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A Conceptual Framework For Acceptance of Autonomous Vehicle In Malaysia

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Abstract

Mobility is evolving globally. Automated vehicle technology is consistently advancing with the development of Artificial Intelligence and information communication technology. The Autonomous Vehicle is acknowledged with the benefits of reducing traffic fatalities, reduced emissions and convenience. If autonomous vehicles are widely adopted, the Sustainable Development Goals could be achieved. Various studies have been conducted to investigate the psychological factors (internal) as well as assess the efforts of institutions (external) in promoting the adoption of autonomous vehicles. Nonetheless, there is very few studies examined the impacts of internal and external factors on the acceptance of autonomous vehicles simultaneously. Therefore, this study is taken to close the gap in understanding the acceptance of autonomous vehicles in Malaysia by integrating the internal factors and external factors in a model. By reviewing the past studies, a conceptual framework which can offer a comprehensive insight to the policymakers and car makers from the public's perspective is proposed. Implications from this study can serve as a basis for prioritising the budget resources and development guidelines for the successful implementation of autonomous vehicles in Malaysia.

Keywords: Conceptual Framework, Autonomous Vehicle, Acceptance

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1.0 Introduction

The past fifty years have seen significant growth in the mobility of both people and commodities. This expansion of movement, while having contributed to great social and economic development, is also found underpinning certain merits that it has generated. According to the report by the World Health Organization (WHO, 2023), traffic crashes is the 8th leading cause of death for people of all ages in the world. Annually, nearly 1.19 million people are killed and up to 50 million people experience various degrees of injury as a result of traffic crashes. More than half of the deaths are among vulnerable road users (pedestrians, cyclists and motorcyclists) and the occurrences were 3 times higher in low-income countries than in high-income countries. Besides, the transport sector is another contributor to greenhouse gases (GHG) and GHG emissions are estimated to rise 1.5% annually for the past decade (Ackaah et al., 2021). It was reported that approximately 20% of deaths in the United Kingdom, United States and Germany were due to traffic-related air pollution (Sohrabi et al., 2021).

Acknowledging the adverse impacts brought by the transportation system, The United Nations General Assembly (GA) has made resolutions with various initiatives to promote global sustainable development. Two resolutions related to transportation are 64/255 and 70/1 (UN, 2018). In the quest to achieve Resolution 64/255, the decade of 2021 – 2030 has been declared as the Decade of Action for Road Safety whereby the goal is to stabilize and minimise road traffic fatalities by intensifying world collaborations in various aspects and levels (national, regional and global). On the other hand, resolution 70/1 (Transforming our world: the 2030 Agenda for Sustainable Development) has outlined two targets related to road safety: Target 3.6 which aims at halving road traffic fatalities and Target 11.2 which promotes accessible, safe, affordable transportation system to all people especially the poor, disabled groups, children, elderly and woman.

The emerging technology of autonomous vehicles (AVs) is propagated to be the sustainable mitigation for the traffic mishaps and provide transportation needs to the elderly and disabled groups. By sensing the environment and using the artificial intelligence software, the Autonomous vehicle (AV) can be operated without human

control. In terms of Malaysia, the autonomous vehicle also known as Next Generation Vehicle is expected to be deployed on the roads by the year 2025. With the forthcoming AVs, it is of urgent need to understand the causal factors for the acceptance of AVs as well as the readiness of the country to accept the AVs.

The propagated benefits would not be materialised until there is an extensive adoption of AVs in the markets. Despite huge amount of resources that have been devoted to the development of AVs, however, global surveys have revealed that the acceptance of AVs is still very low (Nastjuk et al., 2020). Zhang et al. (2009a) concur that the biggest barrier to the adoption of AVs is due to psychological factors rather than the technological aspect. Apart from this, the deployment of AVs is also highly dependent on external factors such as the legal issues, public health challenges and environmental issues (Sohrabi et al., 2021). Against this backdrop, very limited studies are conducted in the Malaysian context.

There are extant studies on the influence of psychological factors on the acceptance of AVs (Nastjuk et al., 2020; Xu et al., 2018; Zhang et al., 2019). However, very few studies look into the acceptance of AVs at macro level (Sohrabi et al., 2021) as well as the relationship between the adoption of AVs and the Sustainable Development Goals (Adnan et al., 2017; Jain et al., 2022). Therefore, this study is taken by synthesizing the existing scattered knowledge on the potential adoption of AVs in achieving sustainable development goals. A conceptual framework is proposed by examining the impacts of psychological and external factors such as public health factors, technology, legislative issues and build environment perspectives.

2.0 Literature Review

2.1 Concept of autonomous vehicles

Autonomous vehicle (AV) refers to a vehicle functioning without a physical control or supervision from a human driver (Department of Motor Vehicles, California (DMV, 2020). The technology of AV has steadily evolved from standard driver-operated vehicle to partial/conditional automation over the past decades. The technology of AV has been

started since year 2000 and the evolution are classified into 6 phases by Tyagi et al. (2021) as shown in Figure 1. While the roadmap outlined the AVs are expected to obtain full automation by 2030, however, the achievement of full automation by 2030 seems to be over-ambitious. The Department for Transport, UK notes that it is still a long way to achieve the ideal vision of autonomous vehicles as it involves extensive testing (Ackaah et al., 2021).

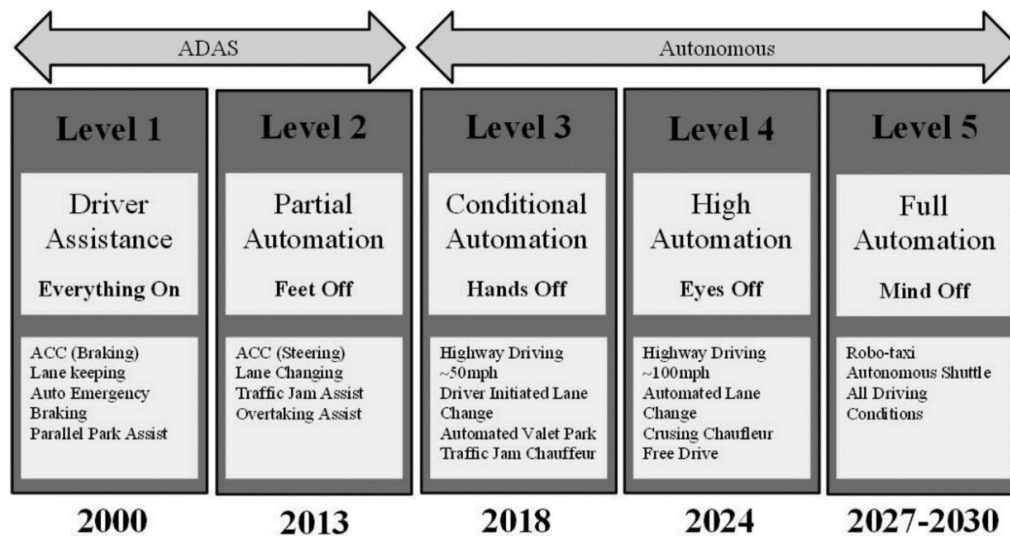


Figure 1: Evolution of autonomous intelligent vehicles (Source Tyagi et al., 2021)

The AVs are assisted by various advanced driver- assistance (ADAS) systems in terms of crash warning system, adaptive cruise control (ACC), lane-keeping systems, self-parking technology in respect to the level of automation. The introduction of AVs is believed can decrease almost 94% of the traffic crashes through eliminating the driver's errors (National Highway Traffic Safety, 2018). Specifically, it is estimated that the ADAS features such as the adaptive headlights, forward collision warning, lane departure warning and blind spot assistance can effectively reduce a substantial number of traffic crashes (IIHS, 2010; Bagloee, et al., 2016). In translating into the monetary values, a 90% of AV market penetration can contribute to a total of \$27 billion saving in healthcare costs through reduction in traffic crashes (Luttrell et al., 2015).

3.0 Theoretical Background and Hypotheses Development

A lot of research has been conducted to examine the factors influencing the acceptance of AVs from psychological perspectives (Choi and Ji, 2015; Nastjuk et al, 2020; Xu et al., 2018; Zhang et al., 2019). However, very limited studies investigated the influential factors from external perspectives. This study proposes a conceptual model that integrates internal psychological determinants and external factors in influencing the adoption of AVs. The internal psychological determinants in this study refer to the cognitive factors that play critical role in shaping behavior in accepting a new technology. Contrary, the external factors represent the environmental and social factors that determine the acceptance of people. By combining both aspects of causal factors, the deployment of AVs can be implemented successfully and gain acceptance of the public. Ultimately, it is expected that the successful diffusion of AVs would help to attain the sustainable development goals.

3.1 Internal Psychological Determinants

There are many psychological factors influencing the shaping of acceptance of AVs in the literature. Judging from the current development of the AVs whereby the AVs are actively tested in the testbeds located in Cyberjaya, Putrajaya and Johor (Futurise, 2024), two constructs deemed the most relevant at the initial stage of pilot testing are perceived safety and trust. The two constructs are discussed in detail in the following section.

3.1.1 Perceived Safety

The development of AVs is currently at Level 3 (conditional AV) where the dynamic driving task is automated but the human driver is expected to take over the driving task upon request (Pascale et al., 2021). However, there are many studies indicating that Level 3 automation with hand-off features are indeed risky because it creates fraught to the drivers due to the disconnection from driving for a longer period of time (The Verge,

2023). In the event of emergency, the driver who is not paying attention maybe over-reacted and leads to overcorrect driving, resulting in very serious even a fatal incident.

It has seen that many car makers are competing to test the AVs on open public roads since the past decade. Despite many challenges, the first Level 3 AV commercial vehicle by Mercedes has been granted approval to be on the roads in California and Nevada in 2024 (The Verge, 2023). Operating AVs in the mixed traffic condition exposes the vulnerable road users (pedestrians and cyclists) to the risk of collision and the severity increases with the speed of collision. Ever since the deployment of AVs, many safety related incidents were reported where the first fatal incident involving a pedestrian was reported in 2018. The concern is aggravated by the recent incident occurred in California where a robotaxi ran into a pedestrian and continued to pull the victim another 6 m before coming to a stop (TheGuardian, 2023).

Globally, Americans have higher safety concerns as compared to their counterparts in other countries. Based on an international survey conducted by Continental AG, it was found that 66% of the Americans involved in the survey worry about the safety brought by the autonomous vehicles while only 66% of the respondents in both Germans and China as well as another 42% of the Japanese respondents had the similar opinions (Sommer, 2013). A survey conducted by American Automobile Association (AAA, 2019) revealed that 71% of the respondents indicated that they were afraid to take fully autonomous vehicles. Pyrialakou et al. (2020) further confirmed that one's acceptance of AVs is highly depending on their perceived safety of AVs. Of the various road users interviewed, pedestrians had the most concerns as they often feel that they are the less attended group on the roads as compared to other motor vehicles on the roads, thereby making them anxious about their safety (Musselwhite et al., 2014).

The factor of perceived safety is rarely examined in the emerging market. Xu et al. (2018) assessed the perceived safety among the Chinese and showed that the self-driving vehicle is generally viewed four to five times safer than traditional vehicles while Dong et al. (2019) asserted that perceived safety is critically influencing the acceptance of AVs. Zhang et al. (2019) on the other hand examined the perceived safety risk on

initial trust towards AVs and revealed that the perceived safety risk negatively correlated with one's initial trust.

H1: Perceived safety negatively affects the acceptance of AVs.

3.1.2 Trust

The autonomous vehicle is expected to achieve Fully Autonomous Vehicles (FAV) by 2030. Nonetheless, as of today, the development as well as the acceptance for AVs is still far behind the market expectation (Tan et al., 2022). The reason can be attributed to the psychological effect rather than the technological effect (Xu et al., 2018). Many studies have been conducted to understand the determinants from psychological and socio-economic determinants (Tan et al., 2022).

The maxim of “No Trust No Use” is also applied in AVs. Trust plays an important role as it influences an individual to attain the objective in the event of uncertainty and vulnerability (Lee and See, 2004). Various evidences suggest that trust is a significant positive predictor of future intentions to use AVs (Buckley et al., 2018) and the trust grows in relation to the experience or engagement with the technology (Abe et al., 2002; Gold et al., 2015). People would accept the AVs if they have adequate trust in AV technology (Noy et al., 2018; Shariff et al., 2017). Gunther and Proff (2021) also commented that adopting the technology in realizing daily needs would require adequate trust and confidence in the technology.

H2: Trust positively affects the acceptance of AVs.

3.2 External Factors

While the AV is operated based on sensing and communicating with the environment, the readiness of the environment and infrastructure are the prerequisites for a successful deployment of AVs. However, due to many uncertainties, the risks associated with the operation of AVs are debatable, therefore demanding an established legal structure and

system to safeguard all road users particularly the vulnerable ones in the event of crashes. All in all, the safe operation of AVs can help in achieving the sustainable goal.

3.2.1 Public Health Factors

The development of AVs can bring various potential environmental benefits. Anderson et al. (2014) suggested that widely used of AVs can improve the transport efficiency and travel convenience of the disadvantaged groups, promote safer travels and reduce the private vehicle ownerships. When the AVs are powered by electricity, the impacts towards the environment would be further reduced. Noise and emission pollution resulted from the traditional fueled transport can be further improved thereby reducing the diseases related to air pollution and noise (Hardy & Liu, 2017; Rojas-Rueda et al., 2020).

AVs can improve the public health from several perspectives. First, Freedman et al. (2018) have proved that the associated expenses and safety merits of automated taxi are higher than private vehicles in terms of saved quality-adjusted life-years. Secondly, the use of AVs can ensure an independent lifestyle for the elderly thus promoting their health and well-being (Singleton et al., 2020). Thirdly, the AVs can also potentially reduce the traffic congestion thus able to realise psychological health benefits (Singleton et al., 2020).

H3: Public health positively affects the acceptance of AVs.

3.2.2 Technology

AVs are the outcome of the evolution of technology in automotive industry. AVs are designed in a way that the technology transforms the active driving role of a driver to the passive role. Therefore, those who choose to travel with AVs are the ones familiar with technology. Their attitudes and perceptions of the emerging technology are positively related to the ease of usage, perceived sense of efficacy and higher level of control (Nastjuk et al., 2020). On the other hand, around 70% of the respondents reported their concerns about the failure of AVs in adverse weather conditions, crashes caused by

equipment/system failure and the security of AVs against hackers' attacks (Hussain et al., 2021).

H4: Technology development positively affects the acceptance of AVs.

3.2.3 Legislative Issues

Many countries have passed the policies in supporting the deployment of AVs (Wu., 2019) despite the existence of challenges related to insurance, privacy and responsibility remain unresolved, particularly in the event of traffic crashes (Boeglin, 2015; Garza, 2011). In addition, ethical issue on the automated programming in terms of vehicles and human role during critical scenarios is also regarded as another important threat to the road users (Nyholm and Smilds, 2016). Therefore, Liu et al. (2020) insisted that inter-institutional cooperation is of essential to promote a comprehensive framework and agreement on threats and responsive countermeasures in managing the associated risk with AVs.

H5: Legislative framework affects the acceptance of AVs.

3.2.4 Build environment

Comfortable and accessible AVs tend to make people to undertake longer distances which may lead to urban sprawl and reduce the urban density. In other words, improve the living standard of the people. Besides, the parking issues can also be solved by relocating the parking to farther away from city centres due to no driver and passenger pressure (Sohrabi et al., 2021).

Apart from this, AVs have great impacts on the existing infrastructure as the AVs are operated based on the signal. The intelligence signals, control devices, roadway markings and other furniture need to be installed apart from the existing traffic controls. Huge investment costs are needed before the AVs can be implemented for the

communication between AVs and the environment. Thus, the adoption AVs is less likely to be adopted in low-income countries, of which the built environment is less developed.

H6: Built environment and infrastructure positively affect the acceptance of AVs.

4.0 Conceptual Model

Aligned with the literature reviewed, a conceptual model is proposed as shown in Figure 2. The model consists of six constructs and a total of six hypotheses are developed. The dependent variable in this model is acceptance of AVs. There are many definitions for acceptance (Tan, 2022). For instance, the acceptance can be the general acceptance (Liu et al., 2019a), willingness to purchase (Liu et al., 2019b), behavioural intention (Zhang et al., 2019) as well as the positive attitude towards AVs (Acheampong and Cugurullo, 2019). As the AVs is still in the infancy stage in Malaysia, the acceptance in this study refers to the general acceptance.

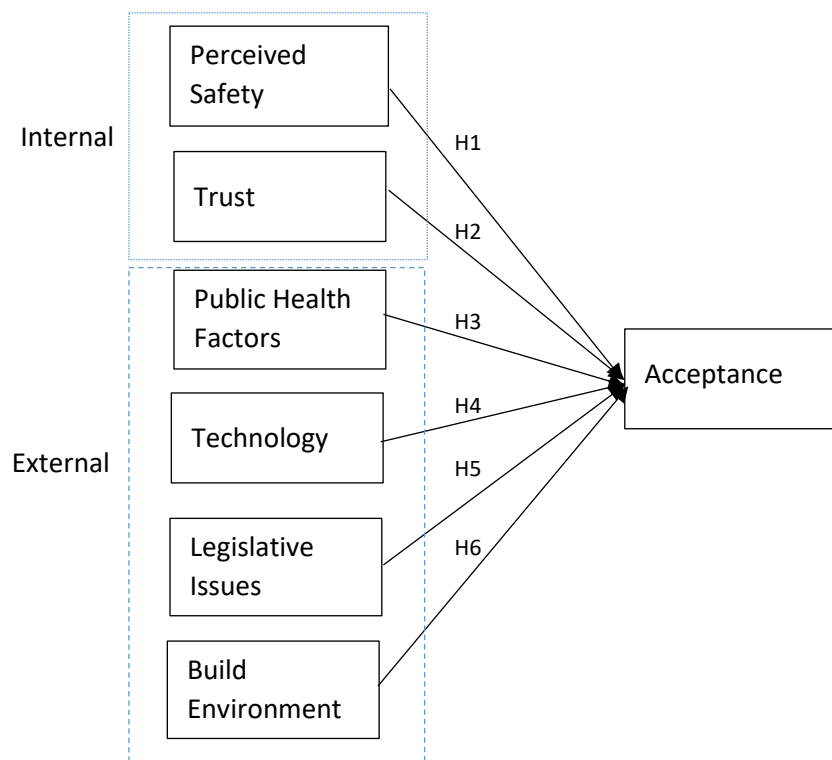


Figure 2: Proposed conceptual model for the adoption of AV

5.0 Conclusion and Recommendation

The penetration of AVs in the global market is still early, let alone in Malaysia. It is expected that the Level 3 AVs will be deployed on the road in year 2025. While the creation of AVs is to mitigate the traffic safety and achieve the sustainable development goals (SDG) in traffic safety, pollution and social equity areas, there are still many unknown and uncertainties on the outcomes brought by the AVs. In the quest to achieve the SDG goals, the AVs have to be widely adopted. Trust and perceived safety are among the most important determinants in influencing the acceptance. Therefore, the two constructs are included in this framework to understand the perception of Malaysians in order to ensure smooth and successful diffusion of AVs in the country.

The review of literature also shows that many initiatives and intervention by the policymakers are essential before the adoption of AVs. Firstly, a policy that supporting the AVs as well as protects the vulnerable road users should be in place. The provision of necessary infrastructure without offsetting the disadvantaged groups is also required. The integration between the existing transportation system and new AVs should be properly planned in order to balance the existing social equity. Fourth, to the designer as well as the manufacturers, the AVs should withstand the cyberattacks and enhance the trust by the users. The service providers should also focus on the benefits such as the cost, comfort, accessibility, efficiency and safety. Above all the initiatives discussed, monetary investment is the most important element in materialising the target of AVs. Policies to make the safe integration among the vulnerable groups mixing with other vehicular, particularly the AVs should be planned properly. This also includes the regulations on land use, the vulnerable parties and the well-being of affected or disadvantaged segments.

It is acknowledged that the proposed framework is built on a few numbers of constructs given that the development of AVs in Malaysia is still in the early stages. The over-propagated of the lives saved from traffic collisions has yet to be confirmed. This is because the reduction of risk to one party might migrate or transfer to another party. Distribution of risk in terms of temporal and spatial might also be affected by the

introduction of AVs. Hence, more careful interpretation and assessment over time should be considered.

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