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Critical Factors Influencing Acceptance of Automated Vehicles by Hong Kong Drivers

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ABSTRACT
This study aimed to identify critical factors that influence acceptance of automated vehicles among drivers. The focus of this study was on automated vehicles (AVs) of level 3 (conditional driving automation) as defined by the Society of Automotive Engineers. A research model was proposed here by using the technology acceptance model (TAM) with trust, risk perception (perceived safety risk and perceived privacy risk), compatibility, and system quality. A cross-sectional structured questionnaire survey was used to collect quantitative data from 237 drivers in Hong Kong. The data were analyzed to test the proposed research model by structural equation modeling. The proposed research model was found to explain 68% of the variance in intention to use AVs. In contrast with the TAM constructs of perceived usefulness and perceived ease of use, the results of this study indicated that trust was the most important factor in shaping a positive attitude towards using AVs, which affected driver intention to use AVs. Also, trust was found to be influenced by perceived safety risk, compatibility, and system quality. This study is the first attempt to consider technological factors related to AVs (compatibility and system quality) in explaining AV acceptance among drivers and highlighted the importance of the technological factors in the context of driver acceptance of AVs. Based on the findings of this study, several recommendations are discussed to help AV developers and governments to improve driver attitudes towards adoption of AVs.

INDEX TERMS
Acceptance, automated driving, compatibility, risk perception, system quality, trust.

I. INTRODUCTION
Vehicle automation is one of the most fundamental applications in the field of intelligent transportation systems. With new in-vehicle technologies such as adaptive cruise control and global positioning systems incorporated into modern automobiles, the control of driving tasks may shift from a human driver to a machine system [1]. Automated vehicles (AVs) are defined as vehicles capable of navigating, controlling, and avoiding hazards partly or totally without human intervention. According to the Society of Automotive Engineering [2], AVs can be categorized into six levels, ranging from no automation (SAE level 0) to full automation (SAE level 5). Vehicles in SAE levels 0-2 require driver support and supervision with human intervention when necessary. Vehicles in SAE levels 3-5 are able to sense their surrounding environment and take autonomous appropriate driving actions. Human drivers are removed from the driving loop when AV systems of vehicles in SAE levels 3-5 take over driving tasks. This study focused on the AVs of conditional automation (SAE level 3) because this type of AVs will become increasingly prevalent in the near future when the relevant technologies are mature.

Compared with conventional human driven vehicles, AVs have numerous advantages, including driving safety improvement, efficiency enhancement, and an increase in convenience and mobility for people. First, AVs help increase driving safety by largely taking human error out of the driving loop [3]. AVs should greatly reduce human error-induced crashes, which contributed to 94% of total crashes in the United States [4]. Second, AVs can provide effective route planning and efficient vehicle operation to significantly relieve road congestion and reduce fuel consumption [3], [5]. Third, AVs can free drivers from driving tasks and allow them to perform other activities while on route because AVs can reduce overall driving task demands [6]. Fourth, AVs can
revolutionize the travel behavior of the public, notably in the form of increased mobility for children, the elderly, the disabled and those who are not able to drive a conventional vehicle [7].

Naturally the abovementioned advantages will require the successful widespread implementation of AVs. However, a recent survey conducted by Abraham, et al. [8] showed that the public has a low level of intention to accept AVs. Also, previous studies have stressed the importance of the acceptance of AVs among drivers for successfully implementing AVs to achieve the potential benefits [9], [10]. Therefore, how to encourage drivers to accept AVs has become a pressing issue and has been given increasing research attention. In order to develop effective interventions for increasing the acceptance of AVs among drivers, it is essential to understand the factors that influence such acceptance. The majority of previous studies relevant to the problem have considered the psychological factors that affect drivers and their acceptance of AVs. For instance, Choi and Ji [11] discovered that perceived usefulness and trust were important in determining intention to use AVs and that the constructs; system transparency, technical competence, and situation management; affected trust in a positive way. Also, locus of control had a positive effect on intention to use AVs. Xu, et al. [12] also found that trust related to AVs positively influenced the intention to use AVs among drivers. Zhang, et al. [9] found that perceived safety risk negatively influenced trust related to AVs. All these studies used the technology acceptance model (TAM) as a theoretical foundation to explain the acceptance of AVs among drivers.

Although these studies have made significant contributions to the relevant literature, little mention has been made about the effects of technological factors in explaining driver acceptance of AVs. This study aims to fill this gap in research and will propose and validate an AV acceptance model that integrates the factors, trust, and risk perception into TAM. The technological factors, compatibility and system quality, were selected in accordance with previous studies on technology acceptance [13], [14].

This study is the first attempt to combine TAM with trust, risk perception, and technological factors to explain AV acceptance by drivers. Also, this study proposes that technological factors are the key to shaping trust and other psychological determinants of TAM. The results of this study are expected to offer an in-depth understanding of how psychological determinants, such as perceived usefulness, perceived ease of use, trust, risk perception and attitude toward using AVs, interact with each other to shape AV acceptance. From a practical view, this study will help AV developers and governments in developing effective interventions to promote AV acceptance.

The paper is organized as follows. Section II provides a literature review on TAM, trust, risk perception, compatibility, and system quality, and includes model development. Section III presents the details of the methodology of this study, including research design, measurements, participants, and data analysis. Section IV shows the results obtained by analyzing the collected quantitative data. Section V discusses the results in terms of theoretical contributions, practical implications, study limitations, and future research opportunities. Section VI provides concluding remarks for the study.

II. LITERATURE REVIEW AND MODEL DEVELOPMENT
A. TECHNOLOGY ACCEPTANCE MODEL

![FIGURE 1. Technology acceptance model by Davis, et al. [15].](image)

The technology acceptance model (TAM) was first introduced by Davis, et al. [15] who proposed that perceived usefulness (PU), perceived ease of use (PEOU), and attitude towards using a technology (ATUT), are antecedents for technology acceptance. As demonstrated in Figure 1, PU and PEOU positively influence ATUT while PU and ATUT positively affect intention to use the technology (ITU) which shapes the actual use of the technology. In addition, PU and PEOU can be affected by external factors.

In line with the definitions by Davis, et al. [15] and considering the context of this study, PU is defined as the extent to which drivers believe that using an AV will enhance their performance. PEOU refers to the extent to which drivers believe that using an AV will require little effort. ATUT is driver positive or negative impressions towards using an AV. ITU refers to the degree to which drivers are willing to use an AV. Actual use of an AV among drivers was not considered because at the time of this study AVs of SAE level 3 were not available to the public.

TAM has been widely used as a theoretical foundation for explaining acceptance of a variety of technologies such as e-learning system [16]–[19], 3D virtual reality system [20] and mobile payments [21]. For AV acceptance among drivers, TAM has been used to explain the acceptance of AVs among drivers [9], [12]. Based on TAM, it was hypothesized in this study that:

H1. Attitude towards using an AV has a positive effect on intention to use an AV.
H2. Perceived usefulness has a positive effect on intention to use an AV.
H3. Perceived usefulness has a positive effect on attitude towards using an AV.
H4: Perceived ease of use has a positive effect on attitude towards using an AV.
H5: Perceived ease of use has a positive effect on perceived usefulness.
B. TRUST
Trust is the attitude that an agent will assist in achieving the goals of people in a situation characterized by vulnerability and uncertainty [22]. In this study, trust is defined as the extent to which drivers willingly become vulnerable when using an AV. Trust has been considered an important factor in explaining why people accept technologies such as sustainable energy technology [23], internet banking [24] and restaurant service robots [25]. For automation technology, it was found that trust plays a critical role in the relationship between human and automation because of the principle “no trust, no use” [26]. This principle can be applied to AV acceptance by drivers. For instance, Xu, et al. [12] investigated the effect of trust on perceived usefulness in the context of AV acceptance by drivers and discovered that trust had a positive effect on perceived usefulness. Zhang, et al. [9] examined how trust affects attitude towards using an AV and found that trust positively influenced driver attitude towards using an AV. Also, Elwalda, et al. [27] conducted a review on factors influencing customer trust and found that customer trust can be determined by perceived ease of use. Therefore, it was hypothesized in this study that:

H6: Trust has a positive effect on attitude towards using an AV.

H7: Trust has a positive effect on perceived usefulness.

H8: Perceived ease of use has a positive effect on trust.

C. RISK PERCEPTION
Risk perception is the intuitive risk judgment of people to assess hazards [28]. The concept of risk perception has been widely applied to understanding human behavior such as risk-taking behavior [29], [30], driving behavior [31], and technology acceptance [9]. Despite the many advantages of AVs, the public has been found to be very concerned about risks associated with AVs [32]. It has been reported that, generally, people consider two types of risks with use of an AV, namely safety risk and privacy risk [9]. Driving on the road is one of the safety-critical activities when using an AV, because people must entrust their safety to the automated system. Also, privacy risk may result from the possibility that behavioral data or travel data may be obtained by third parties such as AV developers and insurance companies without the consent of users. Based on the study results of Li, et al. [21] and Zhang, et al. [9], risk perception negatively influences perceived usefulness and trust. Therefore, it was hypothesized in this study that:

H9: Perceived safety risk has a negative effect on perceived usefulness.

H10: Perceived safety risk has a negative effect on trust.

H11: Perceived privacy risk has a negative effect on perceived usefulness.

H12: Perceived privacy risk has a negative effect on trust.

D. COMPATIBILITY
Compatibility can be defined as the degree to which a technology complies with the needs and lifestyles of users [33]. To enhance the explanatory power of TAM, it has been integrated with the compatibility construct to account for the acceptance of different technologies such as mobile banking [14], smartphone [34] and driver support system [35]. It was found that compatibility positively influenced perceived usefulness and perceived ease of use in the mobile banking acceptance study of Mutahar, et al. [14].

In the context of AV adoption, Van Loon and Martens [36] suggest that compatibility should be considered during the transition period from non-automated vehicles to fully-automated vehicles. According to Van Loon and Martens [36], although AV users may not be involved in driving tasks, incompatibility between system and user expectations could lead to frustration, reducing comfort, and hypothetically creating a mistrust of the system. Also, the automated driving system in AVs may lead to potential changes in driving behavior and the type of information that the drivers shall receive, which form great challenges for AV deployment [37]. However, it was observed that little attention has been paid to how compatibility influences AV acceptance by drivers. Therefore, it was hypothesized in this study that:

H13: Compatibility has a positive effect on perceived usefulness.

H14: Compatibility has a positive effect on perceived ease of use.

H15: Compatibility has a positive effect on trust.

E. SYSTEM QUALITY
System quality refers to overall consumer perceptions of the excellence and effectiveness of a particular system [38] and has been used with TAM to explain technology acceptance. For instance, McKnight, et al. [39] examined the effect of system quality on trust in the context of information technology acceptance and found that system quality positively influenced trust. Salloum, et al. [16] investigated how system quality influenced perceived usefulness and perceived ease of use towards using an e-learning system among students. Although AVs have an automated driving system able to automatically navigate and monitor road conditions, previous studies did not consider the effect of system quality on AV acceptance among drivers. More research efforts are needed to fill this research gap. Therefore, it was hypothesized in this study that:

H16: System quality has a positive effect on trust.

H17: System quality has a positive effect on perceived ease of use.

H18: System quality has a positive effect on perceived usefulness.

F. MODEL DEVELOPMENT
To obtain an in-depth understanding of AV acceptance among drivers, an AV acceptance model is proposed here based on the hypotheses developed in previous sections. Specifically, this model involves TAM, trust, perceived safety risk,
perceived privacy risk, compatibility, and system quality (Figure 2).

III. METHODOLOGY
A. RESEARCH DESIGN
A cross-sectional structured questionnaire survey was used to collect quantitative data from drivers in Hong Kong. The data collected were analyzed to test and validate the proposed model and identify important factors that influence AV acceptance among drivers, using structural equation modeling (SEM). SEM is an effective method to investigate technology acceptance in various research areas such as smart e-learning systems [16], electricity meters [40] and social media [41]. Therefore, SEM was used in this study to investigate AV acceptance among drivers.

B. MEASUREMENT
The questionnaire contained three sections. Prior to the first section, a brief definition of AVs of SAE level 3 was given as follows: “A level 3 automated vehicle is capable of sensing surroundings and navigates from origin to destinations without human control. Drivers are expected to respond appropriately to a request to intervene.”

The first section included questions (Table 1) for measuring the constructs in the proposed model (Figure 2) with a five-point Likert-type scale format ranging from 1 (strongly disagree) to 5 (strongly agree). The constructs included perceived usefulness, perceived ease of use, attitude towards using an AV, intention to use an AV, trust, perceived safety risk, perceived privacy risk, compatibility, and system quality. The items for each construct were adapted from previous studies on technology acceptance to fit the research context of this study. Table 1 shows the scale items and questions for each construct with corresponding references. The second section included questions about demographic characteristics such as age, gender, and education. The last section had driving-related questions including average driving frequency per week in the last 12 months and number of traffic accidents involved in during the last three years.

TABLE 1. Scale items for measuring the constructs in the proposed model with references.

<table>
<thead>
<tr>
<th>Construct</th>
<th>Scale Item</th>
<th>Content</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perceived usefulness (PU)</td>
<td>PU1</td>
<td>Using an AV will be useful in meeting my driving needs.</td>
<td>Davis, et al. [15]</td>
</tr>
<tr>
<td></td>
<td>PU2</td>
<td>Using an AV will enhance my effectiveness while driving.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>PU3</td>
<td>I will find an AV useful in my life.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>PU4</td>
<td>I will find an AV useful when I am impaired (e.g. tired, drunk, drugs).</td>
<td></td>
</tr>
<tr>
<td>Perceived ease of use (PEOU)</td>
<td>PEOU1</td>
<td>Learning to operate an AV will be easy for me.</td>
<td>Davis, et al. [15]</td>
</tr>
<tr>
<td></td>
<td>PEOU2</td>
<td>It will be easy for me to become skillful at using an AV.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>PEOU3</td>
<td>I will find an AV easy to use.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>PEOU4</td>
<td>Interaction with an AV will not require a lot of my mental effort.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>PEOU5</td>
<td>I will find it easy to get an AV to do what I want to do.</td>
<td></td>
</tr>
<tr>
<td>Attitude towards using an AV (ATUA)</td>
<td>ATUA1</td>
<td>Using an AV will be a good idea.</td>
<td>Davis, et al. [15]</td>
</tr>
<tr>
<td></td>
<td>ATUA2</td>
<td>Using an AV will be a wise idea.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ATUA3</td>
<td>I like the idea of using an AV.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ATUA4</td>
<td>Using an AV will be a pleasant experience.</td>
<td></td>
</tr>
<tr>
<td>Trust (TRU)</td>
<td>TRU1</td>
<td>AVs are dependable.</td>
<td>Choi and Ji [11]</td>
</tr>
<tr>
<td></td>
<td>TRU2</td>
<td>AVs are reliable.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>TRU3</td>
<td>Overall, I can trust AVs.</td>
<td></td>
</tr>
<tr>
<td>Perceived safety risk (PSR)</td>
<td>PSR1</td>
<td>I am worried that the failure or malfunctions of an AV may cause accidents.</td>
<td>Zmud and Sener [7]</td>
</tr>
<tr>
<td></td>
<td>PSR2</td>
<td>I am worried that the general safety of using an AV is worse than that of driving a common vehicle.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>PSR3</td>
<td>It is unsafe to use an AV.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>PSR4</td>
<td>In general, using an AV is less safe than driving a common vehicle.</td>
<td></td>
</tr>
<tr>
<td>Perceived privacy risk (PPR)</td>
<td>PPR1</td>
<td>I am concerned that AV companies will collect too much personal information from me.</td>
<td>Wang and Lin [42]</td>
</tr>
<tr>
<td></td>
<td>PPR2</td>
<td>I am concerned that AV companies will use my personal information for other purposes without my authorization.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>PPR3</td>
<td>I am concerned that AV companies will share my information with other parties without my authorization.</td>
<td></td>
</tr>
</tbody>
</table>
TABLE 1. (Continued.) Scale items for measuring the constructs in the proposed model with references.

<table>
<thead>
<tr>
<th>Scale items for measuring the constructs in the proposed model with references.</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>PPR4 I am concerned that unauthorized persons (e.g., hackers) have access to my personal information.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PPR5 I am concerned about the privacy of my personal information while using an AV.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PPR6 AV companies will sell my personal information to others without my permission.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Compatibility (COM) COM1 I believe that using an AV is compatible with most aspects of my driving habits.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>COM2 I believe that using an AV fits my lifestyle.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>COM3 I believe that using an AV fits well with the way I like to drive.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>System quality (SQ) SQ1 I believe that AV systems can display sufficient environmental information.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SQ2 I believe that AV systems can provide precise and perfect services in line with the purpose of the systems.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SQ3 I believe that AV systems can provide efficient routes for where I want to go.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SQ4 I believe that AV systems will always display an accurate location in real time.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SQ5 I believe that services provided by AV systems can be quickly loaded and displayed at my request.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SQ6 I believe that I can receive prompt responses to my requests from AV systems.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SQ7 I believe that the rapid processing speed of services provided by AV systems is the biggest advantage of the systems.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intention to use an AV (IUA) IUA1 I will intend to use an AV in the future.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IUA2 I will expect that I would use an AV in the future.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IUA3 I will plan to use an AV in the future.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

TABLE 2. Summary of demographic characteristics and driving-related information (n = 237).

<table>
<thead>
<tr>
<th>Demographic characteristics</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18 – 25</td>
<td>82</td>
<td>34.60%</td>
</tr>
<tr>
<td>26 – 35</td>
<td>110</td>
<td>46.41%</td>
</tr>
<tr>
<td>36 – 45</td>
<td>27</td>
<td>11.39%</td>
</tr>
<tr>
<td>46 – 55</td>
<td>14</td>
<td>5.91%</td>
</tr>
<tr>
<td>&gt; 55</td>
<td>4</td>
<td>1.69%</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>103</td>
<td>43.5%</td>
</tr>
<tr>
<td>Female</td>
<td>134</td>
<td>56.5%</td>
</tr>
<tr>
<td>Education</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grade 12 or less</td>
<td>26</td>
<td>11.0%</td>
</tr>
<tr>
<td>High school graduates</td>
<td>29</td>
<td>12.2%</td>
</tr>
<tr>
<td>Bachelor’s degree</td>
<td>92</td>
<td>38.8%</td>
</tr>
</tbody>
</table>

C. PARTICIPANTS

This study used a convenience sampling technique to collect quantitative data from licensed drivers in public car parks. Specifically, a face-to-face questionnaire survey was conducted in public carparks in Hong Kong. Potential participants were drivers who parked their cars in the carparks during our visit. This study focused on the AVs of SAE level 3, where drivers were required to take control of vehicles when necessary. Prior to the commencement of this survey, people who were interested in our survey were asked to answer three filter questions, including “do you have a valid driving license in Hong Kong?”, “have you ever heard of AVs before this survey?” and “have you ever participated in surveys with similar topics before?” Only those who owned a valid driving license in Hong Kong and had heard of AVs and never participated in similar surveys before could take part in the survey. A total of 237 participants were involved in this survey.

The demographic characteristics and driving-related information of respondents are summarized in Table 2. For demographic characteristics, the age of participants ranged from 18 to 62 with a mean of 30.3 and SD of 8.1. 56.5% of participants were female. Most of them (89.0%) had at least a high-school education level. The majority of participants drove at least twice weekly on average in the past 12 months (62.0%) and had no accident in the past three years (84.8%).

D. DATA ANALYSIS

This study used confirmatory factor analysis (CFA) to investigate the psychometric properties of the scales. When the model fitness indices; ratio of Chi-square value to degree of freedom ($\chi^2/df$), comparative fit index (CFI), standardized root mean square residual (SRMR), and root mean square error of approximation (RMSEA); achieve required levels, the construct validity of the measurement model is considered acceptable [44]. Generally, the higher the value of CFI and the lower the values of the other three indices, the better the fit of the measurement model to data. A model is considered as a good fit when CFI is greater than 0.90, SRMR and RMSEA are smaller than 0.08, and $\chi^2/df$ is smaller than 3 [45]. Convergent validity is the extent to which multiple scale items of the same construct are in agreement while discriminant validity refers to the assessment of how constructs differ from each other empirically [46]. According to Fornell and Larcker [47], to indicate acceptable convergent validity of the measurement for each construct, the factor loading for each item on its designed construct and the composite reliability for each construct should exceed 0.7. Also, the average variance...
extracted (AVE) for each construct should be greater than 0.5. For acceptable discriminant validity of the measurement for each construct, the square root of AVE (SAVE) for each construct should be greater than any of the bivariate correlations among the constructs in the model [47]. Cronbach’s alpha was used to assess the internal consistency of the measurements for each construct. If Cronbach’s alpha is greater than 0.7, the internal consistency is considered acceptable [48].

After the acceptable model fit of the measurement model was achieved, the hypotheses in the proposed model were tested using SEM. The same goodness-of-fit criteria (i.e. \( \chi^2/df < 3 \), CFI > 0.90, SRMR < 0.08, RMSEA < 0.08) were used to assess the model fit of the proposed model. The CFA and SEM analyses were performed in AMOS software.

### IV. RESULTS

#### A. MEASUREMENT MODEL ASSESSMENT

Two items (PSR1 and PU4) were removed because the factor loading of these items was less than 0.7 [49]. The model fit indices of the measurement model, \( \chi^2/df \), CFI, SRMR, and RMSEA, are shown in Table 3. The value of all model fit indices for the measurement model met the recommended criteria, showing that the measurement model fitted sufficiently to the data. Table 4 shows that the factor loading of each item and the composite reliability were greater than the recommended value of 0.7. Also, the AVE of each construct was larger than 0.5. These results concluded that the convergent validity of the measurement was acceptable. All SVEs (Table 5) were larger than each bivariate correlation among the model constructs, showing acceptable discriminant validity of the measurement. Also, the value of Cronbach’s alpha for each construct exceeded the required value of 0.7, demonstrating good internal consistency of the measurement for each construct.

#### B. DESCRIPTIVE ANALYSIS OF THE CONSTRUCTS IN THE MODEL

Respondents on average believed that using an AV will be easy for them (Mean = 3.814, SD = 0.791) and AVs are useful (Mean = 3.702, SD = 0.854). There was no significant difference between male drivers and female drivers in perceived ease of use (\( M_{\text{male}} = 3.734 \), \( SD_{\text{male}} = 0.791 \); \( M_{\text{female}} = 3.876 \), \( SD_{\text{female}} = 0.789 \); \( F(1,235) = 1.886, p = 0.171 \)) but significant difference in perceived usefulness (\( M_{\text{male}} = 3.463 \), \( SD_{\text{male}} = 0.913 \); \( M_{\text{female}} = 3.889 \), \( SD_{\text{female}} = 0.760 \); \( F(1, 235) = 15.114, p < 0.001 \)). Also, the effect of education level on PEOU was not significant (\( F(3, 233) = 1.046, p = 0.373 \)), but the effect of education level on PU was significant. Tukey post-hoc test indicated that participants with an education level of 12 grades or less believed AVs are less useful than those who had a high school level education (\( M_{12\text{grade}} = 3.333 \), \( SD_{12\text{grade}} = 1.037 \); \( M_{\text{high}} = 3.943 \), \( SD_{\text{high}} = 0.812; p = 0.040 \)). PU was negatively associated with driving frequency (\( r = −0.157, p = 0.016 \)) but not significantly associated with the number of driving accidents. PEOU was not significantly associated with driving frequency or number of driving accidents.

#### C. STRUCTURAL MODEL ASSESSMENT

All model fit indices of the structural model achieved the recommended criteria (Table 3), showing that the proposed model can adequately represent hypothesized relationships. The results of the structural model assessment are shown in Figure 3 where solid lines and dotted lines represent significant and non-significant paths, respectively. Table 6 summarizes the path coefficients with corresponding p-values. Three out of the five hypotheses (H1–H5) derived from the original TAM were supported. Specifically, it was found attitude towards using an AV positively influenced intention to use an AV (\( \beta = 0.761, p < 0.001 \), which supported H1). Perceived usefulness significantly influenced attitude towards using an AV (\( \beta = 0.485, p < 0.001 \)), but did not significantly affect intention to use an AV (\( \beta = 0.064, p = 0.514 \)). Also, perceived ease of use did not significantly affect attitude towards using an AV (\( \beta = −0.035, p = 0.575 \)) but did positively influence perceived usefulness (\( \beta = 0.279, p < 0.001 \)). Therefore, H3 and H5 were supported while H2 and H4 were rejected.

Four out of seven proposed hypotheses related to trust and risk perception (H6–H12) were supported. Specifically, trust positively influenced attitude towards using an AV (\( \beta = 0.505, p < 0.001 \) and perceived usefulness (\( \beta = 0.299, p < 0.001 \)), supporting H6 and H7. Also, trust was positively determined by perceived ease of use, supporting H8. Among two types of risk perception (perceived safety risk and
perceived privacy risk), only perceived safety risk negatively influenced trust (β = −0.146, p = 0.004), supporting H10. Perceived safety risk did not significantly affect perceived usefulness (β = 0.027, p = 0.640) while perceived privacy risk did not significantly influence perceived usefulness (β = 0.079, p = 0.145) or trust (β = −0.062, p = 0.201), rejecting H9, H11, and H12.

Five out of six proposed hypotheses related to technological factors (H13-H18) were supported. Specifically, compatibility positively influenced perceived usefulness (β = 0.378, p < 0.001), perceived ease of use (β = 0.227, p = 0.003), and trust (β = 0.290, p < 0.001), supporting H13, H14, and H15. System quality positively affected trust (β = 0.261, p < 0.001) and perceived ease of use (β = 0.389, p < 0.001) but did not significantly influence perceived usefulness (β = −0.042, p = 0.570). Therefore, H16 and H17 were supported while H18 was rejected.

Overall, 12 out of 18 proposed hypotheses were supported. The proposed model can explain 60.1% of the variance in perceived usefulness, 30.3% of the variance in perceived ease of use, and 59.5% of the variance in trust. Also, 77.3% of the variance in attitude towards using an AV and 66.1% of the variance in intention to use an AV were explained. These results demonstrated that the proposed model had very good explanatory power for factors affecting understanding AV acceptance among drivers.

V. DISCUSSION

This study extended TAM by involving trust, risk perception, compatibility, and system quality to examine the causal determinants of driver intention to use an AV in Hong Kong. The proposed AV acceptance model suggests that acceptance towards AVs is determined by attitude towards using an AV. This attitude is shaped by perceived usefulness, perceived ease of use, and trust which are influenced by perceived safety risk, perceived privacy risk, compatibility, and system quality. The results of this study supported 12 of the 18 proposed hypotheses. Also, the proposed AV acceptance model can explain 66.1% of the variance of AV acceptance among drivers. With the results of this study, the theoretical insights into the TAM, trust, risk perception, and technology factors, practical implications for AV developers and the government, the limitations of this study and future research opportunities will be discussed in the following sections.

A. THEORETICAL CONTRIBUTIONS

1) TAM

Three out of the five proposed hypotheses related to TAM were supported, in this study, thereby validating the contribution of TAM to understanding AV acceptance among drivers. Specifically, driver attitude towards using an AV was the most important positive factor in shaping their intention to use an AV, implying that drivers who hold a positive attitude towards AV intend to use an AV. This result was in agreement with the notion of TAM [15] and consistent with that of Zhang, et al. [9] who found that attitude towards using an AV had a positive effect on behavioral intention to use an AV among drivers in Shenzhen, China. However, in contrast to the results of Zhang, et al. [9], in this study of Hong Kong drivers, perceived usefulness was found to positively influence attitude towards using an AV but perceived ease of use did not affect attitude towards using. A possible explanation for these contradictory results is that Hong Kong drivers want high performance effectiveness and fuel efficiency rather than ease of use in driving due to oil prices that are of great concern to Hong Kong drivers [50]. Although perceived ease of use did not directly influence attitude towards using an AV, it had an indirect positive effect on attitude towards using an AV mediated by perceived usefulness. This finding was similar to that of Hu, et al. [51] who found that in the context of fintech services acceptance among bank users, perceived ease of use positively influenced perceived usefulness which then positively affected attitude towards using fintech services. The proposed TAM of this study can explain 66.1% of the variance in intention to use an AV, which is higher than previous studies on AV acceptance among drivers. For instance, the proposed TAM models of Zhang, et al. [9] and Xu, et al. [12] for explaining AV acceptance among drivers found 61% and 55% of the variance in intention to use an AV, respectively. These results indicate that the proposed TAM model in this study contributes to a better understanding of factors affecting AV acceptance by drivers.

2) TRUST

Trust has been regarded as an important factor in human-automation interaction [22]. Ghazizadeh, et al. [52] proposed an automation acceptance model (AAM) which included trust as a crucial contributor to explain user acceptance of automation technology. Previous studies have used trust to explain technology acceptance related to automation such as automated sinks for hand decontamination [53]. In the context of AV acceptance, the AAM was embraced by Körber, et al. [54] who suggested that trust in AVs is a vital precondition for facilitating the acceptance AVs to take advantage of benefits such as human error reduction. This study found that trust had a positive influence on attitude towards using an AV and perceived usefulness, which is consistent with the findings of Zhang, et al. [9] and Xu, et al. [12]. These findings support the extension of TAM of Davis, et al. [15] by taking trust into account in shaping attitude towards using an AV with direct and indirect effects. The indirect effect was mediated by perceived usefulness. Compared with two TAM constructs (perceived usefulness and perceived ease of use), trust was the strongest predictor of attitude towards using an AV among drivers. In addition, this study found that trust was positively determined by perceived ease of use, confirming the suggestion of El walda, et al. [27] that customer trust in a technology can be influenced by perceived ease of use. In other words, perceived
Ease of use can indirectly affect attitude towards using an AV through mediation of trust. Therefore, driver distrust in AVs may become the biggest challenge for the mass adoption of AVs.
3) RISK PERCEPTION

In this study, risk perception was classified into two aspects, namely, perceived safety risk and perceived privacy risk. The results here showed that perceived safety risk negatively influenced trust but perceived privacy risk did not significantly influence trust, a result consistent with the findings of Zhang, et al. [9]. These results suggest that Hong Kong drivers were concerned more about safety risks than privacy risks when using an AV. When Hong Kong drivers believed that the safety risks in using an AV are acceptable, they tend to have a high level of trust in AVs. This result can be explained by the fact that potential losses resulting from privacy violations are less observable and less immediate than safety risks in the context of driving. Moreover, Hong Kong is one of the first jurisdictions outside Europe to pass a data protection law, namely the Personal Data (Privacy) Ordinance (PDPO) [55]. Under the PDPO, the office of the privacy commissioner in Hong Kong has the responsibility to oversee the compliance of the PDPO and handle privacy violation complaints made by the public.

4) TECHNOLOGY FACTORS

In this study, the technology factors in relation to AVs were compatibility and system quality. Although previous studies have taken compatibility and system quality into account to explain individuals acceptance of a variety of technologies such as; learning management systems [56], smartphone credit card [57], tablet computer [58] and Uber mobile application [59]; no studies have investigated the role of compatibility and system quality in AV acceptance among drivers. Therefore, this study is the first attempt to fill this knowledge gap by considering compatibility and system quality to explain AV acceptance among drivers. The results of this study showed that compatibility and system quality positively influenced trust and perceived ease of use while compatibility positively affected perceived usefulness, which are results similar to those of Ahmad, et al. [60] and Min, et al. [59]. These results suggested that if AVs have good compatibility and system quality, drivers tend to have a high level of trust in AVs and perceive that AVs are useful and easy to use. The importance of compatibility and system quality in shaping AV acceptance among drivers was a significant finding for this study.

B. THEORETICAL CONTRIBUTIONS

1) AV DEVELOPERS

The results of this study can serve as an important basis to help AV developers to design AVs and decide how to promote the adoption of AVs among drivers. Trust that can be determined by compatibility, system quality, and perceived safety risk was found to have the greatest effect on attitude towards using an AV. As a result, AV developers should focus on improving compatibility, system quality, and safety of AVs because these factors are so significant in shaping driver trust. For example, AV developers need to understand the driving needs and styles of drivers by conducting user surveys so that they can design AVs with good compatibility and good system quality for drivers. Notably, the compatibility of AVs may be improved by designing a user-friendly human-machine interface which can help improve human performance generally and in handling emergency events when using an AV [61]. Moreover, AV developers should devote attention to addressing the safety issues of using AVs, such as possible driver distractions, overreliance on AVs, skill degradation, potential cyberattacks, and automation system failure. AV exhibitions should be organized to demonstrate how the safety features of AVs are useful to protect passengers in different road situations and weather conditions and offer users opportunities to directly experience AVs.

Apart from trust, perceived usefulness was found to positively influence attitude towards using an AV. Therefore, AV developers can advertise the advantages of using an AV, such as high fuel efficiency, increasing mobility, and relieving congestion by using different media such as television, newspapers, and the Internet to enhance perceived usefulness of AVs among drivers. Additionally, AV developers should provide information about AV features and customer-tailored training to drivers to enhance perceived usefulness of AVs and trust. During such training, the usefulness of the functions of the automation system in AVs should be emphasized.

2) GOVERNMENTS

To facilitate the adoption of AVs among drivers, governments play an important role in balancing AV safety and regulations. Regulations can be developed to provide a framework to set a minimum safety standard for AVs and sufficient manpower to ensure that AV developers comply with such safety standard when designing AVs. Technology support programs...
should be given to AV developers to encourage them to upgrade the safety level of AVs and introduce innovative safety technologies. As well as AV safety, privacy concerns about the disclosure of travel data would be a potential barrier to acceptance of AVs. Governments need to develop regulations to protect the privacy of AV users and effectively handle privacy violation complaints related to the use of AVs.

C. STUDY LIMITATIONS AND FUTURE RESEARCH OPPORTUNITIES

Despite the contributions of this study to the relevant literature and the useful practical implications for enhancing AV acceptance among drivers, the study has some limitations that need to be recognized when utilizing and interpreting the results. First, this study used subjective measurements of trust and risk perception which might involve social desirability bias [62]. Physiological indicators such as galvanic skin response and electroencephalography could be used to more objectively measure trust and risk perception among drivers [63], [64]. Second, although participants in this study had heard of AVs before, they did not have experience of using an AV. Longitudinal studies can be conducted to investigate how the effects of constructs in the proposed research model on AV acceptance among drivers change with experiences and time. Third, this study did not consider other important factors in the proposed research model, such as perceived cyberattack risk [1], inter-vehicle-related compatibility [36], and complexity [59]. Therefore, additional research is needed to examine the effect of these factors on AV acceptance among drivers.

VI. CONCLUSION

In this paper, an AV acceptance model that involved TAM constructs, trust, risk perception, compatibility and system quality for explaining AV acceptance among drivers was proposed and tested using SEM. The results showed that the model explained intention to use an AV among drivers very well and verified the applicability of TAM to the explanation of AV acceptance among drivers. Trust and perceived usefulness positively influenced attitude towards using an AV which positively determined intention to use an AV among drivers. The significant antecedents of trust that were identified here were; compatibility, system quality, and perceived safety risk. This study highlighted the importance of technological factors related to AVs in shaping AV acceptance among drivers and encouraged more research efforts on technological factors in the future. The results of this study can help AV developers and governments to devise effective interventions to facilitate the adoption of AVs among drivers.

REFERENCES


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