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Understanding the adoption of autonomous vehicles in Thailand: an extended TAM approach

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ABSTRACT

Autonomous vehicles (AVs) are receiving attention in many countries, including Thailand. However, implementing an intelligent transport system has many challenges, such as safety and reliability and the lack of policy supporting such technology use, leading to hazards for passengers and pedestrians. Hence, factors affecting the adoption of autonomous vehicles require better understanding. This research proposes and employs an extended Technology Acceptance Model (TAM) by integrating ethical standards, legal concerns, and trust to predict the intended use of autonomous vehicles by Thai citizens. A total of 318 questionnaires were collected from online panel respondents. Research hypotheses were tested using a structural equation modelling approach. The study results suggest that ethical standards have a significant positive effect on the intention to use the technology. Meanwhile, the intention was negatively affected by perceived usefulness, perceived ease of use and legal concerns. On the other hand, the results indicate that perceived ease of use directly affected trust, leading to AV adoption. However, other factors influenced trust insignificantly. This study demonstrates the vital role of trust in AV adoption. The study also suggests ideas for further study and discusses the implications for the government and autonomous vehicle companies. The article aims to forecast a success factor that the Thai government should use to consider the policy for autonomous vehicle adoption in Thailand. This paper relies on the technology acceptance model to assess and forecast autonomous vehicle adoption. The theoretical model also includes ethical issues, legal concerns and trust in technology. The model was analysed using the structure equation modelling technique to confirm the factor affecting Thailand's successful autonomous vehicle adoption. This research confirmed that ethical standards, legal concerns, and trust in technology are the factors significantly affecting the intention to use an autonomous vehicle in Thailand. On the other hand, the perceived ease of use significantly affects the trust in autonomous vehicle technology. This research found that such social factors as ethical standards, legal concerns, and trust in technology affect technology adoption significantly, especially technology related to AI operation. Therefore, the technology acceptance model could be modified to confirm technology adoption in terms of social factors. The government could use the research results to develop a public policy for the regulation and standard supporting autonomous vehicle adoption in Thailand.

KEY WORDS

Technology Acceptance Model, autonomous vehicles, trust, ethical, legal concerns, Thailand

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Introduction

Artificial intelligence advances are revolutionising and disrupting our society (Schwab, 2017). The effects of this technology can be observed in breakthroughs in various sectors, such as finance, healthcare and transportation (Bezai et al., 2021). Conversely, the ageing population, environmental and international security issues are the main chal-

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lenges for future urban development (Ejdys & Halicka, 2018; Manfreda et al., 2021). Thus, adopting the right technologies while protecting the environment could help address such challenges (Shao, 2020).

Among all emerging technologies, autonomous vehicles (AVs) are seen as having a vital role in addressing these issues. Introducing such technology to support the ageing society and reduce energy consumption offers unprecedented opportunities (Nelson, 2020). However, AV adoption still faces challenges. For example, the young generation is more likely to use AV than other generations (Manfreda et al., 2021). Consequently, it may not be worth investing in such technology to serve only one particular group of people. Also, AV adoption is associated with various risks. For example, the use of AV would negatively affect workers and service providers, such as truck and bus drivers.

Safety and privacy problems resulting from AV adoption are among the issues discussed globally (Ljungholm, 2020), as many unpredictable situations can occur when AVs share roads with other vehicles (Tho et al., 2019). This aspect has been noted in previous studies on AV adoption, suggesting that safety issues are likely to affect AV adoption strongly (Bezai et al., 2021; Manfreda et al., 2021). There are safety issues for AV passengers, pedestrians and other road users who could be harmed by AVs (Gill, 2020), which means that AV systems should be in good condition and robust. Another AV hazard is associated with the driving mode (full automation and no automation), which can lead to complications and miscommunication (Kangwansil & Leelasantitham, 2020; Roth, 2019; Straub & Schaefer, 2019). Hazards are not limited to a system failure; other potential risks are associated with cyberattacks (Kim, 2018) and ethical standards, such as accident liability caused by the technology (Roth, 2019). This is particularly important in developing countries where rules and regulations may not keep up with the advancement of technology.

Thailand aims to implement an intelligent transport system. According to the Thai National Strategy Report issued by the Royal Thai Government, by 2037, Thai citizens will have access to autonomous vehicle services in the major cities of Thailand (Chailungka et al., 2021). However, the adoption of such a transportation system in Thailand is uncertain as citizens remain unaware of its safety and do not know how such technology could enhance their quality of life. Therefore, if the Thai government aims to encourage the adoption of Avs, it is necessary to look into the factors that influence this process. Hence, this study aims to investigate the factors that affect AV adoption in Thailand, as the findings could assist in the planning of a suitable AV system to improve the quality of life of Thai citizens while also reducing cost and environmental damage.

This study addresses the above-mentioned aims by employing the Technology Acceptance Model (TAM), which is extensively employed in studies on system user behaviour in various contexts, such as Internet Banking (Rathnaweera & Karunasena, 2020), the Internet of Things (Park et al., 2017; Patil, 2016), e-learning (Thongkoo et al., 2020), wearable devices (Chang et al., 2016), event technology (Sangkaew et al., 2019), healthcare (Alhashmi, Salloum & Mhamdi, 2019; Sıcakyüz & Yüregir, 2020), websites (Noor et al., 2005) and online communities (Chung et al., 2010). Although TAM has been applied in various contexts, the application of this model for AVs is limited.

This study is divided into four main parts. The theoretical background is presented first, followed by the development of the conceptual framework and the hypotheses of this study. An explanation of the relationship between constructs is provided. The second part focuses on the research methodology and data analysis. Next, the results of this study are discussed, including the implications and limitations. The final part is dedicated to conclusions.

1. Theoretical background, hypotheses, and research framework

1.1. Autonomous vehicle

Autonomous vehicles are self-driving and have six levels of driving control (Williams, 2021). No automation is level 0, at which a human fully controls the car. Driver assistance is level 1, providing a human driver with steering and acceleration or deceleration support. Partial automation is level 2, operating many automatic car systems to support a human driver with steering and acceleration or deceleration. Conditional automation is level 3, at which a car uses the self-driving mode, and a human driver may intervene in the case of a possible incident. High automation is level 4, adopting the self-driving mode without human interference and managing unexpected incidents with the guideline system. The last level is full

automation and the full self-driving mode with a human becoming a passenger.

Thailand has many vendors importing autonomous vehicles (Chailungka et al., 2021). However, the Thai environment and, in part, the public infrastructure, streets and telecommunications do not support the full self-driving mode. Sensor technology would not communicate well under the current Thai infrastructure. Therefore, autonomous vehicles of level 3 could be sold in Thailand as they still support a human driver with some steering and acceleration or deceleration.

The Thai government experimented with an autonomous vehicle at a pilot area with installed sensor technology to support the full automation mode (Chailungka et al., 2021). Then, they expanded the experiment to a village, factory and hospital. An autonomous vehicle can transfer a product and passenger within a controlled area. However, an acceptance evaluation among Thai citizens is required before developing a digital public policy on autonomous vehicle implementation in Thailand (Chailungka et al., 2021).

Technology adoption studies are extensive. The Technology Acceptance Model (TAM), developed by Davis (1989), is one of the most popular frameworks in the study of technology adoption (Sangkaew et al., 2019). The TAM model is derived from the Theory of Reasoned Action (TRA) by Ajzen and Fishbein (Luarn & Juo, 2010; Sangkaew et al., 2019; Venkatesh et al., 2003), and explains the reasons affecting the success of adopting a technological solution and policy in many organisations and countries (Chao, 2019; Sıcakyüz & Hacire, 2020). This model is developed based on the assumption that the technology adoption not only depends on solid innovation but also individual user motivations (Liu & Chou, 2020) and that such motivations influence attitudes towards new technology, which leads to behavioural intention to use such technology (Sangkaew et al., 2019). These motivations are perceived usefulness (PU) and perceived ease of use (EOU) (Davis, 1989). Perceived usefulness is the degree to which technology users believe that adopting a given technology will enhance their job performance (Diop et al., 2020), whereas perceived ease of use refers to the expected level of difficulty involved in using such technology. These two determinants help technology developers to understand user behaviour and solve technology adoption issues (Mousa et al., 2021).

Although the traditional TAM framework was successful in investigating technology adoption in various contexts, this model does not integrate psychological factors, such as trust (Akbari et al., 2020; Chong et al., 2003) and facilitating conditions, such as ethical issues and policies (Hutchins et al., 2017; Manfreda et al., 2021), which seem to be essential drivers in the adoption of autonomous vehicles. Consequently, this study extended TAM (Davis, 1989) to investigate the adoption of autonomous vehicles in Thailand by integrating AI ethical standards, legal concerns and perceived trust. To be precise, this study argues that four core factors determine the adoption of autonomous vehicles in Thailand with trust as the mediator.

1.2. Perceived usefulness

TAM indicates that the perceived usefulness of technology has a direct impact on the individual's intention to use it (Raut et al., 2018; Yin et al., 2019; Zhao et al., 2018; Alzamel, 2021; Alraja, 2016) as it determines related benefits (Luarn & Juo, 2010). In this study, perceived usefulness refers to the expectation for autonomous vehicles to help Thai citizens travel for work or leisure. Previous research confirmed the influence of perceived usefulness on the behavioural intention to use a particular technology. Park et al. (2017) investigated the positive relationship between perceived usefulness and intention to use the Internet of Things. Similarly, Alhashmi, Salloum and Abdallah (2019) proved that perceived usefulness strongly impacted the intention to use artificial intelligence in healthcare. This study proposes the following hypothesis:

Hypothesis 1: Perceived usefulness positively affects the intention to use autonomous vehicles.

1.3. Perceived ease of use

Perceived ease of use indicates the degree of difficulty in using particular technology (Jamšek & Culiberg, 2020). In the current study, perceived ease of use refers to the convenience and ease that an individual will feel when using an autonomous vehicle. To be precise, this variable reflects the ease of autonomous vehicle operation and the resolution of possible problems. Many studies have shown that perceived ease of use also impacts the user's intention to use the technology (Patil, 2016; Thongkoo et al., 2020), which is supported by the findings on the wireless Internet (Lu et al., 2003), Internet Banking systems (Nasri & Charfeddine, 2012), social media (Lee et al., 2012), the Internet of Things (Patil, 2016),

Near Field Communication (NFC) (Luarn & Juo, 2010) and artificial intelligence (AI) (Alhashmi, Salloum & Abdallah, 2019). Thus, this study proposes the following hypothesis:

Hypothesis 2: Perceived ease of use positive affects the intention to use autonomous vehicles.

1.4. Ethical issues

Ethics refers to the rightness or wrongness of an action (Lee & Charles, 2021). As artificial intelligence (AI) can produce automated decision-making machines, some complex ethical issues need to be addressed (Wright, 2020; Zhou et al., 2020). In the context of autonomous vehicles, it means that technology should not harm people, and safety should be a priority (Yijia et al., 2019). In contrast to human-driven vehicles, it may be difficult to determine the proximate cause of accidents and other events that may cause damage to people and property. Additionally, there are also ethical issues regarding AI use (Hutchins et al., 2017). For example, citizens expect AVs to follow traffic laws like other vehicles (Prakken, 2017). Thus, manufacturers and governments face challenges in resolving such issues (Showalter, 2005). In this study, the ethical issues related to the production, development and regulation of autonomous vehicles, ensuring they do not threaten human life and property.

The impact of ethical standards on behavioural intention has been investigated in various contexts (Hadi et al., 2021; Lee & Charles, 2021; Nadeem & Al-Imamy, 2020). For instance, Lee and Charles (2021) showed that ethical standards affect repurchase intention in online retailers. Likewise, Nadeem and Al-Imamy (2020) suggested that ethics could drive the intention to create value in digital sharing economy platforms. Wang et al. (2020) found that consumer perceptions of AI significantly affected the intention of customers to use its service. The fear of privacy issues, security, reliability and service recovery, may prevent individuals from using autonomous vehicles. Thus, this study proposes the following hypothesis:

Hypothesis 3: Ethical standards positively affect the intention to use autonomous vehicles.

1.5. Legal concerns

AV-related privacy and security issues may restrict technology adoption (Carr, 2019; Manfreda et al., 2021) as it may impact people inside and outside the vehicle (Księżak & Wojtczak, 2020; Manfreda et al., 2021). In this research context, legal concerns refer to legal conditions covering the liability related to passengers, pedestrians and other drivers, which may affect the intention to use autonomous vehicles. The study by Manfreda et al. (2021) revealed that legal concerns led to defensive behaviour in AV adoption. The potential for AV malfunction and damages raises legal concerns among prospective adopters. Therefore, this study proposes the following hypothesis:

Hypothesis 4: Legal concerns negatively affect the intention to use autonomous vehicles.

1.6. Trust in technology

In technology studies, trust is a user's confidence in purchasing and using technology (Wang, 2011). More specifically, it refers to an individual's belief that a given technology's functionality and reliability will help them accomplish tasks despite the risks in the working environment (Akbari et al., 2020; McKnight et al., 2020). It is unquestionably an important factor influencing the intention to use new technology (Gempton et al., 2013; Hernandez-Ortega, 2011; Manfreda et al., 2021), as trust can help potential users overcome their scepticism or fear about using new technology (Akbari et al., 2020). This study refers to trust as the extent to which Thai citizens believe that using autonomous vehicles is reliable and safe.

Trust affects the intention to use autonomous vehicles despite possible convenience, saved time and reduced energy consumption (Nelson, 2020). Perceived usefulness, perceived ease of use, ethical standards and legal concerns have been included among trust-related factors in many information systems' studies investigating their influence on trust regarding the intention to use new technology (Amin et al., 2014; Coeckelbergh et al., 2016; Felzmann et al., 2019; Lui & Jamieson, 2003; Revels et al., 2010). For example, Amin et al. (2014) proved that perceived usefulness and perceived ease of use directly influenced trust in mobile phones. Likewise, Revels et al. (2010) stated that although mobile users enjoyed the flexibility of access and the use of many applications, trust was still considered the main antecedent to intention when compared to perceived usefulness and perceived ease of use. Furthermore, Lee and Wan (2010), who predicted the level of success of e-Ticket implementation in China by TAM, found that ease of use of technology had a significant effect on trust in technology usage. In terms of ethical standards,

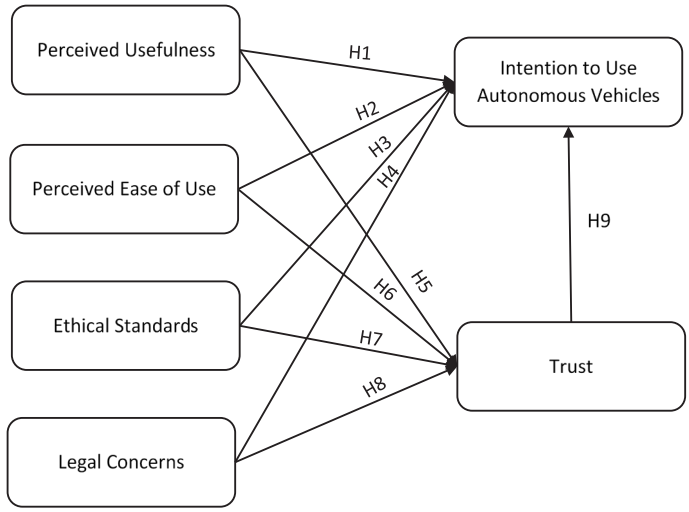


Fig. 1. Proposed model of technology acceptance for autonomous vehicles in Thailand

Coeckelbergh et al. (2016) found a strong relationship between ethics and trust. Their studies confirmed that individuals tended to trust robot assistance with children with an autism spectrum disorder. Furthermore, Felzmann et al. (2019) stated that the transparency of legal policy on artificial intelligence directly influenced trust in such technology. Although legal concerns may be a significant antecedent to the intention to use, transparency of legal issues in the specific context could strengthen the trust of technology users.

Hypothesis 5: Perceived usefulness positively affects trust.

Hypothesis 6: Perceived ease of use positively affects trust.

Hypothesis 7: Ethical standards positively affect trust.

Hypothesis 8: Legal concerns positively affect trust.

Numerous studies confirmed the significance of trust on the intention to adopt technology (Akbari et al., 2020; Gempton et al., 2013; Kaushik et al., 2015; Zolotov et al., 2018; Ejdys, 2020). For example, Luarn and Juo (2010) proved that trust directly affected e-wallet payments. Likewise, consumers with high levels of trust tend to have a greater intention to use online services (Al-Sharafi et al., 2017). In the case of highly reliable emerging technology, trust in 5G technology affects consumer expectations related to usage (Akbari et al., 2020). This seems significant when trust is based on benefits obtained from the technology (Liao et al., 2011; Ejdys, 2018). Lack of trust was one of the most common issues for those not wishing to use artificial intelligence (Gempton et al., 2013; Kaushik et al., 2015). Kaushik et al. (2015) observed defensive behaviour in using self-service machines in hotels, which reflected the lack of trust among consumers. Similarly, Gempton et al. (2013) revealed that the lack of trust was one of the reasons for not using autonomous vehicles by passengers. Different people have different opinions towards a given technology as they may expect different outcomes when using it. Consequently, trust plays a vital role in regard to perceived usefulness, perceived ease of use, ethical standards, legal concerns and, ultimately, the intention to use AVs. The positive effect of these four core factors increases the level of trust, which results in a greater intention to use autonomous vehicles. Therefore, this study proposes the following hypothesis:

Hypothesis 9: Trust positively affects the intention to use autonomous vehicles.

The constructs and their hypothesised relationships are presented in Fig. 1. The following sections present the research methodology and the results of this study, respectively.

2. Research methodology

2.1. Measurement development

The questionnaire consists of two parts. The first part presents the demographic profiles of the respondents, including age, gender and education. The second part involves the measurements of this

Tab. 1. Measurement items from the proposed model with references

Latent Variables	Observed Variables	Content	Reference
Perceived usefulness (PU)	PU1	Autonomous vehicles are a type of transportation that supports me when I am physically unable, such as drunk or sick	Alhashmi, Salloum & Abdallah (2019); Kangwansil and Leelasantitham (2020)
	PU2	When I am a passenger in an autonomous vehicle, I can do other activities	
	PU3	Overall, autonomous vehicles have improved my quality of life	
Perceived ease of use (PE)	PE1	I think it is easy to learn how to operate an autonomous vehicle	Alhashmi, Salloum & Abdallah (2019); Kangwansil and Leelasantitham (2020)
	PE2	I think I can understand the controls on autonomous vehicles	
	PE3	Overall, I think autonomous vehicles are easy to use	
Ethical standards (ES)	ES1	The autonomous vehicles company is liable for any damage caused by autonomous vehicles	Hadi et al. (2021); Lee & Charles (2021)
	ES2	When an autonomous vehicle is in unexpected situations, it ensures safe travelling	
	ES3	Overall, the determination of liability is an ethical issue for AVs	
	ES4	Overall, I think information regarding autonomous vehicles' ethics is clearly presented	
Legal concerns (LC)	LC1	The current law in Thailand is not yet capable of dealing with AVs due to their complexity	Manfreda et al. (2021)
	LC2	I worry about legal-related issues	
	LC3	I worry about cybersecurity-related issues	
Trust (T)	T1	I trust in the safety of autonomous vehicles	Akbari et al. (2020); Luarn & Juo (2010)
	T2	I trust that autonomous vehicles can protect me from accidents	
	T3	Overall, I trust autonomous vehicles	
	T4	Overall, autonomous vehicles are trustable	
Intention to use an autonomous vehicle (IU)	IU1	I definitely intend to use autonomous vehicles	Man et al. (2020)
	IU2	I expect that in the future, I will desire to use autonomous vehicles	
	IU3	Overall, I plan to use autonomous vehicles	

study, which adopted a deductive approach to operationalising the proposed conceptual model by obtaining the measurement items from previous studies (Hinkin, 2005). Scales measuring the latent variables, including perceived usefulness, perceived ease of use, ethical standards, legal concerns and trust, were derived from the literature on technology acceptance in general and artificial intelligence (AI) acceptance in particular. In addition, the items measuring intention were gathered from the literature on technology acceptance in various contexts. All measurement items used in this study are presented in Table 1. All items were measured using a Likert scale from strongly agree (5) to strongly disagree (1).

The survey was pretested using 50 industry professionals and academic researchers in the digital transformation field to check the research instruments' clarity, reliability and validity (Creswell & Creswell, 2017). Based on the pretest, the intercorrelation and validity of dimensionality were examined by employing Exploratory Factor Analysis (Hair, 2010). No items were eliminated. Therefore, six factors were tested: perceived usefulness (3 items), perceived ease of use (3 items), ethical standards

(4 items), legal concerns (3 items), trust (4 items) and intention to use (3 items).

2.2. Data collection and sample characteristics

This study employed a quota sampling method. Official census data from the Thailand National Statistical Office (2021) was obtained to calculate the adequate number of Thai respondents in the gender category. The online questionnaire was distributed between January and June 2021. A total of 320 questionnaires were returned; however, some were defective and eliminated, leaving 318 fully completed questionnaires. The demographic characteristics of respondents are shown in Table 2.

In summary, there were slightly more female (59.4 %) than male (40.3 %) respondents. The majority of the respondents were aged between 36 and 45, which accounted for 34 % of all valid questionnaires, and the group aged 25–35 accounted for 31.1 % of all valid questionnaires. Interestingly, the group aged 46–55 had the smallest sample size (22 %) in this study. The number of respondents with a bachelor's degree and middle and high school education were 250 and 52, respectively, which accounted for 78.6 % and 16.4 %, respectively. The proportion of those with a post-graduate degree was 5 %.

Tab. 2. Demographic characteristics of respondents (N = 318)

	Characteristics	Frequency	%
Gender	Male	128	40.3
	Female	189	59.4
Age	18 – 25	41	12.9
	26 – 35	99	31.1
	36 – 45	108	34
	46 – 55	70	22
Education	Middle and high school	52	16.4
	University (4-year college degree)	250	78.6
	Graduate School	16	5
Total		318	100

3. Analysis and results

3.1. Measurement model

This study employed Structural Equation Modelling (SEM) for data analysis to assess the causality between model parameters. Conducting SEM for data analysis, the model research should have: 1) an assessment of the measurement model's adequacy with Confirmatory Factor Analysis (CFA), and 2) tests of the adequacy of the structural model for hypothesis testing (Gerbing & Anderson, 1992; Bharadwaj & Deka, 2021). Therefore, CFA was performed to test the measurement model using AMOS 21.0. Several goodness-of-fit assessments were adopted to assess how measurement items were associated with the constructs. These include a value of 3.0 or lower for the ratio of Chi-square (X2) to degrees-of-freedom (d.f.), a value of 0.90 or higher for goodness-of-fit index (GFI), a normalised fit index (NFI), a comparative fit index (CFI) and the Tucker-Lewis index (TLI), a value of up to 0.80 for root mean square error of approximation (RMSEA) and a value up to 0.60 for standardised root mean square residual (RMSR) to determine acceptable model fit (Bagozzi & Yi, 1988; Hu & Bentler, 1999). In addition, three criteria for construct reliability and validity were employed: factor loading (0.70 or higher), average variance extracted (AVE) value to measure convergence validity (0.50 or higher) and composite reliability indicating internal consistency reliability (0.60 or higher) (Fornell & Larcker, 1981).

As shown in Table 3, one item with low factor loadings of below 0.50 was dropped from further analyses. Composite reliability (CR) scores of all constructs were above 0.6 (Fornell & Larcker, 1981); average variance extracted (AVE) scores exceeded the cut-off point of 0.50, indicating convergent validity (Fornell & Larcker, 1981). The X2 fit was 236.103 with 137 degrees of freedom ($p<0.000$). The goodness-of-fit index (GFI) presented a good model fit (i.e., GFI= 0.900; NFI = 0.946; SRMR = 0.20 CFI = 0.976; TLI = 0.971; RMSEA =0.048). Table 4 presents the discriminant validity of the construct in this study. The square root of the AVE between each pair of constructs exceeds the estimated correlation between constructs, thus indicating adequate discriminant validity (Bagozzi & Yi, 1988; Hair, 2010).

Tab. 3. Measurement model from confirmatory factor analysis

Constructs and variables	Standardised factor loading	CR	AVE
Usefulness		0.835	0.629
PU1. Autonomous vehicles are a type of transportation that supports me once I am physically unable, such as drunk or sick	0.798		
PU2. When I am a passenger in an autonomous vehicle, I can do other activities	0.778		
PU3. Overall, autonomous vehicles have improved my quality of life	0.804		
Ease of Use		0.808	0.587
PE1. I think it is easy to learn how to operate an autonomous vehicle	0.774		
PE2. I think I can understand the controls on autonomous vehicles	0.774		
PE3. Overall, I think autonomous vehicles are easy to use	0.744		
Ethical Standard		0.876	0.876
ES1. The autonomous vehicles company is liable for any damage caused by autonomous vehicles	0.802		
ES2. When an autonomous vehicle is in unexpected situations, it ensures safe travelling	0.800		
ES3. Overall, the determination of liability is an ethical issue for AVs	0.799		
ES4. Overall, I think information regarding autonomous vehicles' ethics is clearly presented	0.797		
Legal Concerns			
LC1. The current legal-related technology in Thailand is not yet capable of dealing with AV due to their complexity [c]		0.752	0.752
LC2. Worried about legal-related issues	0.830		
LC3. Worried about cyber security-related issues	0.720		
Trust		0.874	0.633
T1. I trust in the safety of autonomous vehicles	0.798		
T2. I trust that autonomous vehicles can protect me from accidents	0.782		
T3. Overall, I trust autonomous vehicles	0.789		
T4. Overall, autonomous vehicles are trustable	0.814		
Intention to use Autonomous Vehicles		0.902	0.754
IU1. I definitely intend to use autonomous vehicles	0.890		
IU2. I expect that in the future, I will desire to use autonomous vehicles	0.866		
IU3. Overall, I plan to use autonomous vehicles	0.848		

a. Model Fit Indices: X^2 = 236.103, df= 137; *sig* = 0.000; GFI= 0.900; NFI = 0.946; SRMR = 0.20 CFI = 0.976; TLI = 0.971; RMSEA =0.048.

b. CR = composite construct reliability; AVE = average variance extracted. c. Items were deleted after CFA analysis.

Tab. 4. Discriminant validity of the constructs in this study

	1	2	3	4	5	6	Mean	SD
1. Perceived Usefulness	*0.793*						4.005	0.69521
2. Perceived Ease of Use	0.586	*0.766*					3.883	0.66629
3. Ethical Standards	0.600	0.610	*0.935*				3.874	0.64307
4. Legal Concerns	0.485	0.491	0.533	*0.867*			3.872	0.68695
5. Trust	0.582	0.685	0.586	0.491	*0.795*		3.786	0.68980
6. Intention to Use	0.613	0.615	0.644	0.596	0.645	*0.868*	3.745	0.74590

Diagonal: correlation estimated between the factors; diagonal: square root of AVE.

3.2. Structural model

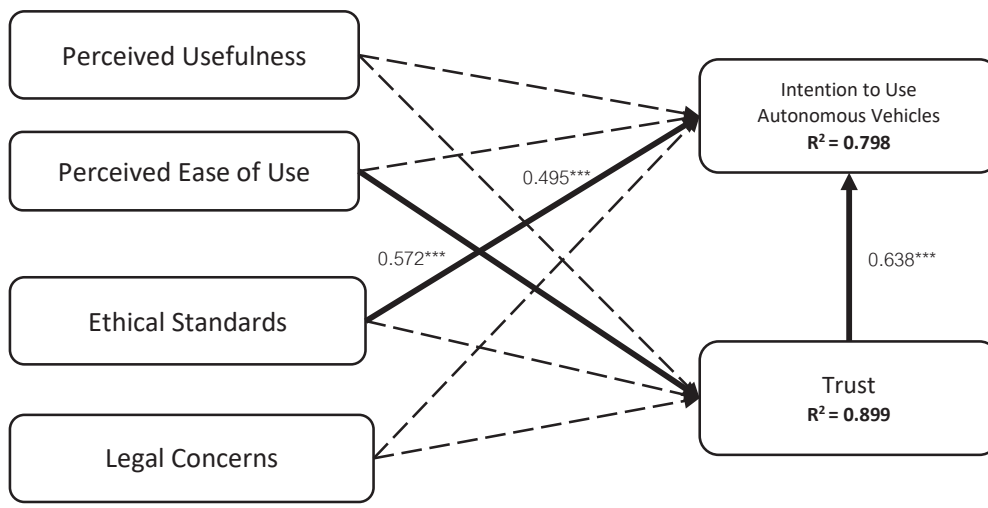
For the structural model, the X2 fit was 206.81 with 136 degrees of freedom (p<0.000). The GFI was 0.936, the NFI was 0.953, the RMSR was 0.16, the TLI was 0.979, the RMSEA was 0.041, and the CFI was 0.983. All fit indices in this study are confirmed, indicating that the estimated structural equation model is statistically suitable and valid for hypothesis testing. The squared multiple correlation (R2) for the structural equations for trust and intention to use AV were 0.899 and 0.798, respectively. Over 70 % of the variance (R2 = 0.798) in the intention to use AV was determined by the effects of trust, perceived usefulness, perceived ease of use, ethical standards and legal concerns. For trust (R2 = 0.899), most of the variance was explained by the effects of perceived usefulness, perceived ease of use, ethical standards and legal concerns.

The testing of hypotheses H1, H2, H3, and H4 determined whether perceived usefulness, perceived ease of use, ethical standard, legal standard affect the intention to use AV. Only one determinant of intention to use was identified; ethical standards positively affected the intention to use (β = 0.495, p = 0.01). On the other hand, three negative effects of intention to use were identified: perceived usefulness (β = 0.022, n.s.); perceived ease of use (β = -0.021, n.s.); and legal

Tab. 5. Standardised structural estimates and tests of hypotheses

Path (hypotheses)	Standardised coefficient	P-value	Results
H1 Perceived Usefulness → Intention to use	0.022	-	Rejected
H2 Perceived Ease of Use → Intention to use	-0.021	-	Rejected
H3 Ethical Standards → Intention to use	0.495	0.01	Supported
H4 Legal Concerns → Intention to use	-0.018	-	Supported
H5 Perceived Usefulness → Trust	0.161	-	Rejected
H6 Perceived Ease of Use → Trust	0.572	0.01	Supported
H7 Ethical Standards → Trust	0.188	-	Rejected
H8 Legal Concerns → Trust	0.080	-	Rejected
H9 Trust → Intention to use	0.638	0.01	Supported

a. Model Fit Indices: X^2 = 206.81, df= 136; *sig* = 0.000; GFI= 0.936; NFI = 0.953; SRMR = 0.16 CFI = 0.983; TLI = 0.979; RMSEA =0.041.



Note: * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$;
Bold Line: Supported, Dash Line: Rejected

Fig. 2. Results of the structural model

concerns (β = -0.018, n.s.). Hence, the results provide support for hypotheses H3 and 4. However, H1 and H2 were not supported.

The set of hypotheses H5, H6, H7 and H8 examined whether perceived usefulness, perceived ease of use, ethical standards and legal concerns influenced trust. Perceived ease of use had a positive effect (β = 0.572, p = 0.01). However, three negative effects of trust were identified: perceived usefulness (β = 0.161, n.s.); ethical standards (β = 0.188, n.s.); and legal concerns (β = 0.80, n.s.). Thus, the results provide support for hypothesis H2 but do not support hypotheses H1, H3 and H4. Finally, the results confirm that trust positively affected the intention to use AV (β = 0.638, p = 0.01). Thus, H9 was supported. The results of the hypothesis testing are shown in Table 5. The results of the structural model are presented in Fig. 2.

4. Conclusions and implications

4.1. Conclusions

Autonomous vehicles are receiving attention in many countries, including Thailand. However, implementing an intelligent transport system has many challenges, such as safety and reliability and the lack of policy supporting the technology use, leading to hazards for passengers and pedestrians. Therefore, factors affecting the adoption of autonomous vehicles require better understanding. Few studies on autonomous vehicle adoption have investigated the effect of trust. Therefore, this study aimed to develop a theoretical framework that extends the TAM model by integrating ethical standards, legal concerns and trust and to test the effect of these factors on the intention to use autonomous vehicles. The study results suggest that Thai citizens are likely to use autonomous vehicles if this technology is perceived as trustworthy.

Previous studies in different contexts (Alhashmi, Salloum & Abdallah, 2019; Kangwansil & Leelasantitham, 2020; Park et al., 2017) demonstrated that perceived usefulness positively affected intention in the case of adopting the Internet of Things and artificial intelligence. However, perceived usefulness does not affect AV adoption (H1), implying that perceived usefulness is not an issue for potential adopters as the vehicles are assumed to be implemented as a form of basic transport in the near future. Thai residents expect to use intelligent transport systems regardless of the travel purpose. Similarly, the hypothesis regarding the perceived ease of use (H2) was not confirmed either. Patil (2016) and Alhashmi, Salloum and Mhamdi (2019) studied individual intention to use emerging technologies, such as artificial intelligence and the Internet of Things, and their results confirmed that the perceived ease of use is a factor in using these technologies. Less effort in using technology tends to encourage individuals to use it. However, in the case of autonomous vehicles, navigating may be fully controlled by a transport centre. Therefore, the complexity in using this technology may not be an issue for passengers unless there is an incident requiring the passenger's intervention.

Ethical standards (H3) and legal concerns (H4) were influential factors for AV adoption, but the former had a positive influence while the latter had a negative influence. The literature suggests that individuals perceiving artificial intelligence as reliable are more open to this technology (Lee & Charles, 2021; Nadeem & Al-Imamy, 2020; Wang et al., 2020). Furthermore, this study also found that the liability needs to be covered no matter the incident caused by an autonomous vehicle. Thus, before implementing this policy, the Thai government should investigate AI ethical issues, such as the production process, the import procedure, traffic laws, and the liability law. The findings are consistent with the study of Manfreda et al. (2021), who established that legal concerns negatively affected the intention to use autonomous vehicles. Legal concerns are among the factors that cannot be ignored when exploring the intention to adopt AV due to potential incidents using AV. For instance, the Thai government should have the policy to support passengers and pedestrians in the case of accidents. Once the vehicle is on the road, it affects more than just the passenger's safety.

Noticeably, the effects of perceived usefulness (H5), ethical standards (H7) and legal concerns (H8) on trust differ from the results of previous studies (Amin et al., 2014; Coeckelbergh et al., 2016; Felzmann et al., 2019; Lui & Jamieson, 2003; Revels et al., 2010). The negative effect of these factors implies that Thai citizens who may trust autonomous vehicles do not consider their usefulness, ethical standards or legal concerns. Although these factors do not seem to be an issue in this study, the government should not ignore them as they could strengthen the level of trust in the technology. Interestingly, Thai user perceptions about the ease of use of autonomous vehicles (H6) positively affect trust in the use of autonomous vehicles. This is in line with studies by Lee and Wan (2010) and Revels et al. (2010), which revealed the effect of

ease of use on trust in the context of emerging technology. This means the convenience of autonomous vehicles is crucial in enhancing trust among Thai citizens. Hence, the Thai government should prepare measures related to imported autonomous vehicles that start at automation level 3 (conditional automation) (Poisson et al., 2016). This level is a form of autonomous driving that allows a human driver to intervene in certain situations. Automation modes support the ease of use of autonomous vehicles.

Finally, trust has a significantly positive effect on Thai citizens' intention to use AVs (H9), which is consistent with previous studies (Akbari et al., 2020; Gempton et al., 2013; Kaushik et al., 2015; Zolotov et al., 2018). Additionally, trust also plays a mediating role between perceived usefulness, perceived ease of use, ethical standards, legal concerns and the intention to use AVs. This could mean that trust strengthens the level of confidence among Thai citizens, increasing the level of autonomous vehicle adoption.

4.2. Implications and limitations

Few studies have investigated the adoption of autonomous vehicles. Thus, this study aims to examine factors influencing autonomous vehicle adoption. The results of this study have both theoretical and practical implications. First, it extends TAM by integrating other factors, such as ethical standards, legal concerns and trust, which had positive and negative impacts on the intention to use autonomous vehicles.

For the practical implications, this study provides insight that may assist the government in preparing strategic plans and implementing infrastructure development to support the use of autonomous vehicles in Thailand. For example, the findings show that ethical standards affect autonomous vehicle adoption. The Thai government should initiate a policy related to autonomous vehicles ethics and industry standards, including public transportation, which will use autonomous vehicles in the near future. Another important implication for the government is related to the role of trust. The study found a highly significant and positive relationship with the intention to use. Thus, to enhance citizens' trust in autonomous vehicles, the government should encourage trust. For instance, developing Internet of Things technologies could support autonomous vehicle communication with other vehicles and satellites. Furthermore, the improvement of road surfaces would help the government reduce hazards related to autonomous vehicle use. The study also suggests that the intention to use is related to perceived usefulness, perceived ease of use, ethical standards and legal concerns as mediators of trust.

Some limitations of this study should be noted. First, it examined the opinion of citizens in a single country. The technology is relatively new and not yet widely analysed; thus, the results may not be generalisable. Future research should investigate these issues in different countries and under different legal conditions that could affect the intention to use autonomous vehicles. Another important limitation of this study is related to the mode of autonomous vehicles (e.g., full automation and no automation). This study did not address such distinctions. Hence, indicating the mode of autonomous vehicles may provide more insightful findings that may assist in decision making. Autonomous vehicle companies may be interested in identifying the differences for each mode since it could help them identify their target market more effectively. Different AV modes may result in different levels of trust. Lastly, this study also shows that AV adoption factors are required since perceived usefulness, perceived ease of use and legal concerns were found to have negative effects on the intention to use. Consequently, future studies in this area need to be conducted to obtain more detail.

To sum up, rapid technology development will transform passenger transportation in many countries. The use of autonomous vehicles will change transportation businesses and impact the citizens' quality of life. To keep up with this paradigm shift, governments have to provide standards, policy and a supportive environment that facilitates business efficiency and competitiveness.

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