Predicting RFID Adoption Towards Urban Smart Mobility in Ulaanbaatar, Mongolia

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Abstract

Smart city technologies such as transportation and parking systems make our daily lives more efficient and intelligent. However, it is impossible to implement a smart mobility system without analyzing the individual's behavior toward the new technology. This research study attempts to develop a framework for predicting smart mobility antecedents using SEM in primary data analysis. The Technology Acceptance Model (TAM) was the conceptual foundation for this study. To achieve the objectives of the study, one thousand five hundred and twelve effective questionnaires were collected and analyzed using Smart PLS 3.3. The results show that perceived usefulness, perceived ease of use, and perceived risk significantly affect attitudes towards adopting smart mobility systems. Our study provides a comprehensive framework to understand individual-level smart city technology adoption. This study offers implications for policymakers to update existing policies concerning road technology.

Keywords: Perceived risk, Perceived ease of use, Perceived usefulness, Attitude, Behavioral intention

1. Introduction

A city is a system created to ensure human comfort and peace. Therefore, the solutions that make the city more innovative aim to ensure human peace. Consequently, we are looking at reforms to make city life better and smarter. A smart city is a city that uses a wide range of technological advances to make its operations more efficient and faster. The primary purpose of a smart city is to improve the quality of life of its residents without the need for human intervention. Smart mobility is one of the most critical aspects of smart city management since it allows for a safe, clean, and efficient transport mechanism. Smart mobility intends to use digital devices and equipment to solve various problems, including traffic congestion, traffic management, and infrastructure security. Numerous technologies, such as RFID (Radio-Frequency Identification) sensors, support this smartness of things (see Figs. 1–3).

Mongolia's shift from a centrally planned to a market economy has resulted in considerable migration from rural to urban areas during the last 30 years. Migration to Ulaanbaatar is causing overcrowding and congestion. As of 2020, Ulaanbaatar covers 0.3% of the country's land area, but it's home to 67.2% of the population. Overcrowding has led to many problems, including air and environmental pollution and traffic congestion. Currently, almost 70 percent of the population lives in Ulaanbaatar. In December 2020, Mongolia had a total of 715,309 registered automobiles.

Moreover, according to national statistics, Ulaanbaatar's population will increase by 30,000 per year by 2025, and the number of cars will increase by 27,000 (https://livetv.mn/). Interestingly, many households own at least one car. As a result of the increasing use of private vehicles over public transportation. Therefore, traffic congestion, environmental pollution, traffic safety, and infrastructure damage have arisen daily. For this reason, people are spending more time on the road, and traffic congestion is increasing year by year. In other words, Ulaanbaatar residents spend more time on the road than they do with their families, working, or learning. As of 2020, there are:

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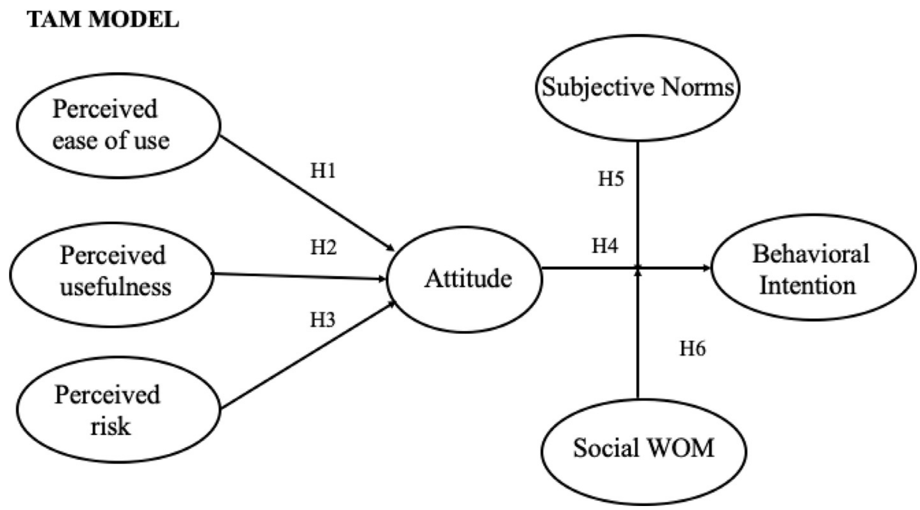


Fig. 1. Proposed model.

- 1.1 million vehicles nationwide
- 715,309 cars,
- 241,268 trucks,
- 36,084 buses,
- 20,672 vehicles are in particular use,
- Fifty-four percent of total vehicles are in Ulaanbaatar (615,622) https://montsame.mn/en/read/285862.

To address the above issues, authorities and policymakers are trying to find ways, such as social marketing, to be adequately implemented to address society's challenges. In today's technologically advanced world, social media significantly impacts citizens. Any new technology and systems may face some challenges, and the best approach is to employ social marketing to generate a positive impression on the whole population. Implementing the RFID system in the capital city of Ulaanbaatar is expected to begin in the second half of 2022. So, before that, it's better to give them a common understanding of what RFID and smart mobility systems are and why we should have them. The primary purpose of our study is to implement a project to reduce traffic congestion in the capital city of Ulaanbaatar and determine residents' attitudes towards smart mobility systems.

1.1. Need for smart mobility

Smart mobility allows residents to move freely around the city. Smart mobility can help with better traffic management. Such smart mobility services must provide congestion-free and environment-friendly for residents. The introduction of the RFID system aims to monitor traffic in Ulaanbaatar, plan and reduce traffic congestion, and provide information to drivers through the SMART CAR mobile application https://smartcar.mn/#/home. They will be able to pay all types of payments (checkpoints, parking, insurance, etc.) electronically. It consists of two parts: an RFID READER and an RFID TAG. We can benefit from smart mobility systems in two ways: for citizens and governments. In the case of citizens, they will benefit as follows: time savings, fuel savings, less congestion, cost-effective travel, etc.; in the case of governments: real-time traffic monitoring, dynamic traffic decisions, citizen-centric route planning, traffic-based route planning, etc., The proposed model aims to address issues about the contextual elements that influence the adoption of smart mobility services. From the aspect of the digital environment, the model will also investigate the impact of demographic characteristics on the behavior to adopt and use smart mobility systems. The effect of contextual variables (i.e., electronic word of mouth and subjective norms) combined with TAM will initiate the first step towards filling the gap in determining the constructs of smart mobility service adoption. The proposed model will be validated entirely through extensive data collection across the capital city of Mongolia. The findings will potentially clarify the critical aspects of individuals' adoption behavior of smart mobility systems.

2. Theoretical background and development of hypotheses

2.1. Technology acceptance model

The Technology Acceptance Model (TAM) is a theory of information systems that describes how people accept and use technology. Davis (1986) was

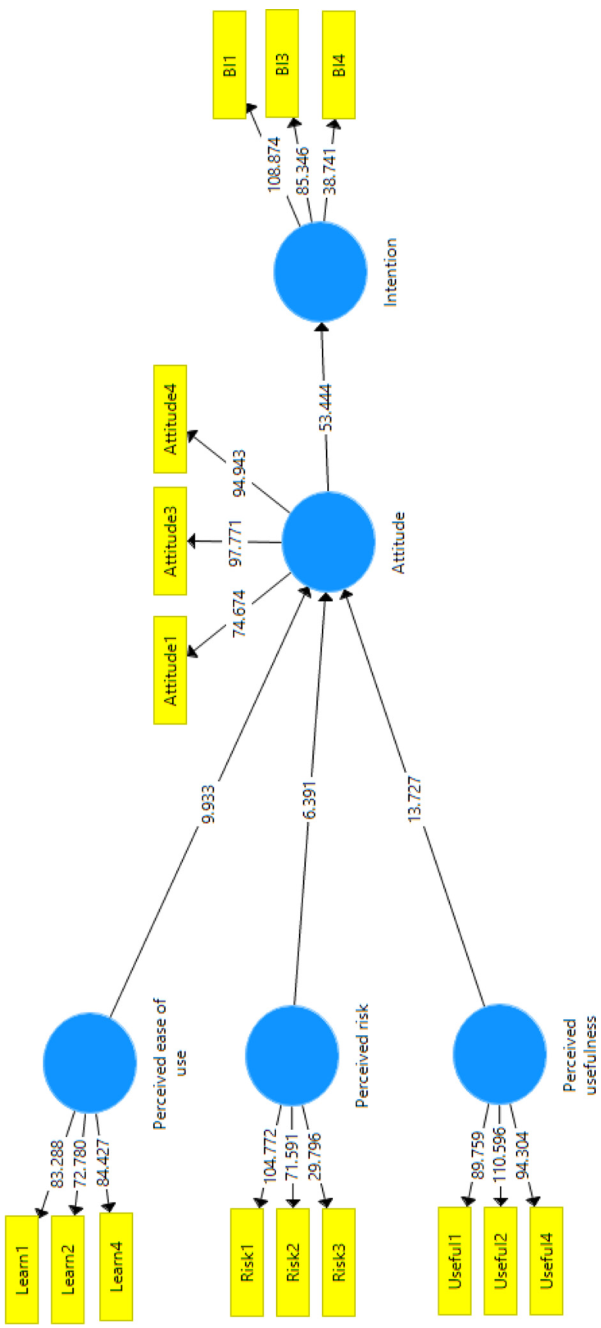


Fig. 2. Research model.

the first to offer this idea, which was based on a Theory of Reasoned Action (TRA) by Davis (Ajzen and Fishbein, 1980). The TAM identifies new technology acceptance based on people's attitudes. This model is the most often used for developing new information technology applications. TAM also indicates that when introducing new technology to people, various factors influence how and when to apply it. When this model is first offered to people, many factors determine how and when they use it. It consists of two concepts, perceived usefulness and perceived ease of use, which influence attitudes toward adopting new technology (Ajzen and Fishbein, 1980; Oh and Kim, 2022). The customer's attitude toward adoption will determine whether they will engage in positive or negative conduct in the future regarding new technologies.

2.2. Perceived ease of use

According to Davis (1989), perceived ease of use is determined as "The degree to which a person feels that utilizing a specific technology would be easy." In other words, perceived ease of use describes how confident consumers are that they can accomplish everything they want without the interruptions that come with it when they use technology. Moreover, perceived ease of use is a significant factor in influencing users' attitudes through improving system usefulness, which subsequently affects the system's behavioral intention (Davis, Bagozzi and Warsaw 1989). Drivers' attitudes regarding the use of transportation technology are supported by perceived ease of use (Kervick et al., 2015). Some studies also found that the perceived ease of use directly or indirectly influences a user's behavioral intention (Davis, Bagozzi and Warsaw 1989). Based on the above theoretical background, we posit the following hypothesis:

H1. Perceived ease of use will positively affect attitudes towards adopting smart mobility systems.

2.3. Perceived usefulness

The TAM defines perceived usefulness as people's belief that employing a specific technology would improve people's performance. Although, perceived usefulness is defined as a person's opinion that information technology will benefit its users (Davis, 1986). According to Davis (1993), perceived usefulness is the individual's belief that employing new technology will increase their performance. Similarly, Mathwick et al. (2001) defined perceived usefulness as how a person believes a specific system

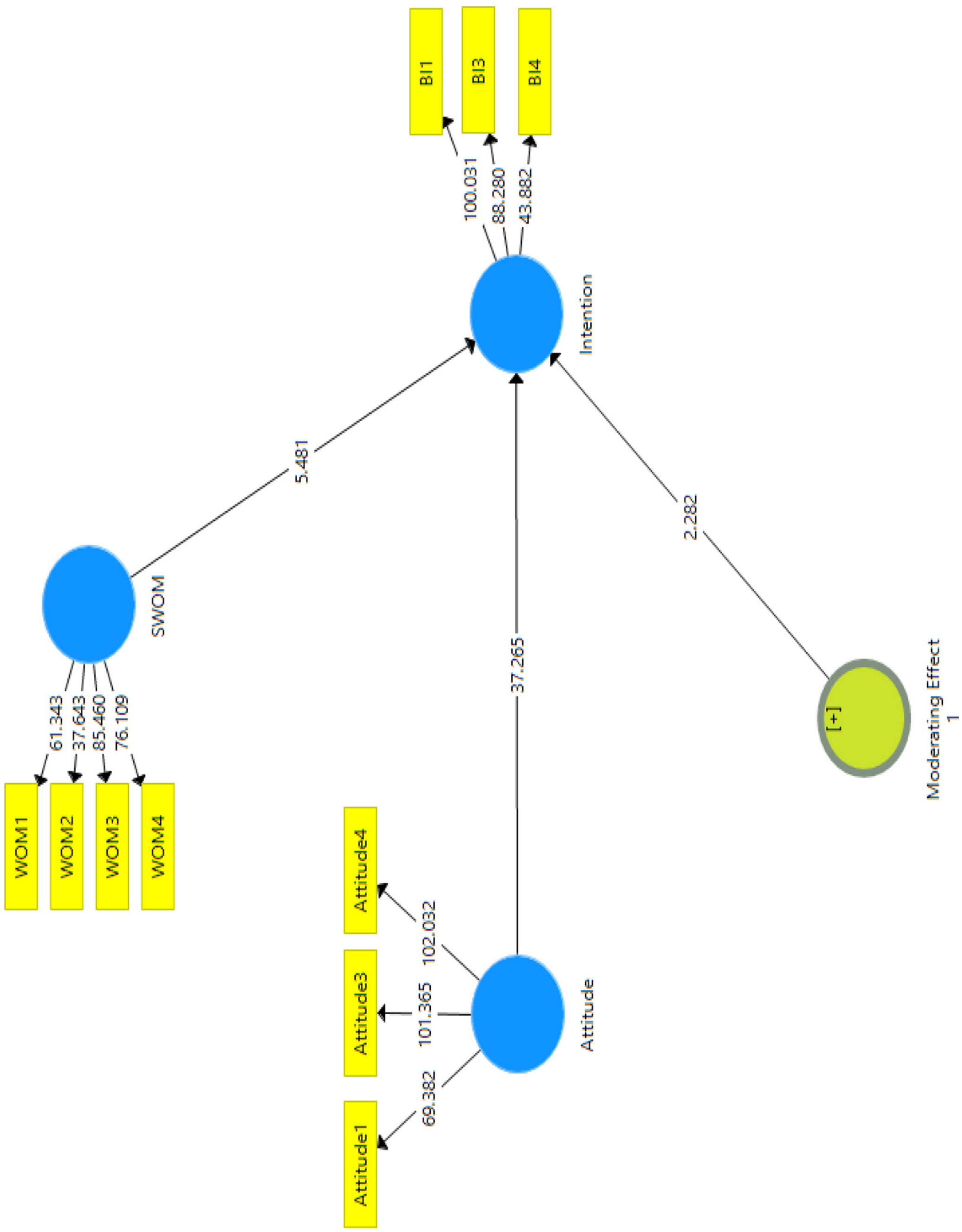


Fig. 3. The moderation test analysis.

will improve their job performance. Moreover, perceived usefulness is the most influential factor in the TAM model because it defines the user's opinion of the relevance of information technology use (Pfoser et al., 2018).

Furthermore, it has a positive and critical impact on the attitude in the transportation area. Because perceived usefulness influences user adoption of electronic vehicles, it was linked to behavioral intention to use new technologies (Venkatesh and Davis, 2000). Also, the perceived usefulness of technology is affected directly and indirectly by the person's behavioral intention (Davis, Bagozzi and Warsaw 1989). Based on the above theoretical background, we posit the following hypothesis:

H2. Perceived usefulness will positively influence attitudes towards adopting a smart mobility system.

2.4. Perceived risk

Perceived risk is an essential component of the technology adoption process. It influences people's confidence in their decisions. In previous studies, perceived risk was described as consumers' uncertainty about the consequence of any decision (Arslan et al., 2013). This entails a 'risk' because users do not know the significance of this discrepancy. A new technology or system would provide certain benefits to its users. Adopting new technology is likely to offer both advantages and disadvantages to users. People can suffer financially and psychologically due to the use of new technologies. Based on the above theoretical background, we posit the following hypothesis:

H3. Perceived risk will negatively affect attitudes towards adopting smart mobility systems.

2.5. Attitude

Consumer attitudes are the cornerstone of their behaviors (Keller, 1993), and they are a consistent positive or negative reaction to a particular product or service (Fishbein and Ajzein, 1975). Achrol and Kotler (1999) describe an attitude as an individual's favorable or unfavorable emotional sensation and behavioral propensity. Hoffler and Keller defines attitude as a general assessment of products or services. According to the planned behavior model theory, attitudes are judgments that people make about the conduct that they like or dislike (Ajzen, 1991). This implies that positive sentiments about a particular action may impact using technology. Attitude usually determines behavioral intention. Behavioral intention refers to the elements that influence people's decisions to use technology. Based on the above theoretical background, we infer as follows.

H4. Attitude will positively affect behavioral intention to adopt smart mobility systems.

2.6. Social WOM

Social media is essentially a communication tool where people share their thoughts on something. e-WOM can be broadly defined as exchanging information about a people's product or service through the internet or social media (Ahmad et al., 2020; Chu and Kim, 2011). Compared to WOM, e-WOM communication is more effective due to its speed and ability to reach many individuals at once (Ahamad, 2019).

The impact of e-WOM on retail sales has been extensively studied over the last years (Yang et al., 2012). Numerous studies have been conducted on e-WOM and their components can be divided into volume and valence (Jeon et al., 2020). Volume represents the total size of the WOM, and valence represents the positive or negative emotional side (Liu, 2006).

People use online reviews as an alternative information source (Kim, 2021). Studies show that positive reviews posted by individuals favorably affect the demand for a particular product (Huang and Chen, 2006). Zhang et al. (2013) have studied the impact of online reviews on camera sales and found that a greater number of reviews and review ratings significantly improve sales. Therefore, in this study, we choose e-WOM valence rather than volume.

According to the TAM (Davis et al., 1989), perceived usefulness is a stimulant for creating a favorable attitude toward the use of technology. According to Ayeh (2015), customers who believe consumer-generated information is valuable and more likely to adopt and use it. As a result, we anticipate that if people think the information on social media platforms from someone is beneficial, they will adopt a favorable attitude toward it. Based on the above theoretical background, we infer as follows.

H5. Social WOM will moderate the relationship between attitude and behavioral intention.

2.7. Subjective norms

A subjective norm is defined as "a person's belief that the majority of individuals who are important to him/her believe he/she should or should not engage in the activity at issue" (Ajzen, 1991). According to Choi et al. (2003), perceived usefulness, free use opportunity, and subjective norms positively and significantly influence new technology adoption. And subjective norms have an essential factor on behavioral intention. According to Khalil and Michael (2008), subjective norms formed by friends, family members, and co-workers favorably affect individuals' decision-making. Therefore, we hypothesize as follows:

H6. Subjective norms will moderate the relationship between attitude and behavioral intention.

3. Research methodology

3.1. Sample

The convenience sample method was employed in this study to meet the research goals. This study consists of citizens of the capital city of Mongolia. In terms of research methodology, fifty-three selected questions were analyzed using SPSS24 and Smart PLS 3.3 to test citizens' attitudes towards smart mobility system. As a result, the study's target participants were automobile owners in Ulaanbaatar. According to the national statistics website www.1212.mn, the population of Mongolia reached 3,400,312 in 2021. There are frequently used methods utilized in determining sample size. First, to achieve precise statistical analysis, the sample size should be over 300 (Stevens, 1996). Second, we used the following formula:

$$n = \frac{{z_{a/2}}^2 \times N \times [\pi \times (1-\pi)]}{\epsilon^2 \times (N-1) + Z_{a/2}^2 \times [\pi \times (1-\pi)]}$$

Here n is the sample size; $Z_{a/2}^2$ is the critical value of the standard distribution = 1.96 with 95% reliability, N is the population size; π is 0.5, ϵ is the sampling error of 5%. According to this calculation, the optimal sample size was 384 individuals. Participants were shown posters that explained how the RFID system works and then asked questions. We received 1512 valid responses.

The demographic characteristics of the participants are shown in Table 1. In the case of gender, 52% of the respondents were women, and 48% of the respondents were men. 31% of the respondents were 31–40 years old; in terms of household income, 42.8% have 1.000.000MNT-2.000.000MNT income/month (1USD = 2920MNT, 2022 January), and 66.5% have a bachelor's degree.

Table 1. Demographic information of participants.

Variable	Data	Number	Percentage
Gender	Male	726	48%
	Female	786	52%
Age	>20	131	8.7%
	21–30	434	28.7%
	31–40	469	31%
	41–50	291	19.2%
	51–60	135	8.9%
	60+	52	3.4%
Income	Up to 1 million	97	29.2%
	1-2 million	142	42.8%
	2-3 million	63	19%
	More than 3 million	30	9%
Education	Elementary school	64	4.2%
	Middle school	75	5%
	High school	368	24.3%
	Bachelor	1005	66.5%

3.2. Analysis

The information gathered from a self-administered survey was put into the SPSS spreadsheet. The collected data was analyzed using SMART PLS 3.3 and SPSS 24.0. The SMART PLS 3.3 was mainly adopted to test the hypotheses. A high level of significant value in this study is determined by $p \le 0.05$ (5%). A correlation with a significance level of $p \le 0.05$ is considered significant. Crosstab was used to evaluate the influence of gender on the attitude toward RFID tags and readers. For assessing the control variables, the One-Way ANOVA test was applied.

3.3. Measurements

Twenty-one items were used to measure the seven structures, based on the "Five Points Likers Scale" anchored on strongly disagree to strongly agree. The measure of perceived usefulness uses three items (e.g., It helps me be more effective, makes the things I want to accomplish easier to get done, and meets my needs) developed by Pikkarin et al. (2004). The measure of perceived ease of use also uses three items (e.g., This system is easy to use, it requires the fewest steps to accomplish what I want to do with it, and I can use it without written instructions) developed by Pikkarin et al. (2004). Perceived risk was measured with three items (e.g., It is probable that would frustrate me because of its poor performance, compared with other technologies, using new technology has more uncertainties, and it is not as effective as I think) developed by Im et al. (2008). The measure of subjective norms was measured using three items (e.g., My friends would encourage me to use this system, My family members would encourage me to use this device, and Most of my friends will use the fact that I use this system) developed by Kolvereid and Isaksen (2006) and The measure of e-WOM used three items (e.g., I would like to post something about the new system on my Facebook, I would like to add information about the new system on my Facebook, and I would like to share the new system on Facebook in the future) created by Lee and Ma (2012). The measure of attitude was used a 3-items (e.g., I think it is a good idea to use this system to monitor my car or road, this system is worth using, and I plan on using this system for innovation processes regularly in the future) scale developed by Shih and Fang (2004). Finally, the behavioral intention was also measured with three items (e.g., I have the intention to use this system when it becomes available, I intend to use this system, and Assuming I have access to this system, I intend to adopt it) scale developed by Shih and Fang (2004).

4. Results

4.1. Data analysis procedure

A Partial Least Square (PLS) was employed to test the model and hypotheses. Model estimation was performed by Smart PLS 3.3 (Ringle et al., 2013). T-values were calculated using a bootstrapping procedure with 1000 re-samples (Chin 1998). Smart PLS-3.3 path models have two linear equations: the inner (structural) and the outer (measurement) models. The internal model specifies the relationship between unobserved or latent variables, and the external model defines the relationship between the latent variable and its observed manifest variable (Heeler et al., 2009).

4.2. Measurement model

The general approach recommended by Gefen et al. (2000) for evaluating validity and reliability was followed. Convergent and discriminant validity was examined to assess validity. The average variance extracted (AVE) is used as a convergent validity criterion. If AVE is more significant than 0.5, the construct has sufficient convergent validity. To measure internal consistency, composite reliability (CR) is used. The value of CR must be higher than 0.7. Our data shows that CR is more than 0.7 and AVE is more than 0.5, so all constructs have convergent validity. The Fornell and Larcker criterion assessed discriminant validity. The AVE of each latent variable should be higher than the squared correlations with all other latent variables (AVE > φ^2). Our data shows that all AVEs exceed the squared correlation, so all constructs have discriminant validity. Cronbach's alpha and composite reliability are used to measure internal consistency and reliability based on the interrelationship of the observed item variables. Table 2 shows that the data are reliable because Cronbach's alpha and the composite reliability are above 0.6 (Eisingerich and Rubera, 2010). The Average Variance Extracted (AVE) measures the convergent validity. The data has adequate convergent validity if the AVE score exceeds 0.5.

4.3. Structural model

As the outer model shows that the data is reliable and valid, we can evaluate the inner model. The structural model (inner model) specifies the relations among latent constructs. We tested the significance level of path coefficients with bootstrapping and 1000 re-samples. Results indicate that all hypotheses are supported. Table 3 shows the results of the hypothesis testing and the PLS structural model. Path coefficients and significance levels test the hypotheses. First, the researcher analyzes the indirect effect between the independent and intervening variables. A direct relationship exists between the variables if the t-value is above 1.96. The results show that PEU-ATT (9.933), PR-ATT (6.391), and PU-ATT (13.727) all exceeded 1.96. Empirical data support the proposed conceptual model. The path analysis provides support for all the hypotheses in this research. The results of the hypothesis testing are summarized in Table 3.

Table 2. Reliability, convergent and discriminant validity.

Constructs	Cronbach's Alpha	CR	AVE	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Intention	0.766	0.865	0.681	1.000						
Subjective norm	0.858	0.903	0.700	0.742	1.000					
Social WOM	0.829	0.845	0.658	0.567	0.486	1.000				
Perceived ease of use	0.825	0.894	0.737	0.519	0.539	0.526	1.000			
Attitude	0.810	0.888	0.725	0.596	0.696	0.428	0.489	1.000		
Perceived risk	0.722	0.845	0.648	0.821	0.822	0.338	0.579	0.593	1.000	
Perceived usefulness	0.851	0.910	0.770	0.710	0.726	0.331	0.621	0.634	0.671	1.000

Table 3. Path coefficient results.

	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics	P-value	
Dependent: Attitude						
Perceived ease of use	0.250	0.251	0.025	9.933	0.000***	
Perceived risk	0.186	0.187	0.029	6.391	0.000***	
Perceived usefulness	0.437	0.435	0.032	13.727	0.000***	
R2						0.480
R2 adjustment						0.481
Dependent: Intention						
Attitude	0.748	0.749	0.014	53.444	0.000***	
R2						0.491
R2 adjustment						0.488

***p < 0.00, ***p* < 0.05, **p* < 0.10.

Table 4. The results of moderation analysis.

Path	Model 1		Model 2	
	path	t-value	path	t-value
Attitude-> BI	0.475	5.622	0.512	5.481
EWOM-> BI	0.346	13.038	0.478	37.263
ATT*EWOM-> BI			0.137	**2.282**
R2	0.321	0.324		

Bold denotes the result indicates that hypothesis (H6) is significant. Path coefficient from Attitude to EWOM was significant (t = 2.282 p < .000).

4.4. The moderation analysis

We choose subjective norms and e-WOM as moderator variables on the relationship between attitude and behavioral intention. Subjective norms were measured using three items adapted from Kolvereid and Isaksen (2006), and e-WOM was also measured using three items created by Lee and Ma (2012). In the case of subjective norms, participants were asked to indicate the opinions of a set of people (parents, relatives, and close friends) regarding their new system's adoption.

We tested the subjective norms as moderator variables, but there were no significant differences between the two models. Subjective norms don't have much significant effect on attitude and behavioral intention. However, interestingly, when the e-WOM variable becomes a moderating variable, it makes attitude significantly impacts behavioral intention (see Table 4). Therefore hypothesis 5 was accepted (see Table 5).

5. Discussion

This research has investigated the influence of perceived ease of use, perceived usefulness, perceived risk, e-WOM, subjective norms, and attitudes towards behavioral intentions in Ulaanbaatar, Mongolia. This study relied on Ajzen's theory of planned behavior (Ajzen, 1991). The findings from the SEM analysis showed strong support and accepted five of the six hypotheses (i.e., H1, H2, H3, H4, and H5), indicating a significant positive direct relationship between independent and dependent variables. A notable aspect of the research model was that perceived ease of use, perceived usefulness, perceived risk, and e-WOM were determinant variables of behavioral intention to use smart mobility systems. Among them, perceived usefulness had a stronger influence on behavioral intentions than perceived ease of use, with the t-test being 13.727 and 9.933, respectively. This finding might explain that people were more likely to prefer useful technologies when adopting new technologies. While this result was consistent with some prior studies (Ahmed et al., 2020). Another important conclusion from this research is the impact of perceived ease of use on behavioral intention. This means that perceived ease of use also has a positive and significant impact on behavioral intention. In other words, as the system becomes easier to use, individuals tend to use it more often. Another interesting aspect of the results was that e-WOM significantly influenced the relationship between attitude and behavioral intention. e-WOM

Table 5. The results of the hypothesis test.

	Hypotheses	Results
H1	Perceived ease of use will positively affect attitude to adopt smart mobility services.	Confirmed
H2	Perceived usefulness will positively influence attitude to adopt smart mobility services.	Confirmed
H3	Perceived risk will negatively affect attitude to adopt smart mobility services.	Confirmed
H4	Attitude will positively affect behavioral intention to adopt smart mobility services.	Confirmed
H5	e-WOM will moderate the relationship between attitude and behavioral intention.	Confirmed
H6	Subjective norms will moderate the relationship between attitude and behavioral intention.	Rejected

information on social media platforms like Facebook and Instagram will positively influence most citizens' behavior. According to Urandelger et al. (2021), almost 70 percent of Mongolian citizens actively use social media. This result is also consistent with those of (Kazmi and Mehmood (2016). Therefore, involving influencers in social media is more effective since most people obtain information from social media and generally trust the information of social media influencers.

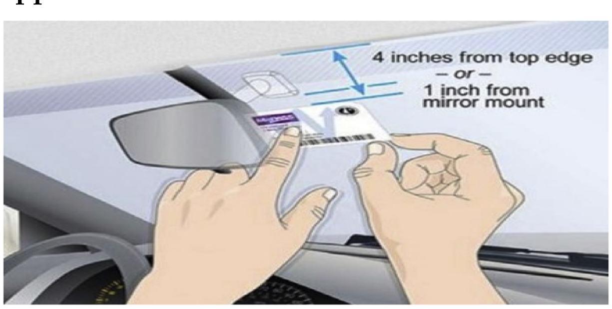
5.1. Managerial implications

The first step in marketing is to make consumers aware of the importance of smart mobility systems. Public relations should focus on public attitudes towards smart mobility and increase their confidence. It is more effective to involve celebrities (influencers) in social media, as most citizens receive information from social media and generally trust the information of celebrities and influential people. Based on the results, some of them do not follow influencers, so citizens (especially car owners) need to organize public marketing campaigns. In order to reduce traffic congestion in the future, it is important to organize social marketing activities to create good habits for citizens and the public. For example, encourage the public to make better use of public transportation and to practice short-distance walking. For policymakers: considerable market research will be required to develop and test appropriate social marketing campaigns. It will take a long time to change the citizen's behavior, and there will be a need for advertising and educational campaigns that will influence people who have a car.

Conflicts of interest

The authors declare that there is no conflict of interest.

Appendix.



Perceived Ease of use

1. This system is easy to use.
2. It requires the fewest steps to accomplish what I want to do with it.
3. I can use it without written instructions.

Perceived Usefulness

1. It helps me be more effective.
2. It makes the things I want to accomplish easier to get done.
3. It saves me time when I use it*
4. It meets my needs.

Attitude

1. I think it is a good idea to use this system to monitor my car or road
2. This system is worth use
3. I plan on using this system for innovation processes regularly in the future.

Behavioral Intention

1. I have the intention to use this system when it becomes available
2. I intend to use this system
3. Assuming I have access to this system, I intend to adopt it

E- WOM valence

1. I decide what influencers choose
2. I make the decision based on what my Facebook friends suggest
3. I would recommend this store to my Facebook friends.
4. I am proud to tell my Facebook friends that I bought from this store. *

Subjective norms

1. My friends would encourage me to use this system
2. My family members would encourage me to use this device
3. Most of my friends will use the fact that I use this system

* *Items that were removed during the scale purification process*

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