servislerini kullandığımda kişisel bilgilerim çalınabilir.					
22. Akıllı Şehir Servislerinin kullanımı başkalarının kişisel verilerimi kullanmasına olanak tanır.					
23. Birileri Akıllı Şehir Servislerini kullanarak benim kişisel verilerimi çalabilir.					
24. Akıllı Şehir Servislerinin kullanıcıları, siber güvenlik tehditlerinden iyi şekilde korunmaktadır.					
25. Akıllı Şehir Servislerinde işlem yaparken kendimi güvende hissederim.					
26. Akıllı Şehir Servisleri (genel olarak) güvenilirdir.					
27. Devlet kurumları, belediyeler, özel firmalar vb. servis sağlayıcılar Akıllı Şehir Servislerinde benim en iyi çıkarlarımı gözetir ve dikkate alırlar.					
28. Devlet kurumları, belediyeler, özel firmalar vb. servis sağlayıcılar Akıllı Şehir Servislerinde verdikleri söz ve taahhütleri yerine getirmektedirler.					
29. Akıllı Şehir Servislerinde sunulan bilgiler güvenilirdir.					
30. Akıllı Şehir Servislerini kullanmayı başkalarına tavsiye edeceğim.					
31. Akıllı Şehir Servislerini sıklıkla kullanacağım/kullanmaya devam edeceğim.					
32. Akıllı Şehir Servislerini yakın zamanda kullanmak/kullanmaya devam etmek istiyorum.					
33. İmkanım olursa Akıllı Şehir Servislerini yakın zamanda kullanmayı/kullanmaya devam etmeyi planlıyorum.					

34. Akıllı Şehir Servislerini kullanmanın genel yaşam kalitemi artıracağını düşünüyorum.					
35. Akıllı Şehir Servislerini kullanarak işlerimi halletmek zaman kazanmama yardımcı olur.					
36. Akıllı Şehir Servislerini kullanmak işlerimi daha kolay halletmeme yardımcı olur.					

Akıllı Şehir Servislerini kullanmanıza ya da kullanmamanıza neden olan size göre en önemli faktörler nelerdir? Kararınızı etkileyen ama ankette içerilmediğini düşündüğünüz hususları burada belirtebilirsiniz.

APPENDIX F

Ethical Approval for the Semi-Structured Interviews

UYGULAMALI ETİK ARAŞTIRMA MERKEZİ
APPLIED ETHICS RESEARCH CENTER

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02 KASIM 2020

Konu: Değerlendirme Sonucu

Gönderen: ODTÜ İnsan Araştırmaları Etik Kurulu (İAEK)

İlgi: İnsan Araştırmaları Etik Kurulu Başvurusu

Sayın Prof.Dr.Sevgi ÖZKAN YILDIRIM

Danışmanlığını yaptığınız Fırat BEŞTEPE'nin "Kent Sakinlerinin Akıllı Şehir Uygulamalarına ve Bu Uygulamaların Kullanımına Karşı Tutumu: Yapısal Eşitlik Modeli Kullanarak Bir Kabul Modeli Geliştirilmesi" başlıklı araştırmanız İnsan Araştırmaları Etik Kurulu tarafından uygun görülmüş ve 314-ODTU-2020 protokol numarası ile onaylanmıştır.

Saygılarımızla bilgilerinize sunarız.

Prof.Dr. Mine MISIRLISOY
İAEK Başkanı

APPENDIX G

Semi-Structured Interview Questions

1. Akıllı Şehir Servislerini kullanmanızı kolaylaştıran ve sizi bu servisleri kullanmaya teşvik eden en önemli faktörler nelerdir?

2. Peki, bu servisleri kullanmanızı zorlaştıran ya da sizi kullanmamaya iten faktörler nelerdir?

3. Bu tür servisleri kullanabilmek için teknolojik ürünlere ilgi duymak ve teknolojiye yatkın olmak sizce ne kadar önemlidir?

4. Sunulan servisin kalitesi, kullanışlılığı ve kolaylığının Akıllı Şehir Servislerini kullanma kararınıza etkisini nasıl değerlendirirsiniz?

5. Etrafınızdaki kişilerin, akraba ve arkadaşlarınızın, Akıllı Şehir Servisleri ile ilgili olumlu görüşleri olması ve bu servisleri kullanıyor olmaları sizin bu tür servislere olan yaklaşımınızı nasıl etkiler?

6. Gerçekten işinizi kolaylaştıran ve size zaman kazandıracak bir Akıllı Şehir Servisi için ekstra ücret ödemek durumunda olmanız kullanma kararınızı nasıl etkiler? (Bu noktada ne kadarlık yani yüzde kaçlık ekstra bir maliyet sizin açınızdan makul karşılanabilir?)

7. Kişisel verilerinizin gizliliği sizin için ne kadar önemlidir? Kişisel veri gizliliğine dair risklerin Akıllı Şehir Servis sağlayıcılarına duyduğunuz güvene ve bu tür servisleri kullanma niyetinize etkisini nasıl değerlendirirsiniz?

8. Şehir hayatını düşündüğünüzde, bu tür Akıllı Şehir Servislerinin ve bunlara benzer çözümlerin genel yaşam kalitenize etkisi ile ilgili ne söylemek istersiniz?

9. Son olarak, Akıllı Şehir Servislerinin vatandaşlar tarafından kullanılmasına yönelik eklemek istediğiniz herhangi bir husus var mı?

CURRICULUM VITAE

PERSONAL INFORMATION

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EDUCATION

Degree	Institution	Year of Graduation
MS	METU Faculty of Engineering Department of Electrical and Electronics Engineering	2004
BS	Gazi University Faculty of Engineering Department of Electrical-Electronic Engineering	2001
High School	Gazi Anatolian High School Department of Computer	1995

WORK EXPERIENCE

Year	Place	Enrollment
2020-Present	Turkish Accreditation Agency	IT Auditor
2018 - 2020	Turkish State Meteorological Service	Internal Auditor
2017-2018	Republic of Turkey Ministry of Development	Chief Audit Executive
2012-2017	Republic of Turkey Ministry of Development	Internal Auditor
2005-2012	Turkish State Meteorological Service	Expert in Remote Sensing
2002-2005	Turkish State Meteorological Service	Deputy Expert in Remote Sensing

2001-2002	Aktif Energy Limited Company	Systems Engineer

FOREIGN LANGUAGES

Native Turkish, Advanced English