Analysis of Smart Home Systems in the Context of the Internet of Things in Terms of Consumer Experience

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ABSTRACT

Smart homes, which are an important component of the Internet of Things (IoT) provides an effective service for users by communicating with various digital devices based on IoT. IoT-based smart home technology has transformed the lives of humans by providing everyone with a connection independently from time and space. However, due to various challenges such as privacy, security, and price, problems are experienced by consumers in terms of accepting smart home technologies. In the study, it was aimed to develop a model for accepting smart home technologies, and based on the results obtained, it was attempted to determine what factors affect the consumers' intention to buy smart home systems. In this context, with the help of Technology Acceptance Model (TAM), a research model was designed for the purchaser of a home as a product. In the research model, it was investigated what kind of effects perceived psychological factors (perceived ease of use, perceived intelligence, perceived suitability, perceived price, and perceived risk of privacy) have on the purpose and behavior of using IoT systems through perceived benefit. In addition, the relationship between sensory and emotional experiences of consumers, psychological perception factors and perceived usefulness was tested. Data was collected by conducting an online survey questionnaire completed by 430 respondents. Partial least squares (PLSs) was explored to test the theoretical model. The research results show that perceived psychological factors (perceived ease of use, perceived connectivity, perceived intelligence, perceived convenience, and perceived privacy risk) have significant effect on the intention and behavior of IOT systems usage through perceived benefit. In terms of sensory and emotional experience, it only softens the relationship between the perceived privacy risk of emotional experience and the perceived benefit.

Keywords: Consumer Survey, Internet of Things, Technology Acceptance, Information and Communication Technology, Consumer Experience
JEL Classifications: M15, M31, O33

1. INTRODUCTION

The Internet came in view with ARPANET (Advanced Research Projects Agency Network), which emerged in 1969, enabled very few devices to communicate, constituted the foundation of the Internet, and provided communication between a limited number of devices (Naughton, 2016). Nearly two billion people worldwide use the Internet to communicate, browse the Web, access content and multimedia services, play games, interact on social networks and many other applications (Santos and Sales, 2018). Despite the slow progress of the internet in its early days, the development, communication capacity, and speed of the internet, which is expressed as the network of networks, has reached extraordinary levels (Gündüz and Daş, 2018). With the

development of network infrastructure and the high-speed internet becoming more and more widespread, the internet has evolved into a global platform for people, machines and objects to interact autonomously. Internet-based applications not only increase the efficiency of trade, production and education but also provide various services in people's work and life. At this point where we are today, the Internet offers a new technological position called Internet of Things (Santos and Sales, 2018; Liang et al., 2019) by being used to connect devices, machines, and other objects via wired and wireless networks.

The developments in information and communication technology have transformed people's lifestyles in society and their inter-personal interactions, thus their interactions with information,

devices, and services. One of the most significant impact areas is the Internet of Things (IoT). IoT, which is a paradigm change in IT technology, is a broad concept that refers to connecting various devices from virtual networks to physically connected devices in the real world (Siddiqa et al., 2018; Makadam et al., 2015). Although Gubbi et al. defined the Internet of Things as "synonymous with the fully interconnected world" in 2013, there is not a definite description of what IoT really means, what fundamental ideas are behind it, and what the social, economic, and technical implications of IoT are. The difficulty in understanding the concept is caused by the words "internet" and "object" that make up the concept. Differences in definitions are due to the fact that commercial organizations, shareholders, research and standards-setting institutions have made the definition according to their own commercial activities and interests (Atzori et al., 2010).

(Kranenburg, 2008) defines IoT as "dynamic global network infrastructure with self-configuration capabilities based on communication protocols," (Dorsemaine et al., 2015) as the "infrastructure group that connects objects and allows data to be accessed, managed and data mining," (Perera et al., 2015) as "a concept that allows people and objects to be connected with anything and everyone anytime, anywhere using any road/network and any service," (Madakam et al., 2015) as a "network of smart objects capable of auto-organizing that act and react to situations and changes in the environment, in addition to sharing information and data resources" and (Govinda and Saravanaguru, 2016) as "human-to-object or object-to-object communication using standard Internet protocols in embedded networks."

In today's world, where we are experiencing the Internet age and its reflections very rapidly, the Internet of Things (IoT) applications that are incessantly developing and increasing in number make our lives easier (Taştan, 2019). Thanks to perfect sensing, identifying, remote control, and other technologies, the Internet of Things has become the guide for the development of science and technology, has been applied to many physical sectors, and has brought great economic benefits (Choi et al., 2020). In fact, these developments experienced in the Internet of Things (IoT) technologies have also encouraged the transformation of traditional homes into smartly-connected homes (Arif et al., 2020).

The Internet of Things is called the backbone of the home automation system (Yao et al., 2020). Through multiple sensors such as photoelectric sensors, radio frequency identification, etc., information exchange and communication take place between the home environment and the smart system (Gnotthivongsa et al., 2020). A smart home, which refers to a private house that sends and receives data in real-time, provides automated and intelligent services through various home devices such as TV, lighting, and refrigerators (Lee et al., 2020). Some of the leading home IoT platforms to emerge in recent years are Samsung's SmartThings, Apple's HomeKit, and Google's Android Things. These platforms are energy-efficient, connect heterogeneous devices and protocols, facilitate remote control and operation, and support third-party application development (Khoa et al., 2020). Smart homes are defined by (Lutolf, 1992 and Aldrich, 2003) as economical, safe, fun, and comfortable houses equipped

with information technology, by (Gross, 1998; Ricquebourg et al., 2007; by Ricquebourg et al., 2007; Sripan et al., 2012; Balta-Özkan et al., 2014; Hargreaves and Wilson, 2017; Georgiev and Schlögl, 2018; Javed et al., 2018; Marikyan et al., 2019; Hall et al., 2020; Asaithambi et al., 2021; Yang and Han, 2021; Qashlan et al., 2021;) as homes that connect sensors, household appliances, and devices that can be monitored, accessed or controlled remotely, equipped with a communication network that can be used and provides services that meet the needs of their residents, by (Robles and Kim, 2010; Kadam et al., 2015) as an integration of technology and services through the home network for a better quality of life and by (Dewsbury et al., 2001) as "a house in which the scope of a standard house goes beyond brick and mortar and is equipped with technological devices."

Looking at the recent studies on smart home adoption, (Kim et al., 2017) developed a new model that combines VAM (Value-Based Adoption Model) and TAM (Technical Acceptance Model), and based on the Unified Theory of Acceptance and Use of Technology and Elaboration Likelihood Model, they concluded that, through a set of variables, perceived value was affected by both perceived usefulness and perceived sacrifice, especially perceived usefulness had a strong positive effect on perceived value, whereas privacy risk and innovation resistance limit perceived value. (Gu et al., 2019) observed with 488 Chinese respondents that the service quality and perceived usefulness of smart home systems affected the degree of satisfaction of the users positively, and a higher degree of satisfaction contributed to the habit formation of the users. (Hubert et al., 2019) measured in his research the acceptance of smart home systems with 409 random people in Germany by combining the Innovation Diffusion and Risk Theories and stated that the usefulness and compatibility factors were the most important determinant of the intention to use, and the perceived risk factor was the most important inhibitor of the intention to use through the perceived benefit. (Marikyan and Papagiannidis, 2021) proposed in their study a model investigating the values of individuals, technology performance perceptions, and attitude beliefs of users regarding user behavior and satisfaction while using smart technologies at home, and using a sample of 422 participants in the USA, concluded that hedonic and utilitarian beliefs were critical for the perception of task fit, while privacy and financial factors were not important, the fit between tasks and technology played an important role in predicting perceived usefulness, perceived ease of use, user behavior and satisfaction, and lastly, usage behavior was positively correlated with the satisfaction.

According to the research conducted by Statista, the number of Smart Homes in the Smart Home market in Turkey is expected to be 5.0 million by 2025. In addition, the revenue in the Smart Home market in Turkey is expected to reach US $ 538 million in 2021 (Statista, 2020). Since the concept of "Internet of Things" appeared in Turkey, although businesses have invested heavily in it, the IoT industry has only had small-scale activities in the field of consumption. However, when we look at developed countries, IoT systems are applied in areas such as public services, transportation, personal users, retailing, manufacturing, business/service, agriculture, construction, and finance. In the research

conducted by (Dong et al., 2017), personal use comprises the most important area of IoT applications. The most used services in this field are location/navigation, security, mobile payment, measurement detection, automation/remote management, and remote medical. In the research conducted by Statista in August 2021, the rate of use of Smart Home devices in Turkey is approximately 21%. The McKinsey and Company (2018) report highlights that consumers still do not understand the connected device value propositions, and early adopters face significant issues that have yet to be addressed. To better understand the admission process, academics regularly use various theories in their studies, especially the technology acceptance model (TAM; Davis, 1989). In this research, TAM and experience theory were combined to explore the antecedents of consumers' IoT use, and a model was developed to explain the acceptance of smart home systems, and it was investigated which factors affect the consumer's intention to buy smart home systems. The purpose of the study is to respond to the following questions: "Why do consumers use IoT systems in Turkey?" and "Do consumers' sensory and emotional experiences soften the relationship between psychological perception factors and perceived utility?" These factors to be determined within the scope of the study will constitute an important parameter for the design of smart homes, which are not yet very popular.

2. LITERATURE REVIEW

2.1. Historical Development of the Internet of Things
With the development of technology, humans' needs and their perspective of technology have changed, the Internet has become an indispensable communication tool, and it has rapidly evolved into a platform on which billions of smart objects/devices can now be controlled (Erdal and Erguzen, 2020). The idea of the existence of smart objects first emerged in Carnegie Mellon University in the early 1980s with the setting up of a slot machine that could record in its register the number of beverages left and whether the beverages were cold enough (Anita and Abhinav, 2017). The automation of daily objects was first tried by a few industries in the 1990s with small-sized packages by transmitting data from one node to another. The concept of device-to-device communication was first introduced by Bill Joy at the World Economic Forum in 1999. In the same year, Ashton proposed the term "the Internet of Things," and actually it gained momentum after this proposal (Tewari and Gupta, 2020).

The joining of the physical and digital world over the traditional Internet has paved the way for the Internet of Things (IoT) in the future. IoT is considered as a network model that will fill the gap between the cyber and physical world (Nauman et al., 2020). In 1999, Kevin Ashton described the Internet of Things as an epoch in which humans and objects would connect to each other over the Internet. The most important feature of IoT is that it provides multidimensional and context-sensitive smart environments for all aspects of our lives (Fortino et al., 2020).

2.2. The Concept of the Internet of Things
In the period we are living in, countries are experiencing a rapid digital transformation. Individuals, institutions, business fields, and even objects are moving fast towards digitalization. Along with

this digital transformation, the individuals' daily lives, working styles, habits and value judgements have started to change, and radical changes have occurred in almost every area of daily life (Göçoğlu, 2020). The first wave of the digitalization, the fourth wave of which we are currently experiencing, started with the introduction of computers into many areas of the society in the 1980s. The widespread use of the Internet, access to information, and ease of sharing in the 1990s is defined as the second wave. The third wave was experienced in the period when mobile Internet was introduced. The fourth wave of digitalization represents the period when individuals started to use the Internet which they used for accessing and sharing information in different types of entities such as tools, applications, and machines (Davidsson et al., 2016).

The developments in information and communication technology have changed the individuals' life styles in society and their inter-personal interactions, or their interactions with information, devices, and services. One of the most significant impact areas is the Internet of Things (IoT). IoT, which is a paradigm change in the field of IC technology, is a broad concept that refers to connecting various devices from virtual networks to physically connected devices in the real world (Siddiqa et al., 2018; Makadam et al., 2015). IoT is a vast ecosystem in which data, processes, humans, objects, and the Internet are associated with one another (Aman et al., 2020; Gubbi et al., 2013).

IoT, as a system that can be defined as unique and being composed of connected components that have virtual representation and virtual accessibility; has led to a construct similar to the Internet for distance locating, perceiving, and/or operating through the real-time flow of information of the components (Ingemarsdotter et al., 2019). Besides, the universe composed of actuators, sensors, mobile phones, Radio Frequency Identification (RFID) tags, and other devices has led to the creation of the Internet of Things (Al-Turjman et al., 2020). From a conceptual point of view, we can define the Internet of things (IoT) with three features (Miorandi et al., 2012):
- Smart objects/devices must be "identifiable,"
- Smart objects/devices must have the property of "establishing communication" among themselves,
- Objects/devices must have "interaction" among themselves.

The Internet of Things provides not only the virtual world but also the physical world integration. With this new concept, individuals experience many conveniences both in their working lives and daily routines. Considering today, IoT applications have been widespread in many areas and sectors. With the IoT property, the devices that provide continuous tracking, real-time information sharing, and connection between things have been appealing for both individual users and the business world (Doyduk and Bayarçelik, 2019). So much so that, many research companies offer perspectives and trends for the future of IoT and recommend the Internet of Things of the future. The total worldwide Internet of Things (IoT) market is expected to be approximately US$389 billion in 2020 and more than US$1 trillion in 2030 (Statista, 2021c). Moreover, it is estimated that Internet nodes would be available in all objects, and that therefore, the number of devices connected to the Internet would increase. In a report published by

Cisco, it was emphasized that the number of devices connected to the Internet would reach 27 billion by 2022 and 500 billion by 2030 (Shafique et al., 2020; Bouzidi et al., 2020).

Some statistics on IoT are as follows:
- Cisco estimates that there will be 3.5 connected devices per person by 2020 (Tewari and Gupta, 2020).
- About 80% of the consumer services will be used by IoT by 2020 (Tewari and Gupta, 2020).
- It is estimated that the number of IoT devices all over the world will almost be tripled by 2030, increasing from 8.74 billion in 2020 to more than 25.4 billion in 2030. As of 2020, the highest number of IoT devices is in China with 3.17 billion devices (Statista, 2020).
- In the visual network of Cisco, it is expected that the Internet will connect 3.9 billion devices by the end of 2022 with a 32% increase (Asmat et al., 2020).
- It is stated that the Internet Protocol (IP) traffic had a threshold level of 1.54 zettabyte (ZB) (1 ZB = 1000 exabyte) in 2018 and 2.54 ZB in 2020, and it is estimated that this number will reach to 3.9 ZB in 2022 (Naeem et al., 2018; Statista, 2021a).

2.3. Application Areas of the Internet of Things
IoT is considered as an innovative technology that is rapidly growing with various applications, functions and services in daily life, in a variety of markets and industries. Although the recent developments in information and communication available everywhere and the potentials offered by IoT make it possible to develop numerous applications, there are only a few of them for the time being. IoT applications aim to increase the quality of life for the end-user community and support the infrastructure and general-purpose operations (Lampropoulos et al., 2019; Rueda and Portocarrero, 2021). IoT devices, which have unlimited application areas, can be seen in many areas such as tracking wild life in nature, evaluating the performances of machines in the industry, monitoring the density of traffic in the city, determining the safety of structures, detecting earthquakes, ensuring border security in terms of military, etc. (Taş and Kiani, 2021).

2.4. Smart Home Systems
In today's world, where we are experiencing the Internet age and its reflections very rapidly, the Internet of Things (IoT) applications that are incessantly developing and increasing make our lives easier (Taştan, 2019). Thanks to perfect sensing, identifying, remote control, and other technologies, the Internet of Things has become the guide for the development of science and technology, has been applied to many physical sectors, and has brought great economic benefits (Choi et al., 2020). In fact, these developments experienced in the Internet of Things (IoT) technologies have also encouraged the transformation of traditional homes into smartly-connected homes. According to the report published by Statista in March 2021 titled "smart home devices worldwide from 2020 to 2025," the total number of smart home devices worldwide reached 349 million, and it is expected to display a strong increase in the next few years and reach 1.77 billion by 2025 (Arif et al., 2020; Statista, 2021b).

The Internet of Things is named as the backbone of home automation systems that aim to improve the welfare of humans (Marikyan et al., 2019). Through multiple sensors such as photoelectric sensors, radio frequency identification, etc., information exchange and communication take place between home environment and the smart system. The basic logic here is to realize real-time connections between objects and objects, objects and humans, all components and networks, and to facilitate identification, management, and control (Gnotthivongsa et al., 2020; Lee et al., 2020). Information and Communication Technology (ICT) has moved the scope of a standard home by expanding it to beyond the "bricks and mortar." Now, the technology is not limited only to the traditional products such as lighting, washing machines or refrigerators, but now the user can monitor and control the door to the home, stove, refrigerator, and water in the garden without human intervention even from remote distances (Dewsbury et al., 2001; Al-Ali and Al-Rousan, 2004). Therefore, we can define a smart home as "a residence that can be remotely monitored, accessed, managed or controlled, that provides residents with developed services, that connects sensors and home appliances, and that is equipped with a high-technology network" (Nikou, 2018).

2.5. Customer Experience
2.5.1. The concept of experience
We can define experience as "testing" on one's own (Carù and Cova, 2003). Alvin Toffler first explained the term "experience" in his prestigious work "Future Shock" and divided the experience in different environments into two as "experience in real environment" and "experience in virtual environment." Hirschman and Holbrook (1982) defined experience as a phenomenon related with the important factors of consumption, which are imagination, emotion, and entertainment (Luo, 2020) (Cham et al., 2020; Cham et al. 2020a), while it was described as feelings and memories developing as a response to physiological reactions (Meng and Sidin, 2020), and Arnould and Price (1993) identified it extraordinary events that individuals can easily remember even after many years but have difficulty in describing due to their affective content.

2.5.2. Customer experience
The roots of customer experience can be traced back to the 1960s when theories shedding light on marketing and consumer behavior, and especially to the studies of Philip Kotler (1967) and John Howard and Jagdish Sheth (1969) (Lemon and Verhoef, 2016). Later, customer experience was discussed by Hirschman and Holbrook (1982) in the mid-1980s as the concepts of consumer experience and hedonic consumption, and it was made popular by Pine and Gilmore (1998) and Carbone and Haeckel (1994) in the marketing literature. Gentile et al. (2007) argued that customer experience stemmed from a series of interactions between the customer and a part of the product or the organization, and that this led to a reaction.

2.5.3. The dimensions of customer experience
In the model he developed for the businesses to meet the needs of consumers, Schmitt (1999b) categorized the dimensions of customer experience as "sensory, affective, intellectual, behavioral, and relational," while Haeckel et al. (2003) and Berry et al. (2006) classified the dimensions leading to customer experience in three as "functional, mechanical, and human." While Verhoef et al.

(2009) stated that customer experience had cognitive, social, affective, and physical aspects, Lemke et al. (2011) proposed three dimensions as communication encounter, service encounter, usage encounter (Belabbes and Oubrich, 2020). While Meng and Sidin (2020) examined how the cognitive, affective, sensory, and hedonic dimensions of customer experience could be formed in the consumption journey of a company's offers, Piotrowicz and Cuthberston (2014) suggested that the experience should include the technological dimension in order for the customers to be in full interaction with the company and for the company to offer convenience to the customer. Dub'e et al. classified the experience dimension as "pleasure experiences" of the customers, while Gentile et al. (2007) analyzed the experiential components in six dimensions as sensory, affective, cognitive, pragmatic, life style, and relational.

3. METHODOLGY AND RESULTS

As a result of the detailed analyses performed in the literature within the scope of the study, it was observed that many studies were conducted in the literature on the Internet of Things, Smart Home Systems, Technology Acceptance Model, and Customer Experience. Hence, scales that were thought to be valid for the study topic and yield the best results were sought and included in the study, and a questionnaire form was created. The questionnaire form created in order to develop a technology acceptance model for smart home systems consisted of 11 items related to user information in the first part, 53 items in the second part which also included the scales of the model, with a total of 64 items.

Through a pilot study of the questionnaire created for the research model, firstly field data were collected from 102 potential users. The field research was conducted face-to-face and through online surveys. Factor analysis, and validity and reliability analyses of the data obtained as a result of the questionnaire administered to potential users were performed, and the final questionnaire items were created. Following the field research and creation of finalized questionnaire items, the finalized questionnaire was administered to 430 potential users.

3.1. Hypotheses
The research hypotheses are:
H1. Intention to use has a positive effect on usage behavior.
H2. Perceived benefit has a positive effect on intention to use.

In the study conducted in order to explain the relationship between Smart Home Systems and Customer Experience within the context of the Internet of Things, integrated technology acceptance model and customer experience scale were employed. The variables of integrated technology acceptance model and the variables in the customer experience scale were adapted to the study.

3.2. Research Data Collection
Questionnaire method, which is very common in social sciences, was used in the study as data collection method. The questionnaire were uploaded in Google Forms web site, and they were sent to various e-mail groups by announcing over the social media. The study was carried out with the participation of individuals who

were over the age of 18 and had a certain income all over Turkey.

3.3. Basic Statistics
The demographic data of the participants are important in terms of obtaining a qualitative profile of the participants. 11 demographic items were added to the questionnaire used in the study, and the results were interpreted in detail.

When the data collected were examined and evaluated in general, it was seen that the ratio between the male and female participants was almost 50%. When the age distribution of the participants were examined, it was seen that it was youth weighted, similar to the age distribution of Turkey. The fact that the questionnaire respondents were working people with a profession was important in terms of being able to own smart home systems. Also, a great majority of the participants had undergraduate and graduate education levels. The majority of the questionnaire respondents lived in 2-4 person homes as nuclear families in their own standard homes.

The detailed numerical distribution of the items added to the questionnaire in order to determine demographic properties of the participants are presented in the Table 1 below:

3.4. Analysis
In order to simultaneously measure the compatibility of the statements to the constructs, construct validity and hypothesis tests in the model proposed for the acceptance of Smart Home Systems within the scope of the study, "Partial Least Squares (PLS) method-based Structural Equation Modelling" was used. It is advantageous to use PLS-SEM when the sample size is small, there are data which do not show normal distribution, or when complicated models that have relationships with many elements are estimated (Guhr et al., 2020).

In the field study conducted, it was seen that the study sample was not suitable for normal distribution both on the basis of statements and on a multiple scale (multiple normality). Therefore, when

Table 1: Demographic Properties

Frequency Analysis of the Demographic Variables			
Demographic Variable	Option	Number (Frequency)	Percentage (%)
Gender	Female	186	43.3
	Male	244	56.7
Age	Under the age of 30	104	24.18
	Between 36-45 years	218	50.7
	Between 51-70 years	108	25.11
Education	Primary School and below	26	6
	High School	98	22.8
	Undergraduate Degree	214	49.8
	Master's Degree	62	14.4
	PhD Degree	30	7
Marital Status	Married	283	65.8
	Single	147	34.2
Residence	Owner	267	62.1
	Tenant	163	37.9
Is the home smart?	Smart Home	25	5.8
	Standard Home	425	94.2

it is considered that PLS yields more valid and reliable results regarding the validity and reliability analyses of constructs in a data set that does not show normal distribution, it was decided to use this method in order to obtain correct results in the study.

In the study, PLS-SEM 3.3.3 software was employed in order to verify study constructs and test the hypotheses. In the study, PLS-Sem path model with a path weighting scheme was applied for internal approach, and in order to obtain the standard errors of estimations, it was analyzed with non-parametric bootstrapping approach with 1,000 re-sampling.

In the evaluation of the validity of the proposed model, the reliability of each item was evaluated by the loading of latent variable that matches each item. In order to test the internal validity, combined reliability (CR) and Cronbach's alpha values were examined, and it was seen that CR and Cronbach's alpha values in Table 2 were higher than the criteria of 0.8 and 0.7, respectively. Also, in order to test convergent validity, average variance extracted (AVE) was analyzed, and as shown in Table 2,

AVE values were observed to be greater than the criteria of 0.5 proposed by Bagozzi and Yi (1988). Thus, these results show that the reliability, internal consistency and convergence validity of our model were ensured.

In order to test discriminant validity, the square root of AVEs is compared with the correlations between the variables (Hong et al., 2017). As shown in Table 3, the diagonal values which are the square root of AVEs are respectively greater for each construct, and our measurement model attained discriminant validity (Fornell and Larcker, 1981).

3.5. Path Coefficients and Hypothesis Tests

PLS method was also used in order to verify the hypothetical relationships between the constructs in the model. The importance of the paths included in the proposed model was tested by using a bootstrapping resampling procedure. While evaluating PLS model, firstly, squared multiple correlations (R^2) for each internal latent variable were examined, and the importance of structural paths was evaluated (Alshibly, 2015).

Table 2: The Evaluations of the Proposed Structural Model: Convergent Validity

Latent Variable	Indicator	Factor Loads	Cronbach's α	CR	AVE
Perceived Ease of Use	PEU1	0.937	0.0911	0.939	0.794
	PEU2	0.946			
	PEU3	0.933			
	PEU4	0.732			
Perceived Connectivity	PC1	0.951	0.935	0.958	0.885
	PC2	0.948			
	PC3	0.923			
Perceived Intelligence	PI3	0.959	0.908	0.956	0.916
	PI4	0.954			
Perceived Suitability	PSU1	0.928	0.830	0.922	0.855
	PSU2	0.921			
Perceived Risk	PR1	0.815	0.914	0.933	0.700
	PR2	0.845			
	PR3	0.861			
	PR4	0.866			
	PR5	0.843			
	PR6	0.788			
Perceived Benefit	PB1	0.898	0.929	0.949	0.824
	PB2	0.893			
	PB3	0.917			
	PB4	0.922			
Sensory Experience	SE1	0.957	0.907	0.956	0.915
	SE2	0.956			
Affective Experience	AE1	0.931	0.852	0.931	0.871
	AE2	0.935			
Intention to Use	IU1	0.963	0.922	0.962	0.927
	IU2	0.963			
Perceived Price	PP1	0.944	0.934	0.958	0.883
	PP2	0.930			
	PP3	0.944			
Realized Usage	RU1	0.884	0.700	0.869	0.769
	RU2	0.870			

Table 3: Fornell-Larcker Criterion Matrix of the Model

	Perceived Smartness	Perceived Connectivity	Perceived Benefit	Perceived Risk Of Privacy	Perceived Easy Of Use	Perceived Suitability	SE-PEU to PB	SE-PR to PB	AE-PEU to PB	AE-PR to PB	Affective Experience	Sensory Experience	Price	Realized Usage	Intention to Use
Perceived Smartness	0,955														
Perceived Connectivity	0,948	0,949													
Perceived Benefit	0,880	0,893	0,920												
Perceived Risk Of Privacy	0,645	0,621	0,606	0,781											
Perceived Easy Of Use	0,863	0,878	0,854	0,616	0,811										
Perceived Suitability	0,868	0,877	0,861	0,564	0,859	0,926									
SE-PEU to PB	-0,692	-0,682	-0,644	-0,560	-0,671	-0,652	1,000								
SE-PR to PB	-0,604	-0,595	-0,551	-0,357	-0,568	-0,557	0,766	1,000							
AE-PEU to PB	0,643	-0,642	-0,615	-0,483	-0,621	-0,596	0,865	0,719	1,000						
AE-PR to PB	-0,507	-0,506	-0,454	-0,240	-0,481	-0,453	0,657	0,827	0,721	1,000					
Affective Experience	0,582	0,560	0,648	0,560	0,553	0,578	-0,407	-0,333	-0,291	-0,200	0,826				
Sensory Experience	0,714	0,732	0,807	0,580	0,707	0,701	-0,437	-0,385	-0,436	-0,351	0,748	0,811			
Price	0,727	0,733	0,706	0,717	0,666	0,656	-0,571	-0,465	-0,516	-0,376	0,562	0,642	0,940		
Realized Usage	0,357	0,349	0,407	0,418	0,370	0,358	-0,269	-0,189	-0,223	-0,059	0,512	0,460	0,419	0,877	
Intention to Use	0,707	0,704	0,809	0,460	0,708	0,731	-0,487	-0,429	-0,450	-0,319	0,671	0,696	0,538	0,547	0,961

Perceived Benefit, Intention to Use, and Realized Usage are internal latent variables in the Technology Acceptance Model of Smart Home Systems. R² coefficients of the relevant variables are given in Table 4.

Two criteria were used in order to evaluate the structural model: the statistical significance (t-tests) of the estimated path coefficients (β) and the model's capability to explain the variance in dependent variables, identifying coefficient (R²). R² is a goodness of fit criterion for linear regression models. This statistic shows the percentage of the variance in the dependent variable which the independent variables explain as a whole (Dufour, 2011).

In the analysis of the model, bootstrapping was used to estimate t values. T, p, and f² values for evaluating statistical significance are presented in Table 5. For a significant effect at 95% confidence interval, t value must be 1.96 or above. (Kwong and Wong, 2013). On the other hand, f² value gives information about the impact size of the relationship. As f² value increases, impact size will also increase. In the literature, f² values between 0.02 and 0.15 show a small impact size, those between 0.15 and 0.35 indicate medium impact size, and those above 0.35 show a large impact size.

In the structural model consisting of 14 hypotheses tested within the scope of the study, 9 hypotheses were supported, while 5 were not supported.

Structural model was used to test the hypotheses in the research. Figure 3 shows the results of path coefficients and corresponding significance levels. The results showed that intention to use (β = 0.553, P < 0.001) was a significant predictor of the consumers' physical usage behaviors and that it constituted 31% of the variance explained (R² = 0.310). As it was hypothesized in the study that intention to use (H1) would positively affect realized usage, H1 was supported.

The results also showed that perceived benefit (β = 0.758, P < 0.001), perceived ease of use (β = 0,123, P < 0.05), and perceived risk (β

= −0.099, P < 0.05) were significant predictors of intention to use, and that they constituted 68% of the variance explained (R² = 0.680). As it was hypothesized in the study that perceived benefit (H2) and perceived ease of use (H3) would have a considerably positive effect on intention to use, perceived risk (H9) would have a considerably negative effect on intention to use, and H2, H3, and H9 were also supported. Besides, ease of use (β = 0.123, P < 0.05), perceived intelligence (β = 0.143, P < 0.05), perceived connectivity (β = −0.132, P < 0.05), and perceived suitability (β = 0.178, P < 0.01) were significant predictors of perceived benefit, which corresponds to 84% of the variance explained (R² = 0.840). As it was hypothesized in the study that perceived ease of use (H4), perceived connectivity (H5), perceived intelligence (H6), and

Table 4: R² Values of the Model

	R²	Adjusted R²
Perceived Benefit	0.840	0.836
Intention to Use	0.680	0.676
Realized Usage	0.310	0.301

Table 5: Statistical Values for the Hypotheses, Results, and Impacts

Hypothesis	t Statistic	p Value	f²	Result	Impact
H1	14.012	0.000	0.410	Supported	Large
H2	12.977	0.000	0.485	Supported	Large
H3	1.987	0.047	0.013	Supported	Small
H4	3.084	0.002	0.036	Supported	Small
H5	1.982	0.048	0.014	Supported	Small
H6	2.344	0.019	0.019	Supported	Small
H7	3.240	0.001	0.041	Supported	Small
H8	0.354	0.723	0.001	Not supported	_
H9	2.200	0.028	0.013	Supported	Small
H10	0.389	0.698	0.001	Not supported	_
H11	1.212	0.226	0.009	Not supported	_
H12	1.715	0.087	0.011	Not supported	_
H13	2.084	0.037	0.023	Supported	Small
H14	0.566	0.571	0.001	Not supported	_

Figure 1: The estimated number of devices connected over the internet (2015-2025)
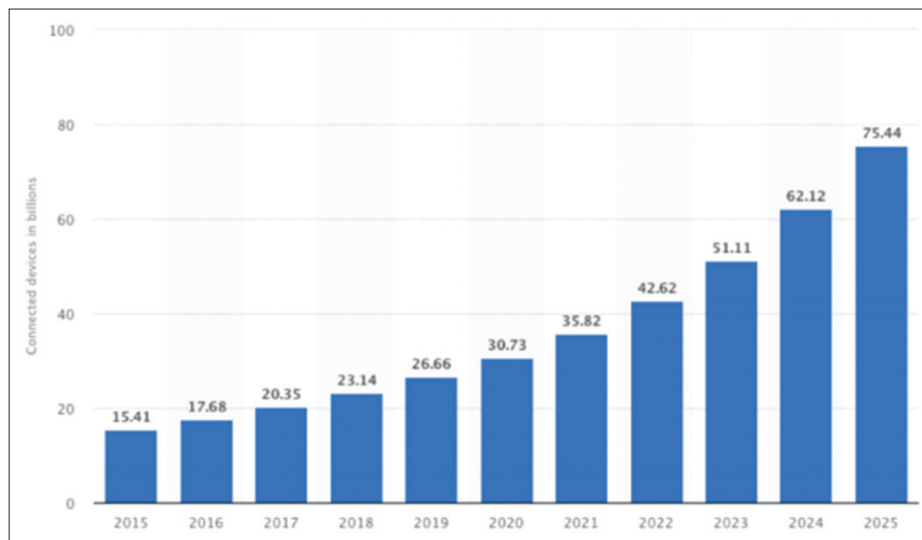
Source: Erdal and Erguzen, 2020. The Internet of Things (IoT), International Engineering Research and Development Journal UMAGD, 12 (3):29
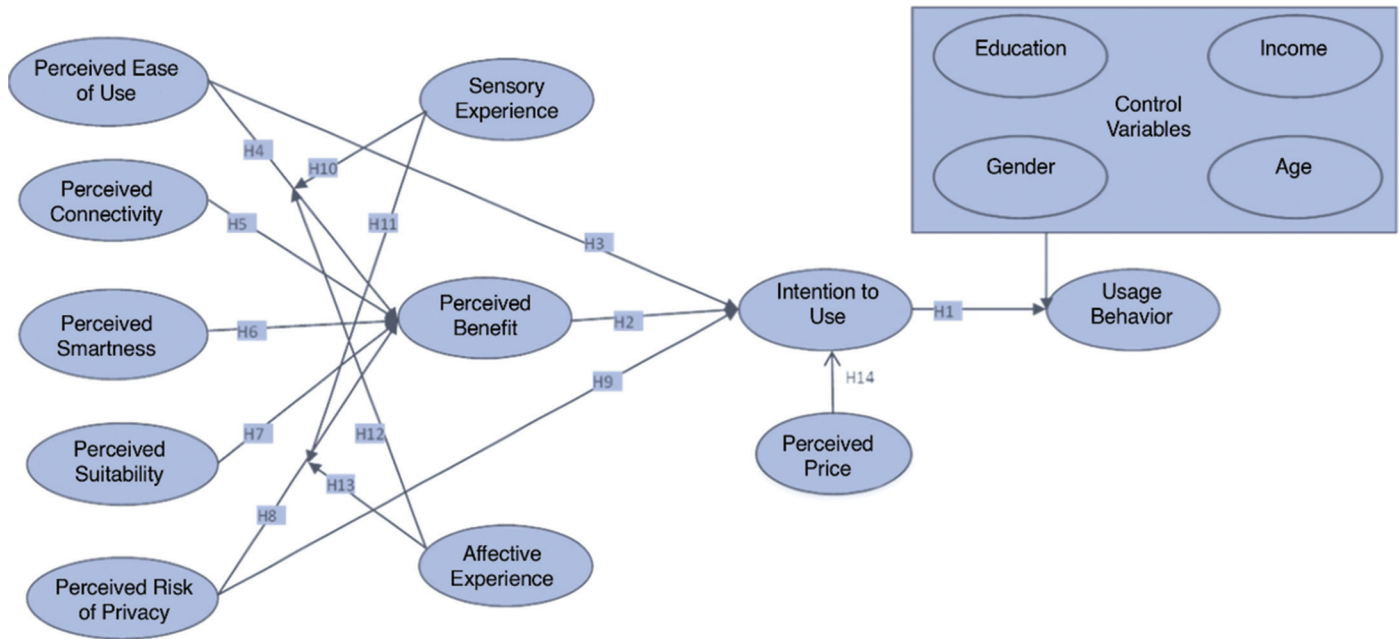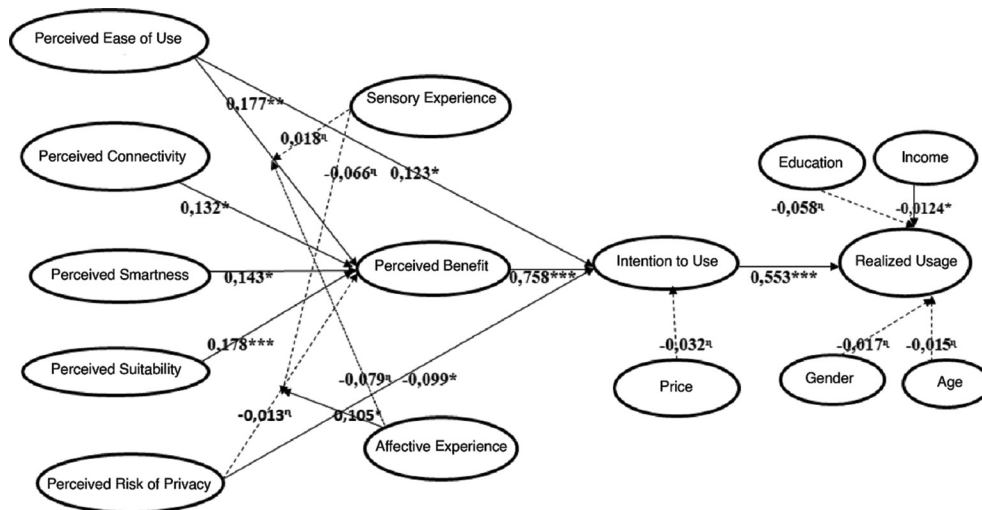
Figure 2: Research Model

Figure 3: PLS Analysis of Research Model

Source: n, neutral, *P < 0.05; **P < 0.01;***P < 0.001

perceived suitability (H7) would have a considerably significant effect on perceived benefit, H4, H5, H6, and H7 were supported, and H8 was not supported as no significant effect of perceived risk (H8) on perceived benefit was found. In addition, it was observed in the model that perceived price (H14) had no significant effect on intention to use, and H4 was not supported.

In the analysis of the regulatory effects, regarding the empowering effects of sensory experience in the relationship between perceived ease of use and perceived benefit, and perceived risk and perceived benefit, it was seen that H10 and H11 were not significant. As it was hypothesized that H13 would have a significant effect regarding the significant relationship between perceived risk and perceived benefit ($\beta = 0.104$, P = 0.05), and the empowering effects of affective experience in this relationship, H13 was supported.

Regarding the empowering effects of affective experience in the relationship between perceived ease of use and perceived benefit, it was seen that H12 was not significant.

As for the control variables, it was found that monthly income significantly affected real usage ($\beta = -0.124$, P < 0.05), and that gender, age, and education level had no significant effects on real usage.

4. CONCLUSION

The findings of the study showed that the five psychological perception factors of consumers about IoT (perceived ease of use, perceived connectivity, perceived intelligence, perceived suitability, and perceived risk of privacy) were effective on

intention to use and real usage through perceived benefit, and that in terms of sensory and affective experience, only affective experience softened the relationship between perceived risk of privacy and perceived benefit. The main findings were summarized in Table 5 and discussed below.

Perceived benefit and perceived ease of use have a significant and positive effect on intention to use IoT systems. Perceived ease of use has an indirect effect on intention to use IoT systems through perceived benefit. Therefore, the findings of the present study showed that it was not sufficient to increase the effectiveness and performance of IoT systems in order to get consumers to use IoT systems, and that making the use of IoT systems easier was more important. Only when consumers believe that it is easy to use and remember how to use IoT systems, they will perceive it as beneficial. Perceived ease of use will significantly increase behavior intention. Another important issue that users worry about in using IoT systems is leaking of their information. Users send their daily usage activities information to a terminal. However, if this information is leaked and their privacy is violated, it will significantly affect individuals' intention to use. Perceived risk of privacy will significantly undermine behavior intention. In the study, it was determined that the risk of privacy in smart home technology negatively affected the users' behavioral adoption intentions. In this case, trust in service providers plays a significant role. Smart home technology service providers can ensure transparency by assuring the users about their policies regarding the prevention of personal data leakage.

In addition to perceived ease of use, perceived intelligence and perceived suitability significantly increase perceived benefit. In the study, it was seen that users prefer smart home technology in such a way to help them in their daily lives, that is, to perform daily routines fast and efficiently. For this reason, while system developers are developing a smart technology for home, they should design the interface as convenient as possible to provide usefulness for the user. This study also revealed that users did not want to make more efforts in order to learn something new, and that they did not want to accept technologies which are not compatible with current technologies. Therefore, service providers should produce smart home systems that are compatible with the existing home appliances of potential users and very easy to use.

However, no significant relationship was found between perceived risk of privacy and perceived benefit. While it was determined in the model that perceived risk of privacy had a greater effect on intention to use, when its indirect effect was examined, it was seen that perceived risk was not understood. A probable reason for this is that leaking of personal data, easy breaking down of the devices, and worry about this malfunctioning affecting other devices and causing them to fall out of the system outweighed the benefit of technology in the users' behavior of accepting smart home systems.

No significant relationship was found between price and intention to use. A possible reason for this is that the users' intentions to accept smart home systems were not in near future, and therefore, they did not prioritize cost.

Those who use IoT systems experience two types of experience: sensory and affective experience. In the model, sensory experience did not have a significant effect on perceived benefit. To be more specific, it was found that sensory experience did not have a regulatory role in the relationship between perceived ease of use and perceived benefit, and the relationship between perceived risk of privacy and perceived benefit. Similarly, it was determined that affective experience did not have a regulatory role in the relationship between perceived ease of use and perceived benefit. In other words, benefit perception of ease of use of smart home systems is not affected by any external factors.

4.1. Contributions and Impacts

The results obtained from the current study present some suggestions for future research. First of all, as a basic model, TAM was used in order to investigate the consumers' use of IoT systems. In addition, perceived benefit, perceived ease of use, and perceived risk of privacy are the three main determinants of intention to use, and perceived benefit is affected by external psychological factors. Our study provides evidence for the fact that TAM should be considered in the real smart home usage context.

Secondly, the psychological factors affecting the consumers' use of IoT systems have not been investigated in previous studies. The five external factors examined in the study are perceived ease of use, perceived connectivity, perceived intelligence, perceived suitability, and perceived risk of privacy. A high reliability and validity was ensured to be a reference for future studies about psychological factors in the context of IoT systems.

Thirdly, the present study showed that external factors except perceived risk of privacy created a significant and positive effect on perceived benefit. In the model, the effect of perceived risk of privacy on perceived benefit was found to be insignificant. This situation may have resulted from the fact that the users did not believe smart home systems were safe enough. In the studies conducted in foreign countries (especially in South Korea where technology use is widespread), a significant and negative effect of perceived risk of privacy was found on perceived benefit and intention to use, and worries were dissipated by getting the users to experience the technology. However, in countries such as Turkey where smart home systems are not widely used, consumers have a tendency not to use these systems as they have worries about the leakage of personal data, these devices easily breaking down and affecting other devices in the system. For this reason, these users don't care whether smart home systems are beneficial or not. Yet, if businesses can establish an affective bond with the brand by preventing the worries that form in the minds of users, they can enable them to see the benefit of the system. Therefore, smart home systems producing companies should develop various tactics and policies in order to reduce the concerns of users and to make them feel safer in terms of accepting the technology. In addition, although some studies on information technology/information systems used or emphasized the importance of perceived ease of use, perceived suitability, or perceived connectivity, it is needed to investigate more the common effects of these on perceived benefit.

Fourthly, consumers' experiences of IoT systems include sensory and affective experiences that both are expected to have a significant effect on perceived benefit. However, in the model, affective experience has a medium level effect on only the relationship between perceived risk of privacy and perceived benefit. Besides, the findings obtained from the study provides inferences for practitioners. It was revealed that perceived benefit had a significant and positive effect on intention to use IoT systems. Therefore, in order to make consumers use IoT systems more, companies should consider consumers' perceived factors, especially by introducing the practicality of IoT systems to their target consumers. Companies can also take suitable precautions in line with the psychological factors in order to improve perceived benefit. Perceived ease of use has a significant and positive effect on perceived benefit. Producers have to develop a system that is easy to use in order to increase consumers' perceived benefit regarding IoT systems.

Perceived intelligence has a significant and positive effect on perceived benefit. High intelligence must be task-oriented by automatically arranging the best alternative for system users. Producers have to develop a smart IoT system that has the ability to learn by itself in order to increase consumers' perceived benefit of the system. Perceived suitability also has a significant and positive effect on perceived benefit. By benefiting from the properties of mobile technology, producers can design an IoT system for users that can work anytime and anywhere, this will make the users feel that they are saving time, and thus, their perception of the practicality of the system is strengthened.

4.2. Limitations and Future Research

Although significant results and inferences were obtained in the study, there are various limitations that should be addressed in future research. First of all, in the present study, mainly the precursors of consumers' usage behaviors of IoT systems were tested, but the consequences of using the information system were not investigated. Future research can examine the consequences by using expectation-approval theory (i.e., satisfaction, perceived value). Secondly, in the study, mainly the effect of consumers' psychological perception on perceived benefit was investigated. In future research, various variables such as "individual differences and intrinsic motivations" can be considered for investigating.

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