TING-WEI LIN, Ph.D.
E-mail: twlin@mail.mcu.edu.tw
Ming Chuan University,
Department of Tourism
5 De Ming Rd., Gui Shan District,
Taoyuan County 333, Taiwan
CHIA-YEN LIN, Ph.D.
E-mail: lin.chiayen@gmail.com
National University of Tainan,
Department of Public Administration and Management
33, Sec. 2, Shu-Lin St., Tainan 700, Taiwan
WEN-HO HSU, M.Sc.
E-mail: tcmhsu@hotmail.com
Taiwan Semiconductor Manufacturing Company Limited,
Logistics & Warehouse Management Department

Intelligent Transport Systems (ITS)
Preliminary Communication
Accepted: Jan. 19, 2013
Approved: Oct. 12, 2013

EFFECTS OF SYSTEM CHARACTERISTICS ON ADOPTING WEB-BASED ADVANCED TRAVELLER INFORMATION SYSTEM: EVIDENCE FROM TAIWAN

ABSTRACT

This study proposes a behavioural intention model that integrates information quality, response time, and system accessibility into the original technology acceptance model (TAM) to investigate whether system characteristics affect the adoption of Web-based advanced traveller information systems (ATIS). This study empirically tests the proposed model using data collected from an online survey of Web-based advanced traveller information system users. Confirmatory factor analysis (CFA) was performed to examine the reliability and validity of the measurement model, and structural equation modelling (SEM) was used to evaluate the structural model. The results indicate that three system characteristics had indirect effects on the intention to use through perceived usefulness, perceived ease of use, and attitude toward using. Information quality was the most important system characteristic factor, followed by response time and system accessibility. This study presents implications for practitioners and researchers, and suggests directions for future research.

KEY WORDS

Web-based advanced traveller information system (ATIS), System characteristics, Travellers' adoption, Technology acceptance model (TAM), Behavioural intention model

1. INTRODUCTION

In the field of intelligent transportation systems (ITS), advanced traveller information systems (ATIS) are a systematic application that applies information and communication technologies (ICTs) to collect travel-related data, as well as processes and delivers valuable information to travellers. In recent years, the tremendous growth and acceptability of the Internet has caused Web-based ATIS to become a fundamental service for disseminating pre-trip and en-route information to travellers. World Wide Web (WWW) is a logically integrated system, even though different components (viz., clients, servers, and database) of Internet are physically located at different locations. This capability offers the provision of combining heterogeneous traveller information from different information sources (e.g., Variable Message Signs or Radio broadcasting) so as to deliver traffic information through an integrated and consistent interface to travellers [1]. This type of Web service has the ability to deliver various kinds of static and dynamic traveller information to travellers in multimedia form (e.g., maps and CCTV images). Such information can help travellers make better travel decisions (e.g., change travel route, departure time, and travel plan), and provide direct benefits to travellers (e.g., less travel time, greater reliability of travel time) and higher indirect benefits to the transportation system (e.g., less congestion) or the environment (e.g., less air pollution) [2]. These expected benefits are not maximized unless travellers use this system. In order to promote this service, it is necessary to better understand what factors affect travellers' adopting a Web-based ATIS.

The ATIS literature has paid increasing attention to traveller information use. Empirical surveys and descriptive reports have evaluated travellers' demographic characteristic, awareness, usability, trip characteristic, satisfaction, and the benefit of using the existing ATIS services (e.g., [3-6]). These findings provide meaningful and useful clues to improving and promoting current services, and highlight the potential factors affecting traveller willingness to consult traveller information. Other empirical studies attempt to model and identify the use and effects of current ATIS services based on factors such as trip purpose, trip frequency, socio-economic characteristics, and information types (e.g., [7-9]). Some studies construct a conceptual framework of traveller information use based on manifest determinants such as traveller characteristics, trip purpose and context, travel alternatives availability, and information service characteristics (e.g., [8,10]). Undoubtedly, traveller acceptance and adoption of ATIS is a prerequisite for traveller information acquisition and use. Although numerous studies have examined the critical factors affecting traveller information usage, investigations on how travellers' perceptions influence the adoption of Web-based ATIS are still lacking [11, 12].

Previous studies have validated the vital role of system characteristics in predicting the technology acceptance of information systems (IS) in various contexts [13-18]. Most of these studies have either used a dummy variable to represent different systems or substituted a single overall construct for the system characteristics [18]. Regarding these simplistic treatments, the effects of individual system characteristics on user acceptance for all systems are difficult to emphasize. In the ATIS field, some general system characteristics are believed to be critical in affecting the use of ATIS [7, 8]. However, how various system characteristics influence the acceptance of specific ATIS is not yet clear.

The objective of this study was to identify specific system characteristics and examine their individual effects on the behavioural intention of adopting Web-based ATIS. To achieve this goal, this study proposes a behavioural intention model based on the technology acceptance model (TAM). The TAM [19, 20] is a well-established, robust, powerful, and parsimonious model for predicting and explaining the adoption of information systems (IS), and has been widely adopted in various contexts of IS use [21]. Following the introduction, Section 2 illustrates the theoretical background and hypotheses of this study. Section 3 describes the measures and data collection method. Section 4 presents the data analysis and empirical results. Section 5 discusses the research findings. Finally, Section 6 presents implications for practitioners and researchers, and provides suggestions for future research.

2. THEORETICAL BACKGROUND AND HYPOTHESES

2.1 Technology acceptance model (TAM)

TAM [19, 20] is an adaptation of the theory of reasoned action (TRA) proposed by Fishbein and Ajzen [22]. TAM is ideally suited to model the user acceptance of information systems (IS) to explain and predict the behaviours of system use. *Figure 1* depicts the original TAM [20], in which the individual's beliefs including perceived usefulness and perceived ease of use are the two most important factors explaining IS adoption behaviour. Perceived usefulness refers to the degree to which users believe that using a specific application system will increase their job performance. Perceived ease of use refers to the degree to which users believe that using a specific application system is free of effort [23]. While both of these factors affect an individual's attitude toward using a system, perceived ease of use has direct effect on perceived usefulness. These two beliefs also mediate the effects of external variables on attitude toward usage. Behavioural intention to use determines the actual IS usage. Behavioural intention to use, in turn, is affected by attitude toward using and the direct and indirect effects of perceived usefulness and perceived ease of use [20].

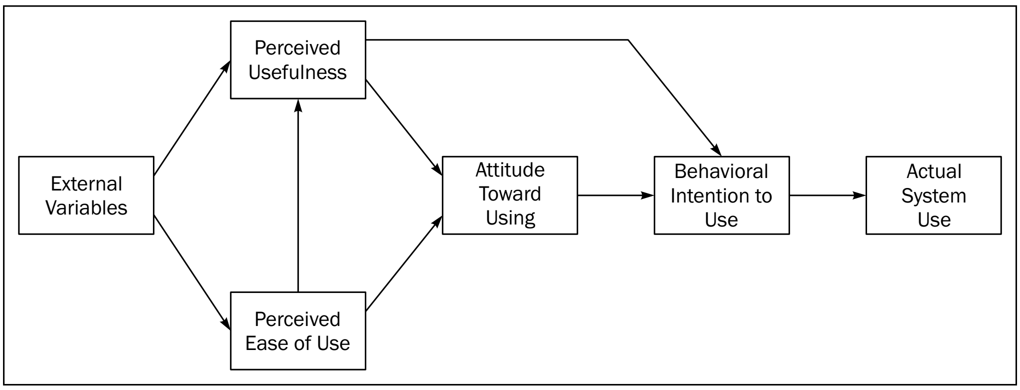

Figure 1 - Original TAM [20]

2.2 System characteristics

Davis et al. [20] argued the effects of system characteristics on user beliefs in TAM. Subsequent studies provided extensive assessments of this aspect, and proposed and examined a variety of general IS characteristics in other contexts [13-18]. In this study, three system characteristics are selected as external factors affecting the travellers' adoption of Web-based ATIS.

Information quality and system quality are two important IS characteristics in the context of IS success [24-26]. A previous study on traveller information system operators and users indicated that providing travellers with timely, accurate, reliable, and relevant information is necessary to satisfy their needs when making travel decisions [27]. Another evaluation of ATIS deployment also identified the quality of traveller information as a critical determinant of traveller information use [28]. Chorus et al. [8] summarized studies on ATIS use [29-31] and determined that information quality is essential to traveller information use. Therefore, in this study, we examined the role of information quality on travellers' adopting Web-based ATIS.

System quality is often measured in terms of system's technical characteristics [25, 32, 33]. The quality of the Internet connection is an essential concern for a Web-based system [34], and response time is an example of the system qualities most valued by Internet users [35]. Because users cannot tolerate the slow response time caused by poor Web design, the server host, or transmission delays on the Internet, their negative feelings cause them to avoid revisiting the Web site involved [25]. Studies on Web waiting time have observed that user tolerance of responsive delay differs according to various types of tasks [36-38]. When waiting occurs in situations in which the user is performing an essential task, the negative reaction of the user is amplified [37]. Travellers on time-sensitive trips are potential users [8]. Under such time constraints, travellers expect that acquiring and using ATIS information can reduce their trip uncertainties. Acquiring the needed traveller information is thus an essential task for Web-based ATIS users. In addition, a considerable amount of multimedia traveller information used on Web pages may lead to long download times than other general Web sites. Slow response times may cause users to lose patience with the service involved and, consequently, visit the site less frequently or avoid it completely. In this study, we examined whether the behavioural intention to adopt Web-based ATIS is affected by response time.

System accessibility is the third system characteristic considered in this study. Perceived accessibility is a critical system characteristic affecting IS use and success [39-41]. In other words, the more accessible an IS is, the less effort is required to use it. Accessibility represents the degree to which a user can attain meaningful contact with an information channel [42]. Culnan [43] investigated online IS and suggested that accessibility is a multidimensional concept encompassing physical access to the terminal and information system, as well as the ability to use the system successfully. Because of the continued popularity of using the Web as a source of information, this study focused on the physical accessibility of Web-based ATIS because physical access is a necessary condition for using this service. Travellers may require pre-trip or en-route traveller information at any routing decision point on their trips. Because terminal devices (e.g., a personal computer (PC), notebook, netbook, or tablet PC) with network connections can be used to access Web-based ATIS, travellers may be willing to adopt this service to acquire traveller information at decision points. Therefore, we used the proposed research model to examine the effect of system accessibility on traveller adoption of Web-based ATIS.

2.3 Research hypotheses

Some previous studies argue that information quality has a positive effect on the user beliefs of perceived usefulness and perceived ease of use (e.g. [44]). The current study defines information quality as the degree to which a Web-based ATIS provides travellers with complete, accurate, and timely traveller information for making their travel decisions. The higher traveller information quality is provided, the better travelling planning can be made by travellers. Thus, travellers' high satisfaction may enhance their perceptions on usefulness and ease of use. It is therefore reasonable to expect that higher information quality may increase travellers' perceptions of usefulness and ease of use when accessing Web-based ATIS. Thus, this study proposes the following hypotheses:

H_1: Information quality has a positive effect on the perceived usefulness of a Web-based ATIS.

H_2: Information quality has a positive effect on the perceived ease of using a Web-based ATIS.

Several TAM studies indicate that system quality has a significantly positive effect on perceived ease of use (e.g., [45,46]). This study defines response time as the degree to which a traveller perceives that the response from the Web-based ATIS is fast, consistent, and reasonable in retrieving traveller information. It is reasonable to expect that a speedy response time may increase travellers' perception of ease of use when accessing Web-based ATIS. Thus, this study proposes the following hypothesis:

H_3: Response time has a positive effect on the perceived ease of use of a Web-based ATIS.

This study defines system accessibility as the degree to which a traveller has physical access to the browsing devices and networking connections required to use Web-based ATIS. System accessibility is a necessary condition for the use of Web-based ATIS. The more accessible a browsing device with Internet connection is, the less effort is needed to use Web-based ATIS. Accordingly, this study proposes the following hypothesis:

H_4: System accessibility has a positive effect on the perceived ease of use of a Web-based ATIS.

Many TAM studies demonstrate the importance of perceived usefulness, showing that it has positive effects on attitude toward using and intention to use (e.g., [34]). This study defines perceived usefulness as the degree to which travellers believe that using a Web-based ATIS would increase their travelling benefits. These benefits include avoiding traffic congestion, deciding a better departure time and routing selection, and arriving at the destination on time. If travellers perceive the Web-based ATIS to be useful, their attitude toward using and intention to use to this system would likely improve. Therefore,

H_5: Perceived usefulness has a positive effect on attitude toward using a Web-based ATIS.

H_6: Perceived usefulness has a positive effect on the intention to use a Web-based ATIS.

Perceived ease of use is a casual antecedent of perceived usefulness [23]. Several studies using TAM confirm this relationship (e.g., [34, 40, 45]). The current study defines perceived ease of use as the degree to which a traveller believes that using a Web-based ATIS is free of effort. If travellers believe that they exert little effort to use a Web-based ATIS, their perceived usefulness and attitude toward using would likely increase. Accordingly, this study hypothesizes that

H_7: Perceived ease of use has a positive effect on the perceived usefulness of a Web-based ATIS.

H_8: Perceived ease of use has a positive effect on attitude toward using a Web-based ATIS.

Davis et al. [23] showed that attitudes toward using a specific system have direct effect on behavioural intention to use that system. Other TAM studies provide strong and positive empirical support for this relationship (e.g., [34]). This study defines the attitude toward using as a traveller's positive or negative feelings about using a Web-based ATIS, and defines the intention to use as a traveller's motivation or willingness to exert effort to use a Web-based ATIS. Thus, this study proposes the following hypothesis:

H_9: Attitude toward using has a positive effect on the intention to use a Web-based ATIS.

3. METHODOLOGY

3.1 Measures

A questionnaire survey was conducted to collect empirical data. The development of measures was based on a comprehensive review of relevant literature, the ATIS services context, interviews with travellers, and discussions with executives and experts in the ITS field. The interviews provided suggestions on wording modifications and examples for some measurement items; while six ITS executives and experts judged whether the items on the questionnaire were relevant. Once the initial questionnaire was generated, a pre-test survey was conducted with a pilot sample of 30 travellers to further refine the measurement items. Thus, the content validity of the measures was deemed adequate.

The questionnaire consisted of two parts. The first part asked respondents to indicate their agreement level for each item. Responses to these items in each construct were measured by a five-point Likert scale, with anchors of "strongly disagree" (1) to "strongly agree" (5). The *Information quality* construct was measured by three items adapted from the related studies [28, 29, 45], with minor modifications made to increase the applicability of these items to the current study following Fayish and Jovanis [29]. The *Response time* construct was measured by three items adapted from Tarafdar and Zhang [35], and Pituch and Lee [15]. The *System accessibility* construct was measured by three items, which were taken from Ilie et al. [39]. The *Perceived usefulness* construct was measured by three items adapted from Davis [23]. The *Perceived ease of use* construct was measured by three items adapted from Davis [23]. The *Attitude toward using* construct was measured by three items adapted from Davis [23]. Finally, the *Intention to use construct* was measured by two items adapted from Davis [23]. The second part of the questionnaire recorded the respondents' demographic profiles based on gender, age, education level, Internet access site, trip purpose, and mode use.

3.2 Sample and data collection

The data for this study were collected from the travellers who had used a Web-based ATIS in Taiwan. An online questionnaire survey was conducted using a convenience sampling method aimed at users of the Taiwan Area National Freeway Bureau (TANFB) Traffic Information System Website (http://1968.freeway.gov.tw/). The TANFB Traffic Information System Website is the oldest of all the Web-based ATISs available in Taiwan's public sector, and was established in 2004. This Website provides travellers with comprehensive and detailed real-time traveller information for Taiwan's entire freeway/expressway network, and is an important Web-based ATIS in Taiwan.

The online questionnaire was designed in Webpage format with JavaScript programming to check for incomplete responses and prompt respondents to answer them. An advertisement banner was posted on the TANFB Traffic Information System home page to recruit participants for a voluntary online intercept survey. Prospective respondents were linked to the questionnaire Web pages upon clicking the banner. The online questionnaire survey remained for about one month.

4. ANALYSIS AND RESULTS

4.1 Descriptive statistics

A total of 289 useful questionnaires were collected during the survey period. *Table 1* summarizes the major demographic profile of respondents. Most respondents accessed the TANFB Traffic Information System Website at home (56.4%), and working place (37.4%). For most travellers, common trip purposes were commuting (35.6%) and leisure (27.7%), followed by business (16.3%) and returning home (13.2%). Most respondents were passenger car drivers (96.8%), with only 1.4% and 1.1% driving a bus or pick-up truck, respectively.

4.2 Measurement model

This study uses confirmatory factor analysis (CFA) to test the adequacy of measurement model using AMOS software, which provides estimates of fit indices. The *p*-value of the Chi-square (χ^2 = 257.12, *df* = 149) was 0.000. The p-value should generally be greater than 0.05 to indicate an adequate fit, but the Chi-square (χ^2) value is very sensitive to sample size and frequently causes rejection of a well-fitting model. Therefore, the normed Chi-square value is often a better indictor than χ^2 [47]. An acceptable level of the χ^2/df value is a critical value between 1 and 3. The normed Chi-square value of the measurement model in this study was 1.726, indicating a good fit. This study also considers other goodness-of-fit indices. The goodness-of-fit index (GFI) and the adjusted goodness-of-fit index (AGFI) were 0.918 and 0.885, respectively, indicating an acceptable fit [48, 49]. The comparative fit index (CFI) was 0.977, and the Tucker Lewis Index (TLI) was 0.971. Both of these values exceeded the recommended value of 0.9 [50], providing further support for the measurement model. Finally, the root mean square residual (RMR) was 0.019 and the root mean square error of approximation (RMSEA) was 0.05. The RMR value provides evidence of model fit as it was below 0.05, while the RMSEA value should be less than a critical value ranging from 0.05 to 0.08 [47]. In summary, the CFA results indicated a good fit between the collected data and the proposed measurement model. This study also evaluates the reliability, convergent validity, and discriminant validity of the measurement model.

Table 1 - Major demographic profile of the respondents (N=289)

	Frequency	Percentage (%)
Gender		
Male	231	79.9
Female	58	20.1
Age		
11-20	8	2.8
21-30	103	35.6
31-40	130	44.9
41-50	30	10.4
51-60	17	5.9
61 or above	1	0.4
Education level		
Under senior high school	4	1.4
Senior high school	34	11.8
College/University	187	64.7
Graduate school	64	22.1
Monthly income (NTD) 1USD≒30NTD		
Less than 20,000	35	12.1
20,001-40,000	101	34.9
40,001-60,000	113	39.1
60,001-80,000	19	6.6
80,000-100,000	13	4.5
100,001 or above	8	2.8
Internet access site		
Home	163	56.4
Working place	108	37.4
School	13	4.5
Freeway resting area	2	0.7
Others	3	1.0
Trip purpose		
Commuting	103	35.6
Business	47	16.3
Returning home	38	13.2
Leisure	80	27.7
Visiting friends or relatives	7	2.4
Others	14	4.8
Mode use		
Passenger car	280	96.8
Pick-up trunk	3	1.1
Bus	4	1.4
Truck	0	0
Others	2	0.7

Composite reliability was estimated to evaluate the internal consistency in a set of latent construct indicators. The composite reliabilities for all constructs in the measurement model ranged from 0.857 to 0.934

Table 2 - Measurement model results

Constructs	Items	Factor loading	Standard error	Standardized loading	t-value	R^2	Composite reliability	AVE
Information quality	Web-based ATIS provides complete traveller information	1.000	-	0.876	-	0.767	0.857	0.667
	Web-based ATIS provides accurate traveller information	1.029	0.065	0.824	15.862***	0.679		
	Web-based ATIS provides timely traveller information	0.883	0.064	0.744	13.778***	0.554		
Response time	When you are using the Web-based ATIS, system response is fast	1.000	-	0.877	-	0.769	0.920	0.793
	In general, the response time of the Web-based ATIS is consistent	1.026	0.048	0.902	21.264***	0.814		
	In general, the response time of the Web-based ATIS is reasonable	1.026	0.050	0.893	20.547***	0.798		
System accessibility	It is easy to have device to access web-based ATIS	1.000	-	0.948	-	0.898	0.934	0.826
	It is easy to have Internet connection to access web-based ATIS	0.929	0.034	0.924	27.257***	0.855		
	My access to web-based ATIS is unrestricted	0.852	0.038	0.851	22.322***	0.724		
Perceived usefulness	Using web-based ATIS helps in avoiding traffic congestion	1.000	-	0.878	-	0.771	0.879	0.708
	Using web-based ATIS helps in deciding a better departure time and routing selection	0.997	0.057	0.854	17.403***	0.729		
	Using web-based ATIS helps in arriving at the destination on time	0.954	0.061	0.790	15.752***	0.625		
Perceived ease of use	It is easy to learn to use web-based ATIS	1.000	-	0.841	-	0.707	0.917	0.788
	It is easy to inquire traveller information from web-based ATIS	1.216	0.057	0.951	21.382***	0.903		
	Web-based ATIS is easy to use	1.143	0.061	0.867	18.627***	0.752		
Attitude toward using	It is worthwhile to use web-based ATIS	1.000	-	0.897	-	0.805	0.914	0.781
	It is pleasant to use web-based ATIS	1.009	0.045	0.902	22.429***	0.814		
	Using web-based ATIS is a good idea	0.940	0.047	0.851	19.877***	0.725		
Intention to use	I will continue to use web-based ATIS	1.000	-	0.942	-	0.887	0.925	0.860
	I will recommend others to use web-based ATIS	1.007	0.042	0.912	23.948***	0.831		

*Note: ***p<0.001*

Table 3 - Correlations and squared correlation between constructs

Constructs	AVE	Information quality	Response time	System accessibility	Perceived usefulness	Perceived ease of use	Attitude toward using	Intention to use
Information quality	0.667	1						
Response time	0.793	0.454 (0.206)	1					
System accessibility	0.826	0.263 (0.069)	0.288 (0.083)	1				
Perceived usefulness	0.708	0.561 (0.315)	0.312 (0.097)	0.094 (0.009)	1			
Perceived ease of use	0.788	0.475 (0.226)	0.503 (0.253)	0.337 (0.114)	0.449 (0.202)	1		
Attitude toward using	0.781	0.539 (0.290)	0.383 (0.147)	0.168 (0.028)	0.671 (0.450)	0.537 (0.288)	1	
Intention to use	0.860	0.512 (0.262)	0.338 (0.114)	0.173 (0.030)	0.703 (0.494)	0.516 (0.266)	0.809 (0.654)	1

(see *Table 1*), exceeding the cut-off value of 0.6 recommended by Bagozzi and Yi [50]. The average variance extracted (AVE) was greater than 0.5 in all constructs (see *Table 1*), indicating that more than one-half of the variances in the items were explained by their latent construct rather than the measurement error [51]. Convergent validity was also tested by examining the factor loadings and item reliability through CFA. Based on Dunn et al.'s [52] recommendations, the statistical significance on the factor loading estimation for each item can be determined by the t-value. *Table 2* shows that each item exceeded the critical value at the 0.001 significance level. Item reliability measures the amount of variance in an item explained by the underlying construct. As *Table 2* shows, the R^2 value can be used to estimate the reliability of a particular item [53]. All the R^2 values in this study were greater than the reliability acceptable value of 0.5 proposed by Bollen [48]. These results indicate that the factors in the measurement model had adequate reliability and convergent validity.

Discriminant validity is confirmed if the AVE for a construct is greater than its squared correlations with other constructs [51, 53]. As *Table 3* illustrates, the AVE value of each construct was greater than all other squared cross-correlations with other constructs. These results confirm the discriminant validity of the measurement model.

4.3 Structural model

To further confirm the proposed hypotheses, this study also examines the structural model using structural equation modelling (SEM) through AMOS software. The same set of fit indices provided evidence of a good model fit (χ^2 = 270.942, df = 158, p = 0.000, χ^2/df = 1.715, GFI = 0.915, AGFI = 0.887, CFI = 0.976, TLI = 0.971, RMR = 0.025, RMSEA = 0.05). Given the satisfactory performance of the structural model, the estimated path coefficients were then examined to evaluate the proposed hypotheses. *Figure 2* shows that the information quality variable had a significantly positive effect on perceived usefulness and perceived ease of use (β = 0.462, t-value = 6.696, $p < 0.001$, and β = 0.290, t-value = 4.429, $p < 0.001$, respectively), thus supporting H_1 and H_2. As expected, the response time had a significantly positive effect on perceived ease of use (β = 0.327, t-value = 5.092, $p < 0.001$), supporting H_3. The system accessibility had a significantly positive effect on perceived ease of use (β = 0.167, t-value = 3.009, $p < 0.001$), supporting H_4. Perceived usefulness had a significantly positive effect on intention to use and attitude toward using (β = 0.294, t-value = 4.872, $p < 0.001$, and β = 0.539, t-value = 9.056, $p < 0.001$, respectively), supporting H_5 and H_6. In addition, perceived ease of use had a significantly positive effect on perceived usefulness and attitude toward using (β = 0.231, t-value = 3.552, $p < 0.001$, and β = 0.305, t-value = 5.380, $p < 0.001$, respectively), supporting H_7 and H_8. Finally, the attitude toward using had a significantly positive effect on intention to use (β = 0.613, t-value = 9.942, $p < 0.001$), supporting H_9. The proposed model accounted for a proportion of the variance (R^2) for four endogenous variables: 36.9% of the variance in perceived usefulness, 36.1% of the variance in perceived ease of use, 53.3% of the variance in attitude toward using, and 70.6% of the variance in intention to use. Based on SEM analysis, we can find that information quality had the greatest effect on intention to use (0.385), followed by response time (0.108), and system accessibility (0.055).

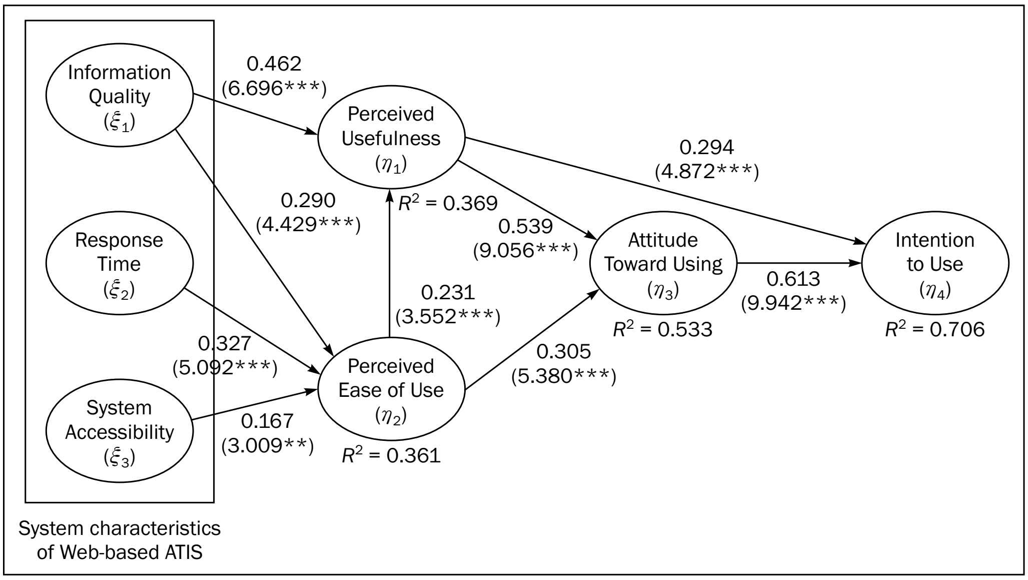

Figure 2 - Structural model results

***Significant at p<0.01; ***Significant at p<0.001.*

5. DISCUSSION

This study validates the importance of system characteristics when developing Web-based ATIS. In other words, travellers who perceive that an ATIS has system characteristics that are more profitable not only indicate that the system is easier to use or more useful but also report greater intention to use the system. In addition, the findings of this study suggest that Web-based ATIS developers and service providers should ensure that these system characteristics exist prior to implementation. For instance, travellers who perceive the system to have traveller information that is more accurate, a more favourable response time, and easier access to the system, also indicate that the system is easier to use. Therefore, not only system quality (e.g., information quality and response time) is critical, but the availability of terminal devices with Internet access influences traveller use of the system involved. However, system accessibility has not received much attention from Web-based ATIS developers and providers.

The findings of this study also confirm the well-established importance of relevant belief constructs [23]; that is, perceived ease of use and perceived usefulness are two critical determinants of Web-based adoption. The research results showed that travellers who perceive that the system is easy to use and helps them in making travelling plans express greater intention to use this system. To ensure that travellers perceive a system as easy to use, Web-based ATIS should provide online instructional materials that demonstrate how to acquire traveller information. Furthermore, Web-based ATIS should illustrate what types of traveller information are provided and describe how the information can benefit and help them in making effective travelling decisions. In addition, the attitude toward use is a crucial mediator between perceived usefulness and intention to use. Therefore, the system provider should strive to increase travellers' perceived usefulness or positively change their attitudes toward using Web-based ATIS. For example, changeable message signs (CMSs) can display short text messages that advertise the benefits of using Web-based ATIS to increase travellers' perceived usefulness and attitude toward use.

Information quality also exposes the importance of traveller information completeness. The present study suggests that the provision of more complete information can evoke travellers' willingness to use this service when they require traveller information. The finding about completeness of traveller information has two managerial implications. First, because Web-based ATIS has the ability to provide traveller information that is more varied than other traveller information sources, the system developers should strive to offer diverse types of traveller information that is as comprehensive as possible, prior to implementation. Travellers can thus obtain complete traveller information. Such comprehensive information can assist travellers in making travel plans that are more effective. Second, system managers should avoid the irregular outcomes of traveller information shown in Web-based ATIS. For example, once travellers find that the CCTV real-time traffic stream image is unavailable, they may perceive that the provided traveller information is incomplete. Thus, they might believe that the system is unreliable and that the information quality is low, thus decreasing intention to use. Furthermore, increasingly more people have tablet PCs, which did not support specific multimedia platforms used to add animation, video, and interactivity to Web pages. For instance, the iPad does not support Adobe Flash, which is frequently used for displaying real-time traffic conditions in Web-based ATIS. System designers should avoid such a situation to ensure information completeness.

More accurate traveller information is required to facilitate travellers' intentions to use Web-based ATIS. In particular, providing accurate predictive traveller information, such as travel time or incident duration forecasting, is a challenge in developing ATIS [54]. The Web-based ATIS provider should continually strive to develop lower-error forecasting techniques to ensure the accuracy of predictive traveller information.

The findings regarding response time and system accessibility have two implications. First, this study validated the positive effect of response time on perceived ease of use and intention to use Web-based ATIS. System developers should strive to avoid responsive delays resulting from possible Web server overloading, especially during long-term vacations. The distributed Web server framework of cloud computing is effective for balance loading, thus expediting response times and facilitating perceived interaction with the system. In addition, Web designers should avoid creating complicated interface design to decrease transmitting delays [55]. Providing a customized function that allows travellers to select useful traveller information on a single page can effectively reduce delays caused by waiting for several Web page downloads. Second, a Web-based ATIS agency should provide physical access to Web-based ATIS devices at possible key travel decision points, such as scenic spots, travel information centres, or freeway rest areas, where traveller information kiosks can be set up to increase travellers' accessibility to Web-based ATIS. The free Internet hotspots provided at the mentioned possible decision points to access Web-based ATIS can also promote travellers' adoption of an ATIS Web site by using their portable devices.

6. CONCLUSION

Based on extensive literature reviews of IS use, Web-based application adoption, and ATIS implementation, this study integrates information quality, response time, and system accessibility into TAM to identify critical system characteristics affecting travellers' adoption of Web-based ATIS. This study confirms the results of previous TAM studies in different contexts, and shows the applicability of TAM in explaining the acceptance of Web-based ATIS. This study also paves the way to investigate crucial antecedents of traveller acceptance for other ATIS technologies. The results of this study show that three system characteristics have significant positive effects on intention to use through perceived usefulness, perceived ease of use, and attitude toward using, while information quality has the greatest effect on intention to use. The meaningful insights and implications presented in this study can help policy makers develop effective promotion strategies and plans to increase travellers' intention to use Web-based ATIS.

The results of this study are subject to the following limitations. Firstly, this study was conducted in Taiwan; additional studies should determine whether traveller acceptance of Web-based ATIS varies in different levels of system awareness, Internet infrastructure settings, penetration rates of Internet usage, socio-economic characteristics, or cultural backgrounds. Secondly, the empirical results were drawn based on cross-sectional data. However, the relative importance of each antecedent in predicting behavioural intention may change over time as users gain more experience [21]. A longitudinal study that evaluates this research model during different time periods would provide a more rigorous test of this argument. Finally, this study only adopts the TAM. Future research could compare TAM with other technology adoption models, such as the Task-Technology Fit model [56] and DeLone and McLean IS updated success model [25], to determine which model can better explain the travellers' adoption of Web-based ATIS.

ACKNOWLEDGEMENT

The authors would like to thank the National Science Council, Taiwan, for financial support (NSC98-2410-H-130-007), and the Taiwan Area National Freeway Bureau, Ministry of Transportation and Communications, Taiwan, for data collection.

林庭煒 博士，助理教授
銘傳大學觀光事業學系（所）
臺灣桃園縣龜山鄉德明路5號
林佳燕 博士，助理教授
國立臺南大學行政管理學系
臺灣臺南市中西區樹林街二段33號
許文和
台灣積體電路製造股份有限公司

摘要

系統特性對於用路人使用旅行者資訊系統的影響：以臺灣高快速公路旅行者資訊系統網站為例

本研究以科技接受模式（TAM）為基礎，研究資訊品質、反應時間、系統易及性等三個系統特性對於用路人使用旅行者資訊系統的影響。本研究利用線上問卷蒐集系統使用者的意見，採用驗證性因素分析（CFA）檢驗測量模式的信效度，結構方程模式（SEM）則用來檢驗結構模式。研究結果顯示三個系統特性藉由知覺易用性、知覺有用性及使用態度對於使用傾向皆有顯著且正向的影響，其中以系統品質影響最大，其次是反應時間及系統易及性。本研究亦對於研究結果提出理論與實務意涵，並針對未來研究提出建議。

關鍵詞

旅行者資訊系統網站　系統特性　用路人使用　科技接受模式 行為傾向模式

REFERENCES

[1] **Singh, V.**, **Kumar, P.**: *Web-based Advanced Traveller Information System for developing countries*, Journal of Transportation Engineering, Vol. 136, No. 9, 2010, pp. 836-845

[2] **Toledo, T.**, **Beinhaker, R.**: *Evaluation of the potential benefits of Advanced Traveller Information Systems*, Journal of Intelligent Transportation Systems, Vol. 10, No. 4, 2006, pp. 173-183

[3] **Cluett, C.**: *Travellers' use of the WSDOT traffic conditions Web site: Customer satisfaction evaluation*; Metropolitan model deployment Initiative: Seattle, Washington. Seattle, WA: Washington State Department of Transportation. 2000

[4] **Goulias, K.G.**, **Kim, T.G.**, **Pribyl, O.**: *A longitudinal analysis of awareness and use for Advanced Traveller Information Systems*, Intelligent transportation systems, Vol. 8, No. 1, 2004, pp. 3-17

[5] **Peirce, S.**, **Lappin, J.**: *Why don't more people use advanced traveller information? Evidence from the Seattle area*. In Annual Meeting Compendium, Transportation Research Board of the National Academies, Washington, D.C., 10-17. 2004.

[6] **Sauer, G.**, **Rose, E.**, **Kolko, B.E.**, **Haselkorn, M.**: *Analysis of Web-based WSDOT Traveller Information: Testing Users' Information Retrieval Strategies*. Seattle, WA: Washington State Department of Transportation. 2002

[7] **Chorus, C.G.**, **Arentze, T.A.**, **Timmermans, H.J.P.**: *Information impact on quality of multimodal travel choices: conceptualizations and empirical analyses*, Transportation, Vol. 34, No. 6, 2007, pp. 625-645

[8] **Chorus, C. G.**, **Molin, E.J.E.**, **Van Wee, B.**: *Use and effects of Advanced Traveller Information Services (ATIS): A review of the literature*, Transport Reviews, Vol. 26, No. 2, 2006, pp. 127-149

[9] **Polak, J.**, **Jones, P.**: *The acquisition of pre-trip information - A stated preference approach*, Transportation, Vol. 20, No. 2, 1993, pp. 179-198

[10] **Kenyon, S.**, **Lyons, G.**: *The value of integrated multimodal traveller information and its potential contribution to modal change*, Transportation Research Part F: Traffic Psychology and Behaviour, Vol. 6, No. 1, 2003, pp. 1-21

[11] **Farag, S.**, **Lyons, G.**: *What affects use of pretrip public transport information? Empirical results of a qualitative study*, Transportation Research Record, No. 2069, 2008, pp. 85-92

[12] **Xu, C.**, **Wang, W.**, **Chen, J.**, **Wang, W.**, **Yang, C.**, **Li, Z.**: *Analyzing travellers' intention to accept travel information*, Transportation Research Record, Vol. 2156, 2010, pp. 93-100

[13] **Davis, F.D.**: *User acceptance of information technology - System characteristics, user perceptions and behavioral impacts*, International Journal of Man-Machine Studies, Vol. 38, No. 3, 1993, pp. 475-487

[14] **Hong, W.**, **Thong, J.Y.L.**, **Wong, W.-M.**, **Tam, K.-Y.**: *Determinants of user acceptance of digital libraries: An empirical examination of individual differences and system characteristics*, Journal of Management Information Systems, Vol. 18, No. 3, 2001, pp. 97-124

[15] **Pituch, K.A.**, **Lee, Y.-k.**: *The influence of system characteristics on e-learning use*, Computers & Education, Vol. 47, No. 2, 2006, pp. 222-244

[16] **Polančič, G.**, **Heričko, M.**, **Pavlič, L.**: *Developers' perceptions of object-oriented frameworks – An investigation into the impact of technological and individual characteristics*, Computers in Human Behavior, Vol. 27, No. 2, 2011, pp. 730-740

[17] **Saeed, K.A.**, **Abdinnour-Helm, S.**: *Examining the effects of information system characteristics and perceived usefulness on post adoption usage of information systems*, Information & Management, Vol. 45, No. 6, 2008, pp. 376-386

[18] **Shim, S.J.**, **Viswanathan, V.**: *User assessment of personal digital assistants used in pharmaceutical detailing: system features, usefulness and ease of use*, Journal of Computer Information Systems, Vol. 48, No. 1, 2007, pp. 14-21

[19] **Davis, F.D.**: *A technology acceptance model for empirically testing new end-user information systems: Theory and results*. In Doctoral Diddertation, Sloan School of Management: Massachusetts Institute of Technology, Cambridge, MA. 1986

[20] **Davis, F.D.**, **Bagozzi, R.P.**, **Warshaw, P.R.**: *User acceptance of computer technology - A comparison of 2 theoretical models*, Management Science, Vol. 35, No. 8, 1989, pp. 982-1003

[21] **Venkatesh, V.**, **Davis, F. D.**: *A theoretical extension of the Technology Acceptance Model: Four longitudinal field studies*, Management Science, Vol. 46, No. 2, 2000, pp. 186-204

[22] **Fishbein, M.**, **Ajzen, I.**: *Belief, attitude, intention, and behavior: An Introduction to theory and research*. Reading, MA: Addison-Wesley. 1975

[23] **Davis, F.D.**: *Perceived usefulness, perceived ease of use, and user acceptance of information technology*, MIS Quarterly, Vol. 13, No. 3, 1989, pp. 319-340

[24] **DeLone, W.H.**, **McLean, E.R.**: *Information systems success: The quest for the dependent variable*, Information Systems Research, Vol. 3, No. 1, 1992, pp. 60-95

[25] **DeLone, W.H.**, **McLean, E.R.**: *The DeLone and McLean model of information systems success: a ten-year update*, Journal of Management Information Systems, Vol. 19, No. 4, 2003, pp. 9-30

[26] **Wang, Y.-S.**: *Assessing e-commerce systems success: A respecification and validation of the DeLone and McLean model of IS success*, Information Systems Journal, Vol. 18, No. 5, 2008, pp. 529-557

[27] **Jelusic, N.**, **Anzek, M.**, **Ivankovic, B.**: *Information source quality in intelligent transportation systems*, PROMET - Traffic & Transportation, Vol. 22, No. 2, 2010, pp. 125-131

[28] **Jensen, M.**, **Cluett, C.**, **Wunderlich, K.**, **Deblasio, A.**, **Sanchez, R.**: *Metropolitan Model Develoyment Initiative Seattle Evaluation Report Final Draft*. U.S. Department of Transportation. 2000

[29] **Fayish, A.C.**, **Jovanis, P.P.**: *Usability of statewide web-based roadway weather information system*. In Driver and Vehicle Simulation, Human Performance, and Information Systems for Highways; Railroad Safety; and

Visualization in Transportation, 44-54 Washington: Transportation Research Board Natl Research Council. 2004

[30] **Hato, E.**, **Taniguchi, M.**, **Sugie, Y.**, **Kuwahara, M.**, **Morita, H.**: *Incorporating an information acquisition process into a route choice model with multiple information sources*, Transportation Research Part C: Emerging Technologies, Vol. 7, No. 2–3, 1999, pp. 109-129

[31] **Polydoropoulou, A.**, **Ben-Akiva, M.**: *The effect of advanced traveller information systems (ATIS) on travellers' behaviour*. In Behavioural and Network Impacts of Driver Information Systems, 317-352 (Eds Emmerink RHM, Nijkamp P). Aldershot, Ashgate, UK. 1998

[32] **Kim, T.G.**, **Lee, J.H.**, **Law, R.**: *An empirical examination of the acceptance behaviour of hotel front office systems: An extended technology acceptance model*, Tourism Management, Vol. 29, No. 3, 2008, pp. 500-513

[33] **Lin, H.-F.**: *The role of online and offline features in sustaining virtual communities: an empirical study*, Internet Research, Vol. 17, No. 2, 2007, pp. 119-138

[34] **Al-Somali, S. A.**, **Gholami, R.**, **Clegg, B.**: *An investigation into the acceptance of online banking in Saudi Arabia*, Technovation, Vol. 29, No. 2, 2009, pp. 130-141

[35] **Tarafdar, M.**, **Zhang, J.**: *Analysis of critical website characteristics: A cross-category study of successful websites*, Journal of Computer Information Systems, Vol. 46, No. 2, 2005, pp. 14-24

[36] **Nah, F. F.-H.**: *A study on tolerable waiting time: how long are Web users willing to wait?*, Behaviour & Information Technology, Vol. 23, No. 3, 2004, pp. 153-163

[37] **Ryan, G.**, **Valverde, M.**: *Waiting in line for online services: a qualitative study of the user's perspective*, Information Systems Journal, Vol. 16, No. 2, 2006, pp. 181-211

[38] **Valacich, J.S.**, **Parboteeah, D.V.**, **Wells, J.D.**: *The online consumer's hierarchy of needs*, Communications of the ACM, Vol. 50, No. 9, 2007, pp. 84-90

[39] **Ilie, V.**, **Van Slyke, C.**, **Parikh, M.A.**, **Courtney, J.F.**: *Paper versus electronic medical records: The effects of access on physicians' decisions to use complex information technologies*, Decision Sciences, Vol. 40, No. 2, 2009, pp. 213-241

[40] **Park, S. Y.**: *An analysis of the technology acceptance model in understanding university students' behavioral intention to use e-learning*, Educational Technology & Society, Vol. 12, No. 3, 2009, pp. 150-162

[41] **Rotchanakitumnuai, S.**, **Speece, M.**: *Modeling electronic service acceptance of an e-securities trading system*, Industrial Management & Data Systems, Vol. 109, No. 8-9, 2009, pp. 1069-1084

[42] **Allen, T. J.**: *Managing the flow of technology*. Cambridge, Mass.: MIT Press. 1977

[43] **Culnan, M. J.**: *The diminsions of accessibility to online information - Implications for implementing office information systems*, Acm Transactions on Office Information Systems, Vol. 2, No. 2, 1984, pp. 141-150

[44] **Kuo, R. Z.**, **Lee, G. G.**: *KMS adoption: the effects of information quality*, Management Decision, Vol. 47, No. 10, 2009, pp. 1633-1651

[45] **Ahn, T.**, **Ryu, S.**, **Han, I.**: *The impact of Web quality and playfulness on user acceptance of online retailing*, Information & Management, Vol. 44, No. 3, 2007, pp. 263-275

[46] **Oh, S.H.**, **Kim, Y.M.**, **Lee, C.W.**, **Shim, G.Y.**, **Park, M.S.**, **Jung, H.S.**: *Consumer adoption of virtual stores in Korea: Focusing on the role of trust and playfulness*, Psychology & Marketing, Vol. 26, No. 7, 2009, pp. 652-668

[47] **Hair, J.F.**, **Anderson, R.E.**, **Tatham, R.L.**, **Black, W.C.**: *Multivariate Data Analysis*. NJ: Prentice-Hall. 1998

[48] **Bollen, K.A.**: *Structural Equations with Latent Variables*. New York: Wiley. 1989.

[49] **Hu, L.-T.**, **Bentler, P.M.**: *Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives*, Structural Equation Modeling, Vol. 6, No. 1, 1999, pp. 1-55

[50] **Bagozzi, R.P.**, **Yi, Y.**: *On the evaluation of structural equation models*, Journal of the Academy of Marketing Science, Vol. 16, No. 1, 1988, pp. 74-94

[51] **Fornell, C.**, **Larcker, D.F.**: *Evaluating structural equation models with unobservable variables and measurement error*, Journal of Marketing Research, Vol. 18, No. 1, 1981, pp. 39-50

[52] **Dunn, S.C.**, **Seaker, R.F.**, **Waller, M.A.**: *Latent variables in business logistics research: scale development and validation*, Journal of Business Logistics, Vol. 15, No. 2, 1994, pp. 145-172

[53] **Koufteros, X.A.**: *Testing a model of pull production: a paradigm for manufacturing research using structural equation modeling*, Journal of Operations Management, Vol. 17, No. 4, 1999, pp. 467-488

[54] **Wei, C.-H.**, **Lee, Y.**: *Development of freeway travel time forecasting models by integrating different sources of traffic data*, IEEE Transactions on Vehicular Technology, Vol. 56, No. 6, 2007, pp. 3682-3694

[55] **Cao, M.**, **Zhang, Q.Y.**, **Seydel, J.**: *B2C e-commerce Web site quality: An empirical examination*, Industrial Management & Data Systems, Vol. 105, No. 5-6, 2005, pp. 645-661

[56] **Goodhue, D.L.**, **Thompson, R.L.**: *Task-technology fit and individual performance*, MIS Quarterly, Vol. 19, 1995, pp. 213-236