December 2002

AN INVESTIGATION OF IT USAGE OVER TIME

En Mao
University of Wisconsin-Milwaukee

AN INVESTIGATION OF IT USAGE OVER TIME

En Mao
University of Wisconsin-Milwaukee
enmao@uwm.edu

Abstract

The majority of IT adoption and usage research has been limited to investigating the key determinants and validating the technology acceptance model or similar models in a static fashion. IT usage, however, is a dynamic process. Thus, the current research lacks the means to guide firms in providing a long-term IT management strategy. In this study, we investigate IT usage behavior of 80 end-users in four organizations at two points in time. TAM was assessed and the differences between the two assessments are discussed.

Introduction

Companies continue to invest in information technology despite the current economic condition because of the returns that many information technologies promise. It is more vital than ever to maximize the benefits from IT investment. However, it is not uncommon that after they spend millions of dollars in the implementation of a state-of-the-art technology, organizations have difficulty promoting the usage of the technology among the end-users. It is apparent that the management of the adoption and usage of IT require a continuous attention from the managers. However, the research in IT adoption has mainly focused on testing the key determinants, which are important for the following reasons.

First, systems development efforts can be focused on issues that affect usage. Second, with such knowledge, IT managers can predict usage of software or systems by evaluating known determinants on a trial basis that would minimize underutilization risks. Third, and most important, management can use such knowledge to promote usage. But such knowledge is static in nature while the beliefs and attitude of the end-users would change over time.

In general, there is a lack of IT usage studies over time and current research findings in the IT acceptance area provide little guidance to IT practitioners in developing strategic and long-term IT management programs. This study would demonstrate that the beliefs and determinants of IT usage are not static and IT managers must develop dynamic strategies to control IT usage.

Literature Review

In the IT acceptance research area, the technology acceptance model (TAM, Davis 1986, 1989), based on the Theory of Reasoned Action (TRA), is widely known and studied. In TAM, "perceived usefulness" and "perceived ease of use" are hypothesized as key determinants of IT acceptance through two mediating variables, user attitude and intention. The TAM model has been replicated and tested extensively and the main constructs of the model are found to be reliable and valid (e.g., Adams, et al., 1992; Chau, 1996; Chin and Todd, 1995; Davis and Venkatesh, 1995; Segars and Grover, 1993; Taylor and Todd, 1995). However, many studies proposed extensions and modifications (e.g., adding constructs and variables) to TAM based on the theory of reasoned action (TRA, Ajzen and Fishbein, 1980; Fishbein and Ajzen, 1975), the theory of planned action (TPA, Ajzen and Madden, 1986), innovation diffusion theory (Rogers, 1995), and empirical results. Next, the relevant theories are discussed.

Innovation Diffusion Theory

Among the research concepts and paradigms developed in innovation diffusion research, a major finding is that innovations (e.g. IT) possessing certain attributes are adopted more rapidly. Relative advantage, compatibility, complexity, observability, and

trialability are five perceived attributes of innovation identified by Rogers (1995), who stated that these attributes are extensively studied and tested in many innovation diffusion studies.

In their meta-analysis of innovation diffusion literature, Tornatzky and Klein (1982) reviewed 75 articles and discovered more than 30 innovation characteristics. They investigated ten major innovation characteristics: compatibility, relative advantage, complexity, cost, communicability, divisibility, profitability, social approval, trialability, and observability. The results show that compatibility, relative advantage, and complexity are the most robust measures of innovation attributes that affect innovation diffusion.

Theory of Reasoned Action (TRA)

While innovation diffusion research provides strong empirical evidence in many areas, it lacks the vigor and theoretical foundation required to explain human behavior. The theory of reasoned action model (TRA) proposed by Fishbein and Ajzen (1975) (also see, Ajzen and Fishbein, 1980; Fishbein and Ajzen, 1979) has been incorporated into recent social science literature. The theory focuses on predicting behavioral intention and actual behavior based on behavioral beliefs and subjective norms. According to TRA, " a behavioral intention measure will predict the performance of any voluntary act, unless the intention measure does not correspond to the behavioral criterion in terms of action, target, context, time-frame and/or specificity" (Sheppard et al. 1988, p. 325). Its strong predictive power of human behavior has drawn attention from multiple disciplines, such as psychology, sociology, marketing, and MIS (Sheppard, et al., 1988). In the MIS area, it serves as a theoretical foundation for technology acceptance and usage models and theories.

Technology Acceptance Model (TAM)

In a search for measures for key constructs predicting information technology use, Davis (1986, 1989) suggested and validated two key determinants of technology use: "perceived usefulness" (PU) defined as "the degree to which a person believes that using a particular system would enhance his or her job performance" (p. 320), and "perceived ease of use" (EOU) as "the degree to which a person believes that using a particular system would be free of effort" (p. 320). Simply put, the more useful and easier to use the technology is, the more likely the user will use it. The two constructs echo some of the major innovation attributes proposed in innovation diffusion research. In fact, perceived usefulness parallels relative advantage and perceived ease of use parallels complexity (Davis, et al., 1989; Karahanna, et al., 1999). The resulting model was named technology acceptance model (TAM) (Davis, 1989).

Compared to innovation diffusion theory in which a larger set of innovation attributes are proposed, TAM only accounts for two behavioral beliefs, PU and EOU. However, the literature reveals that EOU is insignificant in some studies (e.g. Adams, et al., 1992; Hu, et al., 1999, see also Table 1; Igbaria, et al., 1995). Some recent studies include a fuller set of perceived beliefs about using an innovation (e.g., Agarwal and Prasad, 1997; Karahanna, et al., 1999; Moore and Benbasat, 1991). Although the studies show the importance of other behavioral beliefs, the combinations of the behavioral beliefs are inconsistent.

In addition, the findings of the effect of subjective norm on attitude are inconclusive. In early TAM studies, subjective norm, the combination of the "beliefs that certain referents think the person should or should not perform the behavior in question" (Fishbein and Ajzen, 1975), was investigated and found to have no impact on behavioral intention. Instead of questioning the results, many studies simply excluded the dimension of subjective norm, a significant construct in TRA. Many argue that the research settings of the studies (e.g., Davis et al. 1989; Mathieson 1991) that found subjective norm had no significant influence on intention were different from organizational environment. Many of those studies were set in a laboratory environment and participants were students; therefore, there were no real consequences associated with behaviors (Taylor and Todd, 1995). The absence of consequences resulted in insignificant subjective norm effect. In the field studies, subjective norm was found to be a significant determinant of usage (e.g., Lucas and Spitler 1999; Karahanna et al. 1999; Robertson 1989).

A possible explanation to the differing results is that the attitude and beliefs and their effect on usage change over time. In the next section, we discuss the research design.

Research Methodology

First, the questionnaire was developed using the existing TAM scales and measures found in the literature. Due to space limitation, the items are not presented. The model being tested and compared across time is depicted in Figure 1. The constructs and the number of items included in each construct are shown in Table 1.

Eighty users of E-Mail from four organizations participated in this study. They were given the same survey at two different times, in June 2000 and June 2001. Shown in Table 1, the scale reliability coefficients, Cronbach's alpha, were assessed for the data collected at time 1 and time 2 and combined. All the coefficients are above the generally acceptable cutoff of .70 (Nunnally, 1967).

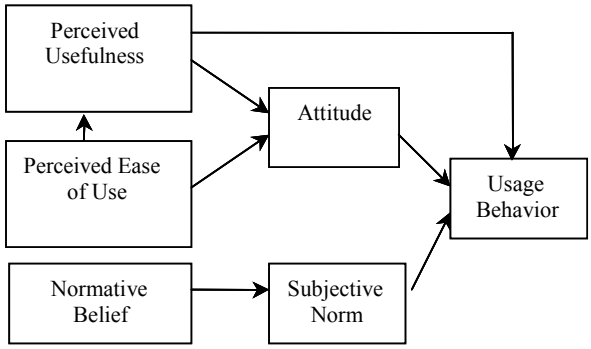


Figure 1. Research Model

Table 1. Reliability Coefficients

	Cronbach's α		
Construct (# of Items)	**Time 1**	**Time 2**	**Overall**
Perceived Usefulness (6)	.84	.96	.88
Perceived Ease of Use (5)	.74	.93	.84
Attitude (4)	.85	.95	.90
Normative Believes (6)	.92	.98	.95
Subjective Norm (2)	.90	.97	.94
Usage (4)	.74	.91	.81

Data Analysis and Results

Table 2 presents the demographic information of the subjects who participated in the survey.

Structural Model Testing

The structural model was assessed for Time 1 and Time 2 individually. Seven structural paths were evaluated. The model fit statistics are presented in Table 3. Overall, the model fit statistics suggest the model fit were adequate for both data sets to evaluate the results of the structural model.

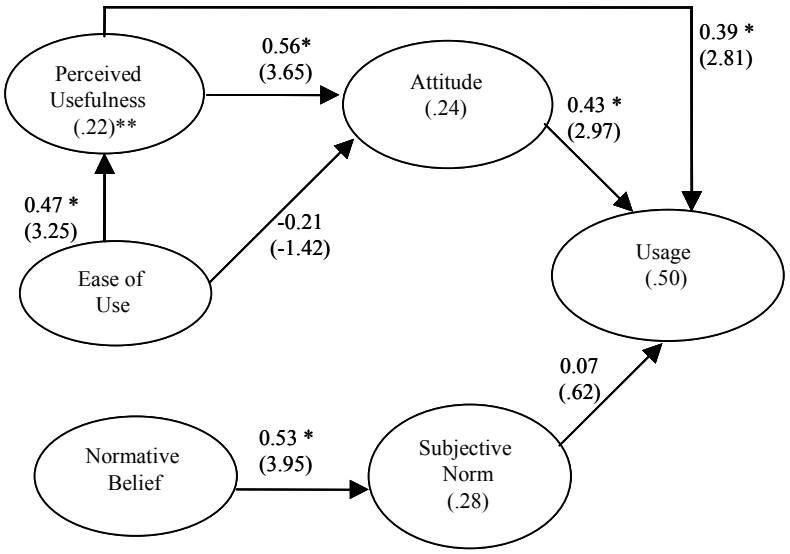
The model fit statistics for the Time 1 data were χ^2 (266 df, N = 80) = 409.44, $p < .001$, RMSEA = .083, and CFI = .88. Overall, the statistics demonstrated a marginally adequate fit of the model to the potential adopter data. Figure 2 shows the estimated standardized path coefficients and their *t*-values in the structural model for the potential adopters and the variance explained for each of the constructs. The model explained approximately 50% of the variance in usage behavior. Significant paths ($p < .05$) are indicated in Figure 2. Ease of use→attitude and subjective norm→usage are the only insignificant structural path.

The model fit statistics for the Time 2 data were χ^2 (266 df, N = 80) = 683.53, $p < .001$, RMSEA = .10, and CFI = .87. Overall, the statistics demonstrated a marginally adequate fit of the model to the potential adopter data. Figure 2 shows the estimated standardized path coefficients and their *t*-values in the structural model for the potential adopters and the variance explained for each of the constructs. The model explained approximately 49% of the variance in usage behavior. Significant paths ($p < .05$) are indicated in Figure 3. Ease of use→attitude and perceived usefulness→usage are the only insignificant structural path.

The model had adequate predictive power: $R^2_{PU} = .22$, $R^2_A = .24$, $R^2_{SN} = .28$, and $R^2_U = .50$ for the Time 1 data and $R^2_{PU} = .24$, $R^2_A = .36$, $R^2_{SN} = .40$, and $R^2_U = .49$ for the Time 2 data.

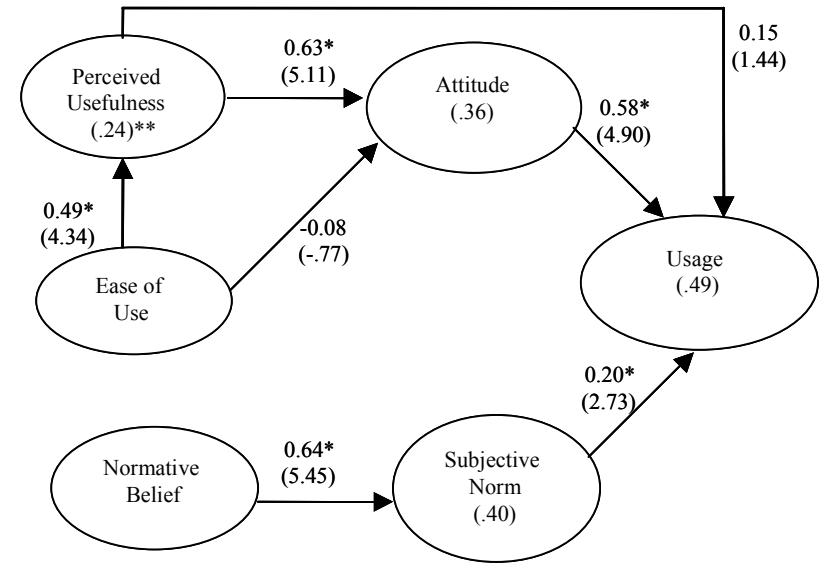
Table 2. Sample Demographics		
Variables	**Sample Composition**	Percentage
Age	18-22	7.1%
	23-28	41.1 %
	29-34	23.2 %
	35-44	16.6%
	45-55	8.4%
	55+	1.6 %
	Not reported	2.1%
Gender	Men	72.7 %
	Women	24.0 %
	Not reported	3.2%
Highest Educational Level Attained	Junior high	.6 %
	High school	1.9 %
	Associate degree	18.8 %
	College degree	50.0 %
	Master's	20.1 %
	Doctorate	5.8%
	Not reported	2.6%
Organizational level represented	Executive	17.4%
	Management Professional	72.8%
	Technical/clerk	4.3%
	Student	2.2%
	Not reported	3.3%

Table 3. Summary of Structural Model Fit Statistics				
Data Set	χ^2	*df*	**RMSEA**	**CFI**
Time 1	409.44	266	.083	.88
Time 2	683.53	266	.10	.87



* $p < .05$
** R^2
t-values of the estimated coefficients are in parentheses

Figure 2. Standardized Path Coefficients for the Time 1 Data



* p < .05
** R^2
t-values of the estimated coefficients are in parentheses

Figure 3. Standardized Path Coefficients for the Time 2 Data

The structural path coefficients estimated for both Time 1 and Time 2 are summarized in Table 4. Perceived usefulness→attitude, ease of use→perceived usefulness, normative belief→subjective norm, and attitude→usage were significant for both data sets. The structural path ease of use→attitude was not significant for either data set.

Table 4. Summary of Path Coefficients

Structural Path	Time 1	Time 2
Perceived Usefulness→Attitude	.56*	.63*
Ease of Use→Attitude	-.21	-.08
Perceived Usefulness→Usage	.39*	.15
Ease of Use→Perceived Usefulness	.47*	.49*
Normative Belief→Subjective Norm	.53*	.64*
Attitude→Usage	.43*	.58*
Subjective Norm→Usage	.07	.20*

Note: * $p < .05$

Discussions and Conclusion

The diffusion and usage of information technology certainly is not guaranteed and automatic and must be managed to realize its benefits. The findings of the study indicate that the key variables in TAM operate differently in determining attitude and usage overtime. Perceived usefulness had a significant and direct impact on usage at Time 1, however, the effect was not significant at Time 2, while the variance explained in usage did not decrease significantly. This suggests that the determents of usage are different at a later time. The management implication of this finding is that in order to promote usage, it may be more effective to gear training towards the usefulness of the technology at an early stage than later. The effect of norms showed significant difference at Time 1 and Time 2. At Time 1, the effect of subjective norm was not significant on usage; but it was significant at Time 2. The implication may be that norms play a more important role in the long run.

In this study, we demonstrated that the relationships of some key variables in the TAM model differ over time. However, future studies may be required to draw conclusive inferences from the findings. Such lines of research may help organizations design better end-user IT acceptance and usage strategies.

References

Adams, D.A., Nelson, R.R. and Todd, P.A. "Perceived Usefulness, Ease of Use, and Usage of Information Technology: A Replication," *MIS Quarterly* (16:2), 1992, pp. 227-247.

Agarwal, R. and Prasad, J. "The Role of Innovation Characteristics and Perceived Voluntariness in the Acceptance of Information Technologies," *Decision Sciences* (28:3), 1997, pp. 557-582.

Ajzen, I. and Fishbein, M. *Understanding Attitudes and Predicting Social Behavior*, Prentice-Hall, Englewood Cliffs, NJ, 1980.

Ajzen, I. and Madden, T.J. "Prediction of Goal-Directed Behavior: Attitudes, Intentions, and Perceived Behavioral control," *Journal of Experimental Social Psychology* (22), 1986, pp. 453-474.

Chau, P.Y.K. "An Empirical Assessment of a Modified Technology Acceptance Model," *Journal of Management Information Systems* (13:2), 1996, pp. 185-204.

Chin, W.W. and Todd, P.A. "On the Use, Usefulness, and Ease of Use of Structural Equation Modeling in MIS Research: A Note of Caution," *MIS Quarterly* (19:2), 1995, pp. 237-246.

Davis, F.D. "Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology," *MIS Quarterly* (13:3), 1989, pp. 319-339.

Davis, F.D., Bagozzi, R.P. and Warshaw, P.R. "User Acceptance Of Computer Technology: A Comparison Of Two," *Management Science* (35:8), 1989, pp. 982-1003.

Davis, F.D. and Venkatesh, V. "Measuring User Acceptance of Emerging Information Technologies: An Assessment of Possible Method Biases.," *Proceedings of the The 28th Hawaii International Conference on Systems Sciences*, Los Alamitos, Calif., 1995, pp. 729-736.

Fishbein, M. and Ajzen, I. *Belief, Attitude, Intention, and Behavior: An Introduction to Theory and Research.*, Addison-Wesley, Reading, MA, 1975.

Fishbein, M. and Ajzen, I. "A Theory of Reasoned Action: Some Applications and Implications," In *Nebraska Symposium on Motivation*, H. Howe and M. Page (Ed.), University of Nebraska Press, Lincoln, NB, 1979, pp. 65-116.

Hu, P.J., Chau, P.Y.K., Sheng, O.R.L. and Tam, K.Y. "Examining the Technology Acceptance Model Using Physician Acceptance of Telemedicine Technology," *Journal of Management Information Systems* (16:2), 1999, pp. 91-112.

Igbaria, M., Guimaraes, T. and Davis, G.B. "Testing the Determinants of Microcomputer Usage via a Structural Equation Model," *Journal of Management Information Systems* (11:4), 1995, pp. 87-114.

Karahanna, E., Straub, D.W. and Chervany, N.L. "Information Technology Adoption Across Time: A cross-Sectional Comparison of Pre-Adoption and Post-Adoption Beliefs," *MIS Quarterly* (23:2), 1999, pp. 183-213.

Moore, G.C. and Benbasat, I. "Development of an Instrument to Measure the Perceptions of Adopting an Information Technology Innovation," *Information Systems Research* (2:3), 1991, pp. 192-222.

Nunnally, J.C. *Psychometric Theory*, McGraw-Hill, New York, 1967.

Rogers, E.M. *Diffusion of Innovation*, Free Press, New York, 1995.

Segars, A. and Grover, V. "Re-Examining Perceived Ease of Use of Usefulness: A Confirmatory Factor Analysis," *MIS Quarterly* (17:4), 1993, pp. 517-525.

Sheppard, B.H., Hartwick, J. and Warshaw, P.R. "The Theory of Reasoned Action: A Meta-Analysis of Past Research with Recommendations for Modifications and Future Research," *Journal of Consumer Research* (15), 1988, pp. 325-343.

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