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A Review of Perceived Risk Role in Autonomous Vehicles Acceptance

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Abstract

The purpose of this study is to critically review literature pertaining to the theoretical concept of perceived risk and its role in autonomous vehicle (AV) studies. A mapping on the placement of perceived risk to explain its position concerning AV acceptance either as a direct predictor or mediator as well as the number of dimensions used (i.e., single or multi-dimensions) in the context of AV, will be derived based on the critical review. Interestingly, a critical gap was discovered in which very little attention had been paid to the use of perceived risk as the multidimensional constructs that included financial risk, time risk, performance risk, psychological risk, social risk, and physical risk. The embedded meaning in the single perceived risk term might be one of the reasons leading to the inconclusive findings on the understanding of public acceptance of AVs. Furthermore, the review revealed that the role of perceived risk could be classified into four clusters using a knowledge map. This study enriches the literature by providing a summary framework map for various dimensions of perceived risk used in studying the public acceptance of AVs. Insights of the framework can help researchers to formulate better future research directions in evaluating the impacts of constructs in adopting AVs.

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1. Introduction

Autonomous vehicle (AV) is an evolving technology that is widely advocated to bring numerous potential benefits to society and human beings such as reducing traffic crashes due to human error, promoting sustainable development as well as providing alternative transport to disabled groups (Xu et al., 2018; Bennett et al., 2019). Contrary to the conventional vehicle where the human driver has full control of the vehicle, the AVs require most minor or no supervision. It can be classified into six levels from Level 0 (no automation) to Level 5 (full automation) (SAE, 2018). It is estimated that the Level 5 AV will capture 50% of the new car market share by 2050 (Kyriadikis et al., 2015). However, the doubt on the safety of AVs is always a concern and intensified following a fatal incident where a pedestrian was killed by an automated vehicle in 2018 (National Transportation Safety Board, 2019). Hence, the greatest challenge faced by a high-tech firm is getting customers to try the technology, rather than managing the technology. (Zhang et al., 2019).

Subsequently, the safety aspect of AVs, or more to be known as perceived risk towards the AVs has drawn serious attention from the practitioners and researchers. The recent definition of the perceived risk includes "the uncertainty that consumers face when they cannot foresee the consequences of their purchase decisions" (Schiffman and Kanuk 2014, p.153). It focuses on the uncertainty and the severity of an outcome (Bauer, 1960). In the context of AVs studies, many studies have proven that consumers' perceived risk is one of the major barriers to public acceptance on AVs as people have very little experience with AVs (Park et al. 2005; Nordhoff et al., 2016; Zhang et al., 2021). Nevertheless, the role of risk on acceptance of AVs has been widely explored but the findings are mixed (Kenesei et al., 2022) due to the different dimensions used to measure perceived risk. Kenesei et al. (2022) attributed the reason behind the ambiguous evidence is because the perceived risk is often treated as one-dimensional construct in the AVs acceptance studies though the perceived risk can be further expanded into six (6) facets: performance risk, financial risk, social risk, psychological risk, safety risk and time risk (Hsieh, 2015).

This study explores the types of perceived risk theoretically and empirically in the public acceptance of AVs studies as well as the relationships with other antecedents. This study has three objectives: (1) introducing the concept of perceived risk; (2)

reviewing the evolution of different dimensions of perceived risk in past studies particularly related to AVs; (3) presenting a knowledge mapping of the inter-relationships between different types of perceived risks and behaviour intention to use AVs and (4) suggesting the future research direction. The findings of this study are expected to provide insights to the practitioners and researchers on the role of different types of perceived risk in influencing the public acceptance of AVs thereby devising the most appropriate policy or intervention to adapt to the user's perceptions.

2. Literature Review and Hypotheses Development

2.1 Definition of Perceived Risk

According to Cox and Rich (1964), perceived risk can be defined as "the nature and amount of risk perceived by a consumer in contemplating a particular purchase decision" (Cox and Rich, 1964, pg. 33). Peter and Ryan (1976) described perceived risk as an individual's expected costs incurred from a purchase that impeded future purchase behaviour. In general, perceived risk in consumer behavior research is all about gauging consumer perceptions, cognitive calculations and emotional feeling of risk or threat as in most of the time, the actual risk is unknown (Loewenstein et al., 2001). Taylor (1974) suggested that the perception of risk is influenced by one's ambiguity on the result about the decision's outcome and/or the degree of consequence association. Featherman et al. (2021) surmised that there are some consumers who used to focus on the hedonic benefits instead of the potential losses, thereby leading to the difficulty in measuring the risk concerns. Besides, some consumers might treat risk as a negative force affecting their consumption emotion but there are other peers who would see risk as useful in delaying their purchase decision (Featherman et al., 2021).

2.2 Dimensions of Perceived Risk

Bauer (1960) in his seminal work proposed that there are some elements of risk in consumer behavior particularly on new technology products or services, where the action of a consumer would result in the consequences he or she perceived with some uncertainty. There are two elements of perceived risk (i.e., perceived uncertainty of outcomes and the perceived importance of negative consequences). Bauer (1960) further described that a consumer would find methods to reduce the risk perceived by looking

for information that helps them to behave confidently without fear. Since then, this construct of perceived risk has received wide attention in various aspects of consumer behavior and several definitions have been developed. The literature has accentua ted the evidence of the dimensions of perceived risk. Jacob and Kaplan (1972) categorized perceived risk into five facets: "financial risk, performance risk, physical risk, psychological risk, social risk, and overall risk". Peter and Tarpey (1975) suggested including the time risk as another new element of perceived risk.

Nevertheless, the risk profiles differ in terms of products from the aspects of electric vehicles, e-commerce, and online banking. As such there are various definitions on perceived risk (Featherman and Pavlou, 2003). In online banking studies, perceived risk is always attributed to uncertainty, privacy, security, and vagueness (Yang et al., 2015; Alalwan et al., 2016). The anxiety, privacy as well as the internet infrastructure are among the main concerns related to e-commerce (Hong, 2015) while in the domain of e-healthcare, perceived risks are principally on the inherent and levels of medical officers' exercising the health IT (Hsieh, 2015). With this, Table 1 provides the operational definitions of Perceived Risk (Jacoby and Kaplan, 1974).

Table 1 Operational definitions of perceived risk (Jacoby and Kaplan, 1974)

Type of perceived risk	Operational Definition	Anchor Points
Financial risk	"What are the chances that you stand to lose money if you try an unfamiliar brand of _____ (either because it won't work at all, or because it costs more than it should to keep it in good shape)?"	"1= low chance of losing money; 9 = high chance of losing money"
Performance risk	"What is the likelihood that there will be something wrong with an unfamiliar brand of _____ or that it will not work properly?"	"1 = low functional risk; 9 = high functional risk"
Physical risk	"What are the chances that an unfamiliar brand of ____ or that it will not work properly?"	"1 = low functional risk; 9 = high functional risk"
Psychological risk	"What are the chances that an unfamiliar brand of ____ will not fit in well with your self -image or self-concept (i.e. the way you think about yourself)?"	"1 = low psychological risk; 9 = high psychological risk"
Social risk	"What are the chances that an unfamiliar brand of _____ will affect the way others think of you?"	"1 = low psychological risk; 9 = high psychological risk"

Table 2 illustrates the application of multidimensional perceived risks in different consumer industries. It is interesting to note that perceived social risk is the most studied variable in consumer marketing in the past decades but was found rarely explored in

recent year particularly in AV acceptance study. As expected, over the years, the quality of a product, its performance, the costs incurred and how a new product to be adopted by consumers are the main research elements in consumer behaviour research. This review also shows that privacy risk emerges as an important determinant since 2002 and subsequently captured the attentions of researchers. In contrast, only one research examined security factor while the safety factor was explored in other five studies which implies there is inherent issue on the embedded meanings between security and safety. Based on Table 2, perceived risk is another determinant examined since 2015. The single term used to encompass the overall uncertainty components may be one of the reasons contribute to the ambiguous results.

Table 2 Type of perceived risks

Risk type	Researchers	Frequency
Delivery	Hong (2015)	1
Environmental	Ali L. and Ali F. (2022)	1
Financial (economic loss)	Jacoby and Kaplan (1972), Peter and Ryan (1976), Stone and Gronhaug (1993), Kurtz and Clow (1997), Schiffman and Kanuk (2014), Hong (2015), Ali L. and Ali F. (2022)	7
Functional	Taylor (1974), Stone and Gronhaug (1993), Schiffman and Kanuk (2014)	3
Perceived risk	Choi and Ji (2015), Lee et al. (2019), Liu et al. (2019), Zhu et al. (2020), Kapser and Abdelrahman (2020), Ribeiro et al. (2022)	6
Physical	Jacoby and Kaplan (1972), Peter and Ryan (1976), Stone and Gronhaug (1993)	3
Product performance (quality)	Jacoby and Kaplan (1972), Peter and Ryan (1976), Kurtz and Clow (1997), Hong (2015), Waung et al. (2021), Benleulmi and Ramdani (2022), Kenesei et al. (2022)	7
Privacy	Belanger et al. (2002), Kaur and Rampersad (2018), Zhang et al. (2019), Man et al. (2020), Waung et al. (2021), Benleulmi and Ramdani (2022), Kenesei et al. (2022)	7
Psychological	Jacoby and Kaplan (1972), Peter and Ryan (1976), Stone and Gronhaug (1993), Kurtz and Clow (1997), Schiffman and Kanuk (2014), Hong (2015), Ali L. and Ali F. (2022)	7
Safety	Schiffman and Kanuk (2014), Hong (2015), Xu et al. (2018), Zhang et al. (2019), Man et al. (2020)	5
Security	Kaur and Rampersad (2018)	1
Social	Jacoby and Kaplan (1972), Taylor (1974), Peter and Ryan (1976), Stone and Gronhaug (1993), Kurtz and Clow (1997), Schiffman and Kanuk (2014), Hong (2015), Ali L. and Ali F. (2022)	8
Time (convenience, time loss)	Peter et al. (1975), Peter and Ryan (1976), Schiffman and Kanuk (2014)	3

2.3 Perceived Risk (PR) in AV Acceptance

Despite touting the benefits of AVs in saving lives due to traffic crashes, many people associated AVs with potential hazards, ambiguity, and loss of control (Kyriakidis et al., 2015). Waycaster et al. (2018) pointed out that people usually have higher demand for safety in AVs as they must entrust their safety to the automated technology system. Liu et al. (2019) has shown in their study that respondents contend that Self-Driving Vehicle (SDV) must be four to five times safer than the conventional human-controlled vehicles. When a new technology product is yet to be available massively in the market, lack of direct experience can make risk perception and uncertainty become salient (McKnight et al., 2002). Perceived risk means the degree of peril experienced by users and it differs from actual or operational risk (Kolekar et al., 2020; Griffin et al., 2020). When the perceived risk is low, users would feel at ease, comfortable and safe (Osswald et al., 2012; Xu et al., 2018). Inversely, users would be more likely to stay alert or cautious when he/she perceived high risk. Perceived risk was affected by individuals' experiences, attitudes, personalities (Jin et al., 2020; Ping et al., 2018) and road conditions (Cox et al., 2017). People who have experienced traffic accidents would be more likely to switch to AVs (Bansal et al., 2016). In short, perceived risk results from an adverse outcome of a purchase or use intention.

Extant studies have noted that perceived risks associated with AVs are mainly related to safety risk due to the malfunction of technology or system failures, privacy risks on the possibility of travel or personal data leakage, cyber security risk as well as performance risk where AVs are unable to perform up to expectation (Benleulmi and Blecker, 2017; Menon et al., 2016; Kenesei et al., 2022). More than 80% of respondents in the US were worried about the potential safety issues while as high as 33% of surveyed drivers expressed concerns on privacy disclosure (Menon et al. 2016).

A critical review of the past studies related to perceived risk in AV was conducted and the summary is documented in Table 3 and the knowledge map is presented in Figure 1. Only literature related to the influence of perceived risk on the intention to use AVs behaviour are included in Table 3. Kenesai (2022) noted that there is very little research that has differentiated the types of perceived risk as described by Jacoby and Kaplan (1974). Of the prominent six dimensions of risk described earlier, the unified measure of perceived risk, performance risk, privacy or security risk and perceived safety risks were

mainly explored in past studies. Results revealed that the causal links for perceived risk were predominantly established between perceived risks and trusts or behavior intention. Nonetheless, mixed results are found leaving the mechanism of perceived risk pathway in the argument (Kenesei et al., 2022). Kenesei et al. (2022) further suggested that the mixed results might be due to the embedded meaning in a single term. For instance, performance trust influences performance risk but not privacy risk. Therefore, distinguishing the dimensions of risk can help researchers differentiate between their different facets and make better interpretations.

On the other hand, it is also interesting to note the relationship between availability of information and perceived risk in shaping AV acceptance. Zhu et al. (2020) found that mass media and social media have a direct impact on consumer self-perception and AV perception which would indirectly affect adoption intention. While AVs are yet to be commercialized in the market, its presence and benefits discussed in social media can have a great effect on the adoption of AVs (Anania et al., 2018). Therefore, a negative incident of AVs can be magnified with the influence of social media, thereby affecting consumers purchase decision (Darshan, 2018).

Table 3 Selected literature related to perceived risk on AV

Authors	Objective	Theory	Path Related to Perceived Risk	Results
Zhang et al. (2019)	To explore factors affecting users' acceptance of automated vehicles (AVs, Level 3).	Extended TAM theory with the initial trust build theory	PSR→TRU PCR→TRU	Significant Not significant
Xu et al. (2018)	To assess the effect of direct experience of an automated vehicle (AV Level 3) and estimating the public acceptance via a psychological model	TAM	Mediation model: TRU→PSR→BI TRU→PSR→WTR	All were significantly related
Waung et al. (2021)	To evaluate the effect of information on BI	-	SCR/Privacy→BI PFR→BI PFR→TRU PCR→TRU	All were significantly related
Ribeiro et al. (2022)	To determine factors influencing commuters' intentions to use autonomous vehicles (AVs)	Cognitive Appraisal Theory and the Artificially Intelligent Device Use Acceptance	PR→EMO PR→EMO→BI PR→EMO→OBJ HM→PR SI→PR	All were significantly related

		model		
Zhu et al. (2020)	To explore the factors that might influence potential users' perception and acceptance of AVs.	-	MM→PR SM→PR SE→PR SN→PR PR→BI	Significant Significant Not significant Significant Significant
Lee et al. (2019)	To examine factors influencing the intention to use autonomous vehicles	TAM	SE→PR PEOU→PR PR→BI	Not significant Not significant Significant
Liu et al. (2019)	To assess and forecast FAD acceptance based on the trust heuristic in risk perception study.	-	ST→PR PR→GA PR→WTP PR→BI	Significant Significant Significant Not significant
Benleulmi and Ramdani (2022)	To investigate the influence of of instrumental, symbolic, and affective motives on the behavioral intention to adopt full automation vehicles	Instrumental, symbolic, and affective model (Dittmar, 1992)	PFR→BI PCR→BI	Significant Not significant
Choi and Ji (2015)	To investigate the factors influencing the people in trusting the autonomous vehicle.	TAM	TRU→PR PR→BI	Significant Not significant
Kapser and Abdelrahman (2020)	To investigates the users' acceptance of ADVs in Germany	UTAUT2	PR→BI	Significant
Kenesei et al. (2022)	To examine the roles of trust and perceived risk on AV acceptance	-	PFR→BI PCR→BI PFT→PFR MT→PFR MT→PCR IT→PFR IT→PCR	Not significant Significant Significant Not significant Significant Not significant Not significant
Man et al., 2020	To identify critical factors that influence acceptance of automated vehicles among drivers.	TAM	PSR→PU PSR→TRU PCR→PU PCR→TRU	Not significant Significant Not significant Not significant
Kaur and Rampersad, 2018	To examine the influential factors in the adoption of driverless	-	SC→TRU PV→TRU	Significant Significant

cars.

Notes: BI= Behavioral Intention; HM= Hedonic Motivation; IT= Institutional Trust; MM= Mass Media; PEOU= Perceived Ease of Use; PCR=Perceived Privacy Risk; PFR=Perceived Performance Risk; PFT= Perceived Performance Trust; PR=Perceived Risk; PSR=Perceived Safety Risk; PU=Perceived Usefulness; PFT= Perceived Performance Trust; PV= Privacy; MT= Manufacturer Trust; SE= Social Efficacy; SC = Security; SM= Social Media; ST= Social Trust; TRU=Trust

As illustrated in the knowledge map (see Figure 1), the study of perceived risk determinants can be divided into four clusters. In the first cluster, perceived risk is the mediator between the other constructs and behavioral intention, and the perceived risk is classified into four facets namely: perceived risk, perceived performance risk, perceived privacy risk and perceived safety risk, of which, perceived ease of use (PEOU) and social influence have no impact on perceived risk. In the second cluster, four dimensions of perceived risk (i.e., perceived performance risk, security risk, perceived safety risk and perceived privacy risk) are constructed to have the indirect effects on the behavioral intention via trust and perceived usefulness. Perceived performance risk and perceived safety risk acted as the direct predictors of trust. In the third cluster, perceived risk, performance risk, and privacy risk have direct relationship on behavioral intention to use AVs. In the last cluster (cluster 4), perceived risk is served as a unidimensional construct that influence the intention through emotion.

It is also vital to note that the numerous past studies have revealed the relationships between trust and risk, concerning the pathway and constructs have been studied extensively. Hence, understanding how and which perceived risk would affect AV acceptance deserves further attention (Zhang et al, 2019). Lee et al. (2019) pointed that wrongly defined perceived risk is one of the reasons that led to inconclusive findings in previous studies (Choi & Ji, 2015; Xu et al., 2018). Lee et al. (2019) further elaborated that it is essential to take the underlying structure of perceived risk into consideration in order to reach a comprehensive understanding of the potential adoption of autonomous vehicles.

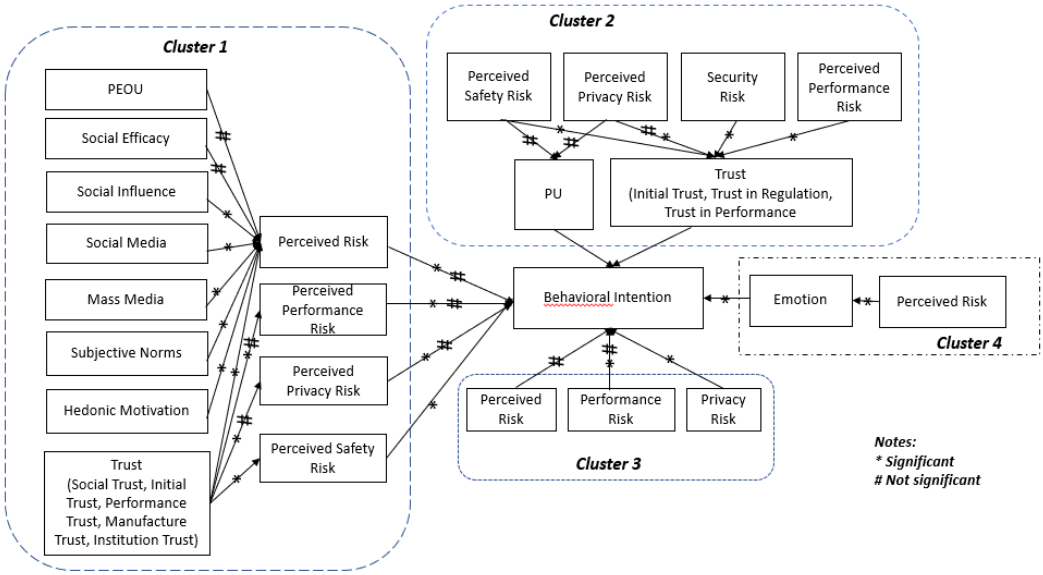

Figure 1 Knowledge map of perceived risk

3. Conclusion

Since the seminal work by Bauer (1960), research in consumer behaviour has extensively examined the elements of perceived risk. The use of autonomous vehicles on the road is still relatively new in the Asian market, particularly in Malaysia, a developing country. Although AVs have been reported as a much safer alternative than traditional human-driven vehicles, the high perceived risk can be a main obstacle to the user acceptance. Many academics and practitioners have been interested in the user perception of the risk of using Avs, but studies have frequently yielded conflicting results. Therefore, this paper provides a critical review pertaining to the role of perceived risk in relation to AVs acceptance and presents a knowledge map with a clearer picture to explain its role in AV acceptance into four clusters. The knowledge map exhibits the placement of perceived risk as a direct or indirect predictors (i.e., mediator) of the AVs adoption. Nonetheless, through the critical review, the mixed results reported on the AVs acceptance could be due to the different facets of perceived risk used in the past studies. There is an urgent call for additional studies with more dimensions of perceived risk to be included. For instance, the perceived risk in terms of financial risk, physical risk, psychological risk and social risk as proposed by Jacoby and Kaplan (1974) are yet to be explored fully in the acceptance of AVs' studies. Consumer might be reluctant to try AV if there is a risk of financial loss due to the immature maintenance and support in the country.

Additionally, the psychological risk such as the concerns and worry while riding in a AV might also hinder the potential acceptance of AVs. Meanwhile, the consequence of physical damaged either to the environment or property in the event of crashes can be another challenge to the diffusion of AVs. Hence, a better understanding of public acceptance in the context of various facet risks in AVs can help practitioners increase their efforts to reduce risk and build confidence, thereby increasing the adoption of this technology among road users.

Last but not least, the research is not without limitations. This study is based on a few selected glimpsed of literature applying perceived risk constructs. The use of perceived risk dimensions should be employed together with other variables such as trust and other attributes of interests. While it is acknowledged that socio-demographic, level of AVs studied (Level 3, 4 or 5, full automation) and spatial distribution play an important role in adopting AVs, the framework of this study was not established on the foundation of these factors. Further research should investigate more extensive web of framework mechanisms to study the impact of multi dimension perceived risk and societal impacts of adopting AVs with different causal link pathways.

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