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Sung Kim
University of Wisconsin, Madison, skim@bus.wisc.edu

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Sung S. Kim (skim@bus.wisc.edu)

Assistant Professor, School of Business, University of Wisconsin–Madison

975 University Avenue, Madison, WI 53706, USA

Phone 608-262-3481, Fax 608-263-3142

Please address all correspondence to Sung S. Kim (skim@bus.wisc.edu)

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Abstract

The integrative framework of technology use (IFTU) posits that to fully explain technology adoption and sustained usage, four mechanisms—namely, reason-oriented action, sequential updating, feedback, and habit—should be taken into account simultaneously in a unified model. Recently, a TAM-based two-wave panel model drawing on the IFTU paradigm has been shown to be superior to other partial models in explaining individuals' use of a Web-based portal. In a continuing effort to reinforce the IFTU paradigm, this study first develops and tests a TPB-based three-wave panel model to explain individuals' use of a software application in an organizational context. In addition, this study attempts to refine the IFTU paradigm by examining long-time (as opposed to short-time) effects of the four mechanisms that cannot be systematically examined in a two-wave setting. The findings of this three-wave panel study indicate that the proposed model integrating the four mechanisms represents technology use better than other conventional models. Yet, this research also shows that IFTU should be refined further in a way to represent the distal effects of sequential updating and habit on post-adoption phenomena. Overall, this research clearly reveals that a refined IFTU paradigm will be a simple, but powerful, conceptual tool for explaining how user evaluations and behavior evolve with experience. This article concludes with a discussion of distal effects vis-à-vis proximal effects and suggestions of interesting avenues for further development of the IFTU paradigm.

Key Words: Longitudinal Study; Panel Model; Technology Adoption; Technology Use; Initial Use; Continued Use; Theory of Planned Behavior (TPB); Path Analysis

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1. Introduction

Several studies have proposed that continued use of an information technology (IT) application involves processes different from those that initial use entails (Bhattacherjee 2001, Bajaj and Nidumolu 1998, Venkatesh et al. 2000). One consistent premise of those studies is that user evaluations and behavior at post-adoption stages relate somehow to prior evaluations and/or behavior. For example, Bhattacherjee (2001) theorized that the formation of user evaluations would involve the referencing of prior judgments as supplemental information. In addition, Bajaj and Nidumolu (1998) demonstrated that past use positively influenced current evaluations of the use of an IT application. Similarly, Venkatesh et al. (2000) showed that past use had a direct impact on current use.

Although, as mentioned previously, pioneering work has been conducted on continued use, few researchers try systematically to integrate disparate perspectives on post-adoption phenomena. Recently, Kim and Malhotra (2005) proposed an integrative framework of technology use (IFTU) that combines four mechanisms—that is, reason-oriented action (i.e., judgments to action), sequential updating of judgments (i.e., judgments to judgments), feedback (i.e., action to judgments), and habit (i.e., action to action)—into a unified framework. In their study, the new idea of IFTU was applied specifically in the form of a two-wave panel model (2WPM) in which the technology acceptance model (TAM), which represents the reason-oriented framework, is complemented by the other three mechanisms, i.e., sequential updating, feedback, and habit. Based on data collected from 189 individual users' of a Web-based information system (IS), Kim and Malhotra (2005) demonstrated that the TAM-based 2WPM explained technology use better than any of the partial models, thus providing initial support for the IFTU paradigm.

The objective of this study is twofold. First, to further validate IFTU, this research develops and tests a new, specific panel model that draws on the generic theoretical paradigm. In particular, the new model drawing on IFTU is developed to explain the longitudinal data reported in a study by Venkatesh et al. (2000). In an effort to explain technology use by organizational workers, Venkatesh et al. (2000) developed a three-wave panel model (3WPM) by combining the theory of planned behavior (TPB) with a concept of habit. However, when viewed from the perspective of IFTU, their model appears to pay insufficient attention to other mechanisms (e.g., sequential updating and feedback) that may be vital during post-adoption stages. Thus, this present study applies IFTU, which was embodied in the form of a *TAM-based 2WPM designed to explain individuals' use of a Web-based portal in an educational environment*, to a new *TPB-based 3WPM designed to explain individuals' use of a software application in an organizational setting*. Because the research setting in Venkatesh et al. (2000) differs considerably from the one in Kim and Malhotra (2005), the results of this study are expected to help evaluate the robustness of IFTU as a generic theoretical paradigm.

Second, this study is intended to refine IFTU further by examining any temporally distal effects that the four mechanisms may have on post-adoption phenomena beyond their temporally proximal effects. Although IFTU in its current form sheds light on the four mechanisms that drive technology use, it does not specify the extent to which these mechanisms carry over across time. For example, the 2WPM proposed by Kim and Malhotra (2005) explicitly indicates that because of the habit mechanism, past use tends to have a positive relationship with current use. Yet, their article devotes little attention to whether past use will influence distal use beyond proximal use. This lack of a description of long-time effects in IFTU is mainly because the theory was framed initially in a two-wave setting—as opposed to a three-or-more-wave setting. However, for a deeper understanding of technology use over multiple periods in time, investigators should be equipped with a theoretical framework that explicitly specifies any distal effects that the four mechanisms may have on post-adoption phenomena. To this end, this study critically examines such potential distal effects in a three-wave setting and their implications for IFTU. In doing so, this research will contribute to the development of a more refined theory on technology use over time.

2. Theory Development

First, this section proposes a TPB-based 3WPM that integrates, in a straightforward manner, the four mechanisms posited by IFTU. To compare the integrative perspective with other competing, yet partial, views, four intermediate models are also presented, all of which are nested within the proposed model.

Second, this section discusses potential distal effects on post-adoption phenomena, which are not explicitly considered in the development of the proposed model. Specifically, four rival models are developed, in each of which the proposed model is nested, to highlight the theoretical meanings associated with the distal effects of the four mechanisms vis-à-vis a lack of such effects.

2.1. Integrative View of Four Mechanisms Underlying Technology Use

2.1.1. TPB-Based 3WPM Incorporating Four Mechanisms

At a micro level, the TAM-based 2WPM proposed by Kim and Malhotra (2005) relies heavily on two key concepts, namely, perceived usefulness and perceived ease-of-use. Nevertheless, at a macro level, the rationale behind the TAM-based 2WPM is more general than its hypothesized causal relationships. In particular, the integrative view implied by the TAM-based 2WPM maintains that to better explain technology use over time, the reason-oriented action framework (e.g., TAM, TPB) also should take into account that past judgments influence subsequent judgments (i.e., sequential updating), past behavior determines subsequent judgments (i.e., feedback), and past behavior affects subsequent behavior (i.e., habit). Therefore, IFTU—which was previously embodied in the form a TAM-based 2WPM—can take a variety of other forms depending on the reason-oriented action framework chosen and on the number of data collections in a particular study. Accordingly, it also is possible to deduce from IFTU a TPB-based 3WPM required for reanalyzing the data collected by Venkatesh et al. (2000). Figure 1 depicts such a TPB-based 3WPM proposed in this study as an attempt to integrate the four mechanisms of IFTU into a unified model.

First, much research on technology use builds on a premise that users' behavior is controlled by their deliberate evaluations of the pros and cons associated with the outcome of the technology use in question (Davis et al. 1989, Taylor and Todd 1995). As one of such reason-oriented action frameworks, TPB states that three types of evaluation criteria, namely, attitude (ATT), subjective norm (SN), and perceived behavioral control (PBC) influence behavioral intention (BI), which, along with PBC, determines system usage (USE) (Ajzen 1991). According to IFTU, this type of a reason-oriented action mechanism is a key driver that translates users' evaluations into technology use. Thus, the TPB-based 3WPM in Figure 1 proposes that the TPB mechanism represented with a solid arrow—that is, the path from TPB determinants at t = i to USE at t = i + 1—will occur over time within the context of technology use.[1]

Insert Figure 1 about here

Second, IFTU holds that users' evaluations at post-adoption stages are not made from scratch. The rationale for this proposition is that with all things being equal, the prior judgment on a certain issue is a valuable piece of information, and accordingly individuals tend to take advantage of this information in making a new decision on the same problem (Hogarth and Einhorn 1992, Bolton 1998). Specifically, this mechanism, in which prior judgment serves as an input to the formation of later judgment, is known as the sequential updating process. Kim and Malhotra (2005) demonstrated in a two-wave panel setting that user evaluations at t = 1 had significant effects on the same factors at t = 2, thus providing empirical support for a relatively unknown driver of technology use. The TPB-based 3WPM consistently predicts that TPB determinants at t = i affect the same factors at t = i + 1. A causal relationship reflecting this sequential updating mechanism is represented with a dashed arrow in Figure 1.

Third, Bem's (1972) self-perception theory posits that especially in a routine environment, individuals do not deliberately assess the pros and cons related to the outcome of their actions. Instead, when questioned by external investigators, respondents tend to infer their judgments directly from past behavior. Accordingly, Bem's theory suggests that through this type of heuristic process a feedback loop will be created at post-adoption stages. Furthermore, Bem's theory holds that this feedback loop is represented by the relationship between users' prior behavior and users' current evaluations (Melone 1990, Bajaj and Nidumolu 1998). As shown in Figure 1, the TPB-based 3WPM incorporates this feedback mechanism, which is represented with a dot-dash arrow from USE at t = i to TPB determinants at t = i.

[1] In this present study, USE at t = i + 1 is specified to reflect system usage made between t = i and t = i + 1.

Note that unlike the previous two mechanisms (i.e., TPB and sequential updating), which emphasize a deliberate decision-making approach, this feedback mechanism implies a "quick-and-dirty" heuristic strategy employed to arrive at users' evaluations.

Finally, IFTU posits that in addition to the feedback mechanism mentioned previously, another process, called habit, regulates continued use in a less-conscious manner (Ouellette and Wood 1998, Triandis 1977). In particular, habit literature suggests that with repeated performances, a certain behavior becomes automatic—that is, a situational cue automatically activates it without any conscious effort (Aarts and Dijksterhuis 2000, Bargh et al. 2001). Coupled with the heuristic decision-making strategy involved in the feedback mechanism, this type of automaticity is believed to save precious cognitive efforts required for performing occasionally encountered tasks (Gollwitzer 1996, Bagozzi and Dholakia 1999). In the IS literature, this habit process also is known to be a driver of repeated behavioral patterns and ultimately produces a strong correlation between past use and current use (Venkatesh et al. 2000, Kraut et al. 1999). Consistent with the literature, the model in Figure 1 explicitly incorporates the habit mechanism, which is represented with a dotted arrow from USE at $t = i$ to USE at $t = i + 1$.

The proposed model in Figure 1 shows that all of the four mechanisms—which represent causal relationships (1) from judgments to action (i.e., TPB), (2) from judgments to judgments (i.e., sequential updating), (3) from action to judgments (i.e., feedback), and (4) from action to action (i.e., habit)—are essential in describing individuals' technology adoption and sustained usage. It remains to be seen whether the proposed TPB-based 3WPM, which is a straightforward application of IFTU, reasonably explains the longitudinal data reported in Venkatesh et al. (2000).

2.1.2. Four Intermediate TPB-Based 3WPMs

The efficacy of a model can be better established if the model under scrutiny is shown to be superior to competing models in its fit with the empirical data (Anderson and Gerbing 1988). As a way to examine the comparative validity of the proposed TPB-based 3WPM, this article develops four intermediate models, each of which highlights a unique, yet partial, perspective on the phenomena underlying technology adoption and sustained usage. The detailed specifications of these models are described in Table 1.

The first intermediate model, named IM1, is the most parsimonious form of the competing models. In particular, IM1 posits that technology use, including adoption and sustained usage, can be explained succinctly by the TPB framework. Although this approach appears to be extremely naïve and simplistic, it is used often in those studies that collect panel data but only analyze them wave-by-wave without taking into account inter-wave mechanisms. As mentioned previously, IM1 does not include any connotations regarding inter-wave processes, and thus IM1 can serve as a test bed for evaluating the other models that incorporate inter-wave processes. Next, as shown in Table 1, the second intermediate model, called IM2, adds the sequential updating mechanism into IM1, which serves as the base model of the other alternative models including the proposed model. Similarly, the third intermediate model, or IM3, integrates the feedback mechanism into IM1. Meanwhile, the fourth intermediate model, namely IM4, is designed to combine the habit mechanism with the TPB framework. Note that a longitudinal model proposed by Venkatesh et al. (2000) is much like IM4.

Insert Table 1 about here

The TPB-based 3WPM proposed in this study integrates four bundles of mechanisms into a unified framework. In the context of technology use, the proposed model is likely to perform better than the four intermediate models that do not control for some of the important inter-wave mechanisms. Meanwhile, a key issue of much interest here is whether each of the four mechanisms will prove to be significant when the other mechanisms are controlled for at the same time. Based on the data collected from a two-wave panel study of Web-based IT use, Kim and Malhotra (2005) demonstrated that each of the four mechanisms contributes uniquely to the explanation of technology use across time. If each of the four mechanisms is again shown to be significant on the data in Venkatesh et al. (2000), more credibility can be given to the generalizability of IFTU.

2.2. IFTU with the Notion of Distal Effects vis-à-vis Proximal Effects

2.2.1. Potential Distal Effects in a TPB-Based 3WPM and Their Theoretical Meanings

Although helpful in understanding user evaluations and behavior over time, the relatively new IFTU paradigm in its current form leaves numerous phenomena unexplained. For example, while IFTU holds that USE at t = i will influence USE at t = i + 1 because of the habit mechanism, it does not explicitly specify whether USE at t = i has an overriding effect on the USE variable measured after t = i + 1 (e.g., USE at t = i + 2, USE at t = i + 3, etc). Because of IFTU's lack of a detailed specification of long-time effects, the TPB-based 3WPM in Figure 1 currently assumes that each of the mechanisms has no distal effects, i.e., no relationships between factors temporally distal (e.g., between t = i and t = i + 2), beyond its hypothesized proximal effects, i.e., the relationships between factors temporally proximal (e.g., between t = i and t = i + 1). However, it is not yet certain whether the assumption of no distal effects is true. Thus, for a deeper understanding of post-adoption phenomena, this assumption, which cannot be systematically studied in a two-wave setting, needs to be examined in the current three-wave setting. To this end, this article explicitly specifies different types of distal mechanisms and elaborates on the theoretical implications of their effects for the IFTU paradigm. Figure 2 schematically illustrates four distal mechanisms added atop the proximal mechanisms shown in the proposed model.

Insert Figure 2 about here

First, the reason-oriented action framework maintains that current judgments made in the course of performing a behavior determine later behavior by fully mediating all other effects (Davis et al. 1989, Ajzen 1991). Therefore, within the TPB framework, current evaluations are thought to fully mediate the impacts of past evaluations on later usage (Bamberg et al. 2003). Put simply, according to this conceptual framework, no distal effects of TPB are expected. On the other hand, Figure 2 represents potential distal effects of TPB on post-adoption phenomena; specifically, it predicts that TPB determinants at t = i influence not only USE at t = i + 1 but also USE at t = i + 2 (solid arrow). If the distal effects of TPB on technology use are found to be significant, the assumption of no distal TPB mechanism is considered to be erroneous.

Second, within the framework of sequential updating, current judgments are assumed to be updated based on the most recent judgments (Oliver 1981, Bolton and Drew 1991). Therefore, the proposed model in Figure 1 seems in line with the sequential updating framework, which does not appear to predict the distal effects of sequential updating on later judgments. Meanwhile, Figure 2 shows potential distal effects of sequential updating on post-adoption evaluations (dashed arrow). As shown in Figure 2, the distal sequential updating mechanism holds that TPB variables at t = i affect not only the same variables at t = i + 1 but also those measured at t = i + 2. If such distal effects are found to exist, the current notion of the sequential updating mechanism—as implied by the proposed model in Figure 1—needs reexamination.

Third, as discussed earlier, the feedback mechanism is believed to occur heuristically, instead of analytically (Bem 1972). Hence, to quickly form their attitudes, individuals are likely to simply consider their recent behavioral tendencies without attempting to retrieve memories of older behavioral patterns. Consistent with this logic, the proposed model in Figure 1 implies that individuals infer their judgments from proximally lagged USE, but not from distally lagged USE. Kim and Malhotra (2005) actually tested this hypothesis in a two-stage setting and found no significant distal effects of feedback. Nevertheless, it is still hypothetically possible for decisionmakers to use distally lagged USE as a basis for the formation of judgments. The potential distal effects of feedback are depicted in Figure 2, which suggests that USE at t = i has an impact not only on TPB variables at t = i but also on TPB variables at t = i + 1 (dot-dash arrow). It is important to note that if such distal effects are observed, the earlier proposition that the feedback mechanism relates to “quick-and-dirty” heuristics must be regarded as being flawed. Thus, the results of an empirical examination related to this issue will have significant connotations for the IFTU paradigm.

Finally, contemporary research in the area of habit concurs that habit is strengthened by frequent activation of the same behavior over time. Thus, both the distally and proximally lagged USE variables can reasonably be expected to contribute jointly to habit formation and ultimately to sustained usage. Figure 2 represents such potential distal effects of habit on post-adoption behavior (dotted arrow). In particular, it indicates that the distally lagged USE variable (e.g., USE at $t = i$) may have a direct impact on later use (e.g., USE at $t = i + 2$) over and above the proximally lagged USE effect (e.g., USE at $t = i + 1$). Although contrary to the proposed model, which states that USE at $t = i$ has no impact on USE at $t = i + 2$, this proposition seems reasonable on the basis of the literature on habit (Aarts and Dijksterhuis 2000, Ronis et al. 1989).

In sum, the discussion mentioned previously reveals that the distal effects of the four mechanisms have theoretical implications that qualitatively differ from their proximal effects. Moreover, it also suggests that IFTU generally predicts that distal effects will occur for the habit mechanism but not for the other mechanisms. Thus, a careful treatment of the potential distal effects is a must for the further development of IFTU.

2.2.2. Four Rival TPB-Based 3WPMs

Four rival models are developed by incorporating four different types of distal effects into the proposed model. Table 1 describes the detailed specifications of the rival models. The first rival model, named RM1, adds the distal effects of TPB to the proposed model. As discussed previously, RM1 is not necessarily in line with the premise of TPB—that is, technology use is controlled by the proximal TPB mechanism, and the effects of all other factors on behavior are indirect because they are fully mediated by the proximal TPB mechanism. However, this proposition needs to be empirically validated, and RM1 is developed particularly for this empirical test. The second rival model, RM2, incorporates into the proposed model the distal effects of sequential updating. Although research generally suggests that one's judgments are updated based on those formed most recently, its validation requires the empirical test of RM2. The third rival model, RM3, predicts that past behavior will influence only proximal judgments, but not distal judgments. Because the self-perception mechanism does not employ a conscious decision-making process, individuals are unlikely to use the old piece of information for making a decision. RM3 can be used to explicitly test this unique aspect of self-perception. Finally, RM4 integrates the notion of the distal habit mechanism and the proposed model. In particular, it reflects the possibility that past use can influence not only proximal use but also distal use. It is impossible to test this hypothesis in a two-wave study; thus, this three-wave setting provides a rare opportunity to examine this interesting idea empirically.

To sum, each of the rival models implies a different theoretical connotation depending on the distal mechanism incorporated in a particular model. Because distal mechanisms represent processes that qualitatively differ from proximal mechanisms that lack any distal effects, it is essential to examine whether such distal effects exist in this three-wave panel setting. Moreover, the findings of distal effects (or a lack of such effects) in this three-wave setting are likely to generalize to four-or-more wave settings. Consequently, the results of the four rival TPB-based 3WPMs are expected to help to further refine the IFTU paradigm, which is currently in its infancy with much left to be accounted for.

3. Data Analysis and Results

This section first describes the procedures for data analysis. Then it presents the results of the intermediate, proposed, and rival models. Finally, a revised model is developed, and the results of the revised model are discussed.

3.1. Procedures for Data Analysis

Two sets of the three-wave panel data reported by Venkatesh et al. (2000) in the form of correlations were used for model testing. The two sets are categorized according to gender, and the samples for men and women, respectively, consisted of 195 and 160 data points. The two sets of data include correlation coefficients between 15 variables (i.e., five factors/wave * three waves), respectively, for the men's and women's groups. Accordingly, all the models were estimated on each set of the data using path analysis implemented in LISREL 8.3 (Jöreskog and Sörbom 1996).

To assess model-data fit, four commonly used fit measures were employed. CAIC is often used to compare alternative models, and a lower value is considered an indication of better fit (Steenkamp and Baumgartner 1998). In addition, a model is said to be moderately acceptable if CFI ≥ .90, RMSEA ≤ .08, and SRMR ≥ .10 (Chin et al. 1997, Hu and Bentler 1999). To be more conservative, the use of stringent criteria such as CFI ≥ .95, RMSEA ≤ .06, and SRMR ≥ .08 is also recommended (Hu and Bentler 1999). Table 2 presents fit statistics of the nine alternative models for both user groups.

Insert Table 2 about here

3.2. Results of Path Analyses

3.2.1. Intermediate Models

Intermediate Model 1. IM1 is the base model, which represents only the causal flows explicitly postulated by TPB. Although it has been applied successfully to numerous IS studies, TPB, at least in its original form, seems to fall short of accurately describing how users' evaluations and behavior evolve over time. As shown in Table 2, the fit of this unembellished TPB model is nowhere near satisfactory, even if less stringent criteria are applied [$\chi^2(87) = 510.73$, CAIC = 717.74, CFI = 0.48, RMSEA = 0.16, SRMR = 0.22, for men; $\chi^2(87) = 431.10$, CAIC = 631.59, CFI = 0.54, RMSEA = 0.16, SRMR = 0.23, for women]. Table 3 reports path estimates and squared multiple correlations (SMC) for the base model. As Table 3 shows, IM1 explains little of the variance in BI and USE. For example, SMC for BI is as low as .18 for the men and .15 for the women. Similarly, SMC for USE is as low as .26 for the men and .24 for the women. Overall, the results strongly indicate that IM1, which is a naïve application of the original TPB to a three-stage context, does not properly reflect technology use.

Intermediate Model 2. IM2 integrates the sequential updating mechanism and IM1. The results revealed that IM2 fit both sets of the data considerably better than IM1 [$\Delta\chi^2$ (8) = 230.41, p <0.001, for men; $\Delta\chi^2$ (8) = 183.85, p <0.001, for women]. For instance, all the fit indices for IM2 were considerably closer to cut-off values than were those for IM1 (Table 2). However, while comparatively superior to the base model, IM2 fit the data unsatisfactorily, even if less stringent criteria were used. Therefore, although the notion of intertemporal updates was shown to be helpful, IM2 still seemed to leave much room for improvement.

Intermediate Model 3. IM3 combines feedback effects and IM1. The difference in fit between IM3 and IM1 was strikingly large [$\Delta\chi^2$ (8) = 166.38, p <0.001, for men; $\Delta\chi^2$ (8) = 165.95, p <0.001, for women]. All of the fit indices consistently and unambiguously pointed out that IM3 represented the data better than IM1 did. Nevertheless, the addition of feedback into TPB was not enough to bring model fit to an acceptable level. Thus, these results suggest that although organizational users might employ self-perception processing, post-adoption phenomena would involve extra processes other than self-perception.

Intermediate Model 4. IM4 adds the past use-current use relationship into the original TPB. This model is similar to the longitudinal model used by Venkatesh et al. (2000) in that both are designed to reflect repeated behavioral patterns in addition to the process represented by TPB. Table 2 shows that as with IM2 and IM3, IM4 exhibits significantly better fit than IM1 [$\Delta\chi^2$ (2) = 75.11, p <0.001, for men; $\Delta\chi^2$ (2) = 64.28, p <0.001, for women]. Nevertheless, the improvement achieved by controlling for habit effects was found to be less substantial than that gained by adding sequential updating or feedback mechanisms into TPB. Thus, although it has recently received much attention from researchers, habit seems to be merely one of many mechanisms that influence post-adoption phenomena.

Insert Table 3 about here

3.2.2. Proposed Model

The main theme of IFTU is that each of the four mechanisms contributes uniquely to an understanding of technology adoption and sustained usage. Accordingly, the model proposed in this study integrates all of the four mechanisms into a coherent three-wave panel structure. Table 2 reveals that as predicted by IFTU, the proposed TPB-based 3WPM achieved statistically significant improvement over the intermediate models. In addition, the proposed model was found to explain the data satisfactorily at least from the viewpoint of a liberal standard [$\chi^2(69) = 143.54$, CAIC = 463.46, CFI = 0.88, RMSEA = 0.075, SRMR = 0.090, for men; $\chi^2(69) = 121.30$, CAIC = 431.13, CFI = 0.90, RMSEA = 0.070, SRMR = 0.093, for women]. Yet, when subjected to rigorous criteria, the model still was unacceptable and required further refinement.

Table 3 shows path estimates and SMC for the proposed model. Concerning path estimates, most of the relationships representing the three inter-wave processes (i.e., sequential update, feedback, and habit mechanisms) were statistically significant. More specifically, out of 18 causal relationships, 14 paths (78%) were significant in the men's group and 13 paths (72%) in the women's group. In contrast, it should be noted that out of 15 TPB relationships, only nine (60%) and eight paths (53%) were significant, respectively, in the men's and women's groups. Thus, each of the three inter-wave mechanisms appeared to be as important as, if not more so, than the widely recognized TPB mechanism. In addition, Table 3 shows that compared with the base model (i.e., IM1), the proposed model explains at least 10% (at t = 2 for the men) and even as much as 22% (at t = 3 for the women) more variance in BI during post-adoption stages. Likewise, the proposed model, as compared with the base model, increases SMCs for continued use by 11% (at t = 3 for the men) to 14% (at t = 4 for the men and at t = 3 for the women).

Overall, the proposed model, as compared with the intermediate models, was considered a more reasonable representation of technology use. However, the results also indicated that the original form of the proposed model was unable to explain some aspects of user evaluations and behavior that unfold over time.

3.2.3. Rival Models

Rival Model 1. RM1 incorporates into the proposed model eight paths reflecting distal TPB effects. As shown in Table 2, the fit of RM1 does not appear to be better than that of the proposed model [$\chi^2(61) = 135.12$, CAIC = 505.23, CFI = 0.89, RMSEA = 0.080, SRMR = 0.090, for men; $\chi^2(61) = 116.65$, CAIC = 475.08, CFI = 0.90, RMSEA = 0.076, SRMR = 0.091, for women]. The results of chi-square difference tests also indicated that the eight paths incorporated into the model did not help improve fit [$\Delta\chi^2$ (8) = 8.42, p < ns, for men; $\Delta\chi^2$ (8) = 4.65, p < ns, for women]. In fact, CAIC suggested that compared with RM1, the proposed model explained the data more succinctly. Therefore, as predicted in the theory section, current evaluations appeared to drive technology use by mediating the impacts of prior evaluations.

Rival Model 2. Previously, this article predicted that intertemporal updates would occur only between the judgments temporally proximal, but not temporally distal. To formally test this proposition, RM2 was designed to explicitly include the path from each of the TPB variables to the same variable measured not only at one period later but also at two periods later. Surprisingly, the results were found to be contrary to our expectations, suggesting that prior judgments influence later judgments for a longer period than predicted by the proposed model. For example, the fit of RM2 was significantly better than that of the proposed model [$\Delta\chi^2$ (4) = 29.70, $p < 0.001$, for men; $\Delta\chi^2$ (4) = 31.41, $p < 0.001$, for women]. In addition, other fit indices such as CAIC, CFI, RMSEA, and SRMR also indicated that RM2 offered a better explanation of actual phenomena than did the proposed model. While processes underlying this unexpected outcome need further clarification, these results imply that the notion of distal sequential updating effects may enhance our understanding of technology use over time.

Rival Model 3. RM3 is the amalgamation of the proposed model and the lagged effects of feedback. This rival model was developed primarily to examine whether people infer their judgments from both distally lagged USE and proximally lagged USE. Results from the model demonstrated that extra paths indicating distally lagged USE effects were redundant in the description of post-adoption phenomena [$\Delta\chi^2$ (4) = 6.19, p < ns, for men; $\Delta\chi^2$ (4) = 8.67, p < ns, for women]. In fact, these results were consistent with those observed by Kim and Malhotra (2005). Therefore, the earlier proposition—to save cognitive efforts, self-perception refers only to proximally lagged USE—received further empirical support.

Rival Model 4. RM4 adds into the proposed model the new idea of the distal effects of USE on later usage. The results of path analysis showed that the addition of a relationship from USE (t = 2) to USE (t = 4) significantly increased fit [$\Delta\chi^2$ (1) = 7.12, $p < 0.01$, for men; $\Delta\chi^2$ (1) = 7.49, $p < 0.01$, for women]. Interestingly, these results were consistent with the earlier prediction that over time a series of past USE measures would represent habit better than would reliance on only one recent past usage measure. Overall, the results suggest that the proposed model should be revised so that it incorporates the distal effects of USE on later usage.

3.3. Revised Model

3.3.1. Development of a Revised Model

The results of the four rival models revealed that the proposed model should also incorporate such concepts as the distal mechanisms of sequential updating and habit. First, contrary to the earlier prediction, individuals' judgments were found to exert influences on distal judgments beyond proximal judgments. Research suggests that in an analytical processing mode, people tend to use as much information as is available to arrive at an accurate decision (Chaiken 1980, Beach and Mitchell 1978, Fazio 1990, Hammond et al. 1987, Petty and Cacioppo 1986). Therefore, it seems reasonable in such an analytical mode for individuals to use distally lagged judgments (in addition to proximally lagged judgments) as long as the information can help lead to a more accurate decision. That is, the unexpected finding can be attributed largely to the very nature of sequential updating in which decisions are reached through deliberation instead of through the spontaneity associated with heuristic decisions.

Insert Figure 3 about here

Second, individuals' usage was found to have distal effects on later usage over and above proximal usage. This result was in line with the earlier speculation that current use would be influenced by both proximally and distally lagged usage. Of course, some cases may exist in which distally lagged usage may not affect current usage. For example a habitual tendency to use the same technology may disappear with a sudden change in the application that transforms a once routine task into an unfamiliar one (Aarts and Dijksterhuis 2000, Bargh et al. 2001). In such cases, past use before the major change is less likely to influence later usage (Bamberg et al. 2003). However, in a stable environment, as was the case in a study by Venkatesh et al. (2000), the mental linkage that allegedly activates an automatic response is strengthened with repetition (Ouellette and Wood 1998); thus, a measure of technology usage obtained during one brief period cannot fully capture the strength of habit and consequently in this study failed to predict later usage.

The discussion mentioned previously leads to a general conclusion that IFTU should be extended to incorporate the mechanisms of distal sequential updating and habit. To examine this proposition, the proposed TPB-based 3WPM was modified to incorporate simultaneously the distal effects represented in RM2 and RM4. Figure 3 depicts a schematic representation of the revised TPB-based 3WPM.

3.3.2. Results of the Revised Model

The results of path analysis revealed that the addition of five paths representing the two types of distal effects on post-adoption phenomena improved model performance considerably. As Table 2 illustrates, the revised model is better in terms of CAIC than any other model tested in this study. Moreover, the revised model yielded a fit that finally met stringent criteria; specifically, except for CFI in the men's group (0.93), fit indices for both sets of data were well within the satisfactory ranges [$\chi^2(64) = 106.39$, CAIC = 457.68, CFI = 0.93, RMSEA = 0.059, SRMR = 0.075, for men; $\chi^2(64) = 81.85$, CAIC = 422.06, CFI = 0.96, RMSEA = 0.042, SRMR = 0.071, for women].

Table 3 shows path estimates for the revised model for the men's and women's groups. The structural paths representing the two distal mechanisms are generally significant for both men and women. More specifically, with the exception of one path from SN (t = 1) to SN (t = 3) in the men's group, all the new paths added into the model were significant in both groups. Consistently, SMC for BI (t = 3) increased by 4% to 6%. Similarly, SMC for USE (t = 4) increased by 2% to 3%. In conjunction with the improved model fit found previously, these results provide strong support for the proposition that distal sequential updating and habit mechanisms should be taken into account to gain a better understanding of how individuals adjust their evaluations and behavior over time.

4. Discussion and Conclusions

This study is designed mainly to validate and enhance the IFTU paradigm recently proposed in the form of a *TAM-based two-wave panel model* (2WPM) by Kim and Malhotra (2005). Specifically, the purpose of this study was twofold: (1) to validate IFTU by developing a *TPB-based three-wave panel model* (3WPM) as implied by IFTU and then test the proposed model on the data reported by Venkatesh et al. (2000); (2) to enhance the IFTU paradigm by examining long-time effects that the four mechanisms may have on post-adoption phenomena over and above their short-time effects. First, this study showed that the proposed model was superior to other conventional models in representing the longitudinal data. Second, this study demonstrated that sequential updating and habit had distal effects on post-adoption phenomena even after controlling for their proximal effects, suggesting further refinement of IFTU. Overall, these findings suggest that an enhanced IFTU paradigm can serve as a simple, but powerful, conceptual tool for explaining how users' evaluations and behavior evolve with experience.

4.1. Contributions of the Research

4.1.1. Validation of IFTU as a General Conceptual Framework

One major contribution of this study to the IS literature lies in its empirical revalidation of IFTU as a general framework on technology use. In particular, this study shows that IFTU can generalize straightforwardly from TAM to TPB (i.e., base theory), from a two-wave setting to a three-wave setting (i.e., periods in time), from personal use to organizational use (i.e., type of technology use), and from a Web-based portal to a software program (i.e., target application). Because the four mechanisms identified in IFTU describe *generic* decision-making and action processes, their applications seem more wide-ranging than the two specific forms mentioned previously. For example, Venkatesh et al. (2003) recently have developed a new model called the unified theory of acceptance and use of technology (UTAUT) that is strongly rooted in the reason-oriented action framework (Jasperson et al. 2005). At least from a purely theoretical perspective, therefore, UTAUT also can serve as a basis for other longitudinal (e.g., four-or-more-wave) models of technology use. Consequently, this research contributes to the IS literature by shedding light on the abstract nature of IFTU, which transcends a particular form of longitudinal model.

Interestingly, the findings of this study reveal that three inter-wave processes such as sequential updating, feedback, and habit mechanisms were at least as important as the TPB mechanism, if not more so. These findings suggest that an exclusive focus on the reason-oriented action mechanism can easily result in biased inferences. For example, in IS research investigators often have analyzed panel data discretely wave-by-wave without taking a holistic view. Yet an important and noteworthy implicit assumption of this procedure is that inter-wave mechanisms (e.g., sequential updating, feedback, and habit mechanisms) are irrelevant to the actual phenomena under scrutiny. Contrary to this implicit assumption, this study demonstrated that the unembellished TPB model, i.e., IM1, fit the data poorly, suggesting that the common approach to analyzing panel data has flaws.

Meanwhile, the superior performance of the TPB-based 3WPM proposed in this present study over that of IM4, which closely resembles the one used in a study by Venkatesh et al. (2000), is noteworthy. Recall that whereas Venkatesh et al. (2000) explicitly controlled for the past use-current use relationship, they paid little attention to sequential updating and feedback mechanisms that may be vital, especially at post-adoption stages. Given that neither sequential updating nor feedback mechanisms are supposed to have direct impact on technology use, these processes can be ignored if the objective of a study is to predict system usage in particular. However, if one wants to *explain* actual phenomena in general, omission of these mechanisms is likely to distort our understanding of reality. Overall, this study contributes to the literature by showing that each of the four mechanisms in the IFTU paradigm is a critical driver of technology use, and thus lack of attention to any one of them is likely to lead to biased conclusions.

4.1.2. Theoretical Refinement of IFTU by Examining Distal Effects beyond Proximal Effects

This study makes another major contribution by showing that IFTU requires further elaborations on long-time (in addition to short-time) effects of user evaluations and behavior on post-adoption phenomena. Specifically, the results of rival models demonstrated that some mechanisms have temporally distal effects on post-adoption phenomena while others do not. These findings are important from a theoretical perspective because such distal effects (or lack of them) can apply to four-or-more-wave contexts in addition to this three-wave setting. Thus, this research is believed to take an important step toward understanding the distal effects, as opposed to proximal effects, of user evaluations and behavior, both of which are hard to examine in a two-wave panel setting. The implications of the observed distal effects, as well as the implications of their absence, are discussed as follows:

TPB. The reason-oriented action maintains that an individual's judgments (e.g., A, SN, and PBC) fully mediate the effects of external variables (e.g., system, task, personal characteristics) on behavioral intention and behavior. Therefore, within this TPB framework, current judgments (i.e., TPB determinants) are believed to represent relatively rich information that contains even the old judgments. Because of this richness of current judgments, technology use can be predicted solely by proximal TPB determinants without requiring distal TPB determinants. This study consistently shows that once other mechanisms are controlled for, individuals' evaluations only had proximal effects on technology use. These findings clearly indicate that an additional notion of distal effects is redundant for TPB—that is, the TPB framework as it has been understood without the notion of distal effects is fairly realistic.

Sequential Updating and Feedback. IFTU states that individuals' judgments are formed in two ways. The sequential updating mechanism is one of them, and in this analytical processing mode, people tend to process all the relevant information to arrive at an accurate decision. Self-perception is the other mechanism, and in this heuristic processing mode people quickly arrive at their answers based on prior behavior. Interestingly, the findings of this study suggest that the difference in the two types of decision-making processes leads to systematic difference in their distal effects on post-adoption phenomena.

First, current judgments were found to be formed based on both proximally and distally lagged judgments. Although unexpected at first, the distal effects of sequential updating seem to be in line with the nature of the analytical decision-making mode. This is because a person in this mode is known to collect as much information as he or she can possibly process (Hammond et al. 1987, Petty and Cacioppo 1986). In particular, as shown in this study, people seem to be willing to retrieve even an old memory of technology use as long as the extra effort leads to an accurate calculation of the pros and cons associated with future use.

A piece of empirical evidence supporting the distal sequential updating mechanism can be found in a three-wave study by Bolton and Drew (1991) of customers' perceptions of service quality within the context of telephone service. While their study did not formally test the distal sequential updating mechanism, we reanalyzed the correlation matrix to examine the distal effects of perceived quality beyond its proximal effects. Interestingly, the results of path analysis revealed that the distal sequential updating mechanism was significant ($\beta = 0.20$, $p < 0.05$), even after controlling for other relevant variables that included the proximal sequential updating mechanism ($\beta = 0.20$, $p < 0.05$). This finding indicates that the distal effects of sequential updating are a more or less general phenomenon instead of something specific to technology use.

Second, this study found that past behavior affected only proximal perceptions, and its distal effects on perceptions were almost negligible. This finding suggests that when the heuristic self-perception mechanism is employed, people simply follow a quick and simple process in which only readily available information is considered and relatively older information is ignored. Within the context of individuals' use of a Web-based portal, Kim and Malhotra (2005) also found that the feedback mechanism did not have distal effects beyond its proximal effects. These findings from two different studies strongly indicate that the proximal feedback mechanism is sufficient in describing how past behavior affects individuals' judgments.

Overall, the observed distal effects of sequential updating as well as the lack of the distal effects of feedback is consistent with the classification of the psychological mechanisms underlying sequential updating and feedback. In light of the generic nature of the two mechanisms, (Bem 1972, Hogarth and Einhorn 1992), their distal effects on post-adoption phenomena that are revealed in this study likely can be generalized across other contexts.

Habit. The habit mechanism is considered one of the key processes that help enhance an individual's *overall* task performance in everyday life (James 1890, Beach and Mitchell 1978, Nardi 1996, Ackerman 1992). Through this automatic process, the person can perform routine tasks effortlessly, and consequently the remaining cognitive energy that otherwise would have been spent can be allocated to important tasks. Researchers often have inferred such a habit mechanism from past behavior because habit is theorized to increase with behavioral frequency in the past (Conner and Armitage 1998, Triandis 1977). In fact, in a variety of contexts—including technology use (Kraut et al. 1999), physical exercise (Terry and O'Leary 1995), class attendance (Fredricks and Dossett 1983), and product purchase (LaBarbera and Mazursky 1983)—past behavior has been shown to influence later behavior, a finding that provides support for the existence of habit.

Although numerous studies show that past behavior relates to later behavior, few have examined how two temporally different measures of past behavior jointly affect later behavior. As prescribed in the literature, the key notion of habit is that habit is strengthened with repeated performance over time. Therefore, it is theoretically meaningful to examine the hypothesized distal effects of past behavior on later behavior. If past behavior is shown to influence not only proximal behavior but also distal behavior, more credibility can be given to the extant theory of habit and accordingly to the IFTU paradigm building on the habit theory. Though such studies are rare, a few have empirically shown that a prediction derived from the habit theory holds true. For example, Bagozzi (1981) found from a study on blood donation that past behavior influenced distal behavior over and above proximal behavior. In addition, LaBarbera and Mazursky (1983) showed within the context of product purchase that prior purchases at two different periods collectively affected later purchases. Nevertheless, the study presented here is one of the first findings within the context of technology use to confirm the important premise of the habit theory, that is, past behavior influences both proximal and distal behavior. Collectively, these finings imply that habit is most likely a fact of life; therefore, to the extent that a behavior in question is routinized within everyday life (e.g., online purchase of products/services, online community activities, etc), past behavior will have not only short-term effects but also long-term effects on later behavior.

4.2. Limitations and Further Research

A lack of access to raw data caused the present study to rely on path analysis instead of a more rigorous data analysis technique such as structural equation modeling (SEM). Yet, note that panel research by its nature often ends up with a small number of samples. In such a typical case of panel research, the use of SEM, which is usually associated with a large number of free parameters, tends to lead to problems such as nonconvergence and negative variance estimates (Boomsma and Hoogland 2001). In particular, in the present three-wave panel study with fewer than 200 longitudinal data points (n = 195, for men; n = 160, for women), the use of SEM might have incurred similar estimation problems. Therefore, the approach employed in this study, in which structural relationships were examined based on factor correlations via path analysis, seems reasonably justifiable (e.g., Kim and Malhotra 2005). Nevertheless, the findings of this research should be viewed with this shortcoming in mind.

The integrative view of technology adoption and sustained usage opens up several exciting avenues of research. One of the new areas will be to examine the role of user experience with a target system in regulating user evaluations and behavior. For example, self-perception theory predicts that the influence of past use on judgments will increase with user experience, suggesting that all other things being equal, feedback loops will be stronger over time. This line of reasoning can be legitimately tested by comparing the relationships between past use and judgments over time. Unfortunately, such propositions cannot be tested here because the original study employed unequal intervals between waves, and the nature of past use may vary with the time interval employed (e.g., one week, three months, etc). However, future research can rigorously test in the manner described here the moderating effect of experience on user evaluations and behavior.

Similarly, further research can examine how the lagged patterns of repeated behaviors that were discovered by the present study will vary with respect to user experience. Although habit can be described as a function of both distally lagged USE and proximally lagged USE, the weight of those variables is likely to be unequal. All things being equal, recent usage will contribute more than old usage to the formation of habit. If this is the case, the proximal effect of USE on later usage should outweigh its distal effect. Actually, the results reported in Table 2 show such tendencies in that the influence of USE at $t = 2$ is stronger on USE at $t = 3$ ($\beta = .40$, $p < 0.001$, for men; $\beta = .35$, $p < 0.001$, for women) than on USE at $t = 4$ (i.e., $\beta = .18$, $p < 0.01$, for men; $\beta = .21$, $p < 0.01$, for women). In this way, the revised theory will help us to gain a deeper understanding of the habit formation process.

4.3. Conclusion

To conclude, this present study, in combination with a study by Kim and Malhotra (2005), presents a fairly clear message that technology adoption and use cannot be completely understood without considering the mechanisms incorporated in the integrative theory. Thus, the conceptual framework presented in this study will serve not only as a useful conceptual tool for understanding user evaluations and behavior over time, but also will help to pose and answer numerous challenging questions related to post-adoption phenomena. It is hoped that the integrative framework of technology use will be helpful in this important line of inquiry.

References

Aarts, H., and A. Dijksterhuis (2000), "Habits as Knowledge Structures: Automaticity in Goal-Directed Behavior," *Journal of Personality and Social Psychology*, 78, 1, pp. 53-63.

Ackerman, P.L. (1992), "Predicting Individual Differences in Complex Skill Acquisition: Dynamics of Ability Determinants," *Journal of Applied Psychology*, 77, 5, pp. 598-614.

Ajzen, I. (1991), "The Theory of Planned Behavior," *Organizational Behavior and Human Decision Processes*, 50, pp. 179-211.

Anderson, J.C., and D.W. Gerbing (1988), "Structural Equation Modeling in Practice: A Review and Recommended Two-Step Approach," *Psychological Bulletin*, 103, 3, pp. 411-23.

Bagozzi, R.P. (1981), "Attitudes, Intentions and Behavior: A Test of Some Key Hypotheses," *Journal of Personality and Social Psychology*, 41, 4, pp. 607-627.

Bagozzi, R.P. and U. Dholakia (1999), "Goal Setting and Goal Striving in Consumer Behavior," *Journal of Marketing*, 63, Special Issue, pp. 19-32.

Bajaj, A., and S.R. Nidumolu (1998), "A Feedback Model to Understand Information System Usage," *Information and Management*, 33, pp. 213-224.

Bamberg, S., I. Ajzen, and P. Schmidt (2003), "Choice of Travel Mode in the Theory of Planned Behavior: The Roles of Past Behavior, Habit, and Reasoned Action," *Basic and Applied Social Psychology*, 25, 3, pp. 175-187.

Bargh, J.A., P.M. Gollwitzer, A. Lee-Chai, K. Barndollar, and R. Trötschel (2001), "The Automated Will: Conscious Activation and Pursuit of Behavioral Goals," *Journal of Personality and Social Psychology*, 81, 6, pp. 1,014-1,027.

Beach, L.R., and T.R. Mitchell (1978), "A Contingency Model for the Selection of Decision Strategies," *Academy of Management Review*, 3, 3, pp. 439-449.

Bem, D. (1972), "Self-Perception Theory," in *Advances in Experimental Social Psychology*, L. Berkowitz (Ed.), New York: Academic Press, 6, pp. 1-62.

Bhattacherjee, A. (2001), "Understanding Information Systems Continuance: An Expectation-Confirmation Model," *MIS Quarterly*, 25, 3, pp. 351-370.

Bolton, R.N. (1998), "A Dynamic Model of the Duration of the Customer's Relationship with a Continuous Service Provider: The Role of Satisfaction," *Marketing Science*, 17, 1, pp. 45-65.

Bolton, R.N., and J.H. Drew (1991), "A Longitudinal Analysis of the Impacts of Service Changes on Customer Attitudes," *Journal of Marketing*, 55, 1, pp. 1-9.

Boomsma, A., and J.J. Hoogland (2001), "The Robustness of LISREL Modeling Revisited," In *Structural equation models: Present and future. A Festschrift in honor of Karl Jöreskog*, R. Cudeck, S. du Toit & D. Sörbom (Eds.), Chicago, IL: Scientific Software International, pp. 139-168.

Carte, T.A., and C.J. Russell (2003), "In Pursuit of Moderation: Nine Common Errors and Their Solutions," *MIS Quarterly*, 27, 3, pp. 479-501.

Chaiken, S. (1980), "Heuristic versus Systematic Information Processing and the Use of Source versus Message Cues in Persuasion," *Journal of Personality and Social Psychology*, 39, November, pp. 752-766.

Chin, W.W., A. Gopal, and W. D. Salisbury (1997), "Advancing the Theory of Adaptive Structuration: The Development of a Scale to Measure Faithfulness of Appropriation," *Information Systems Research*, 8 (4), pp. 342-67.

Conner, M., and C.J. Armitage (1998), "Extending the Theory of Planned Behavior: A Review and Avenues for Further Research," *Journal of Applied Social Psychology*, 28, 15, pp. 1429-1464.

Davis, F.D., R.P. Bagozzi, and P.R. Warshaw (1989), "User Acceptance of Computer Technology: A Comparison of Two Theoretical Models," *Management Science*, 35, August, pp. 982-1,003.

Doll, W.J., A. Hendrickson, and X. Deng (1998), "Using Davis's perceived usefulness and ease-of-use instruments for decision making: A confirmatory and multigroup invariance analysis," *Decision Sciences*, 29, 4, pp. 839-869.

Fazio, R.H. (1990), "Multiple Processes by Which Attitudes Guide Behavior: The MODE Model as an Integrative Framework," in *Advances in Experimental Social Psychology*, M.P. Zanna (ed.), 23, San Diego, CA: Academic Press, pp.75-109.

Fredricks, A.J., and D.L. Dossett (1983), "Attitude-Behavior Relations: A Comparison of the Fishbein-Ajzen and the Bentler-Speckart Models," *Journal of Personality and Social Psychology*, 42, 3, pp. 201-212.

Gollwitzer, P.M. (1996), "The Volitional Benefits of Planning," in *The Psychology of Action: Linking Cognition and Motivation to Behavior*, P.M. Gollwitzer and J.A.. Bargh (eds.), New York, NY: The Guilford Press, pp. 287-312.

Hammond, K.R., R.M. Hamm, J. Grassia, and T. Pearson (1987), "Direct Comparison of the Efficacy of Intuitive and analytical cognition in Expert Judgment," *IEEE Transactions on Systems, Man, and Cybernetics*, SMC-17, 5, pp. 753-770.

Hogarth, R.M., and H.J. Einhorn (1992), "Order Effects in Belief Updating: The Belief Adjustment Model," *Cognitive Psychology*, 24, 1, pp. 1-55.

Hu, L., and P.M. Bentler (1999), "Cutoff Criteria for Fit Indexes in Covariance Structure Analysis: Conventional Criteria Versus New Alternatives," *Structural Equation Modeling*, 6, 1, pp.1-55.

Jaccard, J., and C.K. Wan (1996), *Lisrel Approaches to Interaction Effects in Multiple Regression*, Newbury Park, CA: Sage.

James, W. (1890), *The Principles of Psychology*, New York: Dover Publications.

Jasperson, J., E.C. Carter, and R.W. Zmud (2005), "A Comprehensive Conceptualization of the Post-Adoptive Behaviors Associated with IT-Enabled Work Systems," *MIS Quarterly*, 29, 3, pp. 525-557.

Jöreskog, K., and D. Sörbom (1996), *LISREL8: User's Reference Guide*, Chicago, IL: Scientific Software International.

Kim, S.S., and N.K. Malhotra (2005), "A Longitudinal Model of Continued IS Use: An Integrative View of Four Mechanisms Underlying Postadoption Phenomena," *Management Science*, 51, 5, pp. 741-755.

Kraut, R., T. Mukhopadhyay, J. Szczypula, S. Kiesler, and B. Scherlis (1999), "Information and Communication: Alternative Uses of the Internet in Households," *Information Systems Research*, 10, 4, pp. 287-303.

LaBarbera, P., and D. Mazursky (1983), "A Longitudinal Assessment of Consumer Satisfaction/Dissatisfaction: The Dynamic Aspect of the Cognitive Process," *Journal of Marketing Research*, 20, November, pp. 393-404.

Melone, N.P. (1990), "A Theoretical Assessment of the User-Satisfaction Construct in Information Systems Research," *Management Science*, 36, 1, pp. 76-91.

Nardi, B.A. (1996), "Activity Theory and Human-Computer Interaction," in *Context and Consciousness: Activity Theory and Human Computer Interaction*, B.A. Nardi (ed.), MIT Press, pp. 7-16.

Oliver, R.L. (1981), "Measurement and Evaluation of Satisfaction Processes in Retail Settings," *Journal of Retailing*, 57, 3, pp. 25-48.

Ouellette, J.A., and W. Wood (1998), "Habit and Intention in Everyday Life: The Multiple Processes by Which Past Behavior Predicts Future Behavior," *Psychological Bulletin*, 124, 1, pp. 54-74.

Petty, R.E., and J.T. Cacioppo (1986), *Communication and Persuasion: Central and Peripheral Routes to Attitude Change*, New York, NY: Springer-Verlag.

Ronis, D.L., J.F. Yates, and J.P. Kirscht (1989), "Attitudes, Decisions, and Habits as Determinants of Repeated Behavior," in *Attitude Structure and Function*, A.R. Pratkanis, S.J. Breckler, and A.G. Greenwald (Eds.), Hillsdale, NJ: Lawrence Erlbaum Associates, pp. 213-239.

Steenkamp, J.E.M., and H. Baumgartner (1998), "Assessing Measurement Invariance in Cross-National Consumer Research," *Journal of Consumer Research*, 25, June, pp. 78-90.

Taylor, S., and P.A. Todd (1995), "Understanding Information Technology Usage: A Test of Competing Models," *Information Systems Research*, 6, 2, pp. 144-176.

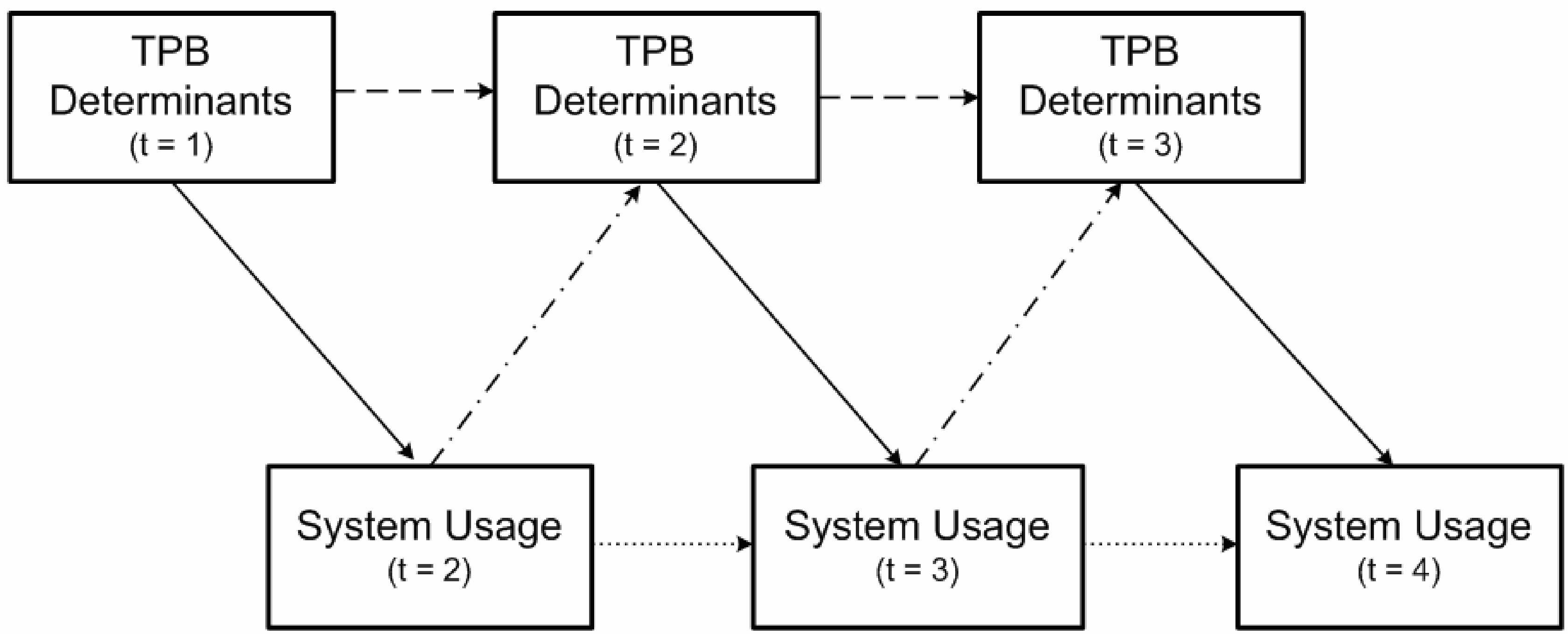
Terry, D.J., and J.E. O'Leary (1995), "The Theory of Planned Behaviour: The Effects of Perceived Behavioural Control and Self-Efficacy," *British Journal of Social Psychology*, 34, pp.199-220.

Triandis, H. C. (1977), *Interpersonal Behavior*, Monterey, CA: Brooks/Cole.

Venkatesh, V., M.G. Morris, and P.L. Ackerman (2000), "A Longitudinal Field Investigation of Gender Differences in Individual Technology Adoption Decision-Making Processes," *Organizational Behavior and Human Decision Processes*, 83, 1, pp. 33-60.

Venkatesh, V., M.G. Morris, F.D. Davis, and G.B. Davis (2003), "User Acceptance of Information Technology: Toward a Unified View," *MIS Quarterly,* 27, 3, pp. 425-478.

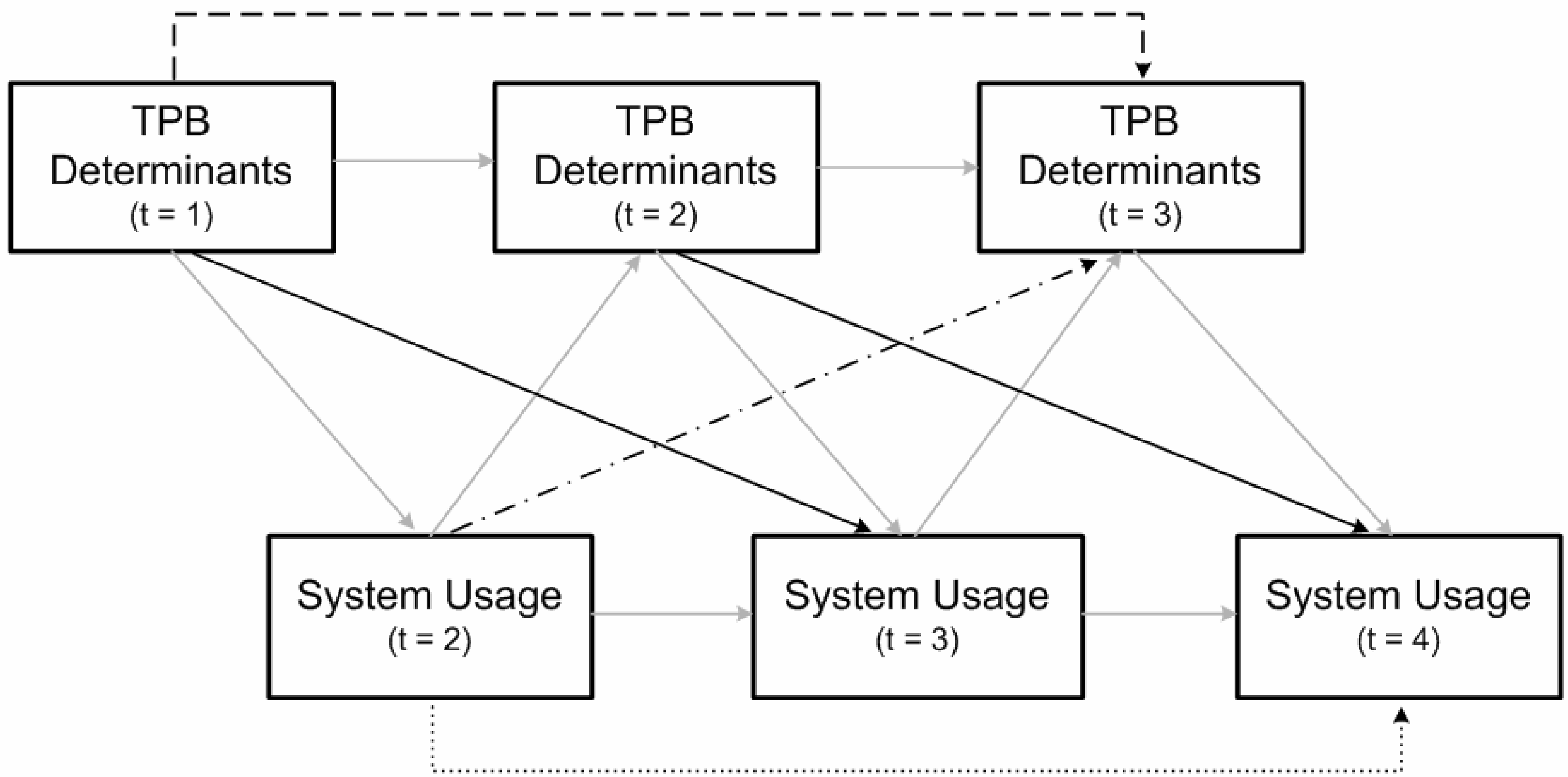
Figure 1. Four Mechanisms Underlying IT Adoption and Use



Notes:

- TPB mechanism:
- Sequential updating mechanism:
- Feedback mechanism:
- Habit mechanism:

Figure 2. Potential Distal Effects



Notes:

- Gray arrows indicate the hypothesized paths in the proposed model (Figure 1)
- Distal TPB mechanism
- Distal sequential updating mechanism
- Distal feedback mechanism
- Distal habit mechanism

Figure 3. Revised Model

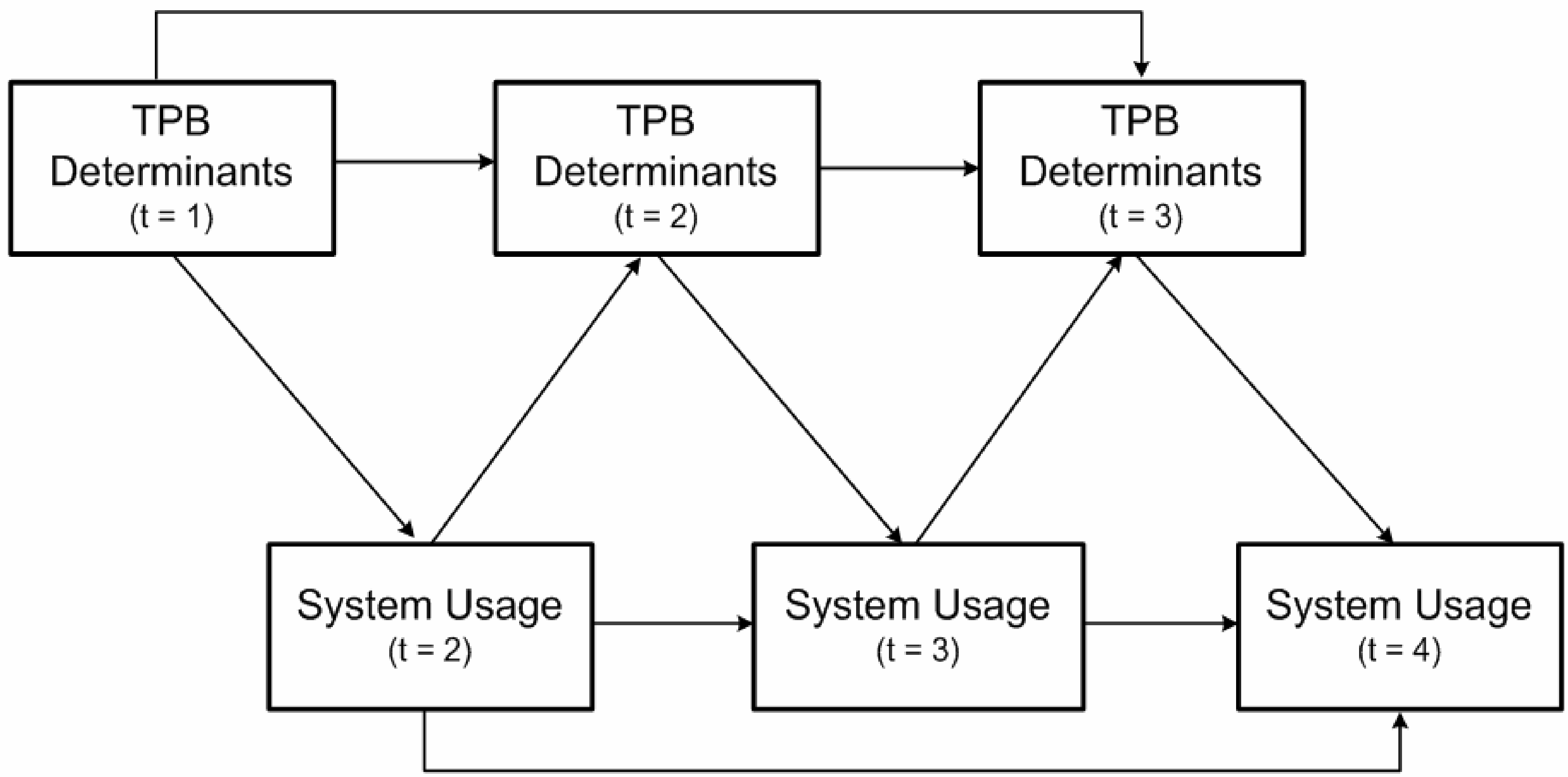


Table 1
Alternative Models and Their Hypothesized Relationships

	Causal Paths	Total Paths	IM1	IM2	IM3	IM4	Proposed Model	RM1	RM2	RM3	RM4
	Proximal Effects										
The theory of planned behavior	A (t) → BI (t)	3	√	√	√	√	√	√	√	√	√
	SN (t) → BI (t)	3	√	√	√	√	√	√	√	√	√
	PBC (t) → BI (t)	3	√	√	√	√	√	√	√	√	√
	BI (t) → USE (t+1)	3	√	√	√	√	√	√	√	√	√
	PBC (t) → USE (t+1)	3	√	√	√	√	√	√	√	√	√
Sequential updating	A (t) → A (t+1)	2		√			√	√	√	√	√
	SN (t) → SN (t+1)	2		√			√	√	√	√	√
	PBC (t) → PBC (t+1)	2		√			√	√	√	√	√
	BI (t) → BI (t+1)	2		√			√	√	√	√	√
Feedback	USE (t) → A (t)	2			√		√	√	√	√	√
	USE (t) → SN (t)	2			√		√	√	√	√	√
	USE (t) → PBC (t)	2			√		√	√	√	√	√
	USE (t) → BI (t)	2			√		√	√	√	√	√
Habit	USE (t) → USE (t+1)	2				√	√	√	√	√	√
	Distal Effects										
The theory of planned behavior	A (t) → BI (t+1)	2						√			
	SN (t) → BI (t+1)	2						√			
	PBC (t) → BI (t+1)	2						√			
	BI (t) → USE (t+2)	2						√			
	PBC (t) → USE (t+2)	2						√			
Sequential updating	A (t) → A (t+2)	1							√		
	SN (t) → SN (t+2)	1							√		
	PBC (t) → PBC (t+2)	1							√		
	BI (t) → BI (t+2)	1							√		
Feedback	USE (t) → A (t+1)	1								√	
	USE (t) → SN (t+1)	1								√	
	USE (t) → PBC (t+1)	1								√	
	USE (t) → BI (t+1)	1								√	
Habit	USE (t) → USE (t+2)	1									√

Notes:
- A = attitude; SN = subjective norm; PBC = perceived behavioral control; BI = behavioral intention; USE = system usage.
- √ = path included in a model

Table 2
Model Fit

Table 2.1
Men

Fit indices	Intermediate Model 1	Intermediate Model 2	Intermediate Model 3	Intermediate Model 4	Proposed Model	Rival Model 1	Rival Model 2	Rival Model 3	Rival Model 4	Revised Model
χ^2	510.73	280.32	344.35	423.08	143.54	135.12	113.84	137.35	136.42	106.39
df	87	79	79	85	69	61	65	65	68	64
CAIC	717.74	537.52	601.55	642.63	463.46	505.23	458.86	482.36	462.61	457.68
CFI	0.48	0.72	0.62	0.58	0.88	0.89	0.92	0.89	0.89	0.93
RMSEA	0.16	0.12	0.13	0.14	0.075	0.080	0.063	0.076	0.073	0.059
SRMR	0.22	0.16	0.16	0.21	0.090	0.090	0.078	0.083	0.087	0.075

Compared with the proposed model	Intermediate Model 1	Intermediate Model 2	Intermediate Model 3	Intermediate Model 4		Rival Model 1	Rival Model 2	Rival Model 3	Rival Model 4	Revised Model
$\Delta\chi^2$	367.19	136.78	200.81	279.54		(-)8.42	(-)29.70	(-)6.19	(-)7.12	(-)37.15
Δdf	18	10	10	16		8	4	4	1	5
p-value	< 0.001	< 0.001	< 0.001	< 0.001		ns	< 0.001	ns	< 0.01	< 0.001

Table 2.2
Women

Fit indices	Intermediate Model 1	Intermediate Model 2	Intermediate Model 3	Intermediate Model 4	Proposed Model	Rival Model 1	Rival Model 2	Rival Model 3	Rival Model 4	Revised Model
χ^2	431.10	247.25	265.15	366.82	121.30	116.65	89.89	112.63	113.81	81.85
df	87	79	79	85	69	61	65	65	68	64
CAIC	631.59	496.33	514.23	579.45	431.13	475.08	424.02	446.76	429.71	422.06
CFI	0.54	0.72	0.68	0.63	0.90	0.90	0.95	0.91	0.91	0.96
RMSEA	0.16	0.12	0.12	0.15	0.070	0.076	0.050	0.069	0.066	0.042
SRMR	0.23	0.17	0.16	0.21	0.093	0.091	0.075	0.082	0.089	0.071

Compared with the proposed model	Intermediate Model 1	Intermediate Model 2	Intermediate Model 3	Intermediate Model 4		Rival Model 1	Rival Model 2	Rival Model 3	Rival Model 4	Revised Model
$\Delta\chi^2$	309.80	125.95	143.85	245.52		(-)4.65	(-)31.41	(-)8.67	(-)7.49	(-)39.45
Δdf	18	10	10	16		8	4	4	1	5
p-value	< 0.001	< 0.001	< 0.001	< 0.001		ns	< 0.001	ns	< 0.01	< 0.001

Notes:
- na = Not applicable.
- ns = Not significant.

Table 3
Completely Standardized Path Estimates and Squared Multiple Correlations

Table 3.1
Men

Hypothesized Mechanisms	Causal Paths			Base model (IM1)	Proposed model	Revised model
The Theory of Planned Behavior	A (t=1)	→	BI (t=1)	0.43***	0.43***	0.43***
	SN (t=1)	→	BI (t=1)	0.06	0.06	0.06
	PBC (t=1)	→	BI (t=1)	0.09	0.09	0.09
	PBC (t=1)	→	USE (t=2)	0.05	0.05	0.05
	BI (t=1)	→	USE (t=2)	0.50***	0.50***	0.50***
	A (t=2)	→	BI (t=2)	0.36***	0.24***	0.24***
	SN (t=2)	→	BI (t=2)	0.10	0.08	0.08
	PBC (t=2)	→	BI (t=2)	0.11	0.02	0.02
	PBC (t=2)	→	USE (t=3)	0.17**	0.13*	0.13*
	BI (t=2)	→	USE (t=3)	0.47***	0.31***	0.31***
	A (t=3)	→	BI (t=3)	0.36***	0.22***	0.23***
	SN (t=3)	→	BI (t=3)	0.13	0.11*	0.08
	PBC (t=3)	→	BI (t=3)	0.06	-0.06	-0.06
	PBC (t=3)	→	USE (t=4)	0.20***	0.14*	0.12*
	BI (t=3)	→	USE (t=4)	0.49***	0.34***	0.31***
Sequential Update	A (t=1)	→	A (t=2)		0.25***	0.25***
	SN (t=1)	→	SN (t=2)		0.16*	0.16*
	PBC (t=1)	→	PBC (t=2)		0.30***	0.30***
	BI (t=1)	→	BI (t=2)		0.32***	0.32***
	A (t=2)	→	A (t=3)		0.20**	0.16*
	SN (t=2)	→	SN (t=3)		0.19**	0.17*
	PBC (t=2)	→	PBC (t=3)		0.24***	0.17*
	BI (t=2)	→	BI (t=3)		0.42***	0.34***
Feedback	USE (t=2)	→	A (t=2)		0.21**	0.21**
	USE (t=2)	→	SN (t=2)		0.09	0.09
	USE (t=2)	→	PBC (t=2)		0.11	0.11
	USE (t=2)	→	BI (t=2)		0.15*	0.15*
	USE (t=3)	→	A (t=3)		0.31***	0.27***
	USE (t=3)	→	SN (t=3)		0.06	0.04
	USE (t=3)	→	PBC (t=3)		0.18*	0.17**
	USE (t=3)	→	BI (t=3)		0.13	0.07
Habit	USE (t=2)	→	USE (t=3)		0.40***	0.40***
	USE (t=3)	→	USE (t=4)		0.37***	0.29***
Distal Sequential Update	A (t=1)	→	A (t=3)			0.17*
	SN (t=1)	→	SN (t=3)			0.09
	PBC (t=1)	→	PBC (t=3)			0.23**
	BI (t=1)	→	BI (t=3)			0.24***
Distal Habit	USE (t=2)	→	USE (t=4)			0.18**
Squared Multiple Correlations						
	BI (t=1)			0.23	0.23	0.23
	USE (t=2)			0.26	0.26	0.26
	BI (t=2)			0.16	0.31	0.31
	USE (t=3)			0.26	0.40	0.40
	BI (t=3)			0.15	0.37	0.41
	USE (t=4)			0.29	0.41	0.43

Table 3.2
Women

Hypothesized Mechanisms	Causal Paths			Base model (IM1)	Proposed model	Revised model
The Theory of Planned Behavior	A (t=1)	→	BI (t=1)	0.12	0.12	0.12
	SN (t=1)	→	BI (t=1)	0.46***	0.46***	0.46***
	PBC (t=1)	→	BI (t=1)	0.28***	0.28***	0.28***
	PBC (t=1)	→	USE (t=2)	-0.01	-0.01	-0.01
	BI (t=1)	→	USE (t=2)	0.50***	0.50***	0.50***
	A (t=2)	→	BI (t=2)	0.29***	0.18*	0.18*
	SN (t=2)	→	BI (t=2)	0.08	0.04	0.04
	PBC (t=2)	→	BI (t=2)	0.28***	0.20**	0.20**
	PBC (t=2)	→	USE (t=3)	0.10	0.06	0.06
	BI (t=2)	→	USE (t=3)	0.47***	0.35***	0.35***
	A (t=3)	→	BI (t=3)	0.10	0.03	0.01
	SN (t=3)	→	BI (t=3)	0.04	0.04	0.00
	PBC (t=3)	→	BI (t=3)	0.46***	0.36***	0.37***
	PBC (t=3)	→	USE (t=4)	0.06	-0.03	-0.05
	BI (t=3)	→	USE (t=4)	0.46***	0.35***	0.31***
Sequential Update	A (t=1)	→	A (t=2)		0.22**	0.22**
	SN (t=1)	→	SN (t=2)		0.14	0.14
	PBC (t=1)	→	PBC (t=2)		0.33***	0.33***
	BI (t=1)	→	BI (t=2)		0.22**	0.22**
	A (t=2)	→	A (t=3)		0.21**	0.16*
	SN (t=2)	→	SN (t=3)		0.20**	0.17*
	PBC (t=2)	→	PBC (t=3)		0.20**	0.14
	BI (t=2)	→	BI (t=3)		0.34***	0.26***
Feedback	USE (t=2)	→	A (t=2)		0.31***	0.31***
	USE (t=2)	→	SN (t=2)		0.16	0.16
	USE (t=2)	→	PBC (t=2)		0.18*	0.18*
	USE (t=2)	→	BI (t=2)		0.15	0.15
	USE (t=3)	→	A (t=3)		0.14	0.10
	USE (t=3)	→	SN (t=3)		0.20**	0.14
	USE (t=3)	→	PBC (t=3)		0.30***	0.28***
	USE (t=3)	→	BI (t=3)		0.06	0.01
Habit	USE (t=2)	→	USE (t=3)		0.35***	0.35***
	USE (t=3)	→	USE (t=4)		0.42***	0.33***
Distal Sequential Update	A (t=1)	→	A (t=3)			0.22**
	SN (t=1)	→	SN (t=3)			0.22**
	PBC (t=1)	→	PBC (t=3)			0.17**
	BI (t=1)	→	BI (t=3)			0.26***
Distal Habit	USE (t=2)	→	USE (t=4)			0.21**
	Squared Multiple Correlations					
	BI (t=1)			0.40	0.40	0.40
	USE (t=2)			0.25	0.25	0.25
	BI (t=2)			0.18	0.28	0.28
	USE (t=3)			0.26	0.37	0.37
	BI (t=3)			0.24	0.36	0.42
	USE (t=4)			0.24	0.38	0.41

Notes:

- A = attitude; SN = subjective norm; PBC = perceived behavioral control; BI = behavioral intention; USE = system usage.
- $^{*}p$ <0.05, $^{**}p$ <0.01, $^{***}p$ <0.001 (two-tailed).