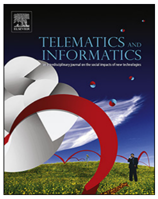
Telematics and Informatics 47 (2020) 101318

Contents lists available at ScienceDirect

Telematics and Informatics

journal homepage: www.elsevier.com/locate/tele



User acceptance of smart wearable devices: An expectation-confirmation model approach

Eunil Park

Department of Interaction Science, Sungkyunkwan University, Seoul, Republic of Korea

ARTICLE INFO

Keywords:
Smart wearable devices
Expectation-confirmation model
Technology acceptance
Flow

ABSTRACT

Smart wearable devices have become one of the most popular interactive items in the "*smart*" era that prioritizes "*mobility*." There is significant scholarly interest in not only promoting the successful diffusion of this technology but also providing improved user experience to users of these devices. In line with this trend, this study explores users' perceptions of smart wearable devices and introduces a comprehensive research model that employs factors that are primarily extracted using the expectation-confirmation, technology acceptance, and flow models. The results derived using both confirmatory factor analysis and structural equation modeling methods (N = 1,380) indicate that users' intentions to use smart wearable devices are determined by five influential factors: satisfaction, enjoyment, usefulness, flow state, and cost. Both users' confirmation and service and system quality play notable determinative roles in the research model. Implications and suggestions are presented considering the results.

1. Introduction

With rapidly distributed technologies of the Internet of Things, smart wearable devices and related services have attracted significant attention. While these devices and services have been employed widely in the information and communication technology (ICT) industry, they have been increasingly employed in various fields such as healthcare, management, sports, and communications as well. In 2019, Statistica (2019) presented that about 141 million smart wearable devices were sold, which is approximately double the total sales from 2017.

Similar to smartphone markets, smart wearable devices load various operating systems. In accordance with loaded operating systems, both market and product share ratios are determined. With this trend, Apple (35.8%), Samsung (11.1%), and imoo (9.2%) have secured more than 55% of the global smart wearable devices market share in 2019 (Sinha, 2019). Currently, smart wearable devices are considered particularly well-known devices in our daily lives (Sinha and Gupta, 2019). Product manufacturers consistently make significant efforts to improve both the software and hardware of their products with explosively introduced applications for responding to consumers' demands. Alongside such efforts, consumers' intentions to purchase products with correspond with their positive perceptions of the products.

Several researchers have attempted to address consumers' usage behaviors regarding smart wearable devices by extracting potential technical and psychological factors using notable user-oriented theories and models. Representative examples include the following studies. Chuah et al. (2016) extended the technology acceptance model (TAM) to explore user adoption of smart wearable devices and identified the roles of visibility and usefulness in determining device adoption. Hong et al. (2017) employed two mediators as the linkages between consumers' personal innovativeness and their continuance intention to use smart wearable

E-mail address: eunilpark@skku.edu.

https://doi.org/10.1016/j.tele.2019.101318
Received 27 September 2019; Received in revised form 28 October 2019; Accepted 22 November 2019
Available online 03 December 2019
0736-5853/

devices. Hsiao and Chen (2018) considered multidimensional aspects of smart watches to address users' intention to use smart wearable devices, while noting that hardware, software, value, and design factors have notable effects on users' purchase intention.

The majority of prior studies on smart wearable devices have attempted to investigate users' initial employment of the devices, while only a small number of studies have explored their behaviors related to and intention to continue usage. Thus, this study attempts to consider users' post-consumption behavior with regard to smart wearable devices for the successful distribution of the devices and related services.

Therefore, in order to address this issue, the current study employs both the expectation-confirmation model (ECM) and the TAM in the integrated user adoption model of smart wearable devices. The concept of ECM has been employed to understand users' perspectives toward various technologies, such as mobile applications (Hsu and Lin, 2015) or payment services (Kujala et al., 2017). However, only few studies attempted to employ the concept of ECM for understanding users' perspectives toward smart wearable devices. By employing the ECM into the integrated research model of smart wearable devices, the current study can provide a more comprehensive understanding of consumers' usage behavior with regard to smart wearable devices. Moreover, the findings of the current study can present the potentiality and possibility of multiple theories in proposing the integrated research model for user behavior.

The remainder of this article is organized as follows: Following the review of smart wearable devices and theories relating to the research model, study methodologies are explained. Then, the structural results and reliability tests are examined. Finally, the discussion and concluding remarks are presented.

2. Literature review and theoretical model

2.1. User studies of smart wearable devices

As wearable computing devices, smart wearable devices can facilitate various daily tasks for users. Many mobile applications and accessories are operable and compatible with users' daily tasks. Similar to smartphones, the majority of smart wearable devices have touch screens, interactive interfaces, and wireless communication functions, among other functions (Dehghani and Dangelico, 2017).

As an interactive tool, smart wearable devices are employed for multi-purpose functions. For instance, many scholars have employed smart wearable devices for healthcare services. Lu et al. (2019) employed smart wearable devices as real-time feedback devices to examine the delivery of cardiopulmonary resuscitation by healthcare professionals. As another example, Ali and Li (2019) developed a smart wearable device notification system for nursing home services and found that both users' response times and professional staff workload were significantly reduced. Dubey et al. (2015) proposed the concept of *EchoWear*, a smart watch technology that facilitated the efficient treatment of Parkinson's disease, and validated the role of smart wearable technology in supporting Parkinson patients.

With the emergence of smart wearable devices, several studies have investigated the value and significance of user behavior and experience in the diffusion and success of smart wearable devices. Wu et al. (2016) explored users' behavioral intentions of employing a smart wearable device on the basis of three well-known user-oriented theories: innovation diffusion theory, TAM, and the unified theory of acceptance and use of technology. They identified significant determinants of user intentions by examining 212 Taiwanese participants. Jeong et al. (2017) conducted a longitudinal investigation on 50 users of smart wearable devices and investigated the determining factors of users' wearing behavior. The 203-day data revealed that multi-dimensional factors (contextual, multifaceted, and nuanced) significantly affected users' wearing behavior. Jeong et al. (2017) also investigated the adoption of wearable devices with new product perspectives and identified the role and effects of information processing innovativeness and perceived attributes on device adoption. Table 1 presents the summary of prior studies on user behavior and experience of smart wearable devices. These studies indicate that investigating users' perspectives toward smart watches and explaining their initial and continual intention to use smart watches are essential and critical for the success and diffusion of smart wearable devices.

Table 1
Summary of prior studies on users' perceptions of smart wearable devices

Products or services	Descriptions
Health monitoring wearable devices (Wen et al., 2012)	● Users are generally optimistic in employing wearable devices. ● Users' significant demand is observed on healthcare functions in using wearable devices.
Wearable fitness devices (Liang et al., 2018)	● Wearable devices can provide various fitness functions. ● Manufactures of wearable devices should make notable efforts on innovative functions and usability of the devices.
Smart watches (Mani and Chouk, 2017)	● Users' resistance to smart watches is significantly affected by their perceived usefulness, novelty, cost, intrusiveness and novelty.
Smart watches (Ha et al., 2017)	● Users' think that their smart watches are more functional and useful than general watches or smartphones.
Personal health devices (Sun et al., 2015)	● Five potential factors are employed to predict users' intention to use personal health devices. ● Users' social norm and perceived ease of use have significant effects on their intention to use. ● Users generally have positive attitude toward functions and services of the devices.

2.2. Expectation-confirmation model

In the fields of information systems and technologies, ECM is considered one of the notable theories that explain users' post-adoption behavior. On the basis of the theoretical background of the expectation-confirmation theory, which reflects the academic validity of relationships among users' intention to repurchase, satisfaction, perceived performance, and expectations (Oliver, 1980), ECM has been employed to explain users' continuance intention to use specific ICT products and services.

As a representative example, Bhattacherjee (2001) found that users' continuance usage of information technologies and services can be explained by the causal connections and initial decision of adopting technologies and services, and they provided an academic framework for examining the relationships between expectation and confirmation concepts.

On the basis of the self-perception theory proposed by Bem (1972), ECM was developed and employed to provide the explanation that users continually update their expectations upon gaining new information related to their own and others' behavior (Bhattacherjee, 2001). This means that users' expectations toward information technologies or services are updated according to new information and experience. Finally, this indicates the level of users' post-acceptance behavior (Thong et al., 2006).

The current paper reviews several prior studies focusing on the ECM to facilitate a more comprehensive understanding of the research model. Furthermore, the hypotheses based on user-oriented theories employed in this study are introduced to the context of the smart wearable devices. Recently, the ECM has tended to include perceived usefulness as a notable determinant of users' perceived satisfaction whey they use specific information systems and services. Thus, integrating the ECM and TAM into a comprehensive framework may be an efficient approach for explaining users' continuance intention to use specific information systems and services.

In ECM, confirmation is defined as "*the users' level of the appropriateness between their actual performance and expectation of the usage of information systems and services*" (Hsu and Lin, 2015). As one of the key factors in ECM, confirmation plays a significant role in determining users' perceived satisfaction of information systems and services, while their satisfaction is associated with their intention to use the systems and services. Moreover, because the satisfaction is generally defined as "*the users' post-evaluation on their overall experience with a specific information system or service*" (Bhattacherjee, 2001), several prior studies employed users' perceived satisfaction as one of the core determinants of their intention to continue use. Thus, the following sections present the roles of satisfaction and confirmation.

2.2.1. Satisfaction

Users' perceived satisfaction is one of the psychological concepts after their purchase and usage experience (Bhattacherjee and Premkumar, 2004). The current study focuses on users' overall feelings regarding all aspects of their experience, including their purchase and usage experience of smart wearable devices. ECM argues that users' continuance intention to use specific information systems and services is positively determined by their overall satisfaction in using the systems and services. With respect to smart services and products, the relationship between users' perceived satisfaction and intention to use the services and products has been consistently addressed. For instance, Roca et al. (2006) reported that users' perceived satisfaction in using e-learning services plays a determinant role in their continuance intention to use them. Therefore, the current study introduces the following hypothesis:

- **H1.** Satisfaction is positively related to the continuance intention to use smart wearable devices.

2.2.2. Confirmation

ECM is based on the supposition that users' satisfaction and perceptions of information systems and services, a key factor in their continuance intention to use, is significantly determined by their confirmation levels on the actual usage of systems and services (Bhattacherjee, 2001). As one of the widely confirmed theories in smart technologies, users' confirmation represents their feelings regarding expected advantages with the notable effects on the satisfaction (Bhattacherjee, 2001; Bhattacherjee and Premkumar, 2004).

Moreover, on the basis of cognitive dissonance theory (Festinger, 1962), users may tend to feel psychological dissonance when their perceived benefits are not significantly allowed and confirmed in their actual usage. In order to minimize this dissonance with the perception of the benefits, several prior studies indicated that improving the feeling of confirmation can be an efficient solution (Thong et al., 2006; Roca et al., 2006). Moreover, the TAM and related-adoption theories found that external characteristics and users' cognitive perceptions can be notable determinants of both their hedonic and utilitarian factors in understanding their adoption patterns (Van der Heijden, 2004; Davis, 1989; Davis et al., 1989; Park et al., 2014). To this point, several studies have employed the confirmation concept as key determinants of perceived usefulness, ease of use, and enjoyment (Thong et al., 2006; Chen et al., 2013). For instance, from data on 368 respondents, Chen et al. (2013) found that users' confirmation on mobile services plays a determinative role in their perceived usefulness of and satisfaction with the services. From 811 validated responses, Thong et al. (2006) demonstrated that four factors—users' satisfaction, usefulness, ease of use, and enjoyment of mobile Internet services—are significantly determined by their confirmation. Thus, the same tendencies can apply to users of smart wearable devices. Therefore, the following hypotheses are presented.

- **H2.** Confirmation is positively related to perceived satisfaction of smart wearable devices.
- **H3.** Confirmation is positively related to perceived ease of use of smart wearable devices.
- **H4.** Confirmation is positively related to perceived usefulness of smart wearable devices.
- **H5.** Confirmation is positively related to perceived enjoyment of smart wearable devices.

2.2.3. Service and system quality

After the concept of perceived system quality was proposed (DeLone and McLean, 1992), its definition has generally been considered "*the extent of users' feeling on the performance of a system in their usage*" (DeLone and McLean, 1992; Park, 2013). With respect to the recent issues of information systems and services, users' feelings of perceived system quality extend to the context of its service quality because the majority of users do not interact with the system components and facilities; their perceived system performance tends to include to the context of both system and service quality.

Considering smart wearable devices as unique and innovative information technologies, several scholars have attempted to investigate the role of users' perceived system and service quality in their confirmation and overall satisfaction of the technologies (Roca et al., 2006; Oghuma et al., 2016). When users believe that a specific information system provides excellent service quality, they are more likely to be more satisfied with the system and confirm system use (Chen and Chang, 2018). That is, the greater degree of users' system and service quality leads to the improved levels of their satisfaction and confirmation in using smart wearable devices. Thus, the current study hypothesizes the following:

- **H6.** Service and system quality is positively related to the confirmation of smart wearable devices.
- **H7.** Service and system quality is positively related to the perceived satisfaction of smart wearable devices.

2.3. Technology acceptance model

In addition to ECM, the current study employs the TAM as a basic academic framework to propose the integrated research model of consumers' continuance intention to use smart wearable devices. Thus, the relationships of TAM are applied to user intention.

2.3.1. Perceived ease of use

With respect to smart watches, the current study defines perceived ease of use as "*the level to which each consumer thinks that they do not need to make significant efforts to utilize and operate smart watches*" (Davis, 1989; Davis et al., 1989). Several prior studies validated the role of perceived ease of use as a positive determinant of consumers' perceived satisfaction when using information systems and services (Joo et al., 2018). In the context of mobile and wearable devices, Natarajan et al. (2017) found that perceived ease of use positively affects mobile shopping application users' overall satisfaction. Moreover, this relationship has been validated and explained in the context of mobile and wearable devices with e-books (Hu and Zhang, 2016), healthcare (Cho, 2016), and payment services (Chen and Wu, 2017). Thus, this study proposes the relationship between perceived ease of use and satisfaction of smart wearable device users.

- **H8.** Perceived ease of use is positively related to the perceived satisfaction of smart wearable devices.

2.3.2. Perceived usefulness

The term "perceived usefulness" has been employed as one of the key concepts in TAM. Perceived usefulness is defined as "*the degree of users' assessment of whether employing a specific product or service can improve their job performance and efficiency*" (Davis et al., 1989). In the context of smart wearable devices, this study defines perceived usefulness of smart wearable devices as "*the degree of users' personal assessments of whether using smart wearable devices can improve their job performance and efficiency*".

In the fields of information systems and services, perceived usefulness is employed as a direct determinant of both users' perceived satisfaction and continuance intention to use (Park and del Pobil, 2013; Wang et al., 2012). For instance, Kim et al. (2016) indicated that there are positive relationships between perceived usefulness and satisfaction that explain users' behavior toward augmented reality applications in mobile environments. In a study of mobile shopping applications with 244 respondents, Hung et al. (2012) validated the relationships between perceived usefulness and satisfaction as well as the usefulness and continuance intention to use the applications. Thus, in the context of smart wearable devices, the current study proposes the following hypotheses:

- **H9.** Perceived usefulness is positively related to the perceived satisfaction of smart wearable devices.
- **H10.** Perceived usefulness is positively related to the continuance intention to use smart wearable devices.

2.4. User acceptance of hedonic information systems

Several studies on information systems and user experience have argued that users' hedonic values of information systems and services should be considered key motivations of their perspectives toward the systems and services (Turel et al., 2010). Among various aspects of hedonic values presented in prior studies, the current study employs perceived enjoyment, which is defined as "*the level to which using a specific technology or service is seen as enjoyable*" (Ko et al., 2009). On the basis of this definition, the current study defines perceived enjoyment as "*the level to which using smart wearable devices is seen as enjoyable*" (Ko et al., 2009).

With respect to the context of mobile and wearable devices, several attempts have been made to examine the role of consumers' perceived enjoyment of the devices in determining their satisfaction and intention to use (Kwon et al., 2014). For instance, See-To et al. (2012) found that there is a validated connection between users' perceived satisfaction and enjoyment in explaining their experience on mobile video applications with the responses of 270 subjects. Park et al. (2014) collected data from more than 1,400 users of mobile social networking games and found that perceived enjoyment significantly determined their intention to play the games. Thus, the current study hypothesizes the significant relationships between perceived enjoyment and satisfaction and between enjoyment and continuance intention to use in the context of smart wearable devices.

- **H11.** Perceived enjoyment is positively related to the perceived satisfaction of smart wearable devices.
- **H12.** Perceived enjoyment is positively related to the continuance intention to use smart wearable devices.

2.5. Perceived cost

Among many hindrances in diffusing information technologies and services, economic concerns are always considered to be significant obstructions. This refers to user tendencies to compare potential benefits and consumed costs of the technologies and services. On the basis of the definitions of perceived cost presented in several prior studies, the current study defines perceived cost as "*the burdens on the consumed costs in purchasing, using, and maintaining smart wearable devices*" (Park et al., 2017; Park and Ohm, 2014).

With respect to the context of mobile and wearable devices, several validated connections between perceived cost and continuance intention to use the devices have been supported. Hanafizadeh et al. (2014) indicated that users' perceived cost of mobile banking services negatively affects their intention to employ the services in a study with 361 respondents. Moreover, on the basis of 112 usable responses, Chee et al. (2018) revealed that consumers' intentions to purchase specific products and services is negatively affected by their perceived cost in mobile marketing services. Thus, this study hypothesizes the negative relationship between users' perceived cost of and their continuance intention to use smart wearable devices.

- **H13.** Perceived cost is negatively related to the continuance intention to use smart wearable devices.

2.6. Flow model

After several user experience studies employed the flow model, it has become a widely used academic framework that is useful in explaining users' statements in information systems and services (Nowak and Biocca, 2003). One widely-employed definition of "flow statement" is "*the mental and cognitive state of processes in which a user is totally immersed in what the user is doing characterized by a feeling of cognized focus and full involvement in the activity operation*" (Yang and Lee, 2018). When an individual interacts with a specific service and technology, an energetic sense of being submerged in a virtual environment is generated, which facilitates enquiring behavior. The reflected definition of flow in this study is "*the users' immersed feeling when using smart wearable devices*". Several studies on information services have validated that a sense of immersion is a key attainment target of the services (Nowak and Biocca, 2003). When users feel an impressive presence in the interactive circumstance with smart wearable devices, they are incentivized to consistently use smart wearable devices. Thus, this study proposes the following hypothesis:

- **H14.** Flow state is positively related to the continuance intention to use smart wearable devices.

2.7. Research model

Thus, this study assumes that considering multiple user-oriented theories into a comprehensive integrated research model is valuable and essential for understanding and providing users' perceptions of smart wearable devices. On the basis of the proposed hypotheses, the research model is presented (Fig. 1).

3. Study methodology

3.1. Questionnaire design and measurements

This study follows the guidelines of the questionnaire design procedures which were previously validated (Park et al., 2016). Thirty-five questionnaire items were collected in previous studies addressing user behavior. Two professional translators translated all items into Korean. After the translation, two researchers took part in the back-translation sessions to validate the translation results. Then, four professors of information sciences and communication revised the translated items. With the revised items, a pilot survey was examined with thirty students who had over two months of experience with smart wearable devices. On the basis of the results of the pilot survey, 27 questionnaire items that met the reliability tests were used in the survey, while 8 items were excluded. Table 2 presents the survey items.

3.2. Data collection

A professional survey agency was employed to conduct an online survey for 30 days by contacting 2,004 users of smart wearable devices. The inclusion criterion was at least three months of experience using the devices. Respondents were instructed to reply to each questionnaire item using a 7-point Likert scale (from 1 (Strongly disagree) to 7 (Strongly agree)). The agency received 1,694 user responses. After two filtering procedures were conducted and incomplete responses were excluded, 1,380 valid responses were obtained for the statistical analysis. Table 3 presents the demographic information of the survey respondents.

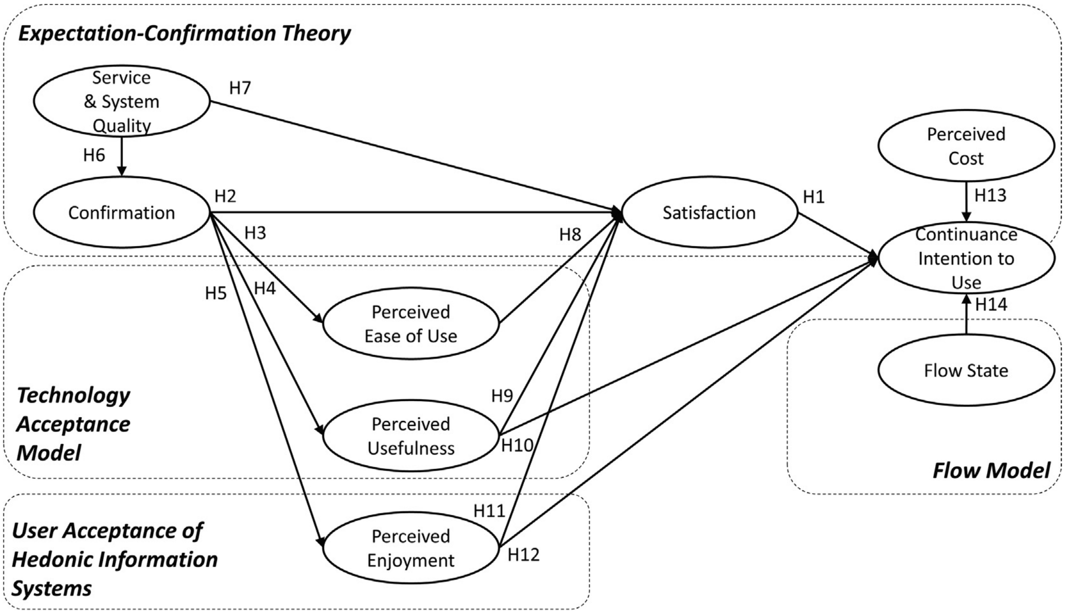


Fig. 1. The research model.

Table 2
Questionnaire items.

Constructs	Items
Service & System Quality (Wang and Lin, 2017; Park and Kim, 2014)	SSQ1: Smart wearable devices fully meet my needs SSQ2: Smart wearable devices provide prompt responses to my request SSQ3: Smart wearable devices provide customized and professional services
Confirmation (Tan and Kim, 2015; Oghuma et al., 2016; Susanto et al., 2016)	CON1: My experience with smart wearable devices is better than what I expected CON2: Overall, the majority of my expectations from using smart wearable devices are confirmed CON3: The functionalities of smart wearable devices are better than what I expected
Perceived Ease of Use (Briz-Ponce et al., 2017; Munoz-Leiva et al., 2017)	PEU1: My interaction with smart wearable devices is clear and understandable PEU2: Using smart wearable devices is easy for me PEU3: Interacting with smart wearable devices does not require mental effort
Perceived Usefulness (Park and Kim, 2014; Davis, 1989; Oghuma et al., 2016)	PU1: I think that smart wearable devices are useful for my life PU2: Using smart wearable devices increases my productivity PU3: Using smart wearable devices helps me conveniently perform many tasks
Perceived Enjoyment (Oghuma et al., 2016; Liu et al., 2015)	PE1: Interacting with smart wearable devices is fun PE2: I enjoy using smart wearable devices PE3: Using smart wearable devices gives me a lot of enjoyment
Perceived Cost (Kim et al., 2014; Hsu, 2014)	PC1: There are financial barriers to using smart wearable devices PC2: I think that smart wearable devices are expensive PC3: Overall, using smart wearable devices costs me a lot of money
Flow State (Bilgihan et al., 2014; Lee and Tsai, 2010)	FS1: I am fully involved when I use smart wearable devices FS2: I am fully engaged when I use smart wearable devices FS3: I feel that time passes quickly while using smart wearable devices
Satisfaction (Park and Kim, 2014; Tan and Kim, 2015)	ST1: Overall, I am satisfied with smart wearable devices ST2: The smart wearable devices I am currently using meet my expectations ST3: I am very pleased with my experience with using smart wearable devices
Continuance Intention to Use (Davis et al., 1989; Park and Kim, 2014; Mouakket, 2015)	CIU1: I am likely to continue to use smart wearable devices CIU2: I intend to consistently use smart wearable devices as much as possible CIU3: I intend to continue using smart wearable devices rather than discontinue using them

4. Results

4.1. Descriptive analysis

Descriptive statistics of the constructs employed in the research model are summarized and presented in Table 4.

Table 3
Participants' information.

Age	n(%)	Living areas	n(%)
20–29	494(35.8%)	Metropolis	823(59.6%)
30–39	601(43.6%)	Small and medium-sized cities	459(33.2%)
40–49	203(14.7%)	Rural areas	98(7.1%)
50–59	53(3.8%)		
Over 60	29(2.1%)		
Gender	n(%)	Usage experience	n(%)
Male	774(56.1%)	3–6 months	118(8.6%)
Female	606(43.9%)	6–12 months	293(21.2%)
		12–24 months	696(50.4%)
		More than 24 months	273(19.8%)

Table 4
Descriptive information of the constructs used in the research model

Construct	Mean (Standard deviation)	Construct	Mean (Standard deviation)
Service & System Quality	4.96(1.55)	Confirmation	5.25(1.64)
Perceived Ease of Use	5.38(1.36)	Perceived Usefulness	5.17(1.50)
Perceived Enjoyment	4.83(1.44)	Perceived Cost	2.96(1.52)
Flow State	4.77(1.47)	Satisfaction	5.00(1.41)
Continuance Intention to Use	5.43(1.24)		

4.2. Validity tests

Confirmatory factor analysis and structural equation modeling methods were employed to explore the research model and were organized according to the introduced hypotheses. To successfully obtain results from the two methods, several reliability tests with over 200 samples were conducted. On the basis of the guidelines of previous studies, values of over 0.7 for Cronbach's alpha, 0.7 for factor loading, and 0.5 for average variance extracted values were required. Moreover, each square root degree of the average variance extracted values in one of the specific constructs must be higher than the correlation values between the construct and other

Table 5
Results of internal and convergent reliabilities

Factors	Items	Cronbach's alpha	Factor loadings	Composite reliability	Average variance extracted
Service & System Quality	SSQ1	0.864	0.851	0.917	0.788
	SSQ2		0.925		
	SSQ3		0.885		
Confirmation	CON1	0.807	0.829	0.886	0.723
	CON2		0.909		
	CON3		0.809		
Perceived Ease of Use	PEU1	0.912	0.933	0.947	0.857
	PEU2		0.944		
	PEU3		0.899		
Perceived Usefulness	PU1	0.829	0.861	0.898	0.746
	PU2		0.891		
	PU3		0.839		
Perceived Enjoyment	PE1	0.811	0.724	0.903	0.758
	PE2		0.957		
	PE3		0.914		
Perceived Cost	PC1	0.928	0.934	0.955	0.877
	PC2		0.954		
	PC3		0.927		
Flow State	FS1	0.938	0.949	0.960	0.890
	FS2		0.957		
	FS3		0.924		
Satisfaction	ST1	0.872	0.916	0.922	0.798
	ST2		0.898		
	ST3		0.866		
Continuance Intention to Use	CIU1	0.936	0.832	0.919	0.791
	CIU2		0.932		
	CIU3		0.901		

Table 6
Results of discriminant reliability

Factors	1	2	3	4	5	6	7	8	9
1. Service & System Quality	0.888								
2. Confirmation	0.369	0.850							
3. Perceived Ease of Use	0.173	0.074	0.926						
4. Perceived Usefulness	0.313	0.265	0.215	0.864					
5. Perceived Enjoyment	0.289	0.150	0.195	0.488	0.871				
6. Perceived Cost	−0.146	−0.111	−0.007	−0.365	−0.359	0.936			
7. Flow State	0.346	0.217	0.157	0.463	0.488	−0.357	0.943		
8. Satisfaction	0.309	0.157	0.199	0.532	0.507	−0.312	0.444	0.893	
9. Continuance Intention to Use	0.142	0.053	0.202	0.168	0.300	−0.158	0.312	0.224	0.889

constructs for discriminant validity. As computed in Table 5 and 6, the current study passes a set of reliability tests.

4.3. Fit indices

The fit indices of the research and measurement models were computed. On the basis of the suggestions of several prior studies, the indices were considered generally acceptable (Table 7).

4.4. Hypothesis tests

Fig. 2 and Table 8 summarizes the research model. Users' continual intention use is primarily determined by their satisfaction (H1, $\beta = 0.633$, $CR = 18.068$, $p < 0.001$), while the other four factors—perceived usefulness (H10, $\beta = 0.120$, $CR = 5.004$, $p < 0.001$), enjoyment (H12, $\beta = 0.129$, $CR = 4.201$, $p < 0.001$), cost (H13, $\beta = -0.093$, $CR = -4.064$, $p < 0.001$), and flow state (H14, $\beta = 0.118$, $CR = 5.073$, $p < 0.001$)—are significantly related to the intention ($R^2 = 0.676$).

Two technology acceptance factors, perceived usefulness (H9, $\beta = 0.262$, $CR = 9.833$, $p < 0.001$) and ease of use (H8, $\beta = 0.069$, $CR = 2.293$, $p < 0.01$), as well as hedonic motivation (H11, $\beta = 0.587$, $CR = 20.282$, $p < 0.001$) positively affect user satisfaction. Users' service and system quality is significantly associated with their satisfaction (H7, $\beta = 0.121$, $CR = 4.278$, $p < 0.001$), whereas their perception of confirmation has no effects on satisfaction (H2, $\beta = -0.036$, $CR = -0.981$, $p < 0.001; R^2 = 0.510$).

The confirmation, which is affected by service and system quality (H6, $\beta = 0.513$, $CR = 16.146$, $p < 0.001$), plays significant roles in determining perceived ease of use (H3, $\beta = 0.604$, $CR = 20.133$, $p < 0.001$), usefulness (H4, $\beta = 0.389$, $CR = 12.696$, $p < 0.001$), and enjoyment (H5, $\beta = 0.323$, $CR = 10.839$, $p < 0.001$).

In addition to users' satisfaction, which has greatest effects on their intention, perceived enjoyment has notable standardized effects on intention (0.501 = 0.129 (direct) + 0.372 (indirect), Table 9). Moreover, although the relationship between users' confirmation and satisfaction is not supported, the confirmation has notable indirect effects on the intention (0.276 (indirect)).

5. Discussion and conclusions

The current study aims to investigate the motivation factors underlying users' continuance intention to use smart wearable devices using an integrated research model, which was primarily developed via the ECM and TAM. The structural results indicate that four positive and one negative factor play notable roles in deciding the continuance intention to use the devices, supposing that users' comprehensive perceptions of the devices are crucial in understanding their behavior with regard to the devices.

Furthermore, this study finds the influence of user confirmation on perceived ease of use, usefulness, and enjoyment but not satisfaction. The confirmation indirectly affects satisfaction through three factors presented by the TAM and user acceptance of hedonic information systems. This indicates that users feel greater degrees of utilitarian and hedonic values when their expectations are confirmed at the beginning of using smart wearable devices. Then, the positively formed feelings of both values lead to higher levels of users' satisfaction and intention.

Moreover, the roles of service and system quality as key determinants of users' confirmation and satisfaction were verified. This reveals that users' perceptions of service and system quality should be considered when designing and manufacturing smart wearable

Table 7
Fit indices (Hoelter, 1983; Henseler and Sarstedt, 2013; Yuan, 2005; Barrett, 2007; Wu et al., 2009; Yadama and Pandey, 1995).

Indices	Measurement model	Research model	Recommendation
Comparative fit indices	0.904	0.906	>0.900
Normed fit indices	0.911	0.920	>0.900
Goodness-of-fit indices	0.902	0.904	>0.900
Root mean square error of approximation	0.077	0.077	<0.080
Incremental fit indices	0.902	0.902	>0.900

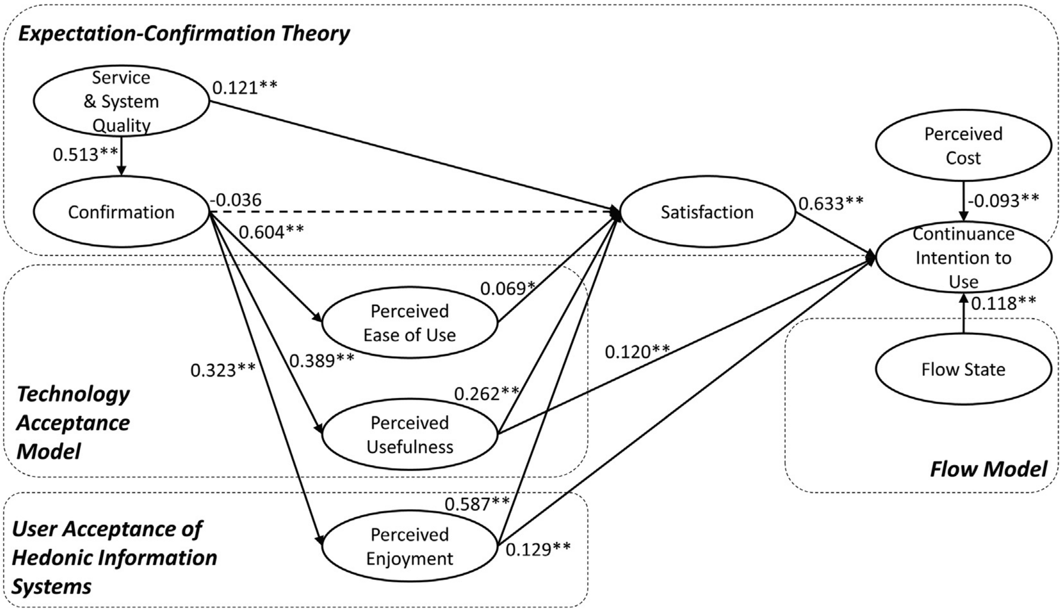


Fig. 2. Summary of the results.

Table 8
Results of the research model (** $p < 0.001$; * $p < 0.05$).

Hypothesis	Standardized Coefficient	S. E.	Critical Ratio	Results
H1. Satisfaction → Intention	0.633**	0.036	18.068	Supported
H2. Confirmation → Satisfaction	−0.036	0.039	−0.981	Not supported
H3. Confirmation → Ease of Use	0.604**	0.029	20.133	Supported
H4. Confirmation → Usefulness	0.389**	0.029	12.696	Supported
H5. Confirmation → Enjoyment	0.323**	0.029	10.839	Supported
H6. Quality → Confirmation	0.513**	0.036	16.146	Supported
H7. Quality → Satisfaction	0.121**	0.034	4.278	Supported
H8. Ease of Use → Satisfaction	0.069*	0.033	2.293	Supported
H9. Usefulness → Satisfaction	0.262**	0.030	9.833	Supported
H10. Usefulness → Intention	0.120**	0.027	5.004	Supported
H11. Enjoyment → Satisfaction	0.587**	0.032	20.282	Supported
H12. Enjoyment → Intention	0.129**	0.035	4.201	Supported
H13. Cost → Intention	−0.093**	0.021	−4.064	Supported
H14. Flow → Intention	0.118**	0.021	5.073	Supported

Table 9
Total effects on the intention.

Factors	Direct effects	Indirect effects	Total effects
Service & System Quality	–	0.218	0.218
Confirmation	–	0.276	0.276
Perceived Ease of Use	–	0.043	0.043
Perceived Usefulness	0.120	0.166	0.286
Perceived Enjoyment	0.129	0.372	0.501
Perceived Cost	−0.093	–	−0.093
Flow State	0.118	–	0.118
Satisfaction	0.633	–	0.633

devices as well as providing a set of services related to the devices because user perception can affect the confirmation between their expectations and actual experiences.

The relatively weak effect of perceived cost on intention was unexpected. Although a number of previous studies and scholars presented economic hindrances of smart wearable devices as a notable determinant of the success of the devices (Ali and Li, 2019; Park et al., 2016), the hindrance is not considered among the current users of the devices. That is, among several economic burdens, the initial economic hindrances, such as purchasing the devices and accessories, can be ignored by the participants in the survey who already own and use the devices.

From an academic perspective, this study confirms the effectiveness and validity of the ECM and TAM in understanding users' behavior with regard to smart wearable devices. Moreover, the relationships among ECM, TAM, and hedonic values can be addressed in understanding users' perspectives toward innovative and smart technologies with the integrated research model. Furthermore, users' utilitarian, hedonic, and usability perspectives toward smart wearable devices lead to greater levels of satisfaction while their perspectives play a mediation role between their perceived satisfaction and confirmation.

From an industrial viewpoint, the findings of the research model can be utilized to allow service providers of smart wearable devices to institute their own guidelines and instructions for providing improved user experiences in using the device services. Providers should offer useful and enjoyable services with improved usability while attempting to minimize the gap between user expectations and their actual usage experience by improving the system and service quality.

5.1. Limitations and Future Studies

This study exhibits several limitations. First, there may be other notable user-oriented theories that are able to provide better explanations of users' behavior with regard to smart wearable devices. For instance, the unified theory of acceptance and use of technology is considered to be a suitable alternative and extended user-oriented theory for understanding users' behavior with regard to innovative and smart technologies (Adapa et al., 2018; Chang et al., 2016). Second, participants' demographic information is not considered in the research model. Several previous studies indicated that users' demographic information can be significantly related to their adoption patterns of specific technologies and services (Guo et al., 2015). Thus, future research should utilize the results and implications of the research model presented by the current study for addressing the notable limitations to provide a more comprehensive understanding of users' behavior with regard to smart wearable devices.

Acknowledgement

This work was supported by the National Research Foundation of Korea (NRF) grant funded by the Korea government (NRF-2017R1C1B5017437).

References

Adapa, A., Nah, F.F.-H., Hall, R.H., Siau, K., Smith, S.N., 2018. Factors influencing the adoption of smart wearable devices. Int. J. Human-Computer Interaction 34, 399–409.

Ali, H., Li, H., 2019. Evaluating a smartwatch notification system in a simulated nursing home. Int. J. Older People Nursing e12241.

Barrett, P., 2007. Structural equation modelling: Adjudging model fit. Personal. Individual Diff. 42, 815–824.

Bem, D.J., 1972. Self-perception theory. In Advances in experimental social psychology (pp. 1–62). Elsevier volume 6.

Bhattacherjee, A., 2001. Understanding information systems continuance: an expectation-confirmation model. MIS Q. 25, 351–370.

Bhattacherjee, A., Premkumar, G., 2004. Understanding changes in belief and attitude toward information technology usage: a theoretical model and longitudinal test. MIS Q. 28, 229–254.

Bilgihan, A., Okumus, F., Nusair, K., Bujisic, M., 2014. Online experiences: flow theory, measuring online customer experience in e-commerce and managerial implications for the lodging industry. Inform. Tech. Tour. 14, 49–71.

Briz-Ponce, L., Pereira, A., Carvalho, L., Juanes-Méndez, J.A., García-Peñalvo, F.J., 2017. Learning with mobile technologies–students behavior. Comput. Hum. Behav. 72, 612–620.

Chang, H.H., Fu, C.S., Jain, H.T., 2016. Modifying utaut and innovation diffusion theory to reveal online shopping behavior: Familiarity and perceived risk as mediators. Inform. Devel. 32, 1757–1773.

Chee, S.W., Yee, W.K., Saudi, M.H.M., 2018. Consumer perceptions and intentions towards malaysian mobile marketing. Asian J. Innovation Policy 7, 338–363.

Chen, C.-C., Chang, Y.-C., 2018. What drives purchase intention on airbnb? perspectives of consumer reviews, information quality, and media richness. Telematics Inform. 35, 1512–1523.

Chen, L.Y., Wu, W.-N., et al., 2017. An exploration of the factors affecting users satisfaction with mobile payments. Int. J. Computer Sci. Inform. Technol. (IJCSIT) 9, 97–105.

Chen, S.-C., Liu, M.-L., Lin, C.-P., 2013. Integrating technology readiness into the expectation–confirmation model: an empirical study of mobile services. Cyberpsychology, Behavior, Social Netw. 16, 604–612.

Cho, J., 2016. The impact of post-adoption beliefs on the continued use of health apps. Int. J. Med. Inform. 87, 75–83.

Chuah, S.H.-W., Rauschnabel, P.A., Krey, N., Nguyen, B., Ramayah, T., Lade, S., 2016. Wearable technologies: the role of usefulness and visibility in smartwatch adoption. Comput. Hum. Behav. 65, 276–284.

Davis, F.D., 1989. Perceived usefulness, perceived ease of use, and user acceptance of information technology. MIS Q. 13, 319–340.

Davis, F.D., Bagozzi, R.P., Warshaw, P.R., 1989. User acceptance of computer technology: a comparison of two theoretical models. Manage. Sci. 35, 982–1003.

Dehghani, M., Dangelico, R.M., 2017. Smart wearable technologies: Current status and market orientation through a patent analysis. In: 2017 IEEE International Conference on Industrial Technology (ICIT). IEEE, pp. 1570–1575.

DeLone, W.H., McLean, E.R., 1992. Information systems success: The quest for the dependent variable. Inform. Syst. Res. 3, 60–95.

Dubey, H., Goldberg, J.C., Abtahi, M., Mahler, L., Mankodiya, K., 2015. Echowear: smartwatch technology for voice and speech treatments of patients with parkinson's disease. In: Proc. Conf. Wireless Health. ACM, pp. (p. 15)..

Festinger, L., 1962. A theory of cognitive dissonance, vol. 2 Stanford University Press.

Guo, X., Han, X., Zhang, X., Dang, Y., Chen, C., 2015. Investigating m-health acceptance from a protection motivation theory perspective: gender and age differences. Telemedicine e-Health 21, 661–669.

Ha, T., Beijnon, B., Kim, S., Lee, S., Kim, J.H., 2017. Examining user perceptions of smartwatch through dynamic topic modeling. Telematics and Informatics, 34 , 1262–1273.

Hanafizadeh, P., Behboudi, M., Koshksaray, A.A., Tabar, M.J.S., 2014. Mobile-banking adoption by iranian bank clients. Telematics Inform. 31, 62–78.

Van der Heijden, H., 2004. User acceptance of hedonic information systems. MIS Q. 28, 695–704.

Henseler, J., Sarstedt, M., 2013. Goodness-of-fit indices for partial least squares path modeling. Comput. Stat. 28, 565–580.

Hoelter, J.W., 1983. The analysis of covariance structures: Goodness-of-fit indices. Sociolog. Methods Res. 11, 325–344.

Hong, J.-C., Lin, P.-H., Hsieh, P.-C., 2017. The effect of consumer innovativeness on perceived value and continuance intention to use smartwatch. Comput. Hum.

Behav. 67, 264–272.
Hsiao, K.-L., Chen, C.-C., 2018. What drives smartwatch purchase intention? perspectives from hardware, software, design, and value. Telematics Inform. 35, 103–113.
Hsu, C.-L., Lin, J.C.-C., 2015. What drives purchase intention for paid mobile apps?–an expectation confirmation model with perceived value. Electron. Commer. Res. Appl. 14, 46–57.
Hsu, J.S.-C., 2014. Understanding the role of satisfaction in the formation of perceived switching value. Decis. Support Syst. 59, 152–162.
Hu, J., Zhang, Y., 2016. Understanding chinese undergraduates continuance intention to use mobile book-reading apps: an integrated model and empirical study. Libri 66, 85–99.
Hung, M.-C., Yang, S.-T., Hsieh, T.-C., 2012. An examination of the determinants of mobile shopping continuance. Int. J. Electronic Business Manage. 10, 29–37.
Jeong, H., Kim, H., Kim, R., Lee, U., Jeong, Y., 2017. Smartwatch wearing behavior analysis: a longitudinal study. Proc. ACM Interactive, Mobile, Wearable Ubiquitous Technol. 1, 60.
Jeong, S.C., Kim, S.-H., Park, J.Y., Choi, B., 2017. Domain-specific innovativeness and new product adoption: a case of wearable devices. Telematics Inform. 34, 399–412.
Joo, Y.J., So, H.-J., Kim, N.H., 2018. Examination of relationships among students' self-determination, technology acceptance, satisfaction, and continuance intention to use k-moocs. Computers Educ. 122, 260–272.
Kim, H., Park, E., Kwon, S.J., Ohm, J.Y., Chang, H.J., 2014. An integrated adoption model of solar energy technologies in south korea. Renewable Energy 66, 523–531.
Kim, K., Hwang, J., Zo, H., Lee, H., 2016. Understanding users continuance intention toward smartphone augmented reality applications. Inform. Devel. 32, 161–174.
Ko, E., Kim, E.Y., Lee, E.K., 2009. Modeling consumer adoption of mobile shopping for fashion products in korea. Psychol. Market. 26, 669–687.
Kujala, S., Mugge, R., Miron-Shatz, T., 2017. The role of expectations in service evaluation: a longitudinal study of a proximity mobile payment service. Int. J. Hum Comput Stud. 98, 51–61.
Kwon, S.J., Park, E., Kim, K.J., 2014. What drives successful social networking services? a comparative analysis of user acceptance of facebook and twitter. Social Sci. J. 51, 534–544.
Lee, M.-C., Tsai, T.-R., 2010. What drives people to continue to play online games? an extension of technology model and theory of planned behavior. Intl. J. Human-computer Inter. 26, 601–620.
Liang, J., Xian, D., Liu, X., Fu, J., Zhang, X., Tang, B., Lei, J., 2018. Usability study of mainstream wearable fitness devices: feature analysis and system usability scale evaluation. JMIR mHealth and uHealth, 6 ,e11066.
Liu, F., Zhao, X., Chau, P.Y., Tang, Q., 2015. Roles of perceived value and individual differences in the acceptance of mobile coupon applications. Internet Res. 25, 471–495.
Lu, T.-C., Chang, Y.-T., Ho, T.-W., Chen, Y., Lee, Y.-T., Wang, Y.-S., Chen, Y.-P., Tsai, C.-L., Ma, M.H.-M., Fang, C.-C., et al., 2019. Using a smartwatch with real-time feedback improves the delivery of high-quality cardiopulmonary resuscitation by healthcare professionals. Resuscitation 140, 16–22.
Mani, Z., Chouk, I., 2017. Drivers of consumers? resistance to smart products. J. Marketing Manage. 33, 76–97.
Mouakket, S., 2015. Factors influencing continuance intention to use social network sites: The facebook case. Comput. Hum. Behav. 53, 102–110.
Munoz-Leiva, F., Climent-Climent, S., Liébana-Cabanillas, F., 2017. Determinants of intention to use the mobile banking apps: An extension of the classic tam model. Spanish J. Marketing-ESIC 21, 25–38.
Natarajan, T., Balasubramanian, S.A., Kasilingam, D.L., 2017. Understanding the intention to use mobile shopping applications and its influence on price sensitivity. J. Retailing Consumer Services 37, 8–22.
Nowak, K.L., Biocca, F., 2003. The effect of the agency and anthropomorphism on users' sense of telepresence, copresence, and social presence in virtual environments. Presence: Teleoperators Virtual Environ. 12, 481–494.
Oghuma, A.P., Libaque-Saenz, C.F., Wong, S.F., Chang, Y., 2016. An expectation-confirmation model of continuance intention to use mobile instant messaging. Telematics Inform. 33, 34–47.
Oliver, R.L., 1980. A cognitive model of the antecedents and consequences of satisfaction decisions. J. Marketing Res. 17, 460–469.
Park, E., 2013. The adoption of tele-presence systems: Factors affecting intention to use tele-presence systems. Kybernetes 42, 869–887.
Park, E., Baek, S., Ohm, J., Chang, H.J., 2014. Determinants of player acceptance of mobile social network games: An application of extended technology acceptance model. Telematics Inform. 31, 3–15.
Park, E., Cho, Y., Han, J., Kwon, S.J., 2017. Comprehensive approaches to user acceptance of internet of things in a smart home environment. IEEE Internet Things J. 4, 2342–2350.
Park, E., Kim, K.J., 2014. An integrated adoption model of mobile cloud services: exploration of key determinants and extension of technology acceptance model. Telematics Inform. 31, 376–385.
Park, E., Kim, K.J., Kwon, S.J., 2016. Understanding the emergence of wearable devices as next-generation tools for health communication. Inform. Technol. People 29, 717–732.
Park, E., Ohm, J.Y., 2014. Factors influencing the public intention to use renewable energy technologies in south Korea: effects of the fukushima nuclear accident. Energy Policy 65, 198–211.
Park, E., del Pobil, A.P., 2013. Modeling the user acceptance of long-term evolution (lte) services. Ann. Telecommun. 68, 307–315.
Roca, J.C., Chiu, C.-M., Martínez, F.J., 2006. Understanding e-learning continuance intention: An extension of the technology acceptance model. Int. J. Human-Computer Stud. 64, 683–696.
See-To, E.W., Papagiannidis, S., Cho, V., 2012. User experience on mobile video appreciation: How to engross users and to enhance their enjoyment in watching mobile video clips. Technol. Forecast. Soc. Chang. 79, 1484–1494.
Sinha, N., Gupta, M., 2019. Taxonomy of wearable devices: A systematic review of literature. Int. J. Technol. Diffusion (IJTD) 10, 1–17.
Sinha, S., 2019. Global smartwatch shipments grew 48 with one in three being an apple watch. https://www.counterpointresearch.com/global-smartwatch-shipments-grew-48yoy-q1-2019-one-three-apple-watch.
Statistica, 2019. Smartwatch unit sales worldwide from 2014 to 2017 (in millions). https://www.statista.com/statistics/538237/global-smartwatch-unit-sales/.
Sun, N., Rau, P.-L.P., 2015. The acceptance of personal health devices among patients with chronic conditions. Int. J. Med. Inform. 84, 288–297.
Susanto, A., Chang, Y., Ha, Y., 2016. Determinants of continuance intention to use the smartphone banking services: an extension to the expectation-confirmation model. Ind. Manage. Data Syst. 116, 508–525.
Tan, X., Kim, Y., 2015. User acceptance of saas-based collaboration tools: a case of google docs. J. Enterprise Inform. Manage. 28, 423–442.
Thong, J.Y., Hong, S.-J., Tam, K.Y., 2006. The effects of post-adoption beliefs on the expectation-confirmation model for information technology continuance. Int. J. Hum Comput Stud. 64, 799–810.
Turel, O., Serenko, A., Bontis, N., 2010. User acceptance of hedonic digital artifacts: a theory of consumption values perspective. Inform. Manage. 47, 53–59.
Wang, E.S.-T., Lin, R.-L., 2017. Perceived quality factors of location-based apps on trust, perceived privacy risk, and continuous usage intention. Behaviour Inform. Technol. 36, 2–10.
Wang, W., Ngai, E.W., Wei, H., 2012. Explaining instant messaging continuance intention: the role of personality. Int. J. Human-Comput. Inter. 28, 500–510.
Wen, D., Zhang, X., Lei, J., 2017. Consumers' perceived attitudes to wearable devices in health monitoring in china: A survey study. Computer Methods Programs Biomed. 140, 131–137.
Wu, L.-H., Wu, L.-C., Chang, S.-C., 2016. Exploring consumers intention to accept smartwatch. Comput. Hum. Behav. 64, 383–392.
Wu, W., West, S.G., Taylor, A.B., 2009. Evaluating model fit for growth curve models: Integration of fit indices from sem and mlm frameworks. Psycholog. Methods 14, 183–201.
Yadama, G.N., Pandey, S., 1995. Effect of sample size on goodness-fit of-fit indices in structural equation models. J. Social Service Res. 20, 49–70.
Yang, H., Lee, H., 2018. Exploring user acceptance of streaming media devices: an extended perspective of flow theory. IseB 16, 1–27.
Yuan, K.-H., 2005. Fit indices versus test statistics. Multivariate Behav. Res. 40, 115–148.