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Service-Oriented Factors Affecting the Adoption of Smartphones

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Abstract

This research investigates the adoption factors of smartphones focusing on the differences of smartphone and feature phone users. We used Technology Acceptance Model (TAM) which incorporates service-oriented and device-oriented functional attributes as exogenous variables for a product-service system such as smartphones. In addition, Decision Tree (DT) and customer surveys were conducted. As a study results, we found that the service-oriented functional attributes - 'wireless internet' and 'mobile applications' - affect the adoption of smartphones regardless of users. However, the DT results revealed that the more important factor is 'mobile applications' to smartphone users but 'wireless internet' for feature phone users. In conclusion, we discovered that a strategy emphasis on the service-oriented attributes is needed for the adoption of smartphones.

Keywords: cellular phone market; technology acceptance model; partial least square; decision tree; smartphone.

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Introduction

The market for cellular phones (now more commonly known as mobile phones, or just 'mobiles') experienced rapid growth until 2002 when it can be considered to have reached maturity. Since then, the market focus has been on phone replacement rather than on first-time purchase, and the profiles of buyers – and of their tastes and needs – have changed to a remarkable extent. A new generation of mobiles – generally labeled smartphones - has been released which have excited growing general consumer interest. It is therefore crucial for sellers to understand the diffusion process of these increasingly popular products and to understand what next steps are required to market smartphones to both in current users and potential new customers.

In general, a smartphone is defined as an advanced cellular handset that provides traditional mobile phone features but also such PDA features as Internet access and portable PC functions. Despite the important changeover in the mobile market from earlier, simpler phones (we refer to them as 'feature phones') to smartphones, few studies have addressed issues related to the evolution of the mobile market in terms of user behaviors. At this growth stage, the characteristics of smartphone users will have substantially from those of feature phone users, with the majority of the former being early adopters or early majorities, willing to try products early in their diffusion process, with feature phone users (themselves potential future smartphone buyers) being more cautious about adopting new products – often older and more set in their ways than the early majorities. We argue that the two groups have distinguishing characteristics, and must be separated to analyze the smartphone diffusion process and the factors affecting that process.

Given that the mobile market has evolved rapidly, we aim to analyze the influence of various factors in customers' decisions to buy smartphone. Technology Acceptance Model (TAM) was used in this research to identify and compare the factors affecting the adoption of smartphones by smartphone and feature phone users. For the purpose of analysis, the primary attributes for applying TAM were derived from a survey of 100 mobile phone users, after which 11 hypotheses were established in the model and verified using the structural equation model (SEM) for two groups; smartphone and feature phone users. Finally, the two groups' actual decision-making processes were analyzed using DT. The analysis results show that the smartphone's service-oriented functional attributes significantly affect its adoption by increasing 'the perceived ease of use' and 'the perceived utility' by both groups, though the degree of influence is not equal, signifying that the mobile market has been moving from a 'product-oriented' to a 'service-oriented' market. We expect our research findings to provide valuable information for understanding how the mobile market has evolved and what values the customer wants as the market evolves.

Acceptance factors	**References**		
Environmental attributes	**Individual attributes**	**Functional attributes**	
Conditional value Social value	Emotional value Epistemic value	Functional value	Bodker et al. (2007)
Media influence Social influence	Attitude towards mobile innovations	Perceived status benefits Perceived flexibility benefits	Carolina et al. (2008)
Company's willingness to fund Job relevance		Perceived cost savings	Kim (2008)
Organization characteristics Environment characteristics Task characteristics	Individual characteristics Self-efficiency	Compatibility Observability	Chen et al. (2009)
	Motivation Attitude towards existing products	Relative advantage Complexity Perceived risk	Khan and Kim (2009)
Social norm	Behavioural control	Technical barriers Perceived enjoyment	Hannu et al. (2010)
	Self-efficacy Technology anxiety		Lim et al. (2011)
	Individual self-efficacy Assisted self-efficacy		Chen et al. (2011)

Table 1. Factors affecting smartphone acceptance

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The paper consists as follows. The theoretical and methodological background of this research is explained in the literature review. Then, we describe the overall research process and establish our hypotheses. Next, we summarize and discuss the empirical analysis results of SEM and DT in measure, and conclude with notes about our contributions and future research directions.

Literature review

A smartphone can be regarded as a handheld computer integrated with a mobile phone that allows users to run multi-task applications: as such, is thus attractive to a wide range of user groups. Smartphones were initially used mainly for specialized purposes such as delivery services and medical services but began to be used as a general-purpose mobile phone when general customer needs were considered and functions such as multimedia and games were included.

Leung and Wei (2000) found that motivations for mobile phone use included 'fashion and position', 'emotion and sociality', 'relaxation', 'mobility', 'instantaneity', and 'relief from work'. However, since the characteristics of smartphones differ greatly from those of feature phones (in incorporating more technologies and providing more functionality via wireless Internet) the factors affecting smartphone adoption are likely to differ from those influencing adoption of feature phone. Table 1 groups the factors that previous smartphone studies have found affected their acceptance into three categories.

This research focuses on smartphones' functional attributes to investigate if their perceived value differ as factors affecting their adoption by smartphone and by feature phone users.

Conceptual model for smartphone acceptance

The Technology Acceptance Model (TAM) was proposed by Davis (1989) specifically to explain and predict consumer acceptance of an information systems and technologies. Especially, it has been frequently used to provide the theoretical foundation for research into mobile commerce (m-commerce) issues (Choi et al., 2008; Lu, Wang and Yu, 2007). A theoretical TAM model assumes that the decision to adopt a particular technology is determined by two key factors: PU and PEOU (see Figure 1). Here, PU is defined as the degree to which a person believes that using a particular technology will enhance their job performance or their life, while PEOU is defined as the degree to which they believe using the technology reasonably easy for them to manage. BI is defined as a measure of an individual's intention to perform a specific behavior and relates to actual behavior, the determinant factor in taking specific action in the future (Ajzen, and Fishbein, 1980). However, most subsequent studies that have used TAM have omitted the attitude variable (Steven, 2003), as have we in this study.

This research also includes functional attributes that influence PU and PEOU in the model as exogenous variables. Smartphones can be considered as typical integrated product-service systems, so their functional attributes can be divided into the two categories of service-oriented and device-oriented attributes. Figure 1 describes a TAM for a product-service integrated system, which we suggest in this research.

PLS (Partial Least Square) analysis

An SEM is a technique for analysing causal relations using a combination of statistical data and assumptions about the relations. In estimating its parameters, there are two approaches available: (1) covariance-based and (2) variance-based (Haenlein and Kaplan, 2004). Though the covariance-based approach, which attempts to minimize the difference

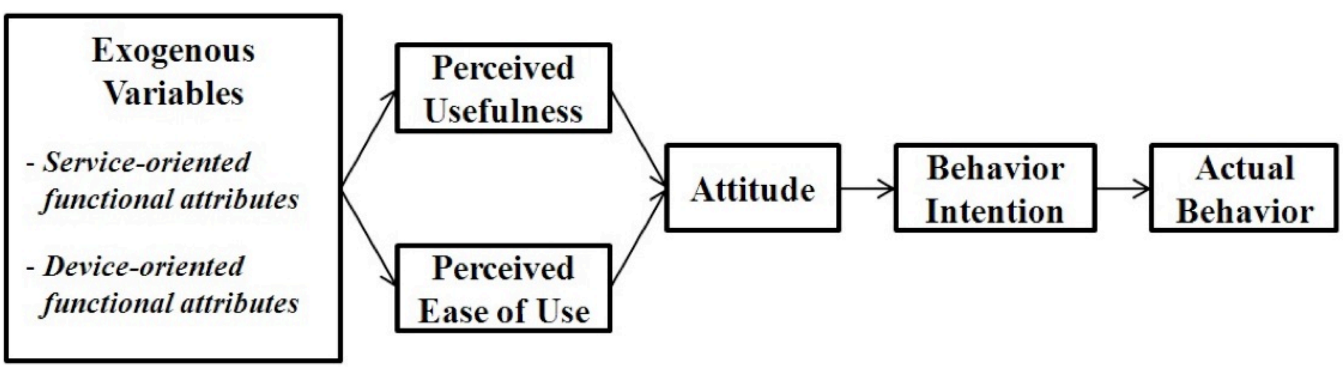

Figure 1. TAM model for an integrated product-service system

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between the sample covariance and those predicted by the theoretical model (Chin and Newsted, 1999), has been popular so far, this research adopts the variance-based one, that is, PLS.

The PLS focuses on maximizing the variance of the dependent variables explained by the independent ones instead of reproducing the empirical covariance matrix and thus has several advantages over the co-variance-based approach. First, it requires no assumptions about the population or scale of measurements (Fornell and Bookstein, 1982) and accordingly can be applied without distributional assumptions and with nominal, ordinal and interval scaled variables. Second, the SEM needs a relatively small number of samples compared to the covariance-based approach (Barclay et al., 1995). Since only about 130 samples were used for analysis and the data collected on an interval scale did not fit the normal distribution, the PLS SEM approach was adopted in this research.

Decision tree

DT, one of the most popular data-mining techniques for knowledge discovery, can analyse the information contained in an abundant data source systematically to extract valuable rules and relationships. DT is widely applied in various areas such as analysing customers' decision-making pattern, marketing and market research, and quality management (Quinlan, 1993), usually for classification and prediction purposes (Ganti et al., 1999), as it creates a model that predicts the value of a target variable based on several input variables. The model takes the form of a top–down tree structure in which decisions are made at each node that correspond to one of the input variables. Each leaf (the tree's terminal nodes) represents a value of the target variable based on the values of the input variables as determined by the path from the root to the leaf. If the target variable has a continuous value, a regression tree is developed; on the other hand, if the variable has a discrete value, a classification tree is developed. A tree can be studied by splitting the source set into subsets based on their attributes, and this process can be repeated on each derived subset in until the subset at a node has the same value as the target variable, or when further splitting no longer adds value to the predictions. We selected DT as an appropriate technique in this research for dealing with survey data that had been collected using 7-point Likert scales, as well as using it directly to analyse customers' decision-making processes in the adopting smartphones.

Research framework - The overall process

Figure 2 outlines the overall research process.

First, 29 smartphone attributes, identified from literature reviews, are used to develop a research model. Five attributes that are considered the most important in smartphone purchase or replacement decisions are selected via first survey and a TAM with 12 hypotheses is established based on these five. Then a second survey is used to test these hypotheses for smartphone and for feature phone users. Based on the same survey results, DT is used to analyze how users make these decisions. Finally, the analysis results for the two groups are compared to identify common and distinguishing features in their adoption process of smartphones (Basic statistical and DT analysis for this research were conducted using SPSS 19.0, and the TAM was analyzed by SEM, using smartPLS.)

Functional attributes of smartphones

A product consists of functional attributes that meet personal needs (Ferber, 1974): their value will vary according to customer, so some will affect customers' purchasing behavior more than others (Green and Srinivasan, 1990). These functional attributes are critical to the product meeting customer needs and satisfaction, so it is important that they are identified - which has been the focus of previous research. We identified 29 functional attributes of these two technologies from previous studies and industry reports on the mobile phone industry. Then the first survey was designed to identify the factors that most influenced smartphone adoption. For the purpose of this survey, 32-item questionnaires with 5-point Likert scale answers were distributed to individuals in their 20s and 30s: this age-group was judged to be suitable target respondents for this research as they use mobile phones most and are at the center of the shift from feature phones to smartphones in the Korean mobile marketplace. 100 responses were collected over a month from the 19 September, 2010, from 70 men and 30 women; 51% of them used feature phones and 49% smartphones. The survey results showed the five most influential attributes were the service-related attributes of 'application' and 'wireless Internet' and the device-related attributes of 'design', 'multimedia' and 'after-service'.

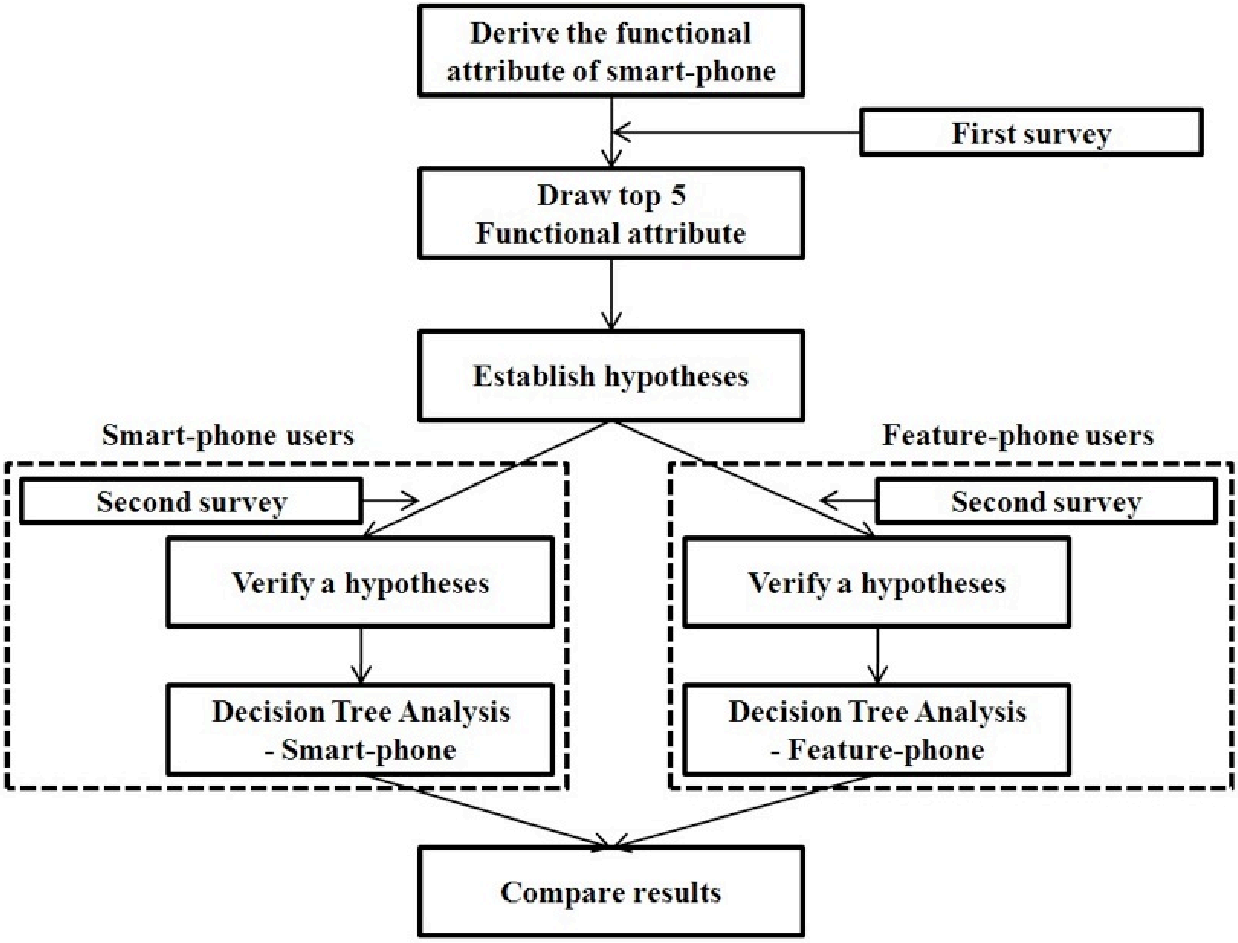

Figure 2. The overall analysis process

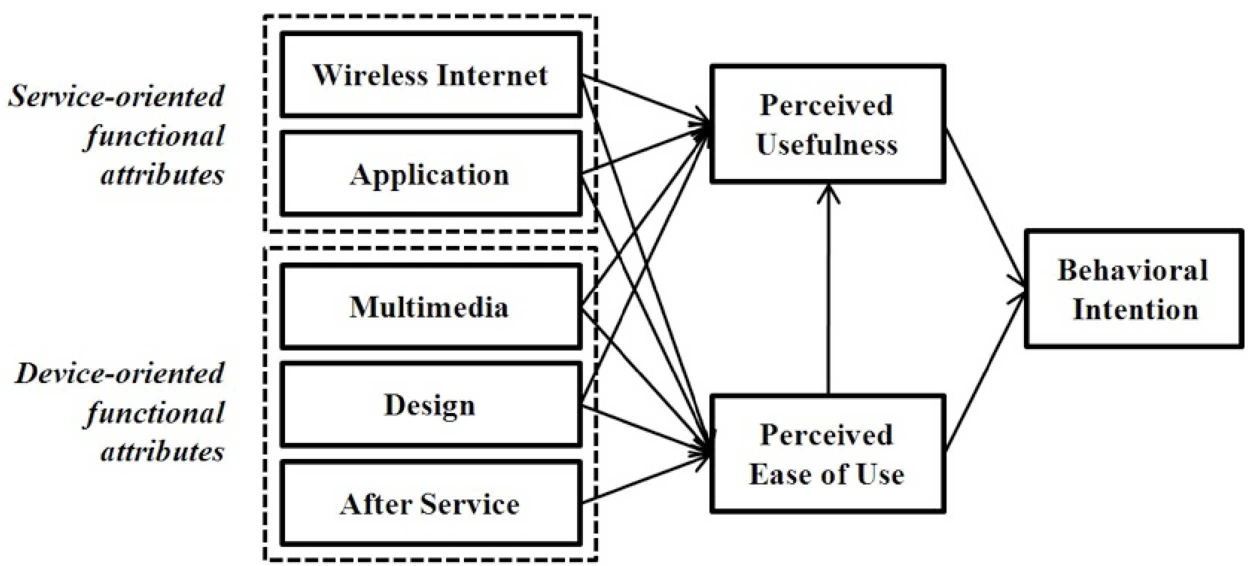

Figure 3. TAM model

Research model and hypotheses

We adopted these five primary functional attributes as independent variables in our TAM were assumed to affect the BI of smartphones through PU and PEOU (as shown in Figure 3). Then, based on this model, we developed 12 hypotheses.

In the first – service functionality– group, we can define, wireless Internet as a service that provides digitised information or content to users via a wireless connection, which thus eliminates time or spatial constraints, and so can be expected to affect PU positively (Ng-Kruelle et al., 2002). At the same time, because wireless Internet can be the basis of many other smartphone applications, it can also be expected to influence PEOU positively: Sarker and Wells (2003) found that wireless Internet greatly affected mobile service acceptance. Therefore we can propose that:

- H1-1: Wireless Internet functionality positively influences the PU of smartphones.
- H1-2: Wireless Internet functionality positively influences the PEOU of smartphones.

The other service attribute concerns applications, i.e. software elements that can be executed on a mobile device to deliver content to a user, and Armstrong et al. (2010) report that they have recently been emphasised as being valuable tools for meeting customer needs and increasing their interactions with others. An increasing range of such smartphone applications are being developed to meet various needs and utilities in a convenient manner, and users can purchase and download them on-line from virtual 'App Stores' We expect their availability to affect both PU and PEOU positively, in other words:

- H2-1: Application availability positively influences PU of smartphones.
- H2-2: Application availability positively influences PEOU of smartphones.

In the second – device oriented – group, smartphone design includes elements such as include the phone's physical layout (shape and size), colour, overall attractiveness of appearance, keypad design, etc. These design elements are expected to affect both PU and PEOU positively. Previous studies have revealed the extent to which mobile phones are regarded as fashion items via which users expressing themselves (Leung and Wei, 2000), implying the significant impact design can have on smartphone adoption, so that:

- H3-1: Attractive design positively influences the PU of smartphones.
- H3-2: Attractive design positively influences the PEOU of smartphones.

Next, multimedia refers to various media functions included in a smartphone's functionality, such as camera, mp3 player, and games. Chang et al. (2009) notes that the integration of so many functions into one mobile device means that multimedia attribute has now become a core smartphone function, diminishing time and space constraints and supporting ease of use. So we can suggest:

- H4-1: Multimedia positively influences PU of smartphones.

Finally, the survey results identified after-sales service as a feature that improves product sales and Jan and Hsiao (2004) list various of its elements that increase customer satisfaction, including complaint management and onsite service, which increase convenience and ease of use for customers and thus contribute to smartphone acceptance. We can therefore suggest:

- H5-1: After-service positively influences PU of smartphones.

PU can be defined as the degree of users' belief that using the focal technology will help improve their job performance and/or quality of life, and in terms of their productivity in achieving their aims or tasks (Davis, et. al, 1989). PEOU indicates how easy users believe the technology will be to use, as determined by the degree of physical and mental effort in learning how to use it as well as its actual use. Adams et al. (1992) claim that PEOU significantly affects BI, and Igbaria, et. al. (1997) found this effect to be more significant than that of PU on BI. Most existing studies confirm PEOU as a precedent of PU, which means that users prefer to use technologies that are easy to use and which that those technologies help to improve the user's performance (Taylor and Todd, 1995). Therefore, the following hypotheses are developed.

- H6-1: The PEOU of smartphone services positively influence the BI of smartphones.
- H6-2: The PEOU of smartphone services positively influence the PU of smartphones.
- H6-3: The PEOU of smartphone services positively influence the users' acceptance of smartphones.

Measures for smartphone acceptance

We conducted a second survey through an extensive online and offline survey to test our hypotheses: again targeting mobile phone users in their 20s and 30s with a questionnaire developed using a 7-point Likert answer scale, and collecting data over two months from 25 October 2010. Of the 284 responses collected, only 262 were suitable for analysis - 206 from men and 56 from women. Of the total 130 used feature phones and 132 smartphones (see Table 2 for detail.). The potential for non-response bias was investigated by comparing answers from respondents and non-respondents whom we contacted personally. Also, the online and offline answers were compared to test if there is any difference between the two channels. As a result, these biases were not considered to be a problem (see Appendix 1).

Operational definition and measure of variables

The variables' operational definitions and measurements items were based on previous studies, and measured smartphone users' experience of their devices, and feature phone users' perceptions of smartphones, for each of the five primary functional attributes:

- Wireless Internet: the quality of the smartphones' telecommunication services - is measured by four items: speed, range, continuity and quickness.
- Design: users' perceptions of satisfaction with smartphone design - is measured by three items: overall design, color and style.
- Multimedia: the superiority of functionality for playing music or video - consists of five subordinates: compatibility, management, UI (user interface), continuity, and clarity.
- Application: the level of users' satisfaction with application use - is measured by three items: UI, diversity, and quality.

Finally, After-service – which concerns the quality and terms of guarantee of such services - consists of three measurement items: quickness, term, and friendliness.

Validity and reliability test for measures

Before verifying the hypotheses, we tested the validity and reliability of the measurements. First, we used Harman's one-factor test for detecting common method bias (Podsakoff and Organ 1986). Eight factors with eigenvalues exceeding 1 were extracted, cumulatively explaining about 75% of the variance, and no single major factor emerged, suggesting that common method bias in not a problem (see Appendix 2).

We conducted confirmatory factor analysis on all multi-item variables to check whether the items measured what they were intended to measure. The analysis results showed that all items except one for feature phone users, which was then removed from our model, loaded appropriately onto eight variables –confirming their reliability and convergent validity (see Appendix 3). The average variance extracted (AVE) values, composite reliability (CR) values, and Cronbach's alpha coefficient values were all over recommended values, 0.5 (Gefen et al., 2000), 0.7 (Werts et al., 1974), and 0.6 (Nunnally, 1967) respectively. We also conducted cross-loading analysis and square root AVE analysis, which verified the external validity of our models (see Appendix 4).

Analysis and results - Model validity

The model's validity was tested prior to testing the hypotheses. The PLS structural model is mainly evaluated by R-square of endogenous latent variable and redundancy index (obtained from the Stone-Geiser Q-square test) for predictive relevance. The average R-square of endogenous latent

Variables	Feature phone	Smartphone			
	Frequency	Percentage (%)	Frequency	Percentage (%)	
Gender	Male	95	73.1	111	84.1
	Female	35	26.9	21	15.9
Total	130	100.0	132	100.0	

Table 2. Demographics of second survey respondents

Fitness measures	Model 1 (Smartphone users)	Model 2 (Feature phone users)	Recommended values	
R squares	BI	0.283	0.275	≥ 0.26: high 0.13 ~ 0.26 : medium 0.20 ~ 0.13 : low
	PEOU	0.258	0.164	
	PU	0.377	0.383	
Redundancy	BI	0.166	0.044	> 0
	PEOU	0.025	0.025	
	PU	0.048	0.058	

Table 3. The results of the fitness for the research models

variables represents an index for validating the PLS model globally, while the redundancy index measure the predictive relevance of the model by reproducing the observed values by the model itself and its parameter estimates. Table 3 presents the fitness test results: the model's validity can be said to be verified, since all index values for the two groups are at the recommended levels.

Analysis results for smartphone users

The SEM analysis results for smartphone users are summarized in Table 4. They show that the service-oriented functional attributes - 'wireless Internet' and 'applications' - have a significant impact on both PU (H1-1 and H2-1 are supported) and PEOU (H1-2 and H2-2 are supported). The 'application' path coefficient has the highest value of all five functional attributes, revealing that this factor has the greatest impact on the choice to use of smartphones. We can find no significant evidence that 'design' has a positive effect on either PU or PEOU (H3-1 and H3-2 are rejected), 'multimedia' positively affects PU and interestingly 'after-service' on PEOU (H4-1 and H5-1 are rejected). Finally, both PU and PEOU are shown to affect BI positively and, as expected, PEOU has a positive effect on PU (H6-1, H6-2 and H6-3 are supported).

DT analysis was then used to investigate detailed decision-making process (see Figure 4), when the most representative items for each of the five attributes were selected as independent variables, and BI as the dependent variable. The CHAID algorithm was applied to determine the optimal tree size, and the maximum numbers of parent and children nodes were set to 20 and 10, respectively. Chi-square statistics at the significance level of 10% was used to split the nodes. The DT analysis results confirmed the results of TAM, revealing that the most critical factor in customers' choice to adopt smartphones is 'applications', followed by 'design': we used these factors to develop the following decision-making rules for smartphone adoption.

- Where customers' satisfaction with both the applications and design of a smartphone are high, their intention to adopt is very high (90.5%).
- Where customers' satisfaction with smartphone design is high, but the satisfaction with applications is low, their intention to adopt will be high (86.7%).
- Where customers' satisfaction with the applications available on a smartphone is high, but their satisfaction with its design is low, their intention to adopt will be medium (73.6%).
- Where customers' satisfaction levels about both these smartphone attributes are low, their intention to adopt will be relatively low (45.5%).

Analysis results for feature phone users

The SEM analysis results for feature phone users are summarised in Table 5. First, 'wireless Internet' and 'applications' positively affect both PU (H1-1 and H1-2 are supported) and PEOU (so H2-1 and H2-2 are supported). Unlike the case of smartphone users, the 'wireless Internet' path coefficient has the greatest value. 'Design' has no significant effect on either PEOU or PU (H3-1 and H3-2 are rejected), and neither 'multimedia' nor 'after-service' have any significant impact on PEOU (so H4-1 and H5-1 are also rejected). Finally, PU has a positive effect on BI (supporting H6-1) and PEOU on PU (supporting H6-2) as expected, while PEOU's influence on PU is insignificant (so, again, H6-3 rejected).

Hypotheses	Assumed paths	Coefficient values	Determination	
Service-oriented functional attributes	Hypothesis 1-1	Wireless Internet à PU	0.148(***)	Supported
	Hypothesis 1-2	Wireless Internet à PEOU	0.169(**)	Supported
	Hypothesis 2-1	Application à PU	0.097(***)	Supported
	Hypothesis 2-2	Applicationà PEOU	0.311(***)	Supported
Device-oriented functional attributes	Hypothesis 3-1	Design à PU	-0.022	Rejected
	Hypothesis 3-2	Designà PEOU	0.053	Rejected
	Hypothesis 4-1	Multimedia à PU	0.116	Rejected
	Hypothesis 5-1	After-serviceà PEOU	0.092	Rejected
User behaviours	Hypothesis 6-1	PU à BI	0.284(***)	Supported
	Hypothesis 6-2	PEOU à PU	0.517(***)	Supported
	Hypothesis 6-3	PEOUà BI	0.297(***)	Supported

Table 4. Path coefficient analysis results for smartphone users

The DT analysis results for feature phone users are shown in Figure 5. The most attractive factor that determines the adoption of smartphones is 'wireless Internet', based on which the following decision-making rules are developed.

- Where the customer's expectations of smartphones' 'wireless Internet' attribute is high, their intention to adopt is relatively high (59.3%).
- If the expectation of 'wireless Internet' on a smartphone is low or average, their intention to adopt is relatively low (37.9%).

Discussion - Comparison analysis

The comparison of the two groups' SEM results shows that the same factors the mobile service-oriented functional attributes –influence both groups of phone users. Because the smartphone provides the wireless Internet function a variety of services have become available, driving the growth of the smartphone market. While both user groups value these mobile service-oriented attributes highly, there are still some differences.

First, 'wireless Internet' has the greater effect on PEOU for feature phone users than for smartphone users, while 'application' is the opposite case, implying that feature phone users believe the wireless Internet function itself (which distinguishes it from the feature phone) adds the most value to smartphones. An interesting finding is that most of the device-oriented factors (including 'after-service') do not have the expected influence on PEOU and PU. It seems that mobile phones' main utility is based on services available, probably, on the Internet – most other device-based attributes are seen as auxiliaries, or as only increasing smartphones' usability. Even 'design' appears not to be a critical factor in customer's purchasing decisions on the contrary to the previous studies. The notion that there are not many options for smartphone designs at this stage perhaps decreases effect on PU or PEOU.

Second, in terms of the relationships between PU, PEOU and BI, PU affects BI directly and PEOU affects BI indirectly via affecting PU. As smartphones are more complex systems than feature phones – so there is more to go wrong and

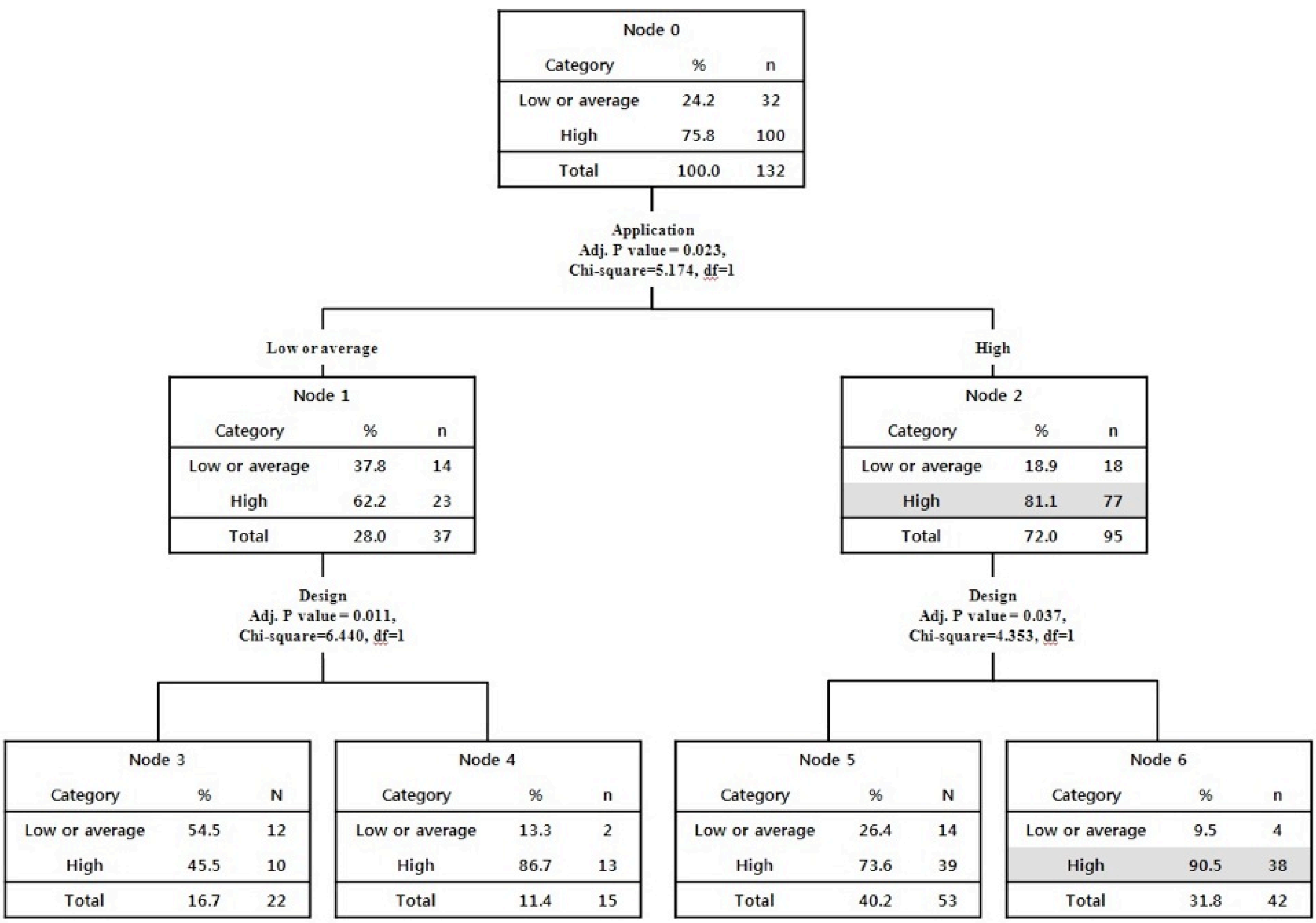

Figure 4. DT results for smartphone users Figure 4. DT results for smartphone users

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Hypotheses	Assumed paths	Coefficient values	Determination	
Service-oriented functional attributes	Hypothesis 1-1	Wireless Internet à PU	0.171(**)	Supported
	Hypothesis 1-2	Wireless Internet à PEOU	0.220(***)	Supported
	Hypothesis 2-1	Application à PU	0.179(***)	Supported
	Hypothesis 2-2	Applicationà PEOU	0.129(**)	Supported
Device-oriented functional attributes	Hypothesis 3-1	Design à PU	-0.053	Rejected
	Hypothesis 3-2	Designà PEOU	-0.053	Rejected
	Hypothesis 4-1	Multimedia à PU	0.091	Rejected
	Hypothesis 5-1	After-serviceà PEOU	0.082	Rejected
User behaviours	Hypothesis 6-1	PU à BI	0.437(***)	Supported
	Hypothesis 6-2	PEOU à PU	0.597(***)	Supported
	Hypothesis 6-3	PEOUà BI	0.108	Rejected

Table 5. Path coefficient analysis results for feature phone usersa

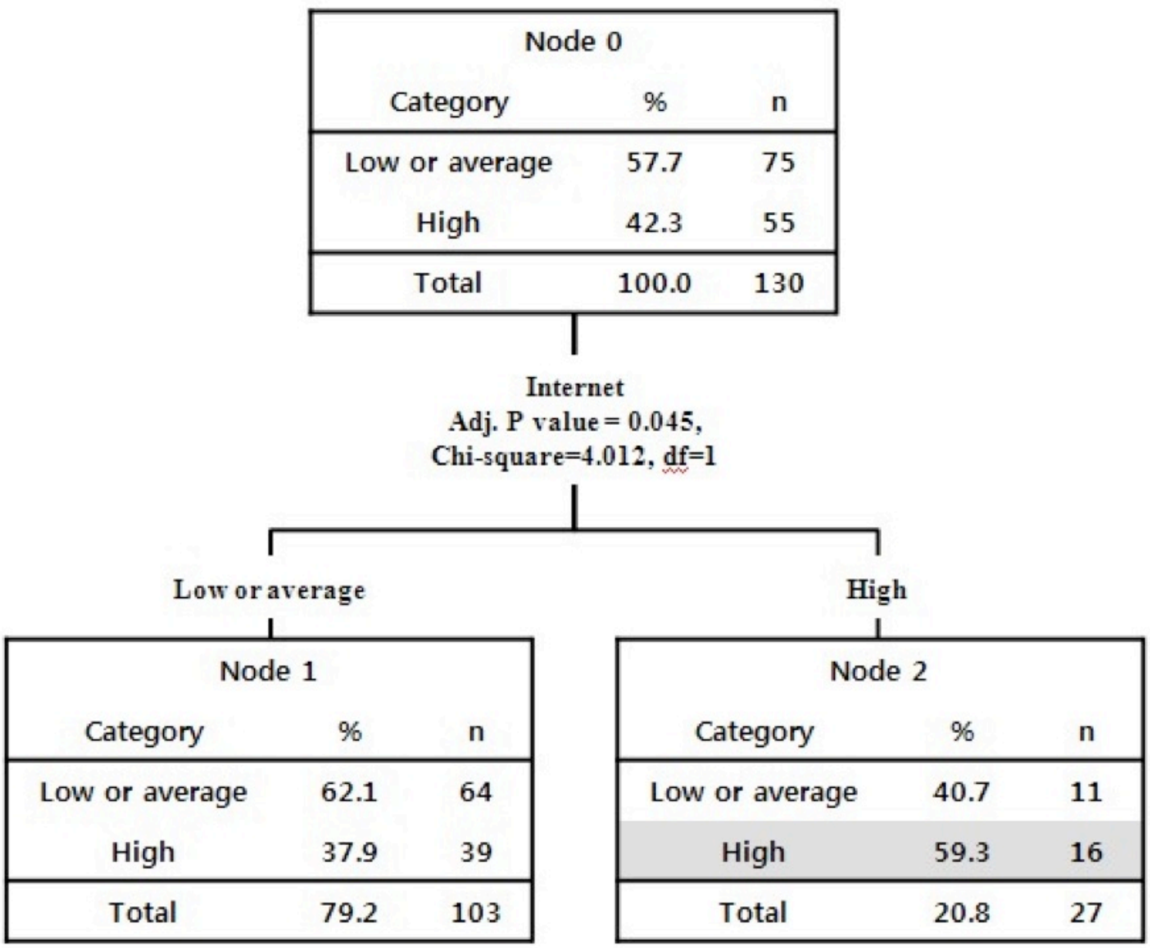

Figure 5. DT results for feature phone users

PEOU has a positive influence on PU. However, investigating by sector shows that the direct impact of PEOU on BI is significant only for smartphone users, which means that customers may not realize the importance of ease of use until they adopt and use smartphones.

Finally, the DT results reveal that, for smartphone uses, who may be early adopters or early majorities in its life cycle, 'design' as well as 'applications' affect purchasing decisions, and thus determine the patterns of smartphone adoptions. On the other hand, feature phone users decisions to buy smartphones are fuelled by their expectation of using of 'wireless Internet' (a significant distinguishing feature of their practicality compared to feature phones).

Managerial implications

Because the factors affecting the adoption of smartphones differ according to user groups, mobile phone manufacturers and retailers need to develop different strategies to increase smartphone diffusion rate among the two groups. First, product development/marketing strategies that emphasises their wireless Internet function will encourage the adoption of smartphones by those currently using feature phones.

Second, development and marketing applications can help smartphone owners in their use. As the applications factor has the greatest impact on smartphones adoption, user satisfaction about applications will increase users overall satisfaction with their smartphones. A policy or strategy to open the application market should be developed so as to increase their size, quality and applicability.

Third, continuous improvement in smartphone design is also necessary, as DT analysis indicate it has a critical impact on the adoption of smartphones by smartphone users. As many current smartphone users are early adopters and early majority, upgrading product design along with its functionalities will attract such users to adopt the next generation of phones.

Finally, with the changes in the mobile phone market, the market is moving more towards service-oriented business. The co-evolution of product and service attributes should be the focus of attention. And more effort is required to identify service-oriented attributes that affect the diffusion of smartphones.

Conclusion

This study aims to investigate the functional factors that affect the adoption of smartphones by focusing on mobile phone consumers at large, and to identify how these factors influence smartphone and feature phone users differently. For this analysis, we suggest a TAM incorporating service-oriented and device-oriented functional attributes as influencing factors, which is appropriate for a product-service integrated IT system such as smartphones. Korean mobile phones users in their 20s and 30s were surveyed, after which SEM and DT were used to analyse the survey data. The research findings indicate that, among the various functional attributes of smartphones, the service-oriented factors affect PU and PEOU most significantly, though the effect of these attributes differed for smartphone and feature phone users. On the contrary, the device-oriented functional attributes does not affect PU or PEOU. Both PEOU and PU have a positive a positive influence on BI in the case of smartphone users, while PU affects BI directly but PEOU affects BI indirectly through PU. This study is one of the earliest attempts to investigate the changing factors affecting the adoption of smartphones. Our research results are expected to reflect the characteristics of the market with regard to smartphones and customers who have, and have not yet, adopted them, and so can help understand the evolution of mobile market, and further develop customised R&D and marketing strategies.

Despite these contributions, this paper has two limitations, which point to future research. First, data collection was limited to the Seoul and Kyungki areas of Korea and the ratio of smartphone to feature phone users in our data differs from the overall ratio in the Korean mobile phone market, so our findings cannot be generalised to the wider population. Future research should use more detailed data collection processes, and the hierarchical random sampling method. Second, in-depth analysis of the SEM and DT results is needed. Why some attributes affect PEOU and PU positively or negatively and why some do not should be examined in detail with supporting data and relevant literature; the differences between smartphone and feature phone users should be more fully investigated.

Acknowledgement

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Appendix 1: Test results of non-response and channel biases

Measures	Respondents and non-respondents	Online and offline responses				
	Average score	t-test results	Average score	t-test results		
	Respondents	Non-respondents	p-value	Online	Offline	p-value
Internet 1	5.2	4.8	0.398	4.8	5.3	0.145
Internet 2	5.1	5.3	0.759	4.4	5.0	0.224
Internet 3	4.9	5.6	0.257	4.5	5.0	0.197
Internet 4	5.1	5.9	0.245	4.7	5.0	0.452
Design 1	5.0	4.8	0.740	5.1	4.9	0.636
Design 2	5.0	4.3	0.296	5.1	4.7	0.377
Design 3	5.4	5.2	0.755	5.4	5.2	0.570
Multimedia 1	5.9	5.4	0.339	5.3	4.8	0.135
Multimedia 2	5.8	5.5	0.534	5.5	4.8	0.051
Multimedia 3	6.1	5.7	0.370	5.6	5.1	0.115
Multimedia 4	5.8	5.2	0.272	5.6	5.0	0.174
Multimedia 5	5.4	5.3	0.828	5.4	5.2	0.507
Application 1	5.9	5.4	0.210	5.8	5.6	0.445
Application 2	5.5	5.4	0.870	5.3	5.0	0.349
Application 3	6.5	5.9	0.137	6.1	6.0	0.600
After-service 1	4.4	3.6	0.358	4.2	4.1	0.445
After-service 2	4.4	3.9	0.532	4.3	4.3	0.349
After-service 3	4.1	3.6	0.516	4.0	3.4	0.600
PU 1	6.2	5.6	0.433	5.9	3.7	0.371
PU 2	6.0	5.7	0.487	5.7	5.2	0.090
PU 3	6.0	5.6	0.146	6.0	5.8	0.218
PEOU 1	6.4	5.8	0.146	5.7	5.5	0.471
PEOU 2	6.1	5.5	0.196	5.3	5.1	0.486
PEOU 3	6.5	6.0	0.164	5.5	5.1	0.274
PEOU 4	6.2	5.6	0.118	5.3	5.1	0.659
BI 1	6.9	6.2	0.196	6.5	6.3	0.537
BI 2	6.8	5.8	0.183	6.4	6.0	0.052
BI 3	6.6	5.8	0.107	6.3	5.9	0.115

Table A-1. Differences between different types of respondents (Smartphone users)

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Factors	Principal Component Analysis results	After Varimax rotation				
	Eigen value	Explained variance	Accumulated variance	Eigen value	Explained variance	Accumulated variance
1	6.020	22.297	22.297	3.691	13.671	13.671
2	3.438	12.735	35.032	2.753	10.196	23.867
3	2.724	10.091	45.122	2.685	9.945	33.811
4	2.024	7.496	52.618	2.609	9.663	43.474
5	1.803	6.676	59.294	2.240	8.297	51.771
6	1.614	5.977	65.271	2.203	8.159	59.930
7	1.481	5.486	70.758	2.112	7.823	67.753
8	1.090	4.037	74.794	1.901	7.041	74.794

Table A- 2a. Explained variance for feature phone

Factors	Principal Component Analysis results	After Varimax rotation				
	Eigen value	Explained variance	Accumulated variance	Eigen value	Explained variance	Accumulated variance
1	7.320	26.142	26.142	3.428	12.244	12.244
2	3.323	11.866	38.008	3.098	11.066	23.310
3	2.872	10.259	48.267	2.821	10.077	33.387
4	2.419	8.638	56.905	2.712	9.687	43.073
5	1.896	6.773	63.678	2.608	9.315	52.388
6	1.350	4.822	68.500	2.539	9.066	61.455
7	1.232	4.401	72.901	2.329	8.318	69.772
8	1.031	3.681	76.582	1.907	6.809	76.582

Table A- 2b. Explained variance for smart phone

Subordinates	Factors	Quality Criteria									
	1	2	3	4	5	6	7	8	Convergent validity (t value)	Cron-bach's Alpha	C.R	AVE
Multimedia 3	.916	.030	.063	.010	.034	.073	.030	-.034	5.588	0.898	0.924	0.709
Multimedia 2	.859	.082	.034	.022	-.067	.045	.010	.034	4.993			
Multimedia 1	.816	-.002	-.058	.032	.103	.112	.075	.083	4.758			
Multimedia 4	.811	.064	-.102	.073	.108	.011	.051	-.005	4.669			
Multimedia 5	.772	-.018	.126	.037	.101	.003	-.030	.091	4.352			
BI 3	-.030	.889	.058	.048	.011	.003	-.046	.198	41.333	0.890	0.933	0.822
BI 2	.093	.878	.111	.018	-.054	.140	-.044	.144	32.493			
BI 1	.078	.794	.258	.091	.044	.036	.004	.175	34.225			
PEOU 3	.028	.124	.825	.043	.038	.064	-.204	.092	11.744	0.818	0.879	0.645
PEOU 2	.083	.237	.784	.223	-.003	.008	.066	.016	17.429			
PEOU 4	.004	.059	.775	.041	-.037	.137	.046	.280	22.594			
PEOU 1	.067	.005	.565	.204	-.135	.081	.014	.514	20.493			
Internet 3	.105	.205	.108	.863	.039	.050	.080	-.006	20.614	0.809	0.876	0.640
Internet 4	.124	.205	.173	.809	.022	.080	.049	-.045	14.173			
Internet 2	-.050	-.093	.139	.723	.008	-.011	.133	2.11	10.042			
Internet 1	-.003	-.207	-.066	.665	.128	.124	.172	.390	7.574			
Design 1	.022	-.089	.017	.053	.917	.000	-.004	.022	5.922	0.915	0.919	0.852
Design 2	.062	-.007	.003	.097	.917	.094	.034	-.172	5.842			
Application 2	.177	.054	.073	.017	.026	.835	.072	.043	17.607	0.803	0.884	0.717
Application 3	-.114	.086	.076	-.004	.089	.830	.002	.177	17.142			
Application 1	.173	.125	.079	.179	.092	.800	.099	.036	19.750			
After-service 3	.053	-.070	.154	.064	-.009	.028	.851	.225	3.770	0.803	0.828	0.628
After-service 1	-.019	-.036	.070	.116	-.009	.160	.833	.013	3.513			
After-service 2	.089	.036	-.125	.145	.103	-.020	.810	-.025	1.864			
PU 3	.160	.301	.118	.218	-.063	.073	.041	.777	20.050	0.787	0.876	0.702
PU 1	-.023	.310	.253	.037	.126	.225	.148	.675	28.700			
PU 2	.058	.301	.357	.086	.047	.053	.081	.567	16.413			

Table A- 3a. Convergent validity results for feature phone users

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Subordinates	Factors								Quality Criteria			
	1	2	3	4	5	6	7	8	Convergent validity (t value)	Cronbach's Alpha	C.R	AVE
Multimedia 3	.899	.103	.058	.005	.049	.107	.088	.084	11.038	0.880	0.912	0.675
Multimedia 2	.800	.124	.046	.114	.194	-.019	.011	-.005	7.099			
Multimedia 1	.788	.086	.060	.008	.148	-.038	-.061	-.041	5.557			
Multimedia 4	.769	.022	.079	-.093	-.020	.240	.094	.181	8.392			
Multimedia 5	.725	-.051	.047	-.029	.074	.322	.205	.172	7.076			
Internet 3	.030	.898	.033	.123	.137	.053	.085	.036	41.752	0.888	0.923	0.750
Internet 4	.093	.834	.069	.100	.159	.134	.122	.098	32.227			
Internet 2	.105	.833	.014	.061	.170	.028	.131	.111	18.226			
Internet 1	.066	.782	.253	.108	-.057	-.041	-.027	-.043	33.036			
PEOU 4	.046	.078	.851	.121	.099	-.050	.135	.139	21.955	0.867	0.909	0.713
PEOU 3	.098	.068	.813	.095	.147	.058	.165	.184	23.502			
PEOU 2	.081	.137	.807	.193	-.029	.097	.173	.097	31.212			
PEOU 1	.094	.139	.564	.318	.059	.033	.399	.200	30.004			
BI 2	.020	.140	.180	.890	-.037	.180	.200	.020	103.016	0.931	0.956	0.880
BI 3	-.003	.176	.160	.871	.007	.217	.213	.048	90.577			
BI 1	-.021	.092	.191	.835	.029	.125	.155	.125	26.130			
After-service 3	.086	.092	.049	.014	.884	-.051	.158	-.011	11.596	0.890	0.932	0.820
After-service 1	.109	.128	.105	-.065	.868	.022	.040	.017	9.926			
After-service 2	.194	.143	.051	.059	.864	-.010	.097	-.005	11.506			
Design 1	.141	.077	.069	.206	-.013	.892	-.014	-.028	8.888	0.869	0.919	0.791
Design 2	.185	.030	.067	.084	-.007	.891	.000	-.069	8.362			
Design 3	.067	.047	-.034	.150	-.021	.786	-.015	.110	4.732			
PU 3	.085	.120	.219	.167	.039	-.039	.814	.127	21.253	0.832	0.898	0.746
PU 2	.053	.034	.159	.181	.142	-.029	.792	.013	20.825			
PU 1	.129	.215	.285	.271	.231	.063	.678	.172	46.507			
Application 1	.069	.046	.118	-.008	-.066	.084	.301	.786	18.927	0.680	0.824	0.610
Application 2	.020	.165	.277	.069	-.141	.016	-.052	.719	15.134			
Application 3	.208	-.014	.113	.136	.216	-.064	.045	.700	7.869			

Table A- 3b. Convergent validity results for smart phone users

	After service	Application	BI	Design	Multimedia	PEOU	PU	Internet
After-service 1	0.845	0.206	-0.005	0.054	0.026	0.127	0.128	0.235
After-service 2	0.522*	0.062	-0.029	0.154	0.109	-0.036	0.086	0.229
After-service 3	0.948	0.130	-0.004	-0.020	0.090	0.221	0.297	0.234
Application 1	0.195	0.851	0.226	0.174	0.229	0.210	0.269	0.266
Application 2	0.158	0.841	0.160	0.127	0.226	0.173	0.232	0.118
Application 3	0.099	0.848	0.201	0.109	-0.032	0.197	0.291	0.105
BI 1	0.078	0.182	0.884	0.009	0.134	0.400	0.485	0.198
BI 2	-0.035	0.249	0.923	-0.058	0.140	0.299	0.436	0.109
BI 3	-0.055	0.208	0.914	0.009	0.034	0.249	0.487	0.131
Design 1	0.034	0.084	-0.049	0.840	0.088	-0.030	0.031	0.098
Design 2	-0.010	0.161	-0.013	0.999	0.124	-0.060	-0.060	0.125
Multimedia 1	0.106	0.188	0.085	0.160	0.830	0.044	0.118	0.108
Multimedia 2	0.043	0.124	0.131	0.014	0.854	0.115	0.152	0.089
Multimedia 3	0.052	0.158	0.085	0.094	0.908	0.094	0.103	0.090
Multimedia 4	0.065	0.103	0.095	0.154	0.796	0.064	0.097	0.137
Multimedia 5	0.024	0.107	0.077	0.123	0.818	0.165	0.172	0.111
PEOU 1	0.214	0.198	0.232	-0.148	0.111	0.796	0.561	0.315
PEOU 2	0.163	0.143	0.346	0.016	0.141	0.808	0.384	0.315
PEOU 3	0.087	0.163	0.291	-0.002	0.080	0.785	0.351	0.184
PEOU 4	0.227	0.226	0.270	-0.031	0.063	0.823	0.465	0.205
PU 1	0.251	0.359	0.432	0.025	0.064	0.457	0.869	0.239
PU 2	0.223	0.205	0.389	-0.063	0.121	0.492	0.821	0.258
PU 3	0.193	0.226	0.478	-0.110	0.213	0.461	0.823	0.355
Internet 1	0.259	0.196	-0.023	0.127	0.057	0.187	0.267	0.721
Internet 2	0.272	0.078	0.063	0.045	0.018	0.276	0.243	0.768
Internet 3	0.155	0.167	0.227	0.124	0.150	0.263	0.297	0.871
Internet 4	0.124	0.185	0.219	0.107	0.162	0.300	0.286	0.832

Table A- 4a. Cross loading results for feature phone users
Note 1. For all but one (denoted by *) items, the factor loadings on their respective latent variable exceed 0.7 with weak cross factor loadings to other unrelated variables.

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	After service	Application	BI	Design	Multimedia	PEOU	PU	Internet
after-service 1	0.909	0.060	0.008	0.012	0.223	0.196	0.210	0.241
after-service 2	0.908	0.070	0.100	0.026	0.296	0.186	0.293	0.280
after-service 3	0.899	0.046	0.060	-0.036	0.197	0.167	0.325	0.216
Application 1	0.018	0.846	0.172	0.080	0.200	0.351	0.363	0.124
Application 2	-0.056	0.769	0.178	0.079	0.104	0.354	0.179	0.196
Application 3	0.190	0.725	0.158	0.005	0.285	0.312	0.282	0.128
BI 1	0.063	0.234	0.892	0.266	0.062	0.440	0.423	0.240
BI 2	0.033	0.173	0.963	0.326	0.097	0.447	0.446	0.280
BI 3	0.073	0.201	0.957	0.358	0.091	0.433	0.468	0.319
Design 1	0.011	0.067	0.366	0.959	0.285	0.151	0.095	0.154
Design 2	0.012	0.032	0.249	0.933	0.315	0.113	0.074	0.099
Design 3	-0.030	0.107	0.276	0.765	0.201	0.069	0.063	0.118
Multimedia 1	0.268	0.101	0.003	0.122	0.723	0.116	0.109	0.156
Multimedia 2	0.304	0.150	0.097	0.171	0.804	0.175	0.212	0.221
Multimedia 3	0.201	0.238	0.071	0.261	0.917	0.193	0.236	0.203
Multimedia 4	0.137	0.254	0.038	0.277	0.823	0.205	0.155	0.122
Multimedia 5	0.198	0.261	0.113	0.361	0.828	0.219	0.244	0.093
PEOU 1	0.189	0.393	0.505	0.123	0.213	0.828	0.591	0.291
PEOU 2	0.093	0.328	0.411	0.163	0.181	0.861	0.430	0.270
PEOU 3	0.217	0.386	0.313	0.125	0.215	0.850	0.453	0.226
PEOU 4	0.182	0.344	0.317	0.025	0.148	0.838	0.439	0.218
PU 1	0.342	0.378	0.481	0.149	0.274	0.578	0.896	0.379
PU 2	0.239	0.210	0.344	0.032	0.151	0.394	0.829	0.168
PU 3	0.180	0.317	0.385	0.025	0.192	0.491	0.864	0.247
Internet 1	0.289	0.190	0.224	0.093	0.206	0.241	0.294	0.870
Internet 2	0.100	0.111	0.237	0.065	0.108	0.295	0.218	0.784
Internet 3	0.268	0.138	0.290	0.122	0.130	0.228	0.267	0.912
Internet 4	0.277	0.199	0.281	0.193	0.211	0.278	0.325	0.892

Table A- 4b. Cross loading results for smart phone users

Note 1. For all items, the factor loadings on their respective latent variable exceed 0.7 with weak cross factor loadings to other unrelated variables.

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	After service	Application	BI	Design	Multimedia	PEOU	PU	Internet
After-service	(0.792)	-	-	-	-	-	-	-
Application	0.177	(0.847)	-	-	-	-	-	-
BI	-0.002	0.233	(0.907)	-	-	-	-	-
Design	-0.010	0.162	-0.013	(0.923)	-	-	-	-
Multimedia	0.064	0.159	0.113	0.124	(0.842)	-	-	-
PEOU	0.222	0.230	0.351	-0.060	0.124	(0.803)	-	-
PU	0.265	0.314	0.519	-0.061	0.161	0.560	(0.838)	-
Internet	0.246	0.195	0.163	0.126	0.126	0.324	0.342	(0.800)

Table A- 5a. Discriminant validity analysis for feature phone users
Note 1. The values in the parenthesis are square root AVEs.
Note 2. For every latent variable, its square root AVE value is greater than its correlation coefficient values with other variables, thus verifying discriminant validity.

	After service	Application	BI	Design	Multimedia	PEOU	PU	Internet
After-service	(0.905)							
Application	0.065	(0.781)						
BI	0.060	0.216	(0.938)					
Design	0.002	0.071	0.338	(0.890)				
Multimedia	0.265	0.254	0.089	0.305	(0.821)			
PEOU	0.203	0.433	0.469	0.132	0.227	(0.844)		
PU	0.301	0.361	0.476	0.089	0.247	0.577	(0.863)	
Internet	0.272	0.187	0.299	0.140	0.193	0.302	0.322	(0.866)

Table A- 5b. Discriminant validity analysis results for smart phone users
Note 1. The values in the parenthesis are square root AVEs.
Note 2. For every latent variable, its square root AVE value is greater than its correlation coefficient values with other variables, thus verifying discriminant validity.

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