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Combined Model of Technology Acceptance and Innovation Diffusion Theory for Adoption of Smartwatch

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ABSTRACT

This study examined the factors influencing the intention to use smartwatches using the integrated model of technology acceptance model (TAM) and innovation diffusion theory (IDT). An online survey was conducted and the data were analyzed using the structural equation modeling (SEM). The results showed that the research model had an acceptable fit, and all paths, except for the one from the perceived ease of use to the intention to use, were supported. Regarding paths from IDT to TAM, it was observed that higher the compatibility, the users perceived greater usefulness. Additionally, both observability and trialability influenced the perceived ease of use. However, perceived ease of use affected the intention only through the mediated effect of perceived usefulness. The implication of the study lies on the major focus on the effects of users' perceptions regarding innovative characteristics of smartwatches on the intention to adopt and attempted to increase the explanatory power of the TAM and IDT by combining both.

***Key words**: Smartwatch, Innovation Diffusion Theory (IDT), Structural Equation Modeling (SEM), Technology Acceptance Model (TAM).*

1. INTRODUCTION

With the advancement of information communication technology, people in modern society can manage their health and obtain necessary health information online. Especially, m-health has opened a new era of healthcare management by monitoring and collecting personal health data using mobile devices [1]. More than half of smartphone users were found to seek health information with their devices [2].

A smartwatch is one of the typical wearable devices that works with a smartphone. It collects and stores personal health information through a sensor and allows people to take care of their own health. According to Statista's data [3], the sales of smartwatches worldwide have been increasing gradually from 2014 to 2017 and the sales are forecast to reach 141 million in 2018. Consumers have decided to purchase smartwatches for two reasons. First, smartwatches function as smart ICT devices including healthcare. On the other hand, users seek values of smartwatches such as brand reputation and aesthetic pleasure [4]. Thus, motivations to purchase smartwatches are quite complicated.

Various studies related to a smartwatch have been emerging. However, most previous studies related to smartwatches had focused on not 'audience driven' but 'technology driven' [4]. Even though smartwatch industry is in early stage, not enough study regarding user-centered factors in adopting smartwatches has been conducted. In addition, since a smartwatch is a device that is used in conjunction with a smartphone, it is necessary to focus on how innovative characteristics of smartwatches can affect consumers' perceptions of the technology and adoption. Therefore, this study suggests integration of the technology acceptance model (TAM) and innovation diffusion theory (IDT) by focusing on perceived innovative factors of a smartwatch.

2. THEORETICAL BACKGROUND

2.1 Technology Acceptance Model

The technology acceptance model (TAM) is a simple and useful model for grasping the intention of utilizing innovative technology. Its explanatory power has been proven in various fields related to new technologies. According to the TAM, users' acceptance intentions are determined by two cognitive

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factors: perceived usefulness and perceived ease of use [5]. Perceived usefulness (PU) refers to the degree to which individuals believe that their work performance will be improved by using a specific technology. Perceived ease of use (PE) is defined as the subjective belief that individuals do not require significant physical or mental effort to use new technologies. The TAM predicts that the higher the PU and PE, the greater the intention to use technology, and PU has been found to mediate between PE and the intention to use (INT) [6]. Therefore, this study presents the following hypotheses based on the TAM:

H1: Perceived ease of use (PE) of using smartwatches will exert a significant influence on perceived usefulness (PU) of using smartwatches.

H2: Perceived usefulness (PU) of using smartwatches will exert a significant influence on the intention to use (INT) smartwatches.

H3: Perceived ease of use (PE) of using smartwatches will exert a significant influence on the intention to use (INT) smartwatches.

However, these predictions do not take into account the characteristics and use context of a particular technology. Since Davis and colleagues [7] wanted to apply two beliefs regarding the model to different computer systems and various user populations, TAM's constructs are measured in the same way in all situations [8]. Additionally, since the TAM was designed to understand the acceptance intention regarding technology used in the work environment in the early stage [7], it needs to be modified according to types of technologies or supplemented by adding external variables.

Thus, to improve the explanatory power of the TAM, this study aims to elaborate regarding the acceptance model by adding external variables. It has been pointed out that the TAM is a fairly simple model that overlooks external factors affecting PU and PE [8]. Therefore, purposes of this study are to identify the factors influencing the adoption of innovation as external variables and determine how these factors affect the intention to use a smartwatch through two cognitive factors of the TAM.

2.2 Innovation Diffusion Theory

Innovation diffusion theory (IDT) is defined as "the process by which an innovation is communicated through certain channels over time among the members of a social system" [9]. It suggests five significant innovation characteristics: relative advantage, compatibility, complexity, trialability, and observability. Moore and Benbasat [10] integrated the more perceived characteristics of innovating into Rogers' classical theory of innovation diffusion [11]. Researchers suggested that different perceptions of innovating can cause different user adoption behaviors [9], [10].

As a representative theoretical framework, IDT has been applied in various disciplines not only for the study of individual innovation adoption but also for innovation diffusion at the social level [12]. Especially, it has been used in a variety of studies to predict information technology adoption [13], [14], even though IDT has shown unsatisfactory results in empirical studies [11], [15]. This is attributed to the fact that the higher correlation between constructs in individuals' perceptions can affect statistical outcomes, although each construct is clearly distinguished at the conceptual level [16]. For this reason, it should not include all perceived characteristics in the same layer. Thus, this study has integrated constructs of IDT into the TAM to divide perceptions of users into two layers like Fig. 1.

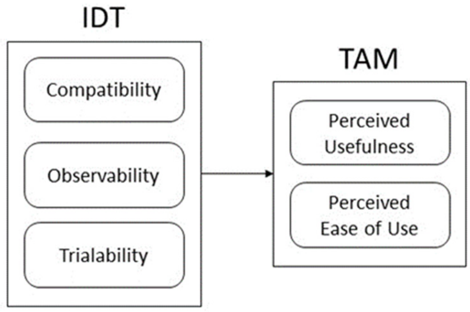

Fig. 1. Combined Model of IDT and TAM

The combination of IDT and TAM has been used in various kinds of information technology studies [17]-[19]. Especially, it has been used in studies related to healthcare systems. For example, Tung and colleagues [20] investigated the acceptance of electronic logistics information systems in the healthcare industry. Wu and colleagues [21] also integrated IDT into the TAM to understand factors that influence INT regarding mobile healthcare. Based on these studies, this study assumed that the combination of IDT and TAM can be applied to acceptance of a smartwatch.

Moore and Benbasat [10] indicated that IDT and the TAM have some similarities. Relative advantage and complexity in IDT are similar to perceived usefulness and ease of use in the TAM, respectively. Thus, this study only includes three perceived characteristics of innovating in IDT—compatibility, observability, and trialability—and integrated these into the TAM. This implies that the perceived characteristics of smartwatch are separated into two layers.

2.2.1 Compatibility: Compatibility (CMP) is defined as "the degree to which an innovation is perceived as consistent with the existing value, past experiences, and needs of potential adopters" [22]. There is a positive relationship between CMP and the rate of innovation adoption [9]. In several studies about the adoption of information technology, CMP was found to significantly influence PU [16], [23], [24]. Especially, Oh and colleagues [18] suggested that CMP cannot solely affect the adoption of innovation. They claimed that CMP indirectly affected INT through the mediation effect of PU and PE. Thus, the following hypothesis was posited:

H4: Compatibility (CMP) of using smartwatches will exert a significant influence on perceived usefulness (PU) of using smartwatches.

2.2.2 Observability: Observability (OSV) is defined as "the degree to which the results of an innovation are visible to others" [22]. It is an objective condition about the environment in adopting innovation [16], and it is positively related to the rate of adoption [9]. For example, OSV affects use of the smartphone [25] and mobile banking adoption [26]. Especially, OSV was found to affect INT through the mediated effect of PE in adopting information technology [16] and broadband Internet in Korea [18]. Thus, the following hypothesis was posited:

H5: Observability (OSV) of using smartwatches will exert a significant influence on perceived ease of use (PE) of using smartwatches.

2.2.3 Trialability: Trialability (TRI) is defined as "the degree to which an innovation may be experimented on a limited basis" [22]. It is a concept associated with risk [27], and the opportunity to test new technology in advance allows the technology to be accepted more rapidly [9]. TRI was found to affect the INT regarding the financial electronic data interchange system of organization [28]. Additionally, TRI has a significant influence on employees' INT regarding e-learning systems through the mediated effect of PE [29]. Thus, the following hypothesis was posited:

H6: Trialability (TRI) of using smartwatches will exert a significant influence on perceived ease of use (PE) of using smartwatches.

3. METHODOLOGY

3.1 Research Design

This study investigated the effects of five latent variables (i.e., compatibility, observability, trialability, perceived usefulness, and perceived ease of use) on the intention to use regarding a smartwatch through a structural equation modeling (SEM). Fig. 2 shows a proposed model of the study. The maximum likelihood estimation method was used to verify the appropriateness of the structural model.

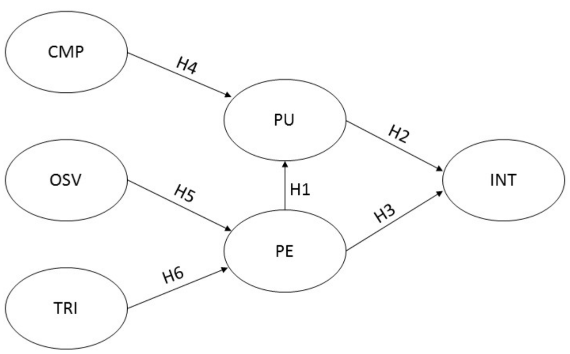

Fig. 2. Proposed Model

3.2 Data Collection

This study conducted an online survey to collect data in cooperation with the Korean research company, *Macromil Embrain*. The company randomly selected 10,465 people listed on the panel and sent them invitations to participate in the study via e-mail. Online questionnaires were distributed to 1,500 participants out of 2,581 eligible individuals in South Korea.

3.3 Measures

Items were adopted from existing previous studies and modified slightly to reflect the context of smartwatch use. Respondents were required to answer using a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree).

The scale of compatibility (CMP), observability (OSV), and trialability (TRI) made by Moore and Benbasat [10] was used. In addition, the scale used by Davis [5] was used to reconstruct perceived usefulness (PU) and perceived ease of use (PE). Table 1 shows questionnaire items.

Table 1. Questionnaire Items

Variables	Statements
Compatibility (CMP)	Using a smartwatch is compatible with all aspects of my work/study.
	Using a smartwatch is completely compatible with my current situation.
	Using a smartwatch fits well with the way I like to work/study.
	Using a smartwatch fits into my work/study style.
Observability (OSV)	I have seen what others do using their smartwatches.
	I have had plenty of opportunity to see the smartwatch being used.
	I have seen a smartwatch in use outside.
	It is easy for me to observe others using the smartwatch.
Trialability (TRI)	Before deciding whether to use a smartwatch, I was able to properly try it out.
	A smartwatch was available to me to adequately test run various applications.
	I can use a smartwatch for long enough periods to try it out.
Perceived Usefulness (PU)	Using a smartwatch is useful in my daily life.
	Using a smartwatch makes my daily life more efficient.
	Using a smartwatch increases my productivity.
	The information gained from using a smartwatch is helpful to me.
Perceived Ease of Use (PE)	Overall, using a smartwatch is easy.
	Using a smartwatch does not require much effort.
	It is not be hard to learn to use a smartwatch.
	Using a smartwatch is clear and easy to understand.
Intention to Use (INT)	I am willing to use a smartwatch.
	I will use a smartwatch in the future.
	I will try to use a smartwatch.
	I am willing to recommend a smartwatch to others.

4. RESULTS

4.1 Sample

The sample consisted of 767 (51.1%) male and 733 (49.9%) female. They were collected from a Korean population aged between 20 and 59 years and the mean age was 40.23 years. Table 2 shows descriptive statistics of sample.

Table 2. Descriptive Statistics

Measures	Items	*n*	%
Gender	Male	767	51.1
	Female	733	49.9
Age (M = 40.23)	20–29	319	21.3
	30–39	362	24.1
	40–49	419	27.9
	50–59	400	26.7
Educational level	Below high school	11	7
	High school	368	24.5
	Undergraduate	1,007	67.1
	Graduate	144	7.6
Income (US dollars)	<2,000	475	31.7
	2,000–2,999	339	22.6
	3,000–3,999	288	19.2
	4,000–4,999	198	13.2
	≥5,000	200	13.3

4.2 Measurement Model

Several fit indices are used to verify structural equation modeling (SEM), and these typically represent three categories of model fit indices: absolute, parsimonious, and incremental fit indices. However, there is no consistent view among researchers as to what is the best comprehensive index to represent the overall fit of a structural model. Thus, it is necessary to present various fit indices together. The following indices are presented in this study: the ratio of $\chi 2$ to its degree of freedom ($\chi 2$/df), the standardized root mean residual (SRMR), goodness-of-fit index (GFI), normed fit index (NFI), Tucker-Lewis index (TLI), comparative fit index (CFI), and the root mean squared error of approximation (RMSEA). In this study, the proposed measurement model has a good fit ($\chi 2$/df = 8.65; SRMR = .04; GFI = .89; NFI = .95; TLI = .95; CFI = .96; RMSEA = .07). In addition, the result indicated that the measurement model had unidimensionality. In other words, the observed variables of this study appropriately explained the latent variables.

Table 3. Results of Measurement Model

	Items	Factor Loading	AVE	CCR	α
Compatibility (CMP)	CMP1	.85	.85	.96	.95
	CMP2	.92			
	CMP3	.94			
	CMP4	.93			
Observability (OSV)	OSV1	.78	.65	.88	.88
	OSV2	.83			
	OSV3	.87			
	OSV4	.74			
Trialability (TRI)	TRI1	.85	.84	.94	.93
	TRI2	.94			
	TRI3	.92			
Perceived Usefulness (PU)	PU1	.90	.82	.95	.94
	PU2	.92			
	PU3	.88			
	PU4	.84			
Perceived Ease of Use (PE)	PE1	.92	.86	.96	.95
	PE2	.94			
	PE3	.91			
	PE4	.87			
Intention to Use (INT)	INT1	.88	.81	.95	.94
	INT2	.93			
	INT3	.90			
	INT4	.88			

Note. AVE = average variance extracted, CCR = composite construct reliability.

Additionally, the value of factor loading for each item and the average variance extracted (AVE) exceeded .70 and .50, respectively. Cronbach's α values and composite construct reliability (CCR) for all latent variables exceeded .70. This indicates that the measured variables have convergent validity and reliability. Table 3 shows the results of measurement model.

Based on findings of Fornell and Larcker [30], this study confirmed discriminant validity through the AVE. If the square root of the AVE for a given variable is higher than the coefficients for the correlations between that variable and all other variables, it could be judged to have an adequate discriminant validity. Table 4 shows that the square root of the AVE for each latent variable is higher than the correlations. Boldfaced diagonal elements are the square roots of the average variance extracted (AVE). To demonstrate discriminant validity, boldfaced elements should be greater than correlation coefficients in the same row and column. This table indicates that the latent variables in the study have adequate levels of discriminant validity.

Table 4. Discriminant Validity Results

	CMP	OSV	TRI	PU	PE	INT
CMP	**.924**					
OSV	.555	**.809**				
TRI	.600	.589	**.915**			
PU	.815	.540	.619	**.903**		
PE	.561	.482	.613	.663	**.926**	
INT	.734	.563	.636	.751	.518	**.901**

Note. CMP = compatibility, OSV = observability, TRI = trialability, PU = perceived usefulness, PE = perceived ease of use, INT = intention to use.

4.3 Structural Model and Hypothesis Testing

This study established a structural model to determine how latent variables such as compatibility, observability, trialability, perceived usefulness, and perceived ease of use affect the behavioral intention using the method of maximum likelihood estimate. Overall, model fit indices showed that the structural model in this study had an acceptable level of model fit (χ^2/df = 9.96; SRMR = .07; GFI = .88; NFI = .94; TLI = .94; CFI = .95; RMSEA = .07). Hu and Bentler [31] suggested that SRMR "close to .09" represented a reasonably acceptable model fit.

Table 5. Hypothesis Testing

Hypothesis		Path Coefficient	*t*	*p*	Result
H1	PE→PU	.31	15.52	***	Supported
H2	PU→INT	.75	25.70	***	Supported
H3	PE→INT	.03	0.82	.41	Rejected
H4	CMP→PU	.68	29.51	***	Supported
H5	OSV→PE	.19	6.66	***	Supported
H6	TRI→PE	.51	17.20	***	Supported

Note. ****p* < .001, CMP = compatibility, OSV = observability, TRI = trialability, PU = perceived usefulness, PE = perceived ease of use, INT = intention to use.

Table 5 and Fig. 3 display the results of hypothesis testing. All hypotheses were supported by the analyzed data. Based on the results of hypothesis testing of the TAM variables, PE was found to have a significant influence on PU (H1: $\beta = .31$, $t = 15.52$, $p < .00$), and PU significantly affected INT (H2: $\beta = .75$, $t = 25.70$, $p < .00$). However, the path from PE to INT was not supported (H3: $\beta = .03$, $t = .82$, $p > .05$). Additionally, CMP had a significant effect on PU (H4: $\beta = .68$, $t = 29.51$, $p < .00$), and OSV was found to influence PE (H5: $\beta = .19$, $t = 6.66$, $p < .00$). Additionally, TRI was found to affect PE (H6: $\beta = .51$, $t = 17.20$, $p < .00$).

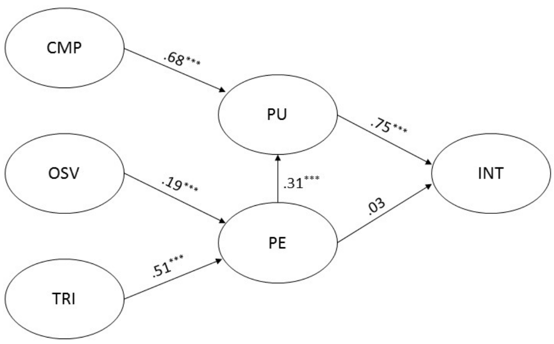

Fig. 3. Results of Hypothesis Testing

5. CONCLUSIONS

To examine factors affect the intention to use a smartwatch, this study focused on perceived characteristics of innovation and suggested the combined model of the technology acceptance model (TAM) and innovation diffusion theory (IDT), which are complementary each other.

According to the results of the analysis, all hypotheses related to the TAM were supported other than one path. Even if perceived ease of use significantly affected perceived usefulness (H1) and perceived usefulness had a significant influence on intention to use (H2), a pat from perceived ease of use to the behavioral intention to use regarding a smartwatch (H3) was not supported. This result is the same as those of previous studies in which the TAM was applied to the acceptance of the smartwatch [32], [33]. This can be attributed to the fact that a smartwatch is a lightweight device that creates no difficulties in daily life activities [32] and it is used mainly for personal purposes in personal situations not in work environment. In addition, since smartwatches work with smartphones, users may not recognize it as difficult to manipulate or use. Thus, it can be inferred that users' perception of ease does not lead to acceptance of smartwatches. To sum up, since there is no difficulty in operating a smartwatch, perceived ease of use does not exert a significant impact on the behavioral intention to use.

In terms of IDT, the higher the compatibility, the greater the likelihood of using a smartwatch through the mediation of perceived usefulness (H4). This result is in line with Oh and colleagues' claim [18] which suggest that compatibility does not solely influence the acceptance of innovation. Since functions of a smartwatch are similar to those of a smartphone, it is easier for users to perceive compatibility of a smartwatch.

Additionally, both observability (H5) and trialability (H6) were found to affect the perceived ease of use. As one of information technologies, observability of using smartwatches was found to influence intention to use through the mediated effect of perceived ease of use (i.e., [16]). Especially, smartwatches have functions same as wristwatches which represent fashionable and luxury items. Thus, Observability by others can be important factor using smartwatches.

In terms of trialability, if potential users can have opportunity to test new technology in advance and then more chances to try the technology, it can make the difficulty in using the technology underestimated. Thus, trialability will increase the probability of accepting technology (i.e., [9]).

However, these two paths were found not to continuously lead to the behavioral intention. That is, the perceived characteristics of innovation can predict the intention to use only through the mediation effect of perceived usefulness. It shows that usefulness of using smartwatches is the most important factor in predicting intention to use. In other words, even if using smartwatches is easy to use, users do not adopt smartwatches unless they consider it useful. It shows that potential adopters recognize the distinct technological advantages of smartwatches well. Therefore, practitioners in smartwatches industry need to emphasize on useful and practical aspects of smartwatches.

Although several empirical studies in the past had shown that IDT variables failed to precisely predict information technology adoption [11], [15], the findings of this study imply that it attempted to increase the explanatory power of the TAM and IDT by combining both. Most of all, this study offers significant implication that the usefulness which technology provides can be the most important factor for adoption when accepting new innovative technologies.

However, this study has a limitation. Although smartwatch provides some health-related functions and these could be critical factors of a smartwatch, but this study does not address a smartwatch from the point of view of healthcare. Therefore, it is necessary to investigate how the factors focusing on health-related functions of a smartwatch are able to affect its acceptance in the future.

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