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Technological and Personal Factors of Determining the Acceptance of Wrist-Worn Smart Devices[1]

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Abstract

With much attention being paid to the rapid growth of wrist-worn smart devices, this study aimed to examine the micro-processes that determine an individual's adoption of smart bands and smartwatches. Primarily relying on the theoretical background of the extended technology acceptance model (TAM II), this study explored relationships between three groups of predictors—social, personal, and device-oriented—and the three main components of the original TAM: perceived usefulness (PU), perceived ease of use (PEOU), and behavioral intention (BI). Results from the path analysis indicated multiple factors played significant roles in increasing the PU, PEOU, and BI of wrist-worn smart devices: subjective norms, social image, self-efficacy, perceived service diversity, and perceived reasonable cost. The main findings from this research contribute to significantly improving the understanding of the main factors leading people to adopt wrist-worn smart devices.

Keywords: wrist-worn smart devices, smart band, smartwatch, technology acceptance model, TAM II

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Introduction

In Korean society today, people tend to place more value on convenience and efficiency in order to improve their quality of life. Under such social contexts, information per se has become an important resource. Information communication technologies (ICTs) have also gained tremendous attention from people. ICTs have been continuously improved and applied to various areas of everyday lives. Recently, wearable devices have begun to dominate the future of ICT. Particularly, the improvement in mobile communication technologies, smart devices, and the Internet of things (IoT), wrist-worn smart devices, primarily smart bands and smartwatches, have received much attention from practitioners and scholars (Årsand, Muzny, Bradway, Muzik, & Hartvigsen, 2015; Gope, 2015; Haghi, Thurow, & Stoll, 2017; Lim, Shin, Kim, & Park, 2015).

Among those technologies, previous research has often emphasized the rapid growth of wrist-worn smart devices (Statista, 2019). IT companies are focusing on broadening the functional and useful aspects provided by these technologies. For example, efforts are being made to extend functions to diverse areas including stress management, sleep patterns, and so forth. In particular, as government agencies have given much attention to the usefulness of mobile health (mHealth) technologies for improving public health nationwide, wrist-worn smart devices have become key technologies of supporting mHealth. Therefore, there have been many studies on the technological aspects of such devices (Årsand et al., 2015; Gope, 2015; Lim et al., 2015).

In spite of the prior research's huge implications in terms of theoretical as well as practical aspects, however, a relatively smaller number of studies have explored the motivational factors that influence the adoption or continuous use of wrist-worn smart devices (Choi & Kim, 2016; Dhgahani, Kim, & Dangelico, 2018; Hong, Lin, & Hsieh, 2017; Lee, Kang, Ahn, Oh, & Kim, 2014; Wu, Wu, & Chang, 2016). However, without an understanding of the micro-mechanisms leading people to adopt those devices, it will be difficult to apply them to other useful services for various purposes (e.g., apps for improving public health). Nevertheless, there still exist many other factors that have not been thoroughly examined but would potentially impact people's adoption of those technologies. Therefore, this study aimed at investigating the micro-mechanisms that determine the adoption of these technologies by using an extended technology acceptance model (TAM) that has been largely applied to research on technology adoption (Lee & Chang, 2011; Park, Lee, & Cheong, 2008).

Theoretical Backgrounds

Research on Wrist-Worn Smart Devices

With a focus on wearable devices, including smartwatches and smartbands, previous studies from various academic disciplines have largely investigated many issues linked to those technologies (Årsand et al., 2015; Haghi et al., 2017; Choi & Kim, 2016; Dhaghami et al., 2018; Yang et al., 2016). In particular, in the areas of engineering and computer science, previous research has intensively investigated the technological aspects of operating wearable devices (Lim et al., 2015; Park et al., 2014). In the case of wrist-worn smart devices, because the explosive growth of these technologies is triggered by smartphone development, research on wrist-worn smart devices is still in the beginning stages. Previous studies on these technologies have intensively delved into the development of system/program modeling in order to develop more efficient hardware and software that could be optimized for specific functions such as health management. Therefore, we can easily observe significant research on the technological aspects of wrist-worn smart devices in various areas (Park et al., 2014). One example is Park et al.'s (2014) study on wearable smart bands as motion recognition systems. Findings from this group of studies have been very meaningful to developing more efficient wrist-worn smart devices.

Moreover, it is also important to examine the motivational factors that potentially lead people to adopt these new technologies. Without a practical comprehension of the mechanisms that motivate people's technology adoption, the development of efficient wearable technologies becomes meaningless. Nevertheless, there has been little research that explores the potential factors that would determine this new technology adoption, implying a necessity to explore more diverse factors. For example, although Hong et al. (2017) found out the significant roles of hedonic vs. utilitarian values of a smartwatch for determining continuance intention to use a smartwatch, there may still exist other factors that significantly affect users' continuance intention.

Accordingly, the main purpose of this research was to develop and test a model that thoroughly explained the micro-mechanisms of determining individuals' adoptions of wrist-worn smart devices. In order to establish that model, based on previous research's main findings (Hong et al., 2017; Wu et al., 2016), this research relied on an extended model of technology acceptance, TAM II, which was proposed by Venkatesh and Davis (2000). Based on its high prediction power, this model has been largely applied to the examination of the processes used in adopting new technologies (Lee & Chang, 2003; Legris, Ingham, & Collerette, 2003; Park et al, 2008).

Technology Acceptance Model (TAM)

Theoretically, TAM is mainly reliant on two theories— theory of reasoned action (TRA) and theory of planned behavior (TPB)— that explain the relationships among people's perceptions about, attitudes toward, and behavioral intentions to use a new technology (Davis, Bagozzi & Warshaw, 1989). According to Davis et al. (1989), those theories are useful for explaining how individuals' attitudes toward a technology influence their behavioral intentions to adopt it. Therefore, Davis et al. (1989) proposed the original model of technology acceptance by adding two perceptual components that determine people's attitudes toward a new technology. One is the perceived usefulness (PU) of a new technology, and the other is the perceived ease of use (PEOU) of that technology. The original TAM proposes that while PU means the extent to which a given technology is useful for accomplishing a given task, PEOU is inversely associated with the amount of resources (time and energy) required to learn the instructions for a new technology (Venkatesh and Davis, 2000). Therefore, when individuals perceive higher level of PU and PEOU, they are likely to have positive attitudes toward a new technology. The main theoretical contribution of the original TAM is the inclusion of perceptual factors determining people's attitudes toward a new technology. Since TAM was proposed, a number of studies have used TAM in order to explain the adoption of various types of new technologies, providing empirical evidence that strongly supports the prediction power of the model (Legris et al., 2003; Schepers & Wetzels, 2007).

However, because of the simplicity of TAM, previous studies tried to extend the original TAM by including predictors of PU and PEOU. In particular, according to Venkatesh and Davis (2000), TAM II gives attention to the potential factors of determining PU and PEOU. In their study, Venkatesh and Davis (2000) proposed the significant roles of technological, affective, and social factors (e.g., subjective norm, social image, and playfulness) for predicting the PU of new technologies. Following this study, many other studies examined diverse predictors' effects on PU and PEOU for various technologies (Lee & Chang, 2003; Park et al., 2008). Therefore, this study also depended on TAM II to examine the roles of personal, technological, and social predictors in determining the PU and PEOU of wearable wrist-worn devices. The following section will further discuss the detailed relationships between those predictors and the PU, PEOU, and BI of wearable wrist devices.

Hypotheses Building

Main Factors of Determining the Use of Wrist-Worn Smart Devices

Primarily depending on TAM II, this study focused on three different groups of predictors that influenced the three components of TAM: PU, PEOU, and BI. These were the *social*, *personal*, and *device-oriented* factors that determined the three main components of TAM. First, the social factors included two motivators that lead people to use wrist-worn smart devices. Those social factors are related not to potential users' own opinions about a new technology but to others' opinions about such a technology. One of those social factors is the subjective norm. According to Venkatesh and Davis (2000), people's perceptions of new technologies are associated with the opinions of influential others who significantly affect their attitudes toward new technologies. In particular, the concept of social influence, which is mainly reliant on the social information processing theory (Fulk, 1993), supports the significance of subjective norms in determining ones' attitudes toward a given technology. In other words, because individuals learn many things directly from their social interactions with others, influential others' opinions on specific topics (wrist-worn smart devices in this study) play crucial roles in determining ones' perceptions of those topics. Regarding this argument, Thakur, Angriawan, and Summey (2016) addressed the importance of technological opinion leadership for people's adoption of a new innovative technology, because people's attitudes toward such technology is significantly influenced particularly by people with technological expertise who are close to them (Choi & Chung, 2013; Park, Nam, & Cha, 2012; Schepers & Wetzels, 2007).

Therefore, with regards to the roles of subjective norms (SN), many previous studies based on TAM II frequently found subjective norms to have significant effects on PU and BI (Choi & Chung, 2013; Park, Nam, & Cha, 2012; Schepers & Wetzels, 2007). Considering those findings, it could be expected that as influential others share positive opinions on wearable devices, a person may perceive a higher level of usefulness in these technologies and potentially intend to use them. Therefore, this present study established two hypotheses:

H1: Subjective norms will be positively associated with the perceived usefulness of wrist-worn smart devices.

H2: Subjective norms will be positively associated with the behavioral intent to use wrist-worn smart devices.

Another social factor motivator was social image. Previous research often conceptualized social image as the extent to which people expect that their social status and image will be improved by using a new technology (Moore & Benbasat, 1991; Venkatesh & Davis, 2000). In particular, in a contemporary society that is characterized by the extremely fast development of numerous technologies, one's adoption and skillful use of new technologies, especially trendy ones, can be considerably helpful in improving one's social image. In other words, when people are recognized as an early adopter of a trendy technology, their social image will be also improved. Therefore, previous studies using TAM found the positive effects of social image on the PU of new technologies (Izuagbe & Popoola, 2017; Sang, Lee, & Lee, 2009; Venkatesh & Davis, 2000). Accordingly, it is comprehensible that when people expect an improvement in their social image, they perceives a higher level of PU in a given technology. As such, this study developed the following hypothesis:

H3: Social image will be positively associated with the perceived usefulness of wrist-worn smart devices.

Secondly, the next group of predictors was personal factors comprised of personal innovativeness and self-efficacy. With regards to new technology adoption, previous studies often found that innovativeness played a significant role in determining an individual's adoption of new technologies (Hong et al., 2017; Lu et al., 2005; Paik et al., 2013). Personal innovativeness is a key factor of leading people to actively explore new ideas (Agarwal & Prasad, 1998). These studies commonly conceptualized innovativeness as a person's positive attitudes towards a new idea. Innovative people are more likely to positively perceive a new idea and tend to be open to the adoption of that idea. Due to such positive attitudes towards a given technology, innovative people are likely to perceive the new technology's usefulness, implying the positive effect of personal innovativeness on PU (Bruner & Kumar, 2007). Lu et al.'s (2005) study found that personal innovativeness positively predicted the PU of wireless Internet service. Moreover, it is also highly plausible that innovative people have more opportunities to learn technologies that are similar to the new technology, implying a higher level of PEOU, implying a significant relationship between PEOU and personal innovativeness. Therefore, based on these findings, this present study developed and tested the following hypotheses:

H4: Innovativeness will be positively associated with the perceived usefulness of wrist-worn smart devices.

H5: Innovativeness will be positively associated with the perceived ease of using wrist-worn smart devices.

Another personal predictor, self-efficacy, can be conceptualized as the level of one's confidence in successfully accomplishing a given task (Bandura, 1997). In other words, when a person is more confident in completing a given task, she/he perceives a higher level of self-efficacy. For example, similar to Cho et al.'s findings (2014), when a smartphone user has more confidence in efficiently finding health information through mobile apps, she/he tends to demonstrate a higher level of self-efficacy in achieving that particular goal. Considering the main concept of self-efficacy, it is understood that self-efficacy is conceptually linked to the PEOU of a new technology (Ozturka, Bilgihan, Nusair, & Okumusa, 2016). This is because a higher level of confidence in accomplishing a given task is based on the assumption of possessing the necessary skills to do so, thus implying a higher level of PEOU. Therefore, potential users' confidence in efficiently using wearable devices can be closely connected with the PEOU of those technologies. With regards to this argument, Cho et al.'s (2014) study found that self-efficacy in effectively searching for online health information positively predicted the PEOU of health apps on smartphones. Therefore, this research proposes the following hypothesis:

H6: Self-efficacy will be positively associated with the perceived ease of using wrist-worn smart devices.

Third, in addition to the user-oriented factors (social and personal), this study also focused on device-oriented factors. Although there are existing diverse variables that are related to wrist-worn smart devices, this study emphasized the following three factors: *perceived service diversity*, *perceived ubiquity*, and *perceived reasonable cost*. First, supported by the development of advanced technologies linked to IoT, as well as smart devices, wearable devices can provide users with various functions including telephone, texting, health management, and more. While connected to smart devices, especially smartphones, wrist-worn smart device users are now able to efficiently conduct diverse activities (Årsand et al., 2015; Gope, 2015; Lim et al., 2015). The developers of wrist-worn smart devices place emphasis on such service diversity. For example, the advertisement for the Apple Watch stresses the efficient control of various functions provided by iPhones. As such, it is significant that a user's efficient completion of multiple functions is closely related to a technology's usefulness. Therefore, the following hypothesis was tested:

H7: Perceived service diversity will be positively associated with the perceived usefulness of wrist-worn smart devices.

The next device-oriented factor was perceived ubiquity. Portability and mobility are among the most significant characteristics of mobile technologies, including wrist-worn smart devices (Årsand et al., 2015; Gope, 2015; Lim et al., 2015). In the case of wrist-worn smart devices, users can bring them everywhere, and not be conscious of the fact that they are wearing the devices. This implies the expansion of use spaces for those devices. Moreover, the development of telecommunication networks allows smartphone users to have access to the Internet at any time and place. This implies both spatial and temporal expansions for people's use of wrist-worn smart devices, thus suggesting the devices' ubiquities. Such ubiquities can be linked to both the PU and PEOU of those technologies. In other words, the ubiquitous use itself is a huge benefit in using a technology to complete a given technology, thus implying the connection between perceived ubiquity and PU. In addition, when users can access a technology at any time and place, they will likely have more opportunities to learn how to use it, which suggests the link between perceived ubiquity and the PEOU of wearable devices. Previous research found significant relationships between the perceived ubiquity of technologies and their PU and PEOU (Kang, 2014; Park & Choi, 2013). Based on those findings, the following hypotheses were developed and tested:

H8: Perceived ubiquity of wrist-worn smart devices will be positively associated with the perceived usefulness of wrist-worn smart devices.

H9: Perceived ubiquity of wrist-worn smart devices will be positively associated with the perceived ease of using wrist-worn smart devices.

The last variable in the device-oriented factors was perceived reasonable cost. It is well known that an influential factor in determining one's product purchase is reasonable expense. Likewise, previous research has often found that people's perception of reasonable cost is significantly associated with their adoption of the technology (Zainab & Bhatti, 2017). As such, it must be considered that the reasonability of the expense incurred when purchasing a technology is determined by the individual's evaluation of the technology's usefulness. In other words, people perceive the cost is reasonable because she/he already anticipates that the technology will be useful. This suggests a potential significant association between the perceived reasonable cost and the PU of the technology. Therefore, this present study tested the following hypothesis:

H10: Perceived reasonable cost will be positively associated with the perceived usefulness of wrist-worn smart devices.

Lastly, primarily relying on TAM II, this study pursued multiple research questions with regard to the potential relationships between the social, personal, and device-oriented predictors and the main components of TAM. Moreover, TAM II focuses on the significant relationships among those three main components—PU, PEOU, and BI of using a new technology (Schepers & Wetzels, 2007; Venkatesh and Davis, 2000). In particular, the meta-analysis conducted by Schepers and Wetzels (2007) summarized that PU and PEOU were significantly associated with BI and that PEOU mediated the relationship between PU and BI. Based on those findings, this present study also established the following hypotheses:

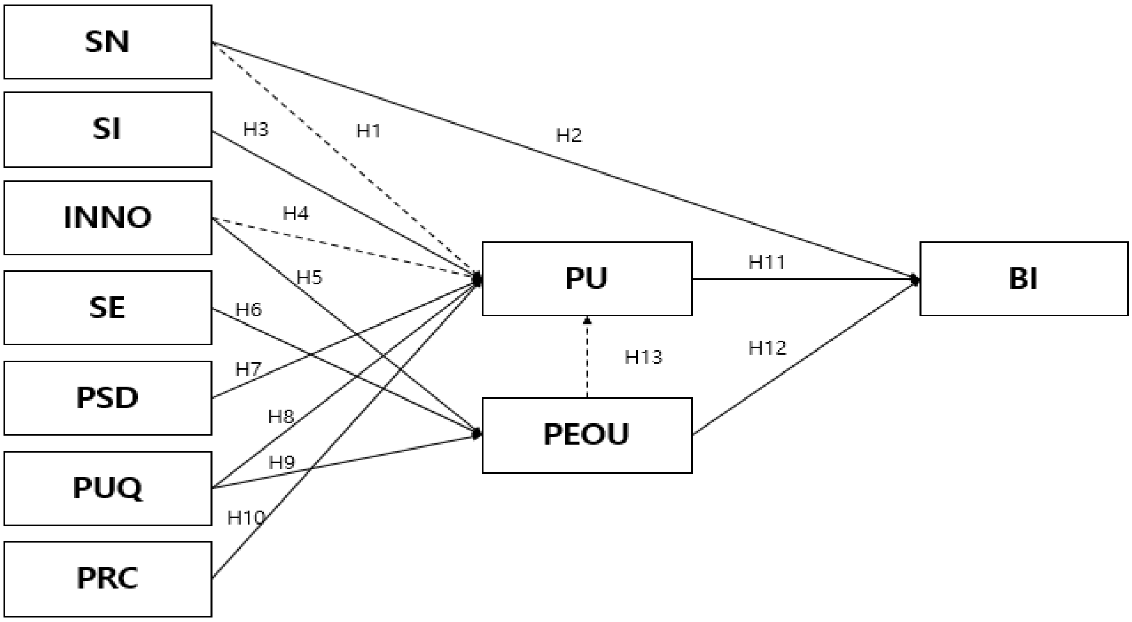
H11: Perceived usefulness of wrist-worn smart devices will be positively associated with the behavioral intent to use wrist-worn smart devices.

H12: Perceived ease of using wrist-worn smart devices will be positively associated with the behavioral intent to use wrist-worn smart devices.

H13: Perceived ease of using wrist-worn smart devices will mediate the relationship between the perceived usefulness and the behavioral intent to use wrist-worn smart devices.

Figure 1 shows this research's model composed of thirteen hypotheses.

Figure 1. Research model



Note. SN=Subjective norms, SI=Social image, INNO=Innovativeness, SE=Self-efficacy, PSD=Perceived service diversity, PUQ=Perceived ubiquity, PRC=Perceived reasonable cost, PU=Perceived usefulness, PEOU=Perceived ease of use, BI=Behavioral intention.

Methods

Participants

For this data collection, a paper-and-pencil survey was distributed to students who were registered at a large-sized university located in Korea and who were generally recognized as the younger generation that is relatively more familiar with digital media for two weeks in May 2015. For this survey, convenience sampling was used. The primary researcher contacted and asked professors in the department of communication to distribute the survey to students enrolled in their classes. In addition, the primary researcher contacted students enrolled in the college of social science who she personally had known, in order to obtain more responses.

To help survey participants more clearly understand the wrist-worn smart devices, the survey listed detailed descriptions of four wrist-worn smart devices—Apple Watch, Samsung Galaxy Gear S, Sony Smartband, and Jawbone UP24— including each one's main functions, application base, and price. After reading this description, the survey participants began to complete the survey. In total, 263 surveys were obtained. The participants were predominantly female (60.5%). The average age was 20.6 years.

Instruments

This study used multiple composite measurements to measure the main study variables. Those measurements were constructed as five-point Likert-type scales (e.g., *1 = Strongly disagree*, *5 = Strongly agree*). All of the scales had acceptable reliability scores, with a Cronbach's alpha score of higher than .70.

Subjective norm (SN). Subjective norm refers to influential others' (e.g., friends, family members) attitudes and behaviors that encourage individuals to adopt a new technology. Five items that had been originally proposed by Venkatesh and Davis (2000) were used to measure the subjective norms for this present study. Two examples of the items are a) People who are important to me think that I should use forearm wearable devices and b) People who influence my behavior encourage me to use wearable devices. The reliability test indicated an acceptable Chronbach's alpha (M = 1.95, SD = 0.87, α = .92).

Social image (SI). This variable is the extent to which people perceive their personal image can be improved by their adoption of a new technology. Moore and Benbasat's (1991) three items were used to measure social image with regards to people's use of forearm wearable devices. The following are the examples of those items: a) I believe that my social image will be improved by wearing forearm wearable devices and b) Wearing forearm wearable devices will be helpful for increasing my competitiveness. The reliability of this measurement was acceptable (M = 2.47, SD = 0.90, α = .86)

Innovativeness (INNO). Innovativeness is a personality trait related to the extent to which a person is open to new ideas and technologies. In order to measure this variable, this study reworded and used three items that were particularly related to "willingness-to-try" from Hurt, Joseph, and Cook's (1977) original scale. Examples of the edited scale for innovativeness are a) I tend to actively seek information about new technologies and ideas and b) I like to introduce new technologies and ideas to others. Cronbach's alpha for this measurement was acceptable (M = 3.09, SD = 0.82, α = .81).

Self-efficacy (SE). Self-efficacy is people's confidence in themselves in terms of solving a given problem. Three items from Eastin and LaRose's (2000) scale were reworded corresponding to this present study's main topic, the adoption of forearm wearable devices. Examples of those three items are a) I am confident in learning the functions of forearm wearable devices and b) I am confident in comprehending the terminologies for forearm wearable devices. This scale had an acceptable reliability score (M = 3.27, SD = 0.84, α = .85).

Perceived service diversity (PSD). PSD was measured through four items based on Oh's (2012) research, focusing on how diverse services would be supported by wrist-worn devices. Two examples of those four items are a) Forearm wearable devices will provide me with various functions (e.g., telephone, texting, exercise management, calorie management, etc.) and b) Through forearm wearable devices, my everyday life activities will be automatically recorded. The reliability for this measurement was acceptable (M = 3.27, SD = 0.67, α = .79).

Perceived ubiquity (PUQ). Perceived ubiquity is related to ubiquitous access to forearm wearable devices. Three items from Park and Choi's (2013) scale were edited to correspond to forearm wearable devices. The following are examples: a) I will be able to use forearm wearable devices at any time that I want to use them and b) I will be able to use forearm wearable devices at any place that I want to use them. Cronbach's alpha for this instrument was acceptable (M = 3.42, SD = 0.86, α = .87).

Perceived reasonable cost (PRC). PRC mainly indicates the extent to which a person perceives how reasonable the price of a wearable device is. To measure PRC, this study reworded three items proposed by Baek, Chon, and Lee (2013). Two examples of this scale are a) I think the price for buying a forearm wearable device is adequate and b) I think the price to purchase a forearm wearable device is reasonable. The reliability test provided an acceptable Chronbach's alpha score for this scale (M = 2.22, SD = 0.78, α = .88).

Perceived usefulness (PU). This variable refers to the level of one's perception regarding the usefulness of wrist-worn devices in everyday life. This study used five items mainly from the original PU scale developed by Davis et al. (1989). Specifically, the original items were reworded to correspond to forearm wearable devices. Two examples of those five items are a) Forearm wearable devices will be helpful for improving the quality of my everyday life and b) Forearm wearable devices will be helpful for increasing productivity. The reliability of this scale was acceptable (M = 3.34, SD = 0.72, α = .87).

Perceived ease of use (PEOU). In this study, PEOU was defined as the level of ease one perceived in regard to learning how to use forearm wearable devices, and it was measured by using three items originally developed by Davis et al. (1989). Examples of these items are a) It will be easy to learn how to use forearm wearable devices and b) To me, it will be easy to operate forearm wearable devices. This factor obtained an acceptable reliability score (M = 3.52, SD = 0.79, α = .87).

Behavioral intention (BI). To measure this variable, which refers to people's intentions to adopt forearm wearable devices, this study reworded three items proposed by Davis et al. (1989). Examples of those three items include a) I predict that I will use forearm wearable devices and b) I plan to use forearm wearable devices. The reliability for this measurement was acceptable (M = 2.71, SD = 0.97 α = .90).

Validation of the Scales

In order to validate scales comprised of multiple items, this study conducted a confirmatory factor analysis (CFA). According to Lee and Lim (2007), it is necessary to confirm both absolute and comparative fit indices for a more conservative review of model fit. Therefore, this study verified four model fit indices including minimum chi-square divided by degree of freedom (CMIN/DF, smaller than 3); comparative fit index (CFI, larger than .90); infinite fit index (IFI, larger than .90); and standardized root mean square residuals (SRMR, smaller than .08). CFA results supported the validity of the tenfactor model (χ^2 (df = 450) = 821.97, CMIN/DF = 1.83, CFI = .93, IFI = .93, SRMR = .06). As shown in Table 1.

Table 1. Correlations for Key Study Variables

		1	2	3	4	5	6	7	8	9
1	Subjective Norms	1								
2	Social Image	.48***	1							
3	Innovativeness	.28***	.31***	1						
4	Self-Efficacy	.24***	.24***	.51***	1					
5	Perceived Service Diversity	.25***	.34***	.12*	.24***	1				
6	Perceived Ubiquity	.07	.23***	.20***	.34***	.39***	1			
7	Perceived Reasonable Cost	.36***	.31***	.13*	.19***	.24***	.19***	1		
8	Perceived Usefulness	.19**	.39***	.24***	.24***	.53***	.39***	.28***	1	
9	Perceived Ease of Use	.09	.16*	.41***	.67***	.25***	.38***	-.02	.26***	1
10	Behavioral Intention	.50***	.48***	.32***	.36***	.43***	.26***	.30***	.51***	.29***

Note: N = 263, ***p<.001, **p<.01, *p<.05

Results

By using the technology acceptance model (TAM), this study established multiple hypotheses linked to the relationships between seven predictors and three main components of TAM. To test those hypotheses, this study conducted a path model. Like CFA, four model fit indices were reviewed: CMIN/DF, CFI, IFI, and SRMR. The proposed path model gained acceptable model fit indices (χ^2(df = 11) = 35.7, CMIN/DF = 3.24, CFI = .97, IFI = .97, SRMR = .03).

First, primarily based on TAM II, this study focused on two social variables' effects on PU and BI: subjective norm (SN) and social image (SI). Results from the path analysis indicated that while SN significantly and positively affected BI (β = .46, p < .001), SN's effect on PU was not statistically significant (β = -.07, p = .17). This implies that while H2 was fully supported, H1 was rejected. In addition, the result from the path analysis reported that SI's effect on PU was statistically significant (β = .16, p < .001), indicating that H3 was fully supported.

Next, this study tested multiple hypotheses related to two personality-oriented variables: innovativeness (INNO) and self-efficacy (SE). Specifically, this study established INNO's effects on PU (H4) and PEOU (H5), as well as SE's effect on PEOU (H6). According to results from the path analysis, while INNO's effect on PU was not statistically significant (β = .08, p = .12), its effect on PEOU was weakly significant at the p-value of .10 (β = .08, p = .09). This indicates that while H4 was rejected, H5 was marginally supported. In addition, it was also determined that SE positively and strongly affected PEOU (β = .53, p < .001). This result fully supported H6.

Next, H7, H8, and H9 were primarily associated with the characteristics in terms of technological functions and service. First, H7 focused on the relationship between perceived service diversity (PSD) and PU. Results from the path analysis fully supported H7 (β = .41, p < .001), indicating that PSD positively and significantly predicted PU. Next, perceived ubiquity's (PUQ) effects on PU (H8) and PEOU (H9) were also tested. Results from the path analysis reported that PUQ significantly and positively predicted both PU (β = .12, p = .01) and PEOU (β = .16, p < .001). This means that H8 and H9 were fully supported.

In addition to those predictors, this study noted the effect of perceived reasonability of cost (PRC) on the PU of forearm wearable devices (H10). According to the path analysis results, PRC significantly and positively predicted PU (β = .11, p = .03). This means that H10 was fully supported.

Finally, the remaining hypotheses corresponded to the relationships between three components of TAM: PU, PEOU, and BI. Results from the path analysis indicated that while both PU (β = .52, p < .001) and PEOU (β = .19, p < .001) significantly predicted BI, PEOU's effect on PU was not statistically significant (β = .05, p = .33). These results

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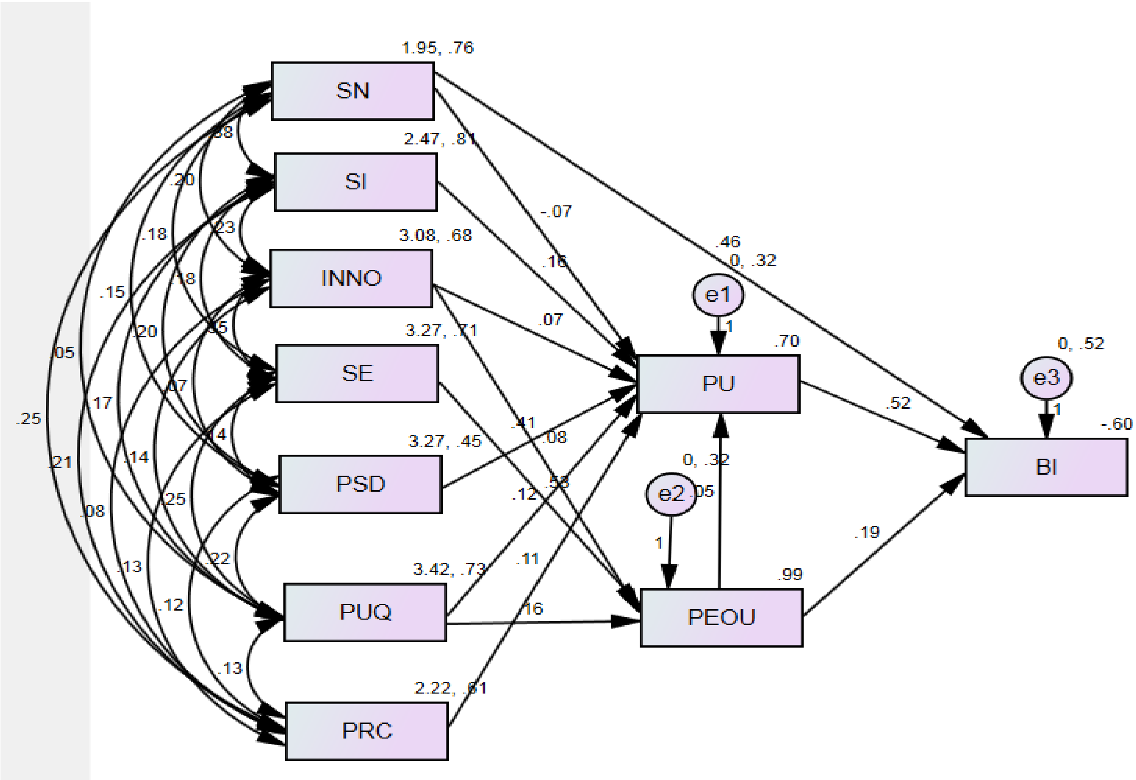
suggested that while H13 was rejected, H11 and H12 were fully supported.

In summary, the inclusion of seven variables—SN, SI, INNO, PSD, PUQ, PRC, PEOU—into the model increased 38% of the explained variance of PU (R^2 = .38). By adding three variables—INNO, SE, PUQ—into the model also increased 48% of the explained variance of PEOU (R^2 = .48). In addition, 46% of the explained variance of BI was increased by including three variables—SN, PU, PEOU—into the model (R^2 = .46). Figure 2 summarizes the results from all of hypotheses tests.

Figure 2. Path model of the main study variables



Note. SN=Subjective norms, SI=Social image, INNO=Innovativeness, SE=Self-efficacy, PSD=Perceived service diversity, PUQ=Perceived ubiquity, PRC=Perceived reasonable cost, PU=Perceived usefulness, PEOU=Perceived ease of use, BI=Behavioral intention, Dotted lines=unsupported hypotheses.

Discussion

Corresponding to the rapid development of mobile communication and IoT technologies, we have observed a notable increase in wrist-worn smart devices as represented by smart bands and smart watches. Because this phenomenon has just entered the general market, there has been little research on many aspects of these technologies. Although there has been much research on the devices' technological improvements (Årsand et al., 2015; Gope, 2015; Lim et al., 2015), we found relatively fewer studies that examined the processes for adopting them. Therefore, this study focused mainly on the motivational factors that potentially led people to adopt these new technologies. Primarily based on TAM II, this study theoretically developed and tested a model comprised of social, personal, and device-oriented predictors and three main components of TAM: PU, PEOU, and BI. Results from the path analysis supported most of the proposed hypotheses. The following points are particularly meaningful to future discussions.

First, previous research relying on TAM II often emphasized the roles of social factors, especially subjective norms and social images that determine the PU and BI of a new technology (Choi and Chung, 2013; Park et al., 2012; Sang et al., 2009; Schepers and Wetzels, 2007; Venkatesh and Davis, 2000). Similar to those studies, SN and SI positively influenced either the PU or BI of wrist-worn smart devices. In particular, SI had a significantly positive effect on the PU of wearable devices. A major critique against wrist-worn smart devices was the lack of unique functions specified only for wrist-worn smart devices. In other words, rather than being independent devices, wrist-worn smart devices are facilitators that support the limited functions provided by smart devices. For instance, although the smart band is useful for health management, numerous smartphones apps also support various functions/services for health management. Therefore, a significant selling point for wrist-worn smart devices is as a "fashion-item" used to improve users' social images. Here, it should be considered that the participants for this study were from a younger generation that could be categorized as digital natives who grew up in digitalized environments and are characterized by their active self-exposure (Thomas, 2011). In other words, they are very familiar with managing their self-images through digitalized media. Therefore, companies need to focus marketing strategies on emphasizing how wearing these technologies would lead to better self-image management.

Next, unlike the original prediction, this study found that the subjective norm did not significantly affect the PU of wrist-worn smart devices. In other words, influential others' positive opinions about wrist-worn smart devices did not significantly lead people to perceive a higher level of usefulness of these technologies. Instead, the subjective norm directly influenced people's intent to use wrist-worn smart devices. This may have resulted from the improved standardization used to evaluate digital technologies' usefulness. In other words, because these young participants already have a certain degree of capability in reviewing digital technologies (Thomas, 2011), influential others' opinions may not be as important in determining their personal evaluations of a given digital technology. Instead, as another finding of this study indicated, this young population's self-confidence in effectively using wrist-worn smart devices affected their perception of these technologies. Therefore, although previous studies often determined the positive effect of the subjective norm on the PU of various technologies (Choi and Chung, 2013; Park et al., 2012; Schepers and Wetzels, 2007), this study's finding suggests that scholars should modify their model based on users' characteristics rather than directly applying the original TAMs onto their research targets.

However, it is still significant that influential others' positive opinions regarding wrist-worn smart devices were positively associated with people's intent to adopt them. In other words, although these opinions did not necessarily increase people's perception of the usefulness of the technologies, they intended to use them. This implies that in order to increase the consumption of wrist-worn smart devices, companies need to build marketing strategies that emphasize word-of-mouth through influential others in order to directly encourage technology adoption. Previous research supported the usefulness of this type of marketing strategy for various services and technologies (Lee and Chang, 2011). Moreover, considering the predominance of SNS use among digital natives, a significant strategy would be to use SNS-driven viral marketing. In particular, it is recommendable for practitioners to encourage loyal users to share their ideas about improving social images through wrist-worn smart devices.

In addition to such marketing strategies, this present research's findings suggested that companies need to provide more diverse services, especially at a reasonable price, for the purpose of improving the PU of wrist-worn smart devices. As the descriptive results indicated, this study's participants reported a considerably low mean score for the perceived reasonable cost (*M*=2.22). This indicated that they perceived the prices to be relatively high when considering the main functions of wrist-worn smart devices. Therefore, companies need to provide various services that offset the relatively high prices.

Finally, another considerable finding of this study was that unlike the original prediction, while the effect of self-efficacy on PEOU was statistically significant, innovativeness did not strongly predict the PU and PEOU of wrist-worn smart devices. As discussed above, in previous research on technology adoption, innovativeness had often been considered an influential factor in determining intent to adopt a new technology (Moore & Benbasat, 1991; Sang et al., 2009; Venkatesh and Davis, 2000). It is understandable that the extent of people's openness to a new idea is positively associated with their adoption of a new technology. However, as this study found, this logic was not directly applied to wrist-worn smart devices. This might have resulted from the main characteristics of innovative people. In other words, because innovative people are more likely to actively adopt and use new technologies (Moore & Benbasat, 1991; Sang et al., 2009), it is very plausible that innovative people have already adopted multiple smart devices. Moreover, because innovative people are more open to new ideas, they may be exposed to more knowledge (e.g., reviews about wrist-worn smart devices). Therefore, when additional smart devices (wrist-worn smart devices in this study) do not provide unique functions, they may be hesitant to adopt them. This finding reaffirms the necessity to carefully investigate the users' personal characteristics in order to more thoroughly scrutinize predictors of a new technology's PU and PEOU.

Considering the meaningful findings from this research, the following theoretical implications can be considered. First, with previous research placing major attention on developing and testing new technologies' support of specific functions of wrist-worn devices (Årsand et al., 2015; Haghi et al., 2017; Choi & Kim, 2016; Dhaghami et al., 2018; Yang et al., 2016), there have been relatively fewer studies that have investigated the predictors that lead to individuals' adoption of those devices. Therefore, this research provides scholars with opportunities to further understand why people intend to adopt those new technologies.

Next, unlike previous research (Choi & Kim, 2016; Hong et al., 2017; Wu et al., 2016; Yang et al., 2016) focusing on the general motivational factors (e.g., hedonic vs. utilitarian values, perceived risks vs. benefits of wrist-worn devices), this research covers more diverse types of specific predictors including social-influence-related, personal, and device-oriented factors that significantly affect people's perceptions about wrist-worn devices. Therefore, this study's findings help scholars and practitioners develop integrative and strategic models that predict and help encourage people to adopt useful services supported by wrist-worn devices. Particularly, this research's main findings can be used for efficiently implementing and invigorating mHealth services for improving public health (e.g., emergency detecting apps through wearable devices for people with physical disabilities).

Limitations and Future Directions

In spite of the practical and theoretical findings, the following limitations should be noted. First, although the selection of TAM II is appropriate for investigating the adoption of an innovative product, the expansion of this well-established model with a few additional predictors may provide a theoretical contribution of interest to scholars. Therefore, in order to develop more theoretically meaningful models, future research needs to consider personal (e.g., personality traits) and contextual factors (e.g., cultural variations in technology adoption) that would moderate the relationships among main components of TAM II. Especially, we recommend that scholars examine factors that would negatively moderate the relationships among the main variables. For instance, considering previous research's findings (Cho & Lee, 2016; Joachim, Spieth, & Heidenreich, 2018), it would be meaningful to investigate the negative moderating effects of innovation resistance on the relationships between the main predictors and behavioral intentions to adopt wrist-worn smart devices.

Next, this study collected data from a younger population, particularly the generation known as digital natives who are technology-savvy, since they are active adopters of smart devices including smartphones and wrist-worn smart devices. This implies the importance of the sample for investigating the adoption of those technologies. However, this young population has their own unique characteristics, especially with regards to technology uses (Thomas, 2011). For instance, even trivial moments of their everyday lives are expressed through multiple new social media platforms, including *Facebook*, *Snapchat*, *Instagram*, and *Tumblr*. Moreover, their dependence on smart devices is so high that people have concerns about the various side effects (e.g., social isolation and pains in wrists and fingers) resulting from the use of those technologies. This young population's behavioral patterns for using new technologies are notably different from older generations. Therefore, future research needs to extend this study's findings to older populations.

Lastly, another recommendation for future research is to focus on more detailed purposes for using wrist-worn smart devices. As elaborated above, people use these technologies for very diverse purposes including health management, schedule management, information searches, social media use, and more. This suggests that the effects of multiple predictors on the PU and PEOU of wrist-worn smart devices would vary according to the specific use purposes. For instance, when people primarily adopt a smartwatch for the purpose of effectively managing their health, the effect of social image on the technology's PU would possibly diminish. Therefore, further research is needed to conduct detailed analyses that will more thoroughly consider the main reasons for adopting and using wrist-worn smart devices.

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