

A REVIEW OF DIFFUSION FOR THE SMART DEVICES BASED ON TECHNOLOGY ACCEPTANCE MODEL

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ABSTRACT. *Due to the rapidly developing of ICT, the appearance of various smart devices and users are also rapidly increasing. Thus, to do research, we first analyzed literature review including CSFs of empirical studies about smart devices, and it derived major variables and factors affecting the acceptance and diffusion of smart devices. Secondly, we suggested an extended TAM in advanced smart devices. This study presents significant factors (personal characteristics, information attributes, product features, business environment and perceived characteristics) in the acceptance and diffusion of smart devices. Personal characteristics, information attributes, product features and the business environment of the derived influence the perceived characteristics and which eventually affects the acceptance and diffusion of smart devices.*

Keywords: TAM, Smart devices, Personal characteristics, Information attributes, Product features, Business environment, Perceived characteristics

1. Introduction. Rapidly developing of ICT is leading to technological developments and the emergence of various smart devices. The boundaries between industries are crumbling down due to this trend, and new type of fusion and convergence is being proceeded, and the competitors appear in unpredictable industries, which appears that you have not experienced the phenomenon until the earlier. Therefore, companies need to understand and aggressively respond to these changes. The smartphone market, the leader in the smart devices market, is showing decreased growth rate¹, but the next generation smart devices such as wearable devices, IoT devices, and smart sensors are showing potential of high growth² and diversification, which has been giving new business opportunities to companies. Thus, establishing the definition of smart devices and coming up with a plan to diffusion are necessary.

The TAM has been studied in technical perspective by many researchers. Also, previous study related to TAM of smart devices suggested the perceived characteristics are important factors, but differentiated study is still lacking. Furthermore, previous studies of smart devices have been conducted into the individually smart device category (Smartphone, Smartwatch, Smart TV, etc.) and only some of factors that influence diffusion have been proposed, but comprehensive study of the significance of smart devices was insufficient. Therefore, it needs a comprehensive research including the basic product features in smart devices, personal characteristics of users basic characteristics of information attributes in smart devices, and business environment surrounding the firms required for the acceptance and diffusion of smart devices. Thus, in this study, through the analysis of previous researches including empirical studies related to critical success factors (CSFs), it

¹The global market growth of smartphone (IDC, '13, %) : '11-51.7 → '13-21.3 → '15-8.9 → '17-5.1

²Next-generation devices (Sa, '14; Gartner, '14, US \$ million): Wearable -2,324 ('14) → 31,104 ('20); IoT- 18,841 ('14) → 23,875 ('20); Smart sensors -9,089 ('14) → 43,472 ('20)

suggests to pursue better main variables and factors that influence the proliferation strategy for accommodating and diffusion of smart devices, and presents conceptual model of extended TAM that is suitable for smart devices.

In this study, we developed the conceptual model of extended TAM for smart devices. For this purpose, first, we analyzed the research background and literature. Second, it proposes to pursue better main variables and factors through literature review with CSFs of empirical researches. Lastly, we suggested conceptual model of extended TAM that is suitable for smart devices and we will explain the research results with limitations of this study.

2. Previous Research.

2.1. TAM (technology acceptance model). The TAM first suggested by Davis (1986) [4] is a design feature affecting user motivation (perceived usefulness and ease to use, attitude toward using), which consists of a actual system used as a behavioral response. It was presented in order to clarify the accepted technology and its factors on the effect to users. Perceived usefulness is defined as “the degree to which a person believes that using information technology would enhance work performance”, and perceived easy-to-use is defined as “the degree to which a person believes that using information technology would be free from effort” (Davis, 1986) [4]. Venkatesh and Davis (2000) [24] suggested the TAM 2 including images, results demonstrability and the theory of reasoned action. Also Venkatesh and Bela (2008) [25] proposed TAM 3 that suggests individual difference, system characteristics, social influence and facilitating conditions as external factors.

Like this, TAM has been the most widely used to identify the technology acceptance in both personal and corporate levels. However, most of preceding studies have suggested only some of factors for diffusion and accommodating of smart devices.

2.2. Smart device. Smart device includes devices such as smart phone, tablet PC, wearable device, and smart car and is defined as “a device that has unlimited function and its functions are expandable and editable through applications” [11].

Vasseur and Denkels (2010) [13] emphasized the importance of communication by defining smart device as a device composed of actuator, sensor, power source and microprocessor from technological perspective. Park et al. (2010) [28] defined it as a device that includes various functions and services provided by the internet connection and OS platform from mobile ecosystem perspective where software, service, network (including mobile terminal, PC, server, router and switch) and content are connected.

Poslad (2009) [20] explained that it is a personalized and easy-to-use information device and argued that it needs mobility, easy accessibility in wireless internet, user-oriented interface and services. Weiser (1991) [15] classified smart device into three categories (Tabs, Pads, Boards) based on method of use in ubiquitous information technology environment.

Overall, based on the preceding researches, smart device can be defined as a device that is easy-to-use, has user-oriented interface, has mobility and gets the information through access to both wired and wireless internet from anywhere. Therefore, people need more easy-to-use smart devices to enjoy their free time.

2.3. TAM and acceptance of smart device. The research of smart devices (smartphone, smart TV and wearable device, etc.) has been performed many times, and most of the research found out that perceived characteristics (usefulness and easy-to-use) have influence on behavioral intention and user behavior.

Venkatesh et al. (2003) [27] proposed UTAUT through research and illuminated that performance expectancy, effort expectancy, social influence and facilitating conditions have influence on behavioral intention and user behavior. Min et al. (2008) [17] found out that personal characteristics, social factors and trust have influence on behavioral

intention and user behavior. Rahman et al. (2011) [1] argued to give the personal characteristics, quality information and service quality have influence on intention to use digital library. Venkatesh et al. (2012) [26] determined that personal characteristics, hedonic motivation, price value, social influence and activation condition have influence on behavioral intention and use behavior.

Lee (2012) [16] has been verified that personal, environmental and perceived attributes have a significant influence on intention to use. Shin and Lee (2015) [14], through their study of wrist wearable devices, determined that the individual innovativeness, self-efficacy, social health concerned cause significant influence on perceived usefulness and perceived easy-to-use. Lee (2013) [5] proved that hardware convenience, information sharing, and emotional evaluation are important factors. Cho et al. (2015) [9] showed information interaction, device quality, social influence and price value influence on intention to use. Lee (2013) [10], in her research related to the relation between smart learning and mobile augmented reality, emphasized the importance of mutual relationship of devices, contextually, direct contents creation, situationally, mobility, real time interaction and customized service.

Putting the previous researches together, there are various external factors in the acceptance and diffusion of smart devices and these factors give influence through interaction rather than individually.

3. Research for Diffusion of Smart Device. This paper provides a comprehensive review of previous researches in the field of acceptance and diffusion of smart devices including empirical study related to CSFs of diffusion of smart devices. Therefore, according to preceding studies, some factors in accommodating and diffusion of smart device are common but there are contextual factors depending on categories in smart devices.

In this study, a comprehensive analysis of previous researches by factors is presented in Table 1.

As shown in Table 1, according to preceding studies, it can be classified into five important variables of affecting the accommodating and diffusion of smart devices: personal characteristics, information attributes, product features, business environment and perceived characteristics and it can be divided into 13 factors for these variables: personal innovativeness, self-efficacy, value (internal or external), easy-to-share & interactive communication, usefulness & fun, hardware innovativeness, hardware convenience, security, facilitating condition, social influence, perceived easy-of-use, perceived usefulness, and perceived playfulness.

Table 2 shows the description of variables and factors.

Table 2 was classified to each of the variables and factors and it was recommended in previous study. Furthermore, it explained how it affects through the meaning and explanation of each factor.

4. Conceptual Model of Extended Technology Acceptance Model. In this study, suggested conceptual model of the extended TAM through literature review including CSFs of empirical studies is as Figure 1.

As shown in Figure 1, the external variables, such as personal characteristics, information attributes, product features and business environment, affect the perceived characteristics and behavioral intention, and perceived characteristics influence the behavioral intention and use behavior.

The TAM that was described by preceding studies is only some external factors and 2 perceived factors (easy-of-use, usefulness) that influence diffusion have been proposed, and they have been conducted into the individually smart devices category rather than comprehensive research.

TABLE 1. Literature review through meta research

Researcher	Personal Characteristics			Information Attributes		Product Features			Business Environment		Perceived Characteristics		
	personal innovativeness	Self-efficacy	Value	easy-to-share & interactive communication	usefulness & fun	innovativeness	hardware convenience	security	facilitation conditions	social influence	perceived ease of use	perceived usefulness	perceiver playfulness
Rahman et al. (2011) [1]		o			o		o						
Compeau and Higgins (1995) [2]		o											
Lee (2013) [5]													
Jo and Lee (2012) [6]				o		o			o				o
Nysveen et al. (2005) [7]		o			o					o	o	o	
Verkasalo et al. (2010) [8]		o							o	o		o	o
Cho et al. (2015) [9]			o	o		o				o		o	o
Lee (2013) [10]				o		o	o		o				
Kang and Kim (2011) [12]	o		o	o			o			o		o	
Shin and Lee (2015) [14]		o				o				o	o	o	
Lee (2012) [16]		o								o	o	o	o
Min et al. (2008) [17]					o		o	o		o			
Agarwal and Prasad (1997) [18]	o					o					o		
Kim et al. (2013) [19]	o				o						o	o	
Weniger (2010) [21]	o				o		o				o	o	o
Zhou et al. (2010) [22]		o				o	o		o	o			
Venkatesh (2000) [23]		o									o	o	
Venkatesh et al. (2012) [26]		o	o				o		o	o			
Venkatesh et al. (2003) [27]		o	o				o		o	o			
Jo et al. (2011) [29]			o	o						o		o	o
Lee (2012) [30]				o	o								
Koo (2015) [31]		o					o	o	o	o			
Ha et al. (2014) [32]			o	o		o		o					
Jeon et al. (2012) [33]	o					o			o		o	o	
Jeon et al. (2014) [34]	o				o						o	o	o
Hwang and Lee (2010) [35]			o								o	o	
Kang et al. (2013) [36]					o	o	o	o					
Jeong et al. (2015) [37]			o		o						o	o	
Lee and Kim (2015) [38]					o	o						o	
Jo et al. (2015) [39]		o										o	
Seo and Song (2011) [40]		o	o			o	o						
Baek et al. (2015) [41]	o	o					o		o	o			
Noh (2014) [42]			o	o	o			o					
Chung and Jung (2013) [43]		o			o				o	o			
Ning and Kim (2012) [44]							o			o		o	o
Lee (2011) [45]		o				o	o		o				
Han (2011) [46]		o	o		o				o				
Kim and Park (2011) [47]				o	o								
Lee (2011) [48]					o		o						
Lee et al. (2014) [49]	o	o				o							
Nam et al. (2013) [50]	o		o				o			o			
Kim and Nam (2012) [51]			o		o	o	o		o				
Do and Heo (2015) [52]		o				o	o		o			o	
Suh and Kim (2015) [53]			o	o									
Ahn and Hong (2014) [54]			o						o				
Jeong (2015) [55]							o		o	o			
Kim et al. (2001) [56]				o			o		o	o			
Ko (2016) [57]						o	o	o					
Pi (2015) [58]		o		o		o	o						
Cho (2015) [59]		o											
Back and Park (2015) [60]			o		o	o	o						o
Jo and Choeh (2015) [61]			o	o	o	o							
Yang et al. (2015) [62]							o	o		o			
Lee and Choi (2012) [63]							o		o		o	o	

TABLE 2. Description of variables and factors

Variables	Factors	Description	Ref. No.
Personal Characteristics	personal innovativeness	Personal innovativeness can be defined as a willingness to voluntarily use new technologies.	12, 18, 19, 21, 33, 34, 41, 49, 50
	self-efficacy	A degree of how much the user believes who is using the smart device effectively.	1, 2, 7, 8, 14, 16, 22, 23, 26, 27, 31, 39-41, 43, 45, 46, 49, 51, 58, 59
	value (internal or external)	The value that individuals feel about smart device includes brand value, price value, product design and emotional values.	5, 9, 12, 26, 27, 29, 32, 35, 37, 40, 42, 46, 50, 51, 53, 54, 60, 61
Information Attributes	easy-to-share & interactive communication	Easy-to-share and interactive communication are important that is caused by the increasing return caused by easy information sharing and real-time communication.	12, 18, 19, 21, 33, 34, 41, 49, 50
	usefulness & fun	The information that can be obtained through smart devices by the users in usefulness and the gained information are fun and leads to commitment.	1, 5, 7, 17, 19, 21, 30, 34, 36-38, 42, 43, 46-48, 51, 60, 61
Product Features	innovativeness	Since smart devices have network function built in, it needs access to the network from anywhere anytime, and needs mobility and immediate response.	6, 9, 10, 14, 18, 22, 32, 33, 36, 38, 40, 45, 49, 51, 52, 57, 58, 60, 61
	hardware convenience	It is for the convenience of smart devices that have easy-to-handle user interface, convenient and easy operation, and customizable contents.	1, 5, 10, 12, 17, 21, 22, 26, 27, 31, 36, 40, 41, 44, 45, 48, 50-52, 55-58, 60, 62, 63
	security	Safe and credible security that can protect one's personal information and consistency are important factors.	17, 31, 32, 36, 42, 57, 62
Business Environment	facilitating condition	A condition for activating the business can be defined as network externalities including openness, platform, related education and supplement.	5, 6, 8, 10, 22, 26, 27, 31, 33, 41, 43, 45, 46, 51, 52, 60, 63
	social influence	Social influence (social interest rate, what others think about it, government-wide support policy, advertisement, cultural background, etc.) is something that other people believe that it is important when using a particular system.	5, 7-9, 12, 14, 16, 17, 22, 26, 27, 29, 31, 41, 43, 44, 50, 55, 56, 62
Perceived Characteristics	perceived easy-of-use	A degree of how a user believes that can easily use the information technology without giving an effort.	7, 14, 16, 18, 19, 21, 23, 33-35, 37, 63
	perceived usefulness	A degree of how a user believes that usage of smart devices is correlated to the increase in work efficiency.	7-9, 12, 14, 16, 19, 21, 23, 29, 33-35, 37-39, 44, 52, 63
	perceived playfulness	Perceived playfulness can be described as an empirical pleasure or expected pleasure after using a smart device.	6, 8, 9, 16, 21, 29, 34, 44, 60

However, in the paper, we were to derive comprehensive critical success factors affecting the diffusion of smart devices and literature reviews of smart devices according to the change of the market and consumer. In other words, to differ from previous research, we improved using four external variables, and the tenth detailed factors, respectively, to accomplish the conceptually extended TAM. In addition, to show the factors about perceived characteristics, we have to add the existing perception of the perceived ease of use and perceived usefulness. Finally, a comparison of extended TAM and TAM shown through previous studies are summarized in Table 3.

5. Conclusion.

5.1. **Research results.** The rapid development of ITC caused the emergence of various smart devices led by smart phone, and this has been providing new business opportunities for companies. Companies that utilize this opportunity well will grow up while companies do not utilize this opportunity well will fall behind in the competition. Due to this, companies need to understand and learn smart device related concepts and main factors that can diffuse them.

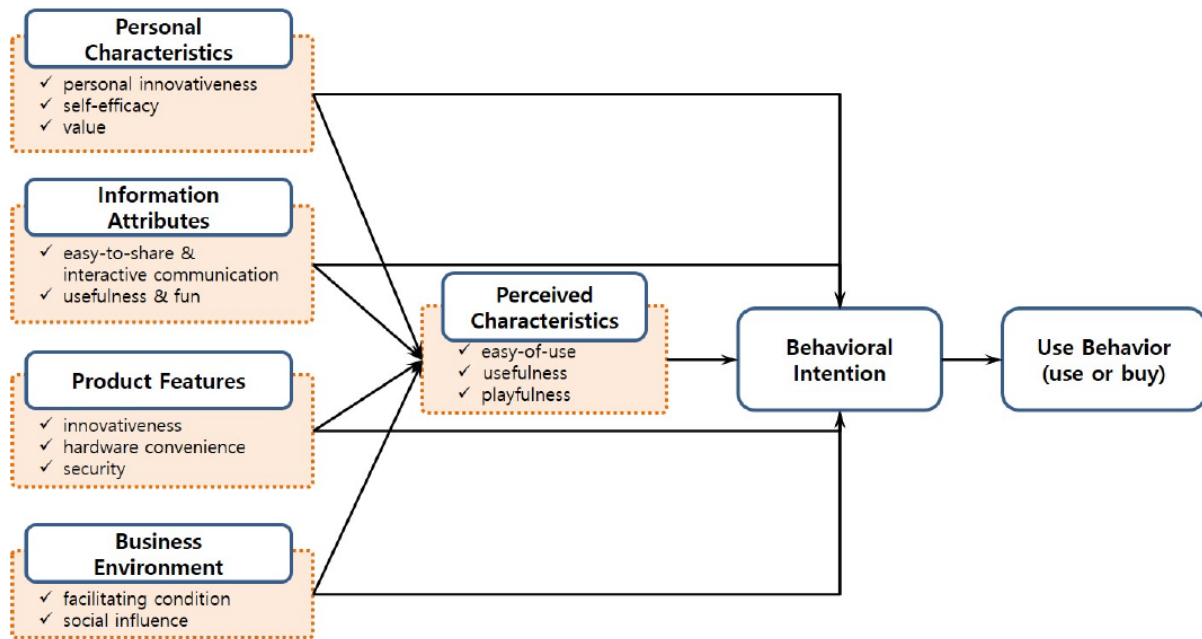


FIGURE 1. Conceptual model of the extend technology acceptance model

TABLE 3. Factor comparison of the TAM and the Extended TAM

	TAM [4]	TAM2 [24]	TAM3 [25]	Extended TAM
External Factors	Design Features (Variable)	Subjective Norm, Image, Job Relevance, Output Quality, Result Demonstrability	Individual Differences, System Characteristics, Social Influence, Facilitating Conditions	4 variables and 10 factors (see Table 2)
Cognitive Response	Perceived Usefulness, Perceived Ease of Use	Perceived Usefulness, Perceived Ease of Use	Perceived Usefulness, Perceived Ease of Use	Perceived Usefulness, Perceived Ease of Use, Perceived Playfulness
Affective Response	Attitude Toward Using	Intention to Use	Behavioral Intention	Behavioral Intention
Behavioral Response	Actual System Use	User Behavior	User Behavior	User Behavior

Hence, this study comes up with basic understandings of smart device and main factors that accept and diffuse it through analysis of previous researches. Personal characteristics, information attributes, product features, business environment and perceived characteristics were obtained as important factors. Personal characteristics are personal innovativeness, self-efficacy, and the value of internal and external. Information attributes are easy-to-share of information, real-time interactive communication, usefulness and enjoyment in information quality aspects. Product features include product innovativeness, high performance, hardware convenience (easy-to-handle user interface, etc.) and security. Business environment includes facilitating condition and social influence. Lastly, perceived characteristics had perceived easy-to-use, perceived usefulness, and perceived playfulness as important factors.

The contribution point of this study that targets smart devices can be divided into two perspectives: theoretical perspective and practical perspective. From theoretical perspective, first, factors derived have proposed an extended TAM based on preceding researches related to the acceptance and diffusion of smart devices. Second, it can contribute to future researches as a reference since it derives main factors through preceding researches related to most smart devices. Lastly, from practical perspective, it proposes the factors that could help develop smart device diffusion strategy based on new extended TAM for all companies. This will help companies to consider consumers' characteristics when building marketing strategy, new services and new products.

5.2. Limitation of the research and future research tasks. This research derives and groups factors that influence the acceptance and diffusion of smart devices through analysis of preceding researches, but has limitations in that it fails to provide empirical result and it only focuses on small-sized smart devices.

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