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# Navigating the Road to Acceptance: Unveiling Psychological and Socio-Demographic Influences on Autonomous Vehicle Adoption in Malaysia

**Suk Min Pang [1], Jen Sim Ho [1,2], Booi Chen Tan [1,*], Teck Chai Lau [3] and Nasreen Khan [1]**

[1] Faculty of Management, Multimedia University, Persiaran Multimedia, Cyberjaya 63100, Selangor, Malaysia; pangsukmin@mmu.edu.my (S.M.P.); jensimho@yahoo.com.my (J.S.H.); nasreen.khan@mmu.edu.my (N.K.)
[2] Malaysian Institute of Road Safety Research, Kajang 43000, Selangor, Malaysia
[3] Entrepreneurship and Enterprise Hub, Xi'an Jiaotong-Liverpool University, Wuzhong District, Suzhou 215000, China; teckchai.lau@xjtlu.edu.cn
* Correspondence: bctan@mmu.edu.my

**Abstract:** Although the autonomous vehicles market is still in its infancy, many people have switched from conventional vehicles to autonomous vehicles due to the numerous benefits and environmental advantages of owning them. Autonomous vehicles which promise to eliminate traffic crashes due to human errors are expected to penetrate the Malaysian market by 2025. However, past research has shown that psychological factors rather than technological aspects could deter the successful diffusion of autonomous vehicles in the market. By integrating the Technology Acceptance Model and the Theory of Planned Behaviour, this study investigates the influencing factors of the Malaysian public towards acceptance of autonomous vehicles and the moderating effects of socio demographic variables. A total of 306 respondents completed the online survey. The results show that the proposed integrated model can explain 82.9% of the variance in acceptance of autonomous vehicles. Among the variables, attitude and perceived behavioural control are significant contributors. In terms of moderating variables, income level, education level, and ethnicity moderated the effects of attitude, perceived usefulness, perceived ease of use, and acceptance. Insights drawn from this study could assist policy makers in devising strategic plans for promoting autonomous vehicles in the country.

**Keywords:** Technology Acceptance Model; Theory of Planned Behaviour; autonomous vehicles adoption; acceptance; moderating effects; sustainability



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## 1. Introduction

Road traffic fatality in Malaysia is the fourth contributor of death, with an average of 18 people of all ages perishing on the roads daily [1]. In 2022, 6080 fatalities were reported, of which about 50% were motorcyclists. When comparing traffic crashes on the international level (among 40 participating countries), Malaysia ranked second in terms of road fatalities per 100,000 inhabitants and accounted for the eighth highest number of road fatalities per 10,000 registered vehicles in 2015 [2,3]. The number of fatalities is estimated to rise in line with the increasing number of car sales in Malaysia. The Malaysian Automotive Association (MAA) further forecasts that the total industry volume will record 698,733 units or 2.2% in year 2027 [4].

The cause for traffic crashes in Malaysia can be summarized into three main areas. The Malaysian Highway Authority [5] reveals that about 82.4% of traffic crashes on expressways were due to human errors, while environmental factors contributed 11.7%, and vehicle failures accounted for the remaining 5.9%. Human errors include speeding or hazardous behaviour [6], mistake of judgement in human information, or fatigue [7]. Over the past decades, various initiatives have been taken to try to eliminate traffic accidents due to human errors; however, challenges remain.

Intelligent transportation systems have been rapidly developed due to the advancement in information and communication technology [8]. In recent years, autonomous vehicle (AV) technology, which is a new emerging technology, has been widely promoted to be able to eliminate traffic fatalities caused by human errors. However, this emerging technology could not be brought forth to the market without public acceptance and large-scale AV adoption. Despite massive advancement in AV technology, global public acceptance rates are evidently low [9]. Shariff et al. [10] claimed that psychological factors rather than technical aspects of AVs are the main barriers to the acceptance of AVs. Much of the past literature suggests that to ensure the successful diffusion of AVs, it is of critical to comprehensively understand the influential factors of AVs adoption [11,12]. Due to this, the acceptance of AVs has attracted attention from many researchers and various studies have been conducted to explore the determinants of the acceptance of AVs.

Nonetheless, gaps still exit, as findings of past studies are inconclusive [9,11,13,14]. For instance, despite many variables that have been examined, the results remain inconclusive as many of these studies were conducted in the settings of developed countries. Apart from this, there are very few studies exploring the moderating effects of the demographic effects (i.e., age, gender, income level, education level) on the association between the determinants and acceptance of AVs. The main research objective of this study is to generate an understanding of the factors potentially influencing AVs adoption in Malaysia. In addition, this study aims to investigate the moderating effect of demographic factors on the relationship between perceived usefulness, perceived ease of use, attitude, subjective norm, perceived behavioural control, and acceptance. The current research will bridge the gaps by investigating potential factors that could affect the adoption of AVs in Malaysia by various segments of society. Two established models, the Technology Acceptance Model (TAM) and the Theory of Planned Behaviour (TPB), are integrated in this study. Policy makers and car manufacturers could gain valuable insights in devising specific strategies targeting different social segments to ensure smooth deployment of AVs in the country, thus achieving the aim of halving traffic fatalities by 2030.

## 2. Literature Review

### *2.1. Development of Autonomous Vehicles in Malaysia*

The global AV market size is projected to create USD 300 billion to USD 400 billion in revenue by 2035 [15]. AVs which are equipped with significant level of autonomy and advanced technologies have provided convenience and improved efficiency to consumers through optimized energy consumption. According to McKinsey's survey in 2023 [15] which polled more than 25,000 respondents about their mobility preferences, about 25% of respondents stated their tendency to choose AVs with advanced autonomous driving features. In order to cater to the increasing demand for AVs, many of the leading automakers are actively investing in autonomous technologies. For instance, Waymo, formerly the Google self-driving car project, offers its fully autonomous ride-hailing service to the public 24 h a day, 7 days a week in the United States. Nonetheless, Asia Pacific held the largest autonomous cars market share in 2023, followed by Europe, which holds the second largest market share [16]. These show that AVs, seen as the future of personal and public means of transport, have gradually gained market share and sparked significant global attention.

In line with the global growth of the autonomous vehicle industry and the Industrial Revolution 4.0 (IR4.0), the Malaysian Ministry of International Trade and Industry (MITI) and the Malaysia Automotive, Robotics and IoT Institute (MARii) formulated the National Automotive Policy 2020. Its aim is to serve as a vision-driven framework to develop new vehicle technologies, such as electrification, autonomous driving, internet of things (IoT), cooperative intelligent transportation system (C-ITS), and Artificial Intelligence (AI) for future vehicle technologies development.

In the context of Malaysia, autonomous vehicles were named "Next Generation Vehicles (NxGVs)" [17] and defined in the National Automotive Policy 2020 as Energy Efficient Vehicles (EEVs) equipped with a minimum of Level 3 automation. The goal of National

Automotive Policy is to introduce NxGVs or Level 3 autonomous vehicle into the Malaysia market by 2025 [18]. To ensure smooth and safe implementation of NxGVs, the government established a company under the Ministry of Finance, called the Futurise Sdn Bhd (Futurise), to lead the National Regulatory Sandbox initiative related to regulation, innovation, and collaboration with other entrepreneurs, regulators, and corporations [19]. Presently, there are nine test sites established in various parts of the country (Johor, Putrajaya, and Bandar Sunway). Alongside with the implementation of AVs testing, Futurise has emphasized the importance of social acceptability, whereby public opinion is essential in the decision-making process.

### *2.2. Theories of Technology Acceptance*

Many established models have been adopted in explaining human behaviour on the acceptance of AV technology. The models include the Technology Acceptance Model (TAM) developed by Davis [20], the Theory of Planned Behaviour (TPB) proposed by Ajzen (1991) [21], the Unified Theory of Acceptance and Use of Technology (UTAUT) by Venkatesh et al. (2003) [22], the Diffusion of Innovation Theory (DOI) by Roger [23], and several extension models such as TAM2 and UTAUT2. These models are built on the theoretical foundation that people's belief and perception of technology can shape acceptance, with behavioural intention (BI) to use a technology and actual usage behavioural as a measure of acceptance. While many psychological models have previously been applied, there is no consensus achieved on which model is the best model [13,24]. Benleulmi and Ramdani [24] concluded that this is mainly because of the underlying study motives (independent variables) in the theory used, as well as the various dependent variables (acceptance, intention, willingness to pay, use intention, and usage). Therefore, there is a need to further investigate a possible suitable framework for understanding the potential adoption of AVs in the Malaysian context.

#### 2.2.1. Theory of Planned Behaviour

The Theory of Planned Behaviour (TPB) proposed by Ajzen [21] is extended from the Theory of Reasoned Action (TRA) to explain human behaviour in a broad perspective. The model comprises three major components: perceived behavioural control, subjective norm, and attitude. Perceived behavioural control denotes the perceived ease or difficulty of performing a behaviour, while subjective norm is defined as "a person's perception that most people who are important to him think he should or should not perform the behaviour in question" [25]. A user's attitude is referring to the outcome or feeling of favour or less favour in carrying the intended behaviour.

TPB model has shown its rigorous predictive power in several studies in relation to the acceptance of AVs [26–29]. For instance, Buckley et al. [26] shown that the TPB model is able to explain about 46% of the variance of AV acceptance among American drivers while a study by Rahman et al. [29] indicated that TPB is able to describe about 80% of the variance in intentions to use AVs. Kaye et al. [27] determined that when examining the acceptance of AVs (Level 3 and Level 5) among Australians, the TPB model is able to capture about 66.3% to 67.8% of the variances. Among the constructs of the TPB model, the findings of perceived behavioural control are found to be inconsistent [27]. Perceived behavioural control is significantly a negative predictor in some studies [29]. In contrast, perceived behavioural control is not a significant variable in the studies by Kaye et al. [27].

While TPB has been widely adopted in various new technology acceptance research, it is worth noting that TPB is fraught with limitations. Several researchers argue that TPB is more prominent in predicting intention rather than behaviour, whereby the behaviour is not always a predictor of intention [30]. This is often addressed as the "intention–behaviour gap" [31].

#### 2.2.2. Technology Acceptance Model

The Technology Acceptance Model (TAM) is extended from TRA theory to explore consumer behaviour on new technologies [20]. The TAM enriches the TRA model by scoping down technology acceptance context and accommodating the effect of other determinants through the moderating impact of perceived usefulness and perceived ease of use [32]. Perceived usefulness is described as "the degree to which a person believes that using a particular system would enhance his or her job performance" [33] while perceived ease of use is defined as "the degree to which a person believes that using a particular system would be free of effort" [33]. On the other hand, attitude construct is often omitted in many technology acceptance studies, as Venkatesh and Davis [34] claimed that attitude can be excluded in the TAM as it has no impact on the predictive power. Due to this, the role of attitude is often underexplored. In fact, the role of attitude is an important construct, whereby Armitage and Christian [35] surmised that attitude is the most important variable in contemporary consumer behavioural studies. The TAM posits that there will be intention to use a new technology when an individual believes that the new technology would improve their performance without much effort. Notwithstanding, the basic TAM inherits many limitations, and researchers have called to extend the TAM [9,11,36].

Review of the literature indicates that the extended TAMs have been applied to investigate causal factors affecting users' adoption of AVs. Among the studies, Choi and Ji [36] integrated trust, perceived risk, system transparency, technical competence, situation management, locus of control, and sensation-seeking in TAM. Hegner et al. [37] adopted concern giving up control, trust in technology, driving enjoyment, and personal innovativeness into the TAM. Another study by Zhang et al. [38] integrated perceived safety risk, perceived privacy risk, and initial trust. Lee et al. [39] pointed out that the TAM appeared to be a major theoretical framework in past AV acceptance studies. There are also few studies combining the TAM and the TPB in predicting the causal factors. The perceived behavioural control (locus of control) in the TPB model is deemed significant in affecting intention to use [26,36] and further influences perceived ease of use [39]. A recent study by Moták et al. [40] applying the TAM and the TPB in assessing the acceptance of autonomous shuttles revealed that all the components of the TAM and the TPB significantly influence public behaviour in using automated shuttles. In this respect, it was found that very few studies applied the combination TAM and TPB model in the context of private AVs.

### *2.3. Hypothesis Development*

Factors Influencing the Acceptance of Autonomous Vehicles

According to Davis [20] and Venkatesh et al. [22], the central constructs of the TAM, perceived usefulness (PU) and perceived ease of use (PEOU), positively correlate with the intension to use a technology. Huang [41] revealed that improving the usefulness and ease of use will enhance users' attitude towards AVs, leading to higher intention to use AVs. Zhang et al. [9] further noted that attitude within the TAM is rarely examined in the past as Venkatesh and Davis [34] stated that attitude is unable to increase the predictive power. However, the results are mixed in the past studies [36,39,42,43]. In the context of AVs, the invention of AVs is expected to meet travel needs of people, reduce human error induced traffic crashes, and achieve other sustainable goals. Therefore, when a user is convinced that AVs are able bring benefits to them, they will be motivated to use the technology.

On the other hand, the complexity of technology hinders a user from adopting the technology. Davis [20] argued that even though a user acknowledges the potential benefit of a technology, the adoption will depend on whether the technology can be operated without any effort or being simple. Nonetheless, in many studies, PEOU is found to have no significant influence in the behaviour intention [44]. Lastly, external influences would transfer attitude of the user to the behavioural intention. In alignment with the TAM, the following hypotheses are developed:

**H1.** *Perceived usefulness positively affects the acceptance of AVs.*

**H2.** *Perceived ease of use positively affects the acceptance of AVs.*

**H3.** *Attitude positively affects the acceptance of AVs.*

Subjective norm or social influence refers to how an individual is influenced by an important other in a society on using a technology. Subjective norm has been found to have significant influence on intention to use an innovation [26,42,45,46]. In the area of AVs, the relationship between subjective norm in influencing motivation to purchase AVs have been well defined by Kapser and Abdelrahman, and Koul and Eydfahi [47,48]. Thorpe and Motwani [46] further explain that an individual tends to pursue what other people do or think, particularly their peers, family members, colleagues, or neighbours.

In the studies related to acceptance of AVs, the concept of perceived behavioural control (PBC) is similar to self-efficacy [39]. The relationship between perceived behavioural control or self-efficacy and acceptance intention have been extensively explored in various fields and is found as a significant factor [26,39,49,50]. Within the studies, it is reported that self-efficacy is closely related to the level of automation [39], and hence leads to the intention to use AVs. Therefore, the following two hypotheses are put forth:

**H4.** *Subjective norm positively influences the acceptance of AVs.*

**H5.** *Perceived behavioural control positively influences the acceptance of AVs.*

### *2.4. Moderating Effect of Socio-Demographic Variables on Acceptance*

There are plenty of evidences indicating that socio-demographic variables such as age, gender, ethnic groups, income level, education level, and occupation significantly influence the acceptance of AVs [51–53]. It is shown that the perception and acceptance of AVs vary in accordance with different segment groups of society, countries, and the level of AVs. The age factor significantly affects the acceptance of AVs [54,55]. Venkatesh et al. [22] indicated that the intention to adopt a new technology reduces significantly with increasing age. In the context of AVs, many studies noted that younger respondents are generally more positive towards AVs and more willing to accept it as compared to older groups [54,55]. The fear of adopting new technology also hinders elderly in accepting AVs [13].

In the acceptance of new technology, particularly AVs, there is a distinction between male and female. Past studies have shown that males tend to accept AVs compared to their female counterparts [56–58]. However, another study argues that men are more concerned with liability issues when the vehicle is involved in an accident due to automation failures [59]. Risk-taking male drivers exhibit more resistance to driverless vehicles, while females prefer AVs as they would have more time to take care of their children behind the steering wheel.

AV technology is complicated, thus the price is more expensive compared to other conventional vehicles. Therefore, lower income group might not be affordable to purchase AVs. In other words, higher income groups are more receptive to accepting AVs [60]. The role of level of education is rarely explored in the acceptance of AVs [53]. However, in general, highly educated people are more likely to embrace autonomous vehicles [61,62]. Socio-demographic variables are incorporated as moderators in the TAM and TPB models, including age (H6), gender (H7), ethnicity (H8), education level (H9), marital status (H10), occupation (H11), and income level (H12). The proposed framework is presented in Figure 1.

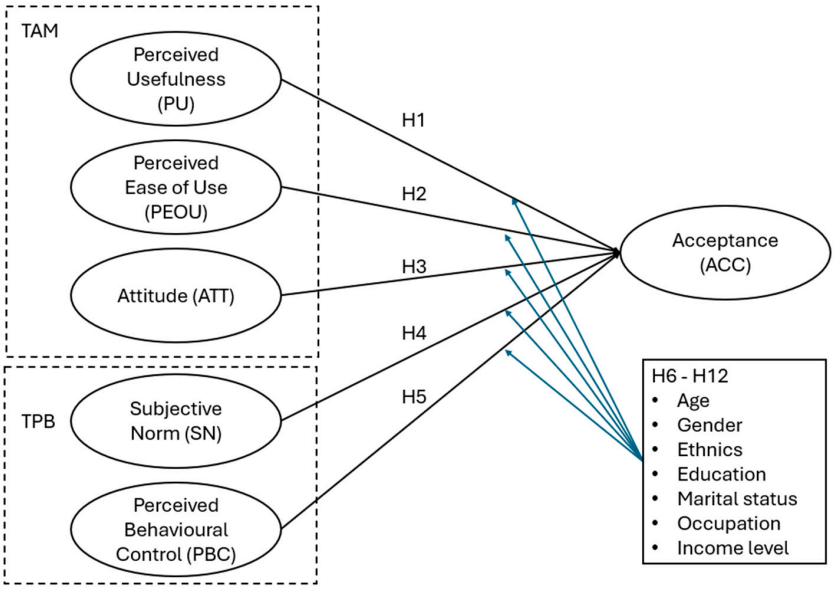


**Figure 1.** Research framework.

## 3. Methodology

### *3.1. Questionnaire Development*

The survey questionnaire was designed in four sections: a briefing of AVs, the screening questions whether the respondents possessed valid driving license, socio-demographic information, and the constructs questions as shown in in Table 1. The questions were measured based on a 7-point Likert scale ranging from 1 (Strongly Disagree) to 7 (Strongly Agree). The items used in the questionnaire were adopted from past studies related to the acceptance of AVs. Based on the review of the literature, five constructs in the TAM and TPB models were identified and each of the constructs contain 3 items. Hence, a total of 15 items are presented in Table 1.

**Table 1.** Research Instruments.

| Construct | Items | Adopted from |
|---|---|---|
| Perceived Usefulness (PU) | 1. I would find AVs useful in meeting my transportation needs.<br>2. The use of autonomous vehicles would be useful.<br>3. Using AVs would enhance my effectiveness while driving. | Panagiotopoulos and Dimitrakopoulos (2018); Davis (1989) [20,42] |
| Perceive Ease of Use (PEOU) | 1. Learning to operate AVs would be easy for me.<br>2. I would find it easy to get autonomous vehicle to do what I want to do.<br>3. Interacting with AVs would not require a lot of my mental effort. | Davis (1989) [20] |
| Attitude (ATT) | 1. I think that using AVs is a good idea.<br>2. I like the idea of using AVs.<br>3. I think that using AVs would be beneficial for me. | Nasri and Charfeddine (2012) [63] |
| Subjective Norm (SN) | 1. People who are important to me would think that I should use AVs.<br>2. People who influence my behaviour would think that I should use AVs.<br>3. People whose opinion I value would prefer that I use AVs. | Nasri and Charfeddine (2012) [63] |
| Perceived Behavioural Control (PBC) | 1. Given the resources, opportunities, and knowledge it takes to use AVs, it would be easy for me to use an AV.<br>2. I have the resources necessary to use AVs.<br>3. I do not have the knowledge necessary to use AVs. | Venkatesh et al. (2003) [22] |
| Acceptance (ACC) | 1. I intend to use AVs in the future.<br>2. I expect that I would use AVs in the future.<br>3. I plan to use AVs in the future. | Choi and Ji (2015) [36] |

### 3.2. Data Collection

This study applied probability sampling, simple random sampling in which everyone has an equal probability of being selected. The questionnaire was distributed online. Prior to distribution, the questions were pretested with 30 respondents (i.e., academics and industry experts in the transport industry, and the general public) to ensure clarity and comprehensibility. During the pretest, discussion with each of the respondents was conducted separately by going through the questionnaire. The questionnaire was improved accordingly based on the feedback and comments received during pretest. The recommendations included enhancing the comprehensibility and simplicity, whereby additional information on AV Level 3 was included. After the amendment, the questionnaire was created using Google Form (https://www.google.com/forms/about/) and was distributed online between August–October 2023. The final online survey involved 330 respondents. Eventually, data were cleaned for straight lining data and 24 samples were discarded. No incomplete responses were accounted for as the questions were preset to be mandatory questions. In brief, a total of 306 responses were collected for the data analysis. The sample size is deemed adequate as suggested by Memon and colleagues [64], who recommended a sample between 160 and 300. In the context of this study, it is believed that the survey reached various segment of society nationwide. However, it should be noted that the online survey approach carries the risks of attrition and careless responding [65].

### 3.3. Sample Profiles

A total of 306 samples remained after they were screened for invalid data. As shown in Table 2, male respondents accounted for a larger proportion at 53.6%, and most of the respondents (54.3%) were Malays. About half of the respondents (49.4%) were aged below 45 years old. In addition, 75.8% of the respondents were married and obtained a minimum of a Bachelor's Degree. About 31.1% of the respondents earned above RM 7,100 per month, and approximately half of them (46.4%) worked in the private sector. The gender sample is quite close to the nation distribution, while in terms of ethnicity, the Chinese respondents were slightly higher than the national population percentage of approximately 21% [66]. The difference might be due to sampling issues, as the survey was distributed online through friend recommendations and voluntary participation.

**Table 2.** Respondent profiles.

| Measure | Items | Frequency | Percentage (%) |
|---|---|---|---|
| Gender | Male | 164 | 53.6 |
| | Female | 142 | 46.4 |
| Ethnicity | Malay | 166 | 54.3 |
| | Chinese | 113 | 36.9 |
| | Indian | 18 | 5.9 |
| | Others | 9 | 2.9 |
| Age | 18–25 | 25 | 8.2 |
| | 26–35 | 47 | 15.4 |
| | 36–45 | 79 | 25.8 |
| | 46–55 | 89 | 29.1 |
| | 56–65 | 53 | 17.3 |
| | 66–75 | 11 | 3.6 |
| | 76 and above | 2 | 0.6 |
| Marital Status | Single | 65 | 21.2 |
| | Married | 232 | 75.8 |

**Table 2.** *Cont.*

| Measure | Items | Frequency | Percentage (%) |
|---|---|---|---|
| | Divorced | 7 | 2.3 |
| | Widowed | 2 | 0.7 |
| Educational Level | Secondary School | 38 | 12.4 |
| | Certificate/Diploma | 59 | 19.3 |
| | Bachehor's Degree | 152 | 49.7 |
| | Postgraduate Degree | 57 | 18.6 |
| Income Level (RM) | RM 2500 and below | 57 | 18.6 |
| | RM 2501–4849 | 90 | 29.4 |
| | RM 4850–7099 | 64 | 20.9 |
| | RM 7100–10,959 | 53 | 17.3 |
| | RM 10,960–15,039 | 22 | 7.2 |
| | RM 15,040 and above | 20 | 6.6 |
| Occupation | Students | 21 | 6.9 |
| | Self-employed | 31 | 10.1 |
| | Private | 142 | 46.4 |
| | Government | 83 | 27.1 |
| | Housewife | 11 | 3.6 |
| | Unemployed | 1 | 0.3 |
| | Retired | 17 | 5.6 |

## 4. Results

Initially the data were analysed using IBM SPSS statistic 26 software for descriptive analysis to understand the characteristics of the data, and the results presented in Table 3 indicate that all items had mean values of more than 3, suggesting that the respondents agreed with most items in the questionnaire. Among the constructs, attitude has the highest value of 4.93. In addition, all the constructs are negatively skewed and the mean is smaller than the median. In terms of kurtosis, all the constructs except perceived ease of use and perceived behavioural control are normally distributed.

**Table 3.** Mean, standard deviation, skewness, kurtosis, correlation test, and reliability results.

| | AGE | GEN | ETH | MAR | EDU | OCC | INC | PU | PEOU | ATT | SN | PBC | ACC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AGE | 1 | | | | | | | | | | | | |
| GEN | 0.008 | 1 | | | | | | | | | | | |
| ETH | 0.202 ** | 0.056 | 1 | | | | | | | | | | |
| MAR | 0.415 ** | −0.054 | 0.010 | 1 | | | | | | | | | |
| EDU | −0.165 ** | 0.147 * | 0.083 | −0.119 * | 1 | | | | | | | | |
| OCC | 0.312 ** | 0.120 * | −0.011 | 0.173 ** | 0.021 | 1 | | | | | | | |
| INC | 0.265 ** | 0.026 | 0.112 | 0.231 ** | 0.356 ** | −0.119 * | 1 | | | | | | |
| PU | −0.041 | −0.048 | 0.040 | −0.019 | 0.030 | −0.117 * | 0.043 | 1 | | | | | |
| PEOU | −0.110 | −0.147 ** | −0.012 | −0.018 | 0.089 | −0.229 ** | 0.067 | 0.475 ** | 1 | | | | |
| ATT | −0.037 | −0.097 | 0.077 | −0.006 | −0.005 | −0.187 ** | 0.056 | 0.658 ** | 0.496 ** | 1 | | | |
| SN | −0.013 | −0.018 | 0.030 | 0.008 | −0.055 | −0.095 | 0.048 | 0.567 ** | 0.400 ** | 0.520 ** | 1 | | |
| PBC | −0.019 | −0.105 | −0.097 | 0.049 | 0.049 | −0.171 ** | 0.116 * | 0.579 ** | 0.530 ** | 0.628 ** | 0.471 ** | 1 | |
| ACC | −0.026 | −0.099 | 0.070 | 0.028 | 0.032 | −0.172 ** | 0.122 * | 0.566 ** | 0.440 ** | 0.821 ** | 0.481 ** | 0.598 ** | 1 |
| Mean | 3.45 | 1.46 | 1.58 | 1.82 | 2.75 | 3.34 | 2.850 | 4.64 | 4.62 | 4.93 | 4.02 | 4.63 | 4.95 |
| Standard Deviation | 1.301 | 0.500 | 0.735 | 0.481 | 0.902 | 1.265 | 1.439 | 1.255 | 1.206 | 1.299 | 1.339 | 1.261 | 1.366 |

**Table 3.** *Cont.*

| | AGE | GEN | ETH | MAR | EDU | OCC | INC | PU | PEOU | ATT | SN | PBC | ACC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Skewness | −0.061 | 0.145 | 1.309 | −0.089 | −0.5 | 0.948 | 0.570 | −0.411 | −0.161 | −0.644 | −0.31 | −0.328 | −0.538 |
| Kurtosis | −0.447 | −1.992 | 1.636 | 2.508 | −0.44 | 2.109 | −0.494 | 0.281 | −0.256 | 0.408 | 0.006 | −0.021 | 0.294 |
| Cronbach α | - | - | - | - | - | - | - | 0.846 | 0.874 | 0.955 | 0.957 | 0.686 | 0.976 |

* $p \leq 0.05$. ** $p \leq 0.005$. Note: GEN: gender; ETH: ethnicity; MAR: marriage: EDU: education; OCC: occupation; INC: income level; PU: perceived usefulness; PEOU: perceived ease of use; ATT: attitude; SN: subjective norm; PBC: perceived behavioural control; ACC: acceptance.

### *4.1. Measurement Assessment*

Following descriptive analysis, data were subsequently analysed using a two-step approach to SEM. In the first step, a correlation test and a reliability test were performed to check validity of the measurement to ensure all measurement variables reliably represented the proposed latent variables in the framework. The correlation test was to investigate the presence of any multicollinearity between factors. For the reliability test, the measurement item's internal consistency test is assessed by using Cronbach's alpha. A high Cronbach's alpha value denotes the items within a construct converge to the same meaning. The results of correlation analysis are presented in Table 3. All coefficients of the factors were less than 0.7, indicating there is no multicollinearity issue. Among the factors, attitude and acceptance are highly correlated (r = 0.821). In contrast, gender and age are the least correlated (r = 0.008). In terms of reliability, the values of all the constructs except perceived behavioural control were more than 0.7 (the recommended value for Cronbach's alpha by Nunnally [67]. Though the value of perceived behavioural control was less than the recommended value of 0.7 by Nunnally, the value falls between the range of moderate reliable scale (0.5 to 0.75) as suggested by Hinton et al. [68]. Therefore, perceived behavioural control was retained for subsequent structural model analysis.

### *4.2. Structural Model Assessment*

#### 4.2.1. Main Effects

Hypotheses H1 to H5 were evaluated using multiple regression analysis. Perceived ease of use, perceived usefulness, attitude, perceived behavioural control, and subjective norm are factors used to predict the acceptance of AVs in the model. As seen in Table 4, two of the five constructs, attitude and perceived behavioural control, are significant and the $R^2$ is 0.829. Notably, the effect of perceived usefulness, perceived ease of use, and subjective norm were not significant. A high value of $R^2$ indicates that the model is able to explain 82.9% of the variance in accepting AVs. In conclusion, hypotheses H3 and H5 were supported.

**Table 4.** Main effect results.

| Hypotheses | Unstandardized Coefficients | Standardized Coefficients | Beta | t | Results |
|---|---|---|---|---|---|
| | B | Std. Error | | | |
| H1: Perceived Usefulness → Acceptance | −0.015 | 0.056 | −0.012 | −0.260 | Rejected |
| H2: Perceived Ease of Use → Acceptance | −0.001 | 0.048 | −0.001 | −0.027 | Rejected |
| H3: Attitude → Acceptance | 0.758 | 0.050 *** | 0.722 | 15.053 | Accepted |
| H4: Subjective Norm → Acceptance | 0.053 | 0.041 | 0.052 | 1.273 | Rejected |
| H5: Perceived Behavioural Control → Acceptance | 0.152 | 0.054 ** | 0.128 | 2.829 | Accepted |
| $R^2$ | 0.829 | | | | |

** $p \leq 0.005$. *** $p \leq 0.001$.

#### 4.2.2. Test of Moderation Effect

The moderating effect of demographic characteristics are also analysed to understand if acceptance varies according to the diverse array of societal segments. The results are presented in Table 5. Among the main effects, only attitude is significant at 0.01 level while SN is found to be significant at 0.1 level. None of the demographic factors have a significant direct effect on acceptance. In terms of moderating effect, the ethnic variable moderates the effect of perceived ease of use. Education level significantly ($p < 0.05$) influences the relationship between perceived usefulness and acceptance. Likewise, there is also a significant moderating effect of income level ($p < 0.05$) on the relationship between attitude and acceptance of AVs. On the other hand, a weak significant moderating effect of occupation level ($p < 0.1$) is found on the relationship between occupation level and perceived behavioural control. It is surprising to note that age and gender are not significant moderators in this study. This finding aligns with the previous studies by Park et al. (2021) [53] but contrasts with the finding by Lee et al. [39]. In conclusion, by incorporating the demographic variables as moderating effects in the model, the total variance increased from 82.9 to 84.5%.

**Table 5.** Moderating effect results.

| | Unstandardized Coefficients | Standardized Coefficients | Standard Error | *p*-Value |
|---|---|---|---|---|
| PEOU | 0.036 | 0.030 | 0.056 | 0.518 |
| PU | −0.040 | −0.034 | 0.064 | 0.533 |
| ATT | 0.765 *** | 0.729 | 0.058 | 0.000 |
| SN | 0.087 * | 0.086 | 0.047 | 0.066 |
| PBC | 0.073 | 0.062 | 0.066 | 0.264 |
| AGE | −0.096 | −0.050 | 0.086 | 0.265 |
| GENDER(GEN) | −0.043 | −0.016 | 0.094 | 0.651 |
| ETHIC (ET) | 0.021 | 0.012 | 0.069 | 0.767 |
| MARITAL (MA) | 0.096 | 0.035 | 0.107 | 0.368 |
| EDUCATION (EDU) | 0.032 | 0.022 | 0.058 | 0.582 |
| OCCUPATION (OCC) | −0.040 | −0.038 | 0.043 | 0.356 |
| INCOME (INC) | 0.047 | 0.052 | 0.038 | 0.209 |
| INT_AGE × PEOU | 0.062 | 0.049 | 0.083 | 0.453 |
| INT_AGE × PU | −0.106 | −0.087 | 0.092 | 0.248 |
| INT_AGE × ATT | 0.119 | 0.098 | 0.092 | 0.196 |
| INT_AGE × SN | −0.049 | −0.037 | 0.073 | 0.508 |
| INT_AGE × PBC | 0.063 | 0.052 | 0.085 | 0.458 |
| INT_GEN × PEOU | −0.037 | −0.028 | 0.059 | 0.525 |
| INT_GEN × PU | −0.078 | −0.059 | 0.075 | 0.299 |
| INT_GEN × ATT | −0.054 | −0.041 | 0.072 | 0.452 |
| INT_GEN × SN | 0.008 | 0.006 | 0.062 | 0.897 |
| INT_GE × PBC | 0.133 | 0.101 | 0.068 | 0.052 |
| INT_ET × PEOU | −0.136 ** | −0.098 | 0.065 | 0.037 *** |
| INT_ET × PU | 0.036 | 0.030 | 0.067 | 0.590 |
| INT_ET × ATT | 0.017 | 0.014 | 0.064 | 0.790 |
| INT_ET × PBC | −0.029 | −0.027 | 0.059 | 0.628 |

**Table 5.** *Cont.*

| | Unstandardized Coefficients | Standardized Coefficients | Standard Error | *p*-Value |
|---|---|---|---|---|
| INT_MA × PEOU | 0.056 | 0.050 | 0.065 | 0.393 |
| INT_MA × PU | 0.112 | 0.111 | 0.087 | 0.201 |
| INT_MA × ATT | −0.048 | −0.045 | 0.088 | 0.589 |
| INT_MA × SN | −0.013 | −0.010 | 0.092 | 0.891 |
| INT_MA × PBC | −0.104 | −0.094 | 0.087 | 0.230 |
| INT_EDU × PEOU | 0.061 | 0.049 | 0.058 | 0.294 |
| INT_EDU × PU | −0.157 ** | −0.124 | 0.079 | 0.048 *** |
| INT_EDU × ATT | 0.092 | 0.071 | 0.086 | 0.285 |
| INT_EDU × SN | −0.067 | −0.053 | 0.070 | 0.336 |
| INT_EDE × PBC | 0.094 | 0.073 | 0.085 | 0.273 |
| INT_OCC × PEOU | 0.012 | 0.009 | 0.068 | 0.858 |
| INT_OCC × PU | 0.091 | 0.065 | 0.074 | 0.221 |
| INT_OCC × ATT | −0.032 | −0.024 | 0.071 | 0.649 |
| INT_OCC × SN | 0.123 | 0.073 | 0.076 | 0.108 |
| INT_OCC × PBC | −0.159 * | −0.112 | 0.082 | 0.053 |
| INT_INC × PEOU | −0.018 | −0.014 | 0.070 | 0.796 |
| INT_INC × PU | 0.076 | 0.057 | 0.091 | 0.406 |
| INT_INC × ATT | −0.278 ** | −0.197 | 0.097 | 0.004 *** |
| INT_INC × SN | 0.049 | 0.039 | 0.076 | 0.520 |
| INT_INC × PBC | 0.018 | 0.013 | 0.084 | 0.828 |

* $p \leq 0.05$. ** $p \leq 0.005$. *** $p \leq 0.001$.

## 5. Discussion

This study was initiated to investigate factors influencing the acceptance of Avs, as well as the moderating effects of the demographic factors. The TAM and TPB models were integrated and a total of twelve hypotheses were developed based on the proposed framework. The rationales of integrating the TAM and TPB models are two-fold. Firstly, as Level 3 AVs are yet to penetrate into Malaysian market, the perception on the adoption of AVs is based on imaginary information. As such, the capability of TPB and TAM to evaluate the intention rather than the behaviour is claimed to be more appropriate in this study [69]. Secondly, the TAM was developed with the aim to forecast the acceptance of a new innovation. The TAM mainly focuses on users' perceptions of the usefulness and ease of use of a particular technology, and ignores the cognitive and psychological aspects of the technology. Integrating TAM-TPB models would enhance the study of the potential factors that influence the acceptance of AVs. Multiple regression analysis results indicated that attitude and perceived behavioural control have dominant effects on the acceptance of AVs, which are consistent with the study by Dai et al. [49]. The result of this study is also consistent with Yuen et al. [70], as people are more willing to accept AVs when they are favourable towards the novel technology and they perceive they have adequate resources to make use of AVs. In other words, this implies that people with positive attitude and those who believe that it is easy for them to operate the AVs or have adequate perceptual resources are more likely to accept AVs. While perceived usefulness has been widely acknowledged as a significant variable in the past studies [9,13,36], it was found insignificant in the current research. The finding is consistent with Man et al. [71], whose study revealed that perceived usefulness did not significantly affect AV acceptance as the consumers are more concerned about other factors such as performance effectiveness

and fuel efficiency rather than the usefulness of driving AVs. Perceived ease of use and subjective norm were also found to have no significant effect. These findings corroborate the work of Choi and Ji [36] and Dai et al. [49]. Another important contribution is the significant finding of the attitude variable. Attitude construct is rarely investigated in empirical research in the context of AV acceptance study following the suggestion by Venkatesh and Davis [34], who suggested that removing attitude construct will have no effect on the predictive power.

Another noteworthy finding is the outcome of moderating roles of the socioeconomic variables. Results indicated that ethnicity, education level, and income level have considerable effects on the acceptance of AVs. The results imply that different races or groups of people are strongly affected by the perceived ease of use of Avs, while perceived usefulness influenced potential users across varying level of education. This might suggest that people with diverse knowledge would appreciate AVs in providing their travel needs. People with higher educational level would anticipate AVs to generate more benefits to meet their expectations. Therefore, the more information and knowledge attained, the more likely that people would be motivated to accept AVs. However, it is interesting to note that age and gender did not moderate the relationships between the variables and acceptance of AVs, which contradicted with the work of Dong et al. [72], Haghzare et al. [54], Hulse et al. [55], and Charness et al. [56]. The findings suggest that there is no distinction among male or female and aged groups in their acceptance of AVs.

## 6. Conclusions

This study adds value to the existing literature by including the attitude variable, which is often neglected in past AV studies on the model. Additionally, as Level 3 AVs are yet to be operationalized on the roads in Malaysia, this first of its kind study exploring the psychological factors in the acceptance of AVs lays an important foundation and serves as a very early benchmark for future research studies when AVs materialise in the country. AVs pave the way to a more sustainable transportation and self-driving future. Implementation of AVs has numerous potential benefits, including providing more reliable and safer transportation alternatives, lowering the carbon emission, and promoting sustainable living by incorporating green infrastructure. Stakeholders should ensure that AVs are introduced and adopted in an environmentally responsible manner in order to maximise their advantages in terms of climate mitigation and sustainability [73]. When policymakers or other industry players review the acceptance AVs, attitude and perceived behavioural control factors should be included in charting the roadmap for AVs deployment in the country. The benefits of AVs in replacing conventional vehicles need to be propagated so as to minimize the impact of AVs being portrayed as complicated technologies. As more people perceived the merits and benefits and be more positive towards AVs, this could lead to wider acceptance of AVs. For retailers, with the outcome of the findings that education and income level are significant moderators in the determinants of AVs (perceived usefulness and attitude), effective marketing strategies could be implemented to target diverse group of potential AVs adopters. For instance, the findings revealed that people with higher income and higher educational attainment tend to accept and adopt AVs. This information is useful for formulating marketing strategies for reaching the right group of the customer without using redundant resources. As this study suggests that the early adopters of the AVs are most likely come from higher income and educational groups, the industry players could focus on the benefits of AVs in daily use through public awareness, education campaigns, and information sharing to other segments. These campaigns can help in educating people, increasing their familiarity and reducing distance from the novel technology, as well as boosting public acceptance and their preparedness for the adoption of AVs. While the ultimate goal of national policymakers is to halve the traffic fatalities by 2030 (of which about 60% are motorcyclists), prioritizing the balance between benefits and the utility costs is crucial, as motorcycles are primarily used for their low operation

costs. Therefore, the policymakers may also consider various incentive measures and demonstrating the safety gains from the use of AVs.

This study is not without limitations. The TAM and TPB models are integrated to investigate the acceptance of AVs with moderating effects of socio-demographic factors. In the future, more analysis can be carried out to delve deeper into other variables or other models, such as UTAUT, to gain better understanding of AV acceptance in Malaysia when the technology becomes more matured in the country. There would also be potential of embarking on a longitudinal study once AVs are fully commercialized in Malaysia. On the other hand, as AVs are yet to be operated in the country, the intangible idea of AVs might lead to variation in the actual magnitude of the findings. Additionally, the deficiency and bias of using an online survey is also acknowledged. Therefore, future research may consider a face-to-face survey, allowing further clarification to assist respondents to better envision the adoption of AVs.

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