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Understanding continued information technology usage behavior: A comparison of three models in the context of mobile internet

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Abstract

This study examines the utility of three prospective models for understanding the continued IT usage behavior. The three models include: Expectation-Confirmation Model in IT Domain (ECM-IT), Technology Acceptance Model (TAM), and a hybrid model integrating TAM and ECM-IT (extended ECM-IT). Based on a survey of 1826 mobile Internet users, the LISREL analysis shows that all three models meet the various goodness-of-fit criteria. When compared using special indices for differentiating among alternative good models, TAM has the best fit to the data followed by ECM-IT, and the extended ECM-IT. In terms of variance explained for intention to continue IT usage, the extended ECM-IT has the highest R^2 (67%) followed by TAM (63%), and ECM-IT (50%). We conclude that TAM is the most parsimonious and generic model that can be used to study both initial and continued IT adoption; the extended ECM-IT explains continued IT usage behavior as well as TAM; and both the ECM-IT and extended ECM-IT models provide additional information to increase our understanding of continued IT usage.

Keywords: Continued information technology usage; Technology Acceptance Model; Expectation-Confirmation Model; Mobile Internet; Survey research

1. Introduction

A core stream of IS research is identifying the determinants of individual users' adoption and usage of information technology (IT) [66,69]. As organizations continue to increase their investment in IT, they are becoming aware of the importance of users' IT adoption and usage as critical prerequisites for productivity gains from IT. As such, understanding users' decision-making processes in IT adoption and usage has generated much interest in both industry and academia. To address this issue, various theoretical perspectives (e.g., Technology Acceptance Model, Theory of Reasoned Action, Innovation Diffusion Theory) have been advanced. However, prior studies based on these perspectives have given more attention to examining factors that drive users to "initially adopt a new IT" (i.e., use an IT for the first time), rather than the factors that influence users to "continue to use an IT" after they have adopted the technology [10,45,58].

According to Bhattacherjee [10], the eventual success of a new IT is more dependent on users' continued usage of the IT rather than its initial adoption. This is because

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infrequent and ineffective usage of the IT after the initial adoption may incur undesirable costs or result in a waste of effort to develop the IT. For example, in subscription-based IT services such as online travel agencies, online banks, and online newspapers, the continued usage (i.e., user retention) is critical to their survival in the marketplace [9,10,58,63]. One reason for the importance of the continued usage of such services is that retaining existing subscribers affects the profitability of such service firms both during the early years of business operations [63] and in the long run [58]. Previous studies showed that increasing customer retention rate by 5% could result in a decrease of operating costs by 18% [21], and contribute to an increase in profits by 25% to 95% [62]. Given the empirical support for the impact of continued usage on the success of an IT, finding the salient factors that affect users' post-adoption behavior, which is either to continue or to discontinue usage of an IT, becomes critical.

Most prior IT adoption studies have not articulated the differences in user perceptions between the initial adoption and the continued usage [10,45]. Despite some theoretical support for the differences between adoption and continued usage (e.g., [39]), the IT adoption literature has implicitly assumed that the processes of adoption decision would be similar to those of continued usage decision (e.g., [51,69]). In recent years, some researchers have raised the question whether the criteria for IT adoption would be the same as those of continued IT usage, and attempted to empirically test the determinant structure of continued IT usage behavior (e.g., [9,10,45]). There have been a couple of approaches in these attempts: (1) employing existing perspectives (e.g., Theory of Reasoned Action, Innovation Diffusion Theory) to explore the continued usage behavior [45,58]; and (2) building a new perspective to explain continued IT usage behavior [9,10]. Although these attempts have shed light on the differences between adoption and post-adoption (i.e., continued usage) in IS research, there has been no empirical effort to compare the different perspectives in terms of their relative utility for understanding continued IT usage behavior.

This study stems from the research question, "Among the different prospective continued IT usage models, which model is more effective in predicting users' continued usage behavior?" To answer this question, this study compares the explanatory power of three models. The first model is the "Expectation-Confirmation Model" in IT domain (ECM-IT)[1]—a relatively new theoretical model by Bhattacherjee [10] that was developed specifically to understand users' continued IT usage behavior. The second is the "Technology Acceptance Model (TAM)", which is widely accepted as a powerful tool to represent the determinants of users' adoption and usage decisions across a variety of IT. The third model is a hybrid ECM-IT that integrates the prior two models. As both TAM and ECM-IT are viable alternatives, a combined TAM and ECM-IT model may better explain users' continued IT usage behavior. This study is one of the first attempts to compare the utility of these prospective continued IT usage models. The findings of this study will provide validation of the factors involved in the continued IT usage decision processes.

2. Theoretical models of continued IT usage

2.1. Model 1: Expectation-Confirmation Model in the context of IT (ECM-IT)

Since the early 1970s, much effort has been made in consumer behavior research to investigate consumers' post-purchase behavioral processes [19]. Among the research frameworks used in this effort, the "expectancy-confirmation[2] paradigm" is popularly used to explain consumers' satisfaction and re-purchase decisions in a wide array of post-purchase contexts (e.g., [5,19,24,54–56,83]).

The vast majority of prior studies using this paradigm posit that consumer satisfaction decisions are determined by two major constructs: initial expectations (pre-purchase expectations) on a product/service, and discrepancies between expectations and product/service performance (disconfirmation). According to this framework, buyers first develop expectations about a product/service before purchase. Second, their consumption experiences with it build perceptions about its performance. Third, by assessing perceived performance against their frame of reference (i.e., expectations), they either confirm or disconfirm pre-purchase expectations. A buyer's expectations are confirmed when a product/service performs as much as expected; negatively disconfirmed when it performs worse than expected; and positively disconfirmed when it performs better than expected [19]. In turn, disconfirmation and expectations additively affect the buyer's level of satisfaction with the product/service. Finally, the buyer's level of satisfaction determines repurchase intentions.

Drawing attention to the substantial differences between initial adoption and continued usage behavior in

[1] For the sake of convenience, the model will be called "ECM-IT" hereafter.

[2] In consumer behavior literature, "disconfirmation" is used interchangeably with "confirmation". For the sake of consistency with Bhattacherjee's model, "confirmation" is used in this paper.

the IT context, Bhattacherjee [10] developed and empirically tested an Expectation-Confirmation Model of continued IT usage (ECM-IT). ECM-IT is rooted in the expectancy-confirmation paradigm (see Fig. 1). Viewing users' continued IT usage decisions as similar to consumers' repeat purchase decisions, the model predicts users' intentions to continue usage of an IT with three antecedent constructs: (1) user satisfaction with the IT; (2) extent of user confirmation; and (3) post-adoption expectations, represented by perceived usefulness.

Despite its structural adaptation from the expectancy-confirmation paradigm, Bhattacherjee's [10] model possesses a few differences. First of all, ECM-IT focuses on post-adoption expectations. It should be noted that in the expectancy-confirmation paradigm, a consumer's expectation is pre-purchase expectation and it extends its role as a frame of reference to determine the level of disconfirmation and satisfaction in the post-purchase stage. This difference stems from the consideration that a user's expectation toward using an IT after gaining experiences from using it should be different from those expectations before using it [10,30,45]. An individual keeps updating expectation toward using an IT as he/she gains experiences from using it. Indeed, the expectancy-confirmation paradigm has been questioned for its implicit assumption that pre-purchase expectations are based on the information from manufacturers, third-party test reports, or mass media sources [83]. LaTour and Peat [49] found that expectations based on consumers' direct experiences were the major determinant of consumer satisfaction. From this perspective, ECM-IT theorizes that the post-adoption expectation (rather than pre-adoption expectation) plays an important role in determining IT users' satisfaction decisions.

Second, post-adoption expectation is represented by perceived usefulness in ECM-IT. The rationale behind this can be found in the definition of expectation. Proponents of the expectancy-confirmation paradigm have defined expectation as individual beliefs (B_i) or sum of beliefs ($\sum B_i$) about the levels of attributes possessed by a product (see [7,19,57]). Following this definition, ECM-IT uses perceived usefulness as the measure of expectation, since among the cognitive beliefs in IS adoption and usage, perceived usefulness has demonstrated itself to be the most consistent and salient one in determining the user intention over time (e.g., [27,45,72]).

Third, perceived performance is not included in ECM-IT. ECM-IT assumes that the effect of perceived performance is already captured by the confirmation construct [10]. The exclusion of perceived performance from the model further implies that the effect of perceived performance is totally mediated by confirmation [83].

There are five hypothesized links in ECM-IT. First, a user's satisfaction has positive influence on his/her intention to continue usage of an IT. In the satisfaction literature, a consumer's level of satisfaction is the main factor in the consumer's decision to re-purchase products or to patronize services (e.g., [7,22,55,59,68]), which is similar to the continued usage of IT products or services. In addition, according to Bhattacherjee [10], empirical evidence supporting the role of affect (attitude) in determining IT adoption intention (e.g., [27]) provides indirect support for this causal link in that satisfaction is a type of affect [23,48].

Next, a user's levels of confirmation and perceived usefulness (i.e., post-adoption expectation) are two key determinants of satisfaction. Since a user's confirmation implies that he or she achieves expected benefits through the usage experiences with the target IT (vice versa for disconfirmation), it affects the user's satisfaction level positively. As in the expectancy-confirmation paradigm, perceived usefulness has a positive impact on satisfaction by acting as a baseline of reference against confirmation judgments. The theoretical support for this relationship can be found in Helson's [37] adaptation level theory. It posits that one perceives stimuli only in

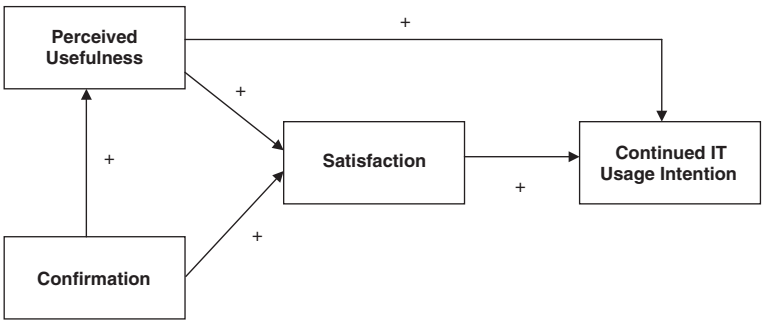

Fig. 1. Expectation-Confirmation Model of continued IT usage (ECM-IT).

relation to an adapted level [83]. Prior consumer behavior research found that the higher (lower) a user's expectation is, the higher (lower) is the subsequent satisfaction level [56].

Moreover, IT adoption studies have consistently found that perceived usefulness is the most important factor in determining users' adoption intentions (e.g., [27,69,74]). In this light, ECM-IT hypothesizes a direct positive link from perceived usefulness to a user's intention to continue IT usage.

Finally, the level of confirmation resulting from the usage experiences is hypothesized to positively affect perceived usefulness. Bhattacherjee [9,10] suggests that perceived usefulness could be adjusted by confirmation experience, especially when a user's initial perceived usefulness is not concrete because he/she is not sure what to expect from the usage of an IT.

In summary, ECM-IT is a newly developed model, which requires empirical validations across different technology contexts to determine its generalizability. In addition to its empirical validation, a comparison with other models can reveal its relative utility for understanding the continued IT usage behavior. An overview of one such model follows in the next section.

2.2. Model 2: Technology Acceptance Model (TAM)

Among the many theoretical perspectives advanced to address IT adoption and usage, the Technology Acceptance Model (TAM) advocated by Davis [25] is widely accepted as a framework to understand users' IT acceptance processes. Indeed, TAM has proven to be a parsimonious model that explains much of the variance in users' behavioral intention related to IT adoption and usage across a wide variety of contexts [69]. According to Mathieson [51], TAM is preferred over alternative models such as the Theory of Reasoned Action (TRA) in diverse user contexts. In addition, "substantial theoretical and empirical support has accumulated in favor of TAM," compared to alternative models such as the Theory of Reasoned Action (TRA) and the Theory of Planned Behavior (TPB) [74].

TAM is an intention-based model stipulating that the intention to adopt a technology is a good predictor of its actual usage. In its formulation[3], users' intention to adopt an IT is explained by two major perceptual factors: perceived ease of use and perceived usefulness. Perceived usefulness is, in turn, influenced by perceived ease of use (Fig. 2).

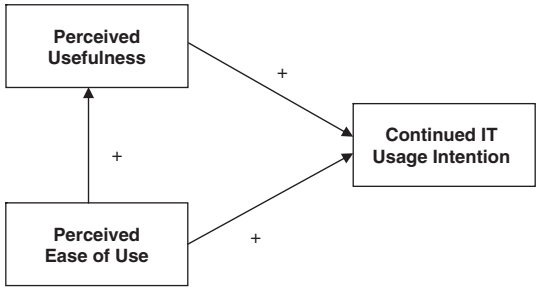

Fig. 2. Technology Acceptance Model (TAM).

TAM was originally developed to predict users' initial adoption of a new IT. TAM is expected to explain and predict future user behavior based on simple measures taken "after a very brief interaction with a system" as a prototype or in a pre-adoption trial ([27], p. 983). Examples of studies of systems with such a pre-adoption situation include the work of Davis et al. [27] on word-processor, Szajna's [67] study on e-mail system, Venkatesh and Davis's [73] work on graphics systems, Venkatesh's [71] work on virtual workplace system, Venkatesh and Davis's [74] work on a proprietary information system, and Venkatesh and Morris's [75] study on a data retrieval system. However, many studies based on TAM seemed to have implicitly assumed, intentionally or unintentionally, that continued usage is an extension of adoption and used TAM in post-adoption situations [10]. These studies applied TAM to examine users' adoption intentions after they had already adopted and were using the IT [45,70]. For example, Taylor and Todd [69] examined students' usage intentions of a computing service facility that had already been widely used by many of them, and Davis [26] studied IBM employees' adoption of an e-mail system and a text editor that were already in use in the organization at the time of the study. Lederer et al. [50] studied the active newsgroup users with the TAM framework. More recently, Konana and Balasubramanian [46] developed a TAM-based model of online investing adoption based on interviews and a survey of experienced online investors. In summary, in the situations where the participants (users) had been exposed to the technology for an extended period, these studies actually investigated experienced users' intentions to continue using the technology, not the intentions of inexperienced users to adopt it.

Although not exhaustive, Table 1 presents some examples of such studies from *Decision Sciences,*

[3] In some early versions of TAM, users' attitude toward using an IT was included. However, due to its inconsistent effect on user intentions, the attitude construct has been excluded in subsequent studies of TAM. In this study, we use the subsequent TAM for comparison.

Table 1
Examples of TAM application to experienced users

Study	Target IT	Subjects	Degree of experience [a]
Adams et al. [1]	E-mail/voice-mail systems; WordPerfect, Lotus 1-2-3, and Harvard Graphics	Users from business organizations; and students	Average of 28 months of e-mail experience and 21 months of voice-mail experience; 13–33 months of experience with the various software
Agarwal and Prasad [2]	Personal computers with a GUI environment	Employees of a major IT technology and service vendor	Mixed: some were using the system at the time of the study; some were using the old system; some were transitioning from the old to the new
Chau [15]	MS Word and Excel	Administrative/clerical staffs of a non-profit organization	50% had used Word at least once a day; 33% had used Excel at least once a day
Davis [26]	IBM e-mail system (PROFS); text editor	IBM employees	Average of 6 months of experience
Gefen and Straub [34]	E-mail system	Knowledge workers using an e-mail system	Users of e-mail system that had been available for many years
Gefen et al. [35]	Online shopping	Students	Average of 7.18 times of online shopping experience
Hong et al. [38]	Digital libraries	Students	2/3 of respondents were current users
Hu et al. [40]; Chau and Hu [18]	Telemedicine technology	Physicians in public hospitals	Mixed: no experience; currently using at the time of the study; had used in the past
Igbaria et al. [41]	Microcomputer	Managers/professionals	At least 6 months of usage experience
Konana and Balasubramanian [46]	Online investing	Individual investors	Mixed: current online investors as well as traditional investors
Lederer et al. [50]	Internet websites	Website users	Current Internet newsgroup users
Taylor and Todd [69]	Computer resource center (CRC)	Students	Mixed: over 60% of participants had prior experience using the CRC
Yang and Yoo [81]	Spreadsheet	Students	Management information systems majors with prior experience with the spreadsheet software

[a] Degree of experience is at the start of survey.

Decision Support Systems, *Information Systems Research*, *Journal of Management Information Systems*, and *MIS Quarterly*. While there is no clear distinction between adoption and continued usage in these studies, TAM has implicitly shown its potential to predict users' continued IT usage decisions. Hence, it would be beneficial to use TAM as a prospective model to understand IT usage continuance.

2.3. Model 3: Extended ECM-IT (EECM-IT)

A hybrid model integrating ECM-IT and TAM was also considered. While ECM-IT and TAM were designed to explain different aspects of user perceptions, there are some similarities between the constructs of ECM-IT and TAM. For instance, both models contain the belief component of perceived usefulness. In the original TAM (which includes the attitude construct), perceived usefulness is hypothesized to be an antecedent to attitude toward using an IT, and intention to use an IT. In ECM-IT, perceived usefulness (a post-adoption expectation) is hypothesized to be an antecedent to satisfaction (an attitude) with an IT, and intention to continue IT usage. In essence, intention to use and intention to continue IT usage are equivalent constructs, measured at different points in time, after an individual has sufficient experience with the behavior to have more informed beliefs (including perceived usefulness) and attitudes (including satisfaction). Viewed from this perspective, TAM and ECM-IT are conceptually very similar. And the similarities provide the motivation for combining these two models into a hybrid model with enhanced predictive power by incorporating their different aspects of user perceptions in the original frameworks. As suggested by Taylor and Todd [69], factors believed to be relevant to the adoption of a technology can be derived from several theoretical frameworks to better understand user behavior, as attempted in previous studies (e.g. [69,75]). Since ECM-IT and TAM are designed to explain different aspects of user perceptions, by combining these two models, the extended ECM-IT (hereafter, EECM-IT) may provide a more complete understanding of continued IT usage behavior relative to the more parsimonious ECM-IT or TAM.

Given the accumulated evidence of the significant impact of perceived ease of use on both perceived usefulness and IT usage intention from previous TAM-based studies, perceived ease of use is added to the ECM-IT. Similar to perceived usefulness, perceived ease of use has been one of the salient beliefs in determining IT acceptance (e.g., [72]). Following the perspective that post-adoption expectation in the ECM-IT consists of users' beliefs about the attributes possessed by an IT [10], the post-adoption expectation in the hybrid model is represented by both perceived usefulness and perceived ease of use. As another component of post-adoption expectation, perceived ease of use is expected to have a positive influence on satisfaction. Further, as theorized in TAM, perceived ease of use is expected to have both a direct influence and an indirect impact via perceived usefulness on continued IT usage intention. With the same line of reasoning applied to the relationship between confirmation and perceived usefulness in the ECM-IT, the level of confirmation is also hypothesized to positively affect perceived ease of use. As a user gains confirmation experience, the user's perceived ease of use will become more concrete and updated. Fig. 3 presents the EECM-IT.

3. Research methodology

3.1. The context of the study

Prior IT adoption studies have investigated innovations at two levels. The first level is at the application level, such as e-mails [1,67], Windows operating system [45], and word processing system [27]. The second level is at the general level of technological innovation, such as computing in general [20]; digital libraries [38]; telemedicine [18,40]; open systems [17]; electronic data interchange [6]; and personal computer [41]. This study focuses on mobile Internet, which is at the general level of innovation.

To compare the three prospective continued IT usage models, data were collected from *current users* of mobile Internet. Current users refer to individuals who had subscribed to mobile Internet service and were using it at the time of the study. In this study, mobile Internet refers to the convergence of mobile communication technologies with information and data communication services [42]. It can be accessed using a hand-held mobile device, such as a mobile phone, over a wide geographical area on a subscription basis. It enables individuals to exchange multimedia messages (e.g., SMS, MMS), download digital information from the Internet, book theater tickets, enjoy online games, and many other services on the road. Mobile Internet has shown exponential growth in terms of subscribers and range of services over the last few years, especially in some Asian and European countries such as Japan, Korea, Hong Kong, and Finland. The number of mobile Internet users is expected to rise to about 1 billion by 2004 [29]. Since mobile Internet can be regarded as a wireless version of subscription-based commercial online information services, subscribers' continued usage behavior is especially critical for its rapid growth in the market.

3.2. Online survey questionnaire

The question items were taken from previous studies and reworded to suit the context of the current study, which is the continued usage of mobile Internet (see Appendix). The items for both the TAM and ECM-IT

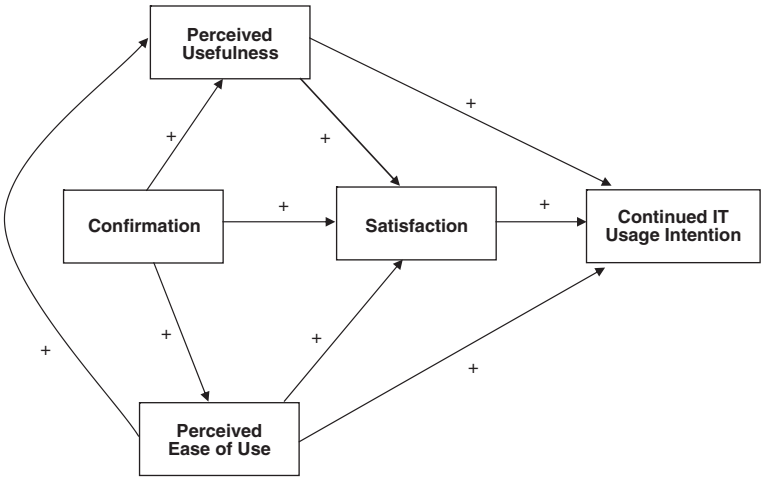

Fig. 3. Extended ECM-IT (EECM-IT).

constructs were adapted from previously validated measurement inventories (e.g., [2,10,26]). All the items, except for those measuring satisfaction on 7-point semantic differential scales, were measured on 7-point Likert scales ranging from "strongly disagree" to "strongly agree". The questionnaire was pilot-tested on 110 existing users of mobile Internet, who were not included in the main survey, and was found to be reliable and valid.

The first question of the online survey was designed to divide the respondents into two groups: current users and potential users. It asked each respondent if one was using mobile Internet[4] at the time of the survey. Depending on the answer (i.e., yes or no), the respondent was presented with a corresponding survey questionnaire. As we are investigating continued IT usage behavior, only those who responded "yes" were included in the subsequent data analysis.

The questionnaire was administered on a non-profit public website run by the Hong Kong government. The website provides residents with a wide array of e-government services, such as filing tax return, booking public facilities, checking traffic information, appointment booking for various government services, and renewal of driving licenses. It is run on a free-membership basis and is open to residents of Hong Kong.

3.3. Data collection procedure

An e-mail soliciting participation in the survey was sent to registered members of the website. Also, a banner advertisement of the survey was made available on the website over a period of four weeks. To reduce the possibility that a respondent participated in the survey more than once, each respondent was required to provide his/her mobile phone number in the survey. Later, duplicate mobile phone numbers were used to filter out multiple responses from the same respondent. To encourage participation, incentives of the latest models of mobile phones and MP3 players were offered as lucky draw prizes.

A total of 1826 valid responses were collected from the current user group.[5] 817 respondents were males (44.7%) and 1009 were females (55.3%). The age of respondents ranged from 13 to 76 years, with a mean of 25.4 years. Most of the respondents were in their 20s (53.1%), 30s (18.0%), and teens (23.6%). The length of experience with using mobile Internet ranged from 1 to 44 months, with 15 months as the median, and 17.2 months as the mean.

[4] In this study, we examined mobile phones with wireless Internet access capability via mobile telephone network.

[5] In total, there were 8941 respondents who successfully completed the questionnaires; of which 7045 were potential users and 1826 were current users.

Table 2
Summary of fit indices (measurement model)

Fit indices	Recommended value	ECM-IT	TAM	EECM-IT
GFI	≥0.90	0.99	0.99	0.99
AGFI	≥0.80	0.99	0.98	0.99
NFI	≥0.90	0.98	0.98	0.97
NNFI	≥0.90	0.98	0.97	0.97
CFI	≥0.90	0.98	0.98	0.98
RMSR	≤0.10	0.07	0.06	0.08
RMSEA	≤0.08	0.05	0.07	0.05
χ^2 (df, p)	–	257.65 (48, p<.01)	156.07 (17, p<.01)	428.46 (80, p<.01)

Note: TAM—Technology Acceptance Model, ECM-IT—Expectation-Confirmation Model, EECM-IT—Extended ECM-IT.

3.4. Instrument validation

Three confirmatory factor analyses using LISREL 8.50 were performed on the measurement models of ECM-IT, TAM, and EECM-IT. The fit of the measurement models was estimated with various indices (see Table 2). However, the chi-square statistic and the normed chi-square were not used in this study because of their inherent sensitivity to large sample size ([36], p. 492). For ECM-IT, the goodness-of-fit (GFI), adjusted goodness-of-fit (AGFI), normalized fit index (NFI), non-normalized fit index (NNFI), comparative fit index (CFI), root mean square residual (RMSR), and root mean square error of approximation (RMSEA) were within the recommended levels, indicating good model fit [16]. For TAM, we observed values of 0.99, 0.98, 0.98, 0.97, 0.98, 0.06, and 0.07 for GFI, AGFI, NFI, NNFI, CFI, RMSR, and RMSEA respectively, also representing good model fit. Finally, the fit indices suggested good model fit for EECM-IT. The observed values for GFI, AGFI, NFI, NNFI, CFI, RMSR, and RMSEA were 0.99, 0.99, 0.97, 0.97, 0.98, 0.08, and 0.05 respectively, all within the recommended levels.

The psychometric properties of the constructs are summarized in Tables 3 and 4. The composite reliability for each construct ranged from 0.85 to 0.94, suggesting acceptable levels of reliability [36]. The average variances extracted (AVEs), ranging from 0.73 to 0.84, were above the recommended 0.50 level [36], which meant that more than 50% of the variances observed in the items were accounted by their hypothesized constructs. All factor loadings were greater than 0.70, indicating excellent convergent validity [31]. Further, the squared multiple correlations of the individual items

Table 3
Summary of psychometric properties of constructs and items

Construct measurement	Mean	Standard deviation	Factor loadings	Squared multiple correlations	Composite reliability	Average variance extracted
Continued IT usage intention					0.85	0.73
INT1	4.71	1.20	0.89	0.79		
INT2	4.94	1.13	0.82	0.68		
Perceived usefulness					0.94	0.84
PU1	4.36	1.26	0.91	0.84		
PU2	4.52	1.21	0.94	0.89		
PU3	4.62	1.30	0.88	0.78		
Perceived ease of use					0.89	0.74
PEU1	4.54	1.12	0.90	0.82		
PEU2	4.11	1.17	0.87	0.76		
PEU3	4.42	1.16	0.80	0.64		
Confirmation					0.93	0.81
CON1	3.92	1.12	0.92	0.84		
CON2	3.86	1.12	0.92	0.85		
CON3	4.04	1.17	0.86	0.74		
Satisfaction					0.92	0.74
SAT1	4.15	1.05	0.85	0.72		
SAT2	4.23	1.02	0.86	0.75		
SAT3	4.00	1.09	0.90	0.80		
SAT4	4.15	1.10	0.82	0.67		

were all above the 0.40 threshold for convergent validity [36]. Finally, the shared variances between constructs (i.e., squared correlations) were lower than the AVEs for the individual constructs, indicating adequate discriminant validity [32].

4. Empirical results

A structural equation modeling analysis was performed using LISREL 8.50 to examine the three prospective continued IT usage models. Structural equation modeling has been suggested not only as being appropriate for comparing alternative models [44,69], but also as being useful for testing theoretically justified models such as the ones in this study [8]. The weighted least squares (WLS) method was used to estimate the coefficients of the associations among the variables. When non-normality of the data exists, which was the case with our sample, employing an estimation method that allows for non-normality is more appropriate ([11], p. 425; [44], p. 45). The advantages of using the WLS estimation method are that it does not assume the normal distribution of variables as a necessary condition for estimation and is asymptotically efficient.

Table 4
AVEs and shared variances

	INT	SAT	PU	PEU	CON
INT	0.73				
SAT	0.18	0.74			
PU	0.52	0.07	0.84		
PEU	0.53	0.18	0.36	0.74	
CON	0.14	0.29	0.11	0.18	0.81

Note: INT—Continued IT Usage Intention, PEU—Perceived Ease of Use, PU—Perceived Usefulness, SAT—Satisfaction, CON—Confirmation, AVEs are shown on the diagonal.

4.1. Model 1: Expectation-Confirmation Model in IT domain (ECM-IT) results

The same set of fit indices was used to examine the fit of the structural models (see Table 5). For the ECM-IT model, all the indices suggested a good fit (GFI=0.99, AGFI=0.99, NFI=0.98, NNFI=0.98, CFI=0.98,

Table 5
Summary of fit indices (structural model)

Fit indices	Recommended value	ECM-IT	TAM	EECM-IT
GFI	≥0.90	0.99	0.99	0.99
AGFI	≥0.80	0.99	0.98	0.99
NFI	≥0.90	0.98	0.98	0.97
NNFI	≥0.90	0.98	0.97	0.97
CFI	≥0.90	0.98	0.98	0.98
RMSR	≤0.10	0.07	0.06	0.06
RMSEA	≤0.08	0.05	0.06	0.05
χ^2 (df, p)	–	258.98 (49, $p<.01$)	156.07 (17, $p<.01$)	428.49 (81, $p<.01$)

Note: TAM—Technology Acceptance Model, ECM-IT—Expectation-Confirmation Model, EECM-IT—Extended ECM-IT.

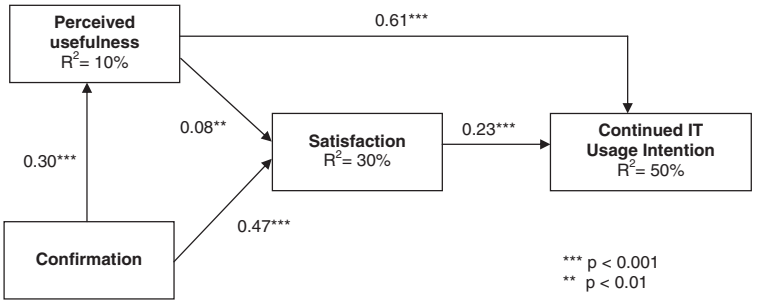

Fig. 4. Summary of ECM-IT results.

RMSR=0.07, RMSEA=0.05). Fig. 4 shows that all the causal relationships hypothesized in Bhattacherjee's [10] model were supported. Users' intentions to continue to use mobile Internet were determined by user satisfaction and perceived usefulness. The paths from confirmation to perceived usefulness and user satisfaction were significant. The impact of perceived usefulness on user satisfaction was significant but small. The model explained 50% of the variance in users' intentions to continue usage, 30% of the variance in user satisfaction, and 10% of the variance in perceived usefulness.

4.2. Model 2: Technology Acceptance Model (TAM) results

From Table 5, the structural model of TAM also showed an adequate fit (GFI=0.99, AGFI=0.98, NFI=0.98, NNFI=0.97, CFI=0.98, RMSR=0.06, RMSEA=0.06). As shown in Fig. 5, the results demonstrate salient relationships between users' intentions and both perceived usefulness and perceived ease of use as hypothesized. The path from perceived ease of use to perceived usefulness was also significant. The model accounted for 63% of the variance in users' intentions to continue usage, and 35% of the variance in perceived usefulness. Compared to the ECM-IT, TAM showed higher R^2 with respect to intentions and perceived usefulness. Interestingly, perceived ease of use was the stronger determinant of users' continued usage intention than perceived usefulness.

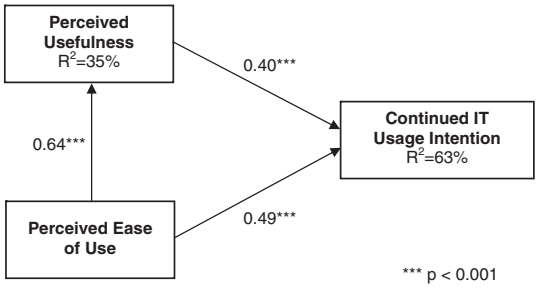

Fig. 5. Summary of TAM results.

4.3. Model 3: Extended ECM-IT (EECM-IT) results

Fig. 6 presents the EECM-IT results with the fit indices providing support for a good model fit (GFI=0.99, AGFI=0.99, NFI=0.97, NNFI=0.97, CFI=0.98, RMSR=0.06, RMSEA=0.05). All the paths among variables were significant as expected, except the path between perceived usefulness and satisfaction. The effect of the newly added perceived ease of use was salient in the extended ECM-IT model. It had direct positive impact on satisfaction, whereas perceived usefulness did not. Also, as observed in TAM, perceived ease of use had a strong direct influence on intentions. A noticeable improvement was gained in R^2 with respect to intentions (67%), compared to ECM-IT (50%). The amount of variance in perceived usefulness explained by confirmation and perceived ease of use was much higher (37%) than that explained by confirmation alone in ECM-IT (10%), and was almost the same as that explained by perceived ease of use alone in TAM (35%). 34% of variance in satisfaction was explained in this hybrid model, which is a slight improvement from 30% in ECM-IT.

4.4. Comparison of models

Three indices, Akaike Information Criterion (AIC; [4]), Consistent AIC [12], and Bayesian Information Criterion (BIC; [61]), were used to compare the three models. AIC, CAIC, and BIC are methods for comparing alternative models to determine which model explains the given data better [36], and have been applied in a wide range of situations relevant to cognitive psychology [79]. Moreover, they take both descriptive accuracy and parsimony into account when evaluating models [12,13,79], whereas R^2 that has been typically used in IS research to compare the explanatory power of alternative

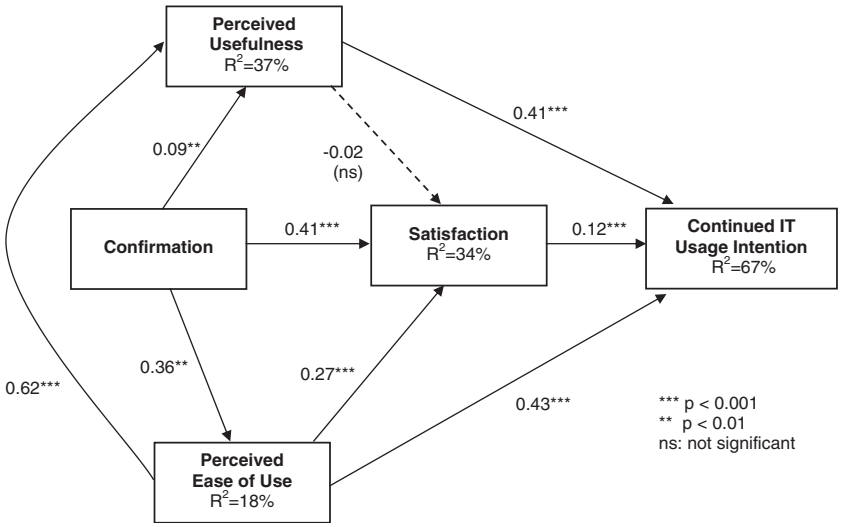

Fig. 6. Summary of extended ECM-IT (EECM-IT) results.

models does not take into account the model complexity. When evaluating the model comparison results, the smaller the AIC, CAIC, and BIC values, the better the model approximates the 'true' process. Table 6 shows that all the information criterion indices favor TAM over ECM-IT and EECM-IT. In terms of R^2, EECM-IT, which was the most complex model, was the highest. However the R^2 for continued IT usage intention in TAM (63%), which was the most parsimonious, was almost as high as that of intention in EECM-IT (67%).

5. Discussion

The objective of the current study was to compare the relative utility of three prospective models of continued IT usage behavior: (1) Expectation-Confirmation Model in IT context (ECM-IT), (2) Technology Acceptance Model (TAM), and (3) extended Expectation-Confirmation Model in IT context (EECM-IT). Data collected from an online survey of 1826 current mobile Internet users were used to test these models. Overall, all three models demonstrated adequate fit with the data. Further, all the causal relationships in these models, except for perceived usefulness to satisfaction in EECM-IT, were found to be significant as hypothesized in prior literature. We discuss some interesting results below.

Table 6
Comparison of models

	R^2 for continued IT usage intention	AIC	CAIC	BIC
TAM	63%	194.07	317.76	298.76
ECM-IT	50%	316.98	505.77	476.77
EECM-IT	67%	506.49	760.38	721.38

Note: TAM—Technology Acceptance Model, ECM-IT—Expectation-Confirmation Model, EECM-IT—Extended ECM-IT.

5.1. Utility of TAM in the continued IT usage context

One of the most interesting finding was that while all three models are shown to be good models, TAM has the best fit to the data. In terms of explanatory power, TAM also accounted for more variance in user intention to continue IT usage than ECM-IT (TAM: 63%, ECM-IT: 50%). It should be noted that the version of TAM used in this study included only two constructs to predict the user intention. Given that TAM was not specifically developed to predict continued usage intention, 63% of variance accountability can be considered very good. Prior adoption research based on TAM explained around 45–50% of variance in adoption intention. For example, in Taylor and Todd's [69] study, TAM accounted for 52% of the variance in adoption intention. In a study of e-mail system, Szajna [67] found that TAM explained 52% of its adoption intention. In the study of Davis et al. [27], TAM accounted for 45% of the variance in intention.

Our result implies that TAM, which was originally designed to understand users' behavior at the initial adoption stage of an IT, may extend its application to the understanding of continued usage behavior of experienced users. This further implies that researchers in this area can enjoy several practical research advantages provided by TAM. First, TAM is well known for its parsimony. The basic version of TAM explains and predicts user intention and usage with only two main constructs—perceived usefulness and perceived ease of

use. According to Davis et al. [27], many external variables that are not specified in the model, such as system design characteristics, training, and other types of support are expected to affect user intention and usage through these two factors. Given the extensive validations in the literature, these two factors are easy to understand and implement in practice.

Second, its general applicability across different technologies and user contexts [51] can provide researchers with practical utility. As more and more IT become available at a rapid pace, the necessity to assess promptly users' continued usage behavior with these technologies increases. Since the components of the model are generalizable across various technologies and users, TAM can be applied quickly in empirical research to predict user behavior without specifying additional factors for different technologies.

Third, the items used to measure the TAM's constructs, such as perceived usefulness and perceived ease of use, have been extensively validated in previous studies and can be easily modified for different research contexts enabling researchers to save time and effort in developing and validating new measures. In short, TAM provides an inexpensive way to gather information about user perceptions of a system [51].

Finally, TAM is flexible as it allows other factors to be incorporated easily into its basic framework, if desired, to better explain users' decision processes. For instance, there have been attempts to incorporate social norm [75], perceived enjoyment [28], and gender/age moderators [52,76] into the TAM's framework to increase further its explanatory power. Hence, the flexibility of TAM makes it suitable for various technologies of different nature.

5.2. Perceived usefulness: the major driver of continued IT usage across models

Another notable finding in this study was the strong influence of perceived usefulness on user intention in all three models. Given the fact that the path from perceived usefulness to user intention has been shown to be consistently strong over time in previous adoption research based on TAM (e.g., [27,74]), the impact of perceived usefulness on user intention of continued usage in TAM is understandable. However, contrary to Bhattacherjee's [10] finding[6], perceived usefulness was again the stronger predictor of user intention than satisfaction in our test of ECM-IT and EECM-IT. This pattern of association is similar to what researchers have found in the early adoption studies based on TAM. Some expectancy-confirmation paradigm researchers suggest that satisfaction is another type of affect [23,48]. In the early version of TAM, perceived usefulness showed strong direct association to intention over and above user affect (e.g., [26,27,51,69]). This is because people are believed to form intentions toward using an IT based on a cognitive appraisal of how it will help them achieve a valued goal, not just on their affective feelings toward using the IT [27]. From this perspective, the objective-contingent cognition seemed to hold stronger than satisfaction (affect) in the current post-adoption context. Further empirical validations on the relative size of impact between these two variables will be useful in future research.

[6] In Bhattacherjee's [10] test of ECM-IT, satisfaction was the stronger predictor of continuance intention than perceived usefulness.

5.3. Strong and sustained impact of perceived ease of use in post-adoption context

Another surprising finding was that the impact of perceived ease of use on continuance intention was stronger than that of perceived usefulness in the TAM and the EECM-IT analyses. This is a slight departure from the findings in the prior adoption studies suggesting that the impact of perceived ease of use is diminished over time as users get used to an IT [27]. Perhaps this strong direct impact of perceived ease of use on continuance intention is due to the nature of the technology (i.e., mobile Internet). The rapid growth of the mobile Internet market is accompanied by the introduction of numerous new features and content. Therefore, while mobile Internet rapidly evolves, mobile Internet users have to continue to put effort into keeping abreast of the changing technology. Further, due to the limited system resources to deliver the contents of mobile Internet service (e.g., small screen, small and inconvenient input method, limited memory), users often need to make extra effort to access or update the contents (e.g., more navigations, extra steps with service menu). Given that these usability issues are closely related to perceptions of ease of using or learning a system [53], it is likely that perceived ease of use could have a larger influence on mobile Internet users' post-adoption behavior.

5.4. Perceived usefulness as a partial determinant of satisfaction

In the ECM-IT, although the path from perceived usefulness to satisfaction was significant, the magnitude of the effect was relatively small (beta = 0.08). Further, the impact of perceived usefulness on satisfaction turned non-significant in EECM-IT. This relatively weak association between perceived usefulness and satisfaction may stem

from the characteristics of the technology used in this study, which is mobile Internet. As Kwon and Zmud [47] noted, IT adoption and usage research should take into consideration the influence of contextual aspects, such as the characteristics of the technology under investigation and their interaction with various external factors. In ECM-IT, perceived usefulness is supposed to represent post-adoption expectation, because perceived usefulness has been the most salient cognitive belief that forms expectation [10]. However, the scope of expectation can be much broader encompassing many different cognitive beliefs, such as perceived ease of use that was observed in other adoption studies. In the case of mobile Internet, the scope of cognitive beliefs may be especially broad, given the wide range of users and usage contexts [29]. Given that, post-adoption expectations about using mobile Internet should capture many different desires and beliefs of a user.

Similarly, the Theory of Reasoned Action (TRA) supports our perspective in that users' attitude toward a target behavior consists of various beliefs [3]. Perhaps, for a technology like mobile Internet, representing expectation with only one belief (perceived usefulness) is inadequate. The current results imply that users' goal-driven aspect of perception, which is instrumental to achieve a certain goal such as gaining productivity or recognition (i.e., perceived usefulness), provide only partial contribution to developing their satisfaction toward using mobile Internet. Given the wide range of user base and the context of mobile Internet, we conjecture that many users may seek satisfaction from various usage contexts rather than from a performance-oriented context, which is the main focus of previous IS research. According to an ITU report [42], mobile Internet will make new demands on our lifestyle. In its vision for the future of the wireless society, the Wireless World Research Forum [80] suggests that it will become more and more important how users perceive the emotional impact and pleasure that the mobile Internet service creates and maintains. One possible future research is to include various beliefs that are thought to be relevant to the IT in the model and observe their impact on satisfaction, which may help better understand the structure of user satisfaction.

5.5. Association between confirmation and post-adoption expectation beliefs

As theorized in Bhattacherjee's [9,10] study, users' confirmation level through the post-adoption usage experience had positive impact on users' post-adoption expectations (in ECM-IT: perceived usefulness; in EECM-IT: perceived usefulness and perceived ease of use). These results support that users' initial expectation changes following their usage experience, and this revised expectation in turn has significant impact on subsequent cognitive processes, such as satisfaction and intention [9,10]. While the variance explained in perceived usefulness in ECM-IT, where the confirmation experience was the only explanatory variable, was relatively small ($R^2 = 10\%$), it went up to 37% in EECM-IT when the indirect impact of confirmation through perceived ease of use was included. One explanation for the relatively small R^2 in perceived usefulness in ECM-IT is that many mobile Internet users in our study might not have had enough mobile Internet usage experience with respect to improving goal-oriented performance, since there are still not many mobile services and applications that can be used for such purposes, given that the development of mobile Internet is still in its infancy. Therefore, users may lack the direct experience or knowledge to update their level of perceived usefulness. However, the result in EECM-IT suggests that users' experience with respect to maneuvering mobile Internet is able to indirectly influence the expectation level in terms of usefulness perceptions such as improving productivity or enhancing performance. This is consistent with what has been theorized in TAM, i.e., the easier an IT is to use, the more useful it is perceived to be. The results also imply that EECM-IT can provide a more complete understanding of the post-adoption belief development. Further empirical studies with different technologies at different development stages will help better understand this association.

5.6. Implications

The theoretical contribution of this study is that it pushes the frontier of IT adoption research further out to users' post-adoption behavior territory by testing the potential utility of newer models (i.e., ECM-IT and EECM-IT) and how they compare to the traditional theory (i.e., TAM) in facilitating such research in the post-adoption context. Comparison of different models is important as it can help researchers determine which model is more useful for performing research on users' IT usage behavior (e.g., Mathieson's [51] comparison of TAM with TPB; Taylor and Todd's [69] comparison of TAM with TPB and Decomposed TPB; the comparison of eight adoption models by Venkatesh et al. [77]). In this study, we contribute to the IT adoption and usage research by providing empirical evidence of the comparative utility of three prospective continued IT usage models.

An important implication of this study lies with the strengths of the newer models (ECM-IT and EECM-IT) in including post-adoption variables, such as perceived usefulness, perceived ease of use, satisfaction, and

confirmation. One of the important criteria to consider when comparing different models is the value of the information that a model can deliver [51]. From this perspective, the newer models can provide abundant information to allow a more complete explanation of users' post-adoption behavior.

A second implication is that the TAM framework can be used as a vehicle to study both IT adoption and continued IT usage behavior. By virtue of its parsimony, generality, flexibility, and extensively validated tools, TAM provides researchers with a quick, relatively easy, and inexpensive way of conducting research on users' post-adoption behavior.

A third implication is that further development and test of the EECM-IT could advance research into the continued IT usage behavior. Potentially, the constructs of EECM-IT could be combined with other synergistic variables in predicting continued IT usage. The current results on EECM-IT have shed light on the possible formulation of a richer post-adoption model. Indeed, EECM-IT could increase the R^2 of continued IT usage intention by more than 15%, compared to ECM-IT. More empirical tests of the EECM-IT in different IT contexts with additional relevant variables will be valuable.

From the practical point of view, the utility of ECM-IT and EECM-IT, as evidenced by the empirical results, can provide IT practitioners, such as online service providers, with deeper insights into how to address customer retention and continued usage of their products and services. Customer retention is crucial to the successful adoption of an IT innovation and may even determine the survival of the company promoting the IT innovation in the marketplace [5]. The results suggest that in order to encourage continued IT usage, managing users' satisfaction levels as well as certain post-adoption beliefs will be critical. User satisfaction is very important for service providers to retain customers and generate profits [9]: satisfied customers are an effective advertising channel via word-of-mouth as well as a stable revenue source via repeat business. In the past, however, user satisfaction with IT products or services did not receive much attention by IT product/service practitioners or IT adoption researchers, because most IT innovations were considered a tool for users to achieve a certain goal within organzations where performance-oriented aspects of IT innovations are more valued than users' affection toward them (e.g., [27]). As more and more IT innovations become commercially available to individual users like consumer products, it is very likely that user satisfaction with an IT plays a crucial role in determining its success in the market.

At a more specific level, the EECM-IT sheds light on the development of mobile Internet user satisfaction and usage intention through their associations with two widely employed beliefs. The strong impact of perceived ease of use on user intentions and satisfaction particularly deserves attention from practitioners as well as the research community. Compared to the effect of the functional usefulness of a system, the effect of ease of use has been underestimated by IT adoption researchers. However, our result implies that a prominence of usefulness over ease of use may not hold in the context of mobile Internet post-adoption. Recent market surveys of mobile Internet users [33,82] and academic research [78] indicate that ease of use is very important in wireless contexts. Perception of ease of use is closely related to usability design in that both are concerned with enhancing the way people interact with a system [53]. A recent view of the usability design research community is that well-designed IT products and services can support people in their everyday life, because IT is no longer just for work [60]. It is widely accepted that good user experience through better usability design can increase the value of IT products in the commercial market [14]. From this perspective, the EECM-IT suggests that mobile Internet service providers should put more effort into making their services easier to use, which can lead to better user satisfaction, and eventually a great market success. For example, most mobile Internet devices (i.e., mobile Internet-enabled phones) are characterized by small screens, awkward input mechanisms, ergonomically problematic form factors (e.g., shape, weight, and size), and so on. One way for the mobile Internet service providers to improve users' perceptions on ease of use may be a close collaboration with mobile device manufacturers to provide devices that best fit their services. At the same time, mobile Internet service providers should continue to improve user experience through easier menu structure, better navigation design, and caring customer services.

There are also other factors that can potentially influence continued IT usage behavior (e.g., perceived enjoyment, social norm, and demographic/socio-economic variables). Future studies can extend the existing frameworks by integrating the impact of these factors on the formation of user satisfaction and continued usage as well as other post-adoption variables.

5.7. Limitations

Our study has some limitations. One limitation originates in the biases inherent in most online survey-based research. The current study does not include users who do not use e-mail, thus excluding the elderly and the non-literate segments of the population. While this limitation is noted, it should not undermine our results because

according to Rogers [64], earlier adopters tend to be relatively young and educated. The profile of our subjects falls into this category. Also, the large sample size of the current study will help to increase the generalizability of the findings. Another potential limitation is that the current study focuses on intention rather than actual usage behavior. One major difficulty of this kind of academic research is the collection of objective and credible real usage data. Mobile service carriers are reluctant to disclose their customers' usage data for various reasons, such as customer privacy protection or possible leakage of critical business information to competitors. Although this study did not measure actual behavior longitudinally, there is considerable evidence that intention to perform a behavior can predict the actual target behavior very well (e.g., [43,65]).

6. Conclusion

This study has compared three prospective models of continued IT usage behavior. According to the LISREL analysis, all three models demonstrate good fit with the data. The results provide evidence of the utility of ECM-IT, a relatively new research framework that provides additional information for explaining continued IT usage, thus supporting Bhattacherjee's [10] model. We also found that TAM, which was originally designed to study the initial adoption behavior could also be used to understand users' continued IT usage intention. Finally, EECM-IT, a hybrid model incorporating the constructs of both ECM-IT and TAM, showed potential to provide a more complete explanation about users' post-adoption behavior. EECM-IT accounted for more variance in continued usage intention, perceived usefulness, and satisfaction than the other two models.

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Appendix A. Questionnaire items

Construct	Item
Perceived usefulness	PU1: Using MOBILE INTERNET helps me accomplish things more quickly. PU2: Using MOBILE INTERNET makes my life easier. PU3: I find MOBILE INTERNET useful in my life.
Perceived ease of use	PEU1: Learning how to use MOBILE INTERNET is easy. PEU2: MOBILE INTERNET is clear and understandable to use. PEU3: I find MOBILE INTERNET easy to use.
Confirmation	CON1: My experience with using MOBILE INTERNET was better than what I expected. CON2: The service level provided by MOBILE INTERNET was better than what I expected. CON3: Overall, most of my expectations from using MOBILE INTERNET were confirmed.
Satisfaction	How do you feel about your overall experience of MOBILE INTERNET use? (7-point semantic differential scale) SAT1: Very dissatisfied/Very satisfied. SAT2: Very displeased/Very pleased. SAT3: Very frustrated/Very contented. SAT4: Absolutely terrible/Absolutely delighted.
Continued IT usage intention	INT1: I intend to increase my use of MOBILE INTERNET in the future. INT2: I intend to continue my use of MOBILE INTERNET in the future.

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