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Abstract

Information systems researchers have applied the theories of reasoned action (Fishbein and Ajzen 1975) and planned behavior (Ajzen 1985, 1988) to predict user intention and usage of information technology (IT). Most studies have assumed independent relationships among the determinants of user intention and usage. It is important to examine the interdependencies among these variables to avoid model misspecifications and misinterpretation of results.

Using a longitudinal sample of 136 users, this study tests interdependencies among the determinants in the theory of planned behavior model of IT usage. The results generally support the predictive validity of the theory and its hypothesized paths with the exception of a nonsignificant link from subjective norms to behavioral intentions. Six hypotheses concerning the crossover effects between the antecedent variables were supported. The addition of these crossover paths significantly improved the overall model fit. These findings suggest that the structure underlying the theory of planned behavior is richer in content and more complex than is often presumed, particularly with regard to the normative components.

1. INTRODUCTION

Understanding usage is an increasingly important area for research in light of its implications for IT effectiveness (DeLone and McLean 1992; Trice and Tracy 1988). A stream of research has emerged that studies the determinants of IT usage by applying theories from social psychology, such as the theory of reasoned action (TRA) (Fishbein and Ajzen 1975) and the theory of planned behavior (TPB) (Ajzen 1985, 1988). From this stream, the technology acceptance model (TAM) developed by Davis and his colleagues (Davis 1989; Davis, Baggozzi and Warshaw 1989) has emerged as a powerful and parsimonious IT-specific framework for understanding user intention and behavior.

Although empirical studies have shown the predictive validity of various intention-based models (e.g., Davis, Baggozzi and Warshaw 1989; Mathieson 1991; Taylor and Todd 1995), these studies have not produced consistent results about the relationships among the determinants of user intention and behavior. For example, Davis, Baggozzi and Warshaw found that social influence variables had no effect on intention and thereby excluded social norms from TAM. Although Mathieson supports Davis, Baggozzi and Warshaw, Taylor and Todd found that social norms directly affected intention. These inconsistent findings and deviations from theory predictions warrant additional research. Furthermore, researchers have accepted the underlying assumptions of TRA and TPB that the antecedent variables of intention and usage are independent. The importance of carefully examining such assumptions when theories are "borrowed" and applied in IS has been pointed out (Zmud and Boynton 1991).

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In fact, although not explicitly investigated, some studies have found these antecedent variables to be correlated. For example, TAM specifies that perceived ease of use impacts directly on perceived usefulness. Taylor and Todd found high correlations among some of the antecedent variables and suggested future research investigate these relationships.

In this spirit, this study expands the intention-based theories by explicitly modeling variable interdependencies that have not previously been examined. Since TRA and TAM are submodels of TPB, the study focuses primarily on the relationships among the antecedent variables in TPB.

2. THEORETICAL BACKGROUND

In this section, we provide a brief review of the general structure and concepts of TRA, TPB and TAM (Figure 1).

2.1 Theory of Reasoned Action (TRA)

TRA hypothesizes that behavior is best predicted by a stated intention to behave in a specified way at some subsequent point in time (Figure 1a). Intentions are assumed to capture the motivational factors that influence a behavior and are postulated to be determined by two conceptually independent determinants: attitude toward the behavior (the degree to which a person has a favorable or unfavorable evaluation or appraisal of the behavior in question) and subjective norm (the perceived social pressure to perform or not to perform the behavior).

Attitude (*Aact*) and subjective norm (*SN*) are each, in turn, functions of underlying belief structures, i.e., $\mathrm{Aact} = \sum_{i=1}^{m} b_i e_i$ (where b_i = the expectation that performing a specific behavior will lead to a certain outcome *I*, e_i = evaluation of the desirability of the outcome); $\mathrm{SN} = \sum_{j=1}^{n} nb_j mc_j$ (where nb_j = normative belief about the behavioral expectations of a significant referent *j*, mc_j = motivation to comply to that referent).

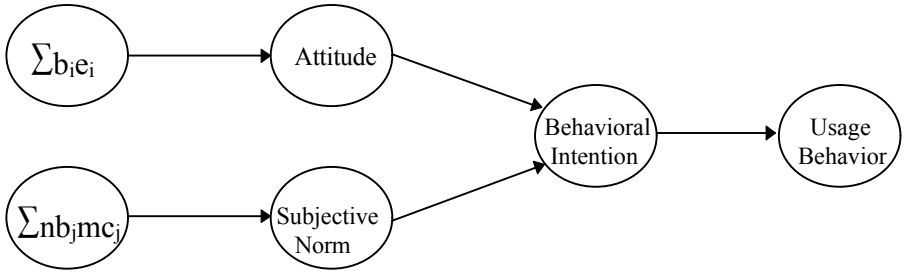
Although TRA has generally received empirical support in various studies (for reviews on TRA, see Farley, Lehmann and Ryan 1981; Sheppard, Harwich and Warshaw 1988), it has been criticized as being only applicable to behaviors that are under volitional control. For behaviors over which the individual does not have volitional control, such as IT use which requires both access to computer systems and skills of using the systems, TRA is probably insufficient.

2.2 Theory of Planned Behavior (TPB)

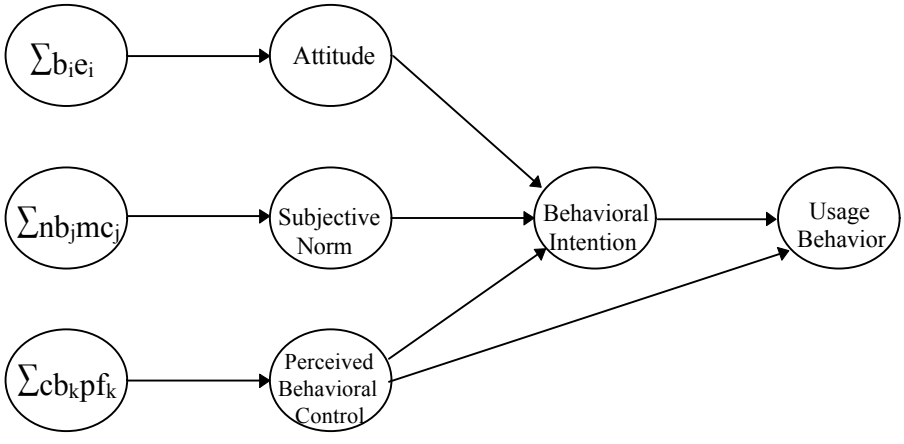
TPB is an extension of TRA to deal with behaviors over which people have incomplete volitional control (Figure 1b). TPB differs from TRA in its addition of perceived behavioral control which refers to people's perception of the ease or difficulty of performing the behavior. It is hypothesized that the performance of a behavior depends jointly on motivation (intention) and ability (behavioral control). Intentions would be expected to influence behavior to the extent that the person has behavioral control, and performance should increase with behavioral control to the extent that the person is motivated to try.

Intention is hypothesized to be jointly determined by attitude, subjective norm and perceived behavioral control, which are independent of one another. Similar to the formations of attitude and subjective norm, perceived behavioral control (*PBC*) is formulated as $\mathrm{PBC} = \sum_{K=1}^{P} cb_k pf_k$ (where cb_k = control beliefs that the individual has skills, resources and opportunities to perform the behavior, pf_k = perceived facilitation of the control belief in either inhibiting or facilitating the behavior).

1a. The Theory of Reasoned Action



1b. The Theory of Planned Behavior



1c. The Technology Acceptance Model

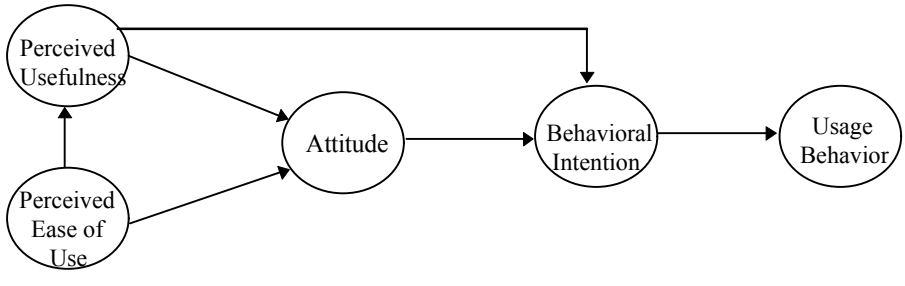


Figure 1. The Intention-Based Models of IT Usage

While TPB has been generally supported by empirical studies in various contexts (for reviews, see Ajzen 1991; Kim and Hunter 1993), many issues remain unresolved. For example, in a review of TPB research, Ajzen (1991) concludes that although attitudes, subjective norms, and perceived behavioral control are related to appropriate sets of salient beliefs, the exact nature of these relations is still uncertain. While the crossover effects in TRA have been studied (e.g., Ryan 1982; Oliver and Bearden 1985), the interdependency among the antecedent variables in TPB have not been subjected to empirical tests.

2.3 Technology Acceptance Model

Adapted from TRA, TAM (Figure 1c) models usage behavior as solely determined by behavioral intention (*BI*). Central to the model are the specifications of two beliefs, perceived usefulness (*U*) and perceived ease of use (*EOU*), as determinants of attitude toward behavioral intention and IT usage (Davis, Baggozzi and Warshaw 1989). *U* refers to the user's "subjective probability that using a specific application system will increase his or her job performance" (p. 985). *EOU* is defined as the "degree to which the. . .user expects the target system to be free of effort" (p. 985). TAM specifies that, while *Aact* is jointly determined by *U* and *EOU*, *BI* is a function of both *Aact* and *U*. In addition, *EOU* impacts *BI* indirectly through both *Aact* and *U*.

In all three models, the constructs of attitude, intention and behavior are conceptually the same. *U* in TAM is similar to behavioral beliefs ($\sum_{i=1}^{m} b_i e_i$) in TRA and TPB, whereas *EOU* can be considered as the skill aspects of control beliefs ($\sum_{K=1}^{P} cb_k pf_k$) in TPB (Mathieson 1991). Thus, TAM and TRA can be described as submodels of TPB.

2.4 Empirical Research Studies

Empirical studies related to the intention-based models of IT usage have centered around (1) comparisons of models (Table 1a), (2) testing IT usage models that are variations of TRA or TAM (Table 1b), and (3) instrument development for TAM's perceived ease of use and usefulness scales (Table 1c).

In general, these studies agree on the validity of the models in predicting intention and usage behavior. Controversies seem to come from model specifications or how salient beliefs, attitude, social norm and perceived behavioral control impact behavioral intentions and usage. Some results deviated significantly from theory predictions. For example, inconsistencies exist as to the roles of social norms and perceived behavioral controls (Davis, Baggozzi and Warshaw 1989; Mathieson 1991; Taylor and Todd 1995). Hill, Smith and Mann (1987) found significant effects of self-efficacy of computer use and instrumentality (behavioral beliefs) on students' intentions to enroll in computer-related courses and subsequent preenrollment. Igbaria, Guimaraes and Davis (1995) found that perceived usefulness and ease of use directly impact usage of IT.

3. RESEARCH MODEL AND HYPOTHESES

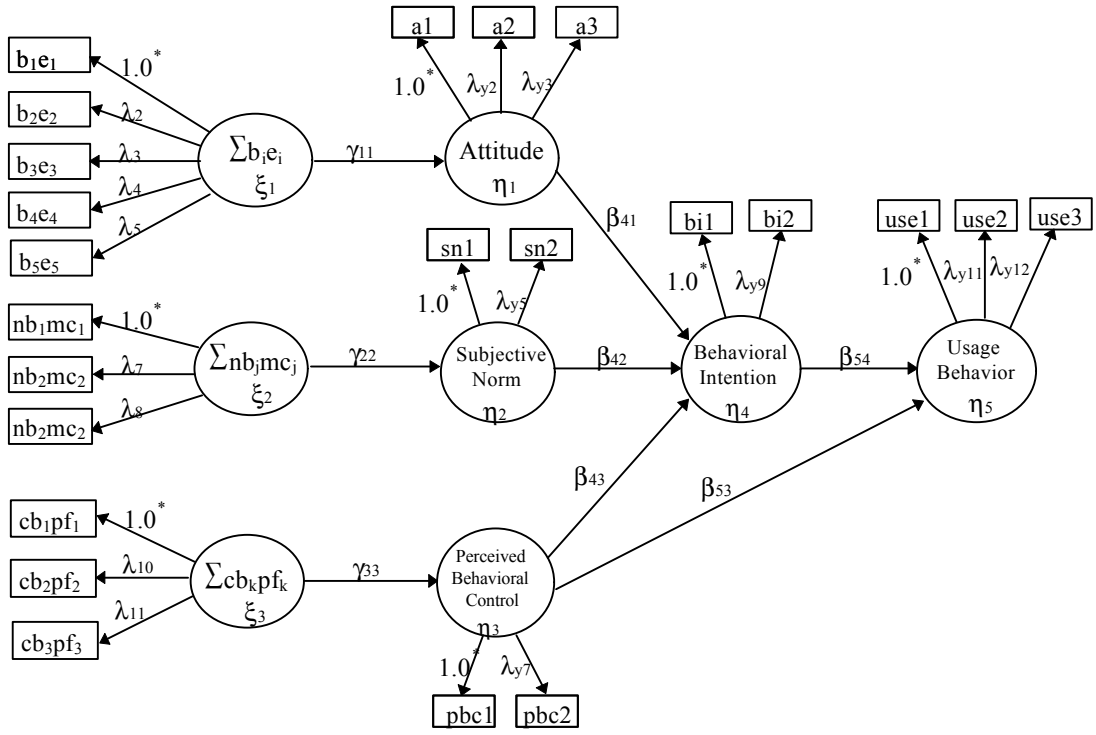
Since TAM and TRA are submodels of TPB, this study focuses on the interdependencies among the determinants in the TPB model. To test alternative models with hypothesized crossover paths, the TPB model is used as a baseline model (see Figure 2). These crossover paths are those which have received the most support in the literature.

3.1 Correlations among the Belief Structures

The assumption of TPB that behavioral beliefs, normative beliefs and control beliefs are parallel and independent (Ajzen 1985, 1988) has been under criticism. Miniard and Cohen (1983) argue that although these behavioral and normative beliefs may be conceptually independent, they are not causally independent. Azjen (1991) acknowledge that the "crossover" effects are unavoidable because these beliefs are intertwined to some extent. Liska (1984) points out that behavioral beliefs and normative

Table 1. Summary of Empirical Studies Related to Intention-Based Models of IT Usage

Authors	Objective of Study	Key Constructs
1(a) Model Comparisons		
Davis Bagozzi and Warshaw (1989)	Compare TAM and TRA	All components of TAM and TRA
Mathieson (1991)	Compare TAM and TPB	All components of TAM and TPB
Taylor and Todd (1995)	Compare TAM, TPB and a decomposed model	All components of TAM and TPB A TPB model with decomposed beliefs (perceived usefulness, ease of use, compatibility,peer influence, superior's influence, self-efficacy, resource facilitation, technology facilitation
1(b) Variations of TRA/TAM Model		
Hill, Smith and Mann (1987)	Test effects of efficacy and beliefs on intention, choice of computer courses	Instrumentality beliefs, efficacy, intentions, preenrollment of computer-related courses
Chin and Gopal (1995)	Test relative importance of salient beliefs on intention to adopt GSS	Relative advantage, ease of use, enjoyment, compatibility, intention to adopt GSS
Igbaria, Guimaraes and Davis (1995)	Test determinants of microcomputer usage	External variables, ease of use, usefulness, microcomputer usage
1(c) TAM Instrument		
Davis (1989)	Development of TAM instrument	Perceived usefulness and ease of use, software usage
Adams, Nelson and Todd (1992)	Replication of Davis (1989)	Perceived usefulness and ease of use, software usage
Hendrickson, Massey and Cronan (1993)	Test-retest reliability of TAM instrument	Perceived usefulness and ease of use
Segars and Grover (1993)	Confirmatory factor analysis of TAM instrument	Perceived usefulness and ease of use
Szajna (1994)	Predictive validation of TAM instrument	Perceived usefulness and ease of use
Chin and Todd (1995)	Factor structure of TAM instrument	Perceived usefulness and ease of use



Hypothesis	Crossover-Links	Parameters
H1	$\sum b_i e_i$, $\sum nb_j mc_j$, $\sum cb_k pf_k$	ϕ_{21}, ϕ_{31}, ϕ_{32}
H2	$\sum nb_j mc_j \rightarrow$ Aact	γ_{12}
H3	SN $\rightarrow$ Aact	β_{12}
H4	$\sum cb_k pf_k \rightarrow$ Aact	γ_{13}
H5	PBC $\rightarrow$ Aact	β_{13}
H6	$\sum b_i e_i \rightarrow$ BI	γ_{41}

Figure 2. Research Models and Hypotheses

beliefs may influence each other because beliefs about others' expectations can be used to infer the consequences of behavior, and beliefs about the social consequences of behavior can be used to infer others' expectations.

Some studies related to TAM have shown strong correlations between perceived usefulness (behavioral beliefs) and perceived ease of use (control beliefs) (e.g., Adams, Nelson and Todd 1992; Davis 1989; Davis, Baggozzi and Warshaw 1989). Taylor and Todd recognized the high correlations among the three belief structures of TPB.

Based on these arguments and findings, we propose:

Hypothesis 1: There are relationships among the three belief structures (behavioral beliefs, normative beliefs, and control beliefs).

3.2 Crossover Effects of Social Influences

Although TPB postulates that normative beliefs and social norms are independent of the other variables, there is both theoretical and empirical evidence that they have strong impacts on the formation of attitude toward the behavior.

Insko and Cialdini's (1969) two-factor theory of verbal conditioning provides a motivational basis for explaining how social influence affects attitude. Normative information from important social referents has two consequences. First, it signals the direction of the attitudinal norm, and second, it implies that important others will like the subject for holding an attitude consistent with these norms. In the case of IT use, Robertson (1989) found that social groups influence the perceptions of individuals by affecting how IT is interpreted and also by placing social pressures and demands on IT usage.

The literature on persuasive communications provides an informational basis for the linkage of social influence to attitude. A persuasive message that attacks beliefs about an object is typically found to produce changes in attitudes toward the object (Petty and Cacioppo 1986). In the case of IT use, the influence of normative structure and social norms on attitude may be strong where a normative referent, e.g., an expert or a superior, serves as a source of information in a person's attitude formation toward IT use. Ginzberg (1981) found that users' exposure to positive, motivational messages tended to improve attitudes, independent of the actual quality of the systems. Galletta et al. (1995) found that social influence from peers through informal word-of-mouth communication significantly impacts new user attitudes toward a software package.

The crossover effects of normative structure and social norms on attitudes have been supported by some empirical studied on TRA (e.g., Ryan 1982; Oliver and Bearden 1985). Shimp and Kavas (1984) found a strong causal effect of normative structure on attitude and the addition of this linkage resulted in a better model fit.

Based on the above review, we propose that:

Hypothesis 2: There is a direct effect of normative beliefs on attitude.
Hypothesis: 3: There is a direct effect of social norm on attitude.

3.3 Crossover Effects of Perceived Behavioral Control (*PBC*)

PBC consists of two belief components: facilitating conditions (which reflect beliefs about the availability of resources and opportunities required to perform a behavior) and self-efficacy (which reflects one's self-confidence in his/her skills or ability to perform a behavior (Bandura 1982).

The effect of *PBC* on attitude formation is supported by the social psychology literature. For example, Van Ryn and Vinokur (1990) argue that *PBC* functions as a precursor to attitudes. Ajzen (1991) suggests that *PBC*, especially its self-efficacy component, can significantly influence choice of activities.

Studies of TAM have shown that perceived ease of use directly affects attitudes (e.g., Adams, Nelson and Todd 1992; Davis 1989; Davis, Baggozzi and Warshaw 1989). Howard and Mendelow (1991) found that computer self-efficacy was related to an individual's attitude toward computers. Howard and Smith (1986) found that computer anxious managers are more negative about the usefulness of computers in management tasks.

This literature suggests that:

Hypothesis 4: There is a direct effect of control beliefs on attitude.
Hypothesis 5: There is a direct effect of perceived behavioral control on attitude.

3.4 Crossover Effects of Behavioral Beliefs

The hypothesis of the direct effects of behavioral beliefs on IT intentions is derived from TAM (Davis 1989; Davis, Baggozzi and Warshaw 1989). An individual's behavioral beliefs and attitude may not be congruent with each other, i.e., a person may dislike a system but still use it because he/she believes the usage will result in better job performance (Davis, Baggozzi and Warshaw 1989). On the other hand, although an individual knows the benefits of using IT, that individual may still not use it because he/she does not like it or its design (Markus 1994).

The direct link from behavioral beliefs to intention usage has received support in the IS literature (e.g., Davis, Baggozzi and Warshaw 1989; Mathieson 1991). Thus:

Hypothesis 6: There is a direct effect of behavior beliefs on behavioral intentions.

3.5 Research Methods

Sample. Data were collected through questionnaires administered in two waves from full-time MBA students during their first term in a large mid-western US university. The first questionnaire was administered to all the new MBA students during their orientation week and contained measures for all of the non-behavioral variables in the TPB model as well as some demographic characteristics. Of the 250 questionnaires distributed, 184 were collected (73.6%). Fifteen questionnaires were discarded because of incomplete responses or unidentified names, which resulted in a total of 169 usable responses (67.6%).

Eleven weeks later, at the end of the first term, the second questionnaire containing usage measures was distributed to the 169 MBA students from the first survey. A total of 138 questionnaires were collected. Due to incomplete responses, two questionnaires were discarded, resulting in 136 usable responses (80.5% for the second survey and 54.4% for the overall).

The sample consisted of 90 males (66.2%) and 46 females (33.8%), with an average age of 26.6, an average working experience of 4.2 years and computer experience of 7.2 years. The demographic profile of the sample was very similar to that of the overall MBA students in the same year, indicating that the sample was not biased in comparison to its population. To test non-response bias, the demographic characteristics of the respondents to the second survey were compared to those of the nonrespondents. The comparison showed no significant differences, indicating that non-response bias was not a serous concern for our results.

Measures. Measures of the salient beliefs were constructed based on the results of an elicitation process (see Appendix A) recommended by Ajzen and Fishbein (1980). This procedure has been used by Davis, Baggozzi and Warshaw. Questions measuring the other constructs were adapted from the literature. A list of the measures is provided in Appendix B.

Behavioral beliefs (b_i) were measured by five questions concerning the expected outcomes of using computers in the MBA program. *Evaluations (e_i)* corresponding to the behavioral beliefs *(b_i)* were measured by asking respondents to evaluate the importance of each outcome item.

Normative beliefs (nb_j) were measured by asking respondents the extent to which they believe professors teaching courses, project teammates, and future employers will encourage their use of computers. *Motivation to comply (mc_j)* was measured by the importance of the referents' opinions to respondents.

Control beliefs (cb_k) were measured by three items regarding the perceived factors that facilitate/impede the MBAs from effectively using computers. *Perceived facilitation (pf_k)* was measured by the importance of the control factors to respondents.

Attitudes toward using computers were measured by three items adapted from Davis, Baggozzi and Warshaw concerning the extent to which they perceive using computers as desirable, good, and useful. *Subjective norms* were measured by three items adapted from Mathieson. *Perceived behavioral control (PBC)* was measured by two items adapted from Davis, Baggozzi and Warshaw regarding the extent to which respondents perceive that they would be able to (1) use computers and (2) get computers to do what they need to do.

Behavioral intention to use computers was measured by two items adapted from Davis, Baggozzi and Warshaw and Mathieson regarding to what extent and how frequently respondents intend to use computers in the program. *Usage of computers* was measured in the second survey by three items adapted from Davis, Baggozzi and Warshaw.

As shown in Figure 2, all constructs were treated as latent variables with multiple measures. For all the belief structures ($\Sigma e_i b_i$, $\Sigma nb_j mc_j$, and $\Sigma cb_k pf_k$) multidimensional rather than unidimensional measures were used. For each component ($e_i b_i$, $nb_j mc_j$, and $cb_k pf_k$) of the belief structures, a score was calculated using the expectancy-value formulation suggested in TPB (Ajzen 1985, 1991). The use of decomposed measures has the advantage of overcoming problems associated with additive formulation of the belief structure scores.

Data Analysis. The hypotheses are tested using LISREL 8 (Jöreskog and Sorbom 1993). LISREL has the advantage of simultaneously testing structural and measurement models and is suggested as an appropriate technique for testing well-developed theories (Bollen 1989). For this study, LISREL is particularly useful because it permits comparisons of alternative models and simultaneous estimation of all path coefficients, including the crossover paths, which are normally ignored in the regression approach.

The data analysis consisted of three stages. First, a confirmatory factor analysis was performed to examine the validity and reliability of the measurement. Second, the hypotheses were tested by (1) comparing model fits of the alternative models and (2) examining the significance of the crossover path estimates. Third, the impacts of the crossover effects were further explored by decomposing their effects on behavioral intention and usage.

The notion of a hierarchy of nested models is particularly useful for testing the importance of the addition of parameter(s) to the overall model (Bentler 1990). In this study, the hierarchy of nested models consists of five alternative models (Figure 3), starting with the baseline model (Model 1). The baseline model is the most restrictive model in the hierarchy with only the paths specified in the TPB model. Model 2 is formed by adding correlational paths among the beliefs structures (Hypothesis 1) to Model 1. Model 3 adds three more paths to Model 2, i.e., paths from normative beliefs to attitude (Hypothesis 2), from control beliefs to attitude (Hypothesis 4), and from behavioral beliefs to intention (Hypothesis 6). Parallel to Model 3, Model 4 adds three additional paths to Model 2, i.e., paths from subjective norms to attitude (Hypothesis 3), from perceived behavioral control to attitude (Hypothesis 5), and from behavioral beliefs to intentions (Hypothesis 6). Model 5, the least restrictive model in the hierarchy, consists of all the hypothesized crossover paths.

Model fits were evaluated using four indexes, including the traditional χ^2 test, the adjusted goodness of fit index (AGFI) (Jöreskog and Sorbom 1993), the relative non-centrality index (RNI) (McDonald and Marsh 1990), and the root mean square error of approximation (RMSEA) (Bollen 1989). In this study, models with AGFI greater than .80, RNI greater than .90, and RMSEA less than .08 are considered as good fit (Marsh 1994).

In addition, two indexes were used in comparing the alternative models: ratio of χ^2 to degrees of freedom and significance test of incremental change in χ^2 between two nested models (Bentler and Bonett 1980; Bollen 1989). Marsh and Hocever (1985) recommend that ratios lower than 2 indicate a reasonable fit.

4. RESULTS

4.1 Measurement Model Evaluation

The measurement model was evaluated by testing the overall model fit and examining the validity and reliability of the indicators. Estimates of the fit indexes for the measurement model were χ^2_{202}=318.05 (p<.0001), AGFI=.81, RMSEA=.065 and RNI=.90. Although the χ^2 value was significant, the other three indexes are all indicative of reasonable fit of the measurement model.

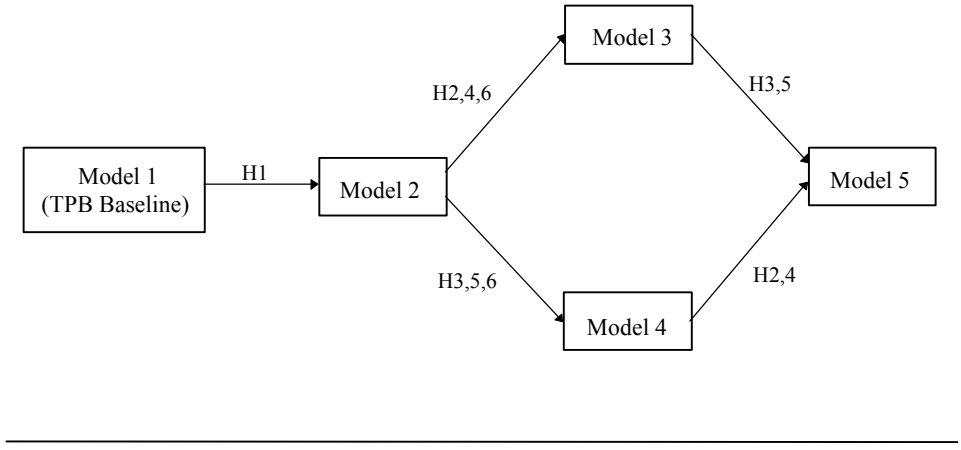


Figure 3. A Hierarchy of Nested Models and Hypotheses

The standardized factor loadings of the items were used as indicators of the validity of the observed variables, with critical values above 2.0 being considered significant (Bollen 1989). The internal consistency indexes which were calculated based on the factor loadings were used as more conservative indicators of the reliability of the measures, with values greater than .70 considered reliable (Fornell and Larker 1981).

Table 2 presents estimates for the standardized factor loadings and their corresponding critical values, and the reliability index for each construct. Each item significantly loaded on its hypothesized construct. In addition, there was little variance in the factor loadings within each construct, indicating that the items seem to contribute equally to the formation of the construct. With the exception of the *perceived behavioral control* scale, reliability estimates for all of the scales were above .70. Overall, the confirmatory factor analysis suggests that the measures provide sufficient validity and reliability.

4.2 Structural Model Results

Prior to testing the crossover effects, we first examined the explanatory power and path coefficients of the baseline TPB model. As shown in Table 3, the overall fit statistics indicate that the baseline TPB model provides a marginal fit to the data (χ^2_{222}=429.27, p<.00001, AGFI=.73, RMSEA=.083 and RNI=.80). The TPB model provides sufficient explanatory power, accounting for 31% of the variance in behavior, 46% in behavioral intention, 52% in attitude, 37% in subjective norms, and 88% in perceived behavioral control. Except for the path from $\sum nb_j mc_j$ to subjective norms, all path coefficients are significant as hypothesized. These results suggest that although the baseline TPB model only fits the data marginally, it does provide sufficient predictive validity.

To compare the differences in overall model fit between the alternative models, a significance test of χ^2 differences was performed (Bentler and Bonett 1980). Table 4 shows that, compared to the baseline TPB model, all four alternative models with crossover paths provide significantly better fit to the data. This suggests that the additions of the crossover paths significantly improve the overall model fit of the TPB model, thus further tests of the crossover effects are warranted.

Table 2. Confirmatory Factor Analysis of Measurement Model

Constructs/Indicators	Standardized factor loadings	Critical ratio	Scale reliability
$\beta_i e_i$			.80
$b_1 e_1$	.70	–	
$b_2 e_2$	.69	6.99	
$b_3 e_3$	.73	7.31	
$b_4 e_4$	.59	6.09	
$b_5 e_5$	.61	5.78	
$\beta nb_j mc_j$			.76
$nb_1 mc_1$	.66	–	
$nb_2 mc_2$	.70	6.45	
$nb_3 mc_3$	.77	6.77	
$\beta cb_k pf_k$			.71
$cb_1 pf_1$	.68	–	
$cb_2 pf_2$	.67	6.13	
$cb_3 pf_3$	.48	4.67	
Attitudes			.78
a1	.64	–	
a2	.74	6.59	
a3	.78	6.70	
Subjective norms			.88
sn1	.91	–	
sn2	.85	9.46	
Perceived control			.65
pcb1	.68	–	
pcb2	.61	5.20	
Intentions			.90
bi1	.84	–	
bi2	.95	9.17	
Usage			.70
use1	.58	–	
use2	.60	4.28	
use3	.64	4.45	

Note: – = a constrained parameter.

Table 3. Parameter Estimates and Model Fit Indexes

		Model				
	Coefficients	1	2	3	4	5
Basic TPB Paths						
$\mathfrak{Z}\, b_i e_i$ — *Aact*	γ_{11}	.72[a]	.75[a]	.56[a]	.56[a]	.55[a]
$\mathfrak{Z}\, nb_j mc_j$ — *SN*	γ_{22}	.61[a]	.62[a]	.49[a]	.62[a]	.58[a]
$\mathfrak{Z}\, cb_k pf_k$ — *PBC*	γ_{33}	.94[a]	.92[a]	.87[a]	.87[a]	.91[a]
Aact — *BI*	β_{41}	.56[a]	.54[a]	.51[a]	.54[a]	.54[a]
SN — *BI*	β_{42}	.11	.14	.13	.15	.13
PCB — *BI*	β_{43}	.40[a]	.45[a]	.38[a]	.39[a]	.39[a]
BI — *Usage*	β_{54}	.32[a]	.32[a]	.33[a]	.35[a]	.35[a]
PCB — *Usage*	β_{53}	.49[a]	.49[a]	.48[a]	.47[a]	.47[a]
Extended Crossover Paths						
$\mathfrak{Z}\, b_i e_i$ — $\mathfrak{Z}\, nb_j mc_j$	ϕ_{21}	—	.27[a]	.26[a]	.27[a]	.27[a]
$\mathfrak{Z}\, nb_j mc_j$ — $\mathfrak{Z}\, cb_k pf_k$	ϕ_{32}	—	.23[a]	.22[a]	.22[a]	.22[a]
$\mathfrak{Z}\, b_i e_i$ — $\mathfrak{Z}\, cb_k pf_k$	ϕ_{31}	—	.31	.30[a]	.31[a]	.31[a]
$\mathfrak{Z}\, nb_j mc_j$ — *Aact*	γ_{12}	—	—	.36[a]	—	.04
$\mathfrak{Z}\, cb_k pf_k$ — *Aact*	γ_{13}	—	—	.39[a]	—	.11
$\mathfrak{Z}\, b_i e_i$ — *BI*	γ_{41}	—	—	.29[b]	.34[a]	.34[a]
SN — *Aact*	β_{12}	—	—	—	.37[a]	.36[a]
PCB — *Aact*	β_{13}	—	—	—	.44[a]	.40[a]
Model Fit Indexes						
Chi-square	χ^2	429.27	344.37	332.91	327.19	327.05
Degree of freedom	df	222	219	216	216	214
Ratio	χ^2/df	1.943	1.573	1.541	1.514	1.528
AGFI		.73	.82	.83	.83	.83
RMSEA		0.83	0.65	.064	0.63	0.63
RNI		.80	.89	.90	.90	.90

Note: AGFI - Adjusted Goodness of Fit Index; RMSEA - Root Mean Square Error of Approximation, RNI - Relative Non-Centrality Index.
Path coefficients shown are standardized solutions; [a]P<.01, [b]P<.05.

The crossover hypotheses were tested based on hierarchical comparisons of alternative models. Model 2 allows the three beliefs structures to be correlated. Table 3 shows that Model 2 fits the data satisfactorily and all three cross-over correlations are significant (ϕ_{21}=.27, ϕ_{32}=.23, ϕ_{31}=.31, all p<.01). In addition, Table 4 shows that, by adding the three correlations, Model 2 provides significant improvement in model fit over the baseline TPB model (χ_3=84.90, p<.0001). Therefore, Hypothesis 1 is supported.

Model 3 adds three more crossover paths (i.e., from $\mathfrak{Z} nb_j mc_j$ to attitude, from $\mathfrak{Z} cb_k pf_k$ to attitude and from $\mathfrak{Z} b_i e_i$ to behavioral intentions) to Model 2. The estimates of the three path coefficients (Table 3) are all significant (γ_{12}=.36, p<.01; γ_{13}=.39, p<.01; γ_{41}=.26, p<.05). Table 4 shows that adding the three crossover paths in Model 3 provides significant improvement in model fit over Model 2 (χ^2_3=11.46, p<.01). Thus, Hypotheses 2, 4, and 6 are supported.

Table 4. Significance Test of Model Fit Difference

	difference in χ^2	difference in d.f.	significance
Model 2 versus Model 1	84.90	3	<.0001
Model 3 versus Model 1	96.36	6	<.0001
Model 4 versus Model 1	102.08	6	<.0001
Model 5 versus Model 1	102.22	8	<.0001
Model 3 versus Model 2	11.46	3	<.01
Model 4 versus Model 2	17.18	3	<.005
Model 5 versus Model 3	5.86	2	n.s.
Model 5 versus Model 4	.14	2	n.s.

Note: d.f.=degrees of freedom, n.s.=nonsignificant.

Model 4 adds three more paths (i.e., from $\sum b_i e_i$ to behavioral intentions, from subjective norms to attitude, and from perceived behavioral control to attitude) to Model 2. Estimates of the three added path coefficients are all significant (Table 3: γ_{41}=.34, β_{12}=.38, β_{13}=.44, all p<.01). Model 4 significantly improves overall model fit over Model 2 (Table 4: χ^2_3=17.18, p<.005). Thus, Hypotheses 3, 5, and 6 are supported.

Model 5, containing all the crossover paths, is a subsequent nested model of either Model 3 or Model 4. Table 4 indicates that the overall model fit of Model 5 is not significantly different from those of either Model 3 or Model 4. The addition of the paths from $\sum nb_j mc_j$ to attitude and from $\sum cb_k pf_k$ to attitude to Model 3 does not improve overall model fit. It can also be interpreted that adding to Model 4 paths from subjective norms to attitudes and from perceived behavioral control to attitudes does not result in better model fit. Thus, Model 3 and Model 4 are superior to Model 5 in both parsimony and model fit. However, the paths from $\sum nb_j mc_j$ to attitude and from $\sum cb_k pf_k$ to attitude are not significant (Table 4), indicating that the effects of $\sum nb_j mc_j$ and $\sum cb_k pf_k$ on attitude become nonsignificant once the crossover paths from subjective norms and perceived behavioral control to attitude are included in the model. Therefore, Hypotheses 2 and 4 are only partially supported, with the condition that the crossover paths from subjective norms and perceived behavioral control to attitude are not included in the model.

In addition, although the addition of the crossover paths does not significantly affect the magnitude of the coefficients of the paths in the baseline TPB model, it significantly enhances the model's power in explaining attitude and behavioral intentions.

4.3 Analysis of Indirect and Total Effects

To test whether adding the crossover paths changes the way through which the antecedent variables impact behavioral intentions and usage, we examined the direct, indirect and total effects of the antecedent variables on behavioral intentions and usage in each of the alternative models (Table 5). In the baseline TPB model, attitude and perceived behavioral control have significant direct effects on behavioral intentions. $\sum e_i b_i$ and $\sum cb_k pf_k$ have significant indirect effects on behavioral intentions. Perceived behavioral control and behavioral intentions impact usage directly. Only $\sum cb_k pf_k$ has a significant indirect effect on usage. $\sum e_i b_i$ and subjective norms do not have significant effects on behavioral intentions whereas $\sum e_i b_i$, $\sum nb_j mc_j$, attitude and subjective norms do not significantly affect usage.

Table 5. Effects of the Determinants on Behavioral Intention and Usage Behavior for Each of the Alternative Models

	Model														
	1			2			3			4			5		
	DE	ID	TE	DE	ID	TE	DE	ID	TE	DE	ID	TE	DE	ID	TE
<u>To Behavioral Intention</u>															
$\Sigma b_i e_i$	–	.40[a]	.40[a]	–	.41[a]	.41[a]	.29[b]	.09	.38[a]	.34[a]	.30[b]	.64[a]	.34[a]	.30[b]	.64[a]
$\Sigma nb_j mc_j$	–	.07	.07	–	.09	.09	–	.25[b]	.25[b]	–	.22[b]	.22[b]	–	.10	.10
$\Sigma cb_k pf_k$	–	.38[a]	.38[a]	–	.41[a]	.41[a]	–	.53[a]	.53[a]	–	.55[a]	.55[a]	–	.61[a]	.61[a]
Aact	.56[a]	–	.56[a]	.54[a]	–	.54[a]	.51[a]	–	.51[a]	.54[a]	–	.54[a]	.54[a]	–	.54[a]
SN	.11	–	.11	.14	–	.14	.13	–	.13	.15	.20	.35[a]	.13	.12	.25[b]
PCB	.40[a]	–	.40[a]	.45[a]	–	.45[a]	.38[a]	–	.38[a]	.39[a]	.23[b]	.62[a]	.39[a]	.22[b]	.61[a]
<u>To Usage Behavior</u>															
$\Sigma b_i e_i$	–	.13	.13	–	.13	.13	–	.18	.18	–	.22[b]	.22[b]	–	.22[b]	.22[b]
$\Sigma nb_j mc_j$	–	.02	.02	–	.03	.03	–	.08	.08	–	.10	.10	–	.11	.11
$\Sigma cb_k pf_k$	–	.58[a]	.58[a]	–	.58[a]	.58[a]	–	.59[a]	.59[a]	–	.60[a]	.60[a]	–	.64[a]	.64[a]
Aact	–	.18	.18	–	.17	.17	–	.17	.17	–	.19	.19	–	.19	.19
SN	–	.04	.04	–	.04	.04	–	.04	.04	–	.12	.12	–	.11	.11
PCB	.49[a]	.13	.62[a]	.49[a]	.14	.63[a]	.48[a]	.13	.61[a]	.47[a]	.22[b]	.69[a]	.47[a]	.21	.68[a]
BI	.32[a]	–	.32[a]	.32[a]	–	.32[a]	.33[a]	–	.33[a]	.35[a]	–	.35[a]	.35[a]	–	.35[a]

Note: DE - Direct Effects, ID - Indirect Effects, TE - Total Effects.
[a]P < .01, [b]P .05.

Table 5 suggests that the patterns of effects in Model 1 and Model 2 are very similar, indicating that correlating the three belief structures does not significantly change the interrelationships among the variables in the TPB model. The effects of variables in Model 3 are similar to those of Model 1 and Model 2 with the exceptions of a significant direct effect of $\sum e_i b_i$ on behavioral intention and a significant indirect effect of $\sum nb_j mc_j$ on behavioral intention. The addition of the crossover paths in Model 4 results in significant effects of $\sum nb_j mc_j$ and subjective norms on behavioral intentions and a significant indirect effect of $\sum e_i b_i$ on usage. Thus, the addition of the crossover paths to the TPB model has the potential of changing the effects of the variables on behavioral intentions and usage.

5. DISCUSSION

The results support six hypotheses regarding the crossover effects of the antecedents in the TPB model of IT usage. The addition of these crossover effects to the TPB model not only significantly improves the overall model fit, but also impacts the mechanisms by which the antecedent variables influence behavioral intention and usage, especially the indirect effects of social and control components.

The results generally support the baseline TPB model's explanatory power and the hypothesized paths, with the exception of a nonsignificant link from social norms to intentions. In addition, normative belief structure and social norms have no significant effects on either intentions or usage. Control beliefs, perceived behavioral control and intentions have significant effects on usage. These results are mostly consistent with the findings of Davis, Baggozzi and Warshaw and of Mathieson.

An interesting result is that the crossover effects of normative beliefs and control beliefs on attitudes are significant only when the crossover effects of social norms and perceived behavioral control on attitudes are absent from the model. In other words, once the crossover effects of social norms and perceived behavioral control on attitudes are added to the model, the crossover effects of normative beliefs and control beliefs on attitudes were overwritten and became nonsignificant. Further research is needed to explore explanations of this phenomenon.

Although normative beliefs do not have any significant effect on behavioral intentions, the addition of crossover effects from normative beliefs on attitudes results in a significant indirect effect of normative beliefs on behavioral intentions. Similarly, a significant indirect effect of social norms is found as a result of adding the crossover effects of social norms to attitudes. These results indicate that attitudes may be an important mediating variable through which normative beliefs and social norms impact behavioral intentions.

This study has some implications. First, it may help to explain the common findings in the intention-based literature that the attitude-intention coefficient was substantially greater than the subjective norm-intention coefficient. Attitude may carry the indirect effects of normative structure as well as cognitive structure, its influence on intention will be increased relative to that of subjective norm alone. Therefore, studies focusing on attitude should expand the list of determinants to include social influence.

Second, even when social norms are not found to have significant direct effects on behavioral intention, it should not be interpreted as that social norms do not have impacts on intention. Rather the crossover effects of social norms on attitudes should be examined to assess whether a significant indirect effect of social norm through attitude exists. The study suggests that the role of normative or social influence may have been somewhat underestimated in the popular conceptualizations of IT usage literature.

Third, the results of the crossover effects from normative beliefs and control beliefs as well as the strong correlations between the belief structures should also cause future research to consider the possible mechanisms by which individuals process various types of belief information. There are quite possibly multiple types of beliefs, namely, cognitive, normative with attitudinal implications, normative with subjective norm implications, control with attitudinal implications, and control with behavioral implications.

6. CONCLUSION

This study attempts to expand the intention-based theories of IT usage by challenging certain of the theories' underlying assumptions. The findings suggest that the structure underlying the theory of planned behavior is richer in content and more complex than is often presumed, particularly with regard to the normative component. Intention to use IT is not simply a function of parallel and independent sets of antecedent variables, but of a rather complex set of interdependencies. Therefore, further applications of the intention-based IT usage theories should routinely test for crossover effects and avoid the temptation to draw conclusions regarding the relative influences of beliefs, attitudes, social norms and behavioral control on intention and usage, unless the crossover effect are trivial.

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APPENDIX A. ELICITATION OF SALIENT BELIEFS

Similar to the study of Davis, Baggozzi and Warshaw (1989), salient beliefs were determined with an elicitation technique recommended by Ajzen and Fishbein (1980). Fifteen second year MBA and twelve Ph.D. students with recent MBA degrees were interviewed. They were asked to list and rank five to seven answers to six open-ended questions concerning the advantages or disadvantages of using computers in the MBA program (behavioral beliefs), who would be the people most likely to encourage/discourage MBAs to use computers (normative beliefs), and what factors would facilitate/impede MBAs' use of computers (control beliefs).

Second year MBA students and Ph.D. students were chosen because (1) they are similar to the first year students in terms of background and knowledge about computer use in the MBA programs, and (2) first year MBAs were not available at the time the questionnaire was developed.

All the responses were listed and then categorized based on common meanings of the statements. Modal items were then chosen, which resulted in five behavioral beliefs, three social referents, and three behavioral control beliefs. In the second stage, these beliefs were transformed into questionnaire items. Ten second-year MBAs were interviewed and asked to assess the appropriateness of the questions. All of the items were identified as appropriate and important and were used in the final questionnaire.

APPENDIX B. QUESTIONNAIRE ITEMS

Behavioral beliefs (b_i) (1- strongly disagree/7- strongly agree)
Using computers will make it easier for me to create/edit documents
Using computers will save me time in doing my assignments/projects
Using computers will help me produce quality presentations for my reports
Using computers will enable me to share files with my project teammates
Using computers will make my assignments/projects more accurate

Evaluations (e_i) (1- very unimportant/7- very important)
How important is it for you to create/edit documents easily
How important is it for you to get your assignments/projects done quickly
How important is it for you to produce good quality report presentation
How important is it for you to share files with your project teammates
How important is it for you to get your assignments/projects does accurately

Normative beliefs (nb_j) (1- strongly disagree/7- strongly agree)
Professors who teach courses would encourage me to use computers
Members in my team projects would want me to use computers
My feature employer will expect me to use computers

Motivation to comply (mc_j) (1- very unimportant/7- very important)
How important are the opinions of professors to you
How important are the opinions of your project teammates
How important are the opinions of your future employer

Control beliefs (cb_k) (1- strongly disagree/7- strongly agree)
I am sufficiently skilled at using computers
I often don't have the time I need to use computers
It is easy for me to learn new computer packages when I need to

Perceived facilitation (pf_k) (1- very unimportant/7- very important)
How important is it for you be sufficiently skilled at using computers
How important is it for you to have the time you need to use computers
How important is it for you to be able to learn new computer packages easily

Attitudes toward using computers (Aact) (strongly disagree/strongly agree)
It would be desirable for MBAs to use computers
Computers would be useful for me in the MBA program
It is good for MBAs ro use computers

Subjective norms (SN) (strongly disagree/strongly agree)
People whose opinions I value will encourage me to use computers
People who are important to me will support me to use computers.

Perceived behavioral control (PBC) (strongly disagree/strongly agree)
I am able to use a computer when I need to
I am able to get a computer to do what I want it to do

Behavioral intention to use computers (BI)
To what extent will you use computers in the MBA program (not at all/great extent)
How frequent do you intend to use computers in the MBA program (not at all/very frequent)

Usage of computers (B)
How many hours per week they use computers
How often do you use computers (1-less than once a week/7-more than 5 times a day)
How frequent do you use computers (1-very infrequent/7-very frequent).