

## 影響高速公路使用者使用ETC行為因素之探討

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### 摘要

高速公路電子收費系統（ETC）為智慧型交通運輸系統（ITS）的重要子系統之一。ETC以資訊科技為基礎的系統，當車輛安裝車上設備（OBU）或電子無線射頻標籤（eTag）後，ETC透過電子識別向車輛收取過路費，讓駕駛人可在免停車或減速的情況下通過收費站完成繳費動作。即使ETC有減少交通擁擠、不用停車之優點，但使用率一直低於預期。高速公路局為了減緩收費站前的停等時間，並考慮公平收費的原則下，預計將實施電子計程收費系統。由於台灣ETC的使用率偏低，本研究主要為探討採用ETC服務的態度和行為意圖之影響因素。由研究結果發現，在以科技接受模式為基礎下，對於ETC的認知有用性與認知易用性對於使用ETC的態度皆有正向影響，而認知易用對認知有用有正向影響。在計畫行為理論的基礎下，高速公路使用者對於ETC的使用主要是受其對ETC使用態度的影響；ETC使用主觀規範與ETC使用知覺行為控制皆無顯著影響。

關鍵詞：電子收費系統、科技接受模式、計畫行為理論

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# The Study of Technology Acceptance of ETC on Freeway Users

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## Abstract

The Electronic Toll Collection (ETC) is part of the Intelligent Transportation System (ITS). It is an information system that makes drivers install On-Board Units (OBU) or eTag and charges vehicles as they pass through a tollbooth without stopping or slowing down. The current ETC is a toll-based collection system in Taiwan. Despite the potential benefits for reducing traffic congestion, the utilization rate of ETC for drivers has been lower than expected. In order to alleviate traffic delay in tollbooths and consider equity principle in toll collection, the electronic distance-based charging system (EDBS) will be implemented overall on freeways.

Because of the low utilization rate of ETC in Taiwan, this study wanted to explore the factors affecting the attitude and behavior intention of ETC service adoption. Based on technology acceptance model and the result of this study, it could be finding that the perceived usefulness and the perceived ease of use are positively associated with users' attitude toward using. A useful and ease of use ITS product can improve users' attitude of using it. Based on theory of planned behavior and the result of this study, users' attitude is positively associated with behavioral intention. Subjective norm and perceived behavioral control are not positively associated with behavioral intention significant. So users' attitude played an important role in using ETC. Besides, perceived usefulness and perceived ease of use are positively associated with behavioral intention indirectly.

**Keywords: The Electronic Toll Collection, Technology Acceptance Model, Theory of Planned Behavior**

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## Introduction

The Electronic Toll Collection (ETC) system was an important element of Intelligent Transport Systems (ITS) that allows for nonstop toll collection and traffic monitoring. ETC system utilizes vehicles equipped with transponders (electronic tags; eTag), wireless communication, in-road sensors, and a computerized system to uniquely identify each vehicle, electronically collect the toll, and provide general traffic monitoring and data collection. ETC technologies and infrastructures provide the necessary capabilities for future applications such as incident management, alternate route guidance, and travel demand management. Properly implemented, ETC can reduce congestion, increase operating efficiency, improve travel time, reduce pollution, and improve safety of the roadway facility and surrounding corridors.

In Taiwan, to improve its services and to reduce personnel costs, the Taiwan Area National Freeway Bureau engaged General Consultant in February, 2003 to launch a project for the establishment of the electronic toll collection system on all the freeways. The project is to be a build-operate-transfer project financed by private fund. It will serve as the foundation of future intelligent transportation system. The contract was won by Far Eastern Consortium and a new company, Far Eastern Electronic Toll Collection Co., Ltd., was formed for the implementation of the project. The signing of contract between TANFB and FETC on 27 April, 2004 is an important job in the history of toll collection (Liang, Lien, Lin, Chen, & Lee, 2004). Taiwan Area National Freeway Bureau has announced that all motorists could be using eTag to access the country's freeway ETC system next step for distance-based highway Toll, but the eTag user is not as much as Taiwan Area National Freeway Bureau which. Make more people using eTag is an important job for Taiwan Area National Freeway Bureau, now.

### **The Electronic Toll Collection (ETC)**

The ETC is a technology that allows for electronic payment of tolls. ETC is used in cordoned urban areas, over bridges, in tunnels, in high occupancy toll lanes, on toll



roads, or through turnpikes. Toll charges are generally based on mileage, maintenance requirements, or congestion levels (Kamarulazizi, & Ismail, 2010). Until recent years most ETC systems were based on using radio devices in vehicles that would use proprietary protocols to identify a vehicle as it passed under a gantry over the roadway.

The ETC system can wireless communication and information change by the device fixed in the vehicle and road head device which was fixed in the toll station's roadway. It composes by automatic vehicle identification system, center control system and other ancillary facilities (Xu, Liu, Tao, & Li, 2007).

ETC was a major component of the ITS. ETC is combination of techniques and technologies that allows vehicles to pass through a toll facility without requiring any action by the driver. In fact, today's conventional toll plaza in not necessary in a fully dedicated ETC facility. ETC components can be categorized as roadway components and customer service center components. Three major roadway components are required for the successful implementation of an ETC. These components are: Automatic Vehicle Identification (AVI), Automatic Vehicle Classification (AVC), and Video Enforcement Systems (VES).

All roadway components are in communication with and controlled by a computer called the lane controller. The lane controller takes input from the AVI, AVC, and VES components. Its database, through which a list a valid tags is maintained, is used to validate the AVI and charge the customer's account. The information from each lane controller is passed on to a plaza host computer. Each plaza host computer is in constant communication with the central computer in the customer service center, thereby consolidating the database, as well as equipment requirements. The customer service center manages the accounts, enrolls customers and issues tags, processes the violations, handles all inquiries, and serves as the facility management center.

### **The Technology Acceptance Model (TAM)**

Based on the theory of reasoned actions (TRA) (Ajzen & Fishbein, 1980), TAM addresses factors influencing a user's attitude toward using (AT) and intention to use



technology (Davis, Bagozzi, & Warshaw, 1989). TAM has been widely adopted in studies exploring technology acceptance due to its parsimonious nature and highly reliable constructs. Examples include studies testing user acceptance of word processors (Davis, Bagozzi, & Warshaw, 1989), spreadsheet applications (Mathieson, 1991), email (Szajna, 1996), and websites (Gefen, Karahanna, & Straub, 2003).

TAM considers perceived usefulness (PU) and perceived ease of use (PE) as two major factors influencing a user's attitude toward using (AT) (as H1 and H2). The former refers to the perceived effectiveness of improving the user's performance, while the later refers to how effortless a user perceives using the technology to be. Perceived usefulness and user attitude in turn influence intention to use, which predicts actual usage of technology (as H3). Prior research has found that PE mostly influences attitude and intention indirectly through PU (Hu, Chau, Liu, & Tam, 1999) (as H7 and H8).

H1: PE of using ETC is positively associated with AT of using ETC.

H2: PU of using ETC is positively associated with AT of using ETC.

H3: PE of using ETC is positively associated with PU of using ETC.

H7: PE of using ETC is positively associated with BI of using ETC.

H8: PU of using ETC is positively associated with BI of using ETC.

### **Theory of Planned Behavior (TPB)**

The most significant model for the current study is Ajzen's (1991) Theory of Planned Behavior (TPB), which attempts to explain the causal link between values, beliefs, attitudes, intentions and behavior. In simple terms, the theory proposes that when given a behavioral choice, an individual will consider the alternatives and assesses their consequences based on their beliefs relating to the actions and their effects. These beliefs determine an individual's attitudes regarding the possible actions, which in turn influence the intention to act with behavioral intention being a strong indicator of the actual behavior chosen (Ajzen, 1991).

Attitude (AT) toward a behavior is the degree to which performance of the behav-



ior is positively or negatively valued. According to the expectancy value model, attitude toward a behavior is determined by the total set of accessible behavioral beliefs linking the behavior to various outcomes and other attributes (Ajzen, 2006). Subjective norm (SN) is the perceived social pressure to engage or not to engage in a behavior. Drawing an analogy to the expectancy-value model of attitude, it is assumed that subjective norm is determined by the total set of accessible normative beliefs concerning the expectations of important referents (Ajzen, 2006). Perceived behavioral control (PBC) refers to people's perceptions of their ability to perform a given behavior. Drawing an analogy to the expectancy-value model of attitude, it is assumed that perceived behavioral control is determined by the total set of accessible control beliefs.

Behavioral intention (BI) is an indication of a person's readiness to perform a given behavior, and it is considered to be the immediate antecedent of behavior. The intention is based on attitude toward the behavior, subjective norm, and perceived behavioral control, with relation to the behavior and population of interest (Ajzen, 2006) (as H4, H5, and H6).

H4: AT of using ETC is positively associated with BI of using ETC.

H5: SN of using ETC is positively associated with BI of using ETC.

H6: PBC of using ETC is positively associated with BI of using ETC.

## MATERIALS AND METHODS

### Research Framework

The research framework of this study was combined TAM and TPB. Figure 1 was the summarize the research framework of this study in a TAM-TPB model in which perceived ease of use, perceived usefulness, information technology experience positively influence users' attitude and intentions.



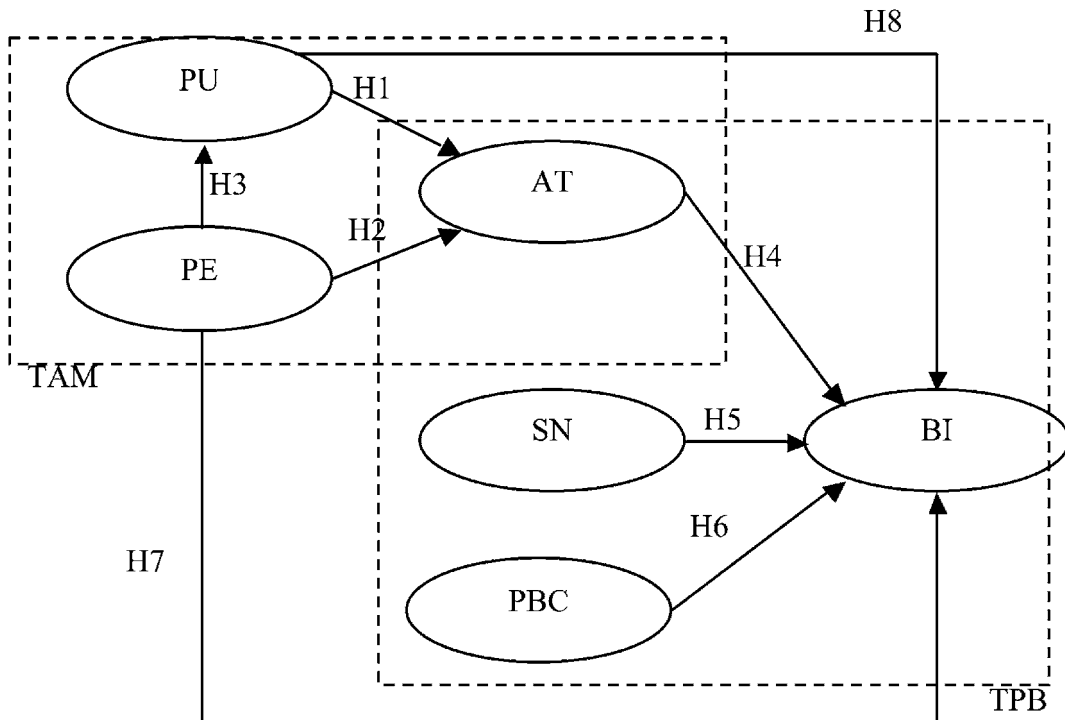


Figure 1: Research Framework

## Research Data

This study focus on these freeway ETC users, and the research data were collected at Qingshui Service Area with ETC system. Finally a total of 152 feedbacks were collected. These data was collected by Chih-Cheng Chen for the research: A Study on the Influences of Evaluation Changes from Media (Word-of-Mouth) Dissemination on the Acceptance Intention of ETC Policy on Freeway Users. This research was finished at July, 31, 2010.

## Methodology

The main data analysis methodology in this study is Structural Equation Modeling (SEM) for these latent variables: PU, PE, AT, SN, PBC, and BI, and the software for data analysis was Mplus 6.1. This study was developed in a way that the model constructs in TAM-TPB were adapted to the context of using ETC system. Scale items on the survey include those measuring perceived usefulness (PU), perceived ease of use



(PE), a user's attitude toward using (AT), Subjective Norm (SN), Perceived Behavioral Control (PBC), and Behavioral Intention (BI). The questionnaire contains no identifying information about the individual participants.

The questionnaires of perceived usefulness (PU) are as follow:

- (1) I can pass the freeway toll stations with ETC faster than before.
- (2) I can pass the freeway toll stations with ETC smoothly.
- (3) I can pass the freeway toll stations with ETC convenient than before.
- (4) I can reduce the time on the freeway to destination with ETC.
- (5) The number of strong point of using ETC is more than the number of the shortcoming of using ETC.

The questionnaires of perceived easiness of use (PE) are as follow:

- (1) The location of setting ETC is very convenient.
- (2) The information that is provided by ETC is very useful.
- (3) Refill ETC is very is very easy for me.
- (4) The location of refill ETC is very convenient for me.
- (5) Paying the ETC fee is very convenient for me.
- (6) The message of ETC chargeback fail is useful for me.
- (7) The ETC service phone is useful for me.
- (8) The ETC web service is useful for me.
- (9) Overall, using ETC is easy for me.

The questionnaires of the user's attitude toward using (AT) are as follow:

- (1) I think I prefer to use the ETC.
- (2) I consider the using of ETC is correct.
- (3) I consider the using of the ETC is a pleasant experience.
- (4) I consider that the ETC is a good measure.

The questionnaire of Subjective Norm (SN):

- (1) Some important people for me in the life think I should continue using ETC.

The questionnaires of Perceived Behavioral Control (PBC):





- (1) I have time for dealing with the problem of using ETC.
- (2) I have the ability of getting the knowledge of using ETC
- (3) I can bear the burden of ETC set up fee.

The questionnaires of Behavioral Intention (BI):

- (1) I intend to drain away the ETC.
- (2) I intend to continue using ETC.
- (3) I intend to recommend my friends using ETC.

There are 6 parts in the research questionnaire with 5 scales..All variables exhibit a high level of reliability with the Cronbach's alpha values (Table 1) exceeding the recommended 0.6 (Nunnally, 1978).

Table 1: Scale Reliability

Scale	N of Items	Cornbach's Alpha
Perceived Usefulness (PU)	5	0.91
Perceived Ease of Use (PE)	9	0.89
Attitude (AT)	4	0.94
Subjective Norm (SN)	1	-
Perceived Behavioral Control (PBC)	3	0.84
Behavioral Intention (BI)	3	0.66

## Model Testing

The structural model was investigated using Mplus 6.1 with maximum likelihood. Path analysis was performed on the model using standardized maximum likelihood estimation. The path analytic method offers the advantage of testing the overall model fit with multiple endogenous variables as in the model as well as individual a priori hypotheses.

The likelihood ratio chi-square test assesses the overall model fit. Chi-square per degree of freedom (CMIN/DF), the relative Chi-square, is 2.55 (677.33/266), satisfying the recommend <5 criterion for a good fit. Standardized Root Mean Square Residual



(SRMR) is 0.076, Root Mean Square Error of Approximation (RMSEA) is 0.101, and CFI is 0.854.

The result of correlation coefficient is as Table 2. It could be found that square of AVE were between 0.81 and 0.16. They are larger than most of other ration in the table.

Table 2: Results of Correlation coefficient

	PU	PE	AT	SN	PBC	ATT
PU	.66					
PE	.63*	.47				
AT	.78*	.65*	.81			
SN	.53*	.53*	.68*	.16		
PBC	.47*	.57*	.52*	.41*	.65	
BI	.47*	.36*	.52*	.37*	.31*	.58

\*: P-value < 0.05

## RESULTS

A total of 152 ETC users' feedbacks were collected. Some basic demographic information is collected, indicating approximately 118 male (77.63%) and 34 female (22.37%) in the sample population, most of them are 31~35 years old, and there are 34 users in this age range (22.37%) (Table 3).

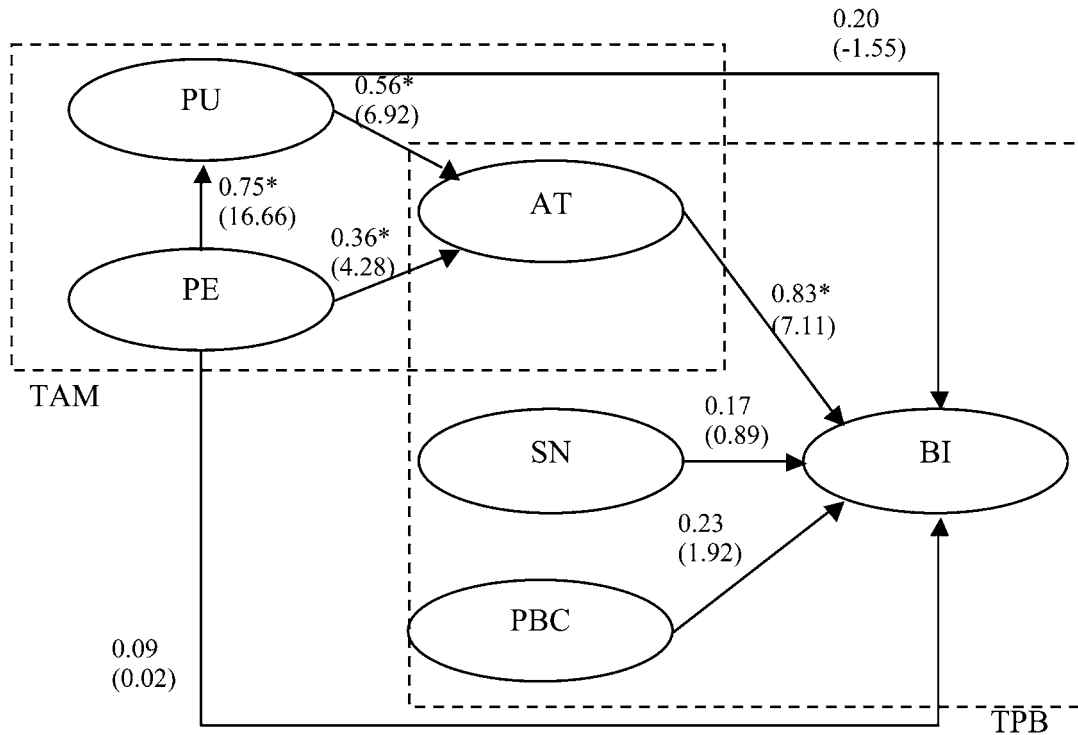
Table 3: Data Summarize

Variable		Frequency	Percent (%)
Gender	Male	118	77.63
	Female	34	22.37
Age	18~20	3	1.97
	21~25	6	3.95
	26~30	16	10.53
	31~35	34	22.37



Variable		Frequency	Percent (%)
	36~40	31	20.39
	41~45	18	11.84
	46~50	12	7.89
	51~55	22	14.47
	56~60	9	5.92
	60~	1	0.66
Education	Under Junior School	9	5.92
	Senior High School	45	29.61
	University	79	51.97
	Above Institute	19	12.50
Total		152	100.0

Correlations among the variables are illustrated in Figure 2. This model explains 51.6% of the variance in attitude and 75.5% of the behavioral intention.



() : t-value  
 \* : P-value < 0.05

Figure 2: Structural Model with Inter-Construct Correlations



Results indicate most of the relationships in the proposed model are statistically significant and in the predicted directions. Each observed variables influence with two ways: direct effect and indirect effect, and the total effect are the sum of direct effect and indirect effect. The Main effect of most of these observed variables is direct effect, but the information technology experience with the perceived usefulness. Six hypotheses are supported at  $p < 0.05$ . Table 4 was the summarization of the hypothesis testing.

Table 4: Results of Hypothesis Testing

	Path	Direct Effect (P-Value)	Indirect Effect (P-Value)	Total Effect	Support
H1	PU → AT	0.56 (<0.00)	-	0.56	Yes
H2	PE → AT	0.36 (<0.00)	-	0.36	Yes
H3	PE → PU	0.75 (<0.00)	-	0.75	Yes
H4	AT → BI	0.83 (<0.00)	-	-0.83	Yes
H5	SN → BI	0.17 (0.38)	-	0.17	No
H6	PBC → BI	0.23 (0.06)	-	-0.23	No
H7	PU → BI	0.20 (0.12)	0.47(<0.00)	-0.42	Yes
	PU → AT → BI	-			
H8	PE → BI	0.09 (0.99)		-0.65	Yes
	PE → AT → BI	-	0.30(<0.00)		
	PE → PU → AT → BI	-	0.35(<0.00)		

## CONCLUSION

Conclusion of this study provide evidence that TAM was an applicable model in examining factors influencing users' attitudes of using ETC and behavioral intentions in relation to the use of the ITS technology, such as eTag.

Based on technology acceptance model and the result of this study, it could be finding that the perceived usefulness and the perceived ease of use are positively asso-



ciated with users' attitude toward using. A useful and ease of use ITS product can improve users' attitude of using it. The perceived ease of use is positively associated with the perceived usefulness. It means the easily operation of ETC technology products is very important for the users, and the easier for set on the ETC technology products, the more people think it is usefulness. These results are the same as the point at issue of Davis (1989). The result is the same as Wu (2010) and Hsieh (2007). So it could be found that people like ETC with e Tag rather than ETC with OBU (On Board Unit) for its easy for using.

Based on theory of planned behavior and the result of this study, users' attitude was positively associated with behavioral intention, the same as Huang's research result (2007). Subjective norm and perceived behavioral control are not positively associated with behavioral intention significant. So users' attitude played an important role in using ETC. Besides, perceived usefulness and perceived ease of use are positively associated with behavioral intention indirectly.

In order to alleviate traffic delay in tollbooths and consider equity principle in toll collection, the electronic distance-based charging system (EDBS) will be implemented overall on freeways in December 2012, and ETC is an important tool in EDBS. But the ETC users were not as much as Taiwan Area National Freeway Bureau which. Increasing the number of ETC users was the big job for Taiwan Area National Freeway Bureau to push EDBS. Based on the result of this study, Taiwan Area National Freeway Bureau should let people know the goodness and the easy of using of ETC for freeway users' attitude of using ETC, and freeway users' behavioral intention of using ETC will improve, and more freeway users will use ETC.

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