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Comprehensive Approaches to User Acceptance of Internet of Things in a Smart Home Environment

Eunil Park, Yongwoo Cho, *Member, IEEE*, Jinyoung Han, *Member, IEEE*, and Sang Jib Kwon

***Abstract*—With rapid improvements in communication technologies and infrastructure, the Internet of Things (IoT) has become a promising sector within the global information and communication technology (ICT) industry. Various fields are employing the concept of IoT for their traditional products and services for convenient use by consumers. In the construction industry, the majority of leading companies and organizations are using IoT technologies in a smart home environment. However, only few studies have focused on the user experience of IoT technologies in such an environment. Thus, the current study explores the key determinants of user acceptance of IoT technologies in a smart home environment, and investigates a research model integrated with five potential user factors and a technology acceptance model. The results of the collected data, which were investigated using a structural equation modeling (SEM) method, show that three positive motivations, compatibility, connectedness, and control, and a negative hindrance, cost, are significant determinants of the technology acceptance behavior of users. The current study can serve as a foundation for future studies on improving IoT technologies in a smart home environment by considering the user experience.**

***Index Terms*—Internet of Things, compatibility, technology acceptance model, connectedness**

I. Introduction

FOLLOWING the introduction of the concept of Internet of Things (IoT), IoT technologies began to be applied to a large number of new information and communication technology (ICT) products and services. According to a recent report [1], about 500 billion objects will be linked through the Internet. With this trend, the majority of key countries in the global ICT industry have indicated that IoT has become widely distributed and emergent in terms of industrial and social development.

Moreover, both practical and academic fields in the ICT industry have also changed. Prior studies have indicated that IoT has significantly affected the overall structure, business concepts, and future directions of the industry [2], [3].

Despite the comprehensive effects of IoT, few studies have focused on IoT user experience and how the current ICT industry can predict the acceptance of IoT in future emerging markets [4]. It may be that products and services using IoT are still in their early stage of diffusion and popularization. Therefore, the current study considers user experience of IoT, and investigates user motivations and hindrances to acceptance of IoT by introducing a comprehensive user acceptance model utilizing the technology acceptance concept. Moreover, the current study also considers a smart home environment, which is one of the most promising contexts in employing and utilizing IoT [5]. Both a confirmatory factor analysis (CFA) and structural equation modeling (SEM) were used to test and verify the model.

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E. Park (Corresponding author), Y. Cho, and J. Han are with the College of Computing and the Graduate School of Human-Computer Interaction, Hanyang University, Republic of Korea (e-mail: pa1324@gmail.com, ywc@hanyang.ac.kr, jinyounghan@hanyang.ac.kr).

S. J. Kwon is with the Department of Business Administration, Dongguk University, Republic of Korea (email: risktaker@dongguk.ac.kr).

II. Internet of Things

A. IoT in a Smart Home Environment

IoT can be described as a network of objects connected through the Internet [3]. The traditional Internet provides connections between users for exchanging information. IoT provides autonomous communication functions among objects using sensors and the components included in each object. Owing to these functions, the functionality and specific details of IoT technologies have been studied with regard to converging sensor networks, as well as in pervasive and ubiquitous computing [6]. Although a definition of IoT has not been officially introduced, a widely employed definition is "*a procedure and technology which includes a set of functional process in object identification, network capabilities, intelligence and autonomous interactions*" [6].

Owing to the distribution of the smart home services concept, companies developing wireless network solutions are considered as key participants in smart home markets [7], [8]. Because such companies have core wireless network technologies based on ZigBee, cellular networks (3G, and 4G), Bluetooth, and so on, they can provide a smart home platform solution for connecting different types of platforms [9].

Because home networks can be used for IoT applications, several IoT companies are already using the smart home platform, one of the most promising IoT sectors, to apply their applications and services to business markets [10]. For example, security, housing, and telecommunication companies can provide several home products and services through the home network of a smart home environment [11]. Moreover, various products including displays, smartphones, and autonomous household thermostats can also use home networks for maintaining the optimal home conditions [12]. In addition, because smart home services with IoT technologies can integrate a smart grid system, both economic feasibility and living convenience can be improved [5].

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TABLE I
THE INTERVIEW RESULTS.

Constructs	Responses(%)
Cost	29 (30.2%)
Control	14 (14.6%)
Enjoyment	12 (12.5%)
Compatibility	12 (12.5%)
Connectedness	10 (10.4%)
Etc.	19 (19.8%)
Total	96 (100%)

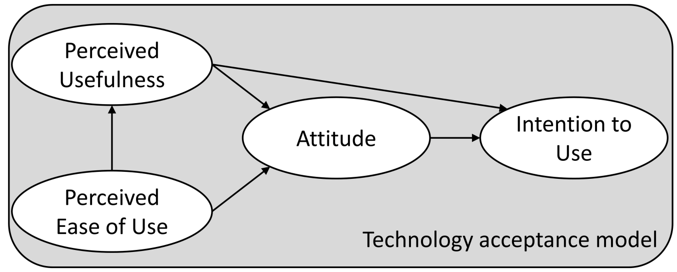

Fig. 1. The original technology acceptance model.

The future concept of smart home services with IoT technologies can have economic advantages and expandability by presenting easy accessibility to wireless networks, as well as the compatibility of various operation systems, languages, and frameworks. This means that smart home services and solutions using IoT technologies have the potential to allow future ICT and housing industries to enter sustainable global markets. However, significant challenges remain that should be overcome, including security, diversified system integration, and standardization issues [13].

Owing to the use of mobile products and services, which are one of the main streams in consumer lifestyles, the recognition of user perceptions in wireless environments has recently become one of the most important factors in determining the success of IoT technologies within the smart home context [14]. In addition, users should be able to enjoy the convenience of various smart products with IoT technologies connected to a home network. To achieve this, users hope to have access to a convenient user interface that provides compatibility between their home appliances and their smart devices.

Therefore, to contribute to the successful popularization of IoT technologies and smart home services, a sufficient understanding of the users should be examined. The current study aims at introducing a unified research model that contains several motivations and hindrances that were examined based on user interviews.

B. Examining Potential Motivations and Hindrances

To present the potential motivations and hindrances of user intentions regarding IoT technologies in a smart home environment, in-depth interview sessions with 15 professors and experts who had considerable expertise in information and communication technology markets were conducted. Based on the interview results, a query analysis was examined. Five factors were then extracted and employed to build the user research model (Table I).

III. RESEARCH HYPOTHESES

A. Technology Acceptance

Examining the user acceptance of new products and services is one of the essential activities to leading to the success of the products and or services in the competitive market. Thus, a large number of theoretical approaches have been conducted to examine the acceptance. Among these approaches, the technology acceptance model (TAM) introduced by Davis [15], is considered as one of the most successful attempts. Four factors are contained in the original TAM, as shown in Fig. 1.

Several prior studies have confirmed and validated the TAM as a key framework for presenting innovative and recent information-related services and products [16]. Relating to IoT technologies, Gao and Bai [17] validated the roles of social influence, perceived control, enjoyment, and two factors of the origin TAM, i.e., usefulness and ease of use, as the determinants of user intentions regarding IoT technologies. Based on a study using more than 300 Chinese users, Dong, Chang, Wang, and Yan [18] explored the psychological factors that affect the perceived usefulness. Hsu and Lin [19] studied about 500 users of IoT services and found that the perceived benefits play a significant role in determining the users' attitude toward such services.

Therefore, based on validated findings of prior research, the current study proposes the following hypotheses:

- H1. Attitude toward IoT technologies in a smart home environment significantly affects the intention to use the technologies.
- H2. Perceived usefulness of IoT technologies in a smart home environment significantly affects the intention to use the technologies.
- H3. Perceived usefulness of IoT technologies in a smart home environment significantly affects the attitude toward the technologies.
- H4. Perceived ease of use of IoT technologies in a smart home environment significantly affects the attitude toward the technologies.
- H5. Perceived ease of use of IoT technologies in a smart home environment significantly affects the perceived usefulness of the technologies.

B. Perceived Enjoyment

The original TAM was examined through a large number of prior studies, and the perceived enjoyment was considered to be one of the notable motivations. Davis, Bagozzi, and Warshaw [20] explored both extrinsic and intrinsic motivations of the TAM, and found that significant relationships exist between enjoyment and the two TAM moderators. Based on the description of perceived enjoyment employed by prior studies, the definition of perceived enjoyment in the present study is "*the degree of which using IoT technologies in smart home environments is considered to be pleasurable and playful*" [20].

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In addition, some prior studies have explored the role of perceived enjoyment as one of the significant predictors of user perspectives [21]. Based on the results of 195 mobile service users, Kim, Park, and Oh [22] showed that there is a respective connection between perceived usefulness and enjoyment. In addition, Chung and Tan [23] indicated that perceived playfulness of information-oriented services has a notable role in forming a user experience. Thus, the following hypothesis is introduced.

- H6. Perceived enjoyment of IoT technologies in a smart home environment significantly affects the perceived usefulness of the technologies.

C. Perceived Connectedness

Users may hope to easily use their home appliances and mobile products in a smart home environment. In such an environment, users can conveniently utilize their appliances and products without physical interaction [24]. Considering a smart home environment, IoT technologies provide a large number of functions with wireless connections between users and their home network [25]. Therefore, users can feel a sense of convenience when they are able to control the components in their household. This means that perceived connectedness between users and their household components is one of the key advantages in using IoT technologies. That is, perceived connectedness may contribute to both usefulness and ease of use. Thus, the current study introduces the following hypothesis:

- H7. Perceived connectedness of IoT technologies in a smart home environment significantly affects the perceived usefulness of the technologies.
- H8. Perceived connectedness of IoT technologies in a smart home environment significantly affects the perceived ease of use of the technologies.

D. Compatibility

The concept of compatibility introduced through innovation diffusion theory has been one of the most important factors in diffusing innovative services and products [26]. Compatibility was introduced by Rogers [26], and was defined as "*the degree to which an innovation is well-operated in harmony with the traditional and present needs.*" In the prediction of network-oriented services, perceived compatibility has been considered one of the key factors in determining a user's adoption of such services [27]. Tsai, Chien, and Tsai [28] presented the idea of perceived compatibility, which plays a core role in improving the perceived usability of a particular system.

For Internet or communication-oriented services, prior research has argued that there are both moderating and mediating roles of perceived compatibility in shaping a user's perceptions regarding such services [29], [30]. Moreover, because the switching costs and significant efforts required by traditional systems or services can be minimized, the compatibility should be considered one of the key characteristics of IoT technologies in a smart home environment [31]. Therefore, the current study proposes the following hypotheses:

- H9. Perceived compatibility of IoT technologies in a smart home environment significantly affects the perceived usefulness of the technologies.
- H10. Perceived compatibility of IoT technologies in a smart home environment significantly affects the perceived ease of use of the technologies.

E. Perceived Control

Prior studies on user behavior have defined perceived control as "*users' perceptions on skills, abilities and resources for easily and naturally using a particular system or service*" [32]. To develop a successful service, manufacturers must do their best to provide their service with a useful user interface that allows the users to maximize their control skills. Based on a definition developed in prior research, the current study defines perceived control as "*the users' sense of how skillful it is to perform a particular activity using IoT technologies in smart home environments*" [16].

Demiris, Hensel, Skubic, and Rantz [33] showed that perceived behavioral control contributes to the perceived needs of consumers in using smart home sensor technologies. Shin, Hwang, and Choo [34] investigated a particular smart home appliance, and found that perceived control, which is one of the components of perceived interactivity, indirectly affects a user's intention to use a smart home appliance based on two moderators, i.e., utilitarian and hedonic factors. Based on the results of data collected on South Korean smart TV users, Yu, Hong, and Hwang [35] also indicated that a user's perceived control is one of the notable predictors of its acceptance.

Therefore, perceived control may have a notable effect on the TAM. The current study presents the following hypothesis:

- H11. Perceived control of IoT technologies in a smart home environment significantly affects the perceived ease of use of the technologies.

F. Perceived Cost

Although there are notable hindrances and motivations to using new and innovative services or products, economic burden has been one of the most significant obstacles to their distribution [36], [37]. This indicates that users will likely consider deeply whether the benefits of a specific service are greater than the costs. Prior studies on information-oriented services introduced the definition of perceived cost as "*the concerns on the costs consumed in buying, using and repairing the component of a particular system or service*" [38]. Based on this definition, the definition of perceived cost used in the present study is "*the concerns on the costs in buying, installing, maintaining and operating IoT technologies in smart home environments*" [38].

Several previous studies on innovative and recent services presented notable evidence regarding the relationships between user perceptions and perceived cost. Based on the collected data on 268 respondents, Al-Debei and Al-Lozi [39] determined that a direct relationship exists between economic value and the adoption of wireless services. Related to the field of smart home environments, Williams, Bernold, and Lu [40] showed the key role of perceived cost of information-oriented technologies in forming the users' intention to employ. Thus, the current study introduces the direct connection between perceived cost and use intention.

- H12.Perceived costs of IoT technologies in a smart home environment significantly affect the intention to use the technologies.

G. Research Model

Based on the hypotheses introduced herein, the research model shown in Fig. 2 is proposed.

IV. Study Method

A total of 40 questionnaire items regarding nine constructs were collected. All items were used and validated through prior studies. Two professional experts and two translators carefully translated all items into Korean. After the translation, a back-translation session was conducted to test the reliability of the resulting translation. Then, three professors of information services, consumer research, and mobile communications, and two experts on smart home services revised the translated items.

Based on the revised items, the pilot survey was conducted with 30 students who had over three-months of experience with IoT technologies. The collected data of the pilot survey were tested through a reliability test. Seven items were then eliminated from the questionnaire list. Table II shows the questionnaire items used in the survey. The current study used a 7-point Likert scale to evaluate the items in the survey (1 = "Extremely disagree," 7 = "Extremely agree").

Two South Korean companies conducted an online survey during a month-long period. They sent out 4,442 emails to users who are employing IoT technologies in a smart home environment. From 1,303 responses, both validation and data-filtering methods were examined. This study retained 1,057 validated samples of these responses for analysis. Table III lists information regarding the validated responses used in the analysis.

V. Results

Table IV summarizes the descriptive results of the present research model.

A. Validity Tests

The current study employed a confirmatory factor analysis (CFA) and structural equation modeling (SEM) methods for investigating the hypotheses introduced herein. To achieve successful results of the CFA and SEM, more than 200 samples were required. In addition, Cronbachs alpha values, the factor loadings, and the composite reliability values were higher than 0.7. The average variance extracted (AVE) was higher than 0.5. In order to test whether the measurements in the current study which should not be related, the discriminant validity was tested. To satisfy the discriminant validity, the correlations between two particular constructs should be lower than the square root degree of the AVE [51], [52]. The current study satisfies the recommendation levels of the validity tests (Table V and Table VI).

B. Fit Indices

In order to assess the goodness of the measurement and research models, this study computed various fit indices, and employed the recommendation levels which were statistically suggested by prior studies [51], [52], [53], [54], [55], [56]. Although several prior studies on absolute fit indices suggested that χ^2/d.f. should be lower than 5.0, it is difficult to satisfy when the size of samples is huge [54], [55]. Therefore, the current study uses 8.0 as the satisfactory level of χ^2/d.f. Table VII shows the fit indices of the measurement and research models. The fit indices satisfy the recommendations.

C. Hypothesis Testing

The results of the research model are summarized in Table VIII and Fig. 3. Although the relationship between perceived enjoyment and usefulness (H6) was not validated, other hypotheses were supported. Three factors, attitude (H1, β = 0.345, *CR* = 9.788, $p < 0.001$), usefulness (H2, β = 0.186, *CR* = 5.203, $p < 0.001$), and cost (H12, β = -0.268, *CR* = -7.888, $p < 0.001$), were shown to determine the intention to use IoT technologies in a smart home environment.

The attitude toward IoT technologies used in a smart home environment was shown to be determined by perceived ease of use (H4, β = 0.413, *CR* = 10.735, $p < 0.001$) and usefulness (H3, β = 0.207, *CR* = 5.435, $p < 0.001$). Three factors, perceived compatibility (H9, β = 0.891, *CR* = 22.653, $p < 0.001$), ease of use (H5, β = 0.142, *CR* = 4.871, $p < 0.001$), and connectedness (H7, β = 0.092, *CR* = 3.085, $p < 0.01$), were significantly associated with the usefulness. However, no relationship was shown between perceived usefulness and enjoyment (H6, β = 0.003, *CR* = 0.114, $p > 0.05$). The perceived ease of use was shown to be determined by three motivations, perceived connectedness (H8, β = 0.202, *CR* = 6.004, $p < 0.001$), control (H11, β = 0.185, *CR* = 4.577, $p < 0.001$), and compatibility (H10, β = 0.171, *CR* = 4.048, $p < 0.001$). Two factors, the perceived cost and attitude, contributed to 34.2% in the variance of the intention, whereas 29.2% in the variance of the attitude was contributed by two motivations, perceived usefulness and ease of use.

Fig. 4 summarizes the total effects of the employed constructs on ones intention to use IoT technologies. In addition to attitude (0.345) and usefulness (0.258), both compatibility (0.260) and cost (-0.268) were shown to have a notable effect on use intention, which indicates their significant roles in such determination.

D. Supplemental Analysis

The current study examined additional SEM analyses with regard to the demographic information of the respondents to investigate whether the acceptance patters of IoT technologies were similar or consistent across subgroups. This study identified that the majority of subgroups presented similar or identical patterns of user acceptance to those investigated in the group as a whole.

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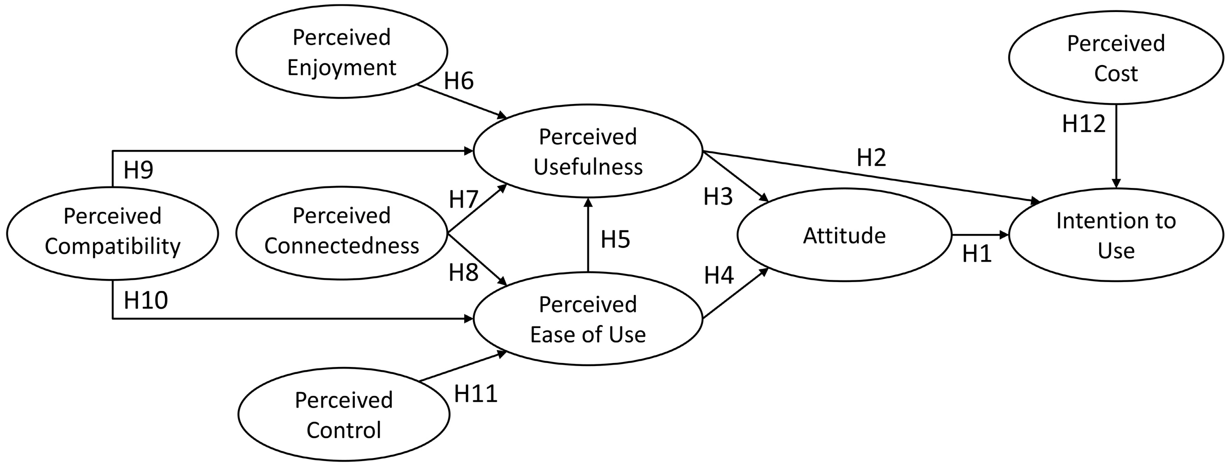

Fig. 2. Research model.

TABLE II
QUESTIONNAIRE ITEMS USED IN THE SURVEY.

Constructs	Descriptions
Perceived enjoyment [41], [42]	ENJ1: I have fun interacting with IoT technologies in a smart home environment
	ENJ2: I enjoy using IoT technologies in a smart home environment
	ENJ3: Using IoT technologies in a smart home environment would be interesting
Perceived compatibility [29], [43]	COM1: IoT technologies are compatible with existing technologies in a smart home environment
	COM2: IoT technologies used in a smart home environment fit with my home lifestyle
	COM3: IoT technologies used in a smart home environment are compatible with my other devices and services
Perceived connectedness [16], [44], [45]	CONN1: I feel good when I can access the components through IoT technologies in a smart home environment
	CONN2: I feel connected to a smart home environment because I can use IoT technologies in such an environment
	CONN3: I feel emotionally comforted because I can use IoT technologies in a smart home environment
Perceived control [16], [46]	PCT1: When using IoT technologies in a smart home environment, I do not feel disturbed
	PCT2: IoT technologies used in a smart home environment enable me to operate necessary services
	PCT3: IoT technologies in a smart home environment enable me to obtain necessary information
Perceived ease of use [15], [42], [47]	PEU1: The use of IoT technologies in a smart home environment does not require significant mental effort
	PEU2: IoT technologies in a smart home environment are easy to use
	PEU3: My interaction with IoT technologies in a smart home environment is understandable and clear
Perceived usefulness [15], [48]	PU1: I think IoT technologies in a smart home environment are useful to my lifestyle
	PU2: It would be comfortable for me to use IoT technologies in a smart home environment
	PU3: IoT technologies in a smart home environment provide me with useful services and information
Attitude [15], [24], [44]	AT1: I think using IoT technologies in a smart home environment is a nice idea
	AT2: I think using IoT technologies in a smart home environment is beneficial to me
	AT3: I have positive feelings toward IoT technologies in a smart home environments
Perceived cost [45], [49], [50]	COS1: Using IoT technologies in a smart home environment is expensive overall
	COS2: Installing and operating IoT technologies in a smart home environment are a burden to me
	COS3: There is a financial barrier to maintaining and repairing IoT technologies in a smart home environment
Intention to use [15], [44]	IU1: I will continue to use IoT technologies in a smart home environment
	IU2: I intend to use IoT technologies in a smart home environment as much as possible
	IU3: I recommend others use IoT technologies in a smart home environment

VI. DISCUSSION

The current study introduced the comprehensive acceptance model for IoT technologies in a smart home environment with the integration of five motivating factors, enjoyment, compatibility, connectedness, control, and cost. Both CFA and SEM methods were employed to present the structural connections in determining the intention to use the technologies. The structural results indicate that users' attitude toward IoT technologies is the greatest predictor of their intention to use. The effects of perceived usefulness on the intention are greater than those of perceived ease of use, whereas the effects of usefulness on the attitude are lower than those of perceived ease of use. Among the selected external motivations, perceived compatibility and cost showed notable impacts on use intention. This highlights that serving compatible technologies with traditional services and devices is one of the core issues in determining the successful diffusion of IoT technologies. Moreover, because the technologies are still in an early competitive market stage, the economic aspects of the technologies are also important in the market success.

As shown in the results of the research model, the intention was determined by three factors, which indicate the importance of building positive attitudes toward IoT technologies through an easy to use and compatible interface.

Another notable finding is that both perceived compatibility and connectedness are two important external predictors of the

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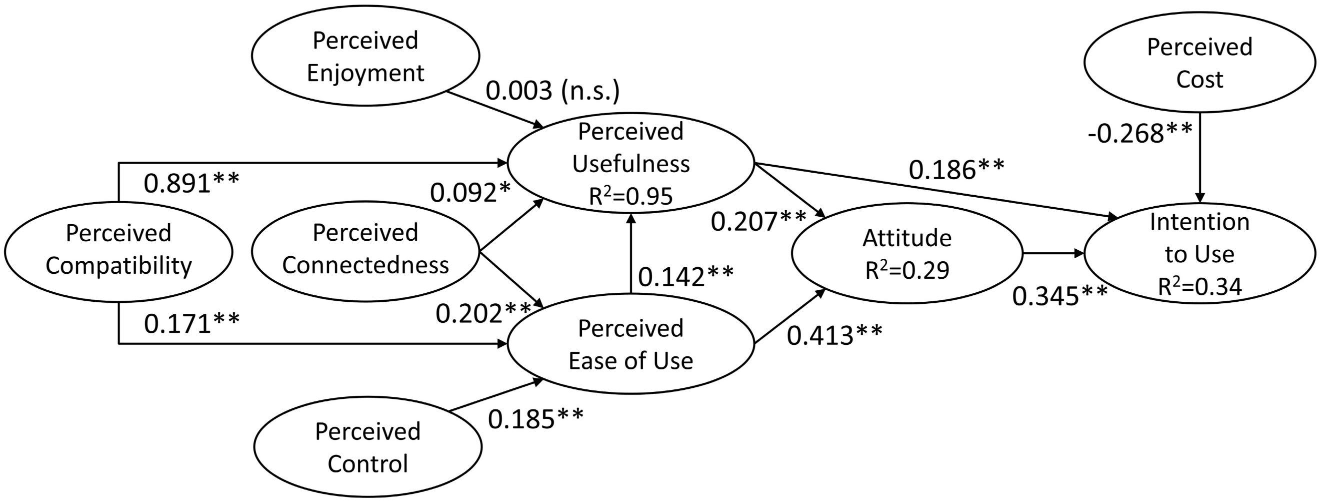

Fig. 3. Results of the research model (**$p < 0.001$, *$p < 0.01$).

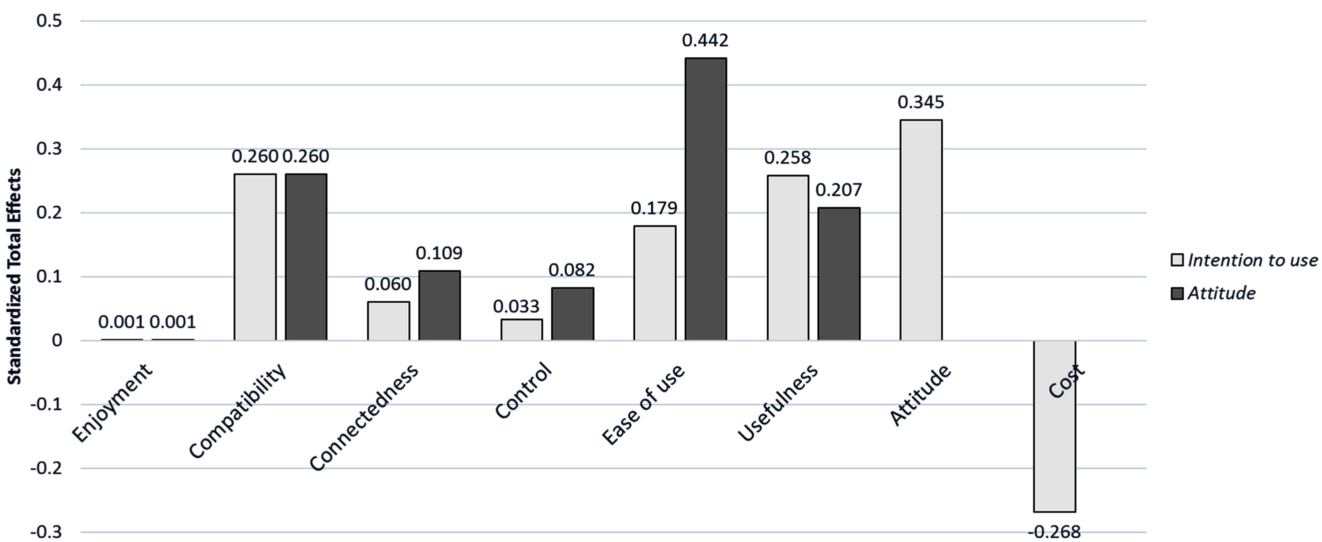

Fig. 4. Total standardized effects on attitude and intention.

TABLE III
INFORMATION REGARDING THE SAMPLES USED IN THE ANALYSIS (N = 1,057).

Age	n (%)	Residential types	n (%)
20−30	355 (33.6%)	Apartment	639 (60.5%)
31−40	452 (42.8%)	Townhouse	187 (17.7%)
41−50	157 (14.9%)	Country and detached houses	114 (10.8%)
51−60	54 (5.1%)	Studio flat	97 (9.2%)
Over 60	39 (3.7%)	Other	20 (1.9%)
Gender	n (%)	Living areas	n (%)
Male	591 (55.9%)	Metropolis	527 (49.9%)
Female	466 (44.1%)	Small- and medium-sized cities	345 (32.6%)
		Rural area	185 (17.5%)
Experience	n (%)	Education	n (%)
6−12 months	98 (9.3%)	High school or below	387 (36.6%)
12−18 months	181 (17.1%)	College	519 (49.1%)
18−24 months	362 (34.2%)	Graduate or above	151 (14.3%)
Over 24 months	416 (39.4%)		

TABLE IV
DESCRIPTIVE RESULTS

Constructs	Mean (standard deviation)
Perceived enjoyment	5.53 (1.21)
Perceived compatibility	5.75 (1.22)
Perceived connectedness	5.18 (1.27)
Perceived control	5.09 (1.19)
Perceived ease of use	5.17 (0.99)
Perceived usefulness	5.23 (1.33)
Attitude	4.55 (1.34)
Perceived cost	3.55 (1.23)
Intention to use	5.22 (1.32)

original TAM. This indicates that users' intention to employ IoT technologies is significantly determined by not only the suggestion of well-connected functionalities with traditional devices and products, but also providing a compatible interface when using both IoT technologies and traditional products in a smart home environment. Although the economic aspects

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TABLE V
CONVERGENT VALIDITY AND INTERNAL RELIABILITY

Constructs	Items	Internal reliability		Convergent reliability		
		Cronbach's alpha	Total-item correlation	Factor loading	Composite reliability	Average variance extracted
Perceived enjoyment	ENJ1	0.801	0.751	0.865	0.878	0.706
	ENJ2		0.710	0.863		
	ENJ3		0.714	0.791		
Perceived compatibility	COM1	0.841	0.749	0.883	0.905	0.761
	COM2		0.622	0.912		
	COM3		0.549	0.820		
Perceived connectedness	CONN1	0.819	0.447	0.731	0.873	0.699
	CONN2		0.721	0.881		
	CONN3		0.461	0.886		
Perceived control	PCT1	0.938	0.758	0.946	0.960	0.890
	PCT2		0.828	0.949		
	PCT3		0.820	0.935		
Perceived ease of use	PEU1	0.913	0.795	0.906	0.945	0.851
	PEU2		0.818	0.945		
	PEU3		0.718	0.916		
Perceived usefulness	PU1	0.861	0.654	0.785	0.854	0.661
	PU2		0.639	0.831		
	PU3		0.850	0.823		
Attitude	AT1	0.808	0.564	0.850	0.887	0.723
	AT2		0.585	0.841		
	AT3		0.603	0.860		
Perceived cost	COS1	0.813	0.514	0.775	0.892	0.735
	COS2		0.754	0.893		
	COS3		0.528	0.898		
Intention to use	IU1	0.932	0.837	0.926	0.957	0.881
	IU2		0.773	0.957		
	IU3		0.854	0.933		

TABLE VI
DISCRIMINANT VALIDITY.

Constructs	1	2	3	4	5	6	7	8	9
1. Perceived enjoyment	0.84								
2. Perceived compatibility	0.114	0.872							
3. Perceived connectedness	0.134	0.243	0.836						
4. Perceived control	0.047	0.427	0.304	0.943					
5. Perceived ease of use	0.037	0.171	0.24	0.209	0.923				
6. Perceived usefulness	0.089	0.672	0.254	0.396	0.185	0.813			
7. Attitude	0.026	0.17	0.173	0.216	0.324	0.169	0.85		
8. Perceived cost	-0.055	-0.228	-0.282	-0.252	-0.492	-0.206	-0.449	0.857	
9. Intention to use	0.027	0.213	0.22	0.399	0.397	0.17	0.381	-0.55	0.939

TABLE VII
THE FIT INDICES OF THE MEASUREMENT AND RESEARCH MODELS [18], [52], [53], [54], [55], [56].

Fit indices	Measurement model	Research model	Recommended levels
χ^2/d.f.	5.948	5.933	< 8.000
AGFI (adjusted goodness-of-fit index)	0.920	0.910	> 0.900
GFI (goodness-of-fit index)	0.933	0.919	> 0.900
CFI (comparative fit index)	0.950	0.950	> 0.900
NFI (normed fit index)	0.940	0.920	> 0.900
SRMR (Standardized Root Mean Square Residual)	0.077	0.079	< 0.080
RMSEA (root mean square error of approximation)	0.067	0.068	< 0.080

TABLE VIII
SUMMARY OF THE PROPOSED RESEARCH MODEL (**$p < 0.001$, *$p < 0.01$).

Hypotheses	Standardized coefficient	*SE*	*CR*	Results
H1. Attitude → Intention to use	0.345**	0.04	9.788	Supported
H2. Perceived usefulness → Intention to use	0.186**	0.043	5.203	Supported
H3. Perceived usefulness → Attitude	0.207**	0.04	5.435	Supported
H4. Perceived ease of use → Attitude	0.413**	0.034	10.735	Supported
H5. Perceived ease of use → Perceived usefulness	0.142**	0.025	4.871	Supported
H6. Perceived enjoyment → Perceived usefulness	0.003	0.023	0.114	Not supported
H7. Perceived connectedness → Perceived usefulness	0.092*	0.021	3.085	Supported
H8. Perceived connectedness → Perceived ease of use	0.202**	0.028	6.004	Supported
H9. Perceived compatibility → Perceived usefulness	0.891**	0.037	22.653	Supported
H10. Perceived compatibility → Perceived ease of use	0.171**	0.046	4.048	Supported
H11. Perceived control → Perceived ease of use	0.185**	0.041	4.577	Supported
H12. Perceived cost → Intention to use	-0.268**	0.046	-7.888	Supported

of the technologies (perceived cost) are considered as one of the notable hindrances to the intention, this hindrance can be reduced by the advancement and development of the technologies. Moreover, because both perceived compatibility and connectedness are also important factors in the future business and competitive markets, focusing on and enhancing the factors lead to that IoT can reach "*Intelligence of Things*".

The results of the current study indicate both practical and theoretical implications. From a practical aspect, the research model introduced in this study presents the process of adopting patterns of IoT technologies in a household environment. In addition, manufacturers and service providers of IoT technologies for a smart home environment can employ the results of the current study. For instance, the developers and researchers of IoT technologies used in a smart home environment should focus on the installation and improvements of their products or services, which includes easy connection and compatible interfaces. This means that both technology- and user-oriented developments are conducted in parallel.

From a theoretical aspect, the research model described in the current study was developed using the original TAM concept and five external factors extracted through in-depth interviews. The structural results indicate the validation of the original TAM in explaining the adoption of network-oriented services in a smart home environment.

However, there are some notable limitations that should be considered in future research. First, individual information from the survey respondents was not considered when investigating the research model. Several prior studies have shown that user adoption of innovative and recent technologies is significantly related to their individual characteristics [57]. Second, because the survey described in the current study was conducted in South Korea, the results cannot be directly applied to other nations [58]. Prior studies have shown that cultural and national differences can be significantly associated with user adoption patterns [59]. Third, despite the rejection of H6 (perceived enjoyment and usefulness), this study cannot present enough explanations. One of the potential reasons on the rejection is the environment that we considered in the survey. Because this study considered a smart home environment, the respondents may feel utilitarian aspects of IoT technologies, instead of hedonic features of the technologies. Therefore, future studies should consider the above-presented limitations for improving the validity and reliability of this research model.

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Eunil Park is an Assistant Professor in the Graduate School of Human-Computer Interaction and co-founding director of Human-Computer Interaction Laboratory at Hanyang University. He also serves as a vice-director of the DTech Institute at Hanyang University.

He received the B.S. and M.S. degrees in computer science and human-computer interaction from Sungkyunkwan University, and the Ph.D. degree in Engineering from Korea Advanced Institute of Science and Technology (KAIST), in 2016.

He was a researcher with ASTA Inc., Sungkyunkwan University, and Jaume-I University. From 2015 to 2017, he was a research specialist with Korea Institute of Civil Engineering and Building Technology. Since 2017, he has worked in Hanyang University. He is the author of 100+ articles and the winner of more than 10 awards.

His main research interests are human-computer interaction, behavioral and psychological outcomes of technology-mediated communication, and user behavior.

Yongwoo Cho is an Assistant Professor in the Graduate School of Human-Computer Interaction and co-founding director of Human-Computer Interaction Laboratory at Hanyang University.

He received the Premedical degree from the University of Ulsan in 1997. In 2000, He joined Dooin Corp. as a research engineer for alternative military service and received B.S. in Computer Science from Korea National Open University in 2004, M.S. and Ph.D. degrees in Electrical Engineering and Computer Science from Seoul National University, in 2006 and 2017 respectively. Before joining Hanyang University, he worked in KT Music as General Manager of Strategic Planning Division, Requiro Music as Chief Executive Officer, and Atelier Schmid as Co-President.

His research interests include cyber-physical systems, healthcare systems, human-computer interaction, and data science. Prof. Cho is a member of the IEEE, IEEE Computer Society, and ACM.

Jinyoung Han is an Assistant Professor in the Graduate School of Human-Computer Interaction and co-founding director of Human-Computer Interaction Laboratory at Hanyang University.

He was a postdoctoral researcher at University of California, Davis, and Seoul National University (SNU). He received his B.S. degree in computer science from KAIST in 2007 and Ph.D. degree in computer science and engineering from SNU in 2013. He has published over 30 referred papers in major conferences and journals. His research interests include social computing, data mining, and ubiquitous computing.

Sang Jib Kwon is an Assistant Professor in the Department of Business Administration at Dongguk University.

He received the Ph.D. degree in innovation and technology management from KAIST in 2015. Before joining Dongguk University, he was a director of human resources and strategic planning teams in CJ E&M.

He has published more than 40 international articles. Moreover, he was the winner of more than 15 research competitions. His research interests include organizational studies, cultural effects of innovative technologies and services, market strategy, and macro management.