UNDERSTANDING THE ACCEPTABILITY OF SHARED AUTONOMOUS VEHICLE (SAV) IN RIDE-HAILING SERVICES

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UNDERSTANDING THE ACCEPTABILITY OF SHARED AUTONOMOUS VEHICLE (SAV) IN RIDE-HAILING SERVICES

by

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LIST OF ABBREVIATIONS

ADAS	Advanced driving assistance systems
AI	Artificial Intelligent
AIDUA	AI Device User Acceptance
AV	Autonomous Vehicle
AVAM	Autonomous Vehicle Adoption Model
CAT	Cognitive Appraisal Theory
EV	Electric Vehicle
IDT	Innovation Diffusion Theory
SAV	Shared Autonomous Vehicle
TAM	Technology Acceptance Model
TPB	Theory of Planned Behaviour
UTAUT	Unified Theory of Acceptance and Use of Technology
VAM	Value based Adoption Model

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PEMAHAMAN PENERIMAAN KENDERAAN AUTONOMI PERKONGSIAN DALAM PERKHIDMATAN PERNIAGAAN PENGANTARAAN (RIDE-HAILING)

ABSTRAK

Industri automotif mengalami perubahan besar dengan diperkenalkannya kenderaan autonomi (AV) yang meningkatkan keselamatan jalan raya dan mobiliti bandar. Namun, kos yang tinggi menjadi cabaran. Kenderaan autonomi perkongsian (SAV), terutamanya Robo-taxi, dengan perkhidmatan perniagaan pengantaraan, adalah penyelesaian yang berpotensi. Penyelidikan terdahulu telah mengkaji faktor penerimaan AV, tetapi kurang memberi tumpuan kepada pandangan kognitif pengguna perkhidmatan perniagaan pengantaraan perkongsian yang berasaskan kecerdasan buatan dalam perjalanan harian. Kajian ini memperkenalkan Model Penerimaan Robo-taxi (RAM) yang menggabungkan Teori Penilaian Kognitif (CAT), Model Penerimaan Penggunaan Peranti Kercedasan Buatan (AIDUA) dan Model Penerimaan Berasaskan Nilai (VAM). Satu tinjauan telah dijalankan pada Ogos 2022 dengan 344 responden. Data dianalisis dengan SmartPLS 4.0.8 dan SPSS 27. Keputusan menunjukkan persepsi kenikmatan, persepsi sokongan dasar, kelebihan relatif, kepercayaan, dan pengaruh sosial mempunyai kesan positif manakala persepsi bayaran memberi kesan negative ke atas persepsi nilai. Kelebihan relatif dan efikasi diri memberi kesan positif ke atas persepsi kegunaan, sementara kepercayaan memberi kesan negative ke atas persepsi risiko. Persepsi nilai memberi ramalan yang kuat terhadap emosi, dan emosi mempengaruhi penerimaan, walaupun setelah mengambil kira kesan gangguan potensi pemboleh kawalan. Penemuan ini memberikan implikasi praktikal kepada penyedia perkhidmatan dan pihak berkuasa dalam menyediakan

penggunaan Robo-taxi, memberikan wawasan tentang faktor-faktor kognitif, afektif dan psikologi dalam interaksi perkhidmatan.

UNDERSTANDING THE ACCEPTABILITY OF SHARED AUTONOMOUS VEHICLE (SAV) IN RIDE-HAILING SERVICES

ABSTRACT

The automotive industry is witnessing a major shift with the introduction of autonomous vehicles (AV) that offer improved road safety and urban mobility. However, the high cost of AV poses a challenge. Shared autonomous vehicles (SAV), particularly Robo-taxi services with ride-sharing capabilities, present a potential solution. While previous studies have explored factors influencing AV acceptance, little research focuses on ride-hailing users' cognitive perspectives on Artificially Intelligent (AI) based SAV in daily commutes. This study introduces the Robo-taxi Acceptance Model (RAM), integrating the Cognitive Appraisal Theory, the Artificially Intelligent Device Use Acceptance (AIDUA) model, and the Value-based Adoption Model (VAM). A survey was conducted in August 2022 with 344 respondents. The collected data was analysed using SmartPLS 4.0.8 and SPSS 27. The results indicated that perceived enjoyment, perceived policy support, relative advantage, trust, and social influence had positive effects, while perceived fee had a negative impact on perceived value. Relative advantage and self-efficacy positively influenced perceived usefulness, and trust negatively affected perceived risk. Perceived value significantly predicted emotion, and emotion influenced acceptance, even after accounting for the potential confounding effects of the control variables. These findings have practical implications for service providers and authorities in preparing for the adoption of AI-based Robo-taxi, providing insights into cognitive, affective, and psychological factors in service encounters.

CHAPTER 1

INTRODUCTION

1.1 Introduction

"In the next 10 years, the auto industry will undergo a profound transformation: the cars it builds, the companies that build them, and the consumers who buy them will all look significantly different." - Goldman Sachs, Technology Driving Innovation (2020)

This chapter delves into the research on the transformative impact of autonomous vehicles on the automotive industry, particularly in the context of the ride-hailing sector. The potential benefits of this technology for individual users and the environment, as well as its role in shaping urban mobility, are extensively explored. Additionally, the chapter provides an overview of Malaysia's current autonomous vehicle policy and program status, analysing its potential advantages for the country's citizens.

The subsequent section addresses the key issues that this study aims to tackle. It outlines the study's objectives, research questions, significance, and the contributions it seeks to make. Furthermore, the chapter offers precise definitions of essential terms used throughout the study and clearly outlines its scope of investigation.

1.2 Background of the research

1.2.1 Autonomous Vehicles

An autonomous vehicle (AV) is defined as a vehicle that either operates without a human driver or requires minimal human intervention (Sener & Zmud, 2019; Yuen et al., 2021; Yuxiao Zhang et al., 2023). AV is also known by various names such as robocar, driverless car, self-driving car, and unmanned vehicle (Foroughi et al., 2023; Jungkun Park et al., 2021).

The rapid advancement of AV technology in recent years has attracted considerable global attention. It is anticipated that within the next few years, AV will become widely available to consumers after extensive testing on public roads (Kosuru & Venkitaraman, 2023; Yokoi & Nakayachi, 2020). The development of AV has been greatly accelerated by substantial investments from information technology giants like Google and Baidu, transportation networking companies like Uber, DiDi, Lyft, and Grab, as well as automakers like Tesla, General Motors, Volvo, and BMW, and semiconductor manufacturers like Intel, Nvidia, and Qualcomm (Ma et al., 2020).

Governments worldwide have also taken initiatives to formulate policies to enable the safe deployment of AV on public roads. For example, on March 10, 2022, the National Highway Traffic Safety Administration (NHTSA) of the U.S. Department of Transportation issued a ground-breaking final rule to ensure passenger safety in AV. This milestone regulation ensures that passengers in AV-equipped vehicles will experience the same high level of occupant accident safety as in traditional vehicles (NHTSA, 2022). This rule also relieves automakers from the obligation to equip AVs with manual driving controls to comply with crash standards, which had previously posed significant challenges for the adoption of AV technology (Shepardson, 2022).

The proliferation of AVs is poised to enhance mobility and travel efficiency, leading to improved traffic flow and reduced congestion(Bouchouia et al., 2023; Jones & Leibowicz, 2019). Furthermore, AVs have the potential to significantly curb carbon emissions and pollution levels (Chehri & Mouftah, 2019; S. A. Cohen & Hopkins, 2019; Foroughi et al., 2023; Manfreda et al., 2021). In essence, AVs hold the power to revolutionize the travel sector (Ribeiro et al., 2021), reshape urban tourism tourism (S. A. Cohen & Hopkins, 2019), transform urban mobility (Acheampong et al., 2023; Foroughi et al., 2023; Golbabaei et al., 2020; Y.-C. Lee & Mirman, 2018; M. Liu et al., 2020; McLeay et al., 2022), and promote sustainability (Prideaux & Yin, 2019).

The introduction of AV could play a pivotal role in reducing traffic accidents (Chehri & Mouftah, 2019; Foroughi et al., 2023; Kacperski et al., 2021; Montoro et al., 2019; Waung et al., 2021). With an alarming global annual toll of 1.3 million fatalities in car accidents (World Health Organization, 2021), human error emerges as the chief culprit, accounting for 94% of severe crashes, as reported by the US Department of Transportation (NHTSA, 2017). Factors such as speeding, driving under the influence, disregard for seatbelts or helmets, and distracted driving are among the primary causes (World Health Organization, 2021). The advent of autonomous driving technology, eliminating the human driver factor, holds the promise of saving lives while simultaneously enhancing overall mobility (Waymo, 2022a).

Despite the prevailing uncertainties and reservations among consumers regarding the practicality of self-driving AVs (Foroughi et al., 2023; I. P. Tussyadiah et al., 2017), these AVs are progressively assuming a substantial role in our daily routines. An increasing number of automobile manufacturers are integrating self-driving capabilities as optional enhancements or standard features. Advanced driving assistance systems (ADAS), encompassing self-parking, lane-keeping assist systems, adaptive cruise control, and blind spot detection, are steadily gaining prevalence as fundamental components of AV deployment strategies (Jun et al., 2019). The Society of Automotive Engineers (SAE) has categorized these technologies as Levels 1 and 2 of automation, as they still necessitate certain driving-related tasks to be performed by the drivers. The evolution of vehicle systems advances through Levels 3 (conditional automation), Level 4 (high automation), and ultimately reaches Level 5, where human driver involvement becomes minimal (full automation). Level 5 signifies a vehicle's capacity to drive itself comprehensively, involving abilities to 'perceive', 'think', and 'reason' akin to a human driver.

In response to these requisites, recent strides in artificial intelligence (AI) have forged a natural alignment between AI and AVs (Foroughi et al., 2023; Golbabaei et al., 2022; Meyer-Waarden & Cloarec, 2022). Nevertheless, beyond technological progress, several notable barriers persist in the widespread adoption of AVs, encompassing ethical, legislative, and societal concerns, notably the acceptance by the public (Cartenì, 2020; Kosuru & Venkitaraman, 2023; Waltermann & Henkel, 2023).

This study delves into the realm of social issues, specifically focusing on the aspect of public acceptance, within the context of Shared Autonomous Vehicles (SAV) in ride-hailing (Robo-taxi).

1.2.2 Ride-Hailing Services

Urban areas are increasingly using on-demand mobility services. The rapid expansion of these services has been made possible by substantial technological advancements that offer straightforward and flexible mobility options. It enabled the implementation of bike-sharing (Zheyan Chen et al., 2020; Eren & Uz, 2020), car-sharing services such as ShareNow in Germany, GIG in the US, Green Mobility in Denmark (Zhu et al., 2021), and other sharing economy services like e-scootering (Degele et al., 2018; Huo et al., 2021).

Additionally, new on-demand mobility services are emerging from these existing services, such as connected autonomous transportation and mobility-as-a-service (Maas). Ride-hailing services, which are internet-based on-demand mobility services that were initially most prevalent in North America and Europe, are now growing in popularity across the globe. Ride-hailing is also known as 'ride-sourcing' (Agyemang, 2020; X. Yan et al., 2019) or e-hailing (Giddy, 2019). Ride-hailing services like Lyft, Uber, Grab (Aw et al., 2019), Bolt/Taxify (Acheampong et al., 2020) or EasyTaxi (Gomez-Morantes et al., 2019) provide a new type of shared mobility for door-to-door transportation. These services are changing how individuals navigate cities due to their advantages. It is commonly agreed that ride-hailing services are transformative. Users can now keep track of a driver's location, pickup time, and fare. (Nguyen-Phuoc et al., 2020). Numerous empirical studies have attempted to determine the effects of ride-hailing services in North America (Grahn et al., 2020; Ward et al., 2019; X. Yan et al., 2019). Additionally, other studies have examined the regulatory, governance, and mobility challenges relating to emerging ride-hailing services in South America (Gomez-Morantes et al., 2019; Haddad et al., 2019), Asia (Aw et al., 2019) and Africa (Agyemang, 2020; Giddy, 2019).

According to research, the introduction of ride-hailing services is linked to a 3% average decline in vehicle registrations in US states and decreased vehicle emissions of volatile organic compounds (VOCs), such as nitrogen oxide (NOx) and carbon monoxide (CO) (Ward et al., 2019). Studies have been conducted to learn more about the characteristics (Dias et al., 2019) and usage (Grahn et al., 2020) of consumers of ride-hailing trip users. These ride-hailing services boost public transportation by reducing wait times and travel times, increasing transit ridership and decreasing operating costs (X. Yan et al., 2019). People could choose not to drive themselves to congested cities with limited parking (Henao & Marshall, 2019; Lavieri & Bhat, 2019).

When compared to other options, ride-hailing services can be both convenient to use and reasonably priced. According to Brazilian research, ride-hailing has helped some people become significantly more accessible, which has decreased overall transportation disparity (Haddad et al., 2019). Ride-hailing services have largely displaced traditional taxis (51%), as well as public transport (36%), private cars (10%) and walking (1%) (Acheampong et al., 2020).

However, preliminary research suggests that the availability of ride-hailing services may eventually cause the demand for currently offered public transportation to decline (Acheampong et al., 2020). It could incur privacy concerns (Lavieri & Bhat, 2019; Pham et al., 2017). The findings also indicate that ride-hailing services affect travel behaviour by encouraging customers to go on additional trips that they otherwise would not have taken (Acheampong et al., 2020; Dias et al., 2019).

1.2.3 Shared Autonomous Vehicles and Robo-taxi

In the imminent future, the integration of artificial intelligence (AI) in AVs is poised to significantly revolutionize our modes of travel (S. A. Cohen & Hopkins, 2019). However, the substantial cost associated with AVs is expected to pose a considerable hurdle for consumers. While the deployment of AVs in the private automobile market captures special attention from both manufacturers and policymakers, it appears more probable that this transformative technology will initially find its application within the domain of public transportation. The infrastructure and services of public transportation are better equipped to navigate the initial challenges posed by this technology's introduction. This sector is poised to better handle the early-stage technological intricacies, and it will likely provide innovative business models aimed at generating revenue from the novel mobility services that AVs bring (Stocker & Shaheen, 2019).

Shared Autonomous Vehicles (SAV) and shared public transport systems employing fully self-driving vehicles (Cartenì, 2020) as alternatives to the existing bus or taxi services present viable solutions to address this challenge. As the realm of shared mobility services (including carsharing, ride-sourcing/transportation network companies (TNCs), ride-sharing, bike-sharing, and micro-transit) continues to expand, numerous companies are displaying keen interest in deploying fleets of SAVs.

The diffusion of SAV technology holds the potential to accelerate the advancement of shared vehicle systems, potentially rendering costly AVs more accessible and budget friendly. Significantly, SAVs are anticipated to operate at a more affordable cost than their human-driven taxi and ride-hailing counterparts. It is projected that SAV may gradually replace on-demand urban transit systems in the future due to their cost-effectiveness (H. Guo et al., 2022). Concerns relating to environmental pollutants, road safety, and the escalating demand for ride-hailing services have been instrumental in driving the expansion of SAVs. Thus, SAVs are poised to assume a pivotal role in the establishment of efficient and sustainable transportation networks (Fidanoglu et al., 2023; H. Guo et al., 2022).

This study characterizes SAVs as Robo-taxis (M. Liu et al., 2022). These vehicles are equipped with advanced cameras and various types of sensors that enable them to identify objects on the road while in motion, prevent collisions, and detect obstacles (Yuen, Huyen, et al., 2020). In contrast to autonomous shuttles and buses utilized in the public transportation context of SAVs, Robo-taxis can be summoned on-demand, similar to ride-hailing services, and are capable of operating on flexible routes (Stocker & Shaheen, 2019). The emergence of disruptive technology in the form of AVs has the potential to enable access to diverse transit modes, thereby supporting the objectives of Mobility as a Service (MaaS), such as enhancing user convenience and facilitating multimodal journeys (Calderón & Miller, 2020; Tang et al., 2023). In the foreseeable future, the implementation of MaaS is expected to provide operators with an additional and dependable source of revenue. Furthermore, the escalating investments made by industry leaders to enhance connectivity will play an active role in driving the expansion of the market.

The acceptance and readiness to pay concerns regarding AV used in public transportation (such as buses and taxis) are a well-known research topic in the literature on SAVs services. SAV services encompass a shared fleet of vehicles designed to cater to passengers in various travel scenarios (Cartenì, 2020). Various tests have been conducted using low-speed autonomous shuttles in urban locations, including Monaco, France, and Italy (Cartenì, 2020) as well as on traditional passenger vehicles, particularly electric SAVs, in the United States. The majority of SAV pilot programs are targeting Level 4 automation, as the elimination of the need for human supervision within vehicles is crucial for the sustainable success of SAV business models (Stocker & Shaheen, 2019).

SAV can transform urban mobility by making it more accessible, affordable, user-friendly, and environmentally benign (Kersten et al., 2019; Patel et al., 2023). Thanks to SAV, users who cannot or shouldn't drive can be mobile (H. Guo et al., 2022). Additionally, SAV will increase mobility for those unable to drive due to youth, ageing, handicap, or infirmity (Harper et al., 2016; Y.-C. Lee & Mirman, 2018).

According to Credit Suisse analysis, in ridesharing, the cost of a human driver accounts for about 60% of the user payment (E. Cheng, 2021). The development of SAV in the future would provide the public to utilise roads or commercial vehicles at a reduced cost per kilometre due to the fact that they operate at far lower costs than existing taxi and ridesharing charges (Patel et al., 2023; Wadud, 2017).

Autonomous technology can reduce carbon emissions by two-thirds, urban commute times by a third, and the use of 30% fewer cars in currently congested cities. Additionally, the number of necessary parking spaces would be reduced by 44%, while the developing requirement for parking spaces would be reduced by more than 40% (Chehri & Mouftah, 2019). Besides, since there are no paying drivers, driverless SAV does not include questionable work circumstances from a societal and economic standpoint.

SAV consideration has benefited greatly and significantly from the recent coronavirus COVID-19 pandemic. Due to expectations for social distance and fear of spreading diseases, people also seek travel experiences that restrict social contact with other passengers and drivers (Gursoy et al., 2019; Ribeiro et al., 2021; Said et al., 2021). The way people prefer to travel will work well with SAV. Regardless of tech-savviness, gender, or political preferences, this trend is apparent. When SAV becomes available, it is anticipated that younger individuals who use shared transportation will use it more frequently (Said et al., 2021). According to studies, the COVID-19 pandemic might increase Chinese participants' willingness to use SAV and their positive reactions to SAV in comparison to conventional, human-crewed taxis (T. Li & Liu, 2022).

In this study, our primary focus lies in assessing the acceptability of SAV within the context of ride-hailing services, commonly referred to as Robo-taxi. This choice is driven by the existing literature's indication of the need for further investigation in the area of autonomous public transportation (Goldbach et al., 2022; Lavieri et al., 2018; Yuen et al., 2022).

Robo-taxi, a form of autonomous transportation, presents passengers with on-demand services and flexible routing options (Yuen, Huyen, et al., 2020). The convergence of SAV systems with public transportation services is encapsulated in the concept of Robo-taxi services. These services encompass fully self-driving vehicles integrated into on-demand ride-hailing platforms, essentially functioning as shared public transport (Cartenì, 2020). Notably, Robo-taxi diverges from personal vehicles in its operational dynamics.

When utilizing personal vehicles, each traveller individually drives their car from the origin to the destination and subsequently parks it at the endpoint. In contrast, a Robo-taxi departs from its starting point, travels to the passenger's location, picks them up, and transports them to their intended destination. While this operational model may entail occasional empty repositioning trips to accommodate travel demand, it has the potential to reduce the overall number of vehicles on the road (Levin et al., 2017).

It is widely recognized that nearly all major established vehicle manufacturers have initiated programs focused on automated vehicles. Prominent entities such as Waymo, Aptiv, DiDi, and Baidu have taken steps to test Robo-taxis on actual roads. Notably, Waymo, for instance, introduced the pioneering commercial autonomous ride-hailing service in 2018, successfully accumulating a remarkable distance of over 20 billion miles in combined real-world and simulated scenarios (Waymo, 2022b). Since 2021, AutoX, a Chinese self-driving startup backed by Alibaba, has introduced its Robo-taxi service without safety drivers aboard, making it accessible to the general public in Shenzhen (Templeton, 2021). Similarly, Baidu's Robo-taxi underwent deployment at Shougang Park in preparation to cater to the daily operational requirements during the 2022 Beijing Winter Olympics (Zhao, 2022). Anticipating a significant expansion, Baidu is set to establish the world's largest fully autonomous ride-hailing or Robo-taxi service area in 2023 (Gobal Times, 2022). Baidu's ambitious plans involve extending its Robo-taxi service from five cities in 2021 to encompass 65 cities by 2025 and eventually encompassing 100 cities by 2030 (Kharpal, 2021).

Policymakers have begun to work on the framework to accelerate the development. For instance, Beijing's municipal government has authorised Baidu's Apollo Go Robo-taxi company to collect fares in a specific area of the city (E. Cheng, 2021).

Between 2021 and 2026, the global Robo-taxi industry is anticipated to expand at a Compound Annual Growth Rate (CAGR) of around 60% (Businesswire, 2021). There will be four times as many autonomous Robo-taxis operating worldwide as taxis in 2022 (Gartner, 2022).

1.2.4 Malaysia in Context

In Malaysia, a proactive push has been undertaken to propel the advancement of AV. The National Automotive Policy (NAP) 2020 (MITI, 2020) is aimed at propelling Malaysia's automotive sector in areas encompassing Next-Generation Vehicles (NxGV), Industrial Revolution 4.0 (IR 4.0), and Mobility-as-a-Service (MaaS) to attain this objective (MIDA, 2021). Figure 1.1 illustrates the novel components introduced in NAP (MITI, 2020).

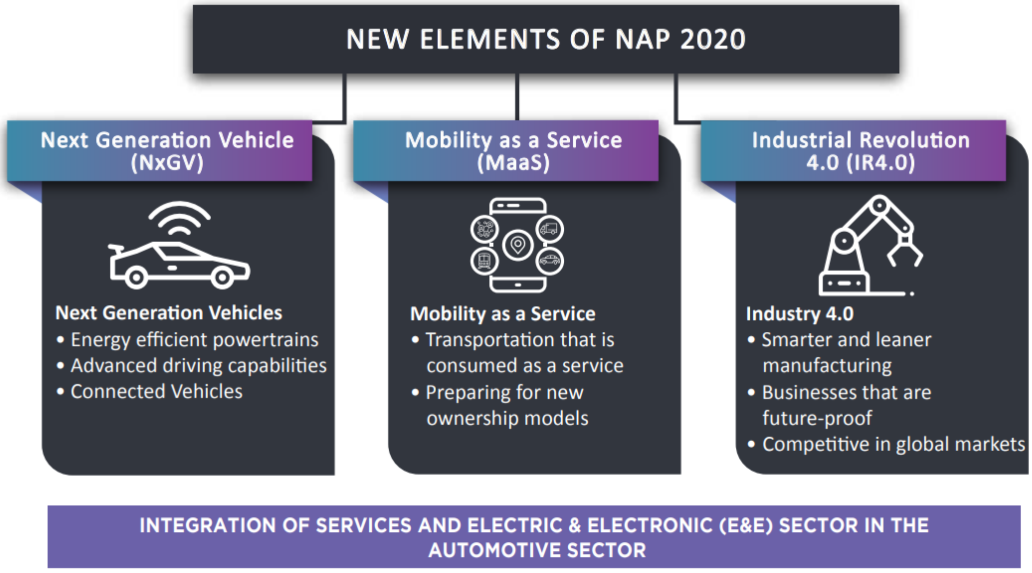

Figure 1.1 New Elements of National Automotive Policy NAP2020

To attain NxGV classification, a vehicle must fulfil the criteria for an Energy Efficient Vehicle (EEV) and incorporate Intelligent Mobility features with a minimum level of level 3 automation (conditional automation) within the framework of the six levels of vehicle autonomy parameters.

A primary focus of NAP 2020 (MITI, 2020), is to enhance the involvement of the domestic automobile industry in the MaaS realm, which encompasses technological advancement and the broader transportation ecosystem, as depicted in Figure 1.2.

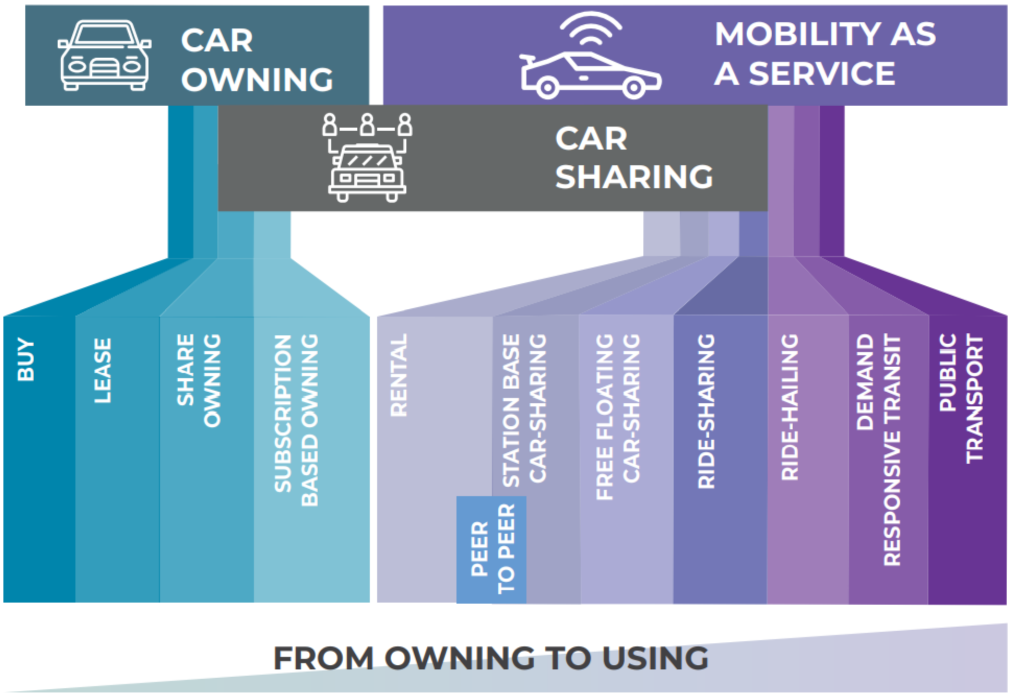

Figure 1.2 Goal of Mobility as a Service

The Malaysian Ministry of Transport unveiled the fourth iteration of the guidelines for public road trials of autonomous vehicles in February 2022 (Guideline for Public Road Trials of Autonomous Vehicles, 2022). This provides a roadmap to meet the growing demand for trials, which is expected to foster further research and development in the field of autonomous vehicles in Malaysia.

Malaysia's Autonomous Vehicle Testing Routes, or MyAV Routes, are designated testbeds that facilitate rigorous testing and data collection for participants in the autonomous vehicle sector (Chan, 2023). The first MyAV Route was established in Cyberjaya in November 2020 and subsequently endorsed by the Ministry of Transportation. AV Testing Guidelines were also introduced to ensure safe and controlled testing conditions, with eMoovit being the pioneer to conduct AV pilot testing (Bernama, 2020). Additionally, new MyAV Routes are being developed in Putri Iskandar, Johor, and Putrajaya. The Johor testbed will focus on public transportation and electric buses, while the Putrajaya route will emphasize Connected Intelligent Transportation Systems (CITS), along with features like Red Light Running, Sensor Pedestrian Crossing, and Collision Avoidance (sudden braking) (Chan, 2023).

Further collaboration between eMooVit Technology (eMooVit) and Rapid Bus has resulted in a trial program for autonomous electric bus operations in Sunway, Selangor, commencing in September 2022. This marks the first autonomous electric bus project in Malaysia led by a public transportation provider, aiming to assess the technological, societal, and economic impacts of autonomous electric buses on urban transportation systems (Yee, 2022).

Given the concerted efforts by the local government and the corporate sector to realize the implementation of AVs, there is an urgent need for additional research on the acceptability of AVs in Malaysia.

1.3 Research Problem

The global market for Robo-taxi is projected to witness significant growth, with an estimated value of $38.61 billion by 2030 and a compound annual growth rate (CAGR) of 67.8% from 2023 to 2030. This projection is based on an estimated market value of $1.03 billion in 2023 (Allied Market Research, 2020). In terms of vehicle count, the global Robo-taxi market is anticipated to experience a substantial increase from 617 units in 2021 to 1,445,822 units by 2030, at a CAGR of 136.8% (MarketsAndMarkets, 2020b). This growth is attributed to factors such as concerns about traffic safety, pollution, and the rising demand for ride-hailing services. Furthermore, the global ride-hailing market is projected to grow at a CAGR of 16.6%, reaching USD 185.1 billion by 2026 (MarketsAndMarkets, 2020a).

Despite the potential benefits and projected growth of Robo-taxi, there remain concerns surrounding the nature of "driverless" vehicles. These concerns have been amplified by a tragic incident involving an autonomous Uber vehicle in Arizona, USA, on March 18, 2018, which has raised public concerns about the risks associated with testing and deploying self-driving vehicles on public roads (P. Liu, Xu, et al., 2019). It is evident that public acceptance poses a significant challenge to the widespread implementation of driverless vehicles, surpassing technical obstacles (Othman, 2021). Kosuru and Venkitaraman (2023) highlighted that the issues that must be addressed when discussing AV are legal and regulatory frameworks, public acceptance, and cybersecurity. Psychological factors, in addition to technological challenges, have been identified as significant hurdles to the widespread adoption of AV (Bansal et al., 2016; Cartenì, 2020). However, social science perspectives remain underrepresented in the scientific literature on AV, comprising only 6% of the total (Cavoli et al., 2017). Given the rapid technological advancements and the scarcity of social science perspectives, there is an urgent need for more research on the socio-behavioural implications of Robo-taxi (S. A. Cohen & Hopkins, 2019; Waltermann & Henkel, 2023). Understanding these implications and addressing public concerns will be crucial for the successful adoption and integration of Robo-taxi into the existing transportation ecosystem.

It is vital to consider the factors influencing consumers' acceptability of Robo-taxi, as public intention, and willingness to utilize them are fundamental to their successful deployment. With the continuous evolution of AV technology, understanding the factors influencing the acceptability of Robo-taxis among the public becomes increasingly important. Moreover, the majority of studies on AV have been conducted in developed countries, highlighting the need for research on the adoption of Robo-taxis in developing nations, particularly in countries like Malaysia that have initiated AV trials (Bernama, 2020).

Therefore, the main research problem of this study is to investigate the factors contributing to the acceptability or reluctance of individuals in Malaysia to use Robo-taxi as a mode of transportation. Despite the potential benefits, including improved road safety, reduced traffic congestion, and enhanced mobility, there may be barriers and concerns hindering their widespread adoption. To address the intricate psychological factors associated with this emerging technology, a comprehensive multi-stage approach will be adopted, drawing upon previous research based on Cognitive Appraisal Theory (Gursoy et al., 2019; Lazarus, 1991b). A comprehensive evaluation of psychological factors is necessary, including the examination of direct effects as well as potential moderating effects that may impact the relationships between these factors. A moderator is included in the model as previous studies have shown that factors such as personal innovativeness can moderate the relationship between certain factors and usage intentions in various technology contexts (Yen, 2022).

The replacement of humans by robots and AI technologies remains a topic of debate, leading to uncertainty among consumers about whether to accept or reject them. People recognize the potential for increased productivity through AI-driven automation and decision support (Borges et al., 2021). Nevertheless, doubts and apprehensions have also emerged concerning the overall capabilities of AI (Abdullah & Fakieh, 2020; Ardon & Schmidt, 2020). Hence, a combination of positive and negative factors can coexist and interact, shaping users' acceptance behaviour. Considering the intricacy of integrating AI devices into consumer service interactions, it is crucial to devise a conceptual framework that addresses decision phases leading to both positive (acceptance) and negative (objection) outcomes.

To address this complexity, a conceptual framework is needed that considers decision phases encompassing both acceptance and objection outcomes. The primary objective will be to gain a deep understanding of the cognitive, affective, and psychological factors that influence users' emotions, subsequently shaping their acceptance or objection to the utilization of SAV in the context of ride-hailing or Robo-taxi services.

1.4 Research Objectives

Based on the discussion in the previous section, this study includes perceived usefulness, perceived policy support, perceived fee, and relative advantage as cognitive factors. Perceived enjoyment is considered an affective factor, while self-efficacy, trust, social influence, and personal innovativeness are treated as psychological factors.

This study attempts to meet the following objectives:

1. To examine the relationship between perceived usefulness and perceived value.
2. To examine the relationship between perceived enjoyment and perceived value.
3. To examine the relationship between perceived fee and perceived value.
4. To examine the relationship between perceived policy support and perceived value.
5. To examine the relationship between relative advantage and perceived value.
6. To assess the relationship between relative advantage and perceived usefulness.
7. To examine the relationship between self-efficacy and perceived value.
8. To examine the relationship between self-efficacy and perceived risk.
9. To assess the relationship between self-efficacy and perceived usefulness.
10. To examine the relationship between trust and perceived value.

11. To examine the relationship between trust and perceived risk.
12. To examine the relationship between social influence and perceived value.
13. To examine the relationship between social influence and perceived risk.
14. To examine the relationship between perceived risk and perceived value.
15. To investigate the moderating effect of personal innovativeness on the relationship between perceived risk and perceived value.
16. To study the relationship between perceived value and emotion.
17. To study the relationship between perceived risk and emotion.
18. To assess the relationship between emotion and the willingness to use SAV in ride-hailing (Robo-taxi).
19. To assess the relationship between emotion and the objection to the use of SAV in ride-hailing (Robo-taxi).

1.5 Research Questions

Based on the research objectives discussed earlier, the research is carried out to fulfil the following research questions:

1. What is the relationship between perceived usefulness and perceived value?
2. What is the relationship between perceived enjoyment and perceived value?
3. What is the relationship between perceived fee and perceived value?
4. What is the relationship between perceived policy support and perceived value?
5. What is the relationship between relative advantage and perceived value?
6. What is the relationship between relative advantage and perceived usefulness?
7. What is the relationship between self-efficacy and perceived value?
8. What is the relationship between self-efficacy and perceived risk?
9. What is the relationship between self-efficacy and perceived usefulness?
10. What is the relationship between trust and perceived value?
11. What is the relationship between trust and perceived risk?
12. What is the relationship between social influence and perceived risk?
13. What is the relationship between social influence and perceived value?
14. What is the relationship between perceived risk and perceived value?

15. Does personal innovativeness moderate the relationship between perceived risk and perceived value?
16. What is the relationship between perceived value and emotion?
17. What is the relationship between perceived risk and emotion?
18. What is the impact of emotion towards the willingness to use SAV in ride-hailing (Robo-taxi)?
19. What is the impact of emotion on the objection to using SAV in ride-hailing (Robo-taxi)?

1.6 Scope of the Study

The scope of this study encompasses an exploration of the factors influencing the acceptability of SAVs in ride-hailing services, specifically focusing on the context of Malaysia. The study aims to investigate the perceptions, attitudes, and behavioural intentions of ride-hailing users towards the adoption of SAVs as a mode of transportation.

The study will primarily focus on the perspectives of ride-hailing users who have had prior experience with ride-hailing services such as Grab, Uber, and local ride-hailing platforms. The research will target individuals who are residing in Malaysia, and who have utilized ride-hailing services within the past year.

The investigation will be carried out using a quantitative research approach, employing a structured questionnaire as the primary data collection instrument. The questionnaire will be distributed electronically through online platforms, including email and social media, to reach a wider pool of potential respondents.

The study will analyse the collected data to identify the key factors that influence the acceptability of SAVs in the ride-hailing context, including aspects such as perceived usefulness, trust in technology, perceived enjoyment, perceived risk, and cost-effectiveness. Additionally, the study will examine the impact of socio-demographic variables such as age, gender, and education level on the acceptance of SAVs as control variables.

It is important to note that this research will focus solely on the acceptability of SAVs in the ride-hailing sector and will not delve into the broader implications of AV technology in other areas such as public transportation or private vehicle ownership. Furthermore, the study will be limited to the perspectives of ride-hailing users in Malaysia, and the findings may not be generalizable to other countries or populations.

By delineating the scope of the study, this research aims to provide valuable insights into the factors influencing the acceptability of SAVs in the ride-hailing (Robo-taxi) sector in Malaysia, contributing to the existing body of knowledge in the field of autonomous vehicle acceptance and informing policymakers, industry stakeholders, and researchers interested in the future of transportation.

1.7 Significance of the research

This study contributes to the existing knowledge on the usage of SAVs in ride-hailing services, expanding our understanding of this emerging field. The integration of AV technology in the ride-hailing or taxi industries has the potential to revolutionize transportation by providing on-demand mobility at a lower cost and enabling multimodality with last-mile travel options. By combining the benefits of access-based consumption and AV technologies, ride-hailing services utilizing SAVs or Robo-taxis can offer a compelling solution (Merfeld et al., 2019).

The adoption and acceptance of AV technology may be accelerated if it is introduced through the increasingly popular ride-hailing services. By leveraging the existing infrastructure and user base of these services, the technology has the potential to gain wider usage and dispel early scepticism. This study seeks to explore and uncover insights that can contribute to the successful integration and adoption of AV in the ride-hailing industry. By identifying the key factors that impact consumers' willingness to use Robo-taxis, interventions can be devised to address potential barriers and enhance the overall user experience.

Several recent studies have explored various factors that can influence people's attitudes and intentions towards accepting AV. However, the cognitive foundations underlying ride-hailing users' attitudes specifically regarding the use of AI-based Robo-taxis for their daily commute have received relatively limited attention. It is worth noting that social science-related research constitutes only 6% of the entire scholarly literature on AV, as the majority of research in this domain primarily focuses on technical and technological aspects (Bai et al., 2023; Cavoli et al., 2017; Feng et al., 2023; Yuxiao Zhang et al., 2023). Given the scarcity of social science perspectives and the rapid advancement of AV technology, there is an urgent need for further research in this field (S. A. Cohen & Hopkins, 2019).

To bridge this gap in understanding, it is crucial to delve deeper into the cognitive aspects and psychological factors that shape ride-hailing users' attitudes towards AI-based Robo-taxis. By investigating these cognitive foundations, researchers can gain valuable insights into the factors that influence user acceptance and facilitate the successful integration of AV in the ride-hailing industry.

Ride-hailing services are a relatively new and evolving phenomenon, and as such, our understanding of their broader effects is still in the process of development and remains somewhat ambiguous. Furthermore, there is a lack of empirical data in the existing literature that would provide insights into the significant challenges associated with ride-hailing in emerging nations like Malaysia. As SAVs continue to advance, there will be a noticeable gap in the body of empirical research that could help elucidate the key factors influencing the acceptance of SAVs among ride-hailing customers.

To address these gaps in knowledge, it becomes essential to conduct further empirical research that specifically focuses on ride-hailing services, considering the unique context of emerging nations. This study aims to investigate the various factors that influence users' acceptance of SAVs in the context of ride-hailing services (Robo-taxis). Unlike traditional technology adoption models such as the Unified Theory of Acceptance and Use of Technology (UTAUT), which were not specifically designed for Artificial Intelligence (AI)-based applications, this study intends to incorporate multiple factors, including individual psychological factors, within an AI adoption framework.

To assess commuters' willingness to accept or object to the use of Robo-taxis, this study employs the Cognitive Appraisal Theory, as well as expands on existing Artificially Intelligent Device Use Acceptance (AIDUA) framework and the Value-based Adoption Model (VAM) by incorporating additional constructs.

By exploring these factors and theoretical frameworks, this study aims to enhance our understanding of the acceptance of SAVs in ride-hailing services (Robo-taxi). The findings will provide valuable insights for both researchers and practitioners in the field, contributing to the development of effective strategies to promote the acceptance and successful integration of SAVs in ride-hailing services. The following sections will outline the theoretical contributions and practical implications of this research.

1.8 Theoretical Contributions

The findings of this research make significant contributions to the existing literature, particularly within the framework of Cognitive Appraisal Theory. This study offers three key theoretical contributions.

Firstly, it is the first study to investigate the applicability of the AI adoption framework in assessing consumers' willingness to accept the usage of Robo-taxi services for their daily commutes, as an alternative to personal vehicles or traditional driver-operated public transportation, such as taxis. This research focuses specifically on utilitarian services related to daily commutes, which distinguishes it from other studies in the field of AV that predominantly examine hedonic services, such as tourism and travel (e.g. Ribeiro et al., 2021). The model developed in this study can be further refined and adapted to better capture the factors relevant to different service delivery scenarios, which holds significant managerial implications.

Secondly, this study addresses the complex nature of AI-operated vehicles by incorporating insights from the three-stage appraisal process in Cognitive Appraisal Theory (Lazarus, 1991b). It builds upon existing empirically tested and theory-grounded conceptual frameworks such as the Value-based Adoption Model (VAM) (H.-W. Kim et al., 2007), the Artificially Intelligent Device Use Acceptance (AIDUA) framework (Gursoy et al., 2019), and the Autonomous Vehicle Adoption Model (AVAM) framework (Ribeiro et al., 2021). These frameworks are extended and adapted to model the determinants of consumers' willingness to use SAVs in ride-hailing services during the pre-adoption phase.

The proposed framework, known as the Robo-taxi Adoption Model (RAM), provides a valuable foundation for further empirical studies and research on Robo-taxis. By integrating the insights from multiple theoretical frameworks, the RAM framework captures the intricate factors that influence consumers' decision-making processes and acceptance of SAVs in ride-hailing services. This framework serves as a valuable tool for researchers to conduct empirical studies and investigations in the field of Robo-taxis, shedding light on the determinants and dynamics of consumer adoption in this emerging domain.

Thirdly, this study aims to uncover the nuanced psychological complexities and characteristics that influence consumers' willingness to accept Robo-taxis in ride-hailing services. By incorporating additional heuristic psychological factors, this research addresses the limitations of previously developed frameworks and contributes new insights to the existing body of literature.

Through this study, we not only validate previous research findings but also extend them, providing a comprehensive understanding of the factors that influence the acceptability of Robo-taxis. By exploring these factors, we fill a crucial gap in the research on consumers' psychological attitudes towards the emerging trend of Robo-taxis.

By delving into the psychological dimensions, this study enriches our understanding of consumer acceptance and provides valuable insights into the factors that shape consumers' perceptions and decisions regarding Robo-taxis. The findings