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Testing the Boundaries of the Technology Acceptance Model

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ABSTRACT

*The technology acceptance model (TAM) has been tested for many different information technology (IT) applications, and has been found useful in explaining user behavioral intention (BI) to use. Studies have mainly focused on the applications, rather than the model itself. A survey on 200 undergraduate students who have previously used IT applications was conducted to determine the behavior of the model for all possible values of perceived usefulness (PU) and perceived ease of use (PEOU). This approach allows us to test the boundary values of PU and PEOU for which the model is applicable. Our findings show that BI could be expressed as a linear regression of PU, PEOU, and an interaction term PU*PEOU, covering all possible values of PU and PEOU. Consistent with previous studies, this study found that PU has a stronger effect than PEOU on BI. The interaction effect, hardly examined in previous studies, indicates that an increase in PEOU has more effect on BI when the PU is high, compared to when the PU is low. Implications for the TAM and practice are discussed.*

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1. INTRODUCTION

User acceptance of information technology (IT) is central to attaining associated performance gains for an organization. Low acceptance of IT applications undermines an organization's investment in IT and its aim for operational and strategic benefits. Hence, having a systematic prediction theory for user acceptance of IT applications is of tremendous importance. Toward this end, much significant progress has been made in the last decade. The technology acceptance model (TAM), derived primarily from the theory of reasoned action, the expectancy theory, and the self-efficacy theory, has received extensive empirical support (e.g. Chau and Hu, 2002; Davis and Wiedenbeck, 2001; Dishaw and Strong, 1999; Straub et al., 1997).

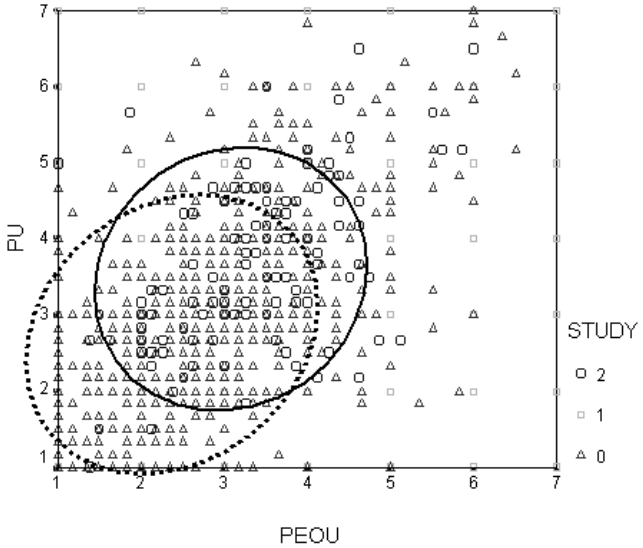
In essence, the TAM theorizes that an individual's behavioral intention to use an information system is determined by his perceptions concerning its usefulness and ease of use (Davis, 1989; Venkatesh and Davis, 2000). Studies typically focused on a specific application, software or technology and measure perceived usefulness (PU), perceived ease of use (PEOU) and behavioral intention (BI), with seven-point scales, as suggested by Davis (1989). These seven-point scales for PU and PEOU form a space, with 49 combinations of the integer values and the space in between. We name this the PU-PEOU space, the space for which the TAM is supposed to be applicable.

Because each of these studies investigated the usage intention of a specific application, it could not cover all the 49 combinations of PU and PEOU, and hence making it difficult to determine if the TAM is applicable for the entire PU-PEOU space. Using two TAM datasets available to us, we found that data points for PU and PEOU were not spread over the entire PU-PEOU space but were clustered over much smaller regions (see figure 1). Note that this clustering of data need not necessarily imply any lack of normality in the data. Rather, the issue is that the boundaries of the theory are not thoroughly explored.

To our knowledge, there is no study on whether the TAM applies to the entire PU-PEOU space of values. For any theory, it is very important to determine the boundaries within which the theory is applicable. For example, we know that water volume increases with temperature, and that this relationship is not applicable for temperatures below 4 degree Celsius. Similarly, it is important to study the boundaries of the TAM. Some interesting questions would be: "Are the effects of PU and PEOU on BI similar throughout this space?" and "Is there any space for which these effects on BI are not significant?" Knowing the boundaries of the TAM may help system designers decide allocation of resources for usefulness and ease of use functionalities.

It is important to have one single study that covers the full PU-PEOU space. To pool data from many studies may not be able to achieve the same impact. Even pooling 10 or 20 studies may not cover the full space, as it appears that spaces near the boundaries are not covered. The technology acceptance model is briefly reviewed in section 2. The survey for the boundary study of the TAM is presented in section 3. The analysis of result, leading to a 3D surface of behavioral intention over the PU-PEOU space, is presented in section 4. Finally the results are discussed in section 5, together with the conclusion.

Figure 1. *PU-PEOU Space*



Study: 0 (left ellipse, Goh 2002), 1 (this study), 2 (right ellipse, Tan and Chan 1998)
Scale: 1 is extremely useful / extremely easy

2. THE TECHNOLOGY ACCEPTANCE MODEL

The TAM seeks "to provide an explanation of the determinants of computer acceptance that is generally capable of explaining user behavior across a broad range of end-user computing technologies and user populations, while at the same time being both parsimonious and theoretically justified." (Davis et al. 1989, p985). The TAM has been proven to be a robust model in predicting user acceptance of IT, and has been applied widely in understanding motivational issues in computer and software adoption and usage of information systems (e.g., Igbaria et al. 1997).

The core of the TAM is shown in figure 2. PU is defined as "the prospective user's subjective probability that using a specific application system will increase his or her job performance within an organizational context" (Davis, 1989, p985). PEOU is defined as "the degree to which a person believes that using a particular system would be free of effort" (Davis, 1989, p985). BI is defined as "a measure of the strength of one's intention to perform a specific behavior" (Fishbein and Ajzen, 1975, p288). PU and PEOU are hypothesized to jointly decide users' intention to accept an IT application. The effect from PEOU to PU is not examined in this study, and will not be further described.

Many studies have extended the TAM by considering other factors affecting user acceptance directly and indirectly. For example, subjective norms, job relevance, and result demonstrability have significant effects on PU (Venkatesh and Davis, 2000); and computer self-efficacy, perceptions of external control, computer anxiety, and objective usability were reported to affect PEOU significantly (Venkatesh, 2000); This study focuses on the core TAM model, studying only BI, PU and PEOU.

2.1 MEASURES FOR THE TAM VARIABLES

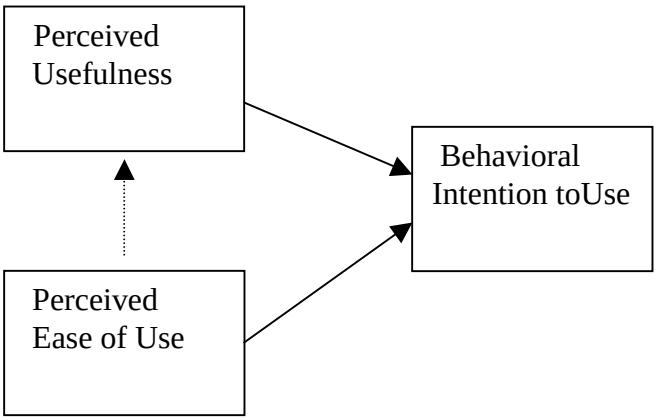
Valid measurement scales are important for empirical studies. Davis (1989) developed and validated 6-item scales for two variables of the TAM: PU and PEOU. Both PU and PEOU scales attained high reliability, and were proven to possess convergent and discriminant validity. These measures have been widely used in later studies on the TAM. These items are also used in our study to explain to respondents the meanings of PU and PEOU.

The BI variable has more variation in measurement. Respondents are usually asked to state their use / future use of the system, typically in terms of the (a) likely frequency of use, (b) likelihood of use, and/or (c) likely amount of usage time.

2.2 THE RELATIONSHIP AMONG THE THREE CONSTRUCTS OF THE TAM

In many studies using TAM, both PU and PEOU have significant influence on the users' intention to use the application. The amount of behavioral intention variance explained is usually below 0.6. Venkatesh and Davis (2000) estimate that the TAM generally explains about 40% of the variance in usage intention. A linear regression of the coefficient of PU and coefficient of PEOU gathered from many recent studies does not show a significant model.

Figure 2. Technology Acceptance Model



The lack of a clear pattern between the coefficients of PU and PEOU leads to many possible conjectures. Some may attribute the chaos to the variety of softwares studied. But without a better understanding of the core theory (BI, PU & PEOU), it is very difficult, if not impossible, to consider and integrate other factors. It is likely that each of these studies is clustered around a small part of the PU-PEOU space. As mentioned earlier, a check with two studies (Goh, 2002; Tan and Chan, 1998) showed that both had clustering patterns. If the BI behave differently over the PU-PEOU space, it will be difficult to compare the coefficients of PU and PEOU from different studies, without details of the datasets.

3. BOUNDARY STUDY ON THE TAM

While it is clear that the TAM is able to explain intention to use, the exact effects that PU and PEOU have on BI are not so clear. There is thus a need for further study to understand this model itself. One important study will be to ascertain the behavior of the TAM over the PU-PEOU space, which can be viewed as a study of the boundaries of the TAM.

"Boundaries typically identify the constructs (or entities of interest) in the domain, the relationships of interest among these constructs, and when these relationships are valid (i.e., for which ranges of construct values the relationships hold)" (Eierman et al., 1995, p19). In this study, the constructs (BI, PU and PEOU) are not tested. These are assumed to be valid, from the numerous tests in the literature. Their relationships are examined in closer detail, and the ranges of values (for PU and PEOU) that the relationships hold are tested.

A face-to-face survey, which allows subjects to clarify their doubts immediately, was performed to gather the necessary data from 200 full-time undergraduate students. They were all IT literate, have had used various kinds of software, and have been exposed to many university applications. It is reasonable to expect them to be able to associate or project suitable systems for evaluation for each of the combination of PU and PEOU values. It is noteworthy that the TAM had been applied successfully to software that the respondents had not tried (Tan and Chan, 1998).

The survey material included a cover letter to the respondents, stating the purpose of the survey, the definitions of the three constructs, and instructions on how to fill in the tabular form. In the tabular form, the values of the PU and PEOU columns were fixed, and respondents were asked to complete the BI column. Seven-point scales were used to indicate the different degrees of PU and PEOU. For each combination, the respondent rated his BI on a scale of 1 (extremely likely to use) to 7 (extremely not likely to use). This is one of the two questions used by Davis (1989).

Respondents received randomly one of two versions of the table. Each version covered 28/21 out of the possible 49 combinations of PU and PEOU values. The reason for using two versions is to minimize subject fatigue. Completing all 49 combinations may be too tiring for respondents.

4. RESULTS

To test the influence of PU and PEOU on BI, regression analyses using SPSS-PC version 10 were performed. Regression of PU and PEOU on BI, using all the 4900 data points, showed systematic error. In addition, a 3D plot of BI against PU and PEOU showed some interaction effect. Thus, a linear regression of BI = a + b*PU + c*PEOU + d*(PU*PEOU) was done. The analysis gives:

BI = 0.291 + 0.765 * PU + 0.340 * PEOU – 0.031 * PU *PEOU

(R square = 0.507; model and all coefficients are significant at p=0.001; standardized coefficients are 0.801, 0.357 & -0.194, respectively).

The coefficient of PU is about two times the coefficient of PEOU, which means that a change in PU has a stronger effect on BI than a similar change in PEOU. A 3D-graph representing the relations among

the predicted BI value, PU and PEOU is generated (Figure 3). The relationship is represented in one slightly curved surface.

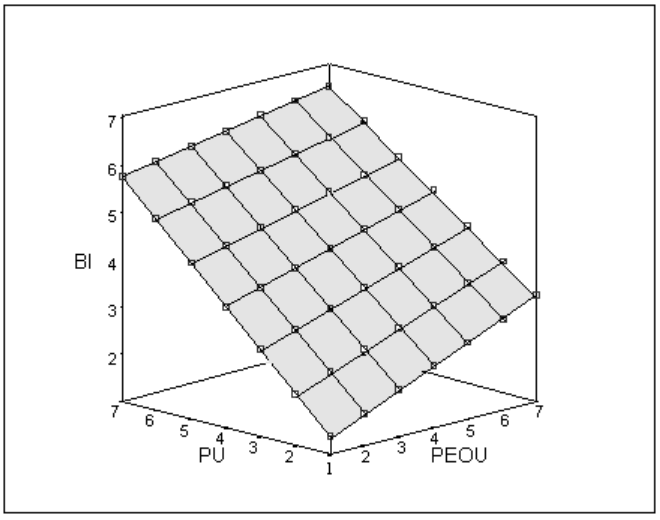
5. DISCUSSION AND CONCLUSION

This study empirically examined the influence of PU and PEOU on BI. Previous studies did not aim to cover all the PU-PEOU space and, in all likelihood, did not do so (e.g. Goh, 2002; Tan and Chan, 1998). According to Eierman, the tendency is that "those that are highly tested are more central within the boundary" (Eierman et al. 1995, p20). Earlier data and findings have not tested fully the PU-PEOU boundaries of the TAM. This study covered the full PU-PEOU space, and, furthermore, showed that the effects of PU and PEOU on BI could be represented in one linear regression model, from which we can make some comparisons and draw important implications.

One particular feature of this survey is that respondents were not directed to any specific software. Limiting to a specific software will limit the range of PU / PEOU values, and will not achieve the objective of covering the complete PU-PEOU space. On the negative side, it could be possible that some subjects could not visualize a software with the given PU / PEOU values, and thus might not be able to assess BI properly. On the other hand, this could be an advantage, as the subjects can focus on PU and PEOU and not be distracted by other characteristics of the software, such as the brand, version, cost or alternatives. It could probably be that the survey has managed to create an environment where respondents could focus on the three variables without the presence of other factors. It creates an ideal situation to study the TAM, just like a study of Newton's Second Law of Motion (force = mass * acceleration) should not be done on a surface of uneven roughness and slope. When the force/acceleration formula is applied to the real world, other factors such as friction, slope and wind resistance can be considered. Similarly, when the regression equation of BI, PU and PEOU is applied to a real software, other factors can be considered.

There are some consistencies in the findings from this survey and the literature review, which provide some support for the validity of this survey. The study showed that the coefficient of PU is generally bigger than the coefficient of PEOU, as found in other studies. More importantly, it showed that the 3D surface is curved, and that the ratio of the PU and PEOU coefficients is not constant, but varies over the surface. Taking the two extreme corners, the ratio of the PU/PEOU effects (including interaction) is 1.77 (for PU=1 and PEOU=7) and 5.97 (for PU=7 and PEOU=1). If we pick a random sample of points on the surface, the ratio will not show any clear pattern. This is consistent with the review in section 3 that finds no clear pattern to relate the coefficients of PU and PEOU.

Figure 3. Estimated Behavior Intention to Use



Note: 1 is extremely useful, extremely easy, or extremely likely to use

The general finding that PU has a stronger effect than PEOU has led to calls for developers to emphasize PU. It has also led to the impressions that users tend to focus more on the system's functions instead of its ease of use. These impressions are not quite correct. This survey provides more information. For systems that are very useful (i.e., PU=1), ease of use can make a sizable difference. BI changes by almost 2 points when PEOU goes from 7 to 1. For useful systems, ease of use is an important factor that should not be ignored. However, for systems that are hardly of any use, ease of use is not an important factor. A limitation of the TAM is that it does not provide specific guideline on how to improve usefulness or ease of use. For that, reference could be made to other studies that included other factors that could affect PU and PEOU.

The interaction effect between PU and PEOU is an important contribution to a better understanding of TAM. This effect has not been studied or identified in the TAM literature. Interaction effects have recently also been considered important in a closely related theory: the theory of planned behavior (Conner and McMillan, 1999). They suggested that "interaction effects may also mark boundary conditions for the applicability of a relationship between variables" (Conner and McMillan, 1999, p. 201), and highlighted "the need to consider potential interactions among predictor variables in increasing our understanding of the determinants of intention" (p.218). Clearly, further research along these ideas could be fruitful for the TAM.

For the development of IS theories, examination and validation with empirical data are very important. Our main contribution is in providing a detailed test of the core part of the TAM, covering the full PU-PEOU space. It provides a new overall picture of the influence of PU and PEOU on users' intention to use. From the results of our study, IS researchers and practitioners can understand the relative importance of PU and PEOU, and their interaction effect. In addition to confirming some of the generally known relationships between PU, PEOU and BI, we have provided additional clarifications on these relationships.

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