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Antecedents in Determining Users’ Acceptance of Electric Shuttle Bus Services

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Abstract: The electric shuttle bus service is a pro-environmental transportation method with the advantages of conserving fossil fuel consumption and reducing greenhouse gas emissions. It could also provide flexible shuttle services and enhance travel convenience for residents. Although it has many advantages, users’ willingness to accept the electric shuttle bus service is crucial to its successful implementation. A theoretical research model that integrates UTAUT and NAM with an attitude construct is developed based on the data collected in China to explore antecedents of using electric shuttle bus services. The validity of the proposed model is examined by partial least squares structural equation modeling. According to analysis results, the proposed research model could explain 73.5% of the variance in adoption intention. Results demonstrate that attitude is the strongest antecedent of using electric shuttle bus services. Performance expectancy, personal norms, and social influence are the direct antecedents, and ascription of responsibility and effort expectancy is demonstrated as the indirect antecedents of using electric shuttle bus services. Results also offer valuable insights into how electric shuttle bus services can be accepted and implemented more readily.

Keywords: electric shuttle bus; electric vehicles; acceptance model; willingness to adopt

MSC: 90C15; 90B50; 90B05; 68U35

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1. Introduction

The electrification of public transportation has been widely discussed due to its environmental benefits. It has considerably been considered an effective method to decarbonize transportation [1]. The electric shuttle bus is an environmentally friendly mode of public transportation powered by electricity, with no emissions during the driving process. It has the potential to conserve fossil fuel consumption and reduce greenhouse gas emissions. Besides using an eco-friendly powertrain, the electric shuttle bus could also provide residents with flexible and on-demand transportation services. It has the advantages of improving the accessibility of public transportation and mitigating road congestion. As a complement to the existing public transportation system, the electric shuttle bus makes it more attractive to residents by improving convenience. The electric shuttle bus service could also enhance public transportation’s environmental performance and sustainability, thus providing a further boost to green transportation systems.

Although the electric shuttle bus service has many advantages, its successful penetration highly depends on user acceptance. The electric shuttle bus service will not be employed, and its expected environmental benefits will not be realized in the absence of user acceptance. Understanding users’ willingness to accept electric shuttle bus services will allow for better promotion of green transportation among the public. It would be possible for governments and operating enterprises to develop and refine electric shuttle bus services based on users’ preferences and attitudes. Public acceptance evaluations contribute to formulating promotion policies and designing operational management mechanisms for electric shuttle bus services. A better understanding of user acceptance is valuable for preventing such issues from deterring the adoption of electric shuttle bus services. Therefore, it is essential to understand the antecedents of using the electric shuttle bus service to ensure its successful implementation.

There have been substantial studies undertaken on the design and management of electric buses, including market demands [1], routing and scheduling [2–4], location planning of charging infrastructure [5–7], operation feasibility [8,9], and environmental impact [10,11]. Previous research addresses operational management issues from the operators' perspective, while the marketization of electric buses also relies on the government, enterprises, and users' willingness to accept this transportation mode. The existing research on electric bus adoption has been mostly conducted from the government and operator perspectives. Li et al. [12] employed the business model canvas to analyze the interaction patterns between the government and businesses in the adoption of electric buses in Shenzhen. Mohamed et al. [13] applied the grounded theory to identify the influencing factors of the adoption of electric buses for transit providers. However, the existing research on the acceptance of electric buses from a user perspective is limited. Prasetio et al. [14] used multinomial logit modeling to investigate factors impacting commuters' intention to adopt electric buses in Indonesia. The authors of [11] studied public willingness to accept electric bus services by a mixed logit model. However, an appropriate theoretical model to explain users' intention to adopt electric bus services has yet to be established.

To remedy existing studies' deficiencies, this paper investigates the elements impacting users' willingness to accept electric shuttle bus services. The following principal objectives are included in this research: (1) Establish a new theoretical acceptance model for understanding the antecedents of using electric shuttle bus services; (2) assess the effectivity of the theoretical acceptance model and appraise it according to the real-life data; and (3) conduct an analysis of the research findings and offer managerial insights for the promotion of electric shuttle bus services.

In this paper, we first propose a theoretical framework by combining the norm activation model (NAM) and the unified theory of acceptance and use of technology (UTAUT) with the consideration of users' attitudes toward electric shuttle bus services. Second, we carry out an online investigation of Chinese urban residents to gather research data on users' intention to adopt electric shuttle bus services. We prepare the questionnaire based on the theoretical framework and improve it with opinions from pre-testing groups. Third, we utilize partial least squares structural equation modeling (PLS-SEM) to assess the effectivity of the theoretical framework and test the proposed hypotheses. We perform heterogeneity analyses among different demographic characteristics. Moreover, we provide managerial insights for implementing electric shuttle bus services.

This study makes the following contributions. First, the originality of our study is that it develops an appropriate theoretical model for the acceptance of electric shuttle bus services from a user perspective. We consider the convenience and pro-environmental values of electric shuttle bus services in the research model. Second, our research model interprets 73.5% of the variance in willingness to accept electric shuttle bus services, suggesting a good explanatory power. Third, our analysis results imply that attitude is the strongest antecedent of using electric shuttle bus services. Additionally, performance expectancy and personal norms also affect users' adoption of electric shuttle bus services. Our research findings shed new light on the promotion policy and managerial suggestions for electric shuttle bus services.

The first section gives a brief introduction of the research background. The second part consists of the theoretical framework and data collection procedure. The third section presents the analysis results of the research model. The fourth part draws together research findings and gives practical suggestions. The final section includes conclusions and future work.

2. Literature Review

Various works of literature have studied the operation and scheduling of electric buses. The operation and scheduling of electric bus services is more complicated than conventional public transport modes due to the limited ranges and fewer routing options [13]. A limited battery range may not allow electric bus services to handle high traffic demand, which may require additional buses and thus increase costs. In addition, the charging period for electric buses is an essential component of the schedule [15]. Previous studies have considered the charging period to address electric bus scheduling problems [16,17]. Existing research has also comprehensively considered electric bus scheduling and charging facilities deployment to satisfy the predetermined schedule and minimize overall investment costs [18]. Huang et al. [19] developed an optimization method for charging scheduling of electric buses to minimize overall charging time. Jiang and Zhang [20] developed a mixed integer programming model with the consideration of vehicle-depot constraints to solve the electric bus scheduling issue. In summary, it is necessary to integrate charging scheduling and route design of electric bus services to resolve operation and scheduling issues [2].

Substantial studies have been undertaken on the planning of electric bus charging infrastructure. The electric shuttle bus is powered by electricity, requiring particular charging infrastructure. The authors of [5] proposed a mixed integer programming model to explore the distribution of charging facilities in city networks for electric buses. Iliopoulou and Kepaptsoglou [21] developed a bi-level programming model to study the location planning of charging infrastructure and the design of the public transportation route network. He et al. [22] investigated the optimal location selection problem of charging infrastructure by a mixed integer programming model. Liu, Qu, and Ma [7] proposed an optimization model considering the effects of power matching and seasonality on electric bus batteries to optimize the charging station location and vehicle flow jointly. The location planning of dynamic wireless power transfer facilities for electric buses was also discussed in previous research [6]. Alwesabi et al. [23] investigated the optimal size of electric bus batteries and the location selection problem of dynamic wireless power transfer infrastructures by using a mixed integer programming model.

Various works of literature have been undertaken on the operation feasibility of electric buses. Previous literature has provided evidence for the operating capacity of electric buses on the basis of operation data in England [9]. Prior literature has also demonstrated the operation feasibility of electric buses for transportation services based on a case study in North America [8]. Perrotta et al. [24] explored the operational feasibility of electric buses in a variety of rout contexts based on a route optimization simulation model. In general, existing studies have regarded the electric bus as a reliable and available method for public transportation services. Nevertheless, electric buses' range and charging time are regarded as critical factors limiting operation feasibility. It has been pointed out by Xu et al. [25] that there is no evidence for the operation feasibility of electric buses in the network of interlined transit services.

Substantial studies have been undertaken on the environmental impact of electric buses. An evaluation of the environmental effects of electric buses emphasized remarkable reductions in greenhouse gas emissions and energy consumption. Prior research has conducted an ecological evaluation of the life cycle of electric and diesel buses in Aachen, Germany [26]. Al-Ogaili et al. [27] proposed a life cycle evaluation framework to investigate the economic and environmental effects of electric bus deployments. Borén [28] developed a strategic sustainable development framework to investigate electric buses' environmental impacts and total cost of ownership. Lajunen [29] conducted cost-benefit analysis based on the energy consumption analysis. In addition, previous literature has calculated CO_2 emissions reduction by mixed logit model and investigated users' preferences [11].

Additionally, existing studies have been conducted to explore electric bus adoption from the government and operator perspectives. The authors of [13] investigated the influencing factors of electric bus adoption applying the grounded theory. The results indicated that demonstration projects and policy support played an important role in determining operators' adoption of electric buses. The authors of [12] analyzed the interaction patterns between the government and businesses in the adoption of electric buses and found that cost factors significantly affected their adoption intention. However, the existing research on the acceptance of electric buses from a user perspective is limited. The marketization of the electric shuttle bus service also relies on users' willingness to accept it. Therefore, it is essential to explore the antecedents of adopting electric shuttle bus services from a user perspective.

3. Methods

3.1. Model Development

Our study attempts to establish a theoretical framework based on pertinent theories to understand the antecedents of using electric shuttle bus services. UTAUT has been reported as a broadly applicable theory to describe users' acceptance of emerging technologies and services. It has been effectively used within the area of transportation, including corporate carsharing [30], electric bicycles [31], electric vehicles [32], and autonomous public transport [33]. NAM has been considered a typical model to predict pro-social behaviors with the consideration of expected outcomes for other persons. The existing research has sought to apply NAM to describe sustainable behaviors in the transportation domain [34–36]. Previous literature has extensively integrated UTAUT and NAM in various fields, including information areas [37], energy fields [38], and agricultural contexts [39,40]. However, the existing research that integrates UTAUT and NAM in the domain of transportation is limited. The first section elaborated that the electric shuttle bus service is a new mode of transit service with pro-environmental characteristics. Consequently, we construct the theoretical framework by incorporating UTAUT and NAM to capture the antecedents of using electric shuttle bus services. Furthermore, we incorporate the attitude to improve the theoretical framework's explanatory power.

Existing studies extensively adopt behavioral intention (BI) as a measure of willingness to accept emerging technologies and services. In the context of our research, behavioral intention is the level of users' acceptance of electric shuttle bus services. Performance expectancy (PE) is the construct used to measure the strength of users' perception of benefits gained from adopting electric shuttle bus services. Prior literature has reported that users' intention to adopt advanced technologies and services is associated with their perception of usefulness [41]. Consequently, the hypothesis is presented as follows.

H1: *Performance expectancy is the direct antecedent variable of behavioral intention to adopt electric shuttle bus services.*

Effort expectancy (EE) is the construct cited to assess the extent of ease related to users' adoption of electric shuttle bus services in the context of our research. The available evidence demonstrated that users' intention to adopt advanced technologies and services is associated with their perceived level of effort [42]. It indicates that the adoption of electric shuttle bus services will be further accelerated by the perceived ease of use and user-friendly characteristics. The existing research has also clarified that users' perception of usefulness is significantly related to their perception of effort to adopt advanced technologies [43]. Consequently, it is proposed that:

H2: *Effort expectancy is the direct antecedent variable of behavioral intention to adopt electric shuttle bus services.*

H3: *Effort expectancy is the direct antecedent variable of performance expectancy of electric shuttle bus services.*

In the context of our research, social influence (SI) is the construct used to describe the perception of the extent to which influential others perceive they should adopt electric shuttle bus services. Previous literature in the field of transport has implied that users' intention to adopt advanced transportation services is related to social influence [44]. Thereby, we hypothesized that:

H4: *Social influence is the direct antecedent variable of behavioral intention to adopt electric shuttle bus services.*

Personal norms (PN) is the construct used to describe an individual's sense of moral obligation to adopt electric shuttle bus services in the context of our research. Current studies' evidence indicates that users' adoption intention of sustainable transportation behaviors is related to moral obligation feelings [34]. Furthermore, prior evidence has also mirrored the positive relationship between perceived opinions of important others and moral obligation feelings [39,45]. Hence, it is anticipated that:

H5: *Personal norms are the direct antecedent variable of behavioral intention to adopt electric shuttle bus services.*

H6: *Social influence is the direct antecedent variable of personal norms of electric shuttle bus services.*

In the context of our research, awareness of consequences (AC) is a measurement of how users perceive the benefits of adopting the electric shuttle bus service to society. Existing studies have documented that moral obligation feelings could be activated by consequences awareness [34]. It implies that people will feel more morally obligated if they realize how beneficial the adoption of advanced services is to society. Thereby, we hypothesize the following:

H7: *Awareness of consequences is the direct antecedent variable of personal norms of electric shuttle bus services.*

In the context of our research, the ascription of responsibility (AR) is a measurement of responsibility sense for beneficial consequences of adopting electric shuttle bus services. Substantial research in the context of green transportation has confirmed the role of responsibility feelings on moral obligation feelings [35,46]. It suggests that people will feel more morally obligated if they are responsible for the pro-environmental consequences of adopting electric shuttle bus services. Accordingly, it is proposed that:

H8: *Ascription of responsibility is the direct antecedent variable of personal norms of electric shuttle bus services.*

The attitude (AT) is a measurement of an individual's motivation to adopt electric shuttle bus services in the context of our research. This measurement construct has been proved to affect users' willingness to accept on-demand transportation services [47]. Empirically, users' attitudes toward green transportation behaviors are associated with their moral obligation feelings. The perception of usefulness and ease of use toward emerging transportation technologies have been reported to be direct determinants of users' attitudes [48]. In addition, users' positive attitudes will be stronger when they perceive the support and encouragement from important others [40]. As such, it is anticipated that:

H9: *Attitude is the direct antecedent variable of behavioral intention to adopt electric shuttle bus services.*

H10: *Personal norms are the antecedent variable of attitude toward adopting electric shuttle bus services.*

H11: *Social influence is the antecedent variable of attitude toward adopting electric shuttle bus services.*

H12: *Performance expectancy is the antecedent variable of attitude toward adopting electric shuttle bus services.*

H13: *Effort expectancy is the antecedent variable of attitude toward adopting electric shuttle bus services.*

UTAUT and NAM are mature theoretical models to explain behavioral intention using reflective measurement for the constructs. Therefore, we selected the above variables to be latent reflective constructs for behavioral intention. Based on the assumptions presented above, a theoretical framework to capture the antecedents of using electric shuttle bus services was constructed and depicted in Figure 1.

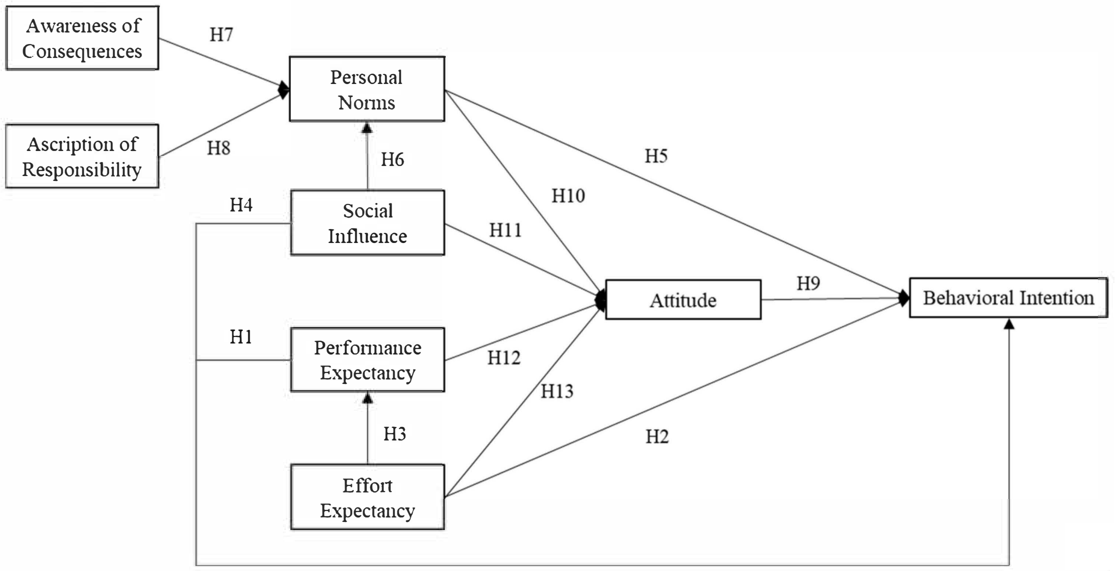


Figure 1. The proposed theoretical model.

3.2. Construct Measurement

An exhaustive review of the literature on the acceptance of emerging transportation technologies and services was conducted to identify the measurement items of each construct. Measurement items were adapted from Venkatesh et al. [49], Onwezen et al. [50], and Wu et al. [51] based on the context of our research. All items were measured on a 7-point Likert scale (7 = strongly agree; 1 = strongly disagree). Before the formal investigation, we carried out a pre-testing in a small range to guarantee the clarity of the questionnaire. We gathered comments from the participants of the pre-testing and made appropriate modifications to the measurement items. The measurement items of each construct for formal investigation are depicted in Table 1.

3.3. Sample Size

A number of methods have been proposed to calculate the minimum sample size requirements for structural equation modeling. The sample size required in the current study would be 80, based on the rule-of-thumb that the sample size should be at least 10 times the maximum number of formative indicators of a latent construct. In addition, we conducted a power analysis applying G*Power version 3.1 [52,53] to calculate the minimum sample size required. During the calculations, the number of constructs, statistical power, effect size, and significance level need to be considered. The number of constructs in the proposed research model for public acceptance of electric shuttle bus services is eight. Thus, the minimum sample size should be 160 with a significance level of 0.05, a statistical power of 95%, and medium effect size (f^2) of 0.15 [54,55]. However, we did not stop the survey after collecting 80 or 160 valid questionnaires. The collected sample size was increased to deal with the selection and non-response bias.

3.4. Data Collection

We implemented an online investigation to collect research data in December 2021 among a sample of Chinese residents. The questionnaire was produced and posted via Questionnaire Star, a professional online investigation platform. As electric shuttle buses are aimed at providing public transportation services for residents, no demographic factors were restricted for questionnaire participants. Participants were asked to read an informed consent form before they participated in the formal survey. They were explicitly informed of the following: (1) The questionnaire consisted of two main parts: basic personal information and the evaluation of the electric shuttle bus service. (2) The data would be used for research purposes only and would be kept strictly confidential. No one could identify the owner of the data from what they see, and no one would be allowed to view the survey data without the authorization of the project manager. (3) Participants could terminate this investigation at any time without any adverse consequence.

Table 1. The measurement items of each construct.

Constructs	Items	Contents and Origins
Behavioral Intention	BI1	I will try to adopt the electric shuttle bus service if it is put on the market [49].
	BI2	I plan to adopt the electric shuttle bus service if it is put on the market [49].
	BI3	I will adopt the electric shuttle bus service in the future [49].
Performance Expectancy	PE1	I find electric shuttle bus services useful in my daily life [49].
	PE2	Adopting electric shuttle bus services improves travel efficiency [49].
	PE3	Adopting electric shuttle bus services helps me reach my destination more quickly [49].
	PE4	In general, adopting electric shuttle bus services makes my life convenient [49].
Effort Expectancy	EE1	Learning how to adopt electric shuttle bus services is easy for me [49].
	EE2	My interaction with electric shuttle bus services is clear and understandable [49].
	EE3	I find electric shuttle bus services easy to adopt [49].
	EE4	It is easy for me to become skillful at adopting electric shuttle bus services [49].
Social Influence	SI1	People who are important to me think that I should adopt electric shuttle bus services [49].
	SI2	People who influence my behavior think that I should adopt electric shuttle bus services [49].
	SI3	People whose opinions I value think that I should adopt electric shuttle bus services [49].
Personal Norms	PN1	I feel a sense of moral obligation to adopt electric shuttle bus services to save road resources, conserve fossil fuel consumption, and reduce greenhouse gas emissions [50].
	PN2	I feel that it is important for people to adopt electric shuttle bus services to save road resources, conserve fossil fuel consumption, and reduce greenhouse gas emissions [50].
	PN3	I feel that I should adopt electric shuttle bus services to save road resources, conserve fossil fuel consumption, and reduce greenhouse gas emissions [50].
Awareness of Consequences	AC1	Adopting electric shuttle bus services can save road resources [50].
	AC2	Adopting electric shuttle bus services can conserve fossil fuel consumption [50].
	AC3	Adopting electric shuttle bus services can reduce greenhouse gas emissions [50].
Ascription of Responsibility	AR1	I have a responsibility to save road resources [50].
	AR2	I have a responsibility to conserve fossil fuel consumption [50].
	AR3	I have a responsibility to reduce greenhouse gas emissions [50].
Attitude	AT1	My attitude toward adopting electric shuttle bus services is positive [51].
	AT2	Adopting electric shuttle bus services is a wise choice [51].
	AT3	Electric shuttle bus services will play an essential role in public transport systems [51].

Ethical approval of the survey was granted by the School of Traffic and Transportation, Northeast Forestry University, China. We performed over-sampling to reduce the non-response bias of the investigation and ultimately received 1185 questionnaires. After deleting low-quality questionnaires, a total of 990 questionnaires were used for data analysis with a valid rate of 83.5%. The valid sample included 53.0% male respondents. In terms of age, the majority of respondents are below 45 years old (75.5%). Of the education level, 12.1% of respondents had completed middle school, 15.8% of respondents had completed high school, and 72.1% had a bachelor's degree or above.

3.5. Data Analysis

Compared to covariance-based structural equation modeling (CB-SEM), PLS-SEM can deal with more complex models [56]. PLS-SEM provides an efficient estimation of complex models using smaller sample sizes and relaxes strict distributional assumptions from maximum likelihood methods in CB-SEM. The maximum likelihood estimability of CB-SEM is stable for violations of normality in the case of large samples [57]. If the sample size is small, CB-SEM may produce anomalous results [58]. At that time, PLS-SEM shows more robust stability [59]. In addition, CB-SEM is mainly to test the applicability of the theoretical model, while PLS-SEM is more suitable for exploratory studies to test whether the causality has a significant relationship. Therefore, we chose PLS-SEM as the statistical methodology to examine the complicated relationships in our research.

We examined the measurement scales' reliability and validity by Smart PLS 3.0. The reliability was assessed by the internal consistency of the scale. The internal consistency was examined by Cronbach's alpha (i.e., Cronbach's alpha > 0.7) and composite reliability (i.e., composite reliability > 0.7) [56,60]. The convergent validity was assessed by the average variance extracted (AVE) index (i.e., AVE > 0.5) and the factor loadings of each item (i.e., factor loading > 0.7) [61]. The discriminant validity was evaluated by the two criteria as follows [56]. (1) Each construct's square root of the AVE is higher than its association with any other construct. (2) All items on their own constructs have higher outer loadings than cross-loadings on any other construct.

We evaluated the theoretical research model through PLS-SEM, which is considered suitable for exploratory studies that propose and test a novel model. We applied the coefficient of determination (R^2) to estimate the proportion of variation interpreted by independent variables. The closer the value of R^2 was to 1, the stronger the explanation power of the electric shuttle bus service acceptance model was. A bootstrapping procedure of 5000 subsamples was used to calculate the proposed hypotheses' path coefficients and statistical significance. Additionally, multi-group analyses were carried out to assess the differences in path coefficients across different demographic features.

4. Results

4.1. Reliability and Validity Analysis

The testing results for convergent validity and internal consistency are displayed in Table 2. We considered the internal consistency satisfactory since all constructs' composite reliability and Cronbach's Alpha exceeded 0.7. We considered convergent validity acceptable since the AVE index of each construct was above 0.5 and factor loadings of each item were above 0.7. The outer loadings and cross-loadings of all items on the related constructs were depicted in Table 3. It can be seen that all items on their own constructs had higher outer loadings than cross-loadings on any other construct. Each construct's square root of the AVE and its association with other constructs was summarized in Table 4. It can be seen that each construct's square root of the AVE was higher than its association with other constructs. We considered discriminant validity acceptable based on the results of Tables 3 and 4.

Table 2. Testing results for convergent validity and internal consistency.

Constructs	Items	Mean (SD)	Factor Loadings	Cronbach's Alpha	Composite Reliability	AVE
BI	BI1	5.998 (1.040)	0.959	0.967	0.978	0.938
	BI2	5.899 (1.085)	0.984			
	BI3	5.865 (1.123)	0.963			
AT	AT1	5.812 (1.106)	0.936	0.944	0.964	0.899
	AT2	5.725 (1.187)	0.960			
	AT3	5.840 (1.135)	0.948			
PE	PE1	5.568 (1.393)	0.917	0.959	0.970	0.890
	PE2	5.720 (1.281)	0.951			
	PE3	5.719 (1.289)	0.950			
	PE4	5.762 (1.278)	0.955			

Table 2. *Cont.*

Constructs	Items	Mean (SD)	Factor Loadings	Cronbach's Alpha	Composite Reliability	AVE
EE	EE1	5.210 (1.613)	0.886	0.933	0.952	0.834
	EE2	5.417 (1.437)	0.928			
	EE3	5.272 (1.535)	0.933			
	EE4	5.423 (1.479)	0.904			
SI	SI1	5.380 (1.344)	0.973	0.975	0.984	0.952
	SI2	5.292 (1.343)	0.981			
	SI3	5.333 (1.344)	0.972			
PN	PN1	6.113 (1.070)	0.958	0.967	0.979	0.939
	PN2	6.152 (1.007)	0.972			
	PN3	6.134 (1.020)	0.976			
AC	AC1	5.665 (1.308)	0.937	0.918	0.948	0.860
	AC2	5.685 (1.304)	0.936			
	AC3	5.828 (1.221)	0.909			
AR	AR1	6.218 (1.006)	0.984	0.985	0.990	0.971
	AR2	6.190 (1.035)	0.987			
	AR3	6.191 (1.035)	0.985			

Table 3. All items' outer loadings (in bold) and cross-loadings.

	BI	AT	PE	EE	SI	PN	AR	AC
BI1	**0.959**	0.794	0.658	0.531	0.567	0.656	0.668	0.645
BI2	**0.984**	0.815	0.664	0.523	0.612	0.640	0.654	0.663
BI3	**0.963**	0.799	0.643	0.510	0.625	0.616	0.629	0.662
AT1	0.768	**0.936**	0.629	0.548	0.604	0.613	0.614	0.642
AT2	0.793	**0.960**	0.685	0.556	0.673	0.598	0.576	0.680
AT3	0.795	**0.948**	0.674	0.510	0.597	0.600	0.581	0.701
PE1	0.618	0.656	**0.917**	0.696	0.523	0.432	0.412	0.564
PE2	0.620	0.656	**0.951**	0.661	0.458	0.457	0.448	0.542
PE3	0.638	0.648	**0.950**	0.688	0.477	0.428	0.437	0.532
PE4	0.675	0.677	**0.955**	0.697	0.481	0.480	0.487	0.571
EE1	0.441	0.488	0.611	**0.886**	0.381	0.334	0.354	0.373
EE2	0.531	0.543	0.684	**0.928**	0.443	0.400	0.403	0.445
EE3	0.484	0.528	0.688	**0.933**	0.449	0.384	0.374	0.445
EE4	0.505	0.510	0.668	**0.904**	0.429	0.389	0.401	0.433
SI1	0.621	0.658	0.518	0.475	**0.973**	0.517	0.452	0.584
SI2	0.600	0.635	0.486	0.450	**0.981**	0.497	0.428	0.566

Table 3. *Cont.*

	BI	**AT**	**PE**	**EE**	**SI**	**PN**	**AR**	**AC**
EE1	0.441	0.488	0.611	**0.886**	0.381	0.334	0.354	0.373
EE2	0.531	0.543	0.684	**0.928**	0.443	0.400	0.403	0.445
EE3	0.484	0.528	0.688	**0.933**	0.449	0.384	0.374	0.445
EE4	0.505	0.510	0.668	**0.904**	0.429	0.389	0.401	0.433
SI1	0.621	0.658	0.518	0.475	**0.973**	0.517	0.452	0.584
SI2	0.600	0.635	0.486	0.450	**0.981**	0.497	0.428	0.566
SI3	0.597	0.635	0.500	0.440	**0.972**	0.492	0.423	0.570
PN1	0.613	0.589	0.457	0.383	0.501	**0.958**	0.840	0.495
PN2	0.649	0.626	0.465	0.408	0.488	**0.972**	0.857	0.527
PN3	0.649	0.635	0.463	0.411	0.509	**0.976**	0.852	0.544
AR1	0.665	0.619	0.474	0.416	0.430	0.865	**0.984**	0.520
AR2	0.655	0.602	0.455	0.409	0.433	0.862	**0.987**	0.530
AR3	0.666	0.618	0.470	0.417	0.454	0.866	**0.985**	0.539
AC1	0.600	0.633	0.516	0.417	0.535	0.487	0.495	**0.937**
AC2	0.618	0.656	0.568	0.439	0.536	0.492	0.498	**0.936**
AC3	0.664	0.687	0.544	0.438	0.561	0.518	0.501	**0.909**

Table 4. Each construct's square root of the AVE (in bold) and its association with other constructs.

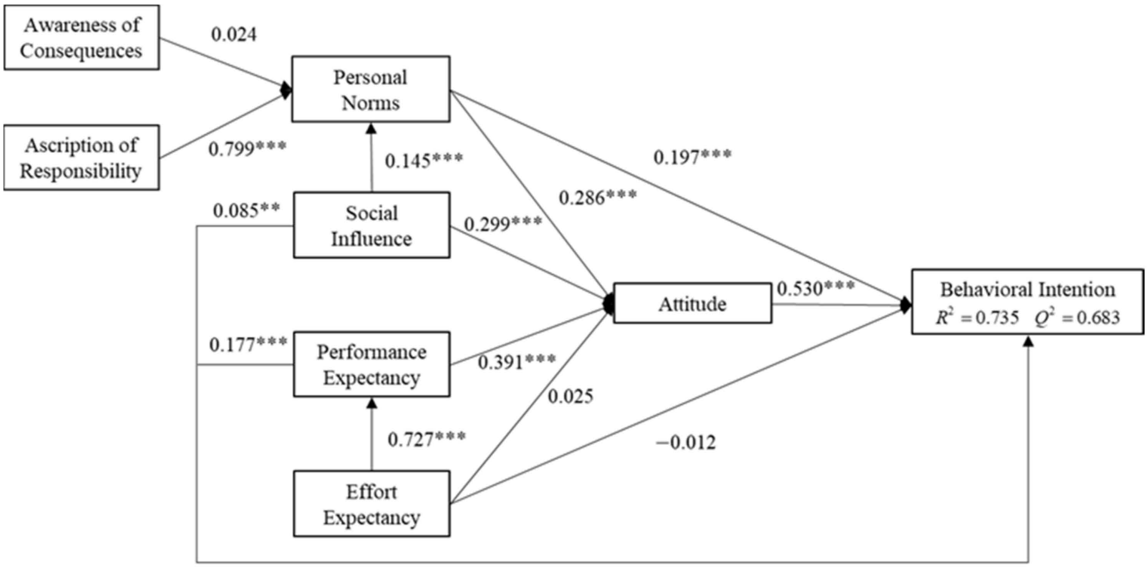
	AC	**AR**	**AT**	**BI**	**EE**	**PE**	**PN**	**SI**
AC	**0.927**							
AR	0.537	**0.986**						
AT	0.711	0.622	**0.948**					
BI	0.678	0.672	0.828	**0.968**				
EE	0.466	0.420	0.567	0.538	**0.913**			
PE	0.586	0.473	0.699	0.676	0.727	**0.943**		
PN	0.539	0.877	0.637	0.658	0.414	0.476	**0.969**	
SI	0.588	0.446	0.659	0.621	0.467	0.514	0.515	**0.976**

4.2. Structural Model Evaluation

The results of hypothesis testing are presented in Table 5 and Figure 2, with 10 out of the 13 hypotheses being supported. To be specific, BI was positively affected by PE ($\beta = 0.177$, $p < 0.001$), SI ($\beta = 0.085$, $p < 0.01$), PN ($\beta = 0.197$, $p < 0.001$), and AT ($\beta = 0.530$, $p < 0.001$),while not directly affected by EE ($\beta = -0.012$, $p = 0.714$). It indicated that H1, H4, H5, and H9 were supported, and H2 was not supported. Moreover, EE was demonstrated to have a significant effect on PE ($\beta = 0.727$, $p < 0.001$), which supported H3. PN was directly and positively affected by SI ($\beta = 0.145$, $p < 0.001$) and AR ($\beta = 0.799$, $p < 0.001$), while not affected by AC ($\beta = 0.024$, $p = 0.400$). It suggested that H6 and H8 were supported, and H7 was not supported. AT was affected by PN ($\beta = 0.286$, $p < 0.001$), SI ($\beta = 0.299$, $p < 0.001$), and PE ($\beta = 0.391$, $p < 0.001$), while not affected by EE ($\beta = 0.025$, $p = 0.503$). It is shown that H10, H11, and H12 were supported, and H13 was not supported. Furthermore, 73.5% of the variance in BI was explained in the acceptance model for electric shuttle bus services. We ran a blindfolding procedure by Smart PLS 3.0 to find out the Q-squared value. The Q-squared index for behavioral intention construct was 68.3%, indicating a good validity of the structural part.

Table 5. Hypothesis testing.

Hypothesis	Path Coefficient (β)	p-Value	Standard Deviation	t Statistics	Supported? (Yes/No)
H1: PE→BI	0.177	<0.001	0.046	3.874	Yes
H2: EE→BI	−0.012	0.714	0.034	0.366	No
H3: EE→PE	0.727	<0.001	0.024	30.036	Yes
H4: SI→BI	0.085	<0.01	0.033	2.615	Yes
H5: PN→BI	0.197	<0.001	0.044	4.521	Yes
H6: SI→PN	0.145	<0.001	0.022	6.537	Yes
H7: AC→PN	0.024	0.400	0.029	0.842	No
H8: AR→PN	0.799	<0.001	0.024	32.738	Yes
H9: AT→BI	0.530	<0.001	0.046	11.621	Yes
H10: PN→AT	0.286	<0.001	0.035	8.170	Yes
H11: SI→AT	0.299	<0.001	0.033	8.991	Yes
H12: PE→AT	0.391	<0.001	0.045	8.752	Yes
H13: EE→AT	0.025	0.503	0.038	0.669	No



** $p<0.01$, *** $p<0.001$

Figure 2. Model evaluation results.

The role of direct and indirect factors in affecting attitude and the behavioral intention was summarized in Table 6. AT appeared to play the most significant role in determining the adoption intention of electric shuttle bus services. Besides, PN, PE, and SI were also shown to be significant antecedents of the acceptance of electric shuttle bus services. The direct effect of EE on BI was not significant, while the indirect and total effect of EE on BI was significant. AR was identified as an indirect antecedent of BI, while AC was shown to have no significant influence on BI. Additionally, the direct effect of EE on AT was not significant, while the indirect and total effect of EE on AT was significant.

Table 6. The effects of predictors on BI and AT.

	Direct Effect (β)	p Value	Standard Deviation	Indirect Effect (β)	p Value	Standard Deviation	Total Effect (β)	p Value	Standard Deviation
PE→BI	0.177	<0.001	0.046	0.207	<0.001	0.032	0.384	<0.001	0.049
EE→BI	−0.012	0.714	0.034	0.293	<0.001	0.040	0.281	<0.001	0.039
SI→BI	0.085	<0.01	0.024	0.209	<0.001	0.022	0.294	<0.001	0.034
AT→BI	0.530	<0.001	0.033	-	-	-	0.530	<0.001	0.046
PN→BI	0.197	<0.001	0.046	0.152	<0.001	0.021	0.349	<0.001	0.048
AC→BI	-	-	-	0.009	0.421	0.011	0.009	0.421	0.011
AR→BI	-	-	-	0.279	<0.001	0.039	0.279	<0.001	0.039
PE→AT	0.391	<0.001	0.045	-	-	-	0.391	<0.001	0.045
EE→AT	0.025	0.503	0.038	0.284	<0.001	0.035	0.309	<0.001	0.034
SI→AT	0.299	<0.001	0.033	0.041	<0.001	0.008	0.340	<0.001	0.031
PN→AT	0.286	<0.001	0.035	-	-	-	0.286	<0.001	0.035
AC→AT	-	-	-	0.007	0.421	0.009	0.007	0.421	0.009
AR→AT	-	-	-	0.229	<0.001	0.028	0.229	<0.001	0.028

4.3. Multi-Group Analyses

Three sets of multi-group analyses were carried out to assess the path differences of the hypotheses among different demographic groups. We grouped the data separately according to gender, age, and education level. Then we employed Smart PLS 3.0 to perform multi-group analyses.

Gender: It demonstrated that the SI→BI path was significant among females while non-significant among males. There was a stronger association between AT and BI for male respondents than for female respondents. The relationship between PN and AT was stronger in female respondents than in male respondents. Males showed a stronger correlation between PE and AT than females. The results are summarized in Table 7.

Table 7. Multi-group analysis by gender.

Hypothesis	Male (n = 525) (β_M)	Female (n = 465) (β_F)	$\beta_M - \beta_F$	p-Value	t Value
H1	0.184 ***	0.143	0.041	0.648	0.471
H2	−0.052	0.036	−0.088	0.189	1.338
H3	0.741 ***	0.710 ***	0.031	0.511	0.654
H4	0.020	0.156 **	−0.136	<0.05	2.237
H5	0.204 ***	0.201 **	0.003	0.968	0.032
H6	0.127 ***	0.170 ***	−0.043	0.329	0.974
H7	0.021	0.019	0.002	0.970	0.025
H8	0.805 ***	0.801 ***	0.004	0.956	0.074
H9	0.627 ***	0.428 ***	0.199	<0.05	2.311
H10	0.204 ***	0.382 ***	−0.178	<0.01	2.695
H11	0.328 ***	0.257 ***	0.071	0.270	1.105
H12	0.474 ***	0.295 ***	0.179	<0.05	1.993
H13	−0.005	0.072	−0.077	0.310	1.018

** $p < 0.01$, *** $p < 0.001$.

Age: Older respondents showed a stronger correlation between EE and PE than younger respondents. It demonstrated that the SI→BI path was significant among older respondents while non-significant among younger respondents. The PN→BI path was observed to be significant among younger respondents while non-significant among older respondents. AC and PN were not significantly correlated in both age groups, but their differences were significant. PN was demonstrated to be strongly affected by AR for older respondents than for younger respondents. In addition, younger respondents showed a stronger correlation between PE and AT than older respondents. The results are summarized in Table 8.

Table 8. Multi-group analysis by age.

Hypothesis	Age <= 45 (n = 747) (β_Y)	Age >= 46 (n = 243) (β_O)	$\beta_Y - \beta_O$	*p*-Value	*t* Value
H1	0.169 **	0.221 **	−0.052	0.531	0.516
H2	−0.011	−0.041	0.029	0.651	0.385
H3	0.701 ***	0.825 ***	−0.123	<0.01	2.259
H4	0.065	0.191 ***	−0.126	<0.05	1.800
H5	0.233 ***	−0.027	0.260	<0.05	2.757
H6	0.145 ***	0.144 *	0.001	0.956	0.010
H7	0.045	−0.114	0.159	<0.05	2.416
H8	0.778 ***	0.923 ***	−0.145	<0.01	2.828
H9	0.520 ***	0.641 ***	−0.121	0.197	1.158
H10	0.289 ***	0.417 ***	−0.128	0.064	2.041
H11	0.296 ***	0.311 ***	−0.016	0.839	0.209
H12	0.429 ***	0.179 *	0.250	<0.05	2.537
H13	0.009	0.164 *	−0.154	0.058	1.816

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Education level: Lower education level respondents showed a stronger correlation between PN and AT than higher education level respondents. Moreover, higher education level respondents showed a stronger correlation between PE and AT than lower education level respondents. The results are summarized in Table 9.

Table 9. Multi-group analysis by education level.

Hypothesis	Completed High School or Below (n = 276) (β_H)	Bachelor's Degree or Above (n = 714) (β_B)	$\beta_M - \beta_H$	*p*-Value	*t* Value
H1	0.199 **	0.171 **	0.028	0.744	0.284
H2	−0.062	0.000	−0.062	0.300	0.877
H3	0.789 ***	0.710 ***	0.079	0.085	1.517
H4	0.135 **	0.082 *	0.053	0.383	0.784
H5	0.228 *	0.181 ***	0.047	0.698	0.447
H6	0.243 ***	0.130 ***	0.113	0.070	2.140
H7	0.038	0.028	0.010	0.913	0.144
H8	0.689 ***	0.803 ***	−0.115	0.061	2.024
H9	0.477 ***	0.540 ***	−0.063	0.615	0.574
H10	0.513 ***	0.245 ***	0.268	<0.01	3.460
H11	0.208 **	0.306 ***	−0.098	0.183	1.381
H12	0.189 *	0.428 ***	−0.239	<0.05	2.508
H13	0.066	0.021	0.045	0.550	0.565

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

5. Discussion

To explore antecedents of using electric shuttle bus services, this paper developed a theoretical research model that integrated UTAUT and NAM with attitude construct. This research offers insights into developing electric shuttle bus services by arguing that service features, environmental value, and individual attributes are the primary determinants of whether the public would accept the service. Based on analysis results, a large proportion of the variance (73.5%) in adoption intention toward electric shuttle bus services can be explained by the proposed research model.

The attitude was demonstrated as the strongest direct antecedent of using electric shuttle bus services, which mirrored the evidence reported by Ajzen [62]. To be more specific, users who derived favorable feelings from the adoption of electric shuttle bus services were more prone to form positive intentions. The attitude was users' subjective thoughts and feelings about target behaviors. Users' subjective positivity assessed it toward adopting the electric shuttle bus service and their perception of this service's anticipated importance to the environment in this research. Previous literature pointed out that attitude was an important influencing factor for users' willingness to accept on-demand transportation services [47]. Our research also provided evidence for this statement as electric shuttle bus services were considered an advanced flexible transportation mode to meet public commuting demands. In addition, the direct effect of effort expectancy on attitude was not significant, while the EE→PE→AT path was significant. We also found that performance expectancy was the motivating factor for a positive attitude. This relationship was also reported in the acceptance of emerging transportation technologies [48]. Specifically, the stronger the perception of performance users had on adopting the electric shuttle bus service, the more positive attitudes users had toward this service. Social influence was shown to significantly affect attitude, suggesting that the perception of the support and encouragement from important others would increase positive feelings about the adoption of electric shuttle bus services. Personal norms were also revealed to have a positive impact on attitude. This indicated that the stronger the moral obligation feelings users had, the more positive attitudes users had toward electric shuttle bus services.

Performance expectancy, following attitude, was the second strongest antecedents of using electric shuttle bus services, which confirmed the findings reported in existing research [63]. It implied that users were more motivated to accept electric shuttle bus services when they had a stronger usefulness and convenience perception of this service. Electric shuttle bus services could provide flexible and convenient transit services for residents. As a consequence, users' performance perception was intensive, which in turn enhanced users' willingness to accept electric shuttle bus services. Consistent with prior findings in the research of advanced technology acceptance, the EE→PE path was significant [45]. We found that the EE→BI path was insignificant, while effort expectancy indirectly impacted users' adoption intention of electric shuttle bus services through mediating performance expectancy and attitude. It was possible that the electric shuttle bus service is an emerging transportation service method and has not been deployed in the market on a large scale. The majority of the respondents in the investigation have never used electric shuttle bus services. As a result, they had difficulty estimating the effort expected to adopt the electric shuttle bus service, reducing the direct impacts of EE on BI.

Personal norms were also demonstrated as important antecedents of using electric shuttle bus services, which identified the evidence in pro-social behavior acceptance studies [64,65]. This displayed that having a strong sense of moral obligation made people more inclined to use the electric shuttle bus service. In recent studies, responsibility was revealed as the motivating factor for personal norms and the indirect element for behavioral intention [46]. This association was also replicated in the context of our research. It displayed that responsibility awareness for protecting the environment and energy activated users' moral obligation sense, which in turn improved the willingness to adopt electric shuttle bus services. It is possible that people become increasingly focused on environmental issues, which makes their responsibility awareness about pro-environmental behavior more intensive. Besides, our results showed that awareness of consequences exerted a non-significant correlation with moral obligation sense and adoption intention. It was probably due to the difficulty of quantifying the amount of fossil fuel savings and greenhouse gas reductions that would result from the adoption of the electric shuttle bus service, which hindered users' perception of the environmental value of adopting this service.

Social influence was also demonstrated as a significant antecedent of using electric shuttle bus services, which confirmed the findings reported in previous literature [34,66]. It indicated that the perception of the encouragement and support from important others would enhance the intention of adopting electric shuttle bus services. A possible explanation is that our investigation was carried out among Chinese residents, who gave great emphasis on collectivism and social relationships [67]. Another possible explanation is that users might not completely understand the electric shuttle bus service as this service has not been deployed on a large scale. Consequently, opinions expressed by important others might be crucial in determining whether the electric shuttle bus service was accepted. In addition, it was also found that the SI→PN path was significant, which confirmed prior findings in the research of advanced technology acceptance [34].

Finally, multi-group analysis findings displayed the path differences of the hypotheses among different demographic groups.

- Gender: The SI→BI path was only significant among females, consistent with previous literature findings [68]. Females may be more likely to be influenced by the opinions of others, while males are more prone to make decisions by themselves without the influence of opinions from others. Results implied that males were more affected by PE in shaping positive attitudes toward electric shuttle bus services, whereas females were more likely affected by PN. This might be because the utility perception is stronger among males than females [69]. In addition, males were more positive toward electric shuttle bus services than females.
- Age: Older respondents displayed a stronger correlation between EE and PE than younger respondents. This may be because older people require more effort to understand advanced technologies, which substantially impacted their perceived performance. The SI→BI path was only significant among older participants; it is possible that older respondents received limited knowledge, resulting in greater influence from others' opinions. Younger respondents displayed a stronger correlation between PE and AT than younger respondents. This may be because younger people are busier with work and have fewer spare moments. Thus, they give more weight to the performance expectancy, which substantially impacts their attitude.
- Education level: Lower-level respondents displayed a stronger correlation between PN and AT than higher-level respondents. This finding should be viewed with caution, as lower education level respondents only account for 27.9% of the dataset, which could not reflect their general personal norms. Furthermore, higher education level respondents displayed a stronger correlation between PE and AT than lower education level respondents.

6. Conclusions

This paper developed a theoretical research model that integrated UTAUT and NAM with an attitude construct to explore antecedents of using electric shuttle bus services. The results illustrated that attitude exhibited the strongest impact on the adoption intention of electric shuttle bus services. Performance expectancy, personal norms, and social influence played crucial roles in determining whether this service would be accepted or not by the public. Ascription of responsibility was demonstrated as the indirect antecedent of using electric shuttle bus services, whereas awareness of consequences had no impact on the adoption intention. Effort expectancy exhibited effects on adoption intention through the mediating roles of attitude and performance expectancy. Besides, the path differences of the hypotheses were displayed among different demographic groups. Results also provide valuable insights into how electric shuttle bus services can be implemented and accepted more readily.

Study results provide valuable insights into how electric shuttle bus services can be implemented and accepted more readily. Following are the practical suggestions. First, from a managerial standpoint, policymakers should emphasize the environmental value of adopting electric shuttle bus services regarding conserving fossil fuel consumption and reducing greenhouse gas emissions, which could activate users' personal norms and responsibility awareness. It is suggested to advocate the benefits of electric shuttle bus services in providing flexible shuttle services and enhancing travel convenience, as performance expectancy was an important antecedent of the adoption intention. It could be vividly advertised through social media and internet channels. Second, from an operational standpoint, the design of the electric shuttle bus service network should offer more flexibility and diversity in public transportation options by complementing the current public transport network, as attitude was demonstrated as the strongest direct antecedent of adoption intention. Optimizing the dispatching strategy of electric shuttle bus services according to commuting demand is recommended to improve the service efficiency, which could activate users' performance expectancy. Besides, the free trial operation could be carried out to allow users to directly experience the service, which is beneficial to improve the evaluation of electric shuttle bus services by early adopters, and then let them promote the service to their relatives and friends, as social influence was an antecedent of the adoption intention.

There are also several limitations in our study. First, our investigation sample consisted of Chinese residents, which could not represent users' acceptance in other countries and regions around the world. Users' attitudes toward electric shuttle bus services might be influenced by different regions and culture. Second, we did not explore the adoption intention for electric shuttle bus services among different usage experience. The increasing usage experience might change users' willingness to accept electric shuttle bus services. Third, our study only discussed the behavioral intention to adopt electric shuttle bus services with no survey on the use behavior.

Studies could be conducted to further examine the antecedents of using electric shuttle bus services. First, the investigation could be carried out in different cultural backgrounds to study users' acceptance of electric shuttle bus services in different regions. Second, future studies could be conducted to explore the adoption intention for electric shuttle bus services among individuals with different usage experience. Third, future studies could be carried out to examine the correlation between usage behavior and behavior intention of electric shuttle bus services. Third, the longitudinal investigation could be carried out to examine the use behavior of electric shuttle bus services.

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