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An Integrated Analysis of Technology Acceptance Behaviour Models: Comparison of Three Major Models

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ABSTRACT: *With the development of technology, the company begins to introduce various kinds of technological equipment. Hence, technology acceptance behaviours have become a famous issue. Researchers also construct many technology acceptance behaviour models. Among them a series models in which extended from Theory of Reasoned Action are the most complete. There are also other models construct from different theories, such as Innovation Diffusion Theory, Social Cognitive Theory, and Motivation Theory. However, various models make researchers more difficult to choose and construct a research model. Therefore, this study selects 3 most representative models which include Technology Acceptance Model, Combined Theory of Planned Behaviour and Technology Acceptance Model, and Unified Theory of Acceptance and Use of Technology. Comparing 3 models' richness and parsimony can help to identify their characteristics. According to the research results, the complex models do not necessarily have better explanation ability. On the contrary, the Technology Acceptance Model concurrently has advantage of richness and parsimony.*

KEYWORDS: *Technology Acceptance Behaviours, Technology Acceptance Model, Combined Theory of Planned Behaviour and Technology Acceptance Model, Unified Theory of Acceptance and Use of Technology.*

1. Introduction

With advancement of technology, to enhance production efficiency and operation efficacy, businesses introduced new technology equipment. The prerequisite condition to have technology equipment exert the expected effects is to make employees accept and become delighted in using the equipment. Only after users are willing to accept technology equipment, the performance of the equipment is maximized. Management and R&D personnel started treating technology system in light of users' ideas from emphasis on compatibility and operatability. That is, they focus on inducement employees to use

the technology system. Issues from practice also attracted researchers' attention, leading to more studies on acceptance behaviours of new technology. It has become a popular issue to study introduction of information system. Some scholars even believed that such study was one of the most mature scopes in recent research on information management (Hu et al., 1999).

From the 1980's, a number of scholars have developed different theoretic models on technology acceptance behaviours from information management science, sociology and psychology, The major model is Theory of Reasoned Action (TRA) proposed by Fishbein and Ajzen (1975). TRA holds that one's actual behaviours are affected by the behavioural intention, which was influenced by individual behaviour attitudes and subjective norms. TRA derived a series of technology acceptance behaviour models include Ajzen (1985)-Theory of Planned Behaviour (TPB), Davis, Bagozzi and Warshaw (1989)-Technology Acceptance Model (TAM) and Taylor and Todd (1995a)-Combined TAM and TPB (C-TAM-TPB). TPB includes perceived behavioural control in TRA; TAM contains perceived usefulness and perceived ease of use; C-TAM-TPB integrates advantages of TAM and TPB.

There are also other scholars presenting different technology acceptance behaviours models, including Rogers (1983)-Innovation Diffusion Theory (IDT) containing individual innovation attitudes, Bandura (1986)-Social Cognitive Theory (SCT) in combination of behaviourism and social learning, Thompson, Higgins and Howell (1991)-Model of PC Utilization (MPCU) in consideration of affect towards use, social factors and facilitating conditions in interpersonal behaviours, Davis, Bagozzi, and Warshaw (1992)-Motivational Model (MM) covering use motivation, and Venkatesh, Morris, Davis, and Davis (2003)-Unified Theory of Acceptance and Use of Technology (UTAUT), integrating technology acceptance behaviours models in the past.

Later researchers verified the preceding theory models on different new technologies or industries (Agarwal and Karahanna, 2000; Lederer et al., 2000; Venkatesh and Davis, 2000; Moon and Kim, 2001; Chau and Hu, 2002; Chen, Gillenson & Sherrell, 2002; Koufaris, 2002; Gefen, Karahanna and Straub, 2003; Riemenschneider, Harrison and Mykytyn, 2003). The focus and booming development of theories of users' acceptance of new technology equipment illustrates the importance of study of technology acceptance behaviours on successful introduction of information system.

Such theory models also bother researchers in selecting and constructing research models. Researchers are forced to pick several constructs to make new models or take a more widely accepted model, ignoring the contribution of other models. These models from different scholars cause confusion and troubles to researchers. For example, Mathieson (1991) believed that simple models failed to bring more information on users'

acceptance of new technology. That is, generality of models is insufficient. Adding new variables in models will enhance models' ability of interpretation. However, Venkatesh (2000) held that too many variables would be difficult for researchers to handle empirical study. Parsimony of models has to be considered. Moreover, Plouffe, Hilland, and Vandenbosch (2001) thought, when using technology acceptance behaviours models, one had to consider models' richness and parsimony. Theory models have different variables and causal relations. Different theories, issues and target of verification would lead to different results (Hung, Liang and Chang, 2005).

To help researchers better understand technology acceptance behaviours and correctly select more reasonable models to understand roles of variables in technology acceptance models, the paper reviews earlier studies on technology acceptance behaviours models to locate models with firm foundation and representation. Three major theory models (TAM, C-TPB-TAM, and UTAUT) are selected. Under empirical analysis, comparison is made on the interpretation ability of the 3 models on individual technology acceptance behaviours and parsimonyof the variables and causal relation in the hope to have more in-depth exploration of technology acceptance behaviours.

2. Literature review and analysis

2.1 Technology acceptance behaviours models from TRA

TRA (Fishbein and Ajzen, 1975) is from social psychology. TRA believes that intnentions strength of individuals affects the actual behaviours. The behavioural intentions is affected by two major factors-attitude toward behaviour and subjective norm. The former refers to the feeling of an individual of certain behaviours in good or bad comments. The latter refers to the social pressure one has in certain behaviours. TRA is one of the most fundamental and influential theories in explaining human behaviours. It has been widely used in study in different fields (Sheppard, Hartwick and Warshaw, 1988). In study of technology acceptance, a lot of studies have proven that this theory model effectively predicts and explains reasons of users using information system (Davis, 1989; Davis, Bagozzi and Warshaw, 1989). Later researchers proposed different frameworks based on TRA:

2.1.1 TPB

TPB was proposed by Ajzen (1985). It is extension from TRA to explain and predict human behaviours in different conditions. Under TPB, one's behaviours are from the own will. One can completely decide whether to have certain behaviours. Other than own will, some behaviours may be affected by resources and opportunities. When people lack of ability, resources or opportunities for certain behaviours or earlier experience making

them feel difficult, it is unlikely for them to have such behaviours in strong will. That is, behaviours are not merely affected by one's motive but also non-motive factors such as time, skills and knowledge. Ability of controlling behaviours is also important in affecting behaviour will. Therefore, Ajzen added perceived behaviour control in TRA. He defined perceived behaviour control as reflected perceptions of internal and external constraints on behaviour and encompasses self-efficacy, resource facilitating condition, and technology facilitating conditions. When predicting behavioural intentions, TPB holds that, other than exploring behaviour attitudes and subjective norm, opportunities, resources and control ability also affect behavioural intentions.

2.1.2 TAM

Based on TRA, Davis et al. (1989) proposed TAM in which outside factors of users accepting new technology are through intermediate factors of perceived usefulness and perceived ease of use to affect users' behavioural intention. The perceived usefulness refers to the degree to shich a person believes that using a particular system would enhance his or her job performance (e.g. reducing time to complete work or providing in time information). The perceived ease of use refers to the degree to which a person believes that using a particular system would free of effort. TAM succeeds the basic spirit of TRA, believing that beliefs affecting attitudes, which affect behavioural intention, which affect actual behaviours. Technology acceptance model does not include subjective norm. In studies of technology acceptance behaviours, TAM has been used as theoretic foundation of many empirical studies with a great number of empirical supports. TAM has advantages of parsimony, specific constructs, powerful theoretic foundation and a lot of supports (Hu et al., 1999). Overall, from results of empirical analysis, TAM has approx. 40% accuracy in predicting users' level in system (Legris, Inghamb and Collerette, 2003).

2.1.3 C-TAM-TPB

Taylor and Todd (1995a) held that TAM failed to include factors of society and control that have been proven to affect actual behaviours. The two factors are also key factors in TPB. As a result, Taylor and Todd (1995b) integrated TAM and TPB to include subjective norm and perceived behavioural control into technology acceptance models and proposed C-TAM-TPB with empirical study made on use of computing resources center by students. The empirical results by Taylor and Todd (1995b) show that C-TAM-TPB has high fitness in explaining users' behaviours of using new technology. From analysis of grouping users based on experience, C-TAM-TPB shows quite good fitness on both experienced and inexperienced users.

2.2 Other related technology acceptance behaviours models

2.2.1 IDT

IDT by Rogers (1983) is most frequently used to predict and explain use of innovation and diffusion behaviours (Moore and Benbasat, 1991). Rogers (1983) believed innovation diffusion referred to new technologies, methods or ideas and when, where, why and how innovation objects were used. IDT believes that determination of certain innovation is not temporary behaviour but a model after a series of activities and decisions. Five factors affecting individuals and attitudes towards innovation include relative advantages, compatibility, complexity, trialability and observability. Innovation issues were valued. Late researchers had study of information technology acceptance behaviours based on IDT. Some researchers had more profound exploration and analysis of innovation characteristic in IDT. Different scales of innovation were designed for different industries (Moore and Benbasat, 1991; Karahanna, Straub and Chervany, 1999). Some researchers combined IDT and other theories for verification. Taylor and Todd (1995c), in the study of consumers using innovation products, combined IDT and Decomposed Theory of Planned Behaviour for as analysis models; Liao, Shao, Wang and Chen (1999) quoted IDT and TPB to explore consumers' behaviours of using virtual banks; Plouffe, Hilland and Vandenbosch (2001) integrated IDT and TAM to explore willingness of retailers to use intelligence card system.

2.2.2 SCT

SCT by Bandura (1986) integrates ideas of behaviourism and social learning. It is a widely accepted model and has been under after a lot of empirical studies on individual behaviours (Compeau and Higgins, 1995a). SCT holds that environment, personal (motivation and attitudes) and behaviour factors affect individual behaviours (Bandura, 1986). SCT further points out that self-discipline behaviour in motivation and behaviour performance are result of different self-discipline mechanism. The key self-discipline mechanism is self-efficacy, which refers to the judgment of one's ability to use a technology to accomplish a particular job or task (Bandura, 1986) or the gathered beliefs. Self-efficacy involves ability of one person to motivation realization, cognized resources and ability to use control during activities. With different self-efficacy levels, people increase or decrease their motivation and efforts to solve problems. Gist and Mitchell (1992), reviewing papers on self-efficacy, categorized causes to self-efficacy into mission need analysis, experience attribution analysis and individual or situational resources limitation. Compeau and Higgins (1995b) believed that self-efficacy was determined by significance, strength and generalization ability. In study of technology acceptance behaviours, Compeau and Higgins (1995b) included emotions and expectation into SCT model for analysis; Igbaria and Iivari (1995) contained anxiety into SCT to discuss use

of computers; Compeau, Higgins, and Huff (1999) integrated the preceding study results on SCT for empirical analysis on variables of direct influence on users using computers; Venkatesh (2000) combined SCT and TAM for analysis.

2.2.3 MPCU

Thompson, Higgin and Howell (1991) established MPCU to explain problems of PC utilization. This model was resulted from individual behaviours model by Triandis (1971). Individual behaviours model held that factors determining one's behaviours included attitudes, social norm, habits and expected results of the behaviours. Attitudes cover cognitive, affective and behavioural components. In MPCU factors affecting PC utilization include perceived consequences, affect, social factors and facilitating conditions. Perception results cover complexity, job fitness and long-term rconsequences. Thompson et al. (1991) had empirical study of knowledge workers in manufacture industry. The findings show only society, complexity, job fitness and long-term results have significant influence on PC utilization. Though MPCU relations were not proved to exist, scholars still had study based on MPCU framework. Thompson, Higgins and Howell (1994) added users' experience into MPCU to explore adjustment results of experience on dimensions of PC utilization models; Al-Khaldi and Wallace (1999) analyzed knowledge workers' behaviours of PC utilization in Saudi Arabia with MPCU; Cheung, Chang and Lai (2000) modified MPCU to explore use of the Internet. Chang and Cheung (2001) revised MPCU to discuss behavioural intention of use of the Internet.

2.2.4 MM

Motivation is the process to push an individual to complete desired goals or work or one's efforts or energy to meet certain needs or achieve certain goals (Herbert, 1976). In technology acceptance research, Davis, Bagozzi and Warshaw (1992) first, with motivation viewpoint, discussed users' technology acceptance behaviour issues and developed technology acceptance behaviours MM to explore users' motivation of utilizing information system. MM claims that behavioural intention of using new technology will be affected by users' internal motivation and external motivation. Internal motivation is the perception that users will want to perfom an activity "for no apparent reinforcement other than the process of performing the activity per se"; external motivation refers to the perception that users will want to perform an activity "because it is perceived to be instrumental in achieving valued outcomes that are distinct from the activity itself, such as improved job performance, pay, or promotions". With information system italicization characteristics, enjoyment of information system is internal motivation and perceived uesfulness serves as users' external motivation (Davis et al., 1992).

Empirical results by Davis et al. (1992) show that perceived usefulness and enjoyment have significant influence on users' utilization of new technology in

behavioural intention. Influence of perceived usefulness on users' behavioural intention far exceeds that of enjoyment on users' behavioural intention. Venkatesh and Speier (1999) continued ideas in MM to discuss influence of users' mood in accepting information system in training on their internal and external motivations. The results show that moods do not have significant influence on external motivation. However, positive moods have significant influence on internal motivation and users' behavioural intention in the short time. Negative moods have significant on both short-and long-term internal motivation and users' behavioural intention.

2.2.5 UTAUT

In the field of study of users on technology acceptance behaviours, a great number of theory models were developed, troubling researchers in selecting and constructing models. Venkatesh et al. (2003) developed an integrative theory -- UTAUT to help future study in this field to find more dimensions affecting users' behavioural intention and enhance explanation ability of the model and comprehension of users' behaviours. Venkatesh et al. (2003) arranged earlier major models with comparative empirical study. It was found models' explanation ability of behavioural intention was between 17% and 42%. Some variables lost explanation ability with increase of experience. Venkatesh et al. (2003) arranged the four most influential variables from earlier studies -- performance expectancy, effort expectancy, social influence and facilitating conditions. Performance expectancy is defined as the degree to which an individual believes that using the system will help him or her to attain gains in job performance; effort expectancy refers to the degree of ease associated with the use of the system; social influence covers the degree to which an individual perceives that impotant others believe he or her should use the new system; facilitating conditions refers to the degree to shich an individual believes that an organizational and technical infrastructure exists to support use of the system.

2.3 Literature analysis

Reviewing technology acceptance behaviour models in the past 30 years, one can find scholars' focus on this issue and technology acceptance behaviours models established based on theories. Some theory models are evolved from a series of development. TRA is one of the most fundamental theories to explain human behaviours and has been widely used in study of technology acceptance behaviours. Models from TRA are more complete, including TPB, TAM and C-TAM-TPB. With control ability of required resources by users, TPB's variables mostly focus on users' personal traits or subjective awareness. They do not have specific suggestions on marketing of technology products. TAM includes technology characteristics. TAM has specific definitions in dimensions and relation among dimensions is simple. Most ensuing studies adopted TAM with a lot of empirical supports. TAM is the most widely used theory model in technology

acceptance behaviour study. Compared with TPB and TAM in single viewpoint, C-TAM-TPB is an integrative model, covering users' personal characteristics and technology product property.

A lot of models are developed from different theories. The most representative ones include IDT, SCT, MPCU and MM. These models explore users' technology acceptance behaviours from innovation theory, sociology, computer utilization and psychology, although they failed to provide complete explanation of technology acceptance behaviours. UTAUT offers more comprehensive exploration. Few studies have verification on UTAUT and its appropriateness still requires further confirmation. Please refer to Figure 1 for relation among technology acceptance behaviour models.

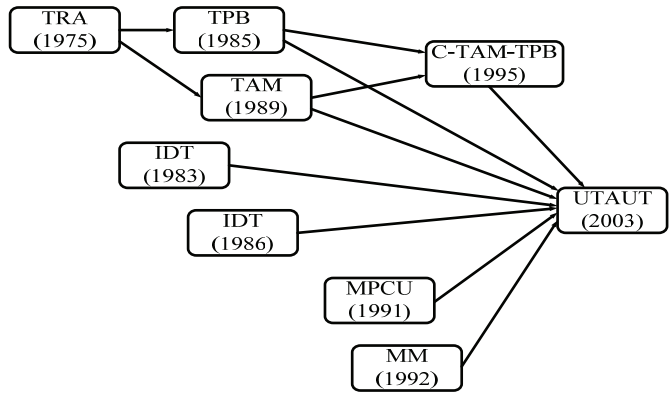

Figure 1 Intergrated Relationship among Previous Technology Acceptance Models

The researcher believes there are three more complete and representative models: TAM, C-TAM-TPB and UTAUT. Names of variables in the 3 are somewhat different, but the basic definitions of variables are the same. Major variables are perceived usefulness (performance expectancy in UTAUT), perceived ease of use (effort expectancy in UTAUT), subjective norm (social influence in UTAUT), perceived behavioural control (facilitating conditions in UTAUT), attitude toward use, behavioural intention to use and actual use.

3. Study methods

3.1 Study models

The research conducts fitness analysis and comparison on the 3 major models of technology acceptance behaviours (TAM, C-TAM-TPB and UTAUT) to understand the fitness and explanation ability of users' behaviours. TAM points out that when users

believe technology's perceived uesfulness and perceived ease of use are higher, they have positive attitude toward use and are willing to use the technology with actual use behaviours. See Figure 2 for details.

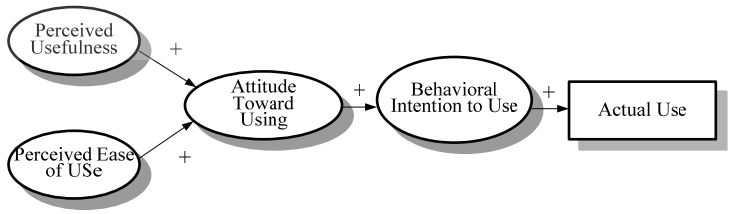

Figure 2 TAM Model

C-TAM-TPB extends most of the ideas in TAM. What is different is that C-TAM-TPB holds users are affected by perceived ease of use on technology products' perceived uesfulness. Perceived uesfulness directly affects users' behavioural intention to use. Besides attitude toward use, behavioural intention to use is affected by subjective norm and perceived behavioural control. Perceived behavioural control directly affects actual use (Figure 3). UTAUT holds that behavioural intention to use is directly affected by perceived uesfulness, perceived ease of use and subjective norm. Other than behavioural intention, actual use behaviours are also affected by perceived behavioural control (Figure 4).

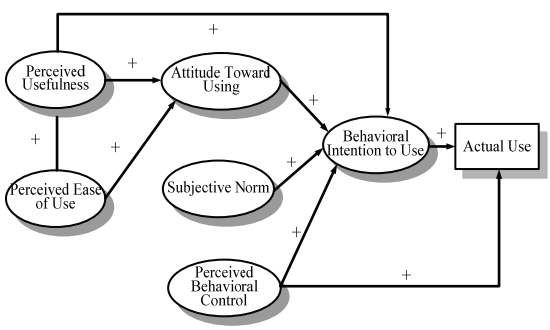

Figure 3 C-TAM-TPB Model

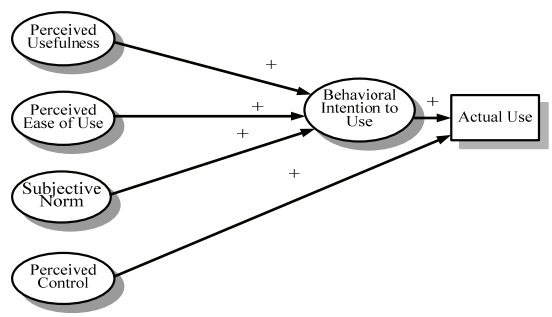

Figure 4 UTAUT Model

The preceding 3 models are only in harmony in behavioural intention to use affecting actual use behaviours. Hypothesis among other variables is different. In attitude toward use, UTAUT does not think the variable shall be included into the model; TAM and C-TAM-TPB held that attitude toward use are affected by perceived uesfulness and perceived ease of use. C-TAM-TPB holds perceived uesfulness is affected by perceived ease of use. In behavioural intention, TAM holds behavioural intention to use is affected by attitude toward use. C-TAM-TPB believes, in addition to attitude toward

use, users' perceived uesfulness, subjective norm and perceived behavioural control directly affect behavioural intention to use. UTAUT holds that perceived ease of use also affects behavioural intention but perceived behavioural control does not affect actual use behaviours. In actual use behaviours, except for TAM, C-TAM-TPB and UTAUT point out that perceived control behaviours directly affect actual use behaviours. See Table 1 for comparison among variables in the 3 models.

Table 1 Comparison of Causal Relationships on TAM, C-TAM-TPB and UTAUT

	TAM	C-TAM-TPB	UTAUT
Attitude Toward Using			
PU→ATU	V	V	
PEOU→ATU	V	V	
PEOU→PU		V	
Behavioural Intention to Use			
ATU→BIU	V	V	
PU→BIU		V	V
PEOU→BIU			V
SN→BIU		V	V
PBC→BIU		V	
Actual Use			
BIU→AU	V	V	V
PBC→AU		V	V

PU: perceived usefulness; PEOU: perceived ease of use; SN: subjective norm; PBC: perceived behavioural Control; ATU: attitude toward using; BIU: behavioural intention to use; AU: actual use

3.2 Potential dimension definition and design of measurement questions

In earlier theory models, there are different names of potential variables as well different measurement questions. The general meaning and content are the same. For example, perceived uesfulness in technology acceptance model (TAM) (Davis, 1989; Davis et al., 1989) is called job-fit in PC utilization model (MPCU) (Thompson et al., 1991); outcome expectations in SCT (Compeau and Higgins, 1995b; Compeau et al.,

1999) is called extrinsic motivation in MM (Davis et al., 1992; Venkatesh and Speier, 1999); relative advantages in IDT (Karahanna et al., 1999; Moore and Benbasat, 1991) is called performance expectancy in UTAUT (Venkatesh et al. 2003). See Table 2 for potential dimensions and names of the variables in same ideas in this study. To maintain consistency and stability of comparison among models, operative definitions of potential variables follow viewpoints in most studies (Table 2).

Table 2 Definition of Research Constructs

Construct	Similar Construct / Definition
Perceived Usefulness	Job-fit (Thompson et al., 1991); outcome expectations (Compeau and Higgins, 1995b; Compeau et al., 1999); extrinsic motivation (Davis et al., 1992; Venkatesh and Speier, 1999); relative advantage (Karahanna et al., 1999; Moore and Benbasat, 1991); performance expectancy (Venkatesh et al., 2003)
	The degree to which person believes that using a particular system would enhance his or her performance
Perceived Ease of Use	Effort expectancy (Venkatesh et al., 2003); complexity (Thompson et al., 1991); ease of use (Moore and Benbasat, 1991)
	The degree to which a person believes that using a system would be free of effort
Subjective Norm	Social factor (Thompson et al., 1991); image (Moore and Benbasat, 1991)
	The person's perception that most people who are important to him think he should or should not perform the behaviour in question
Perceived Behavioural Control	Facilitating conditions (Venkatesh et al., 2003); compatibility (Moore and Benbasat, 1991)
	Reflects perceptions of internal and external constraint on behaviour and encompasses self-efficacy, resource facilitating condition, and technology facilitating

Table 2 Definition of Research Constructs (Continue)

Construct	Similar Construct / Definition
Attitude Toward Using	Intrinsic motivation (Davis et al., 1992); affect toward use (Thompson et al., 1991); affect (Compeau and Higgins, 1995b; Compeau et al., 1999)
	An individual's positive or negative feelings about performing the target behaviour
Behavioural Intention to Use	--
	A measurement of the strength of one's intention to perform a specified behaviour
Actual Use	--
	The degree to which a person's actual of a particular system

After confirmation of operative definitions of potential dimensions, the researcher selects more common measurement questions. Perceived uesfulness includes 4 measurement questions (V_1-V_4); perceived ease of use includes 3 measurement questions (V_5-V_7); subjective norm includes 4 measurement questions (V_8-V_{11}); perceived behavioural control includes 4 measurement questions (V_{12}-V_{15}); attitude toward use includes 3 measurement questions (V_{16}-V_{18}); behavioural intention to use includes 3 measurement questions (V_{19}-V_{21});actual use includes 1 measurement questions (V_{22}) (Fishben and Ajzen, 1975; Davis et al., 1989; Ajzen, 1991; Moore and Benbasat, 1985; Thompson et al., 1991; Taylor and Todd, 1995a; 1995b; Compeau et al., 1999; Venkatesh et al., 2003) as in Table 3.

Measurement of questions ask interviewees' level of agreement in Likert 5-point scale of agree very much, agree, so-so, disagree, disagree very much. Measurement of utilization behaviours is based on actual data the company offered for analysis.

Table 3 Measurement of Each Constructs

Construct	No	Indicator
Perceived Usefulness (F1)	V_1	I would find the system useful in my job
	V_2	Using the system enables me to accomplish tasks more quickly
	V_3	Using the system increases my productivity
	V_4	Using the system would improve my job performance

Table 3 Measurement of Each Constructs (Continue)

Construct	No	Indicator
Perceived Ease of Use (F2)	V_5	My interaction with the system would be clear and understandable
	V_6	It would be easy for me to become skillful at using the system
	V_7	Learning to operate the system is easy for me
Subjective Norm (F3)	V_8	People who are important to me think that I should use the system
	V_9	The senior management of this business has been helpful in the use of the system
	V_{10}	In general, the organization has supported the use of the system.
	V_{11}	I use the system because of the proportion of coworkers who use the system.
Perceived Behavioural Control (F4)	V_{12}	I have the resources necessary to use the system
	V_{13}	I have the knowledge necessary to use the system
	V_{14}	A specific person (or group) is available for assistance with system difficulties
	V_{15}	Using the system fits into my work style
Attitude Toward Using (F5)	V_{16}	Using the system is a bad/good idea
	V_{17}	The system makes work more interesting
	V_{18}	I like working with the system
Behavioural Intention to Use (F_6)	V_{19}	I intend to use the technology system as often as needed
	V_{20}	Whenever possible, I intend not to use the technology system
	V_{21}	To the extent possible, I would use the technology system frequently
Actual Use	V_{22}	Average of Daily Use of the system

3.3 Target and survey method

The target is employees at Parking Management and Development Office, Taipei City Department of Transportation (hereafter Parking Administration). Tickets were issued by handwriting before. To improve efficiency, Parking Administration introduced PDA system. The researcher collects data from fee collectors at Parking Administration with longitudinal collection to understand fee collectors' acceptance of new technology

(PDA). Survey was made at four timing. The first time was after education training of PDA by Parking Administration (T_1). The 2nd one was one week after fee collectors' actual use of PDA (T_2). The 3rd time was one month after fee collectors' actual use of PDA (T_3). The 4th time was two months after fee collectors' actual use of PDA (T_4).

Questions for fee collectors included perceived uesfulness (V_1-V_4), perceived ease of use (V_5-V_7), subjective norm (V_8-V_{11}), perceived behavioural control (V_{12}-V_{15}), attitude toward use (V_{16}-V_{18}) and behavioural intention to use (V_{19}-V_{21}). Fee collectors' actual use behaviours (V_{22}) was analyzed with number of issued tickets provided by Parking Administration. The research adopts two-stage analysis of structural equation model. Confirmatory factor analysis was first made to delete measurement variables that might interfere with causal analysis. In the 2nd stage, path analysis was made on modified measurement models or the potential variables causal relation analysis. With the results of analysis, model fit and parsimony of the 3 models was compared. Explanation ability of behavioural intention to use and actual use behaviours was analyzed to understand advantages and weaknesses of the 3 models.

4. Study results

4.1 Sample structure and questionnaire reliability analysis

With convenience sampling, survey was made on fee collectors afar explanations by Parking Administration at T_1. At T_2 (one week after use), T_3 (one month after use), and T_4 (two months after use), on duty fee collectors were interviewed in Taipei City. At T_1, 224 questionnaires were issued and 204 valid ones were collected (91.07%); at T_2, 147 were issued and 132 valid returned (89.80%); at T_3, 165 were issued and 155 valid ones returned (93.93%); at T_4, 130 were issued and 113 valid ones returned (86.92%). A total of 666 questionnaires were issued and 604 valid ones were collected at 90.69%. Most respondents were women, accounting for 65.7% (397 copies). Most respondents were between 46 and 55 at 47.8% (289 copies) and had worked for over 11 years at 47.7% (288 copies). Most of them were (vocational) high school graduates at 61.6% (372 copies). Experience was mainly from education training at 33.8% (204 copies). See Table 4 for personal data distribution.

Table 4 Descriptive Statistics

	T_1	T_2	T_3	T_4	**Total**
Gender					
Male	54 (26.5%)	30 (22.7%)	40 (25.8%)	20 (17.7%)	144 (26.6%)
Female	136 (66.7%)	83 (62.9%)	102 (65.7%)	76 (67.3%)	397 (65.7%)
Unanswered	14 (6.9%)	19 (14.4%)	13 (8.4%)	17 (15.0%)	63 (10.4%)
Total	204	132	155	113	604
Age					
Under 25 years	1 (0.5%)	2 (1.5%)	0 (0.0%)	0 (0.0%)	3 (0.5%)
26~35 years	7 (3.4%)	8 (6.1%)	10 (6.5%)	5 (4.4%)	30 (5.0%)
36~45 years	87 (42.6%)	43 (32.6%)	67 (43.2%)	42 (37.2%)	239 (39.6%)
46~55 years	91 (44.6%)	69 (52.3%)	70 (45.2%)	59 (52.2%)	289 (47.8%)
Above 56 years	9 (4.4%)	5 (3.8%)	5 (3.2%)	3 (2.7%)	22 (3.6%)
Unanswered	9 (4.4%)	5 (3.7%)	3 (1.9%)	4 (3.5%)	21 (3.5%)
Total	204	132	155	113	604
Seniority					
Under 1 year	5 (2.5%)	5 (3.8%)	7 (4.5%)	4 (3.5%)	21 (3.5%)
1~5 years	30 (14.7%)	19 (14.4%)	16 (10.3%)	10 (8.8%)	75 (12.4%)
6~10 years	34 (16.7%)	24 (18.2%)	25 (16.1)	13 (11.5%)	96 (15.9%)
Above 11 years	101 (49.5%)	57 (43.2%)	75 (48.4)	55 (48.7%)	288 (47.7%)
Unanswered	34 (16.7%)	27 (20.5%)	32 (20.6%)	31 (27.4%)	124 (20.5%)
Total	204	132	155	113	604
Educational Degree					
Junior High	13 (6.4%)	8 (6.1%)	7 (4.5%)	6 (5.3%)	34 (5.6%)
Senior High	134 (65.7%)	79 (59.8%)	94 (60.6%)	65 (57.5%)	372 (61.6%)
College	35 (17.2%)	23 (17.4%)	30 (19.4%)	16 (14.2%)	104 (17.2%)
Unanswered	22 (10.8%)	22 (16.7%)	24 (15.5%)	26 (23.0%)	94 (15.6%)
Total	204	132	155	113	604

To examine non-response bias, the researchers referred to earlier study method (Karahanna et al., 1999) to analyze population statistics from the four timing (genders, ages, seniority and education attainment). From the results of percentage homogenous test, both Pearson chi-square and Cramer's V showed that none of the data from all timing was significant or p-value exceeded 0.001. See details in Table 5. It can be inferred that samples from the survey did not differ in genders, ages, seniority and education attainment at different timing. Impacts of non-response bias were reduced.

Table 5 Test of Homogeneity of Proportions

	Pearson Chi-Square		Cramer's V	
	Statistic Value	**Approx. Sig.[a]**	**Statistic Value**	**Approx. Sig.**
Time and Gender	$2.136_{(3)}$ [b]	0.545	0.063	0.545
Time and Age	$11.271_{(12)}$	0.506	0.080	0.506
Time and Seniority	$5.805_{(9)}$	0.759	0.063	0.759
Time and Educational Degree	$1.277_{(6)}$	0.973	0.035	0.973

a: Approximate Significant; b: Brackets means degree of freedom

Cronbach's α coefficient was used for questionnaire reliability analysis to test internal consistency of latent variables. Results (Table 6) show that perceived uesfulness reliability is between 0.777 and 0.882; perceived ease of use reliability is between 0.723 and 0.793; that of subjective norm is between 0.796 and 0.853; that of perceived behavioural control is between 0.787 and 0.825; that of attitudes toward use is between 0.571 and 0.900 and that of behavioural intention to use is between 0.884 and 0.941. In general, Cronbach's α has to exceed 0.6 to show stability of questionnaire. Figure higher than 0.7 means high reliability. The questionnaire in this study has good reliability.

Table 6 Reliability

	T_1	T_2	T_3	T_4	**Total**
PU	0.882	0.826	0.777	0.856	0.860
PEOU	0.784	0.784	0.723	0.763	0.793
SN	0.806	0.796	0.798	0.853	0.824
PBC	0.819	0.787	0.790	0.825	0.819
ATU	0.831	0.571	0.849	0.900	0.787
BIU	0.884	0.941	0.893	0.915	0.913

4.2 Verificationof models

4.2.1 Confirmatory factor analysis

Confirmatory factor analysis was made as the 3 models contain different dimensions. In measuring model fitness index, $\chi 2$ is affected by number of samples. Under more samples, analysis results tend not to receive null hypothesis (Gerbing and James 1992). $\chi 2$/df value has to be tested and has to be less than 5 in GFI, AGFI, NFI, NNFI, CFI, RMR and RMSEA and larger than 0.9 in GFI, AGFI, NFI, NNFI and CFI. Higher value means higher fitness. RMR has to be less than 0.05; that of RMSEA has to be lower than 0.08. Lower figure means smaller residual and better model fitness (Joreskog and Sorbom, 1993).

Confirmatory factor analysis results of the 3 models are in Table 7. All fitness indexes reach required standard. TAM measurement models have good explanation ability. From C-TAM-TPB and UTAUT initial measurement model analysis results, fitness indexes are acceptable. GFI and AGFI values are lower than suggested standard. Further analysis was made on the two models' residual. From analysis results of Lagrange multiplier test, V_{15}: "new technology system is appropriate for ticket issuing" was highly related to many potential dimensions. Chi-square and residual values are large. They are complicated variables. Hatcher (1998) believed that deleting such variables would avoid interfering with ensuing path analysis results. The paper deleted C-TAM-TPB and UTAUT measurement models V_{15} and had once more confirmatory factor analysis. GFI of the two models exceeded 0.9 and AGFI was close to 0.9. To further understand if there was significant impression, chi-square difference test was made. In C-TAM-TPB, revised chi-square value dropped to 204.62; degree of freedom reduced by 20, showing significant improvement in UTAUT. Modified chi-square value dropped to 201.078 and degree of freedom went down by 17, showing significant improvement, in modified models. Path analysis was then made for modified measuring models.

Table 7 Confirmatory Factor Analysis Results

Model Fit Index	TAM	C-TAM-TPB		UTAUT	
	Initial Model	Initial Model	Revised Model	Initial Model	Revised Model
χ^2	208.774	723.789	519.165	598.560	397.482
df	68	189	169	138	121
χ^2/df	3.07	3.830	3.072	4.337	3.285
GFI	0.952	0.884	0.920	0.887	0.928

Table 7 Confirmatory Factor Analysis Results (Continue)

Model Fit Index	TAM	C-TAM-TPB		UTAUT	
	Initial Model	Initial Model	Revised Model	Initial Model	Revised Model
AGFI	0.926	0.845	0.891	0.844	0.899
NFI	0.963	0.921	0.939	0.920	0.942
NNFI	0.966	0.926	0.948	0.922	0.948
CFI	0.975	0.940	0.958	0.937	0.959
RMR	0.032	0.045	0.039	0.046	0.038
RMSEA	0.059	0.069	0.059	0.074	0.061

Among the 3 models, factor analysis load of potential dimensions and measurement variables is in Table 8. The results showed that most of the factor load exceeded 0.7 in statistics significance. It can be inferred that the 3 measuring models have good convergent validity and discriminant validity.

Table 8 Standardized Factor Loading

	TAM	C-TAM-TPB	UTAUT
Perceived Usefulness			
V_1	0.869***	0.867***	0.863***
V_2	0.759***	0.764***	0.767***
V_3	0.774***	0.770***	0.771***
V_4	0.718***	0.719***	0.720***
Perceived Ease of Use			
V_5	0.754***	0.749***	0.749***
V_6	0.714***	0.717***	0.716***
V_7	0.782***	0.785***	0.786***
Subject Norm			
V_8	--	0.720***	0.712***
V_9	--	0.824***	0.829***

Table 8 Standardized Factor Loading (Continue)

	TAM	C-TAM-TPB	UTAUT
V_{10}	--	0.706***	0.714***
V_{11}	--	0.690***	0.684***
Perceived Behavioural Control			
V_{12}	--	0.769***	0.770***
V_{13}	--	0.828***	0.828***
V_{14}	--	0.734***	0.733***
Attitude Toward Using			
V_{16}	0.737***	0.741***	--
V_{17}	0.643***	0.640***	--
V_{18}	0.887***	0.884***	--
Behavioural Intention to Use			
V_{19}	0.910***	0.911***	0.906***
V_{20}	0.830***	0.830***	0.834***
V_{21}	0.910***	0.910***	0.913***

4.2.2 Path analysis

4.2.2.1 Model fitness analysis

Path analysis was made after confirmatory factor analysis on TAM, C-TAM-TPB, and UTAUT. See results in Table 9. The 3 models meet regular standard in fitness, showing consistency between the causal relation of the 3 models and collected information by the research.

To compare the 3 models, chi-square difference test is used to tell if there are significant differences among the 3 models. In TAM and C-TAM-TPB comparison, the 2 models' χ^2 difference is 364.556 (578.256-213.700); that of degree of freedom is 105(178-73). TAM and C-TAM-TPB have significant difference. TAM is superior to C-TAM-TPB. In comparison between TAM and UTAUT, χ^2 difference is 189.829 (403.529-213.700) and that of degree of freedom is 52 (125-73). TAM outweighs UTAUT in fitness indexes. In C-TAM-TPB and UTAUT comparison, χ^2 difference is 174.727 (578.256-403.529); that of degree of freedom is 53 (178-125). UTAUT is superior to C-TAM-TPB. TAM has best fitness, followed by UTAUT and then C-TAM-TPB.

Table 9 Fit Indices for Each of the Research Models

	TAM	C-TAM-TPB	UTAUT
Model Fit Index			
χ^2	213.700	578.256	403.529
Df	73	178	125
χ^2/df	2.927	3.249	3.228
GFI	0.951	0.912	0.927
AGFI	0.930	0.886	0.900
NFI	0.962	0.932	0.942
NNFI	0.969	0.943	0.950
CFI	0.975	0.952	0.959
RMR	0.032	0.043	0.039
RMSEA	0.057	0.061	0.061
Model Parsimony Index			
ECVI	0.462	1.141	0.827
AIC	67.700	222.256	153.529
CAIC	-326.761	-739.580	-521.917

In SEM competing model analysis, provided models have certain fitness, the simpler models are more ideal. Simplicity consideration index analysis was made. Such index include ECVI (Expected Cross-validation Index), AIC (Akaike Information Criterion) and CAIC (Consistent Akaike Information Criterion). Smaller ECVI, AIC and CAIC (absolute) values mean better parsimony of models. One can not judge the good and bad of models parsimony from the size of the absolute values of the 3 indexes. Researchers must compare size of different models' indexes to judge the parsimony.

From analysis results, TAM has best simplicity (ECVI = 0.463, AIC = 67.700 and CAIC = -326.761), followed by UTAUT (ECVI = 0.827, AIC=153.529 and CAIC = -521.917) and then C-TAM-TPB (ECVI = 1.141, AIC = 222.256 and CAIC = -739.580).

4.2.2.2 Analysis of individual models

Table 10 lists TAM analysis results of samples from different timing. Attitude toward use at T_1 was mainly affected by perception easy access. At T_2 to T_4, attitude toward use was influenced by perceived uesfulness; influence of perceived ease of use was less significant. Attitude toward use had significant influence on behavioural intention to use at four timing. Behavioural intention only affected actual use behaviours at T_1 and T_2.

Table 10 Path Coefficients Comparison for TAM Model

Path	T_1	T_2	T_3	T_4
PU→ATU	0.287*	0.794***	0.505*	0.927***
PEU→ATU	0.642***	0.005	0.384	0.039
ATU→BIU	0.970***	0.978***	0.985***	0.963***
BIU→AU	0.197**	0.161*	0.104	0.128

*: $p < 0.1$; **: $p < 0.01$; ***: $P < 0.001$

TAM analysis results showed all causal relation in hypothesis of overall sample models existed (Figure 5). Attitude toward use was mainly affected by perceived uesfulness; path coefficient was 0.562, followed by perceived ease of use with path coefficient at 0.354. Behavioural intention to use was affected by attitude toward use; path coefficient was 0.972. Actual use behaviours were influenced by behavioural intention to use with path coefficient at 0.128. Attitude toward use R-square was 0.786, meaning that perceived uesfulness and perceived ease of use could explain attitude toward use 78.6% variance degree. Attitude toward use tended to explain behavioural intention variance degree 94.4%; behavioural intention explained actual use behaviours variance degree 1.6%.

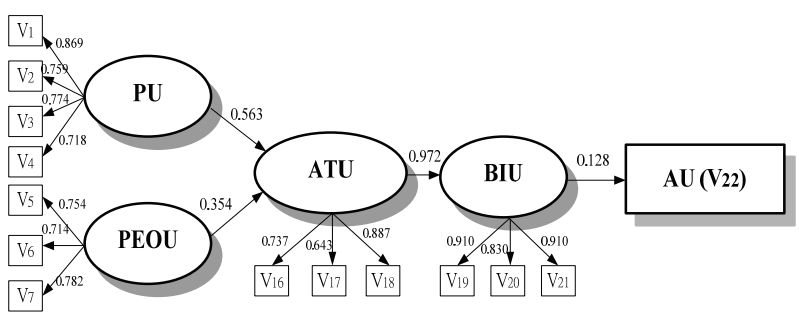

Figure 5 Standardized Path Coefficients for TAM Model (All Samples)

Table 11 lists C-TAM-TPB model analysis at different timing. Attitude toward use at T_1 was mainly affected by perceived ease of use. At T_2 and T_4, attitude toward use was influenced by perceived uesfulness; influence of perceived ease of use not significant. At T_3, perceived uesfulness and perceived ease of use influence was still insignificant. Influence of perceived ease of use on perceived uesfulness was significant at four timing. In behavioural intention influence, attitude toward use was significant at 4 timing and the most significant influential factor from T_1 to T_3. Other than at T_4 when perceived uesfulness and subjective norm had significant influence on behavioural intention to use, analysis results at other timing were not significant. Influence of perceived behavioural control on behavioural intention at 4 timing was not significant in behavioural intention to use. Except for significant influence of behavioural intention to use on actual use behaviours at T_3, perceived behavioural control and behavioural intention did not significantly affect actual use behaviours at other timing.

Table 11 Path Coefficients for C-TAM-TPB Model

Path	T_1	T_2	T_3	T_4
PU→ATU	-0.432	0.670**	0.442*	0.710***
PEOU→ATU	1.385***	0.131	0.497*	0.243
PEU→PU	0.924***	0.861***	0.896***	0.904***
ATU→BIU	1.354***	0.901***	1.330***	0.341*
PU→BIU	0.161	0.006	-0.316	0.380*
SN→BIU	-1.118	0.026	-0.057	0.393*
PBC→BIU	0.603	0.079	-0.017	-0.142
BIU→AU	0.084	0.216	0.185*	0.088
PBC→AU	0.163	-0.087	-0.021	0.505

*: $p < 0.1$; **: $p < 0.01$; ***: $P < 0.001$

The path analysis results on overall samples in C-TAM-TPB (Figure 6) showed that, in the 9 hypothesis variables causal relation, 4 path relations failed to be significant-perceived uesfulness and behavioural intention, subjective norm and behavioural intention, perceived behavioural control and behavioural intention, behavioural intention to use and actual use. The other 5 paths are significant. In the 5 paths, perceived uesfulness was affected by perceived ease of use with path coefficient at 0.905; attitude toward use was mainly affected by perceived ease of use with path coefficient at 0.681,

followed by perceived uesfulness with path coefficient at 0.285. Behavioural intention to use was affected by attitude toward use with path coefficient at 1.018. Perceived behavioural control affecting actual use had path coefficient at 0.107. In R-square analysis, explanation ability of perceived ease of use on perceived uesfulness variance was 81.8%; explanation degree of perceived uesfulness and perceived ease of use on attitude toward use variance was 84.7%; explanation ability of attitude toward use on behavioural intention variance was 94.4%; that of perceived behavioural control on actual use behaviours variance was 2.1%.

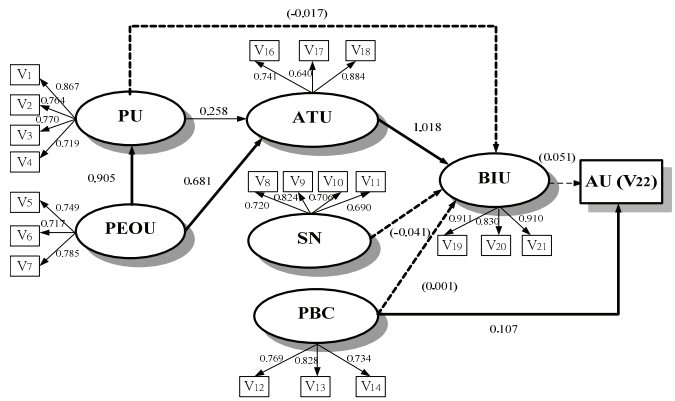

Figure 6 Standardized Path Coefficients for C-TAM-TPB Model (All Samples)

Table 12 lists analysis results of samples at different timing under UTAUT model. In utilization behavioural intention analysis results, at T_1, perceived uesfulness did not have significant influence on behavioural intention to use. From T_2 to T_4, the relation was significant and perceived uesfulness was the major affecting variable. Perceived ease of use only significantly affected behaviour intention to use at T_1; subjective norm had no significant influence on behaviour intention only at T_3. In actual use behaviours analysis results, behaviour intention to use and perceived behavioural control had no significant influence on actual use behaviours at 4 timing.

Table 12 Path Coefficients Comparison for UTAUT Model

Path	T_1	T_2	T_3	T_4
PU→BIU	0.092	0.612***	0.456*	0.693***
PEOU→BIU	0.654***	-0.174	0.260	-0.080
SN→BIU	0.206*	0.405**	0.182	0.361*
BIU→AU	0.073	0.198	-0.043	0.101
PBC→AU	0.172	-0.069	0.200	0.031

Figure 7 showed analysis results of samples at different timing under UTAUT. Except for behavioural intention on actual use behaviours had no significant path relation, other path relations had significant influence. Among the 3 variables affecting behavioural intention, perceived uesfulness had greatest influence with path coefficient at 0.427, followed by perceived ease of use with path coefficient at 0.264. Subjective norm path coefficient was 0.237. Perceived behavioural control affecting actual use behaviours had path coefficient at 0.119. In R-square analysis, explanation ability of perceived uesfulness, perceived ease of use and subjective norm on behaviour intention variance was 76.2%. That of perceived behavioural control on actual use behaviours variance was 2.1%.

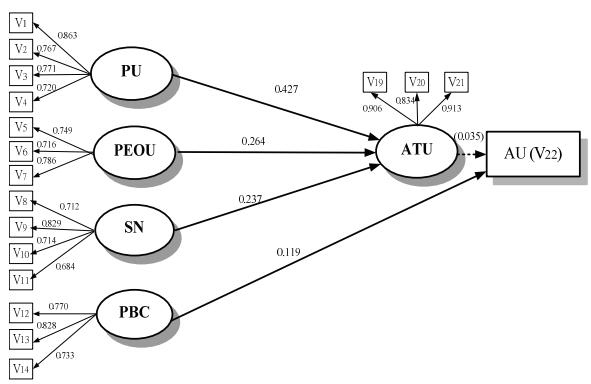

Figure 7 Standardized Path Coefficients for UTAUT Model (All Samples)

Table 13 lists path analysis and R-square analysis results of the 3 models. Perceived ease of use and perceived uesfulness relation helped explain attitude toward use. Attitude toward use significantly helped explain behaviour intention. Percepived behavioural control caused non-existence of relation of behavioural intention on actual use behaviours.

Table13 Path Analysis Comparison among TAM, C-TAM-TPB, and UTAUT Models

	TAM	C-TAM-TPB	UTAUT
R-Square of ATU	0.786	0.847	
PU→ATU	∨	∨	
PEOU→ATU	∨	∨	
R-Square of PU		0.818	
PEOU→PU		ˇ	
R-Square of BIU	0.944	0.944	0.762
ATU→BIU	∨	∨	
PU→BIU		×	∨
PEOU→BIU			∨
SN→BIU		×	∨
PBC→BIU		×	
R-Square of AU	0.016	0.021	0.021
BIU→AU	∨	×	×
PBC→AU		∨	∨

NO: ∨ : significant; ×: not significant

5. Conclusions and suggestions

5.1 Conclusions

We believed that thee are 3 most representative models in the field of technology acceptance behaviours TAM and C-TAM-TPB from TRA and UTAUT integrating theories. Under reliability analysis, measurement variables in this study were quite consistent. Under confirmatory analysis results, except for V_{15} to be deleted as complicated variable (in C-TAM-TPB and UTAUT), other measurement variables had good content and discriminant validity.

In path analysis, 3 models' fitness had good performance, meeting regular standard. TAM had best parsimony, followed by UTAUT and then C-TAM-TPB. Later studies focused on adding dimensions to enhance explanation ability of models on technology

acceptance behaviours. From R-square analysis, under TAM, explanation ability of dependent variables (attitude toward use, behavioural intention to use and actual use) were similar to those of the other 2 models. TAM exceeded the other 2 models in model fitness and model parsimony. TAM is representative and with utilization meaning in study of technology acceptance behaviours.

Earlier studies based on TAM framework did not have consistent results in causal relation among variables. Better understanding of the causal relation will help better under major variables of technology acceptance behaviours such as attitude toward use, behaviour intention to use and actual use behaviours. The paper had more in-depth exploration on the role of each variable in technology acceptance behaviours. From TAM analysis, Perceived uesfulness directly affected attitude toward use and UTAUT analysis showed perceived uesfulness directly affected behaviour intention. In C-TAM-TPB analysis, in consideration of relation among perceived uesfulness, attitude toward use and behaviour intention, perceived uesfulness did not have significant influence on behaviour intention to use. It can be inferred that attitude toward use will completely be intermediate in relation between perceived uesfulness and behaviour intention. That is, even users believed new technology was useful, provided the technology failed to guide them to have good impression or bring positive help, users would not be willing to use. TAM analysis showed perceived ease of use directly affected attitude toward use while UTAUT analysis showed perceived ease of use directly affected behaviour intention. C-TAM-TPB analysis pointed out perceived ease of use affected perceived uesfulness. This causal relation helped explain users' attitude toward use.

Both TAM and C-TAM-TPB analysis showed attitude toward use had great influence on behaviour intention, which corresponded to some viewpoints in TRA-behaviour intention was affected by attitudes. Idea of TRA on subjective norm was not verified in the analysis. Under C-TAM-TPB and UTAUT analysis, when attitude toward use was not included in the models, subjective norm had then significant influence on behaviour intention to use. It can be inferred that users' intention on new technology might be affected by the social environment such as pressure from the organization or comments of colleagues. Behaviour intention to use was still mainly based on users' preference. If users did not like the new technology, no matter how company or the superiors required users, users still would not use. C-TAM-TPB and UTAUT analysis showed perceived behavioural control directly affected actual use behaviours but not behavioural intention. With perceived behavioural control, behavioural intention to use would have no influence on actual use behaviours. This means users still would not really use the technology if they did not feel having control of the required sources.

The researcher believed that attitude toward use was a key factor in technology acceptance behaviour study. Other than being completely intermediate in relation between

perceived uesfulness and behavioural intention to use, attitude toward use were also completely intermediate in the relation between perceived ease of use and behavioural intention and that between subjective norm and behavioural intention. See attitude toward use intermediary effects in Figure 8. Under UTAUT analysis, perceived uesfulness, perceived ease of use and subjective norm had direct influence on behavioural intention to use. With attitude toward use into the models (Figure 8), 3 variables did not have direct influence on behaviour intention. They directly affected attitude toward use and indirectly affected behaviour intention. This further confirmed complete intermediate results of attitude toward use and its importance in technology acceptance behaviour models.

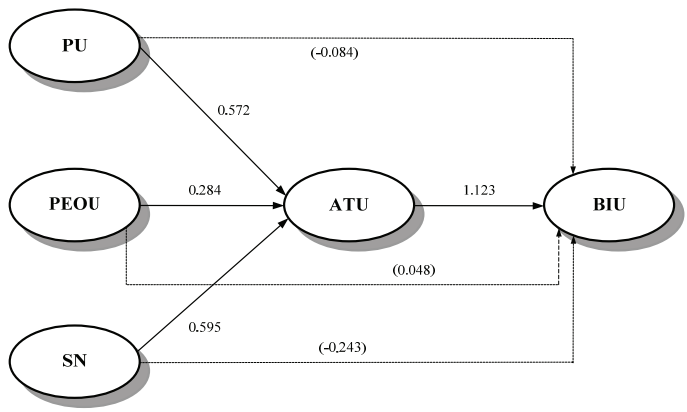

Figure 8 Mediation Effect of Attitude toward Using

5.2 Operation management content

From empirical analysis results on fee collectors at Taipei City Parking Administration on acceptance, there are 3 suggestions for the competent authority:

5.2.1 Importance of perceived uesfulness and perceived ease of use

It was verified that perceived uesfulness and perceived ease of use are indeed important factors in users' acceptance and have positive influence on attitude toward use (directly) and behavioural intention (indirectly). The competent authority, during education training, in addition to familiarity with the system itself, is recommended to make explanation of performance or improvement of other effects in order to enhance users' perception feeling of system usefulness to increase behavioural intention to use. Also, as perceived ease of use directly affects perceived uesfulness, what is more important is, before introduction of new system, utilization interface and operation process of the system shall be modified for users to make learning and utilization as easy as possible. This will enhance feelings of users of system easy access and increase behavioural intention to use.

5.2.2 Complete intermediate effects of attitude toward use

Attitude toward use are the most important part (completely intermediate) in users' acceptance and fully explain how characteristics of the technology (perceived uesfulness and perceived ease of use) affect users' willingness. In entire users' acceptance, other than various perception feelings of the system, fondness of the system also affects behavioural intention. The competent authority shall enhance publicity to users in kind face-to-face manner to have direct communication with users. Users' positive attitudes towards use behaviours will be enhanced and users will have greater behaviour intention to use.

5.2.3 Influence of perceived behavioural control on actual use behaviours

Influence of perceived behavioural control on actual use behaviours is greater than that of behavioural intention on actual use behaviours. This means users care about very much the level of they own the resources (including those from the competent authority and themselves). The competent authority shall provide users with appropriate education training to make users have ability. All resources must be complete. Users must be free from doubts on control of use. They may even be allowed to participate in some R&D and design of new technology to have greater felling of perceived behavioural control and higher use behaviours.

5.3 Study limitations and suggestions for future studies

For study of technology acceptance behaviours, targets must be from organizations introducing new technology. For researchers, locating appropriate target is quite difficult. With support from Parking Administration, survey on users could be made to acquire actual information of use. This is quite rare. If more information can be gathered from different industries for comparison of models, one will have more comprehensive understanding. In measurement of actual use behaviours, non-fixed time and places of ticket issuing by fee collectors as well as passiveness of using PDA might cause deviation in the study on actual use behaviours measurement. It also affected explanation ability of the models.

There are now a lot of technology acceptance behaviour theory models; it causes troubles to researchers in constructing model. It is suggested future researchers shall start with simple or most fundamental models and then add new variables for different targets. When adding new variables into models, correlation between the variables and original variables shall be considered. Some researchers included a lot of important adjustment variables such as voluntariness of use, utilization experience and different technology characteristic. These variables can be included in future studies to make technology acceptance behaviours better understood.

References

1. Agarawal, R. and Karahanna, E. (2000) 'Time flies when you're having fun: Cognitive absorption and belief about information technology usage', *MIS Quality*, Vol. 24, No. 4, pp. 665-694.

2. Ajzen, I. (1985) 'From intentions to actions: A theory of planned behaviour', in Kuhl Julius and Bechmann Jurgen (eds.), *Action Control from Cognition to Behaviour*, Springer, New York, pp. 309-330.

3. Al-Khaldi, M.A. and Wallace, R.S.O. (1999) 'The influence of attitudes on personal computer utilization among knowledge workers: The case of Saudi Arabia', *Information and Management*, Vol. 36, No. 4, pp. 185-204.

4. Bandura, A. (1986) *Social Foundations of Thought and Action: A Social Cognitive Theory*, Englewood, Prentice-Hall, Cliffs NJ.

5. Chang, M.K. and Cheung, W. (2001) 'Determinants of the intention to use internet/www at work: A confirmatory study', *Information and Management*, Vol. 39, No. 1, pp. 1-14.

6. Chau, P.Y.K. and Hu, P.J.H. (2002) 'Examining a model of information technology acceptance by individual professionals: An exploratory study', *Journal of Management Information Systems*, Vol. 18, No. 4, pp. 191-229.

7. Chen, L.D., Gillenson, M.L. and Sherrell, D.L. (2002) 'Enticing online consumers: An extended technology acceptance perspective', *Information and Management*, Vol. 39, No. 8, pp. 705-719.

8. Cheung, W., Chang, M.K. and Lai, V.S. (2000) 'Prediction of internet and world wide web usage at work: A test of an extended triandis model', *Decision Support Systems*, Vol. 30, No. 1, pp. 83-100.

9. Compeau, D.R. and Higgins, C.A. (1995a) 'Application of social cognitive theory to triandis for computer skills', *Information Systems Research*, Vol. 6, No. 2, pp. 118-143.

10. Compeau, D.R. and Higgins, C.A. (1995b) 'Computer self-efficacy: Development of a measure and initial test', *MIS Quarterly*, Vol. 19, No. 2, pp. 189-211.

11. Compeau, D.R., Higgins, C.A. and Huff, S. (1999) 'Social cognitive theory and individual reactions to computing technology: A longitudinal study', *MIS Quarterly*, Vol. 23, No. 2, pp. 145-158.

12. Davis, F.D. (1989) 'Perceived usefulness, perceived ease of use, and user acceptance of information technology', *MIS Quarterly*, Vol. 13, No. 3, pp. 319-339.

13. Davis, F.D., Bagozzi, R.P. and Warshaw, P.R. (1989) 'User acceptance of computer technology: A comparison of two theoretical models', *Management Science*, Vol. 35, No. 8, pp. 982-1003.

14. Davis, F.D., Bagozzi, R.P. and Warshaw, P.R. (1992) 'Extrinsic and intrinsic motivation to use computers in the workplace', *Journal of Applied Social Psychology*, Vol. 22, No. 14, pp. 1111-1132.

15. Fishbein, M. and Ajzen, I. (1975) *Belief, Attitude, Intention and Behaviour: An Introduction to Theory and Research*, Addison-Wesley, MA.

16. Gefen, D., Karahanna, E. and Straub, D.W. (2003) 'Trust and tam in online shopping: An integrated model', *MIS Quality*, Vol. 27, No. 1, pp. 51-90.

17. Gerbing, D.W. and James C.A. (1992) 'Monte carlo evaluations of goodness of fit indices for structural equation models', *Sociological Methods and Research*, Vol. 21, No. 2, pp. 132-160.

18. Gist, M.E. and Mitchell, T.R. (1992) 'Self-efficacy: A theoretical analysis of its determinants and malleability', *Academy of Management Review*, Vol. 17, No. 2, pp. 183-211.

19. Hatcher, L. (1998) *A Step-by-Step Approach to Using the Sas System for Factor Analysis and Structural Equation Modeling*, SAS Institute Inc.

20. Herbert, T.T. (1976) *Dimension of Organizational Behaviour*, Collier Macmillian, New York.

21. Hu, P.J., Chau, P.Y.K., Sheng, O.R.L. and Tam, K.Y. (1999) 'Examining the technology acceptance model using physician acceptance of telemedicine technology', *Journal of Management Information Systems*, Vol. 16, No. 2, pp. 91-112.

22. 洪新原、梁定澎、張嘉銘 (2005)。「科技接受模式之彙總研究」，資訊管理學報，第12卷，第4期，頁211-234。
Hung, S.Y., Liang, T.P. and Chang, C.M. (2005) 'A meta-analysis of empirical research using TAM', *Journal of Information Management*, Vol. 12, No. 4, pp. 211-234.

23. Igbaria, M. and Iivari, J. (1995) 'The effects of self-efficacy on computer usage', *Omega*, Vol. 23, No. 6, pp. 587-605.

24. Joreskog, K.G. and Sorbom, D. (1993) LISREL8: User's Reference Guide, *Scientific Software International*, Chicago, IL.

25. Karahanna, E., Straub, D.W. and Chervany, N.L. (1999) 'Information technology adoption across time: A cross-sectional comparison of pre-adoption and post-adoption beliefs', *MIS Quarterly*, Vol. 23, No. 2, pp. 183-213.

26. Koufaris, M. (2002) 'Applying the technology acceptance model and flow theory to online consumer behaviour', *Information System Research*, Vol. 13, No. 2, pp. 205-223.

27. Lederer, A.L., Maupin, D.J., Sena, M.P. and Zhuang, Y. (2000) 'The technology acceptance model and the world wide web', *Decision Support Systems*, Vol. 29, No. 3, pp. 269-282.

28. Legris, P., Inghamb, J. and Collerette, P. (2003) 'Why do people use information technology? A critical review of the technology acceptance model', *Information and Management*, Vol. 40, No. 3, pp. 191-204.

29. Liao, S., Shao, Y.P., Wang, H. and Chen, A. (1999) 'The adoption of virtual banking: An empirical study', *International of Journal of Information Management*, Vol. 19, No. 1, pp. 63-74.

30. Mathieson, K. (1991) 'Predicting user intentions: Comparing the technology acceptance model with the theory of planned behaviour', *Information Systems Research*, Vol. 2, No. 3, pp. 173-191.

31. Moon, J.W. and Kim, Y.G. (2001) 'Extending the TAM for a world-wide-web context', *Information and Management*, Vol. 38, No. 4, pp. 217-230.

32. Moore, G.C. and Benbasat, I. (1991) 'Development of an instrument to measure the perceptions of adopting an information technology innovation', *Information Systems Research*, Vol. 2, No. 3, pp. 192-222.

33. Plouffe, C.R., Hilland, J.S. and Vandenbosch, M. (2001) 'Richness versus parsimony in modeling technology adoption decision -- Understanding merchant adoption of smart card-based payment system', *Information System Research*, Vol. 12, No. 2, pp. 208-222.

34. Riemenschneider, C.K., Harrison, D.A. and Mykytyn, P.P. Jr. (2003) 'Understanding IT adoption decisions in small business: Integrating current theories', *Information and Management*, Vol. 40, No. 4, pp. 269-285.

35. Rogers, E.M. (1983) *Diffusion of Innovations* (3rd ed.), Free Press, New York.

36. Sheppard, B.H., Hartwick, J. and Warshaw, P.R. (1988) 'The theory of reasoned action: A meta-analysis of past research with recommendations for modifications and future research', *Journal of Consumer Research*, Vol. 15, No. 3, pp. 325-343.

37. Taylor, S. and Todd, P.A. (1995a) 'Assessing IT usage: The role of prior experience', *MIS Quarterly*, Vol. 19, No. 4, pp. 561-570.

38. Taylor, S. and Todd, P.A. (1995b) 'Understanding information technology usage: A test of competing models', *Information Systems Research*, Vol. 6, No. 2, pp. 144-176.

39. Taylor, S. and Todd, P.A. (1995c) 'Decomposition and crossover effects in the theory of planned behaviour: A study of consumer adoption intentions', *International Journal of Research in Marketing*, Vol. 12, No. 2, pp. 137-155.

40. Thompson, R.L., Higgins, C.A. and Howell, J.M. (1991) 'Personal computing: Toward a conceptual model of utilization', *MIS Quarterly*, Vol. 15, No. 1, pp. 125-143.

41. Thompson, R.L., Higgins, C.A. and Howell, J.M. (1994) 'Influence of experience on personal computer utilization: Testing a conceptual model', *Journal of Management Information Systems*, Vol. 11, No. 1, pp. 167-187.

42. Triandis, H.C. (1971) Attitude and Attitude Change, *John Wiley and Sons*, New York.

43. Venkatesh, V. (2000) 'Determinants of perceived ease of use: Integrating control, intrinsic motivation, and emotion into the technology acceptance model', *Information Systems Research*, Vol. 11, No. 4, pp. 342-365.

44. Venkatesh, V. and Davis, F.D. (2000) 'A theoretical extension of the technology acceptance model: Four Longitudinal field studies', *Management Science*, Vol. 46, No. 2, pp. 186-204.

45. Venkatesh, V. and Speier, C. (1999) 'Computer technology training in the workplace: A longitudinal investigation of the effect of the mood', *Organizational Behaviour and Human Decision Processes*, Vol. 79, No. 1, pp. 1-28.

46. Venkatesh, V., Morris, M.G., Davis, G.B. and Davis, F.D. (2003) 'User acceptance of information technology: Toward a unified view', *MIS Quarterly*, Vol. 27, No. 3, pp. 425-478.

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