What factors determine the intention to use and recommend public autonomous shuttles in a real-life setting?

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Abstract

Purpose – User acceptance is a necessary precondition to implementing self-driving buses as a solution to public transport challenges. Focusing on potential users in a real-life setting, this paper aims to analyze the factors that affect their willingness to use public autonomous shuttles (PASs) as well as their word-of-mouth (WOM) intentions.

Design/methodology/approach – Grounded on Unified Theory of Acceptance and Use of Technology (UTAUT2), the study was carried out on a sample of 318 potential users in a real-life setting. The hypothesized relationships were tested using partial least squares structural equation modeling (PLS-SEM).

Findings – The study reveals that performance expectancy, facilitating conditions, hedonic motivation and trust are significant predictors of PAS usage intention, which is, in turn, related to WOM communication. Additionally, the factors that impact the intention to use a PAS are found to exert an indirect effect on WOM, mediated by usage intention.

Practical implications – This study includes practical insights for transport decision-makers on PAS service design, marketing campaigns and WOM monitoring.

Originality/value – While extant research focuses on passengers who have tried autonomous shuttles in experimental settings, this article adopts the perspective of potential users who have no previous experience with these vehicles and identifies the link between usage intention and WOM communication in a real-life traffic environment.

Keywords Autonomous vehicle, Autonomous shuttle, Driverless shuttle, Self-driving bus, Technology adoption, Technology acceptance, Usage intention, Word-of-mouth, Sustainable mobility, Smart mobility, Robots, UTAUT2

Paper type Research paper

1. Introduction

Autonomous vehicles (AVs) are robotic automobiles that sense their surroundings and location and operate without a human driver (Kaur and Rampersad, 2018). Although there are

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still technical, legal and societal issues to be solved before autonomous driving becomes mainstream, this novel mode of transportation is expected to disrupt a wide variety of industries and have a transformative effect on society in the coming decades (Leminen *et al.*, 2022). The deployment of self-driving vehicles includes a host of options that range from privately owned AVs to AV pooling and public autonomous shuttles (PASs) (Paddeu *et al.*, 2020). While extensive research has been conducted on private self-driving cars, the number of studies that explore the adoption of public autonomous buses is comparatively small (Goldbach *et al.*, 2022; Golbabaei *et al.*, 2020).

Implementing PASs comes with several advantages: eased traffic congestion, lower parking space needs, reduced greenhouse gas, fewer noise emissions and more efficient mobility solutions in areas not easily served by traditional buses (Bucchiarone *et al.*, 2021; Jing *et al.*, 2020; Azad *et al.*, 2019). Prior studies dealing with PAS acceptance typically survey passengers who have been in contact with PASs in experimental settings, either through images and descriptions (e.g. Goldbach *et al.*, 2022; Moták *et al.*, 2017) or during short-term trials of public pilot projects (Kaye *et al.*, 2020). Despite their unquestionable merit, their results must be taken with caution since the controlled conditions of pilot trials can affect passengers' perception of the overall experience (Mouratidis and Cobeña-Serrano, 2021) and might lack high external validity. Regrettably, studies that deal with PAS services running as regular public transport lines (Nordoff *et al.*, 2021; Mouratidis and Cobeña-Serrano, 2021) are an exception and leave out important elements that contribute to PAS adoption. Among these elements, word-of-mouth (WOM) communication is particularly relevant since WOM is one of the most influential sources of information about products and services (Ruiz-Mafe *et al.*, 2020; Huete-Alcocer, 2017) and a powerful marketing tool (Yang, 2017).

Lacking an accurate and broad understanding of PAS adoption can affect the successful deployment of this technology private firms and public transport authorities, which might translate into substantially ineffective investments. Thus, this study aims to offer insights into the factors that affect PAS usage intention in real-life contexts, as well as users' willingness to share their opinions about PASs with others. To do so, this research proposes an extension of the Unified Theory of Acceptance and Use of Technology (UTAUT) model (Venkatesh *et al.*, 2003). Particularly, we study a PAS implementation at a university campus, where a free-of-charge autonomous shuttle had been running as a regular public transport option for more than a year before data collection. Since public acceptance is the precondition that will allow emerging PAS services to reach their forecasted benefit levels (Madigan *et al.*, 2017), we focus on individuals who have never used this means of transport before and, therefore, represent the target population of successful PAS adoption initiatives.

This study contributes to extant knowledge about the public acceptance of PASs in several ways. First, our research stands out for providing empirical evidence on PAS usage intention in a real-life setting. Second, the study goes beyond traditional measures of usage intention and investigates its link to passengers' willingness to engage in WOM about the driverless shuttle service. Third, our research specifically studies individuals who have no experience using PASs, offering the necessary insights to provide a practical guide to public and private entities seeking the deployment of PAS technology. In the next section we provide an overview of our research model and present its hypotheses. Subsequently, we describe our methodology and our findings. Finally, we discuss our results and present the conclusions and main limitations of the study.

2. Theoretical background

With the developments in AV technology, research on the acceptance of self-driving vehicles has increased in recent years (Choi and Ji, 2015; Buckley *et al.*, 2018). Previous studies have researched factors that impact AV adoption including perceived usefulness, ease of use, social influence, trust (e.g.: Panagiotopoulos and Dimitrakopoulos, 2018; Zhang *et al.*, 2019), personality traits (Zhang *et al.*, 2020) and cybersecurity concerns (Kaur and Rampersad, 2018) among other topics. Nonetheless, findings from studies on driverless cars might not be directly transferable to public autonomous transport systems. For instance, factors that affect the AV market, such as the social pressure to own the newest technology, do not necessarily apply to PASs (Goldbach *et al.*, 2022). Despite this, research on the drivers of PAS acceptance has received significantly less attention than research on the factors that impact AV adoption (Liew *et al.*, 2023; Narayanan *et al.*, 2020).

Technology acceptance can be defined as the individual's willingness to use a technological solution for the job it is designed to support (Dillon and Morris, 1996). Technology acceptance theories that have been commonly used in the context of PAS include technology acceptance model (TAM) (Davis, 1989), theory of planned behavior (TPB) (Ajzen, 1991) and UTAUT (Venkatesh *et al.*, 2003) or its most recent consumer-oriented version UTAUT2 (Venkatesh *et al.*, 2012). Condensing previous frameworks to study technology acceptance, UTAUT2 posits that performance expectancy, effort expectancy, social influence, facilitating conditions, hedonic motivation, price value and habit are constructs that influence consumer behavioral intentions towards technology use, While UTAUT constructs have been used as predictors of PAS acceptance in trial projects in several European countries including France, Germany, Greece, Switzerland, Belgium and Greece (Liew *et al.*, 2023), there is very limited evidence from UTAUT-based studies on established public bus lines (Table A1). As an exception, Nordoff *et al.* (2021) find that effort expectancy is the strongest predictor of PAS usage intention among users of a PAS service operating regularly in a mixed-traffic environment in Germany. Research on permanent PAS implementations based on other theoretical frameworks is also scarce (e.g.: Mouratidis and Cobeña-Serrano, 2021). Additionally, the fact that research ignores the behavioral intentions of individuals who have never boarded a PAS can be problematic, as the literature shows that experience impacts users' decision-making (Ajzen, 1991) and modifies their behavior (Venkatesh *et al.*, 2003). In the specific context of PAS, there is evidence that passengers' willingness to use this service is higher after experiencing a test ride (e.g.: Goldbach *et al.*, 2022; Dennis *et al.*, 2021), especially when the initial acceptance level is low or not stable (Wicki *et al.*, 2019).

2.1 Model overview

Departing from previous research that applies the UTAUT to study PAS usage intention (Table A1), we propose a new model that includes performance expectancy, effort expectancy, social influence, facilitating conditions, hedonic motivation and trust as predictors for PAS usage intention for people who have never ridden an autonomous minibus. Additionally, we include WOM as a consequence of PAS usage intention (Figure 1).

Performance expectancy refers to the degree to which a certain technology helps an individual improve at a given task. Effort expectancy captures the ease of use associated with technology. Social influence refers to if and how the opinion of a user's reference groups is important in their decision to use technology. Facilitating conditions include the available support to help an individual when using technology and hedonic motivation is the degree of enjoyment perceived by an individual when using technological solutions (Venkatesh *et al.*, 2003, 2012). While trust is not one of the constructs included in UTAUT, it is broadly recognized as an important predictor of technology acceptance and is often included in AV acceptance studies (Wu *et al.*, 2011). Trust captures the expectancy that an agent will help achieve an objective in a situation characterized by uncertainty and vulnerability (Lee and See, 2004). Finally, WOM is a non-transactional behavior that captures the degree to which individuals communicate with other parties about their evaluation of goods and services (Fan *et al.*, 2020).

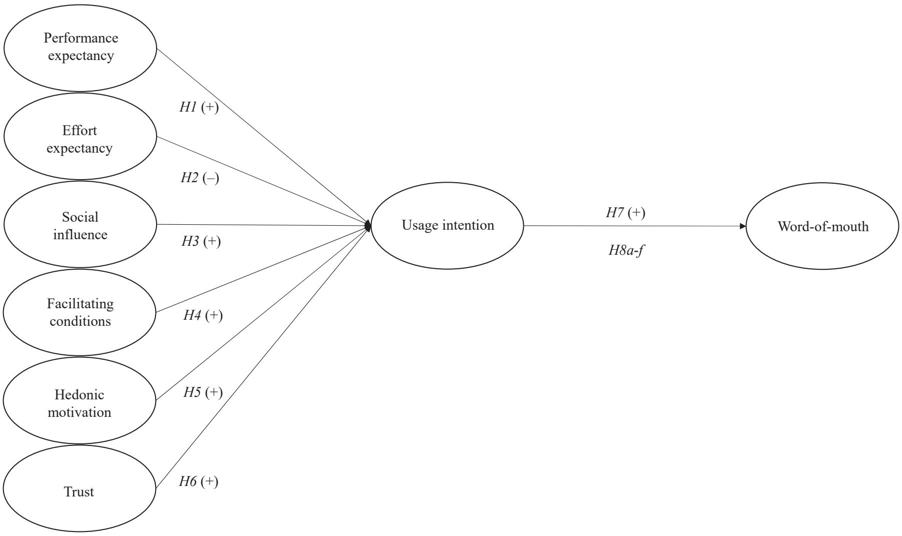

Figure 1.
Research model

Note(s): *H8a-f* correspond to mediating effects
Source(s): Figure by authors

Our proposal complements existing literature in several aspects, as delineated in Table A1: (1) scholars have focused primarily on PAS pilot projects whereas we analyze real-life implementations of a PAS service; (2) in contrast to our research, no PAS studies have explored WOM intentions; (3) prior studies survey passengers who have tried some form of PAS, while we study potential users with no PAS experience. Additionally, our study offers a comprehensive model while previous research does not cover all of UTAUT2's core constructs applicable to the PAS context.

2.2 Hypotheses development

2.2.1 Performance expectancy. Empirical research across different markets corroborates that consumers try and continue to use technological advancements that increase their performance of a task (Venkatesh *et al.*, 2003). Performance expectancy is a relevant predictor of autonomous car acceptance (Kettles and van Belle, 2019; Panagiotopoulos and Dimitrakopoulos, 2018; Kaur and Rampersad, 2018; Solbraa Bay, 2016) and a strong predictor of passengers' behavioral intentions towards PASs (Madigan *et al.*, 2017; Bernhard *et al.*, 2020; Nordhoff *et al.*, 2021). Performance expectancy for PASs is related to the degree to which individuals believe that using a driverless shuttle is convenient and helps them achieve their transport goals efficiently. We expect that individuals who have never ridden a PAS would be more likely to use these vehicles if they perceived that the shuttle helps them accomplish their daily commute. Thus, we formulate the following hypothesis:

> *H1.* Performance expectancy is positively related to PAS usage intention among potential users.

2.2.2 Effort expectancy. Prior research has produced mixed results about the impact of effort expectancy on the adoption of self-driving vehicles. Whilst several studies find that effort expectancy is indeed a strong predictor of both AV and PAS usage intention (Buckley *et al.*, 2018; Panagiotopoulos and Dimitrakopoulos, 2018; Zhang *et al.*, 2019; Rombaut *et al.*, 2020;

Bernhard *et al.*, 2020), other studies conclude that effort expectancy does not affect the intention to use PASs (Madigan *et al.*, 2017; Nordhoff *et al.*, 2021). Thus, the relationship between effort expectancy and behavioral intention towards autonomous shuttles remains unclear. We consider that individuals who have no previous experience with PASs might feel that using the shuttle requires some degree of physical or mental effort that prevents them from boarding it. We hence hypothesize:

H2. Effort expectancy is negatively related to PAS usage intention among potential users.

2.2.3 Social influence. Generally, individuals embrace the values of their reference group during socialization processes and tend to behave according to what the group thinks they should do. This type of peer pressure has a positive and significant effect on people's intentions to accept technology innovations and is stronger when the influence occurs publicly rather than privately (Kulviwat *et al.*, 2009). Likewise, AV pilot projects show that social influence is a significant predictor of the intention to use autonomous cars (Leicht *et al.*, 2018; Kettles and van Belle, 2019) and public shuttles (Madigan *et al.*, 2017; Nordhoff *et al.*, 2020). Since the opinion of others about the usefulness of the PAS is likely to influence users who have not yet experienced the shuttle service, we hypothesize:

H3. Social influence is positively related to PAS usage intention among potential users.

2.2.4 Facilitating conditions. Facilitating conditions include environmental and a technological element (Jewer, 2018). The environmental component refers to persons or machines that the user can rely on for help. The technological component refers to the user's abilities when performing a certain task without external support. The extant literature on PAS acceptance identifies that facilitating conditions are a predictor of individuals' behavioral intentions in pilot projects (Madigan *et al.*, 2017; Nordhoff *et al.*, 2020), suggesting that the resources provided to support the implementation of PASs (e.g.: a safety operator on board, appropriate human-machine interface) influence usage intention. We consider that in a real-life setting, users who feel they don't have the necessary skills to ride a PAS will be more inclined to use the shuttle if they know there are facilitating conditions available to them. Thus, we formulate the following hypothesis:

H4. Facilitating conditions are positively related to PAS usage intention among non-users.

2.2.5 Hedonic motivation. Prior research supports the role of hedonic motivation on AV acceptance. For instance, Zhang *et al.* (2020) studied the influence of sensation-seeking traits on AV adoption. They confirmed that people who enjoy novelty and adventure display a higher intention to use AVs. In the context of pilot PAS tests, Madigan *et al.* (2017) showed that the perceived enjoyment of the transport system has a positive effect on passengers' usage intention. Feys *et al.* (2020) came to the same conclusion and established that the more enjoyable the ride, the higher the usage intention. We consider that, while potential users may find it difficult to assess whether a PAS ride is an enjoyable experience, they can still perceive PASs as innovative and technologically advanced. Thus, the association of PASs with novelty might increase non-users' willingness to use the PAS service. Therefore, we hypothesize that:

H5. Hedonic motivation is positively related to PAS usage intention among potential users.

2.2.6 Trust. Trust is one of the most important enablers of automated technological solutions (Paddeu *et al.*, 2020). People tend to rely on automation that they trust, which is especially relevant when complex situations make it impractical for individuals to comprehensively evaluate automation (Lee and See, 2004). Extant research identifies trust – including safety, privacy and security aspects – as a significant predictor of users' positive attitudes toward self-driving cars (Choi and Ji, 2015; Buckley *et al.*, 2018; Panagiotopoulos and Dimitrakopoulos, 2018; Zhang *et al.*, 2019; Hong *et al.*, 2021). Particularly, trust in PASs implies that the passengers are willing to place themselves in a vulnerable position by boarding the driverless shuttle (Kaur and Rampersad, 2018; Kaye *et al.*, 2020; Paddeu *et al.*, 2020; Nordhoff *et al.*, 2021). As PASs are completely controlled by a built-in automated system, individuals who have no previous experience with PASs might instinctively feel that boarding the shuttle poses a risk to them. However, we expect that trust, if present, can neutralize these concerns. Accordingly, we hypothesize:

H6. Trust is positively related to PAS usage intention among potential users.

2.2.7 Usage intention. WOM communication helps to disseminate information about innovative goods and services and is often perceived as more trustworthy than conventional advertising (Villanueva *et al.*, 2008; López and Sicilia, 2013). Empirical studies across different industries corroborate that technology adopters tend to engage in WOM communication, particularly if they trust the technology (Barreda *et al.*, 2015; Yang, 2017; Kalinić *et al.*, 2020; Shaker *et al.*, 2023). For instance, shoppers who benefit from in-store technologies share positive messages about the retail companies that deploy such technology (Inman and Nikolova, 2017). Similarly, Molinillo *et al.* (2023) found that the intention to use voice assistants significantly influences positive WOM about these devices. Extending these findings, we hypothesize:

H7. PAS usage intention is positively related to WOM among potential users.

Given that performance expectancy, effort expectancy, social influence, facilitating conditions, hedonic motivation and trust might influence usage intention and that usage intention might lead to WOM, we hypothesize that the drivers of usage intention can also affect WOM behaviors. Previous research does not directly test such relationships. However, hedonic and utilitarian elements are known to influence WOM about other disruptive technologies (Mishra *et al.*, 2022). In this regard, it is plausible that topics relative to the antecedents of usage intention that are included in our model could be incorporated into potential users' conversations about the PAS service. The more relevant to passengers these factors are, the more likely to appear in their WOM communication. Hence, we propose that:

H8. Performance expectancy (a), effort expectancy (b), social influence (c), facilitating conditions (d), hedonic motivation € and trust (f) are related to WOM among PAS potential users, via usage intention.

3. Methodology

3.1 Sampling and measurement

Data was collected at the main campus of Universidad Autónoma de Madrid. As indicated by prior studies, university campuses offer a complex context for passenger transport services and thus represent an interesting real-life scenario for AV research (Attard *et al.*, 2020). The above-mentioned university launched a PAS in October 2020 that travels the campus streets, where more than 6,000 vehicles and almost 30,000 people circulate every day (see Plate 1). The PAS connects the main locations of the campus through seven bus stops and can transport up to twelve passengers. An onboard operator assists users if necessary.

To collect the data, a link to an anonymous Qualtrics online survey was distributed among undergraduate students employing a non-probability convenience sampling method. Students represent the core target users of the campus PAS (about 89% of potential users). We employed

Source(s): Image courtesy of Alsa

Plate 1.
Public autonomous shuttle at Universidad Autónoma de Madrid (Spain)

scales from the extant literature and implemented them as 7-point Likert items (see Table A2). We ensured that participants had never used a PAS before by introducing a filtering question at the beginning of our survey, reaching a final sample of 318 valid responses. The participants' mean age was 20.3 years; 50% were female and 50% were male.

3.2 Data analysis

We tested our hypotheses using partial least squares structural equation modeling (PLS-SEM) by applying SmartPLS v. 4.0.9.8 (Ringle *et al.*, 2023). This technique aims to maximize the variance explained in target outcomes (McLeay *et al.*, 2022), being appropriate for structural models that explore theoretical extensions of established theories. Our research specifically extends the UTAUT2 model by integrating trust and WOM. Additionally, our sample size encourages us to use this procedure over covariance-based structural equation models. Finally, PLS-SEM allows for assessing the practical relevance of a model, that is, whether the model can produce adequate predictions (Hair *et al.*, 2019a, b). More specifically, we first assessed the measurement model. Next, we estimated our structural model. Finally, we estimated an extended version of the proposed model to further analyze the indirect effect that our exogenous variables may exert on WOM, mediated by usage intention.

4. Results

4.1 Measurement model and common method bias

We first evaluated our measurement model (Table A2). All our variables achieved indicator loadings greater than 0.70, thereby supporting item reliability. Our measurement model also showed internal consistency reliability: Cronbach's alphas were between 0.71 and 0.95 (Nunnally, 1978); the composite reliability of our items was between 0.84 and 97, higher than 0.70 (Hair *et al.*, 2019a, b); Dijkstra–Henseler's ρ was between 0.73 and 0.95, that is, also higher than 0.70 (Dijkstra and Henseler, 2015). Next, we evaluated the average extracted variances (AVEs) of our constructs, which were above the recommended 0.5 threshold (Fornell and Larcker, 1981), indicating convergent validity. Additionally, our measurement model showed adequate discriminant validity, according to indicators' cross-loadings, together with the Fornell and Larcker Criterion and the heterotrait-monotrait ratio (HTMT) ratio (Table A3). All loadings were higher for their corresponding construct than for others. The AVEs of all variables were higher than their squared correlations with other variables (Fornell and Larcker, 1981), while the HTMT ratios were lower than 0.85 (Kline, 2011). Finally, we evaluated if common method bias is present in our data following Kock and Lynn (2012). Particularly, we estimated a model in which all our latent constructs explain a random dummy variable and checked if full collinearity variance inflation factors (VIFs) were below 3.3. VIFs ranged between 1.31 and 2.40, thus indicating that common method bias is not a problem in our study.

4.2 Structural model: hypotheses testing

We next evaluated our structural model. The adjusted-R^2 for usage intention and WOM was 0.41 and 0.30 (Table 1), respectively, signaling that our model features moderate explanatory power (e.g.: Henseler *et al.*, 2009). Focusing on usage intention as our key construct, we assessed our model's out-of-sample predictive power by employing the PLSpredict procedure (Table 2). Particularly we employed ten folds and ten repetitions (Shmueli *et al.*, 2019). We first evaluated the $Q^2_{predict}$ statistics of the usage intention indicators, which were all higher than zero (0.39 and 0.24). This provides initial evidence of predictive relevance. Second, we analyzed the skewness of the prediction errors, which indicated that their distributions were not highly non-symmetric. Consequently, we based our prediction power assessment on root mean squared errors. Third, we compared the root mean squared errors of our PLS model with the ones provided by a linear model. The prediction statistics of our model were all lower, thus indicating that our model features high out-of-sample predictive power.

Table 1 shows the path coefficients of our structural model. We assessed their significance level by employing a bootstrapping procedure of 10,000 subsamples with no sign change. Our results support H1, which states that performance expectancy is positively related to usage intention among potential users. Our findings also indicate that effort expectancy is negatively associated with usage intention, but not at a significant level. Thus, we reject H2.

	Estimate	f^2	*t*-statistic		Hypotheses
Performance expectancy → Usage intention	0.28	0.06	3.40	***	H1 supported
Effort expectancy → Usage intention	−0.08	0.01	1.51		H2 not supported
Social influence → Usage intention	0.09	0.01	1.83	*	H3 not supported
Facilitating conditions → Usage intention	0.16	0.04	3.04	***	H4 supported
Hedonic motivation → Usage intention	0.24	0.05	2.86	***	H5 supported
Trust → Usage intention	0.12	0.01	2.10	**	H6 supported
Usage intention → WOM	0.55	0.44	12.33	***	H7 supported
Constructs			Variance explained (adjusted-R^2)		
Usage intention			0.41		
WOM			0.30		

Table 1.
Model results

Note(s): *: significant at a 90%; **: significant at a 95%; ***: significant at a 99% level
Source(s): Table by authors

	$Q^2_{predict}$	Skewness	PLS RMSE	LM RMSE	Difference
Using autonomous shuttles when they start to circulate in our environment will be not likely at all/very likely	0.39	−0.13	1.23	1.24	0.01
Using autonomous shuttles for short trips whenever they are available will be not likely at all/very likely	0.24	−0.78	1.34	1.36	0.02

Table 2.
PLSpredict

Source(s): Table by authors

Likewise, we didn't find support for H3, which argues that social influence would increase usage intention among our sample of potential users. Social influence is positively related to usage intention, but only at a 90% confidence level. Our findings support H4, which states that facilitating conditions are positively related to usage intention. Moreover, our results confirmed H5 and H6, which respectively posit that hedonic motivation and trust have a positive impact on the intention to use PASs. H7 proposes that usage intention increases WOM—and indeed, our results indicate that higher usage intention is accompanied by higher WOM among our sample of potential users, thus supporting H7.

To test H8, we next evaluated whether performance expectancy, effort expectancy, social influence, facilitating conditions, hedonic motivation and trust indirectly affect WOM, mediated by usage intention. Particularly, we followed Zhao *et al.* (2010) and computed bias-corrected and accelerated confidence intervals for such relationships (Table 3). Four out of six confidence intervals did not contain the zero value; particularly, we can confirm that usage intention mediates the indirect influences of performance expectancy, social influence, facilitating conditions and hedonic motivation on WOM, hence accepting H8a,d,e,f. These

	Estimate	95% bias-corrected and accelerated confidence interval	Hypotheses
Research model: indirect effects			
Performance expectancy → WOM	0.16	(0.06, 0.25)	H8a supported
Effort expectancy → WOM	−0.05	(−0.11, 0.01)	H8b not supported
Social influence → WOM	0.05	(−0.002, 0.11)	H8c not supported
Facilitating conditions → WOM	0.09	(0.03, 0.15)	H8d supported
Hedonic motivation → WOM	0.13	(0.04, 0.23)	H8e supported
Trust → WOM	0.06	(0.01, 0.13)	H8f supported
Extended research model			
Direct effect performance expectancy → WOM	0.10	(−0.06, 0.26)	
Indirect effect performance expectancy → WOM	0.07	(0.03, 0.14)	
Direct effect effort expectancy → WOM	0.04	(−0.19, 0.02)	
Indirect effect effort expectancy → WOM	−0.02	(−0.06, 0.004)	
Direct effect social influence → WOM	0.03	(−0.09, 0.15)	
Indirect effect social influence → WOM	0.02	(0.001, 0.06)	
Direct effect facilitating conditions → WOM	0.04	(−0.07, 0.14)	
Indirect effect facilitating conditions → WOM	0.04	(0.01, 0.08)	
Direct effect hedonic motivation → WOM	0.16	(0.01, 0.30)	
Indirect effect hedonic motivation → WOM	0.06	(0.02, 0.13)	
Direct effect trust → WOM	0.23	(0.08, 0.37)	
Indirect effect trust → WOM	0.03	(0.04, 0.08)	

Source(s): Table by authors

Table 3. Indirect effects

indirect effects are all positive. In contrast, effort expectancy and social influence do not indirectly affect WOM through the mediation of usage intention.

Beyond hypotheses testing, to shed further light on the indirect effect of usage intention drivers on WOM, we estimated an extended version of our model that included the direct effects of performance expectancy, effort expectancy, social influence, facilitating conditions, hedonic motivation and trust in WOM. Depending on the significance and sign of the product of the direct and indirect effects, the mediated relationship can be classified as indirect-only, complementary, or competitive (Zhao *et al.*, 2010). Except for hedonic motivation and trust, none of our exogenous variables demonstrated significant direct effects. Therefore, their effect on WOM is indirect only, that is, it occurs only through usage intention. This effect also indicates that other variables omitted in our model, beyond usage intention, can mediate the relationship between hedonic motivation and trust and WOM intention.

5. Discussion

Building on the UTAUT2 model, this research analyses the factors that drive potential users' future acceptance of PASs. Particularly, we study whether performance expectancy, effort expectancy, social influence, facilitating conditions, hedonic motivation and trust influence PAS usage intention among individuals who have no previous experience with PASs and if usage intention is then related to WOM communication. In line with previous literature (Madigan *et al.*, 2017; Bernhard *et al.*, 2020; Nordhoff *et al.*, 2021), our results indicate that respondents with higher levels of performance expectancy have a higher PAS usage intention, implying that potential users who may have witnessed that the PAS safely connects key campus locations find the technology useful and, consequently, are more likely to use it. Our results also indicate that the relationship between effort expectancy and usage intention is negative, but not significant. Extant research focused on individuals who have previous experience riding autonomous shuttles shows either a negative (Bernhard *et al.*, 2020; Rombaut *et al.*, 2020) or a null impact (Madigan *et al.*, 2017; Nordhoff *et al.*, 2021) of effort expectancy on the intention to use PASs.

Therefore, our findings support the studies that suggest that effort expectancy is not a key predictor of PAS usage intention. One possible explanation is that our study's participants felt unable to assess the effort required to use the PAS because they had never boarded it. Similarly, Bernhard *et al.* (2020) found that potential users feel skeptical about the ease of use of PASs, although that feeling becomes weaker after a first ride. Alternatively, this finding may also be related to the fact that PASs' potential users might not perceive that using the shuttle on campus requires any special skill (Madigan *et al.*, 2017). The presence of a safety operator is an additional possible reason for the lack of significance of the proposed relationship in the setting of the [*Anonymous University*]. Goldbach *et al.* (2022) found that effort expectancy significantly correlated with PAS usage intention only if the shuttle was fully autonomous. Their results show that when users know about the onboard operator, effort expectancy does not play a role in predicting their willingness to use the PAS.

The anticipated effect of social influence on PAS usage intention was not found to be significant. Most prior studies that deal with PAS trials conclude that if individuals perceive that their friends and family think positively about these vehicles, usage intention is higher (Madigan *et al.*, 2017; Nordhoff *et al.*, 2020). However, Goldbach *et al.* (2022) and Nordhoff *et al.* (2021) report that social influence is not a factor that affects PAS acceptance, suggesting that this relationship deserves further investigation. In an intermediate point, our data show that social influence is positively related to usage intention, but only at a 90% confidence level. A possible explanation is that the potential users who participated in our study felt their reference groups didn't know enough about PASs to have a qualified opinion since these vehicles are not widely available as a means of public transport yet.

Facilitating conditions increase usage intention among our sample, in line with Nordhoff *et al.* (2020)'s findings in a pilot project. Participants who feel they have the necessary support to start using the PAS service show a greater usage intention than those who feel that they need additional help before starting to use the shuttle. Interestingly, results from research focused on other real-life settings do not find a significant influence of facilitating conditions on willingness to use PASs (Nordhoff *et al.*, 2021). Our findings suggest that facilitating conditions appear to be most relevant in the early stages of the PAS adoption process. Our findings also suggest that people who have never used a PAS evaluate this innovative means of transportation not only for its utilitarian benefits but also for hedonic reasons. Following an early study by Madigan *et al.* (2017), who found that hedonic motivation was the strongest PAS usage intention predictor, we propose that potential users associate riding the PAS with fun and entertainment. Consistent with the literature on AV (e.g. Panagiotopoulos and Dimitrakopoulos, 2018; Zhang *et al.*, 2019; Kaye *et al.*, 2020; Paddeu *et al.*, 2020), we find that passengers' trust in the driverless shuttle is important for enhancing usage intention. Our respondents' trust perceptions are probably based on the PAS's reputation for smooth driving across the campus and lack of accidents since its launch.

Our results indicate that usage intention generates WOM, which supports previous research that examines WOM as an outcome variable in environments where users are not very familiar with the operation of a new technology (Molinillo *et al.*, 2023; Mishra *et al.*, 2022). We find that potential PAS users share information about the shuttle with others. The higher the willingness to use the PAS, the higher their intention to engage in WOM communication about it. We also find that the impact of the drivers of usage intention transfers to WOM communication among potential users, suggesting that the factors that impact the willingness to use PAS trigger discussions about these vehicles.

6. Conclusions

Building on the theoretical foundation of the UTAUT2 model (Venkatesh *et al.*, 2012), our study analyses PAS acceptance among potential users in a real setting. Our results indicate that usage intention is increased by the vehicle's performance expectancy, the existence of facilitating conditions, individuals' hedonic motivation and their trust in this technology. We also find that usage intention is positively related to PAS WOM communication. Thus, our findings offer relevant theoretical implications for research on AVs, as well as practical insights for public transport decision-makers.

6.1 Theoretical implications

This study offers several theoretical contributions. First, our results are relatively consistent with others that rely on pilot tests and analyze participants who have some experience with PASs. However, some differences are uncovered. For example, prior research focused on PAS users offers inconclusive results regarding the impact of effort expectancy on people's willingness to ride PASs (either negative or null). We find a non-significant relationship between the two variables. This suggests that previous experience can moderate the impact of the drivers of PAS usage intention. Particularly, effort expectancy might be more relevant for first-time users compared to passengers who use the service frequently. This might indicate a potential dynamic effect of effort expectancy on usage intention. Similarly, our results regarding social influence suggest that this variable stops being relevant when individuals become regular PAS users.

Second, in line with findings from other industries (Molinillo *et al.*, 2023), this study identifies a link between usage intention and WOM in the PAS context. Drivers of usage intention indirectly influence WOM intentions. Thus, our study encourages scrutiny toward other positive outcomes of technology acceptance beyond behavioral intention, both for current users and potential users. Third, we find that usage intention fully mediates the impact of performance expectancy and facilitating conditions on WOM. We also find that usage intention partially mediates the influence of hedonic motivation and trust on WOM. Therefore, other variables beyond usage intention might mediate these partial indirect effects. Finally, our research shows the appropriateness of UTAUT-based models to analyze PAS usage intention. Researchers considering studying PAS adoption can rely on this model for future studies and they can extend it to accommodate other variables that are relevant to PAS adoption.

6.2 Practical implications

PASs are a potential solution to address the existing need to develop urban transport services that not only solve mobility problems but also ensure sustainability (Ruiz-Montañez, 2017; Mouratidis and Cobeña-Serrano, 2021). Based on our study's findings, we provide several recommendations to stakeholders involved with the sustainable development of transportation, which we organize around three aspects: the shuttle service design, marketing campaigns and WOM monitoring.

The self-driving shuttle service design needs to consider several elements. First, the service should meet the potential users' mobility needs. For example, the route layout and frequency of shuttles must be carefully established to ensure high levels of performance expectancy. Incorporating onboard staff, at least during the early stages of PAS implementation, would act as a facilitating condition and might increase usage intention. Furthermore, an onboard operator may help to increase their sense of security and therefore their trust in PASs, which would increase usage intention. Additionally, during the early stages of implementation, PAS staff should be available near the minibus stops to inform passersby who might consider boarding the shuttle for the first time.

Regarding marketing campaigns, they need to convey three important messages. First, using PASs is simple and easy and does not require any special skill. Second, using PASs is safe. Third, riding PASs is fun. These three messages appeal to the existence of facilitating conditions, trust and hedonic motivation, respectively. Companies must carefully evaluate how to disseminate such messages. Our results indicate a weak importance of social influence for PAS acceptance, which might be stronger in other implementation contexts. If so, opinion leaders could be utilized to help disseminate these messages via social media. Otherwise, mass media might be more appropriate. In addition, a key recommendation is to work to maintain high levels of customer enthusiasm regarding PASs over time, since it has been argued that the impact of hedonic motivation on usage intention will decrease when PASs become generally embedded in urban transportation (Madigan *et al.*, 2017). Campaigns based on gamification techniques may be a good option (Bucchiarone *et al.*, 2021). These tactics would also encourage positive WOM. Another possibility to increase WOM would be to develop referral marketing campaigns (e.g. to offer users free PAS tickets or small giveaways in exchange for referring new passengers to the PAS service).

6.3 Limitations and future research

This study features limitations that offer future research opportunities. First, this study employed a non-probabilistic sampling method. New research might replicate our study using a probabilistic sampling method to see if the results are representative of other populations of interest. Second, given our focus on a setting where using the PAS is free, we did not incorporate the UTAUT2 variable "price value" in our model. Further research focused on other contexts might incorporate this variable to better understand PAS usage intention. Third, our results indicate that the WOM links with trust and hedonic motivation do not occur merely through usage intention. New studies about PAS adoption might contribute to identifying additional variables that explain these links further. Fourth, the study participants belong to Gen Z (people born between 1995 and 2010 (McKinsey & Company, 2018). Since their decision-making process might vary compared to other generational cohorts, further research could replicate our study with potential users from other generations. Finally, this study is conducted in a Western country. Given that the implementation of AVs in developing countries faces a host of unique challenges (Kumar *et al.*, 2022), future research should expand beyond countries with modern infrastructure and planned traffic.

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(The Appendix follows overleaf)

Appendix

Table A1.
UTAUT research on PAS adoption

	Independent variables						Dependent variables		
	Performance expectancy	Effort expectancy	Social influence	Facilitating conditions	Hedonic motivation	Trust	Usage intention	WOM	Sample
Bernhard *et al.* (2020)	✓	✓					✓		Pilot project users
Rombaut *et al.* (2020)	✓	✓			✓		✓		Pilot project users
Madigan *et al.* (2017)	✓	✓	✓				✓		Pilot project users
Goldbach *et al.* (2022)	✓	✓	✓			✓	✓		Potential users in a laboratory setting
Nordhoff *et al.* (2020)	✓	✓	✓	✓			✓		Pilot project users
Nordhoff *et al.* (2021)	✓	✓	✓	✓		✓	✓		Users in a real setting
Madigan *et al.* (2017)	✓	✓	✓	✓	✓		✓		Pilot project users
This study	✓	✓	✓	✓	✓	✓	✓	✓	Potential users in a real setting

Source(s): Table by authors

	Mean	Standard deviation	Excess kurtosis	Skewness
Performance expectancy ($\alpha = 0.84$; $\rho_A = 0.86$; CR = 0.9; AVE = 0.76)				
Adapted from Venkatesh *et al.* (2003)				
The autonomous shuttles will be a good option for my trips	4.30	1.57	−0.66	−0.07
The autonomous shuttle will allow me to move more comfortably	4.05	1.56	−0.64	0.21
Autonomous shuttle will reduce the number of accidents	3.94	1.74	−0.91	0.18
Effort expectancy ($\alpha = 0.91$; $\rho_A = 0.92$; CR = 0.94; AVE = 0.79)				
Adapted from Venkatesh *et al.* (2003)				
I think autonomous shuttles will be easy to use	4.67	1.36	−0.30	−0.20
Using autonomous shuttles will be easy	4.71	1.36	−0.12	−0.36
Traveling in autonomous shuttles will be easy	4.83	1.35	−0.05	−0.47
In general, I think that it will not be difficult to get around in autonomous shuttles	4.86	1.36	−0.17	−0.46
Social influence ($\alpha = 0.92$; $\rho_A = 0.92$; CR = 0.95; AVE = 0.86)				
Adapted from Venkatesh *et al.* (2003)				
Regarding me using autonomous shuttles in the future: My colleagues are totally against/agree with me using this means of transport	5.28	1.36	−0.29	−0.39
Regarding me using autonomous shuttles in the future: The people who are important to me are totally against/ agree with me using this means of transport	5.05	1.44	−0.06	−0.52
Regarding me using autonomous shuttles in the future: The people whose opinion I value are totally against/ agree with me using this means of transport	5.17	1.36	−0.45	−0.37
Facilitating conditions ($\alpha = 0.71$; $\rho_A = 0.73$; CR = 0.84; AVE = 0.63)				
Adapted from Venkatesh *et al.* (2003)				
I have the necessary knowledge to start getting around in an autonomous shuttle	3.34	1.73	−0.75	0.46
I can quickly learn to ride autonomous shuttles	5.70	1.25	0.55	−0.93
In my environment, there are people who can show me to use autonomous shuttles	2.95	1.80	−0.58	−0.67
Hedonic motivation ($\alpha = 0.86$; $\rho_A = 0.87$; CR = 0.91; AVE = 0.71)				
Adapted from Venkatesh *et al.* (2012)				
In the future, getting around in an autonomous shuttle will be nice	4.95	1.39	−0.55	−0.29
In the future, using an autonomous shuttle will be fun	4.86	1.50	−0.34	−0.45
In the future, autonomous shuttles will be comfortable	5.01	1.33	−0.47	−0.35
In the future, in global terms, I consider that autonomous shuttles will be a comfortable means of transport for my trips	4.76	1.49	−0.66	−0.28
Trust ($\alpha = 0.95$; $\rho_A = 0.95$; CR = 0.97; AVE = 0.90)				
Adapted from Choi and Ji (2015)				
The autonomous shuttle inspires me with confidence	3.82	1.59	−0.69	−0.02
The autonomous shuttle is reliable	4.07	1.43	−0.25	−0.06
I trust how the autonomous shuttle works	3.97	1.51	−0.60	−0.03
Usage intention ($\alpha = 0.76$; $\rho_A = 0.78$; CR = 0.89; AVE = 0.81)				
Adapted from Venkatesh *et al.* (2003)				
Using autonomous shuttles when they start to circulate in our environment will be not likely at all/very likely	4.51	1.55	−0.67	−0.22
Using autonomous shuttles for short trips whenever they are available will be not likely at all/very likely	5.18	1.53	0.02	−0.82

(*continued*)

Table A2.
Model measurement

	Mean	Standard deviation	Excess kurtosis	Skewness
Word-of-mouth (α = 0.91; ρ_A = 0.91; CR = 0.94; AVE = 0.84)				
Adapted from Inman and Nikolova (2017) and Fan *et al.* (2020)				
I will speak well to other people about the autonomous shuttle	4.64	1.34	0.08	−0.34
I will recommend the use of the autonomous shuttle to the university community	4.44	1.44	−0.33	−0.26
I will encourage other people to try the service	4.65	1.45	−0.25	−0.43

Note(s): All items are measured with a 7-point Likert scale anchoring strongly disagree (1) and strongly agree (7), α = Cronbach's alpha, CR = CR and AVE = Average variance extracted
Source(s): Table by authors

Table A2.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
*Fornell and Larcker's criterion**								
Performance expectancy (1)	*0.87*							
Effort expectancy (2)	0.50	*0.89*						
Social influence (3)	0.46	0.31	*0.93*					
Facilitating conditions (4)	0.32	0.31	0.30	*0.79*				
Hedonic motivation (5)	0.67	0.43	0.46	0.36	*0.84*			
Trust (6)	0.59	0.38	0.44	0.39	0.55	*0.95*		
Usage intention (7)	0.56	0.28	0.40	0.39	0.55	0.48	*0.90*	
WOM (8)	0.53	0.33	0.37	0.33	0.54	0.54	0.55	*0.92*
HTMT <0.90 criterion								
Performance expectancy (1)								
Effort expectancy (2)	0.56							
Social influence (3)	0.51	0.34						
Facilitating conditions (4)	0.40	0.38	0.37					
Hedonic motivation (5)	0.77	0.48	0.51	0.46				
Trust (6)	0.65	0.40	0.47	0.48	0.60			
Usage intention (7)	0.69	0.33	0.48	0.51	0.68	0.56		
WOM (8)	0.60	0.37	0.41	0.41	0.61	0.58	0.66	

Note(s): * Numbers on the diagonal (in italic) show the square root of the AVE; numbers below the diagonal represent construct correlations
Source(s): Table by authors

Table A3.
Discriminant validity

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