An Empirical Test of Technology Acceptance Model: The Case of Object-Oriented Computing

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Abstract

Technology Acceptance Model (TAM) has been widely used for predicting behavioral processes in which information technologies were accepted, but several previous studies point out that TAM may not explain the adoption process of complex information technologies effectively. This study empirically tests the limitation of TAM, and suggests a proposed research model by incorporating the concept of the perceived behavioral control into TAM. Study findings indicate the proposed model can predict the adoption process better than TAM does.

Introduction

Adoption of new information technologies in organizations is critical to surviving in a competitive environment. The life cycle of new information technologies is getting shorter, and the technologies themselves are becoming more complex and hard to understand. Investing new information technologies is a difficult issue for information officers in organizations. In particular, an object-orientation paradigm has been a hot issue academically, but adoption of the technology remains questionable to many information officers. Lots of research literatures on technical issues have been shown, but technology assessment of object orientation has rarely been reported.

Previous researchers have studied a variety of models for technology adoption. The typical theoretical models can be enumerated: (1) a push-pull model (Zmud, 1984), (2) a model for micro-macro relationships (Coleman, 1986), (3) a unified model for technology adoption (Kwon & Zmud, 1987), (4) a theory of reasoned action (Fishbein & Ajzen, 1975), and (5) a technology acceptance model (Davis, 1989; Davis et al., 1989). Of these models, the technology acceptance model (TAM) is considered to be a new and comprehensive one to explain the behavioral process in which an information technology is accepted. Along with the rising importance of the object-orientation technology, analysis of cognitive process of the object-oriented analysis and design has recently been reported (Detienne, 1995; Pennington et al., 1995). Previous research about affecting factors of technology adoption showed that individual, managerial, organizational, and environmental characteristics as well as personal perception of technology were considered to be important factors (Rogers, 1983; Bayer & Melone, 1989; Alexander, 1989; Leonard-Barton, 1987). The purpose of this research is to seek behavioral processes about adoption of the object-orientation technology by incorporating individual, managerial, organizational, and environmental factors into characteristics of technology and to seek the influence of the variables on adoption of that technology. In particular, this research developed a new technology adoption model based on TAM. A new model is developed by incorporating the main idea of planned behavior (Ajzen, 1991) into the original TAM. With the aim of finding a better model to explain the structure and process of technology adoption, this research will compare the original TAM with a modified TAM that is designed for this research.

Technology Acceptance Model

Davis (1986) suggested a specific technology adoption model based on the theory of reasoned action, and applied the model to computer usage behavior. In his model, every exogenous variable is assumed to precede the perception of a specific technology such as the perceived usefulness and the perceived ease of use. The perceived usefulness and ease of use are considered two predecessors affecting attitude toward the technology. Attitude toward the technology affects the behavioral intention to use that technology and then this behavioral intention leads to actual usage of the technology. Figure 1 concisely depicts the process of the technology acceptance model.

Theory of Planned behavior

Modifying the reasoned action theory (Fishbein &

Ajzen, 1975), Ajzen (1991) states that a specific behavior is determined by behavioral intention and perceived behavioral control. Behavioral intention is determined by three factors; attitude toward the behavior, subjective norm, and perceived behavioral control. The planned behavior theory is characterized by the concept of perceived behavioral control. With the idea that behavioral achievement depends on both motivation (intention) and ability (behavioral control), this theory emphasizes that the resources and opportunities available to a person determine the level of perceived behavioral control. Perceived behavioral control plays an important part in the theory of planned behavior in that it affects both the behavioral intention and actual behavior. The theory of planned behavior differs from the theory of reasoned action because of its introduction of the perceived behavioral control.

A Proposed Model

This research develops a new technology adoption model by incorporating the main concept of perceived behavioral control of the planned behavior theory into TAM. In line with the idea of planned behavior theory, the difference between TAM and the new model is the position of individual, managerial, and organizational variables. In the new model, these variables, which were considered exogenous variables to precede usefulness and ease of use of technology in original TAM, are located to affect both the behavioral intention and actual behavior. Figure 2 shows the main picture of the newly developed model.

Data Collection

Data were gathered from active members of the Data Processing Management Association (DPMA) in February, 1996. Before the final questionnaires were distributed, phone calls were made to local presidents of DPMA in order to ask for the support of member's participation in this survey. Subsequently, lists of DPMA directories were obtained with their permission. Eight hundred fifty-four questionnaires were sent to nine DPMA chapters across four mid-western states. Six of these questionnaires were returned because of incorrect addresses. One hundred twenty-seven subjects responded to the questionnaires (the response rate = 14.9%). The response rate was relatively low because using object orientation technique was not so popular to the DPMA members as the authors expected. After losing eighteen persons who did not answer completely because they were not familiar with using object orientation technique, 109 subjects who have experiences in using both the structured methods and object orientation were included in the overall statistical analysis.

88 cases of those were included in the final statistical analysis due to the listwise deletion of missing values. The average age of the subjects is 43.4 years. The percent of males is 78 and that of females is 22. Most subjects have a job title of supervisor (42%), while remaining subjects are distributed among technical and managerial jobs. The average job experience is 18 years, which shows relatively high IS experience.

Measures

This study includes research variables about two types of the object-orientation technology: object-oriented programming (Programming) and object-oriented design & analysis (D&A).
The means, standard deviations, and the internal consistency estimates (Cronbach's alpha) about the research variables with more than one item are shown in Table 1.

Data Analysis

A covariance matrix was used as input to the LISREL 8 program (Joreskog & Sorbom, 1993) in order to analyze the structural model of this research. The estimation method used for the current research is maximum likelihood (ML). The covariance matrix is included in Table 2 and 3. The management support, usefulness, ease of use, attitude and intention were represented by the total scores on these scales.

Based on Technology Acceptance Model (TAM), the original path models of D&A and programming are as the follows. The personal innovativeness, experience for the structured methods, management support, training period, accessibility to champions and the number of professionals in an organization are hypothesized to influence usefulness and ease of use directly. The ease of use and usefulness are hypothesized to mediate influence of all of the exogenous variables and to affect the attitude and behavioral intention directly. In particular, the usefulness is hypothesized to mediate the influence of the ease of use to attitude and behavioral intention and to affect the behavioral intention. Finally, the behavioral intention is hypothesized to affect the actual usage. The point of this model based on TAM is that all of the exogenous variables are hypothesized to affect the actual usage indirectly through the ease of use, usefulness and attitude and intention (See Figure 1).

Besides original TAM model, a proposed research model to better explain the structure and process of the object orientation can be developed by incorporating individual, managerial, and organizational characteristics into the original TAM

model and by changing the position of these variables in accordance with the theory of planned behavior. In this proposed model, except for the perceived usefulness and ease of use of the object orientation,
all the exogenous variables such as the period of formal training, personal innovativeness, managerial support, number of professionals, accessibility to technology champion, and personal experience to former technology are hypothesized to affect both the behavioral intention and the actual usage of the object orientation paradigm rather than to affect both the usefulness and the ease of use of the object orientation. These relationships are in accordance with the role of the perceived behavioral control of the theory of planned behavior. The usefulness and ease of use are hypothesized to affect the attitude toward the object orientation, and then the attitude along with the usefulness is hypothesized to affect the behavioral intention. Actual usage of the object orientation is then affected by the behavioral attention along with the perceived behavioral control variables. Therefore, in the proposed research model, the usefulness and ease of use are shifted from endogenous variables to exogenous variables. Figure 2 concisely shows the relationships among the research variables in the proposed model.

Results

An initial test of the proposed research model showed several paths with non-significant t-values. These paths were deleted one by one at a time and each time the model was re-estimated. The final model was obtained by deleting paths with non-significant t-values. The standardized path coefficients are shown in Table 4.

From Table 4, the perceived behavioral control variables such as training, personal innovativeness, and management support are shown to influence actual usage directly without being mediated by any variables. This finding does not completely follow the prediction of the planned behavior theory. According to the planned behavior theory, the perceived behavioral control variables are said to affect both behavioral intention and actual usage.

The other perceived behavioral control variables such as the number of professionals, accessibility to technology champions, and personal experience to former related technology do not significantly influence both the behavioral intention and actual usage.

In line with the prediction of TAM, usefulness and ease of use of object oriented paradigm are shown to indirectly influence actual usage with the mediating role of behavioral intention. In particular, usefulness are led to behavioral intention as well as attitude.

For the D&A model, these results show that in the proposed model every selected variable is said to follow the prediction of both theories except for the finding that some of the planned behavior variables are not significantly related to the behavioral intention and actual usage. Contrary to the expectation, training period, personal innovativeness, and managerial support do not have significant relationship with the behavioral intention. Furthermore, the number of professionals, accessibility to technology champions, and individual experience of former technology does not affect both the behavioral intention and actual usage.

For the programming model, overall the same results as seen in the D&A model are shown. The only difference between the D&A and programming model is that instead of personal innovativeness, personal experience is found to significantly influence the actual usage of the object orientation.

Decomposition of the effects on the actual usage of exogenous variables confirms the previous results (See Table 5). For the D&A model, there are only direct effects on the actual usage of behavioral intention, personal innovativeness, training period, and managerial support, whereas the remaining variables have indirect effects on the actual usage. For the programming model, instead of personal innovativeness, personal experience has positive direct relationship with actual usage.

Goodness of fit of model

Values of several goodness of fit indices for the original TAM model and the proposed model are shown in Table 6. Bentler and Bonnett (1980) suggested a NFI (Normed Fit Index) that could be interpreted as the improvement in a model fit of a hypothesized model over a baseline model. Because a better model-fit can always be obtained by adding parameters to the model, James, Mulaik, and Brett (1982) have proposed a PNFI (Parsimonious Normed Fit Index) by adjusting the NFI that gains the improvement in a model fit at the expense of degrees of freedom. In addition to these, conventional chi-square statistics is reported for testing the goodness of fit of the models in this research. Except for chi-square value, larger values are desirable for NFI and PNFI. In addition, a single sample cross-validation index (ECVI) was used (Browne & Cudeck, 1989).

As can be seen from Table 6, compared to the original TAM model, the modified TAM model is interpreted as having a better model fit in both D&A and Programming. In particular, for D&A model, compared to the decrease of parameters, the final model has significantly better fit than the original TAM model. For the Programming model, the modified model has improved a lot in a model fit

compared to the original TAM model. The model comparison index in Table 7, tested by the chi-square difference test between the original and final models, confirms that the modified model significantly has improved a lot compared to the original TAM model.

In conclusion, let alone a parsimony criterion that a model with fewer parameters is better, it can be said that the modified model enacted by this research is a lot better than the original TAM model in explaining the effects of the exogenous variables on technology adoption and in interpreting their relationships.

Discussion and Limitation

This research has replicated many of the findings of the previous research. In line with the research findings by Davis (1989), the usefulness and ease of use of object-oriented technology are found to influence the actual usage of the technology through attitude and behavioral intention. While this research includes the concept of the planned behavior (Ajzen, 1991), the main idea of TAM is also confirmed.

This study investigates the superiority between TAM and the proposed model. According to the results of goodness of fit indices, the proposed model is much better than TAM. The difference between these two models is the position of the exogenous variables. In the proposed model, the usefulness and ease of use variables are shifted from endogenous variables to the exogenous variables. In TAM, these two variables should be considered endogenous variables. In addition, the individual, managerial, and organizational variables, which are located in front of usefulness and ease of use in the original TAM, are shifted to the front of behavioral intention and actual usage (See Figure 2).

The comparison of these two models mainly made by the goodness of fit indices tells that the proposed model shows a better model fit than TAM. This seems somewhat encouraging in that the proposed model showed the potential role of the perceived behavioral control in considering the adoption of new technologies. According to TAM that does not consider the concept of the perceived behavioral control, every exogenous variable such as individual, managerial, and organizational are assumed to directly influence the usefulness and ease of use of a new technology. With the concept of the perceived behavioral control, this research finds that it will be better to directly relate these exogenous variables to the behavioral intention and actual usage rather than to directly relate these variables to the usefulness and ease of use.

With regard to the effects of the research variables on the technology adoption, the most results of this study are in accordance with the previous research. The personal innovativeness in the case of D&A (Leonard-Barton & Deschamps, 1988), individual experience in the case of programming (Hill et al., 1987), managerial support (Leonard-Barton & Deschamps, 1988), and training period (Alexander, 1988) are shown to critically influence the adoption of object orientation. Contrary to the previous research, the other variables such as the accessibility to technology champions (Alexander, 1989) and the number of professionals in an organization (Zmud, 1984) are not shown to significantly influence the adoption of object orientation. These unexpected results may be derived from two possibilities. First, this study has small sample size, and it may produce unwanted statistical results. Second, the multicollinearity among the research variables might cause this result. Therefore, it could be said that this result does not tell that in considering adoption of a new technology, these variables such as accessibility to technology champions and the number of professionals should be discarded.

Even though TAM has been widely used for studying the adoption process of new technologies, TAM exaggerates the technology-related variables such as the ease of use and usefulness. This research attempts to overcome the limitations of TAM with the concept of the perceived behavioral control.

The current research has some limitations. First, compared to the number of estimated parameters, the number of sample is somewhat small. Bentler and Chou (1987) recommended that the ratio of sample size to the number of free parameters be at least 10:1. In the light of this criterion, this research could have some problems like unstable estimation of parameters due to small sample size. But according to the recommendation by West et al. (1995) that for small sample sizes, the ML or GLS estimates would be helpful, the parameter estimates of this study might not be so untrustworthy. Second, some of the measurement items used for this study do not show univariate normal distribution measured by kurtosis and skewness criteria. This problem could have exaggerated the chi-square value and lowered SEs and parameter estimates. But in the sense that most items have an appropriate normal distribution, it could be said that this problem is not so serious to reconsider every aspect of this research. Third, the sample has been collected from the mid-west area in U.S. This fact may lower the external validity of this research at different settings.

Figures, Tables, and References

Available Upon Request.