Exploring Public Acceptance of Connected and Autonomous Vehicles with a Focus on Cyber Security and Privacy Risks

by

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Journal Article

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Abstract

Connected and Autonomous Vehicles (CAVs) constitute an automotive development carrying paradigm-shifting potential that may soon be embedded into a dynamically changing urban mobility landscape. The complex machine-led dynamics of CAVs make them more prone to data exploitation and vulnerable to cyber-attacks than any of their predecessors. This increases the risks of privacy breaches and cyber security violations for their users. Cyber security and privacy issues are of significant concern for automated mobility since they can adversely affect the public acceptance of CAVs, give them a bad reputation at this embryonic stage of their development, create barriers to their adoption and increased use, which ultimately complicates the business models of their future operations and ultimately their diffusion. Therefore, it is vital to identify and create an in-depth understanding of the cyber security and privacy issues associated with CAVs as it is something that will support a more systematic identification and contextualisation of the factors determining public acceptance of CAVs.

This empirical research aims to do exactly that by employing a sequential mixed method approach, with a qualitative phase looking in depth cyber security and privacy issues followed by a survey-based phase looking to model the factors underpinning CAV acceptance. For the qualitative research phase, 36 semi-structured elite interviews were organised with CAV experts that already anticipate problems and look for their solutions. Thematic analysis was used to identify and contextualise the factors that reflect and affect CAV acceptance in relation to the privacy and cyber security agendas. Six core themes emerged: awareness, user and vendor education, safety, responsibility, legislation, and trust. Each of these themes has diverse and distinctive dimensions and are discussed herein as sub-themes.

For the quantitative research phase, a theory-based extended technology acceptance model (TAM) model was developed and validated through an online survey of 1162 residents from the UK and China. The confirmative factor analysis-structural equation modelling (CFA-SEM) approach was used to analyse the collected data. Results suggested that perceived usefulness and perceived ease of use remain the most robust predictors that determine the using intention of CAVs. The exogenous variables, namely self-efficacy, facilitating conditions and perceived risks, were significant predictors of the intention to use CAVs. The perceived system characteristics such as the relative advantages of CAVs, the cyber security and privacy risks, and the perceived organisational factors like government, manufacturers, and service providers' facilitation in personal data protection are proved to be crucial in the users' attitude forming process.

Based on the overall findings, policy recommendations were provided to make CAVs more cyber secure and privacy friendly. These include prioritising cyber security and privacy issues in CAVs, utilising social media tools in promoting positive social influences and developing a novel human-machine interface that would enable easy and safe operations. The study also suggests that mitigating the cyber security and

privacy risks embedded in CAVs require inter-institutional cooperation, awareness campaigns and trials for trust-building purposes, mandatory educational training for manufacturers and perhaps more importantly for end-users, balanced and fair responsibility-sharing, two-way dynamic communication channels and a clear consensus on what constitutes threats and solutions. Additionally, recommendations for CAV market-entry and market penetration routes were given based on the multigroup analysis results.

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Nomenclature

Δ	Absolute differences
β	Causal paths beta weight
ρ	Population correlation
λ	Factor loadings
χ^2	Chi-square
η	Endogenous latent variables
ξ	Exogenous latent variables
α	Cronbach's coefficient alpha
ε	Measurement residuals
Adj. R^2	Adjusted R^2
df	Degrees of freedom

Abbreviations

5G	5th Generation wireless systems
ABM	Agent-Based Modelling
AEB	Autonomous Electric Buses
AFV	Alternative Fuel Vehicle
ANOVA	Analysis of Variance
ASV	Average Shared Variance
ATU	Attitude Toward Using
AVE	Average Value Explained
AVs	Autonomous Vehicles
BSRE	Business School Research Ethics Committee
CAN	Controller Area Network
CAQDAS	Computer-Assisted Qualitative Data Analysis Software
CAVs	Connected and Autonomous Vehicles
CELS	Citizenship Education Longitudinal Study
CFA	Confirmatory Factor Analysis
CFI	Bentler Comparative Fit Index
CPSs	Cyber-Physical Systems
CR	Composite Reliability
CUSUM	Cumulative Sum
CV	Connected Vehicle
CVLLA	Connected Vehicles Lower-Level Automation
D2D	Device-to-Device
DA	Driving Assistance
DAD	Duplicate Address Detection
DfT	UK's Department for Transport
DNS	Domain Name Server
DoD	Department of Defence
DOI	Diffusion of Innovation
DoS	Denial-of-Service
DV	Dependent Variable

EDRs	Event Data Recorders
EE	Effort Expectancy
EFA	Exploratory Factor Analysis
ELSA	English Longitudinal Study of Ageing
EM	Don Rubin's Expectation-Maximization
ERTRAC	European Road Transport Research Advisory Council
FC	Facilitating Conditions
FIML	Full Information Maximum Likelihood
gCD	Cook’s D
GDPR	General Data Protection Regulation
GenX	Generation X
GFI	Goodness-of-fit index
GLM	General Linear Model
GNSS	global navigation satellite systems
GPS	Global Positioning System
HMI	Human-Machine Interface
IA	Information Asymmetry
ICT	Information and Communication Technology
IDT	Innovation Diffusion Theory
IDV	Individualism vs. Collectivism
IIHS	Insurance Institute for Highway Safety
IND	Indulgence vs. Restraint
IoT	Internet of Thing
IOU	Intention to Use
IS	Information Systems
ITS	Intelligent Transport Systems
IV	Independent Variable
KMO	Kaiser-Mayer-Olkin
LISREL	linear structural relations
LTO	Long-Term Orientation vs. Short-Term Orientation
MAD	Median Absolute Deviation
MAR	Missing at Random

MAS	Masculinity vs. Femininity
MaxR	Maximum Reliability
MCAR	Missing Completely at Random
MDS	Multidimensional Scaling
MGA	Multiple Group Analysis
MiTM	Man-in-The-Middle
MLP	Multi-Level Perspective
mmWave	Millimetre wave
MNAR	Missing Not at Random
MSV	Maximum Shared Squared Variance
NIST	National Institute of Standards and Technology
NTC	Australia’s National Transport Commission
OBMS	On-Board Monitoring System
OCP	One-Child Policy
OICA	International Organization of Motor Vehicle Manufacturers
PBC	Perceived Behavioural Control
PCP	Personal Contract Purchase
PDI	Power Distance Index
PE	Performance Expectancy
PEOU	Perceived Ease of Use
PLS	Partial Least Square
PPP	Purchasing Power Parity
PR	Perceived Risks
PU	Perceived Usefulness
PUVEC	Platform for Connected Electric Vehicles
RMSEA	Root Mean Square Error of Approximation
RSU	Roadside Unit
SAE	Society of Automotive Engineers
SAV	Shared Autonomous Vehicle
SCT	Social Cognitive Theory
SDSS	Smartphone Driver Support Systems
SE	Self-efficacy

SEM	Structural Equation Modelling
SI	Social Influence
SN	Subjective Norm
SPSS	Statistical Package for Social Science
SRMR	Standardized Root Mean Square Residual
TAM	Technology Acceptance Model
TCP	Transmission Control Protocol
TPB	Theory of Planned Behaviour
TPR	Theory of Perceived Risk
TRA	Theory of Reasoned Action
UAI	Uncertainty Avoidance Index
UTAUT	Unified Theory of Acceptance and Use of Technology
V2I	Vehicle-to-Infrastructure
V2V	Vehicle-to-Vehicle
V2X	Vehicle-to-Everything
VIFs	Variance Inflation Factors
VMT	Vehicle Miles Travelled
WTP	Willingness to Pay

Chapter 1. Introduction

1.1 Research background and research problem

Connected and Autonomous Vehicles (CAVs) is a technology that has the potential to transform automotive transport and urban landscapes (Nikitas, Njoya, and Dani, 2019). CAVs in the future can navigate the road networks without human interventions. There are several models of early CAV applications that are being tested in restricted areas as well as public roads. For instance, in the US, Google Waymo is currently testing its autonomous trucks and autonomous taxies on public roads. UK, Singapore, and Spain are currently focusing on integrating Autonomous Vehicles (AVs) into public transport (e.g., autonomous buses).

CAVs have been introduced as a subset of the Cyber-Physical Systems (CPSs)[1] in the context of highway transportation, which consists of digital software platforms, physical infrastructure and human components. The advent of CAVs has gained worldwide attention and traction, promising economic, social and environmental benefits that can flourish in the era of the smart city. More specifically: from an economic perspective, CAVs can facilitate the reduction of energy costs (Rios-Torres and Malikopoulos, 2016), improve fuel economy (Vahidi and Sciarretta, 2018), create more productive time (Clements and Kockelman, 2017) and promote inclusive economic growth (Meyer *et al.*, 2017). From a social perspective, CAVs are marketed for their increased accident prevention and traffic safety merits (Ye and Yamamoto, 2019), potential to alleviate traffic congestion (Talebpour and Mahmassani, 2016), beneficial impact on public health and wellbeing (Faisal *et al.*, 2019), improvement of travel behaviour (Taiebat, Stolper, and Xu, 2019), increased travel equality and accessibility (Goggin, 2019). From the environmental perspective, CAVs can help in reducing emissions and air pollution (Bauer, Greenblatt, and Gerke, 2018), lessening

[1] Refer to section 2.2.2 to access information about Cyber-Physical Systems.

energy consumption (Wadud, MacKenzie, and Leiby, 2016), optimising fuel use (Mamouei, Kaparias, and Halikias, 2018), preventing environmental degradation (Bagloee *et al.*, 2016) and decreasing noise nuisance (Nikitas *et al.*, 2017).

The UK government seeks to cement its position as a world leader in CAVs, and several actions have been taken to support CAVs development and preparation for their implementation. For instance, the government is encouraging CAV technology development through the current National Infrastructure Delivery Plan (2016–2021) (Law Commission, 2020). The Law Commission of England and Wales and the Scottish Law Commission (the Law Commissions) have announced landmark proposals that will seek to ensure the safety of self-driving vehicles via a comprehensive new legal framework in December 2020, which will be reported in the final quarter of 2021 (Law Commission, 2021). The COVID -19 pandemic has also raised the demand for automation in many fields of industries, from operations to the production. For instance, Ocado, a British online supermarket has experienced success from their automated warehouse transformation (Sillars, 2021).

The UK currently faces a myriad of challenges that would hinder the implementation of CAVs. This includes the need for high-definition maps[2], 5G coverage, established policy and legislation, adequate road infrastructure and consumer acceptance. A number of specific initiatives in tackling the identified issues are underway. For instance, £200 million funding was provided in improving nationally coordinated programme of 5G testbed facilities and trials (5G Testbeds and Trials Programme) (Department for Digital, Culture, Media & Sport, 2018). Cyber security principles for connected and automated vehicles within the automotive sector were also created (Department for Transport, 2017). The Government has also conducted research on public attitudes towards self-driving vehicles[3], which

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[2] In order to successfully run CAVs on the public roads, 3D maps that contain comprehensive road profiles are needed for them to navigate through the road networking using their built-in sensors and software.

[3] See https://www.gov.uk/government/publications/public-attitudes-towards-self-driving-vehicles for more information about public attitudes towards self-driving vehicles research conducted by Department for Transport.

endeavoured to open the dialogues among public, the policy makers, specialists from industry, academia and government.

China has made a national strategic plan ‘Made in China 2025’ in 2015 aimed at industrial upgrading. This plan including autonomous vehicles scale production by 2025. To achieve its goal, research and developments of CAVs was focused on tackling legal and ethical issues associated CAVs, human computer interaction, industrial standard and regulations of CAVs, and CAV testing. Tax incentives has been given to CAV enterprises that conduct CAV research and development activities.

Beijing has started rapidly testing on CAVs since 2018. On March 24, 2021, China has published the first specific CAV legislation. These are key milestones in China’s CAV commercialisation. However, there are still challenges in respect of the CAV technologies as well as the public acceptance of CAVs in China.

At the same time and despite the huge potential of CAVs to deliver the listed improvements, these new vehicles are also linked to some significant concerns relating to: traffic safety and moral issues (Liljamo, Liimatainen, and Pöllänen, 2018); (in)effective interaction between CAVs and other forms of travel including pedestrians (Palmeiro *et al.,* 2018); excessive traffic and unoccupied vehicle trips (Cohen and Hopkins, 2019); displacement of driving professionals (Heard *et al.*, 2018); lack of situational awareness and difficult behavioural adaption for the users (Strand *et al.*, 2014) and drivers’ unwillingness to forfeit driving (Tennant, Stares, and Howard, 2019). Cyber security and privacy risks have also emerged as a key challenge because of CAVs susceptibility to hacking and data exploitation (Nikitas *et al.,* 2019). As with all connected computing infrastructures, increasing the level of computational functionality and connectivity in vehicles increases their exposure to potential vulnerabilities (Parkinson *et al.*, 2017), as well as creating new opportunities for data mismanagement.

1.2 Motivation

The commercialization of this technology will alter transportation networks across the globe. In the short term, it will impact transportation safety, efficiency and accessibility. This technology will also create second-and-third-order effects related to jobs, urban planning, economic models, and roadway rules and regulations. Along with the many benefits of this technology, it will raise public concerns about the safety of these vehicles on public roads, and the potential loss of jobs from those directly and indirectly employed in the transport sector. For policymakers, the most pressing challenge will involve crafting a regulatory regime that fosters innovation, ensures safety and balances the equities of stakeholders at all levels.

Security and privacy issues are critical concerns that may hinder the wide deployment of CPSs if not properly addressed (Giraldo *et al.*, 2017). The connected physical world suffers not only from the attacks targeting today's networked systems, but also from new ones that people may not be able to accurately predict today (Sadeghi, Wachsmann, and Waidner, 2015). Intelligent Transport Systems (ITS) enables CAVs to be connected and allows for traffic optimisation.

The fine-grained, heterogeneous, and sensed big data are vulnerable to different inference attacks, causing privacy disclosure and data safety violations (Song, Fink, and Jeschke, 2017), while the controlling devices, sensors and signals can be manipulated to launch attacks that destabilise the system (Bou-Harb *et al.,* 2017). ITS algorithms will quickly allocate the best route for each car based on the information collected from the road environment and the destination of all the vehicles in a certain area. CAVs would need to share the personal information (such as destination) and allow vehicle tracking with ITS, which could potentially cause privacy breaches. The complex dynamics that emerge between the physical, the automated and the connected dimensions of CAVs create new and unique challenges for end-users, public authorities, car manufacturers and service providers. Therefore, efforts meaning to address privacy and cyber security issues are timely and meaningful.

It is strongly believed that public acceptance will be negatively affected if CAV technology risks are not thoroughly studied (Bou-Harb *et al.,* 2017). Given that the introduction and promotion of CAVs heavily rely upon the ubiquitous access and participation, understanding and demystifying acceptance towards CAVs and the associated risks with their use is fundamental to help detect the gaps in their cyber security and privacy dimensions to develop effective governance.

This work aims to make the first step to understand the factors reflecting and affecting CAV acceptance regarding cyber security and privacy issues through the lens of experts and the general public. More specifically, research was firstly conducted by the means of elite in-depth interviews with field experts. This helped uncovering their views on some of the emerging trends that will shape the CAV privacy and cyber security policy agenda and how industry, government and universities could work together to help harness the identified opportunities. This was followed and complemented by a dedicated effort to explore the different dimensions of CAV acceptance as these currently exist in the minds of members of the general public with a special emphasis on the agenda referring to cyber security and privacy. More specifically, this work set out to create a model that maps out the acceptance framework of people's potential acceptance of CAVs.

1.3 Research aim, objectives and questions

To address these challenges, the aim of this research is to develop a theoretical and empirical understanding of attitudes towards CAVs, reflecting and affecting acceptance with a particular focus on the agendas of cyber security and privacy. This will potentially begin a dialogue between the government and private sector about this transformative technology to identify solutions to those potential problems. Three objectives will direct this research. The first is identifying and contextualising the diverse dimensions of CAV related cyber threats and privacy breaches for the end-users from the lens of CAV experts. The second is modelling the factors influencing public attitudes towards CAV acceptance. The third is proposing policy recommendations for mitigating cyber security and privacy concerns and advancing public acceptance for CAVs. Table 1-1 presents the research aim, objectives and research questions of this study.

Aim: Developing a theoretical and empirical understanding of attitudes towards CAV acceptance with a particular focus on the agendas of cyber security and privacy.	
Research Objectives	**Research Questions**
Identifying and contextualising the diverse dimensions of CAV related cyber security and privacy breaches for the end-users from the lens of CAV experts.	*RQ1:* What types of CAV associated risks may the user face in terms of cyber security and privacy? *RQ2:* What are the key expressions of cyber security and privacy issues? *RQ3:* What can be done to mitigate these risks?
Modelling the factors influencing public attitudes towards CAV acceptance.	*RQ4:* What is the suitable technology acceptance model that can be used as the conceptual framework to examine CAV acceptance? *RQ5:* What are the factors affecting CAV acceptance and in what way they do so? *RQ6:* To what extent do the determining factors influencing CAV acceptance vary or concur in different cultural/gender/generational contexts?
Proposing policy recommendations for mitigating cyber security and privacy concerns and advancing public acceptance for CAVs.	*RQ7:* What can policy makers do to safeguard CAVs cyber security and privacy? *RQ8:* What can end users do to safeguard their cyber security and privacy when using CAVs? *RQ9:* What can stakeholders do to ensure the acceptance and better diffusion of CAVs?

Table 1-1 Research aim, objectives and questions

1.4 Research scope

For the first stage of the study, elite interview respondents were selected from field experts whose countries are committed to the public road testing of CAVs. To the best of the author's knowledge, there are fifteen countries that have passed legislation that allows autonomous vehicles (AVs) to be tested on the public highway (as shown in Table 1-2). Some of these countries (Belgium, the USA, New Zealand, Norway, Netherland, Finland,

and Japan) have given permissions to test CAVs on public roads in some restricted areas without a human driver. Additionally, some countries (e.g., Japan and South Korea) are actively developing and testing the CAVs in pre-defined roads.

Australia
Belgium
Canada
China
Denmark
Finland
Germany
Netherland
New Zealand
Norway
Poland
Singapore
Sweden
UK
USA

Table 1-2 Countries that allow public road testing of AVs

For the second stage of study, the online survey targeted UK and China adult residents. Since 2015, The UK declared ambition to commercialise CAVs by 2021. To date, CAVs are still in the experiment stage due to numerous challenges to overcome in commercialising CAVs that work safely in real-world scenarios. From the legislation and policy point of view, UK is one of the world leaders in terms of CAV development. In 2018, the UK parliament passed legislative piece named the Automated and Electric Vehicles Act (UK Parliament, 2018), which defined initial self-driving mode liabilities. As the UK has not ratified the Vienna Convention on Road Traffic[4], this has provided the country with a supporting environment for public road testing without interruption or intervention. Although the UK has not yet started public road CAV testing without human control (due to CAV technology

[4] Vienna Convention on Road Traffic 1968 is an international framework, which stipulates that a human driver must always remain in full control of and responsible for the behaviour of the vehicle in traffic.

being in its formative early stage), UK's infrastructure barrier (5G coverage, road network) issues, public acceptance are all part of the critical issues that are being studied.

China, in recent years, has quickly emerged as the world largest mobility market (Tsang, Boutot, and Cai, 2018). China leads on market penetration of ride-hailing services, followed by the US and the UK (KPMG, 2019). China had formed a joint venture with New Zealand driverless minibuses company in 2018, in order to try their autonomous bus (Chris Hutching, 2018). The Chinese Government approved the road testing of AVs in early 2018, with Baidu, Jingchi, and Pony.ai being the three leading CAV developers in China. China provides a relatively relaxed regulatory environment that allows for speedy public road CAV testing. The acceptance of CAVs however remains largely unexamined in China.

Moreover, both two countries have comparable information and communication technology (ICT) adoption levels. According to World Economic Forum's Global competitiveness report (Klaus Schwab, 2019), ICT adoption represents a country invested in technology and innovations to support their business activities and the level of adoption by the consumer. As shown in Table 1-3 and Table 1-4, the items in the rows are comprehensively explained in the source report. The interest of this thesis was to compare the adoption affinity to technology, that is, ease of embracing technology and the enabling conditions such as readiness of technology, the strength of internet subscription. Although there are some marked differences in terms of fixed-broadband internet subscription rate, fibre internet subscription rate and internet user rate between the two countries, the overall score of ICT adoption between the two countries was similar.

Index Component	**Value**	**Score***	**Rank/141**
3rd pillar: ICT adoption 0–100	-	73.0	31
3.01 Mobile-cellular telephone subscriptions per 100 pop.	117.5	98	70
3.02Mobile-broadband subscriptions per 100 pop.	96.9	N/Appl.	34
3.03Fixed-broadband Internet subscriptions per 100 pop.	39.6	79.2	10
3.04Fibre internet subscriptions per 100 pop.	0.5	N/Appl.	79
3.05Internet users% of adult population	94.9	94.9	10

Table 1-3 UK's ICT adoption (source: Global competitiveness report 2019)

Index Component	Value	Score*	Rank/141
3rd pillar: ICT adoption 0–100	-	78.5	18
3.01 Mobile-cellular telephone subscriptions per 100 pop.	115.0	95.8	78
3.02Mobile-broadband subscriptions per 100 pop.	95.4	N/Appl.	36
3.03Fixed-broadband Internet subscriptions per 100 pop.	28.5	57.1	32
3.04Fibre internet subscriptions per 100 pop.	23.9	N/Appl.	6
3.05Internet users% of adult population	54.3	54.3	93

Table 1-4 China's ICT adoption (source: Global competitiveness report 2019)

CAV acceptance remains relatively unexplored in both countries (Wu, Liao, & Wang, 2020; Schoettle & Sivak, 2014a; Schoettle & Sivak, 2014b). Also, the comparison between two countries in terms of their CAV acceptance context is something that has yet to be explored. Therefore, the second stage of this research develops a robust CAV acceptance model based on technology acceptance model (TAM), and then validate the robustness using structural equation modelling (SEM) technique.

1.5 Significance and contributions

This study contributes to the understanding of the factors that affect the acceptance of CAVs with regards to their associated cyber security and privacy risks. The main novelty and contributions of this study are:

This study provides a critical review and evaluation of the literature related to the technology acceptance theories.

There are several cyber security challenges in the context of CAVs that have not been adequately addressed. Particularly, public’s awareness, that could eventually transform to trust and acceptance, has been largely ignored by the existing literature. This study thus fills the blank in the literature related to this issue.

The CAV acceptance framework developed from this study contributes to the theory that allows for better understanding of attitudes towards CAV acceptance focusing on the agendas of cyber security and privacy. To the best of the author's knowledge, there is no framework at the current moment that does that effectively and based on real scientific evidence.

The six-theme thematic framework adds to the conversation on CAV cyber security and privacy policy development which requires attention from policymakers and ongoing dialogue with CAV industries. It provides guidance covering the substantive areas in which CAV industries and the public sectors, from eliminating CAV's cyber security and privacy risks to increasing public acceptance of CAVs, contribute to the area of consideration for CAV policy making. To the best of the author's knowledge, this is the first research focusing on user-centred acceptance criteria in CAV policy making.

This study empirically validated the extended TAM in the context of CAV through collecting sample data from both the developed country (UK residents) and developing (China residents). Moreover, the uniqueness of the sample also reflected through the inclusion of the voices from both field experts and general public.

The nature of the methods, data and samples used in this study contribute to the methodological implications. By utilising elite interview and survey techniques in a mixed method providing both research depth and breadth, To the best of the author's knowledge, this is one of the few pieces of research that successfully incorporate thematic analysis results into quantitative theoretical constructs.

1.6 Structure of the thesis

This thesis is made up by 6 chapters.

Chapter 1: Introduction outlines the focus of the study. It first introduces the research background, identifies the research problem and explains the research motivation. Then it clearly articulates the thesis direction by setting out the explicit research aim, objectives and questions that underpin the presented work. It further presents the research scope, the contribution and the methodology applied in this study. Finally, the structure of the thesis is described.

Chapter 2: Literature Review will be constituting a comprehensive review of the literature on a multitude of relevant research areas, including research around: CAVs benefits and risks, public attitude toward CAVs and theories used in information systems (IS) acceptance research. More specifically, this chapter will first define CAVs and distinguishes the terminologies related to them. Then it will present the benefits of CAVs that have been identified in the literature, including improving highway safety, alleviating traffic congestion, reducing air pollution, improving the fuel economy, benefiting public health and improving travel behaviour. This will be followed by a coverage of the CAV risks and barriers associated with driverless automotive technologies, including cybersecurity, privacy and legislation among others. Then the chapter will offer a detailed overview of most influential conceptual frameworks related to this topic, including *diffusion of innovation* (DOI), *theory of reasoned action* (TRA), *theory of planned behaviour* (TPB), *social cognitive theory* (SCT), *technology acceptance model* (TAM) and *unified theory of acceptance and use of technology* (UTAUT). Moreover, this chapter will also compare and evaluate each model, as well as the usage in different cultural contexts. In the end, this chapter will review the methodology and method of analysis used in the technology acceptance literature and present the research gap.

Chapter 3: Research Design & Methodology will describe in detail the methodological approach employed by this study. This chapter will justify the philosophical paradigm of this study, which consists of the ontological, epistemological, axiological, and methodological view of the author. As a result, this research has adopted a mixed method approach that is situated in the pragmatic paradigm and was therefore selected as the conceptual framework. Then, the sequential triangulation mixed method design and the detailed qualitative and quantitative methods adopted in this study will be introduced. In the end, this chapter will conclude with a research ethics declaration for its data collection and data analysis process.

Chapter 4: Qualitative Research Stage will present the methodology of the qualitative research, the results of the thematic analysis and provide the discussion of the result obtained from the elite interview. More specifically, the qualitative research phase involved elite interviews and adopted thematic analysis as the method of analysis. The research finding section will start by presenting the interviewee characteristics. Subsequently, the interview results will be outlined and presented in-depth as the result of the analysis. Six themes, namely, *awareness, user and vendor education, safety, responsibility, legislation* and *trust* emerged. This results section will be concluded with the thematic roadmap conceptualising the privacy and cyber security agendas in CAVs. The discussion section will contextualise the six themes and their key sub-themes, benchmarking them when possible against relevant literature. It will be a discussion that seeks to develop a fluid and recursive frame that elaborates on the qualitative analysis being systematic but not rigid.

Chapter 5: Quantitative Research Stage will present the methodology, the results of the exploratory factor analysis (EFA), confirmatory factor analysis (CFA), confirmatory factor analysis (SEM), multiple group analysis (MGA) and the discussion of the results obtained from the quantitative research stage. More specifically, the quantitative research phase refers to an online survey with the general public in two countries where EFA, CFA and SEM were used for the model development and model validation. Case screening and variable screening will be evaluated based on statistical screening methods which include the checking of missing data, outliers, normality, skewness and kurtosis, linearity and homoscedasticity. EFA analysis will be conducted as a primary analysis for building the fundamental logic and structure of the model. The latent factors that have been identified in EFA will be validated through checking its convergent validity, discriminant validity and the reliability. Further, a CFA measurement model will be established and go through model fit, model validity and reliability and measurement invariance tests. Moreover, SEM will be conducted to compare the direct, indirect and mediation effects among the latent factors. The final structural model will also be validated through an influential outliers' test and multicollinearity test. Finally, MGA will be applied to compare group effects within the model. Then the quantitative results further elaborate and explain the findings from the qualitative results that pertain to the cyber security and privacy factors but go well beyond those. It is a discussion that seeks to develop a model that could potentially generalise CAV acceptance. All constructs in the quantitative model are the key predictors of CAV acceptance, which inspired and extended from the classic TAM model. This chapter will be concluded by synthesising the key lessons of the two research stages and the final process model will be presented with the combined framework identified in the qualitative elite interview phase and the structural model proposed by the quantitative survey research. It will provide a discussion of both sets of results obtained from the two phases of the study. It will also provide policy recommendations.

Chapter 6: ***Conclusion*** will summarise the key results of the present two-phase study, acknowledges the study's limitations, sketch relevant future research areas and confirms the contributions of the work to theory, methods and practice. This chapter will start with an overview of the research and answers briefly but effectively every one of the research questions underpinning the study. It will then highlight the theoretical, practical and methodological contributions of this work. Reflections on what could have been better, acknowledgements of the study's limitations and potential future research directions will then be presented.

Chapter 2. Literature Review

2.1 Introduction

This chapter reviews the literature related to CAV benefits and their associated risk, public attitude toward CAVs, theoretical overview of CAV acceptance research, cultural models and theories related to the technology acceptance, methodologies and method of analysis used in CAV acceptance research and finally identifying the research gaps in CAV research.[5]

2.2 Connected and Autonomous Vehicles (CAVs)

Connected and Autonomous Vehicles (CAVs) constitute an automotive development carrying paradigm-shifting potential that may soon be embedded into a dynamically changing urban mobility landscape. Intelligent transportation systems (ITSs) and highspeed networks such as 5G can make it possible for CAVs to operated safely on roads. Currently, the prospects that CAVs can be introduced into the road industry or market is low because the technological, legal and human conditions necessary for smooth operations of CAVs are being implemented. However, the pioneers in the CAVs industry are actively testing the latest CAV technology and mapping the road and environment in different places around the world in readiness for its inception. For instance, Google Waymo (As shown in Figure 2-1) has been testing their self-driving vehicles on public roads with no one in the driver's seat since 2017. Ford has been testing their highly automated vehicle on the streets of Miami since 2018.

[5] Part of the work of this chapter has been published as a peer reviewed journal paper, which can be found using the following reference: Liu, N., Nikitas, A., & Parkinson, S. (2020). Exploring expert perceptions about the cyber security and privacy of Connected and Autonomous Vehicles: A thematic analysis approach. *Transportation research part F: traffic psychology and behaviour*, *75*, 66-86.

In order to successfully run CAVs on the public roads, 3D maps that contain comprehensive road profiles are needed for them to navigate through the road networking using their built-in sensors and software. CAVs should scan the surrounding environment and objects in the vicinity to identify if they are vehicles, pedestrians, cyclists and so on. Waymo claimed that their vehicles are able to detect up to 1700 square meters (Waymo, 2020). Built-in software (could also be cloud computing in the future) will analyse the gathered information acquired from sensors and predict the movement of every objects based on their speed and trajectory. In this manner, CAVs would evade obstacles and determine the exact speed and route to take to its intended destination. Additionally, ITS could analyse the gathered information from all CAVs in different location and therefore optimize each CAV's route options.

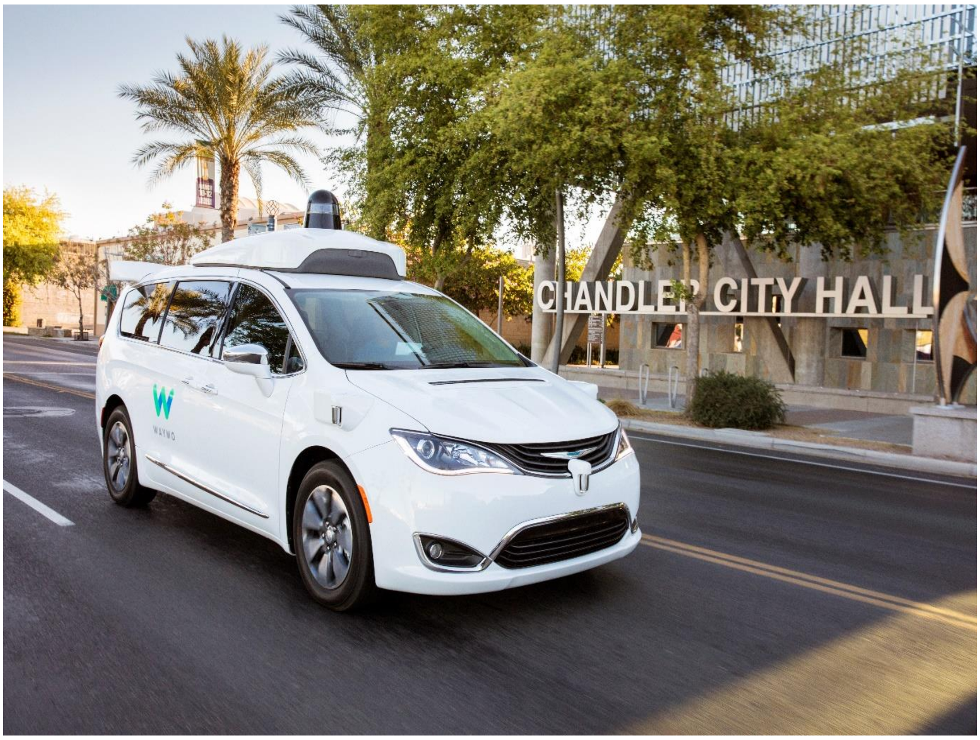

Figure 2-1 Waymo's fully self-driving Chrysler Pacifica Hybrid minivan on public roads

In this regard, CAVs will change the highway driving landscape because the other road users, traffic laws, technology and regulatory framework would have to be configured to accommodate the CAVs. However, before CAVs can be fully implemented, there are many issues that would need to be considered. The following section will clarify some definitions related to CAV.

2.2.1 Defining the terminology of CVs, AVs and CAVs

For the reasons of clarity and consistency, it is important to highlight that this work focuses on CAVs. The future of vehicle automation has many different angles and there is a tendency to employ terms like connected car, smart car, autonomous car, driverless car, self-driving car interchangeably. However, a CAV is not synonymous to a connected vehicle (CV) or an autonomous vehicle (AV); these are different (Talebpour and Mahmassani, 2016).

CV is a vehicle that can communicate and exchange information wirelessly with other vehicles, external networks and infrastructure via vehicle-to-vehicle (V2V), vehicle-to-infrastructure (V2I), vehicle-to-network (V2N) and vehicle-to-everything (V2X) technologies, but that does not necessarily mean that CVs are capable of autonomous driving. Fundamentally, the CV end-users would enjoy a set of services integrating information, infrastructure and communication technologies that improve transportation efficiency and security.

AVs are vehicles that are capable of driving themselves without human intervention. This study adopts the International Organization of Motor Vehicle Manufacturers (OICA)'s definition of levels of automation, which is based on the Society of Automotive Engineers (SAE) International Standard J3016 and refers to six levels of autonomy: 0 being no autonomy; 1 being driver assistance; 2 being partial automation; 3 being conditional automation; 4 being high automation; and 5 being full automation. AVs may not be connected although the two technologies can be complementary.

If a vehicle is both connected and autonomous, then it can be classified as a CAV. According to Nikitas *et al.* (2020), a CAV is any vehicle able to understand its surroundings, move, navigate and behave responsibly without human input which at the same time has connectivity functions enabling it to be proactive, cooperative, well-informed and coordinated. The present study is specifically discussing key privacy and cyber security issues of fully enabled CAVs.

2.2.2 Cyber-Physical Systems (CPSs)

Fundamentally, CAVs are a physical component of cyber-physical systems (CPS) that is monitored and controlled by a network of cyber and physical components. The concepts of security and privacy can be applied to both the cyber and physical sides of CPSs. There are many overlapping terms for these concepts including cyber security, information security, information assurance, and others. For the purposes of this study, the author is concerned in this section with the nonphysical, informational side of CPSs. There are also a number of less empirically rigorous public opinion studies exploring a variety of issues concerning CAVs, these include cyber security and privacy.

Security and privacy are the most critical concerns that may hinder the wide deployment of CPSs in general and CAVs in particular (Song *et al.,* 2017). Possible cyber-attacks, maliciously controlled vehicles and software vulnerabilities might compromise the safety levels of CAVs (Milakis, Van Arem, and Van Wee, 2017), while privacy as the ability to move about in relative anonymity will be lost with control over private information and misuse of that private information arising as a key drawback of this vehicle technology (Collingwood, 2017).

CPS technologies blur the lines between the physical and cyber world and between infrastructural and personal spaces creating opportunities for innovation (Karnouskos and Kerschbaum, 2017). This blurring is being engineered into the Internet of Things (IoT) where personal CPSs (such as smartphones and automobiles) bearing personal data can reach up into public infrastructures to access services. Infrastructural technologies such as smart roads, e-government, and city services have become personal by providing private portals into public services (Song *et al.,* 2017).

Nevertheless, to the larger CPS community, building economically successful CPSs seems to be the priority, since traditionally security and privacy issues can be resolved via patching. This obviously is inappropriate as security and privacy protection must be considered from the early stages when building a CPS – an important lesson learnt from the evolution of the Internet (Romanou, 2018). To educate today's CPS engineers as well as the next generation of CPS stakeholders, studies identifying the state-of-the-art techniques and potential challenges in security and privacy of CPS are in need (Aceto, Persico, and Pescape, 2019).

In the public space where CAVs operate, there is little expectation of privacy and choice may not be available (Rosner and Kenneally, 2018). To improve the acceptance of CAVs and facilitate the development of the technological and policy mechanisms to protect privacy, public requirements and concerns must first be investigated (Tanczer *et al.*, 2019).

Security and privacy have in common the concepts of appropriate use and protection of information (Acquisti, 2004). Privacy is often seen as freedom from observation, interference or unnecessary public attention. It is often seen as part of security and is the reason for providing confidentiality and when possible anonymity. On the other hand, privacy has a more dynamic dimension, allowing owners to control their own information. Strikingly, security on some occasions may be considered a violation of privacy (Song *et al.,* 2017).

Cohen *et al.* (2017) identified that the cyber security and privacy research field is full of unique challenges stemming from various application domains such as healthcare, smart grids, and smart homes, making non-existent the "one-size-fits-all" type of solutions, and that the integration of "cyber" and "physical" worlds opens the doors for insidious and smart attackers to manipulate the system. This leads to new cyber-attacks and defence technologies other than those originated from the traditional computer and network systems. Human-factor researchers and psychologists might improve CAV cyber security and privacy provision by understanding human failure that makes attacks successful, by identifying ways to educate people about safe practices and by proposing ways that could reduce human-induced errors (Linkov *et al.*, 2019).

2.2.3 The levels of automation

The Society of Automotive Engineers (SAE) has classified the levels of autonomous vehicle (AV). It has defined and classified the levels of automation from level zero to five with ranging features and technological endowments (as shown in Table 2-1). Specifically, there are two major categorisations namely the autonomous and semi-autonomous vehicles. Level one is assisted automation while level two is partial automation. The autonomous vehicles are classified from level three to five and are considered to be self-driving automobiles. It is imperative to outline that level three to five are bequeathed with technological features that are enabled with an automated driving system that can operate driving independently.

More specifically, level three is conditional automation where the human drivers are expected to conduct mechanical controls at set intervals. Level four refers to high automation, which implies that additional elements and features are added over and above level three. Level five in vehicle automation is the full automation and the vehicles are expected to fully “self-drive” under the normal traffic conditions in the conventional society (Taeihagh and Lim, 2018). Different international transport agencies such as the European Road Transport Research Advisory Council (ERTRAC), the Government of Ontario, Canada (Ticoll, 2015), Australia’s National Transport Commission (NTC) (Hillier, Wright, and Damen, 2015; Sun *et al.*, 2017), the US National Highway Traffic Safety Administration (NHTSA), and the UK’s Department for Transport (DfT) (Clark, Parkhurst, and Ricci, 2016) have also adopted the definitions and categorisations prescribed by the SAE. This study primarily focuses on the CAV levels four and five and their impact in the society.

SAE Level	**Name**	**Execution of steering and acceleration/ deceleration**	**Monitoring of driving environment**

0	No Automation	Human driver	Human Driver
1	Driver Assistance	Human driver and system	
2	Partial Automation	System	
3	Conditional Automation		
4	High Automation		System
5	Full Automation		

Table 2-1 Vehicle Automation Levels (SAE 2014)

2.3 Benefits of CAVs

The safety benefit is the most spelled out advantage of CAVs compared with the traditional human operated vehicles that are prone to human errors (Chehri and Mouftah, 2019), driving fatigue (Cohen and Hopkins, 2019), drunk or drug driving (Kashevnik, Ponomarev, and Krasov, 2020). It was suggested by the micro-simulation research which examined the connected vehicles lower-level automation (CVLLA) with two automated features in the market (Kapser and Abdelrahman, 2020). Yue *et al.* (2018) had also estimated the exact safety benefits on CV & DA (Driving Assistance) technologies that found that these technologies can reduce vehicle crashes. In terms of AV safety research, AV Morando *et al.* (2018) investigated the safety impacts using a simulation-based surrogate safety measure approaches and proved that AVs improve safety significantly with high penetration rates.

It is also expected that CAVs can travel with shorter headways due to improved safety, leading to increased road and intersection capacities. Table 2-2 shows the highlighted benefits of CAVs from the research literature and official grey literature (UK DfT report). The detailed benefits that CAVs can bring will be discussed in the following subsections.

Improved road safety	Increased comfort
Better economic outcomes through increased productivity and new market demand	Improved environmental sustainability through reduced travel time and distance
Increased travel efficiency	Reduced congestion

Increased access for older people and disabled populations	Reduced road volume through increased ridesharing

Table 2-2 Theoretical benefits of self-driving vehicles (Cohen and Hopkins, 2019; Kyriakidis, Happee, and de Winter, 2015; Ruggeri et al., 2018; Transport Systems Catapult, 2015)

2.3.1 Improving highway safety

More than 1.2 million people die from road accidents yearly (World Health Organization, 2015). This is a devastating statistic considering the adverse effect that it bears on the public health and urban development. Approximately 70% of these accidents were attributed to human error (Dhillon, 2007). CAVs, therefore, present an opportunity to help avoid these deaths because of the expected accuracy of self-driving technology (NHTSA, 2016; Yao *et al*., 2020). In principle, CAVs can sense the traffic environment and independently navigate through the roads without the intervention (Van Brummelen *et al.,* 2018), decision or action of the drivers (Xu *et al.,* 2017). This is a hallmark step because it would seek to enhance road safety by eliminating the incidences of crashes or accidents.

A study that was conducted by the Insurance Institute for Highway Safety (IIHS) concluded that there would be a 31% reduction in the number of highway injuries and fatalities (U.S. Department of Transportation, 2016). For instance, in the United States of America, over 11,000 people lose their lives annually due to road accidents and related injuries (U.S. Department of Transportation, 2016). A considerable amount[6] of these deaths were occasioned by elements of human errors hence the adoption and use of CAV would greatly help to negate this adverse trend.

[6] A longitudinal study conducted by NHTSA survey from 2005 to 2007 estimated that 94% of the accidents on U.S. roadways are due to human error. NHTSA, "2015 Motor Vehicle Crashes: Overview," August 2016, https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/812318

2.3.2 Alleviating traffic congestion

Traffic congestion is a menace that most major cities around the world face. In the US for instance, drivers waste approximately 40 hours yearly caught in traffic jams at a corresponding monetary cost of $121 billion (U.S. Department of Transportation, 2016). The time wasted is even higher in cities such as Mexico, Istanbul, Rio de Janeiro or Moscow where drivers record approximately more than 100 hours yearly waiting in congested traffic (Weinelt, 2016). China has a vehicle population of 126 million which is a 15% increase from the previous year (Wu *et al.,* 2017); this hints at the magnitude of congestion and the number of hours that would be wasted by motorists stuck on the roads and how it is bound to get worse if remedial measures are not adopted.

Approximately 30 percent of traffic congestion around the world is occasioned by drivers circling business centres in search of parking spaces (Shoup, 2006). The circling phenomenon is a cause of air pollution, traffic congestion and environmental degradation. When CAVs are phased into the society, they will interlink with the traffic control systems hence improve the efficiency of traffic flow which will reduce the time motorists spend circling for parking lots (Adegoke *et al*., 2019; Hess, 2020). If provided in a shared use basis (i.e., Shared Autonomous Vehicles (SAVs)) with some 'on-demand' principles they could also reduce the number of cars in need (Narayanan, Chaniotakis, and Antoniou, 2020).

2.3.3 Reducing air pollution

According to Weindelt (2016), cars account for approximately 30% of carbon dioxide emission thereby contributing to climate change and global warming. In most industrial areas, there are records of increased levels of smog and air pollution which are attributed to the high number of cars. Illustratively, a study that was conducted in 2016 indicated that the emission and pollution levels that come from static cars stand are 40% higher than when the car is in motion (Schlossberg, 2016).

Since CAVs are connected and controlled by the computer, it removes human-related idling or braking manoeuvres which could directly improve vehicle fuel economy and reduce transport emissions. However, the new travel behaviour adapted to CAV might increase the traffic emissions as people may be encouraged to make more trips because of the ease of parking and driving around.

The concept of a shared autonomous vehicle (SAV) system has shown merit in the elements of emission reduction. According to Fagnant and Kockelman (2014), there is conservation of energy use and positive environmental outcomes when moving to a SAV system. These scientists studied pollutants such as the particulate matters, volatile organic compounds, oxides of nitrogen, carbon monoxide and sulphur dioxide and realised that there was a positive outcome when using SAVs.

A commercial ride-hailing company Uber has articulated that 50% and 30% of its trips in San Francisco and Los Angeles respectively are pooled or shared rides where several passengers share travel costs (West, 2016b). When people share rides, there is increased environmental gain regarding increased air quality and reduced pollution levels.

2.3.4 Improving the fuel economy

Eco-driving is a concept that helps to lower the cost of fuel consumption. Drivers mechanically accelerate and decelerate thereby altering the fuel usage and creating higher energy depletion. For instance, when the engine is left running during traffic stops or when experiencing traffic congestions this leads to higher wastages and consumption of fuel. Empirical data has indicated that CAVs would minimize fuel consumption by roughly 12% through behaviour mapping, telematics and traffic sensing to reduce wasteful running of engines thereby lower fuel usage (Mersky and Samaras, 2016). Illustratively, the scheme of control algorithms would help to minimize the areas where unconventional stoppages that would lead to fuel wastages (Mersky and Samaras, 2016).

CAVs in the short term would help to save fuel consumption and subsequently reduce harmful emissions. However, in the long run, the impact of CAVs is ambiguous (Milakis *et al.,* 2018). According to (Wu et al. 2017), energy and emission consumption can be lowered exclusively in instances where V2I technologies are employed properly to manage the movement of vehicles at critical intersections and outlets.

2.3.5 Beneficial impact on public health

AVs can positively impact the general welfare of people as outline by van Schalkwyk and Mindell (2018) who suggested that there are various effects that could improve health. More specifically, the mental health of a person may be adversely impacted by inconveniences of the transport networks and systems. Additionally, the nuisance that arises from noise pollution can impair the mental state and health of a person. When the transport network is not properly planned people living with disabilities would be affected because of their physical limitations. Also, a poorly designed transport system negatively affects the urban planning hence adding stress to the people thereby resulting to increased stress levels and ailments by extension (van Schalkwyk and Mindell, 2018). In this regard, AVs can help improve road independence, safety and lower the discomfort that people living with disabilities may experience from the conventional transport system. Hence, CAVs would intuitively lower the prospects of causing health problems.

Similarly, CAVs would aid the elderly drivers avoid the physiological impediments that the conventional road networks may pose to them (Crayton and Meier, 2017). Elderly drivers may engage in crashes, collisions or accidents due to vision impairment arising from old age. Hence, AVs would assist the elderly drivers to avoid such inconvenience. Driving induced stress is a disease that contributes to hypertension and it can be avoided by the use of AVs (Crayton and Meier, 2017).

2.3.6 Improve travel behaviour

CAVs would benefit vulnerable people such as the young or older people who would not otherwise drive (Sochor and Nikitas, 2016) by providing them increased access to door-to-door unassisted transport services. This would imply that travel behaviours would have to change because AVs would offer 'more socially inclusive' travel opportunities to all people such as young or older people.

Similarly, the concept of automobile-oriented development and vehicle miles travelled (VMT) would imply that parking spaces would be less occupied because of the fewer number of vehicles on the road. Increased VMT would bring other associated costs such as high fuel usage and increased emissions.

AVs would allow the concept of sharing rides which would produce higher social and economic benefits. Ridesharing (Kane and Whitehead, 2018; Metz, 2017) allows for the proper use of vehicle space so that there is minimal wastage of resources such as reduced fuel consumption for less number of vehicles used through sharing (Metz, 2017). Alternatively, CAV manufacturers may improvise and introduce service hours rather than sell CAVs (Metz, 2017), which is referred to as the SAV (Fagnant, 2015). SAV services would improve spatial convenience because the users would be driven autonomously (Newman, *et al.,* 2017).) SAVs would be more convenient, efficient and popular as compared to the conventional vehicle services such as Grab and Lyft (Hörl *et al.,* 2016; Fagnant and Kockelman, 2014; Kane and Whitehead, 2018). However, CAVs would rely on technology to operationalise the shared services which presents a challenge because the people who are out of the "digital space" would be marginalized from enjoying the service (Pangbourne *et al.,* 2018).

Furthermore, some authors (Fagnant and Kockelman 2014; Kane and Whitehead 2018) argue that CAV hours would be more convenient for users in rural establishments or dense areas because the service would have been customized to the region and users' preference. As such, the users would save time because CAVs would allow them to access online controls from the CAV systems (Horl *et al.,* 2016). CAVs would help businesses to save on their operational cost because the driverless vehicles would not need labour cost, thereby lowering the cost and increasing profits for the firms.

2.4 Risks associated with CAVs

Whilst CAVs can be used to make people safer, more productive and keep them entertained while in transit, this driverless concept has also the potential to create a transport system vulnerable to attacks through which intruders could possibly access the vehicle's delicate controller area network (CAN). Once inside, hackers can send commands to the vehicle from a remote location in order to, inter alia, steal private data, track individual vehicles or entire fleets and hijack non-safety and safety-critical functions.

Similarly, when access to CAVs increases there will be risks of an increase in congestion because the demand would increase thereby leading to prospects of heavy snarl-ups. For instance, CAVs can be customised by owners/users to make rounds in the block while waiting for the users and in the process cause congestion. Experts suggest that this menace of congestion can be avoided if the CAVs are integrated with other transport systems such as trains, taxis and buses to establish local manageable grid.

Ordinarily, the enterprise model that would guide the profit venture of CAVs would ignore other beneficial modes of transports such as walking and cycling (Pangbourne et al. 2018). Strategic areas such as stations are primarily designed to be walk-paths but CAVs may clutter or congest these sections (Newman, *et al.,* 2017). In this regard, a cost benefit analysis is fundamental to evaluate the gains that CAVs bring against the demerits that the society may experience from its operations.

Particularly, in the short term, concerns of loss of employment would be raised, for instance, traffic officers (Crayton and Meier 2017), taxi drivers (Heard *et al.,* 2018), freight-cargo operators (Horl *et al.,* 2016) may be rendered redundant and jobless in the immediate time.

Cyber security threats constitute a key problem that needs to be addressed alongside socio-psychological barriers that might make individuals, and even societies as a whole, less willing to embrace driverless vehicle technologies. The prospective end-users need to be convinced that the operating technology installed in CAVs is safe and secure. From the onset, it was apparent that AVs would face different threats, namely adverse human attitudes, technological safety challenges and cyber security threats.

Human perception, attitude, fear and acceptance of the self-driving vehicles constitute a significant factor that must be assigned weight when evaluating the driverless vehicles future. It is imperative to articulate that human attitudes drive business directions, such as the form of marketing and human factor design that would be employed to help the manufacturers modify their product to address the fears or reservations of the general public.

2.4.1 Cybersecurity

There are many overlapping terms for cyber security concepts in CAVs including information security, information assurance and network security. For the purposes of this study cyber security is defined, according to the General Data Protection Regulation (GDPR) guidance as 'the use of appropriate technical and organisational measures to secure infrastructure, networks and data from unauthorised or malicious activity'. Cyber security in CAVs according to Olufowobi and Bloom (2019) is the answer to attacks associated with: desire for infamy, vengeance, or twisted pleasure; profit; traffic control so as to create open or congested routes; traffic disruption to create congestion or even panic; intelligence, surveillance, and reconnaissance, whether targeted or en masse; vehicle theft; remote hijacking of an operating vehicle; infecting vehicles with malware; and creating a vehicular botnet.

Cyber security is defined as the system of programmes that damage the flow and nature of information and datasets held by organisations, firms, individuals or governments. These include interruption or disorientation of operations, unauthorised access to private information and identity theft amongst others (Oltramari and Kott 2018). Cyber risk has taken prominence in the recent past because the major stakeholders such as governments and experts have assigned increased attention to the phenomenon. The adverse effects of cyber risk include loss of money, injury to reputation and leakage of sensitive information into the hands of unauthorised parties. The mainstream media has taken steps and measures to interrogate the aptness of security defence systems against cyber risk. As such, there have arisen discussions that seek to highlight the measures undertaken to protect the society against such risks.

The security of CAVs takes eminence because of the sensitivity of this matter. CAVs rely greatly on the vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communication platforms to operate. In all these platforms or pathways there are other additional electronic transmissions such as phone calls, internet surfing, email connections and usage of network data. These imply that the data security must be comprehensive to ensure that all these networks and platforms operate safely and securely.

Security researchers have mentioned that there are chances of security breaches such as sensor manipulation, interferences with radar, ghost vehicles, loss and theft of data, jamming and hacking of network systems (Petit and Shladover, 2015). If there is any disorientation or disturbance on any of these readings, then false actions on the artificial intelligence algorithms will arise that will cause disruption of the smooth operations of CAVs. In order of merit, these scholars rank injection or penetration of fake information, spoofing and global navigation satellite systems (GNSS) as the riskiest because they can potentially result in accidents where loss or damage of property and fatalities are likely.

Technology experts have in the past affirmed their ability to remotely intercept and hack the digital operating system of a Jeep Cherokee. More specifically, technology experts indicated a huge ability to interfere with the windshield wipers, change radio frequencies, control the brakes and steering wheel remotely (Kelarestaghi *et al.*, 2018) They achieved these levels of interruption by tapping into the Uconnect software. This instance articulates the continued need for the CAV manufacturers to improve the operating systems security to avoid such eventualities. Table 2-3 shows attacks for vehicle to everything (V2X) communications in the context of the urban Platform for Connected Electric Vehicles (PUVEC)[7].

	Vulnerabilities		
V2S	DoS, Jamming, False data injection, GPS deception		
V2V	DoS, Selfish attack, Modification, Sybil attack, False data injection, Eavesdropping, Black Hole, Gray Hole and Wormhole attack.		
V2I	Replay, Router Advertisement Forgey, Privacy, RSU Spoofing, DoS of the DAD		
V2N	Mobile Femtocell	MOBIKE	DoS, MiTM, Spoofing
		Femtocell	Physical Attacks, Configuration Attacks, MiTM, DoS, privacy, etc.
	5G	mmWave and D2D: Eavesdropping, privacy. Jamming attack	

Table 2-3 Internet of electric vehicles vulnerabilities (Fraiji et al. 2018)

Existing literature has defined cyber risk as an IT risk. The National Institute of Standards and Technology's (NIST) in its guide for conducting risk assessment describes the phenomenon of risk as a likely vulnerability of a particular threat to occur. In order to realise and ascertain the likely occurrence of vulnerabilities, it is necessary to assess the controls and weaknesses that exist in the digital system (NIST, 2020).

Research has delved into the prospects of cyber security threats of CAVs. By definition, a CAV is controlled and navigated greatly by operating digital systems, which are prone to attacks such as hackings or breaches. In the event of a cyber security attack, the digital systems of the vehicle would not have the ultimate control of their vehicles (Hern, 2016; Lee, 2017). In the absence of full-proof security programmes and services, the V2V and V2I communication mechanisms can be breached and the immediate results may be fatal (Dominic *et al.,* 2016). Penetration of fake or erroneous messages and hoaxing of the GNSS are some of the likely risks that the AVs would face. These threats would lead to a critical undermining of the functionality of the digital system of

[7] Platform for Connected Electric Vehicles (PUVEC) is a context awareness program or application that endeavours to provide solutions such as the autonomy of the drivers, management of battery, energy etc.

CAVs. Similarly, there are also prospective risks such as the interruption of the sensors and in effect the disorientation of the digital operating systems of a CAV. Illustratively, such a disorientation of the digital system may lead to the CAVs being inhibited from perceiving incoming objects and obstacles thereby adversely affecting their operations (Bagloee *et al.,* 2016). Some of these threats can be addressed through systems upgrades that would help to detect such a challenge of disorientation of the CAV operating system (Bagloee *et al.,* 2016).

2.4.2 Privacy

Privacy is 'the act of empowering users to make their own decisions about who can access and process their data and personal space and for what purpose'. Devices such as driverless cars, remote monitoring devices, smart watches and smart devices such as phones generate a huge volume of data that can be used for analysis (Kraijak and Tuwanut, 2015). This data can help business entities such as insurance firms to adjust their insurance covers and policies based on the skills of the drivers and the existing risks (Eling and Lehmann, 2018). With the current CAV technology, the insurance firms have to collect several types of information about the CAV (e.g., the car condition, distance covered and locations visited) in order to determine the compensation rates. These pieces of information could then be relayed to other third parties, a concern that consumer rights activists have voiced. For instance, the CAV would require a certain amount of personal data to conduct troubleshooting operations or restore defective programmes, all of which could be disclosed to a third party for research or marketing purposes.

CAVs greatly depend on high-definition maps and motion sensors to operate smoothly in a secure manner (West, 2016; Dhar, 2016). But issues have been raised on who controls this critical element of information (Anderson *et al.,* 2014; Boeglin, 2015). To this end, it has become increasingly ambiguous and unclear as to the nature of the privacy of this information. Further, it has not been proved or confirmed as to what would be the nature of the information that would be collected, who would collect the information, storage facility of the data and the permission or authorization levels for access of the information that would be collected (Glancy, 2012). V2V and V2I communication platforms enable the fast and seamless transfer of information to be shared between the CAVs. The sharing of information exposes the location of the AV and its movement to other networks and security systems.

In essence, a third-party network can access or view the location and speed of the CAV introducing another element of privacy (Glancy, 2012). There are also inadequate measures to protect the location data of CAV users because the customers authorise consent and approve the terms and conditions without understanding them thereby surrendering their privacy controls (Schoonmaker, 2016). Further, there is the use of event data recorders (EDRs) that would be used to determine the cause of crashes. The EDRs information could then be passed to third parties such as insurance firms against the drivers hence void the element of privacy that ought to have been undertaken (Dhar, 2016; Pinsent Masons, 2016; Schoonmaker, 2016).

Glancy (2012), argues that elements of informational privacy such as identity theft, stealing profile of users and use of drivers' information for promotions and marketing are still eminent concerns that must be enumerated. Additionally, such information may be used to harass the users because the hackers may predict their actions due to the automated systems (Glancy, 2012). There are prospects of anonymizing this personal information, however the anonymity can be removed through deanonymisation algorithms. In principle, the deanonymisation algorithms have the power to identify and re-evaluate the microdata and help re-establish the initial an unencrypted information (Gambs *et al.,* 2014; Narayanan and Shmatikov, 2008). This presents a challenge because the minimal data can be used even with little human interaction to trace the movement of the users and eventually infiltrate on the drivers' privacy (Gambs *et al.,* 2014; Gillespie, 2016). The access of wireless networks by CAVs allows private and governmental agencies to remotely survey and monitor the users thereby limiting their autonomy (Glancy, 2012).

Studies and research on cyber security perception have not exclusively focused on CAVs, rather they have articulated other related contexts of cyber security. These studies have established a connection between different categories of information and the personality features of the users. In this regard, some ailments, disorders or medical conditions have been shown to reduce the users' affinity to cyber security and privacy. Korzaan *et al*. (2008), recorded that neuroticism influenced computer anxiety while agreeableness linked to concerns about the privacy of information. Agreeableness and conscientiousness directly linked to perceptions of privacy such as improper access, unauthorised use and error (Junglas *et al.,* 2017).

2.4.3 Legislation

Most governments across the world have initiated measures to establish guidelines on cyber security policies and practices. As such, the presence of the cyber security measures would help to develop and advance CAV systems. EU, China, Singapore and the US have enacted laws to address the phenomenon of cyber security risks. Specifically, the US has enacted regulations and laws that focus on monitoring computer systems aiming to assess the degree of cyber-risk (Sedenberg and Dempsey 2018). Accordingly, the Office of Management and Budget guided all government agencies to use a safe model of automated cyber monitors to help address the element of cyber-risk (House, 2010).

The main information office for the Department of Defence (DoD) in the US issued a curriculum for continuous monitoring and assessment of the mobile devices and networks. Additionally, the US DoD further issued a directive on cloud monitoring and assessment for cyber-risk. It is critical to outline that risk monitoring involves the process of collecting data from set feeds, automated hosts, scan results from systems such as Nessus, Transmission Control Protocol (TCP) and Domain Name Server (DNS) trees. All these data are subjected through automated evaluation and analysis to check the level of risk on their vulnerabilities. In the event that vulnerable data or feed is flagged off and singled out as a risk element, the automated analysis would provide a holistic analysis of the risk level.

The NHTSA framework recommends that manufacturers of software design have to implement the CAV operating and digital system in compliance with the established international standards. These include the guidelines ratified by the Alliance of Automobile Manufacturers, SAE, NHTSA and the National Institute for Standards and Technology (NHTSA, 2016). These endeavours showcase the seriousness that has been undertaken to help address the concept of cyber security and consequently raise awareness about the phenomenon. In this regard, the SPY Car Act was enacted to advance controls for digital safety for the CAVs (NHTSA, 2017). This law stipulates that the operating software for the vehicles would have to be separated and their analysis and evaluation to be conducted under international standards of cyber security.

Further, the law defines the modalities that would be used to handle the safety of the data while the vehicles are in motion or static. It also dictates that the CAV should be fitted with detection software that would report any attempted data breaches that endeavour to hijack or control the driving controls. This means that the vehicle would instantly notify the user on the measures the system has taken to observe their privacy from prospective cyber threats.

EU has undertaken positive efforts and steps to protect the public against cyber security risks and threats even if such risks are not CAV-related. In 2013, the EU introduced measures and steps to help establish directives on information systems and networks by 2016 (European Union, 2016). The initial step was that the EU initiated comprehensive legislation on the matter to design a legal policy framework on the notion. Similarly, other non-state actors have embarked on awareness campaigns to enlighten the public accordingly. In 2016, the EU advisory agency on data protection recorded its opinions through a publication on cyber security measures and the Internet of Thing (IoT) (Pillath, 2016).

China has also undertaken progressive measures to help address the issue of cyber security and privacy. Some of the primary tenets of this law encompass a clause that protects personal data and information, process of review before sensitive data is moved overseas from China, protection of critical information within the territorial waters of China, sanctions for violation of cyber laws, mandate of network operators in protection of personal data and critical information infrastructure (KPMG, 2020). In essence, before any private company would be allowed to pass data from China to an overseas nation, it would be required to pass from a national review and evaluation test or mechanism (Liang, Das, Kostyuk, and Hussain, 2018).

Singapore has also delved into this sector to gain critical control of data cyber-safety. In 2017, the government introduced the Computer Misuse and Cyber security Act that cushions corporate entities against infiltration and cyber threats. There have also been strategic measures that have been taken between the private actors and institutions of higher learning to help raise awareness and draw attention to the phenomena of cyber security and privacy. This move is aimed at establishing Singapore as a cyber security provider (Srikanthan, 2017).

The UK government does not have a comprehensive approach and mechanism relating to the cyber security and privacy protection of CAVs. However, in the recent past, it has increased efforts to raise awareness on cyber security for all technological systems. In principle, The National Cyber Security Strategy 2016–2021 has been set to promote cyber security for networks and systems in the country. This blueprint supposes that the UK will be a world leader in enforcing cyber security measures before the year 2021 (Cabinet Office, 2016). This postulation follows the decision to institute and establish the National Cyber security Centre (NCSC) which was founded to help in the detection, prevention and rebuttal of cyber threats. This strategy is fashioned towards building the capacity of the citizens by helping them to detect and respond to cyber threats and attacks promptly (Department for Transport, 2017).

2.4.4 Other risks

Apart from the aforementioned issues CAVs can potentially introduce, other risks such as ethical and legal challenges, liabilities and social exclusion amongst others.

In 2018, EU announced the formulation of Commission Expert Group on advising specific ethical issues raised in CAVs (Europen Commission, 2018). The Expert Group consisted of 14 European experts with a professional background in ethics, law, philosophy and CAVs whose aims are to promote ethical considerations in the CAV development and implementation. Research on ethical risks associated with CAVs have been conducted in the past few years (Landini, 2020; Nikitas *et al.,* 2019). Automotive manufacturers have claimed that their AVs will prioritise the users lives inside the cars an assertion that poses ethical issues, legislative concerns and insurance policies. These claims in turn raise issues of ethical algorithms development of CAVs where the CAV developer would be bound to write their algorithms according to the confines of the laws. Further, it highlighted the importance of a clearly defined legislation necessary to incentivise responsible CAV design.

Social exclusion and equality issues were also raised on lack of transparency in the CAV algorithm such as other commercial products that involves AI and big data utilisation, misuse of personal data and discrimination that was found in the algorithm (Drechsler and Benito Sánchez, 2018; Kleinberg *et al.*, 2018). Further, algorithmic auditing tools were promoted (Europen Commission, 2018) in development, testing and evaluating the CAV design in order to achieve CAV inclusivity.

The risk distribution issue is another focus in CAVs research. Research has sought to evaluate and analyse the spread of risk among other road users (e.g., pedestrians, cyclists, motorbike users) when interacting with CAVs (Parkin *et al.*, 2016).

2.5 Public attitudes towards CAVs

A successful future mass adoption of CAVs, ultimately depends on the capability of the CAV system being designed in a way that would inspire public acceptance. Social science research shows that public attitudes and behaviours toward new technology and its associated risks are many and diverse and are affected by psychological (Frewer, Howard, and Shepherd, 1998), cultural (Williams, 2004), and cognitive factors (AU and Enderwick, 2000). In turn, underlying beliefs and perceptions about CAVs (Bonnefon *et al.,* 2016, Howard and Dai, 2014), cyber security threats (Bada *et al.,* 2019, Olmstead and Smith, 2017) and privacy risks (Kokolakis, 2017) have been associated with individual or group demographics.

Given these complex dynamics, it is difficult to predict public response to future CAV adoption in the society. However, social scientists have confirmed few core principles and cognitive structures that frame subsequent attitudes and aid to explain behaviour toward CAVs (e.g., value systems and risk perceptions as per Fraedrich and Lenz, 2016). Cohen et al. (2017) explained the multiple links between socio-psychological factors and the key pathways for designing impactful policy. For example, attitudes informing government action that would influence technological development could affect the public attitudes.

Frequently used theoretical models in CAV human factor research refers to the Technology Acceptance Model (TAM) (Davis, 1989), Multi-Level Perspective (MLP), or the Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh *et al.*, 2003). A number of studies have developed new model by integrating the classic technology acceptance model or theories (Osswald *et al.,* 2012a; Kervick *et al.,* 2015).

Research on CAV adoption has grown in recent years however substantial empirical data on the phenomenon remains limited. An empirical research study conducted by Osswald et al. (2012b) determined two extra factors, safety and anxiety, additional to the UTAUT model.

Ruggeri et al. (2018) researched on generational differences on technology adoption patterns in the UK by using DOI curve. The research established that older people are more likely to be late adopters of technology as opposed to younger people. Shabanpour et al. (2018) applied the DOI theory into the data collected from the Chicago metropolitan area and found that market penetration can achieve a 71.3% effect on changing market price of AV. The researchers also found the strong influential factors on people's AV adoption to include a wide range of socio-demographic factors, travel pattern indicators, technology awareness, and perceptions of AVs.

A person's friends and neighbours were found to be a factor influencing CAV acceptance, a research conducted in Austin, Texas averred. Austin is one of the pioneer cities that started testing CAVs on public roads. Bansal, Kockelman, and Singh (2016)'s research concluded that for 50% of the population, the adoption rates of AVs would depend on the adoptions rates of their friends' and neighbours'. They have also presented people's willingness to pay (WTP) for CAVs and related technologies, as well as CAV sharing preference to be some of the grounds for acceptance of the CAVs.

As this study aims to investigate factors that affect user's acceptance and adoption of CAVs, it is important to understand how acceptance is being examined and grounds that users embrace to adopt CAVs.

2.6 Theoretical overview

According to Jing *et al.,* (2020), a meta-analysis of AV acceptance studies outlined the key theories on AV acceptance as: *technology acceptance model* (TAM), *theory of planned behaviour* (TPB), *unified theory of acceptance and use of technology* (UTAUT), *diffusion of innovation* (DOI) and *theory of reasoned action* (TRA). The following section discusses the theoretical underpinnings of this study.

2.6.1 Diffusion of innovation (DOI)

Diffusion of Innovation (DOI) theory is one of the oldest social science theories that was developed by E.M. Rogers in 1962 (Rogers, 2010). DOI seeks to answer the question of how an idea, behaviour or product gains momentum and diffuses over time through a particular population or culture. This theory postulates the adopter characteristics into five categories: *Innovators*, those who want to be the first to use the innovation; *early adopters*, those who are usually opinion leaders, or influencers in the current society context; *early majority*, those who adopt innovations long after early adopters, they are rarely leaders but do have above average social status; *late majority*, those who tend to adopt innovation after the majority has tried it, and they generally have a high scepticism profile; *laggards*, those who are generally older, very conservative and bound by traditions, tend to be very sceptical and usually found having a low financial liquidity. The proportion of these five groups of adopters in the population nearly forms normal distribution, as shown in Figure 2-2.

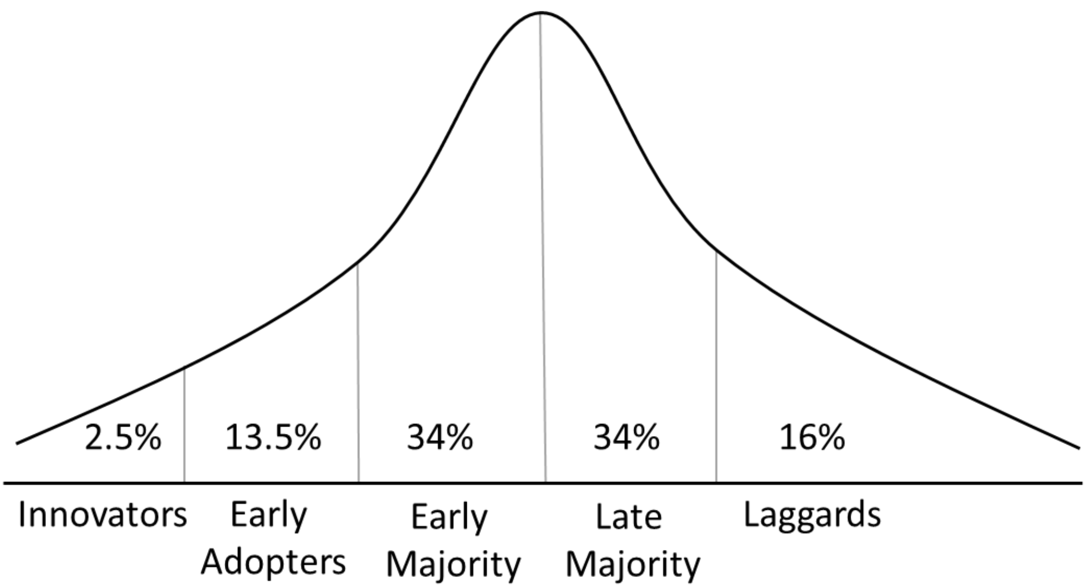

Figure 2-2 DOI curve

Diffusion (or spread) occurs through a five stages decision making process (Rogers, 2010). As shown in Figure 2-3, includes awareness (knowledge) about the innovation, seeking information and process whether they need the innovation (persuasion), deciding on whether to adopt the innovation (decision), initially employ the innovation (implementation) and confirm whether they are going to continuing using the innovation (confirmation).

DOI has been used in various fields of studies namely development studies, organisational studies, and complexity studies. Most of the studies that adopted DOI mainly focused on how people's perception on the innovation characteristics influences the decision of the prospective consumer to adopt that innovation.

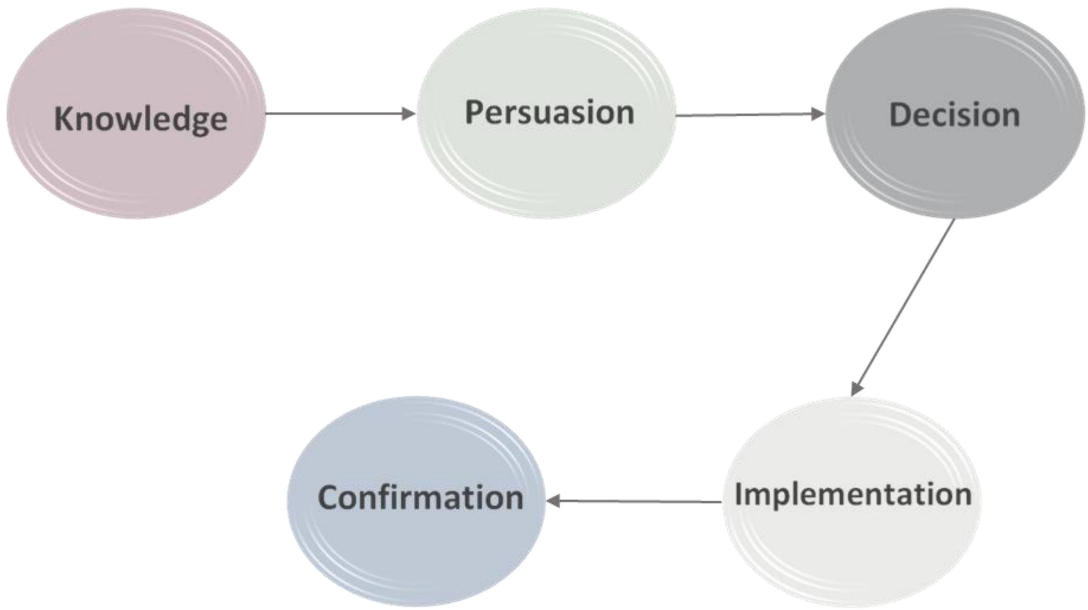

Figure 2-3 Five stages DOI diffusion

For the explicit CAV adoption context, empirical research has been conducted using DOI coupled with Agent-Based Modelling (ABM) where the researcher developed a dynamic model about peer-to-peer communication and media advertisement impact in relation to consumer's adoption decision (Talebian and Mishra, 2018). This study has used the extended seminal mathematical DOI model that was developed by Frank Bass (1969). The results of the study emphasized the impact of the willingness to pay (WTP) on the CAV adoption as a critical influential determinant. On the other hand, pre-introduction marketing campaign may have no impact on CAV adoption at the first six months of its introduction.

An extension of DOI is the innovation diffusion theory (IDT) (Moore and Benbasat, 1991), which has also been fused with TAM on investigating factors influencing AV adoption (Yuen *et al.,* 2020). The findings outline the positive relationship between perceived usefulness (PU) and perceived ease of use (PEOU), innovation characteristics impacts PU and PEOU. However, the study failed to explain the reason of using the initial IDT that was initially presented by Moore and Bombasat in 1991 (Moore & Benbasat, 1991), but not the refined IDT model that was reworked by Rogers in 1995 and 2003 in the later years. The combination of DOI and TAM has also been used in research on mobile services acceptance (López-Nicolás, Molina-Castillo, and Bouwman, 2008) and online travel services (Agag and El-Masry, 2016). DOI has been faulted as being not good for conducting studies on innovations (Downs Jr and Mohr, 1976). In essence, innovation adoption is a dynamic process that considers continuity of concept change to be imperative.

Rogers' DOI and its extended model does not make distinction between acceptance and continuity. However, one of its innovation characteristics; *perceived risk*, has been emphasised and proved in many research works (Aldás-Manzano, Lassala-Navarré, Ruiz-Mafé, and Sanz-Blas, 2009; Gürhan-Canli and Batra, 2004; Ostlund, 1974), as well as in CAV acceptance related research (Chikaraishi *et al.*, 2020; Xu and Fan, 2019). Further, it has been adopted as an important construct in various social science theories. For instance, revealed preference theory (Richter, 1966), cultural theory of risk (Douglas, 2003) and theory of perceived risk (TPR) (Bauer, 1960).

This study contributes to the literature of the risk perception in relation to the TAM model constructs as well as on CAV acceptance, which helps to foster a successful CAV dissemination in a pre-adoption process.

2.6.2 Theory of reasoned action (TRA)

Theory of reasoned action (TRA) was developed by Fishbein and Ajzen in 1975 (Fishbein and Ajzen, 1975) and it explains how people's beliefs and attitudes influence their behaviour intention (as shown in Figure 2-4). TRA sets two independent components as the *behavioural intention* (BI), *attitude toward action or behaviour* and *subjective norm (SN)*. Fishbein and Ajzen (1975) defined attitudes toward action or behaviour as an individual's overall assessments of a particular behaviour after the evaluation of the perceived consequences of the act. SN is defined as a perception that influential, important or valuable people will embrace, approve or support a certain behaviour and as such it provides the impetus to undertake such a behaviour (Fishbein and Ajzen, 1975).

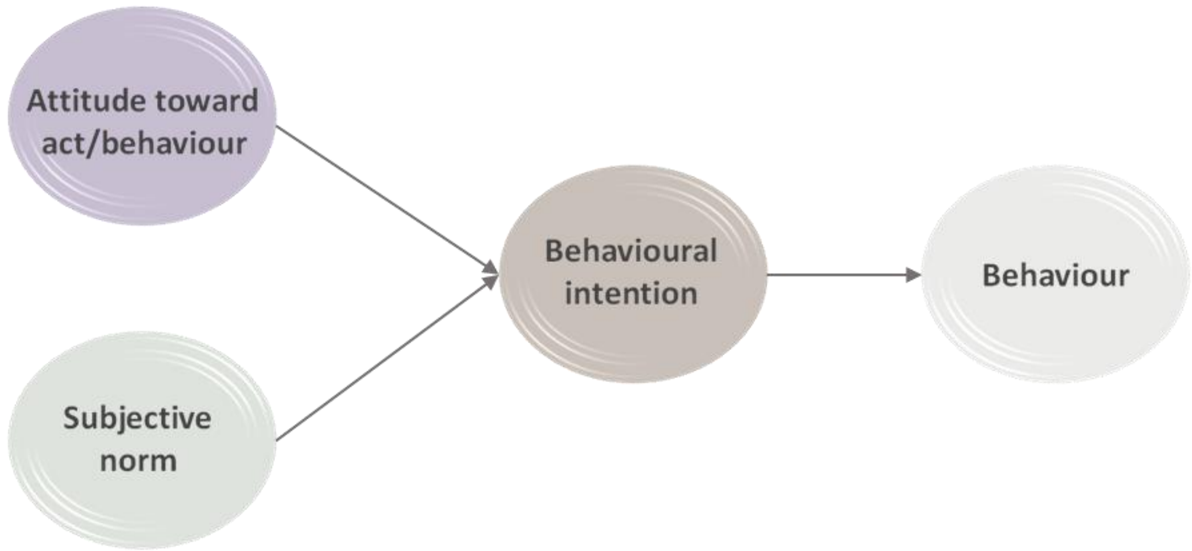

Figure 2-4 TRA model (Fishbein and Ajzen, 1975)

Generally speaking, if the user evaluates the suggested behaviour as good and the user believes that other people will support or approve of the suggested behaviour, they will more likely perform the (suggested) behaviour.

No research has been found utilising TRA to investigate user acceptance for CAVs and its related context. Ogden (2003) has pointed out that TRA has been found weak in predicting certain behaviours in a systematic review on social cognition models. Moreover, it has also been proved that behavioural intention (BI) does not conclusively determine the actual behaviour. This arises because human behaviours cannot simply be performed at will, rather, they need several internal characteristics to successfully execute the prospective, targeted or suggested behaviour such as skills, opportunities, resources, or cooperation (Sutton, 2001). Therefore, these premises led to the development of theory of planned behaviour (TPB) (Ajzen, 1991), a model that has tried to extend the TRA by accommodating non-volitional factors.

2.6.3 Theory of planned behaviour (TPB)

Theory of Planned Behaviour (TPB) (Ajzen, 1991) is derived from TRA and predicts human's voluntary behaviour. On the contrary, TPB intended to explain how humans can exert self-control over behaviour, in other words, TPB intended to predict deliberate behaviour.

Ajzen's TBP model proposed that intention is influenced by three socio-cognitive factors namely *attitude toward act* or *behaviour* (from TRA), *subjective norm* (SN) (from TRA) and *perceived behavioural control* (PBC) (as shown in Figure 2-5). Perceived behaviour control is a newly added construct in TPB and is defined as one's belief in their ability to perform a behaviour successfully. According to Ajzen and Fishbein (1980), attitude is positively related to intention. Furthermore, perceived risk is one of the important determinants that individuals consider when purchasing new products.

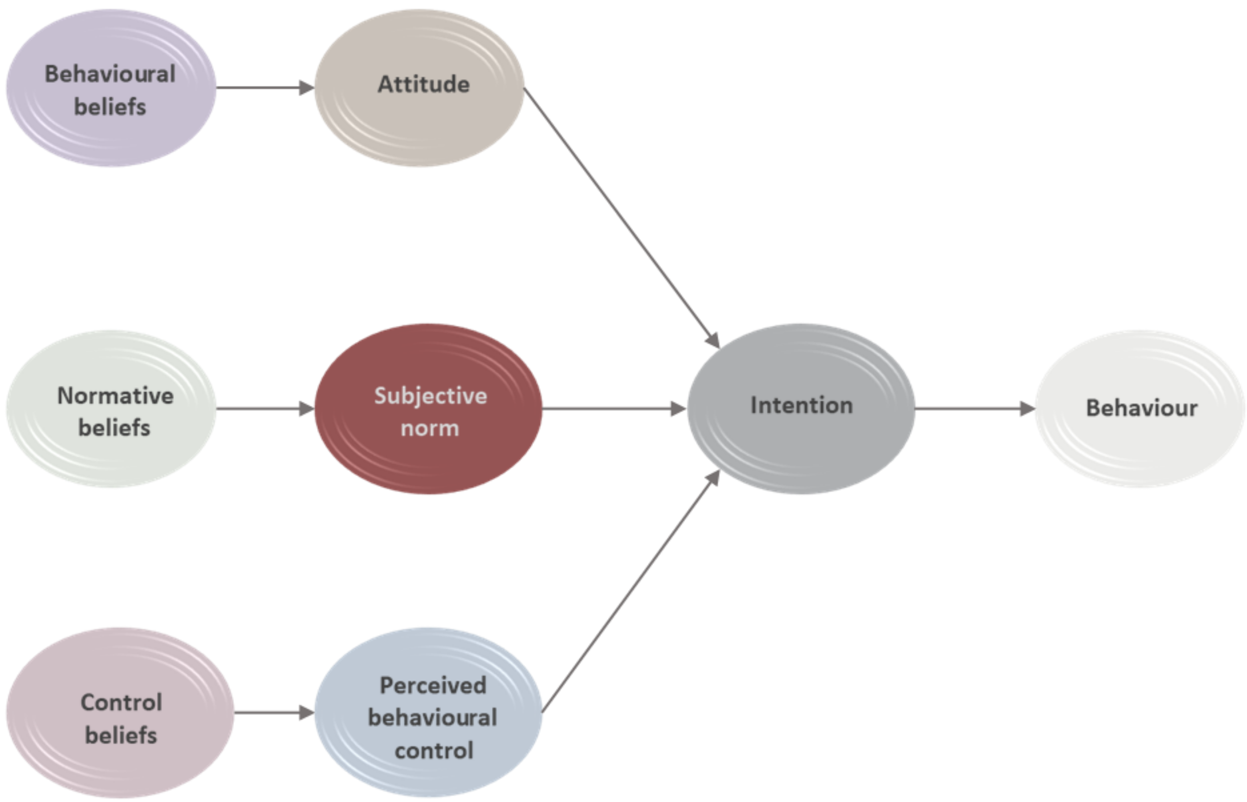

Figure 2-5 TPB model (Ajzen, 1991)

TPB has been successfully adapted in investigating factors influencing behavioural intention of using an AV (Chen and Yan, 2019). Chen and Yan's research did not find significant effect of perceived risk on behavioural intention. Additionally, no significant difference by demographic or socioeconomic characteristic (such as gender, location) were observed on the prospects of AV adoption.

Critiques and criticism arising in the concept of TPB mainly focus on its power of prediction and the residual effect of the past behaviour on the future behaviour. Other research studies did not find the significant relationship between subjective norm and intention (Moriano *et al.*, 2012). Perceived behavioural control associated with the past behaviour is stronger than future behaviour (Albarracin *et al.*, 2001; Reinecke, Schmidt, and Ajzen, 1996).

2.6.4 Social cognitive theory (SCT)

Social cognitive theory (SCT) (Bandura, 1986) emphasised the dynamic reciprocal interaction between personal factors, environmental factors and peoples' behaviour. As shown in the Figure 2-6, SCT has followed a reciprocal determinism approach where three constructs influence each other simultaneously. Contrary to DOI, SCT has taken people perception and attitude into account in its analysis. SCT is characterized by four constructs: *self-efficacy, outcome expectations, goal setting*, and *facilitation*.

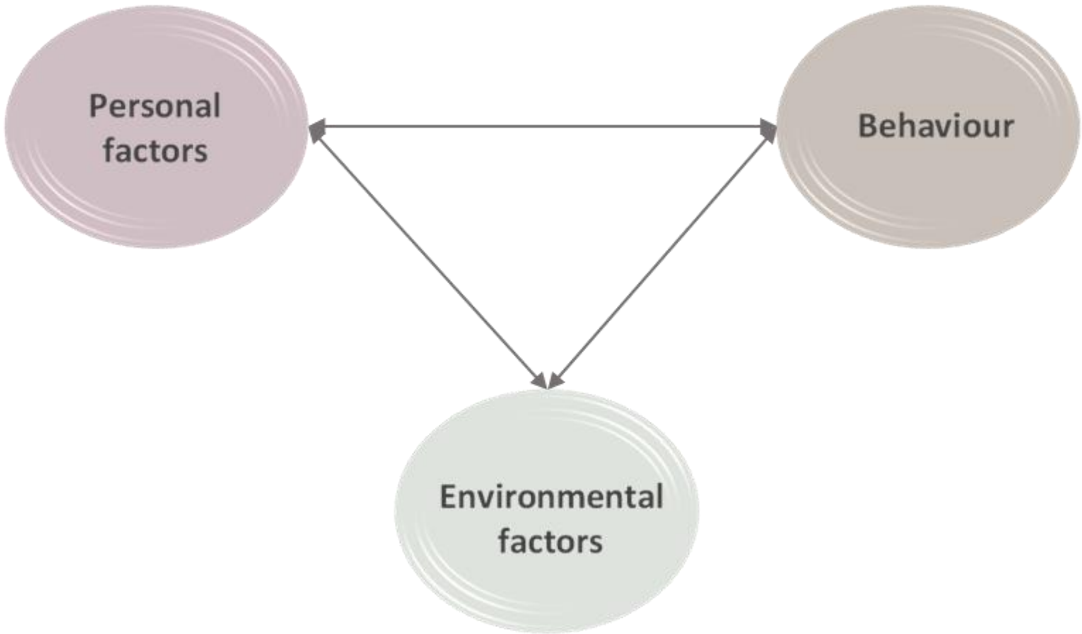

Figure 2-6 SCT (Bandura, 1986)

SCT model denotes that there are multiple ways of changing or influencing human behaviour such as changing the environment or attaining improvement on skills. SCT has also considered that peoples' past experience could influence their behaviour. SCT highlighted the importance of cognition power where people can control and reinforce themselves towards a goal-directed behaviour. In other words, SCT suggests that people have the capacity to make their own choice and impose their desires to the world. In essence, it implies that people have the prerogative, discretion and ability to act as they please regardless of their "environment." Therefore, self-efficacy is the key focus of SCT.

Self-efficacy (SE) refers to “the level of a person's confidence in his or her ability to successfully perform a behaviour” (Bandura, 1986). It is a unique construct specific to SCT, although other theories have also incorporated SE such as the TPB. It has been established that environmental factors (such as barriers and facilitators) alongside individual factors all influence SE (Munce *et al.,* 2014).

Another core determinant in SCT is facilitation which is defined as “providing tools, resources, or environmental changes that make new behaviours easy to perform.” It emphasises on the importance of providing aid towards achieving targeted behaviour. In this endeavour, an intervention approach is necessary to facilitate increase in people’s awareness and skills.

There are several limitations reported on SCT such as its impracticability in the real-life situations; its value may be more theoretic and abstract. For instance, SCT assumes that environmental changes would lead to the change in a person’s behaviour which may not be true in real life. Moreover, the theory underscores the relationship between the constructs, but it fails to rank the strongest construct that would influence others hence opening aperture for ambiguity and vagueness.

To overcome the above-mentioned limitations from DOI, TRA and TPB, another method technology acceptance model (TAM) has been introduced for subsequent consideration as the study’s theoretical framework reviewed in the next section.

2.6.5 Technology acceptance model (TAM)

Technology acceptance model (TAM) was developed by Davis in 1989 (Davis, 1989) who had reworked and adapted on Fishbein and Ajzen's TRA model (Fishbein and Ajzen, 1975) model. TAM sought to explain the factors influencing the users’ acceptance of a technology. TAM has used two constructs from TRA namely *perceived usefulness* (PU) and *perceived ease of use* (PEOU). The definition of each construct is presented in Table 2-4. They are also discussed detail in Chapter 3. TAM has become the most influential and widely used model in the technology acceptance research. Figure 2-7 shows TAM model.

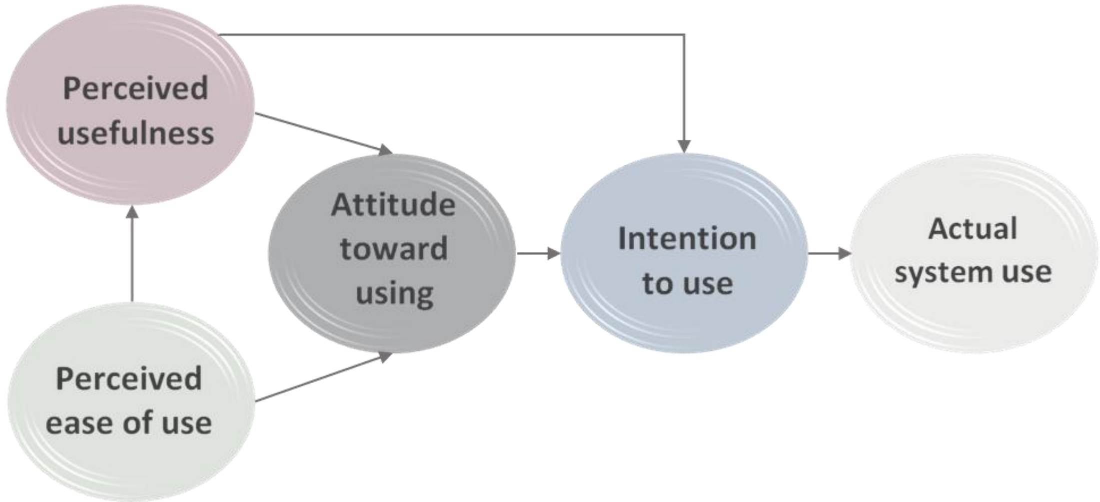

Figure 2-7 TAM model (Davis, 1989)

Perceived usefulness (PU)	"the degree to which an individual believes that using a particular system would enhance his or her job performance"
Perceived ease of use (PEOU)	"the degree to which a person believes that using a particular system would be free of effort"
Attitude toward using (ATU)	"the degree of a person's positive or negative feelings about performing the target behaviour"
Intention to use (IOU)	"the degree to which a person has formulated conscious plans to perform, or not perform some specified future behaviour"

Table 2-4 TAM constructs definition (Davis, 1989)

PU and PEOU have a direct effect on user's attitude of a technology which further influences their behavioural intention on whether they decided to use or not. The behavioural intention is an essential factor in the new technology acceptance research because the actual use of technology emanates from intention (Engel, Blackwell, and Miniard, 1995).

Lee et al. (2003) have listed several TAM limitations from a systematic literature review on the theory used in information system (IS) research, as shown in Table 2-5. The suggested limitations served to guide the researcher to avoid similar mistakes when using TAM. Moreover, Islam et al. (2014) have suggested that it is imperative to carefully select the study that will employ TAM because it is prone to falsification rather than being a "pseudo-science[8] (Popper, 1972)". More specifically, TAM cannot explain all types of human behaviours and as such the researcher "should consider using objective measures of both beliefs and behaviour to test the theories like TAM" (Islam *et al.,* 2014).

[8] Popper (1972) claims that attitude towards science differentiates the true science and pseudo-science. Ture science is set up to challenge its claims and look for evidence that might prove it false, which is testable. In contrast, pseudo-science seeks confirmation that could only fit with imaginable outcomes, which is not testable.

Sample	# of Papers	Explanation	Examples
Self-reported Usage	36	Did not measure the actual usage	Venkatesh and Davis (2000)
Single IS	18	Use only a single information system for the research	Venkatesh (1999)
Student Samples (or University environment)	15	Inappropriate to reflect the real working environment	Agarwal and Karahanna (2000)
Single Subject (or Restricted subjects)	13	Only one organization, one department, MBA students	Karahanna and Straub (1999)
Cross-Sectional Study	13	Mainly performed based on cross-sectional study	Karahanna *et al*. (1999)
Measurement Problems	12	Low validity of newly developed measure, use single item scales	Agarwal and Prasad (1998)
Single Task	9	Did not granulize the tasks, and test them with the target IS	Mathieson (1991)
Low Variance Scores	6	Did not adequately explain the causation of the model	Igbaria *et al*. (1997)
Mandatory Situations	3	Did not classify mandatory and voluntary situation, or assume voluntary situation	Jackson *et al*. (1997)
Others	15	Small sample size, short exposure time to the new IS, few considerations of cultural difference, self-selection bias	Gefen and Straub (1997)

Table 2-5 Summary of Limitations in TAM Studies (Lee at al., 2003)

Lakatos (1970) suggested that a research programme should contain two types of components namely essential, structural components (hard-core and positive heuristic) and non-essential components (a set of theoretical assumptions / protective belt). Based on this, the essential component of this study is the initial TAM model, non-essential components are the additional constructs which the author added, together with the auxiliary hypothesis that is offered to explain acceptance for the CAV context

TAM has been used in AV acceptance in previous studies. For instance, Panagiotopoulos and Dimitrakopoulos (2018) found PU to have the strongest impact on IOU. Panagiotopoulos and Dimitrakopoulos (2018) fronted that 47% of the respondents stated their concern over system security and privacy by incorporating "perceived trust" and "social influence" into the TAM model. However, this research failed to access the relationship between PU and IOU which the initial TAM had proposed. ATU was also missing in the proposed model and no reason sufficed for that failure. Benbasat (2010) emphasised the importance of design and implementation constructs when conducting adoption and acceptance research. Therefore, when implementing the theoretical framework into a specific research, testing the causal relationships among the original constructs is essential. In this regard, this study falls short in explaining the relationship between the antecedents of adoption and the attitudes towards using, as well as examining the falsifiability of the initial TAM model.

Ghazizadeh *et al*. (2012) developed a model for automation acceptance under the evaluation of the interrelationship between attitudes towards an on-board monitoring system (OBMS). The measurement model was an extension of TAM which incorporates trust in the research.

Herrenkind *et al*. (2019) investigated young people's (age < 36) acceptance criteria for AVs. This research used a real-life experience approach rather than a self-reported survey approach like most of the CAV acceptance research studies that exist. *Life choices*, *subjective well-being, factors of travel quality* and *life domains* were found to determine young people's acceptance choices. The author questioned how the research used "life domains" as a predictor (which consist of income and education of the respondents) rather than a moderator in the causal model. The researcher did not mention whether homogeneity of variance holds as such the assumption about "life domain" determining adoption remains doubtful.

Herrenkind et al. (2019) researched on the end-user acceptance of autonomous electric buses (AEB) through expert interviews and questionnaire survey on AEB passengers in Germany. A structural equation model (SEM) as well as the confirmatory factor analysis (CFA) were used to construct and confirm the measurement model. *Individual differences, social impacts*, and *system characteristics* were added into the TAM. Contrary to other research studies, this research did not include sociodemographic characteristics and "life domains" characteristics in the process of model building.

Using an extended TAM, Ernst and Reinelt (2017) postulated that personal driving enjoyment and perceived traffic safety were the two opposing factors that determine acceptance. Specifically, they affirmed that many respondents enjoyed the physical act of driving as such autonomous vehicle manufacturers should weight the hedonic aspects afforded by AVs.

2.6.6 Unified theory of acceptance and use of technology (UTAUT)

Unified theory of acceptance and use of technology (UTAUT) has been used to investigate the acceptance of information system as shown in Figure 2-8 (Leicht, Chtourou, and Ben Youssef, 2018; Osswald *et al.*, 2012). UTAUT is an integration of prominent acceptance and usage models in information system research. It includes one or more factors from TRA, TPB, TAM, DOI and SCT. The four main constructs prominent herein include *performance expectancy, effort expectancy, social influence* and *facilitating conditions*. The UTAUT model assumes that the aforementioned four constructs positively influence behaviour intention. In essence, behaviour intention together with facilitating conditions have a directly positive influence on the actual use of the system. UTUAT also proposes that personal characteristics such as *gender, experience, age* and *voluntariness of use* have a moderating effect on the influence of those four constructs over behavioural intention and actual use.

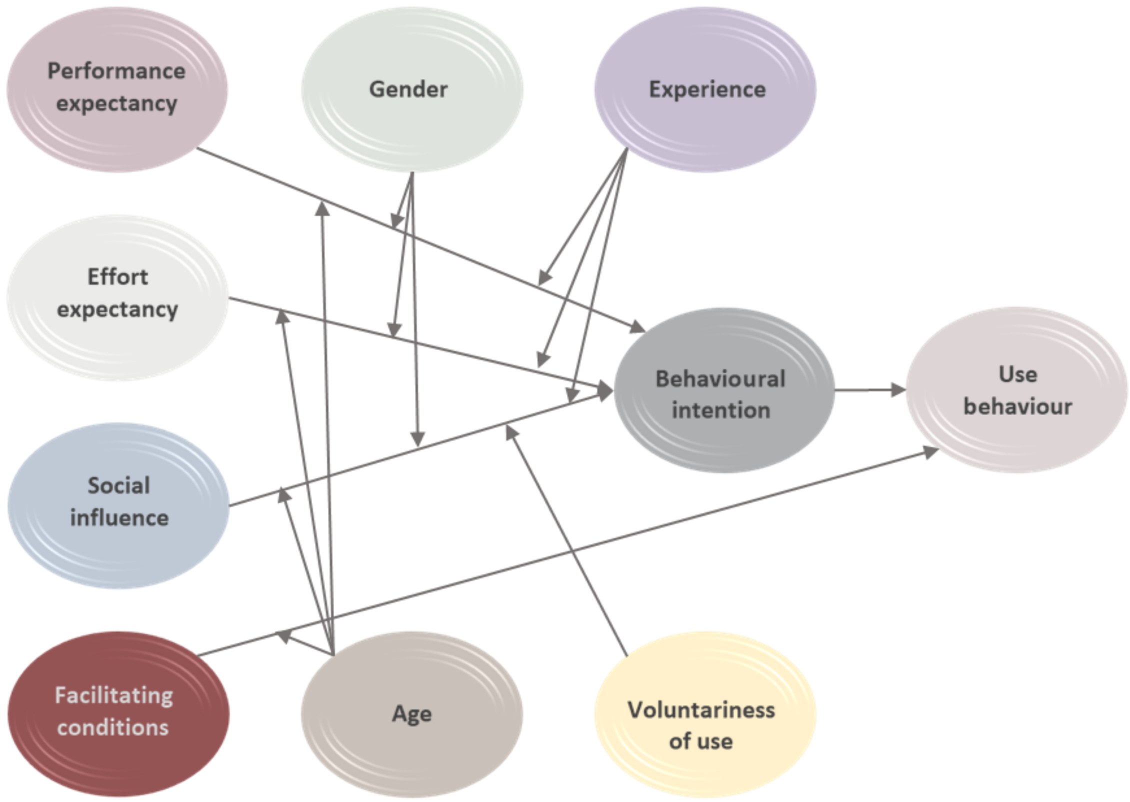

Figure 2-8 UTAUT (Venkatesh et al., 2003)

Performance expectancy (PE) is defined as “the degree to which an individual believes that using the system will help him or her to attain gains in job performance” (Venkatesh *et al.*, 2003). PE has the same meaning as PU in TAM. Effort expectancy (EE) is defined as “the degree of ease associated with the use of the system”. EE is similar to PEOU in TAM. Social influence (SI) is defined as “the degree to which an individual perceives that other important people believe that he or she should use the new system. SI is similar to subjective norm (SN) in TRA. Facilitating conditions (FC) are a term defined as “the degree to which an individual believes that organizational and technical infrastructure exist to support use of the system”. FC express the same meaning as perceived behavioural control (PBC) in TPB.

As mentioned in section 2.6.5, most of the automotive acceptance research have adopted TAM as a base model however there is a limited number of studies that have adopted UTAUT. Still, researchers tend to capture some factors from UTAUT on new model development. For instance, Osswald *et al*. (2012) added four factors (*anxiety, self-efficacy, perceived safety* and *attitude toward using technology*) onto the UTAUT model without the inclusion of personal characteristics. Kervick *et al*. (2015) developed a model of driver willingness to use smartphone driver support systems (SDSS) by using social influence from UTAUT and its model structure. Social influence was found to have a direct influence on willingness to use. Perceived risks (PR) have a negative effect on intention to adopt and adoption of SDSS. In the context of AV acceptance, Hohenberger *et al*. (2016) developed a model that has included personal characteristics such as (age, gender, and education); this was found to have a moderated effect on willingness to use as a function of anxiety and self-enhancement.

Kapser and Abdelrahman (2020) conducted a research on acceptance of autonomous delivery vehicles for last-mile delivery in Germany by utilising an extended UTAUT2 with risk perception. UTAUT2 is an extension of UTAUT with the inclusion of three variables, namely, *habit, hedonic motivation*, and *price value*. Significantly positive relationships were found between FC and BI. Furthermore, significantly negative relationships were found between PR and BI.

Williams *et al*. (2011) faulted the explanatory power of UTAUT. Dwivedi *et al.* (2011) outlined that empirical studies that utilised UTAUT relied on a small sample size which cannot be comprehensively representative of the whole population. Furthermore, most UTUAT related research studies have ignored personal characteristics from the initial model which could distort the actual performance of the theory.

2.6.7 Model evaluation

Several studies compared user acceptance models to ascertain their efficacy. In particular, researchers evaluated and compared the utilization of TAM, TPB and UTAUT on predicting BI. Inferentially, 71% or more of the variability in BI was evidenced, TAM was found to perform the best among all three models - explaining 82% of the variability in BI (Rahman *et al.*, 2017).

For TRA and TAM, the main difference is that TRA believes that the SN directly influences the BI. Davis's TAM model excluded the attention on SN as he believes that the relationship between SN and BI only holds in a small scale. But, once SN scales up, the system usage may not be affected by SN, rather, more possibly on a voluntary basis (Davis, Bagozzi, and Warshaw, 1989; Fishbein and Ajzen, 1975).

Both TPB and TAM theories are good on predicting intention. TAM scored 82% (Adj. R^2 = 0.82) on the variance explanation. TPB scored 80% (Adj. R^2 = 0.80) on the variance explanation (Rahman *et al.,* 2017). Mathieson (1991) and Mun et al. (2006) recommended extending the TAM model with some constructs from TPB to achieve the best performance on technology adoption. Moreover, it has been acknowledged by multiple TAM-TPB studies that TAM is easier to apply and use in comparison to TPB (Lai, 2017).

Tryon (2014) criticised the cognitive theories (including TRA and TPB) for being static. That is the theory does not provide mechanism information on how personal decisions are made and how that decision influences behaviour. Tryon promotes a more dynamic solution which is developed by Orr *et al*. (2013). Additionally, it is founded that people make decisions not only based on their pre-existing beliefs but also through social interactions.

It is important to select a suitable conceptual framework for the study because an inappropriate theory selected for a research process would yield inaccurate or inconclusive inferences susceptible to bias (Strauss, 1987). Considering a meta-analysis review on AV acceptance, a big proportion of studies were found to have an unclear theoretical framework which subsequently introduced bias in the research process. In this regard, TAM ranked as the most suitable theoretical foundation for this study after a careful analysis, comparative inquisition and evaluation of the different theories and AV literature that exists in the current body of knowledge.

Illustratively, TAM was selected because the objective of the paper is to identify the general attitudes of people towards CAVs. Moreover, according to the meta-analysis of AV studies (Jing *et al.,* 2020), TAM has been utilised broadly in investigating public acceptance of vehicle technologies such as eco-innovation (the alternative fuel vehicle, AFV) (Jansson, 2011; Petschnig, Heidenreich, and Spieth, 2014) and autonomous eclectic bus (ABE) (Herrenkind *et al.,* 2019). Additionally, most of the base models adopted in the literature have subtle differences in terms of their suitability and ease of use. TAM remains the most evolutional in understanding factors influencing emerging technology adoption.

Researchers should not ignore the key constructs from the initial theoretical model when developing new models. This is necessary because it could potentially introduce reliability issues into the model due to model distortion.

It is also very important to consider how researchers measure behaviour in studies. More specifically, TRA and TPB theories are more suitable to measure behaviour in a postdictive approach. TAM is more suitable to measure behaviours in the predictive approach. Since CAVs are not yet a reality in the current society, it is therefore more suitable to use TAM to measure the future technology adoption.

In summary, the literature on IS acceptance is in favour of using the TAM model. Most of the empirical research from different contexts of technology arrived at similar findings that proved TAM as being robust and reliable in predicting interrelationships between factors and behaviour intention.

2.6.8 Cultural differences and technology acceptance

This section aims to briefly review the related literature in cultural differences and technology acceptance. The definition of the concept of culture has evolved over time. Kroeber and Kluckhohn (1952) defines culture as “a patterned way of thinking, feeling and reacting, acquired and transmitted mainly by symbols, constituting the distinctive achievement of human groups, including their embodiments in artifacts; the essential core of culture consists of traditional (i.e., historically derived and selected) ideas and especially their attached values." Hofstede (1980) defined culture as "the collective programming of the mind which distinguishes the members of one human group from another". In general, culture is a notion that differentiates the society or groups.

Cultural impact has been examined for its effects on technology acceptance in the society. For instance, Straub, Keil, and Brenner (1997) compared TAM applications in Japan, US and Switzerland. The results indicated that TAM holds for both US and Switzerland but not for Japan. Rose and Straub (1998) examined technology acceptance in five Arab developing countries (LDCs) namely (Jordan, Saudi Arabia, Lebanon, Egypt and Sudan). Chau *et al.* (2002) study on online consumer behaviour difference between Hong Kong and US, established that consumers from different cultures and backgrounds use the internet variably and as such they would have different impressions of the websites. Thus, the cross-culture research literature proposes that different cultures perceive the same innovation differently. Recent studies have also compared China and US' health care data protection and biometric authentication policies (Hulse, Xie, and Galea, 2018); privacy and cyber security integrity was prominent on health data protection in both countries.

Efforts have been made on the validation of the integration of three of Hofstede's cultural dimensions in UTAUT. For example, Nistor *et al.* (2014) found that cultural masculinity positively influences performance expectancy, whereas it negatively influences effort expectancy based on a culturally diverse sample of 2866 participants from Germany and Romania.

There are numerous pieces of research that have been conducted since the late 1990s on technology acceptance and cultural differences. Different cultures were compared and evaluated on a nation-wide basis. Most of the research studies adopted the culture model that Hofstede proposed.

The culture model was developed through a survey of Hofstede's six cultural dimensions theory that provides theoretical foundations in numerous social science research studies aimed to distinguish among different cultures. Six dimensions include power distance index (PDI); uncertainty avoidance index (UAI); individualism vs. collectivism (IDV); masculinity vs. femininity (MAS); long-term orientation vs. short-term orientation (LTO), and indulgence vs. restraint (IND) (as shown in Table 2-6).

Dimensions	Meaning
Power Distance	related to the different solutions to the basic problem of human inequality.
Uncertainty Avoidance	related to the level of stress in a society in the face of an unknown future.
Individualism vs. Collectivism	related to the integration of individuals into primary groups.
Masculinity vs. Femininity	related to the division of emotional roles between women and men.
Long Term vs. Short Term Orientation	related to the choice of focus for people's efforts: the future or the present and past.
Indulgence vs. Restraint	related to the gratification versus control of basic human desires related to enjoying life.

Table 2-6 Hofstede's cultural dimensions theory

Hofstede’s cultural dimensions’ theory is influential in the cross-cultural psychology because this six-dimension model enables cultural comparative research to gain insight about cultural influences on various research fields. Figure 2-9 shows a comparison of China and UK in respect to Hofstede’s Cultural dimensions model. For comparison purposes, two countries score comparison is marked on each index (scale runs from 0 the lowest level to 100 the highest level, with 50 as mid-level). For the initial Hofstede’s four-dimension model that consists of PDI, UAI, IDV, MAS and the value data was collected from 1967 to 1973. These four-dimension indexes were measured in value scores with a scale running from 0 to 100. LTO, the fifth added index data was collected in 1979 (Hofstede, 1991). China scored 118 on LTO and UK scored 25. Hofstede and Minkov (2010) noted the reason why China scored more than 100 was because “2 Factor scores were converted to a 0–100 scale. “The data from China came in after the conversion had been made.” Therefore, for comparison purposes, the scales adjusted on LTO score where China: 118 scaled down to 100 and the UK: 25 scaled down to 21.

As for Hofstede's sixth dimension, IND, was adopted from Minkov's (2007) research that summarized and interpreted World Values Survey in 2007 for up to 72 nations.

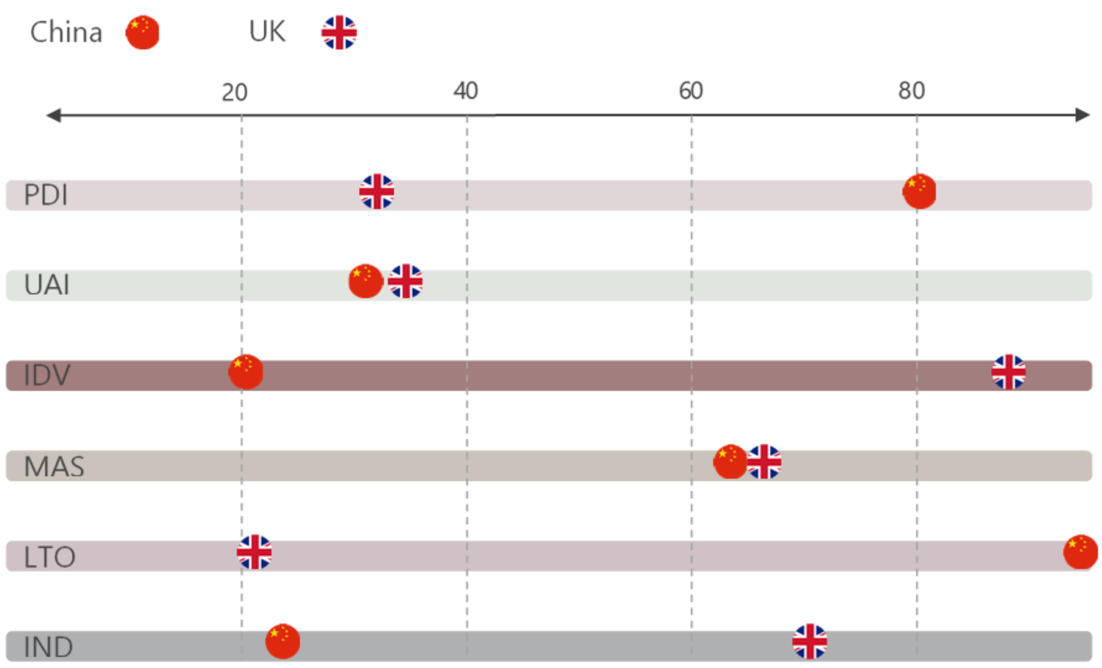

Figure 2-9 China vs UK 's underlying cultural dimensions

Although nation does not equal to culture it is a normal occurrence for people from a geographic location to practice similar cultural patterns and bear homogenous cultural characteristics. Therefore, for the purpose of this research, as UK and China's scores shown in Figure 2-9, China reflects a nation of Asian culture and UK reflects a nation of western culture in a broad sense.

Criticisms have been levelled against these theories or models. Firstly, from the methodological point of view, sampling discrepancy regarding social minorities exclusion and measurement biases were noticed (Hohenberger, Spörrle, and Welpe, 2017; Minkov, 2007). Secondly, the main theory was formed during 1960s and 1970s, as such the validity of such model being used in the 21-century may raise issues of applicability to the modern or current situations (McCoy, 2003). Thirdly, as Hofstede himself pointed out that "one of the weaknesses of much cross-cultural research is not recognising the difference between analysis at the societal level and at the individual level; this amounts to confusing anthropology and psychology" (Hofstede, 2011).

Implying that Hofstede's scale should be properly used to measure culture variables at the country level rather than individual level.

Hofstede stated that "China might be one of those rare cases, where after a period of relative isolation, decades of unparalleled double-digit economic development concurrent with rapid global exposure and integration may be bringing about shifts, especially in the younger generation" (Hofstede, 2011).

Hofstede's theory formed in the last century may need to be periodically adjusted to align with the modern trends and changes because human culture is not static (Forrest, 2007). It is therefore necessary to examine people's technology acceptance profile occasionally to get a better understanding on public attitude toward a certain innovation in line with cultural dynamism.

2.7 Research methodology used in CAV acceptance research

In the context of automotive technology acceptance, the methodology used in these studies are mostly quantitative where researchers collect survey data from the sample unit. Data collection methods are different namely: 1) AV real life ride experience and survey; 2) AV simulation test and survey; 3) survey only. According to Jing et al. (2020), 85.3% of the existing studies used survey only for data collection. As CAVs are still in their prototype stages and are not readily available to the general public the collected data relies on hypothetical public attitude and opinion without true or actual human experience.

For the research design, 93.3% of the studies conducted cross-sectional study (Jing *et al.,* 2020). No longitudinal study was conducted as AVs have not yet been introduced to mass market yet. Cross-sectional design is appropriate when assessing attitude and awareness among people at a given point in time. Therefore, time dimension is not involved in the cross-sectional studies implying importance of specifying the data collection time for each study component.

Cross-sectional studies can be used in both quantitative and qualitative studies. For example, in the public attitude and acceptance qualitative studies, cross-sectional design is used to provide the relevant themes or revealed critical factors around the research topic. Whereas in the quantitative studies, it aims to assess associations between different parameters over the subject matter.

A mixed method research that aims to investigate end-user acceptance of autonomous electric buses (AEB) (Herrenkind *et al.,* 2019) can be used in this context. This study first conducted expert interviews to gain a profound basis for potential acceptance factors on AEB. Subsequently, the research developed a comprehensive research model based on TAM and validated through a survey of 268 passengers in Germany.

In the acceptance of information systems field of study, modelling requires an adequate dataset size for a high-quality prediction model development as a small sample size might lead to inaccurate predictions and consequently incorrect conclusions. The majority (72%) of the previous studies in AV acceptance have thus a sample size more than 300 (Jing *et al.,* 2020).

2.8 Methods of data analysis used in CAV acceptance research

Since almost all AV acceptance research were conducted using a quantitative research method, the analytical methods on statistical analysis are reviewed in this section. In AV acceptance literature, hypothesis-generating and hypothesis testing studies are both prominent.

As mentioned in the section 2.6.7, some research studies adopted a classic conceptual framework and utilised it on their collected data in order to assess the plausibility of their theory. Other research processes collected data and generated new models by borrowing some constructs from the classic model. Using an incorrect modelling method proved problematic in the AV acceptance literature (Jing *et al.,* 2020).

After reviewing 75 AV acceptance studies, Jing *et al*. (2020) found that correlation analysis and regression analysis were commonly utilised. Correlation analysis is a statistical method on evaluating the statistical relationships between variables. It mainly focusses on the strength of the targeted variables rather than the causal relationship between them. Regression analysis is a statistical technique that is used to evaluate the relationship between one dependent variable and one or more independent variable(s). Both methods are however unable to draw causal conclusions. Structural equation model (SEM) also featured prominently in AV acceptance literature. Jing et al. (2020) provided data where the author found 15 out of 75 papers have used SEM as the data analysis method. SEM is a multivariate statistical analysis technique that consists of a diverse set of statistical models that aim to analyse structural and causal relationship between variables.

As such, SEM is considered to be a superior method that combines factor analysis, path analysis and multiple regression analysis when evaluating and analysing the complex relationships between directly and indirectly observed (latent) variables (Stein, Morris, and Nock, 2012).

2.9 Research gap

The existing literature on CAVs is primarily focused on technical, computer and engineering issues. There is a significantly smaller body of work referring to the nexus of acceptance and policy per se. The human factor research for CAVs is mainly focused on their development phases (Anderson *et al.,* 2014) and on implementation including policy and practice challenges and user characteristics (Kyriakidis, Happee, and de Winter, 2015). Studies on user opinions on CAVs referring to law and liability, public acceptability, attitudes, awareness, willingness to use, willingness to pay (Lang *et al.,* 2015, Regan *et al.,* 2017; Daziano *et al.,* 2017), and their fit with other road users like pedestrian and cyclists (Deb *et al.,* 2017, Deb *et al.,* 2018, Edwards *et al.,* 2015) have been also produced. Research looking into the CAVs' cyber security and privacy breaches or risks through the lens of human factors is limited to date with few exemptions (e.g., Lim and Taeihagh, 2018, Sheehan *et al.,* 2019, Taeihagh and Lim, 2019).

In principle, there is no study that has yet examined AV acceptance with a focus of cyber security and privacy considerations collecting and analysing qualitative data reflecting the views of CAV experts about this particular subject matter. However, since CAVs are widely considered to be the next game-changing mobility technology (Nikitas *et al.,* 2017), their associated vulnerabilities should be proactively identified and mitigation techniques developed to ensure that this complex technology will be soon suitable for use (Parkinson *et al.,* 2017).

Efforts have been made in relation to studying public attitude toward and intention of using AVs. However, the author argues that human opinion is not static and can change over time due to influences from other external factors such as marketing, social influence and increased awareness among others. Limited suggestions can be given to the decision maker and the industry on the design, diffusion, and dissemination strategy of CAVs. Therefore, research is needed to understand the causal effect on the factors that influence public acceptance towards the emerging technology from a holistic point of view.

The study of perception reflecting and affecting acceptance towards CAVs, contain various dimensions including public acceptability, attitudes, awareness, willingness to use and willingness to pay. Several studies in the existing literature surveyed general public acceptance of varying vehicle automation levels. Abraham *et al*. (2017) found that younger people were more comfortable with self-driving vehicles than older adults. People with higher trust and higher awareness of CAV technology reported higher possibilities to accept CAVs (Kaur and Rampersad, 2018, Waytz *et al.,* 2014). Invariably, technology anxiety (Hohenberger, Spörrle, and Welpe, 2016) was found to be one of the strong predictors of people's intention to use or not CAVs.

Cavoli *et al.,* (2017) identified that safety and cyber security are two of the key factors underpinning the public perceptions of CAVs. However, there is a scarcity of studies using primary data to identify how exactly the twin narrative of privacy and cyber security affects perceptions towards CAVs per se and no study adopting a qualitative or mixed method approach that examines in-depth the drivers underpinning the acceptance process.

Most of the previous studies on the topic explored literature in which perceptions, not strictly focusing on privacy and cyber security, have been examined by closed questionnaires (yes/no, Likert scales or ranking exercises) and referred directly to the general public.

With the existing literature on AV acceptance, there were concerns on lack of theory utilisation. According to the meta-analysis research conducted by Jing *et al.* (2020), 34,7% of the studies utilised behaviour theories, of which 41% carried out parameter reliability test. They have concluded that a fair number of the AV acceptance studies have methodological quality concerns.

The present study looks not only on public attitudes per se but also explores expert views including transportation professionals, mobility stakeholders, transport academics and employees of the automotive, insurance and consulting industries. Studies as such have been conducted before but on more general topics as reported by Clark, Parkhurst, and Ricci (2016) and Thomopoulos and Nikitas (2019) and not on the agendas of privacy and cyber security. After the exploration of these expert views that allows a better understanding of the relevant CAV acceptance criteria, public opinion is collected and analysed in accordance with a comprehensive theory-based model to understand factors determining CAV acceptance.

Drawing on the above perspectives, this study is combining expert insight and modelling CAV acceptance based on TAM to investigate the causal relationship between *perceived risk* (PR), *perceived usefulness* (PU), *perceived ease of use* (PEOU), *facilitating conditions* (FC), *self-efficacy* (SE), *attitude toward using* (ATU) and *intention to use* (IOU). The next chapter presents the methodology and the research design of this research study.

Chapter 3. Research Design & Methodology

3.1 Introduction

Research design or research strategy refers to the means of answering research questions or testing the proposed hypothesis. This study has used a mixed method approach to generate findings with both depth and breadth as a means of understanding better CAVs introduction and implementation barriers regarding cyber security and privacy. Semi-structured elite interviews and questionnaire surveys were adopted in the study. The aim of this chapter is to present the research philosophy, research design, the underlying theoretical and conceptual framework of the study, and the development of the proposed method. This chapter proceeds premised on the associated research philosophy as well as providing the rationale for pragmatism as the conceptual framework. Subsequently the selection of the mixed methods approach and the research design are discussed.

3.2 Research philosophy

There are expansive debates on the epistemological and ontological rationale of sciences. The handbook of social science inquiry expounds on the benefit of blending the different philosophical stances and their corresponding influence on the research processes (Greene and Hall, 2010) because the plurality of the methods leads to expansive social study (Samar, 1991). Mertens (2003) defines the philosophical paradigm as a “worldview, complete with the assumptions that are associated with that view”, which consists of ontology, epistemology, axiology, and methodology. Ontology is concerned with the nature of reality and how individuals perceive it (Creswell *et al.*, 2011). Epistemology articulates the nature of knowledge and the relationship between the researcher and the research object (Biddle and Schafft, 2015). Axiology outlines the role of values, in other words, axiology concerns the extent to what things are good and how good are they (Zalta *et al.*, 2005). Methodology on its part is the approach to scientific inquiry (Welford, Murphy, and Casey, 2011).

3.2.1 Ontology

Ontology outlines the nature of reality and how individuals perceive it (Creswell *et al.,* 2011). This research has adopted a mixed method approach that is situated in the pragmatic paradigm that is characterised by the ontological assumption that reality is actively created as individuals “prefers action to philosophising” the reality (Tashakkori and Teddlie, 2010). Pragmatism in research supports the idea that research should be oriented to the real world (Rorty, 1982) which fits well within this study’s interest in public attitude in adopting CAVs.

3.2.2 Epistemology

According to Gay and Weaver (2011), epistemology is “the significant (albeit incremental) progression and advancement of knowledge towards the truth”. The term epistemology in the simplest sense refers to the branch of knowledge which deals with the scope, validity and methods used to establish a concept as real. It is also the attempt used to try to differentiate between the opinions of people from the confirmed beliefs. In essence, epistemology focuses on the process of knowing that a concept is true and real away from conjectures, opinions of perceptions. Further, it delves into considering how a person understand or knows an idea. It implies that it considers the totality of circumstances that revolve around the creation of facts and realities.

This study of public acceptance towards CAVs would be conducted through a comprehensive mixed method approach. This is to say that the course of the research process can attain useful insights from the relevant available social science approaches. Particularly, the research process would gather data in order to understand public’s acceptance of CAVs. Lee (1991) opines that qualitative perspectives can be used to guide quantitative investigations. When using the mixed method approach, research has largely suggested that there should be pragmatic grounds or foundations to help guide the research flow (Johnson, Onwuegbuzie, and Turner, 2007; Morgan, 2007). Pragmatism’s practical focus endeavours to utilise researcher’s personal values on the selection of research phenomenon and research methodology (Teddlie and Tashakkori, (2009).

Therefore, the same premise outline that this study would be motivated by the author's values as a potential CAV user.

3.2.3 Axiology

Axiology represents the nature of ethics and the values. It was found that researchers always failed to address axiological stances in pragmatic mixed methods research, and axiological position was underspecified in pragmatist mixed methods approaches (Tashakkori and Teddlie, 2009).

Pragmatic axiology ultimately answers one question that concerns the practical difference between one action or decision that one makes versus another. Since values are perceived differently by different people, there is no "universal principles as an approach to determine value" (Biddle and Schafft, 2015). Hence there is no absolute, permanent or transcendent value as the core of pragmatic axiological stance. This seems ideally suited to the study which values both experts' and public's opinion on CAVs. Furthermore, this study has also inquired opinion among different cultures and generations with the aim of comparing values among the targeted groups in regard to CAVs.

In conclusion, as discussed in previous sections, pragmatism being widely appreciated (Johnson and Onwuegbuzie, 2004; Morgan, 2014) as the best philosophical benchmark for mixed method research, is suited for this study and was therefore selected as the conceptual framework.

3.3 Research design and methodology

3.3.1 Research design: exploratory sequential design

Research design is the overall research strategy chosen by the researcher. Research designs constitute the collection, measurement and the analysis of the data. The author has found thirteen types of common research design as shown in Table 3-1; four types of design are commonly used in social science research namely longitudinal design, case study design, exploratory design, and cross-sectional design. There are other design methods that mainly elaborated on these broad design systems. For instance, the exploratory sequential design is developed from exploratory design and sequential design.

Action Research Design	Exploratory Design
Case Study Design	Historical Design
Causal Design	Longitudinal Design
Cohort Design	Observational Design
Cross-Sectional Design	Philosophical Design
Descriptive Design	Sequential Design
Experimental Design	

Table 3-1 Types of research design

Longitudinal design is used in quantitative research which measures multiple observations over time and endeavours to examine the long-term impact of the research objectives. Non-Governmental Organisations and mass public opinion adopt longitudinal design to investigate socio-economic and political matters of a society. There are three main sub-types of longitudinal design namely: trend study, cohort study and panel study. For example, English Longitudinal Study of Ageing (ELSA) and the Citizenship Education Longitudinal Study (CELS) are two UK government funded projects that have adopted longitudinal design.

Case study design focuses on a single case of some social phenomenon. It is commonly used in qualitative research that assesses a policy or project's success or failure. Case study design has been widely used in business, law and politics.

Cross-sectional design is the most popular quantitative research design used in social sciences research. Cross-sectional design collects data in one-point in time that aims to study the research questions. Cross-sectional designs can be done for exploratory or descriptive research.

The exploratory sequential design consists of an initial qualitative phase of research followed by a quantitative phase of research, the first phase of the research findings provides a more comprehensive basis for the questionnaire design included in the quantitative phase of research. In the final data analysis process, two sets of finding derived from the individual research will be integrated or interlinked.

The purpose of the research design is to ensure that the research strategy effectively and accurately answers the proposed research questions. Thus, research design should always be driven by the research questions. As discussed in 3.2, this study has adopted a pragmatic conceptual framework and intends to understand factors that could potentially influence public acceptance on CAVs especially those relate to cyber security and privacy. The research questions are:

1. What types of CAV associated risks may the user face in terms of cyber security and privacy?
2. What are the key expressions of cyber security and privacy issues?
3. What can be done to mitigate these risks?
4. What is the suitable technology acceptance model that can be used as the conceptual framework to examine CAV acceptance?
5. What are the factors affecting CAV acceptance and in what way they do so?
6. To what extent do the determining factors influencing CAV acceptance vary or concur in different cultural/gender/generational contexts?
7. What can policy makers do to safeguard CAVs cyber security and privacy?
8. What can end users do to safeguard their cyber security and privacy?
9. What can stakeholders do to ensure the acceptance and better diffusion of CAVs?

An exploratory sequential design seems to best fit this study as this research data would be first collected from the field experts and then the public. In addition, the participants would be selected based on existing differences rather than random allocation and it is not geographically bound.

3.3.2 Research methodology: mixed methods

A mixed methods research is a procedure for collecting, analysing and incorporating both quantitative and qualitative research and methods in the same research (Tashakkori, Johnson, and Teddlie, 2020). The triangulation mixed methods focusing on the equal weight of treating each method in the data analysis process (Greene, Caracelli, and Graham, 1989). Overall, the research objectives indicate that both qualitative and quantitative data will provide a better understanding of the research issue which leads to a mixed methods approach setting. Further, considering the qualitative elite interview phase is equally important as the quantitative survey phase, triangulation mixed methods approach is therefore ranking as the best suitable choice for this study.

This research followed Morse (1991) and Creswell and Clark's (2017) sequential triangulation mixed method which constitute both qualitative and quantitative research methods during the same timeframe and with equal weight (Creswell and Clark, 2017). Triangulation mixed method approach combines both advantages from quantitative methods which follow inductive logic, and quantitative methods which follow a deductive logic. The triangulation mixed method typically interprets the combined qualitative results and quantitative results in the analysis status of the study. According to Creswell and Clark (2017), there are four variances of triangulation mixed method design namely the convergence model, the data transformation model, the validating quantitative data model, and the multilevel model.

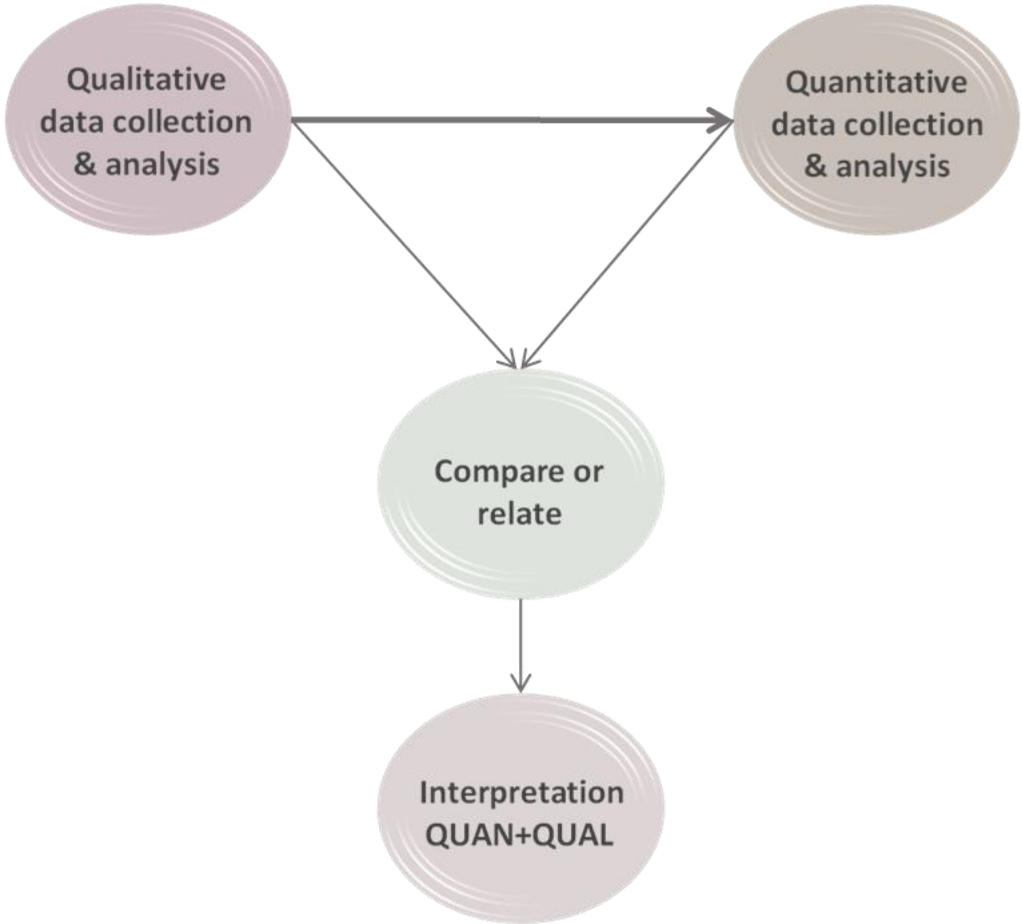

Figure 3-1 Triangulation mixed method: sequential model

The author believes the sequential model (as shown in Figure 3-1) best suits this research process as and qualitative research phase precedes and inspire the quantitative research phase. The sequential mixed method approach in practice requires that "the researcher collects and analyses two separate databases—quantitative and qualitative—and then merges the two databases for the purpose of comparing or combining the results" (Creswell and Clark, 2017; Morse, 1991). Additionally, for sequential mix method design, the quantitative results and the qualitative results can be compared and complemented in the final data analysis process which could potentially derive a deeper understanding of the CAV acceptance from both field experts and public view.

In summary, this study adopts a cross-sectional convergent mixed method design to collect qualitative data from semi-structured interviews with field expert, and quantitative data through close ended survey with the public, as illustrated in Figure 3-2. The next section covers the detailed qualitative phase of this study.

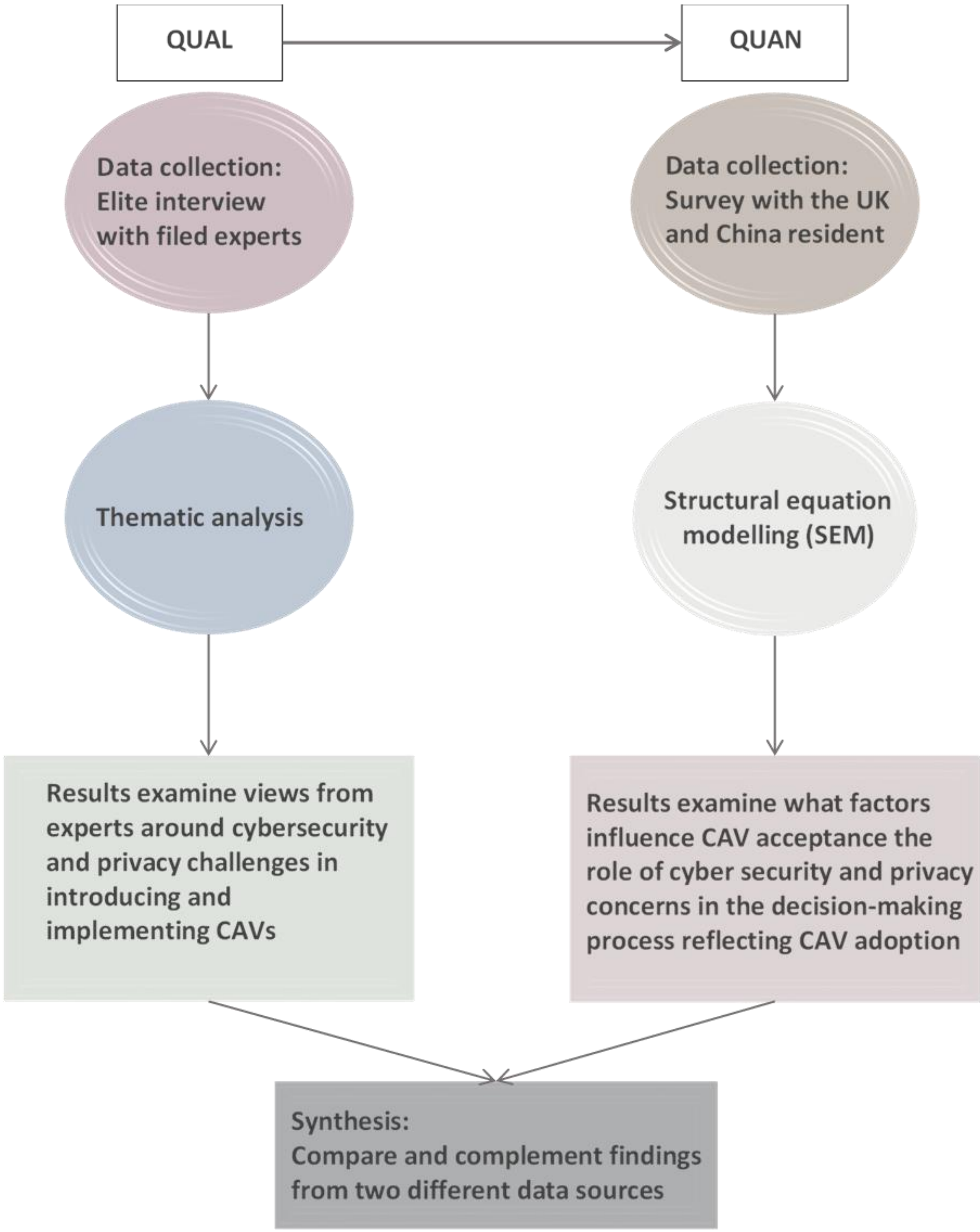

Figure 3-2 Sequential triangulation mixed method research design

3.4 Research ethics

As this research involves human participation, ethical issues must be handled before, during and after the data collection. The central issue that needs to be considered in this research is the anonymity and the confidentiality of the respondents' data in line with the conventional ethical policies and guidelines (Crow and Wiles, 2008).

The survey data collection (and the previous qualitative one too) targeted a population aged 18 years old and over where there are no minor participants. There were no sensitive questions with risky or immoral dimensions neither experimentation involving vulnerable populations. Regarding access to the participants, the recruitment process included connections or contacts from the author and supervisors' network, recommendations from that network and social media (i.e., Linkedin and Twitter), handout print ads on street corners. As of the questionnaire instruments, Qualtrics was used as it is a GDPR (General Data Protection Regulation) compliant online survey software, all the data was collected, recorded and stored in Qualtrics EU centre safely and securely.

During data collection, participants were provided with a written form of informed consent in the first page of the survey. Therefore, the participants were informed about the nature of the study and they (participants) reserved the right to withdraw from the study at any point the process. If a participant withdrew from the study, their data that had been collected would be manually deleted before data analysis.

In terms of confidentiality and anonymity, the participants data specifics were highly confidential; they were kept, stored and used in such a way. None of their names were published (i.e., data were anonymised). The respondents have been given an ID number which was randomly generated by Qualtrics platform. Only the author has access to the password protected data. Further, this research design has been approved by the business school research ethics committee (BSRE) at the University of Huddersfield.

Chapter 4. Qualitative Research Stage

4.1 Introduction

This chapter[9] consists of three parts. The first part introduces the methodology of the elite interview. The second part presents the preliminary analysis of the qualitative interview data obtained from the field experts. The third part gives the explanation and interpretation of results obtained from the elite interview.

4.2 Qualitative research methodology: elite Interview

It appears that a limited range of methodologies have been applied to the study of public perceptions to date when it comes to CAV acceptance (Clark *et al.,* 2016). Most studies employ quantitative survey instruments to investigate public perceptions of CAVs. Considering that most respondents are unlikely to have any real experience of AV technology. The respondents may not have formed opinions on the very specific areas of cyber security and privacy hence a survey answered by the general public would yield inconclusive results susceptible to some forms of bias (e.g., optimism bias, desirability bias or lack of awareness bias) thereby failing to advance our understanding of the subject matter. Qualitative research is an appropriate tool for gaining an in-depth exploratory understanding that would allow the identification of themes that can be later investigated quantitatively. But this can be more effective, when it is conducted with people that have a more critical understanding of CAVs and are aware of the privacy and cyber security issues that abound. Thus, a qualitative study with field experts was first adopted for the

[9] Part of the work of this chapter has been published as a peer reviewed journal paper, which can be found using the following reference: Liu, N., Nikitas, A., & Parkinson, S. (2020). Exploring expert perceptions about the cyber security and privacy of Connected and Autonomous Vehicles: A thematic analysis approach. *Transportation research part F: traffic psychology and behaviour*, *75*, 66-86.

study in order to explore the potential factors that may influence public perception and public acceptance from the experts' point of view.

In-depth interviews with members of the scientific, political, economic, or social elites provide valuable insights that could be critical to the exploration of a research topic but may not be obvious to the general public (Drew, 2014, Jaremba and Mak, 2014, Leblanc and Schwartz, 2007). This is because information on how 'elites' perceive situations and take decisions would provide a privileged perspective which is unique and may not be realised through other data collection methods (Parsons *et al.,* 2014, Zhang *et al.,* 2007). Additionally, it is imperative to outline that the views of the elites may not rhyme with the general public's and as such different set of biases may arise due to that variance in opinion.

In this research, participants were recruited from nine countries in Europe, Asia and North America. The participants were individuals working in CAV relevant disciplines, ranging from computer security to autonomous vehicle production. The participants from the United Kingdom were over-represented due to their close proximity with the research team; however, the author believes that this is not a barrier due to the qualitative character of the work and the generic nature of the questions asked. The interviews were conducted in a face-to-face or via Skype from March to May 2019. Each interview lasted between 30 and 40 minutes and was semi-structured. For consistency an interview guide set out the generic framework of the interviewing process, but spontaneous add-ons were allowed to enable the collection of a more detailed, rich and vivid answers where necessary. The interview guide is presented in the Appendix A.

The interview guide had four key dimensions that would allow each participant to:

1. Identify the current challenges underpinning the cyber security of CAVs;

2. Identify the current challenges underpinning the privacy of CAVs;

3. To make recommendations of cross-domain countermeasures that could be applied to the challenges identified; and

4. To review the areas of responsibility, education and training reflecting and affecting CAV uptake and usage.

4.2.1 Interview guide development

Under the aim of the qualitative phase study, the interview consists of questions about the current status of cyber security and privacy associated with CAVs, recommendations of countermeasures that could potentially resolve the identified issues, and the suggestions and strategies that could promote the CAV acceptance and adoption. In making the decisions about the selection of the interview questions, discussions were held with the supervisor. The interview guide is semi-structured, which is adequate for elite interviews (Saunders and Townsend 2016). The questions are flexible to allow interviewees to provide their insight and develop unique ideas. As CAVs related research is relatively new in the research domain, semi-structured interview settings allow the interviewees to freely talk about what they find the most important for the challenges associated with CAV acceptance. This is what a fully structured interview could not achieve (Wilson and Sapsford, 2006).

At this early stage of CAV development, the experts are best positioned with the knowledge and forecasting ability to help society identify and contextualise the diverse and distinctive dimensions and orientations of this understudied agenda. In this regard, although the interview guide was prepared in advance, the freedom was given to interviewees to express their opinions.

The interview guide is provided in Appendix A. Most of the questions were designed to be open, which allows the obtained responses to contribute towards topics that can be allocated into the literature and develop new ideas. For instance, question 11 ("What is the current state of cyber security and what are the trends for the future regarding cyber security in CAVs?") allows the interviewees to cover the identified cyber security and privacy risks associated with CAVs. Question 22 ("What is the role/responsibilities of end-user for CAVs?") enables the interviewees to mention their ideas of responsibility that end-user could potentially be assigned to in using CAVs.

Preparatory research on the role and responsibilities of each interviewee was completed before each interview. Depending on the professional roles of the interviewee, question 4 ("What can CAV manufacturers do to ensure personal space and privacy?") and question 10 ("What an attacker can do to a car if he/she was able to communicate on CAV's internal network maliciously?") were made flexible to be able to fit interviewee's knowledge. This is because interviewees from a non-technical background may not be able to list some example cases to the question.

It was up to interviewees to explain what challenges are vital in the CAV development and introduction process. However, the interviewees had an opportunity to talk about all topics listed in the interview guide and reveal their opinions. Some topics had an opportunity to be mentioned more. More specifically, question 9 ("What does cyber security mean to ordinary people?") could mention end users' awareness of cyber security and privacy in a broad context. Responses collected from questions 19 ("What are the common cyber security and privacy mistakes users make?") and 20 ("What skills should the user of CAVs have from a cyber security and privacy point of view?") may unavoidably cover users' awareness and knowledge of cyber security and privacy too. This is not considered an issue as mentioning an issue multiple times. The agreement from other interviewees would make the issue be classified an important theme in the data analysis process. The questions designed for the interview guide allows the author to set out priority areas within this diverse agenda that then could be tested with the general public.

4.2.2 Recruitment

Interviewees who occupy management and senior positions in the automotive industry, cyber security firms, universities, government and law consulting firms were targeted to participate in the research. Social media, in particular the LinkedIn platform was used as a recruitment platform to enlist prospective participants. Field experts were recruited mostly through interview requests via the LinkedIn message service. The invitees were all targeted participants that were identified by the researcher meaning that this was a non-probability convenience sampling approach.

The researcher also used to some degree snowballing sampling, since directly recruited participants recommended some of their colleagues who could be potentially interested to participate in the study. No financial incentives were provided for the recruitment purpose; the targeted sample was usually in highly paid posts and this type of incentivisation was deemed to be inappropriate. As a whole, a total of 100 experts were targeted and subsequently formally contacted with an online interview invitation; 65 responded back to the researcher, some of them declined the invitation right away while others cancelled their participation later on. At the end 36 interviews were conducted. The participants were informed prior to their involvement about the interview arrangements; it was communicated to and agreed with them that the sessions would be audio recorded and transcribed, but the data would be anonymised and used only for research purposes. Consent for participation and data use was obtained from all the interviewees.

4.2.3 Method of analysis

Thematic analysis was used as detailed in Braun and Clarke (2006) and adapted in Nikitas, Avineri, and Parkhurst (2018) and Nikitas, Wang, and Knamiller (2019) for identifying, analysing and reporting patterns (themes) within data collected in the interviews. Braun and Clarke's (2006) reflexive thematic analysis approach seek to develop a fluid and recursive frame which is somewhat different from the rigid and structured frame that the traditional codebook approach uses. Table 4-1 presents the six steps of the author's thematic analysis process. Thematic analysis has been used before in transport research (Alyavina *et al.,* 2020, Gössling *et al.,* 2016, Hafner *et al.,* 2017) and has proven to be a sophisticated qualitative tool. It enables the conducting of the research in a precise, consistent and exhaustive manner through recording, systematising, and disclosing the methods of analysis and the study results with enough detail. This enables the reader to determine the credibility and validity of the process (Nowell *et al.,* 2017).

Step 1: Familiarising with data
Step 2: Generating initial coding
Step 3: Searching for themes

Step 4: Reviewing of themes
Step 5: Defining and naming of themes
Step 6: Reporting the findings

Table 4-1 Six-step process for the thematic analysis

The interviews were conducted, transcribed and analysed by the author. The analysis of the interview data follows the thematic analysis principles. The transcription of the audio interviews was first manually typed into Microsoft Word, and the data were then imported to Computer-assisted qualitative data analysis software (CAQDAS) software-Nvivo 20 for further analysis. The coding and theme identification processes in the analysis were data-driven and based on the raw quotes of the interviewees rather than the researcher's own impressions and interpretations. The coding process was performed both manually, through repeated reading of and making notes on interview transcripts, and through the qualitative software NVivo 20. The codes, and the related extracts, were then organised in overarching themes to ensure that the final thematic map is well-aligned with the research objectives of the study.

4.2.4 Reliability and validity of the thematic analysis

To ensure reliability and reduce any analyst-generated bias the coding analysis of the researcher was cross-examined independently by the supervisors of the PhD that acted as checks and balances to eliminate interpretation bias. This process helped the author to create a more universal ''bigger-picture'' narrative. During this synthesis and cross-checking procedure, a consensus on the codes that were eventually the building blocks of our themes was reached through exhaustive discussion; the researcher had to convince the supervisory team about the value and independence of each code, sub-theme and theme. This thorough approach in determining the key topics underpinning the research and the systematic analysis framework as a whole increases the validity of the work.

During the theme identification process, it was observed that some of the themes might have dimensions that might overlap to some degree while a few quotes might underpin more than one theme. This is not a problem though, since Braun and Clarke (2006) suggested that the themes and how they relate to each other do not have to smooth out but instead retain the tensions and inconsistencies within and across the data.

In total, 36 specialists responded to the call for participation, of which 78 % of respondents had a title of Dr or a Professor. Nearly 90 % of the participants occupy management and board level positions. There were 31 people are working in Europe, 3 in the US and 2 in Asia. Responses were submitted by a mixture of individuals, including local authorities, trade associations, transport operators, non-governmental organisations and university academics. The study's sample size was large enough to provide diversity of perceptions.

4.3 Qualitative interview results

This section presents the preliminary analysis of the results of the qualitative interview data obtained from the field experts. The first section presents the interviewee characteristics, then the findings and results from elite interview is discussed.

4.3.1 Interviewee characteristics

In total, 36 specialists were interviewed. The sample size is consistent with the best practice literature. Baker, Edwards, and Doidge (2012), when examining sampling in qualitative research as a means of answering how many interviews are enough, concluded that a sample between six and twelve interviews may offer extremely valuable findings and represent adequate numbers for a research project that studies hidden or hard to access populations such as elites. This study's sample size is large enough to provide diversity of perceptions.

81% of respondents had a title of Dr or a Professor. Nearly 90% of the participants occupy senior, management and board level positions. 31 people are working in Europe, 3 in the US and 2 in Asia. Responses were submitted by a mixture of experts, including people working in local authorities, trade associations, transport operators, automotive and connected technology businesses, non-governmental organisations and universities conducting CAV research. The interviews were male dominated; only 7 female participants were included in the interview. According to a Forbes (2010) report, 95% of the National Automobile Association members are men. Also, the tech industry has always been male dominated at all levels being considerably worse than non-tech industries.

Table 4-2 Interviewee characteristics (Table 4-2) lists some key characteristics of the sample providing information about the participants. The code representing each interviewee consists of a field identifier (CO for consultants, IN for automotive or technology industry, OR for non-governmental organisations, GO for government and AC for academics) and a number for each participant within this group.

Respondent	Titl	Gende	Country	Position
CO1	Dr	M	Sweden	Senior Researcher
CO2	Dr	M	Sweden	Senior Consultant
CO3	Mr.	M	UK	Research Analyst
CO4	Dr	F	UK	Senior Consultant
CO5	Ms.	F	UK	Principal Consultant
OR1	Dr	M	Germany	Lead Tech
OR2	Dr	M	UK	Chair
OR3	Ms.	F	Germany	Senior Project Manager
GO1	Dr	M	UK	Lead Tech
GO2	Dr	M	UK	Lead Innovation
GO3	Mr.	M	UK	Principal Consultant
GO4	Dr	M	USA	Senior Research Scientist
IN1	Mr.	M	UK	Senior Project Manager
IN2	Prof	M	UK	Head of Department
IN3	Ms.	F	UK	Director
IN4	Mr.	M	USA	CEO & Founder
IN5	Dr	M	Germany	Senior Partner
IN6	Mr.	M	Germany	Senior Project Manager
IN7	Dr	M	Ireland	Associate Director & Lead
IN8	Dr	F	Sweden	Researcher

Respondent	Titl	Gende	Country	Position
AC1	Dr	F	UK	Senior Lecturer
AC2	Dr	M	UK	Project Officer
AC3	Dr	M	Greece	Research Associate
AC4	Prof	M	UK	Professor
AC5	Dr	M	USA	Lead Tech
AC6	Dr	M	UK	Research Associate
AC7	Dr	M	UK	Senior Lecturer
AC8	Prof	M	Singapore	Assistant Professor
AC9	Prof	M	UK	Professor
AC10	Dr	M	UK	Senior Lecturer
AC11	Dr	M	UK	Senior Lecturer
AC12	Dr	M	UK	Lecturer
AC13	Prof	M	China	Professor
AC14	Dr	M	UK	Researcher
AC15	Prof	M	UK	Professor
AC16	Dr	F	Netherland	Lecturer

Table 4-2 Interviewee characteristics

4.3.2 Results and analysis

Six core themes emerged during our analysis; these are all critical issues that need to be addressed prior to a full-scale launch of CAVs. Specifically, the themes are: *awareness, user and vendor education, safety, responsibility, legislation,* and *trust*. Each of the themes has diverse and distinctive dimensions that for the means of this study are reported as sub-themes. The author acknowledges that some of the themes and their underpinning dimensions may overlap to some degree.

As this is an elite interview process, all our respondents have knowledge or experience in at least one of our key areas referring to cyber security, privacy and CAVs. During the interview, the participants were asked to provide their opinion on cyber security and privacy in regard to challenges reflecting and affecting CAV technology. It should be noted that although each participant was provided freedom to express one's own views (both positive and negative), the questions directed them to provide their opinion on the problems and challenges, which are primarily negative in nature. A major overarching topic discussed by the experts is the importance of protecting individual privacy and cyber security from criminal and malicious attacks. In the subsections below, themes are presented and evidenced through the presentation of selected relevant quotations. This is one of the most effective and objective ways of delivering a concrete thematic analysis (Nikitas *et al.,* 2019).

4.3.2.1 Awareness

In information security, awareness refers to the ability of the user to recognise or avoid behaviours that would compromise cyber security. Users' awareness is identified as a key element of sensitising them on CAV-related issues and empowering them to obtain sufficient knowledge on what CAVs and related systems are doing and sharing. Awareness of IT systems has long been a challenging problem in regard to security, as when users have insufficient awareness, they are likely to put themselves at unnecessary risk. Many respondents expressed the view that limited user awareness will be a source of problems associated with CAVs, so raising awareness about privacy and cyber security issues is of critical importance. In essence, awareness should be raised to equip the users with the information or knowledge of how to identify risks or threats associated with CAVS. Similarly, the user's awareness would be deemed sufficient when the users would be best placed to embrace CAVs because they would be cognisant of prospective dangers.

> *"CO2: Customers also have a responsibility to be aware about privacy and cyber security and keep up with at least the consumer level knowledge of CAVs."*

> *"CO1: Even if the technology part of CAVs is perfect, humans will put themselves in risk by not knowing how to operate the CAV in the right way."*

"AC2: User awareness is not supported with the right tools and training and thus is an issue."

Understanding the vulnerability of CAV systems is a crucial aspect of user awareness; knowledge on cyber security and conscious conduct should be promoted in schools and societies in general, in order to minimise cyber-attacks based on human error.

"OR3: I think cyber security knowledge should be taught in schools from elementary school."

"AC5: So what the end user can do is to be more aware of the potential consequences when engaging in activities with possible cyber security and privacy consequences."

As with other fundamental rights, privacy can be taken for granted, therefore, lack of awareness about privacy could result in the exposure of sensitive information.

"CO4: Ideally we would expect the user to be aware of what personal data is and how it can be used against them. They need to know how to protect themselves."

"AC8: CAVs have the ability to store and transmit data. This creates privacy concerns that personal information of CAV users may be misused by external companies, for reasons such as advertising, profiling and tracking their location Users should be aware of this risk."

"GO3: A lot of people have these privacy concerns, but at the same time their behaviours, sparked from unawareness, are essentially giving up their privacy rights."

Although in most cases, the user often ignores the detail of consumer notices and consent, the role of such documentation will continue to be important and essential. However, new mechanisms of informing the user may be required to improve the rate and quality of knowledge transfer. Many respondents pointed out that it is vital to inform the user about the potential options referring to user consent, and about their respective benefits and risks.

"IN1: Informing the user about the terms and conditions of CAV use and the risk involved is important, but nowadays that is more of a design issue."

"GO1: Customer consent is not sufficient to ensure data privacy as most customers simply accept the terms and conditions without fully reading or understanding them."

"AC4: Those responsible for CAVs need to come up with some kind of a model or a mechanism to ensure that the drivers are made aware of when their consent is obtained before any data is collected and exploited."

"AC13: I think you are going to have people agreeing to the terms and conditions and being unaware or uninformed of the extent to which their personal data is being used for other purposes."

Some respondents highlighted the importance of designing and offering user-friendly Human-Machine Interface (HMI). It was suggested that efforts to integrate these services would result in better user experience, and it could prevent users from accidentally engaging in cyber-attacks and data breaches.

"AC9: It's rare for people to work their way through the menu from page one. So it's about providing an interface that allows people to understand what is happening. Whereas, if let us say I had a car with really good natural language interface, I would just ask my car, 'what is that flashing icon on the dashboard', and the car would say, 'that is ABC', and I will go okay."

"CO1: It is a common practice that we know everyone have done that in their life, when we see a security warning too often, and without any true effect which mostly likely due to our own knowledge limitation or the hard-to-understand technology design, we start tuning it out and ignoring it."

4.3.2.2 User and vendor education

According to learning theories and learning continuum hierarchy, education is distinctly interlinked with creating and increasing awareness to the members of the public

(Christiansen and Piekarz, 2019). The purpose of raising awareness intends to enable individuals to recognise security problems and act accordingly, whereas education focuses on the knowledge or skill obtained or developed by a learning process (Wilson and Hash, 2003). User and vendor education is a theme expressing that all people involved with CAVs, regardless of whether they are end-users or manufacturers, should be educated on CAV functionality. Education is necessary as a tool enabling the end-user to better prepare and protect oneself, fellow passengers, and the CAV against cyber security threats and ensure that an appropriate standard of privacy is provided.

Several respondents highlighted the importance of user education as well as up-to-date vendor education.

> *"CO3: It is vital to educate the user of this new technology and the risks associated with it."*

> *"IN4: The vendors do not give any introduction of the car, all they care about is the sales."*

> *"AC3: The vendor education is important too, if they do not know anything about the risks embedded in the use of CAVs, then who will warn the user?"*

> *"IN7: Most likely, CAV's vendor will have to have some levels of cyber security vendor's knowledge, because selling CAV is kind of different from selling conventional cars, it requires the vendor have both vehicle knowledge and computer network knowledge."*

Another dimension underpinning the theme of education refers to knowledge supply, with some responses highlighting the problems that lack of information or excess of information might cause to the user. Literature showed that an overload of information could cause analysis paralysis (Stanley and Clipsham, 1997) and information fatigue syndrome (Oppenheim, 1997). Although the developers of software systems might be aware of these issues, the consequences when considering CAVs are high, and it is believed that supplying succinct knowledge at the right level is essential for the end-user.

"AC16: At least from my experience, I wasn't given any information about the connectivity of the car."

"IN6: A user might be faced with a thousand-page CAV menu, which he or she has got to hang through, to try and find the relevant bits."

It was suggested that the automotive industry and all stakeholders should promote CAV education. Campaigns, workshops, and trials are needed to disseminate best practice and support decision-making knowledge.

"IN3: CAV education should be available not just in the school level but also in TV ads, billboards and everywhere."

"AC1: I think workshops could be very helpful. These will help people to understand what the different range of vehicles might be, and what the impact on their lives will be, both positive and negative. CAVs are a disruptive technology, so there will be winners and losers."

"GO2: So, for children to understand what data mean, the trade bodies need to look after the advertising and making sure that there is no misguiding advertising."

All respondents felt user-centred education should be an investment priority for the CAV industry. Many respondents mentioned that governments should also take on the role of facilitating future CAV education for the user, as well as supporting investments improving their current technology.

"GO2: I think user-centred education should be an investment priority for the CAV industry and the policy-makers."

"AC12: You don't always have to change the person per se sometimes you can change the system and the training provision."

A specially designed CAV driving license was also suggested as a means of ensuring people behave in a desired way, whereby the person does not pose a risk to one's or any other persons' safety and privacy through lack of correct cyber security practice.

"IN1: School education should support CAV training. In the end we should create a driving license programme that everyone should take to guarantee that they are knowledgeable enough to use CAVs responsibly. This is important based on the fact that the whole society is impacted by this technology."

4.3.2.3 Safety

Safety was identified as one of the primary factors defining the end-user adoption potential of CAVs by most of our interviewed experts. Specifically, our respondents raised concerns about the existing level of cyber security and privacy in CAVs and how these may link to safety. Making sure that hacking and exposing users to unsafe situations would be avoided at any cause were highlighted as two key priorities for the automotive manufacturers.

"IN3: It'll be up to the car manufacturers themselves and then car clubs and eventually users to know that a CAV is safe. They will have to prove it by testing thoroughly its safety. It is not a game like the one where Top Gear people trying to hack into cars. Safety comes first."

"AC15: One of the key steering points of CAVs is safety; one of the key challenges of CAVs is also safety."

A recurring view was the increasing need to develop skills in cyber security and privacy, across both industry and local authorities for responding to unexpected circumstances. Having a new type of driving license as a compulsory pre-requirement for being allowed on a CAV that would assess and ensure the user's ability to manage safely the potential risks of such a vehicle was considered by some interviewees as a critical safeguard mechanism for the technology.

"AC6: Today we are driving a car that is not fully automated and very different from a CAV. In order to legitimately operate a fully automated car, you must have a driving license specifically for it. This is an enforcement measure which solidifies that you should have a certain level of skills and safety understanding in order to operate CAVs and lessen risks."

Another point concerning safety which has already been heavily discussed in the field and was mentioned in the interviews are edge cases; situations that happen very rarely and indicate that there will always be unforeseen circumstances in future scenarios.

"AC9: For future level four or five vehicles is how to deal with what's known as edge cases, situations that happen very rarely, that they can't necessarily be predicted by the programmer. This means that they are not necessarily understood by CAVs. This car can thus be a hazard."

Furthermore, a number of respondents reported that a better understanding of the user behaviour during a crisis situation was needed.

"OR2: What is the behaviour of people in crisis situations? How to classify and analyse these behaviours is a new problem we need to face."

A similar number of respondents raised the need to improve sustainability, accessibility and safety targeting older people or those with disabilities in order to achieve transport equity.

"IN5: CAV technology should deliver real benefits, in terms of sustainability, access and safety particularly for young, older and disabled people."

"IN4: CAV technology may improve social inclusion. CAV can be a great facilitator if it can make people with disabilities remote."

4.3.2.4 Responsibility

Involving the end-user was also mentioned as a critical factor in ensuring novel transport solutions would be adopted. Respondents frequently felt that the end-user should take responsibilities for the human error accrued. There is an overlap here with liability, as ensuring the end-user understands what they are liable for will help them to act more responsibly.

> *"GO4: Humans are the leading cause of AV accidents in California."*

> *"AC7: It's just about whether or not certain people basically abuse the system, by getting control of the vehicle in some shape or form and then using that control in a potentially negative way."*

> *"AC4: The usual kind of responsibilities or roles that we expect them to be mindful of, in the present environment for security, I think they apply to CAVs as well."*

> *"CO2: Because I know I'm responsible for the car itself, but also for safety, or for the data that I have, for other users of the car I need to be extremely mindful. I think that responsibility of use is a feature critical for making CAVs a success."*

Many of the respondents suggested that collaboration between CAV industry, academia, local governments and non-governmental organisations should be encouraged. It was felt that this would increase the chances of projects leading to new business models that solve real cyber security and privacy problems in CAVs. All stakeholders would need to share and define the CAV-related responsibilities.

> *"CO3: All of the parties involved have certain very important responsibilities. The government has to set up an education system to inform consumers. The users themselves should behave responsibly when on a CAV. Industry has the responsibility for ensuring sufficient engagement between all the important actors of a CAV transition."*

"AC10: I think it should be a joint effort when it comes to responsibility. Because it should not be just the car manufacturer and the car manufacturer's responsibility but also the users."

"OR3: I guess technically the manufacturers don't have to educate the user, but I think it is the morally correct thing for them to do."

"AC9: I guess technically the manufacturers do not have to educate the user, but I think it is the morally correct thing for them to do so.''

"CO1: User responsibility needed to be clarified through education. CAV driving licence will let the people understand their responsibilities, understand the edges cases so that human is more liable when using CAVs, they will understand their safety cannot only rely on the machines, they have to be responsible too."

Respondents emphasised the need to clarify the responsibilities and roles that each stakeholder plays within CAV operations. Establishing a universal framework for ethics when using CAVs that allocates responsibilities when accidents occur is another dimension that underpins this theme according to our findings and is in line with the literature (Borenstein *et al.,* 2017, Hevelke and Nida-Rümelin, 2015).

"CO3: Things like 'if someone's died whose responsibility is this?' need to be better defined. This is a complex responsibility that may lie with the law-maker, decision-makers in the government and also reflect the duties of the involved industries."

4.3.2.5 Legislation

To enable the widespread use of CAVs, it was often stated, that more regulatory and legislative efforts need to be conducted. Several respondents stressed the need for legislation focused on CAVs in general and cyber security and privacy in CAVs in particular. These interviewees emphasised the need that legislation should be established before the implementation of infrastructure. This is necessary as adding legislation in a reactive manner may be less effective at protecting citizen's privacy and well-being.

> *"CO1: It is necessary to have regulations in place about how companies have to communicate."*

> *"AC14: Some of this transition is down to government in terms of regulation. Regulation and licensing need to make sure that the key stakeholders have everything in place when it comes to CAVs to inspire and enable trust."*

> *"IN4: Legislation needs to be ready first, and cyber security and technology communities need to understand to what extent the legal protection should be provided for CAVs."*

Recommendations included ensuring CAV drivers and relevant technicians at all levels (such as those working in the manufacturing, maintenance, vendor industries) will be required by law to be fully qualified. Also introducing a specially designed driving license programme that improves the skill set of those involved with CAV-handling duties, particularly with respect to digital skills and awareness of cyber security and privacy was deemed critical. The interviewees also highlighted the need for the creation of technology-neutral industry codes and standards.

> *"AC4: In the industry, there is little debate and little understanding in terms of any agreements or standards or any consensus around this (driver and vehicle standards). Legislation should be able to clear things up and set the standard that would allow the use of CAVs to be genuinely secure. Licenses for qualified users should be legally enforced."*

> *"IN6: A consensus is needed between the stakeholders that will lead to the standardisation of CAVs in legal terms too."*

A clearer and more accurate assessment of the likely distribution of liabilities need to be allocated. This would help encouraging the stakeholders in CAV industry to have the confidence to take risks where appropriate. At present, it is currently unknown who will have the responsibility of the vehicle’s cyber security aspects. This is an issue greater than cyber security, as it is currently unclear who is responsible in the scenario that a CAV is involved in an accident. Would it be the end-user or the manufacturer? This same issue translates into concerns that might occur from a cyber-attack; will the software developer become a potential candidate for sharing liability if a cyber-attack is successful? The uncertainty regarding liability concerns amongst experts is evident in their reported opinions.

> *“AC5: A good assessment of risk and vulnerabilities should be critical and thus need to be demanded by legislation. Online behaviours that might be accessible to CAV companies need to be screened. The software developers need to have in place tools for identifying and assessing cyber security dangers. Driving insurance companies should play a role in this risk evaluation process.”*

> *“AC8: As the human is no longer in control of the AV, at least some responsibility and liability for accidents involving AVs will shift to the AV system and the third parties who designed and operated them, necessitating reviews of liability laws to clearly delineate different responsibilities among all AV stakeholders.”*

Prohibiting design error from the product-development process would reduce the risk of privacy and cyber security breaches. Many responses discussed the Privacy by Design and Cyber security by Design, with an emphasis on the need for more inclusive and thoughtful design that could be used as an enforcement scheme. As previously mentioned, there is an overlap between privacy by design and privacy by default; however, privacy by design extends beyond the default privacy sharing policy and is focused on ensuring the underlying software and hardware architectures take all reasonable steps to preserve privacy, which includes aspects such as data minimisation, encryption and secure storage mechanisms.

> *“AC11: Focusing on the customer sits at the centre of every management model out there, but design thinking takes it one step further. It places the user at the centre of the solution.”*

"OR3: It's not the car that's providing the security. It's the people who design the car systems and then those that use them."

"IN1: I think this comes down to a design principle. According to the conversation we are having with some of our partners, one of the critical issues with privacy and cyber security is that CAVs should be designed to be safe and mitigate the risk of attacks both physical and cyber security by default."

Respondents called for a discussion on the need to explore a privacy option (such as privacy by default) that could be applied to all, as all devices need to be secure without much intervention by the users who may have limited knowledge about privacy. There is an overlap here with the aspects of the European legal framework of GDPR, where privacy by design is a core principle. This is a challenging aim, as enforcing strong privacy requirements often results in reduced or restricted end-user functionality, and thus the trade-off between privacy and functionality in default configurations needs careful consideration.

"AC5: I'm sure there are bigger and better ways of ensuring security that I'm unaware of, but having them set as a default, which seems not to be the case, it is a clear way to ensure that the data is only used for the intended purpose and by its intended end-users. So, I would say that probably this is an important step towards the right direction."

4.3.2.6 Trust

To fully accept and harness CAVs, it is necessary that end-users trust CAV technology. Trust is another key concept in vehicular networks and underpins acceptability as this is registered by attitudes. Substantial empirical evidence shows that automation faults cause a decline in trust (Lee and See, 2004). One way to cope with public acceptance is to employ social trust when assessing the risks of a new technology (Siegrist and Cvetkovich, 2000). In other words, acceptance of, or willingness to use CAVs, is directly determined by the trust on CAVs.

"IN1: If a cyber security or privacy breach causes a safety problem, that's going to create serious trust problems. Safeguarding privacy and cyber security will eventually mean improved trust and thus improved acceptance for CAVs."

"CO5: User acceptance will be heavily influenced by trust on CAVs as well as the legal frameworks."

"IN7: I think the CAV industry must make important investments on building user trust."

Trust could be built up through campaigns, workshops and trials to ensure the CAV users feel comfortable and confident with them.

"CO3: If people come closer to CAVs through social media, advertising and campaigns, and then really get the experience of a CAV for free, their trust regarding this technology may increase dramatically."

"AC4: Where there are lots of safety campaigns, they are partly funded by insurance companies, partly funded by government, partly funded by car companies, partly funded by campaign groups. This is exactly what needs to happen in the CAV security domain. We need to learn from these existing models advocating for traffic safety and think about how we can adopt similar models that work for the privacy and cyber security agendas of CAVs."

Social media play a big role in shaping public views on some issues and influencing the trust building process. To reach a diverse range of audiences, several respondents advocated the use of different means of communication, including information campaigns and the use of social media.

"OR2: Most of the things which end-users receive about CAVs is coming from social media or the media itself, and that information can be misleading."

"OR3: Manufacturers or leasing companies need to better play up the security features in their advertising. They should be providing messages such as 'while you're in an automated vehicle, all of your data we collect will not be associated with your personal

data, they are not going to be shared with external parties, everything is totally safe and legitimate'. I think that will help to build trust and it will make people more aware of cyber security and privacy."

Transparency is always the key element behind trust; this has been heavily examined in literature of transport interventions (e.g. Pettersson and Karlsson, 2015, Ekman *et al.,* 2019). Several respondents raised the need to provide the public with transparent assurance about the safety of CAVs.

"IN1: Being open about what has happened when things go wrong and about the process that is being followed is a sign about actively looking for ways with which you can overcome challenges and get the necessary help to solve problems. Transparency benefits trust-building."

"AC10: Any effort to try hiding what is happening with CAVs will be the worst-case scenario."

"OR1: There is not much transparency of what they say and what they are actually collecting."

"AC4: Transparency is key, in terms of realising and solving problems whether these are about technical product design and whether these are about legislations and regulations. You need to be honest with the future users as well; people do not like 'games'."

Having a sufficient and prompt reporting and responding mechanism in place is necessary for creating a communication dialogue between all stakeholder groups. This would help to ensure that the CAV industry and the end-users closely engage with technology and its associated risks, resulting in a confidence increase of the user. It is foreseen that reporting mechanisms will enable two-way communication, providing the potential for manufacturers to supply information of security nature to the end-user (e.g., information on software fixes), and also mechanisms for the end-user to inform the manufacturer of any issues they have noticed or are experiencing.

"AC11: There should be functions available about reporting where and when things are going wrong. Having a good two-way support mechanism affects positively the end-user."

"IN2: I think the challenge of course is that there are so many cases of problems we cannot yet appreciate, but what we don't have, and needs to be adopted before CAVs are fully launched, is a publicly transparent reporting mechanism."

"IN5: If we don't have a rigorous transparent way of reporting on threats, failures or attacks and so on, there will be a breakdown of trust between or across the industry."

"IN7: Trust depends fundamentally on security. Interactive real-time communication between the user and a control centre will help in this sense."

4.3.3 The thematic roadmap

The interviews revealed six themes that could play a key role, according to our subject experts, in the way people may respond to CAVs when focusing on the privacy and cyber security agendas. These themes are: a*wareness*, *user and vendor education*, *safety*, *responsibility*, *legislation* and *trust*. These are priority areas for the policy, planning, design and manufacturing of CAVs that must be addressed before their full-scale launch so that the transition to a CAV-centric mobility paradigm can be unproblematic. Each of these themes have their own distinctive and diverse dimensions which have been presented one by one in the analysis section and can be listed as sub-themes. Figure 4-1 is a thematic framework that brings everything together in a single infographic. It specifically conceptualises the key themes, their sub-themes and the interrelations between them representing a very accurate coding snapshot of the present work. The figure presents occurrences of overlapping acknowledging the links that these theme expressions have with one another and the fact that some key concepts fit and reflect more than one theme simultaneously. Therefore, Figure 4-1 presents an evidence-based roadmap of the opportunities and challenges embedded in the cyber security and privacy agendas of CAVs that may define the public acceptance of this emerging technology.

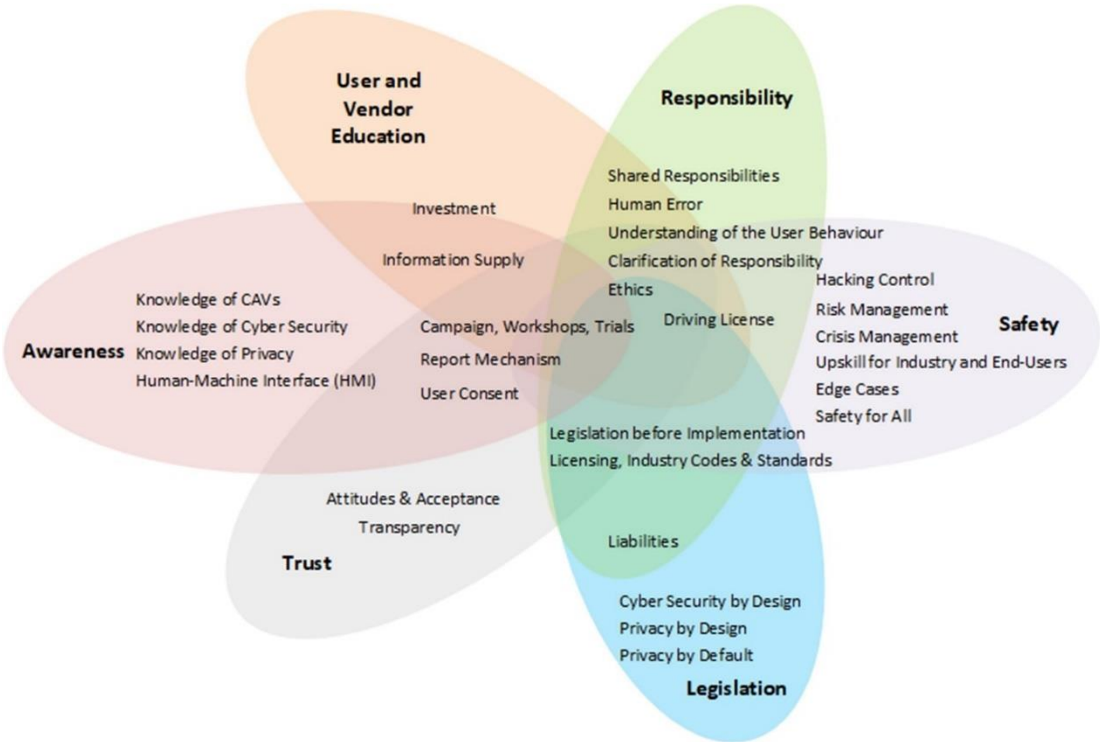

Figure 4-1 A thematic conceptualisation of the cyber security and privacy issues underpinning CAV acceptance

4.4 Qualitative interview discussion

Section 4.3 listed the results of the qualitative research that identified the main themes and their diverse and distinctive dimensions that need to be addressed prior to a full-scale launch of CAVs to make sure that cyber security and privacy are not barriers to their uptake and long-term viability. This subsection[10] will further contextualise the six themes and their key sub-themes benchmarking them when possible against relevant literature. It is a discussion that seeks to develop a fluid and recursive frame that elaborates on the analysis that is systematic but not rigid. All themes and most of their key expressions are discussed thoroughly but not necessarily in the order outlined in the analysis; this is a synthesis designed to help the reader appreciate better the 'big picture' of cyber security and privacy in CAVs.

4.4.1 Trust

CAVs may change the norms in mobility provision dramatically, and as with any other disruptive technology, their public acceptance depends on building trust (Ekman *et al.,* 2019, Nikitas *et al.* 2019, Zhang *et al.* 2020). When the public mistrusts politicians, mobility providers, automotive, telecommunication and intelligence industries or CAV operating algorithms, and even begins to suspect that the underlying motivations of the parties involved in this process of transition may be underpinned by hidden agendas like data exploitation to name one, trust will be hard to develop and establish. And if trust is broken it is very difficult to be reconstructed for the context of transportation provision (Nikitas *et al.* 2018).

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[10] Part of the work of this chapter has been published as a peer reviewed journal paper, which can be found using the following reference: Liu, N., Nikitas, A., & Parkinson, S. (2020). Exploring expert perceptions about the cyber security and privacy of Connected and Autonomous Vehicles: A thematic analysis approach. *Transportation research part F: traffic psychology and behaviour*, *75*, 66-86.

It was suggested by several respondents that building trust could be done through campaigns, workshops, advertisement and test drives; this broad approach can reach a diverse range of audiences. Media are the major player in influencing public opinion by exposing and bringing new technologies under scrutiny daily something that can make the public's trust fragile. Subsequently, the public has become more defensive, demanding that any new technology should be clearly explained. Explanations (i.e., reasons to justify why an action should or should not be taken) in the context of AVs have been found to help trust-building (Du *et al.* 2019). This makes transparency crucial, therefore, creating the need for manufacturers and policymakers to become more accountable. This is supported by the view of several respondents, who highlighted the importance of reassuring the public about the ability of CAVs to provide a secure personal space. A number of respondents stressed the importance of transparency regarding the reporting and responding mechanism that needs to be in place to facilitate an open and systematic dialogue between the CAV industry and its end-users.

Promoting transparency about what data is collected, including both passive and active data collection, and collecting data in a way that is clear and easy for the user to understand is needed. However, it should be recognised that transparency is not always achievable or desirable in algorithms. Companies have legitimate trade secrets that they must keep confidential. Transparency can expose the security apparatus of a company to security risks where hackers and cyber criminals can attack the system. Vulnerability disclosure mechanisms should be established too; a two-way interactive and honest communication should be available in CAVs. In particular, any report or statements made in the event of a cyber security or privacy breach should be as comprehensive and accurate as possible. Through this, the manufacturers will provide genuine information about the cyber security and privacy risks in CAVs, while the end-users will give feedback to the manufacturers regarding safety problems that they will come across, ultimately resulting in building trust between both parties.

4.4.2 Education

Trust on any new technology is inevitably linked to education on the basis that the general public needs to get educated on the dangers that this technology might entail. Cyber security and privacy risks are beyond traditional security risks and as such their consequences may be passively and unconsciously exposed or only impact the end-user long term. Therefore, public opinion on these new digital risks should be treated differently, as the source of threat and danger cannot be easily and clearly identified. It should be noted that most end-users and vendors have limited knowledge to date when it comes to CAV associated risks. Therefore, education and awareness enhancement are vital in order to offset the fear that cyber security and privacy risks might generate as a number of the elite respondents suggested. Studies have found that the lack of sufficient knowledge and awareness among key stakeholders and the public is a major barrier to successful risk prevention (Burt *et al.* 2007, Chang *et al.* 2009, Cohen *et al.* 2007).

Most respondents raised the point that automotive vendors are not well-informed about the potential adverse effects of cyber security and privacy risks to the current level-two AV, which results in the customers not being informed either when they buy the vehicle. It is thus suggested by the present study that vendors should receive as a prerequisite for their engagement in this market a very detailed CAV-specific education that allows them to be fully aware and alerted about digital risks. Specific education about cyber security, privacy, code of conduct should be disseminated to the end-user in the purchase or subscription process.

Licensing for the independent use of CAVs after a training course may also be a necessary step that will enable avoiding cyber security threats and privacy breaches; the elite interviewees argued that a well-educated and trained user is always a better user for the context of CAVs. This study thus recommends, that specially designed CAV driving license courses should be a compulsory element for the transition to the era of CAVs that will teach the end-users specific security-conscious behaviours, in a simple and actionable way. This type of licensing can eventually replace the current driving license that will not be needed in the era of CAVs; so this will not necessarily impose a new untested usage prerequisite but rather be a modernised continuation of a well-established licensing scheme that will require less skill but may be needed for any independent user of CAVs.

4.4.3 Responsibility

Education demystifying innovative technology is one of the few investments in social programmes that may have a high return on investment (Facer, 2011). All of the respondents supported the idea that education should be an investment priority of the CAV industry, while some also recognised this as a government responsibility. Systematic investment plans equipping professionals and the general public with the right skills could mitigate digital risks and help governments to create more secure societies. Based on the evidence provided by the qualitative research phase it is suggested that in addition to the government and the automotive industry, internet, telecommunications and intelligence service providers should take part of the responsibility to educate the end-users about cyber threats and privacy breaches, as they could be the connectivity intermediary that bridges end-users with CAVs. It can be argued that the elites believe that education is a primary solution to the prospective risks associated with CAVs. However, the elites did not infer that educating users is hard and less effective because privacy and cyber risks are dynamic and constantly evolving so this responsibility is a dynamic and challenging one and not particularly straightforward. As such, it is difficult to maintain constant educational updates for the users. Also, it would be perhaps more effective and resource-efficient to educate CAV engineers, developers and retailers to avoid introducing security- and privacy-prone systems.

As such, cyber security and privacy responsibilities need to be decentralised and shared with a diverse group of stakeholders. To exclusively depend on the developer’s design effort can be risky considering the humongous extent of cyber-attacks and privacy breaches that are at times irreparable. Joint efforts should be made to defend against cyber risks associated with CAVs.

Often the required cyber security and privacy configurations are tedious and complicated, and beyond the skill of the average end-user. There is also a lack of clearly defined lines about how end-users are expected to behave when they experience a cyber-attack or a crisis situation. Attribution can be difficult. The elite respondents suggest that the end-user should also take some responsibilities for any human error that occurs when a CAV operates. In 2014, Microsoft drafted International cyber security norms, which introduced a set of norms for acceptable behaviour in cyberspace; this could be an inspiration for defining what a responsible CAV behaviour is. The complex nature of the CAV technology will require inter-institutional cooperation, the exploration of relevant human behaviour modelling, a commitment to incremental interdisciplinary initiative development, a solid ethical framework and consensus on threats and appropriate actions to manage CAVs and their associated risk.

4.4.4 Awareness

Ensuring an improved level of public awareness about cyber security and privacy issues may be the first step of any education programme. Being aware of a risk or a problem is the steppingstone in looking for and eventually adopting responsible and secure ways of operating CAVs and handling their data. Nowadays, cyber threats and privacy breaches are regrettably common and prevalent (Ricci, Breitinger, and Baggili, 2019). At the same time, governments and businesses are investing heavily in cyber security and privacy solutions (Tao *et al.* 2019). In Europe, GDPR has shed light on data privacy and has generated substantial awareness regarding some aspects of the problem of personal data collection and export. Yet, public awareness has not been cultivated to the desired extent (Papoutsi *et al.* 2015). In the case of phishing and ransomware, attacks can lead to the loss of property, whereas in the case of CAVs, they can result in serious injuries or even death.

Therefore, it is essential for the public to become aware of its role in cyber security, so that they can understand that their actions matter and make safe choices. As some respondents suggested, this can be achieved via robust HMI, the development of which is crucial.

According to the literature, awareness raising programmes will be successful if they are tailored to targeted groups of stakeholders (García-Llorente *et al.*, 2008). Robust HMI will enable the required information to be passed on to the end-user quickly and reliably, enhancing the efficiency of awareness cultivation.

Cyber security and privacy awareness are also linked to issues reflecting and affecting user consent. GDPR requires the personal data to only be collected and retained for 'specific, explicit, and legitimate purposes', and only with the user's consent. This work argues that the 'signing of terms and conditions' which is nowadays a common practice to transfer responsibility to the user is only a very basic tick-box exercise that cannot be elevated to user consent; this many times actually works as a camouflage technique for shedding responsibility and not as a facilitator of genuine understanding that will reduce errors and mishandling. This is because many people do not read the terms and conditions to which they have assumingly consented (Steinfeld, 2016) many times due to information overload (Obar and Oeldorf-Hirsch, 2020). Moreover, people who have agreed with the terms and conditions for subscribing to a service usually do not understand them, because of the complex legal and technical terminology used (Tsai *et al.* 2011).

Considering the above, the question of whether the public can consent to things they do not understand arises. It is recommended that raising awareness through the means of legally required education that will be far superior and more extensive than a tick-box exercise will promote genuinely user responsibility. However, at the same time some might argue that the automotive industry has avoided educating the public on the risks of motor vehicles since the 1900s. This might mean that the public would need to get educated to opt for more secure and well-designed products rather than changing their consumer behaviour or attending high-tech training such as those of computer engineers. Legislation should thus be put in place to enforce the good design practice so as to ensure that the end-users are protected from associated cyber risks.

4.4.5 Legislation

Legislation has many more equally critical dimensions when it comes to CAVs' privacy and cyber security. Legislation is especially challenging when the commercialisation of the end-user's data leads to certain stakeholders making profit while damage is imposed on the end-user. Considering the international nature of cyber-attacks, international criminal groups tend to exploit legislation and jurisdictional loopholes (Adamoli *et al.* 1998). Therefore, it is essential to create a framework in which software is developed at international standards. In addition, professional organisations need to address the issues of accreditation and recertification in a modern way in order to keep up with the continuous changes in the industry.

Furthermore, without the necessary legislation in place, the CAV market could potentially fall into what is known as a 'lemon market' in economics, where manufacturers compete only on features that consumers can perceive, ignoring the ones they do not, such as cyber security and privacy. If in the long run CAVs with poor cyber security and privacy standards dominate the market, market failure could arise, resulting in a loss of social welfare. Also, as Nunes, Reimer, and Coughlin (2018) highlighted, exempting developers from safety rules poses risks; if developers are not always required to report system failures or to establish competency standards for vehicle operators, legislation should penalise them. Favouring industry over users will erode support for the technology from an already sceptical public. Legislation should also not sidestep the education of consumers; standards of competency and regular proficiency testing for users should be shaping consumer education programmes.

The complexity of the CAV system makes it particularly difficult for its security to be ensured. A higher degree of complexity can potentially lead to the occurrence of an increased number of errors in the design and development process, as well as to the greater difficulty in testing, consequently making Security by Design and Privacy by Design vital. Starting from the earliest manufacturing stage, the design process, up until the final manufacturing stage, the commercialisation of the technology, the CAV industry should be highly regulated and forced to follow certain principles. Several respondents suggested that the liability law should be improved by setting rules which aim to punish misconduct. In GDPR, executives and board members could face liability for data breaches (EU GDPR Portal, 2018). UK launched the Secure by Design, Secure by Default: Self-Certification Scheme in 2019, to ensure the UK's resilience against different forms of cyber security vulnerability. However, whether this law-like approach fulfils effective regulatory design criteria remains unexamined. Therefore, it is of utmost importance that the liabilities of all different parties, including the end-user, should be clarified.

Furthermore, there has to be a certain limit of liabilities that should be in place, otherwise the development of new technologies will be suppressed. The UK government is an example of a government that chooses to apply relatively soft policies when it comes to liabilities in the CAV industry. UK does not currently contain any specific provisions relating to user liability; Law Commission (2018) has suggested that the legislation must be developed further to clarify the role of the 'user-in-charge'. Upcoming legislation is being prepared based on the security-by-design principle in the UK since the start of 2020.

The research argues that a middle ground, between a heavily regulated industry and an uncontrolled one, has to be found. Maybe it would be more reliable for the insurance market to be encouraged to leverage the risk. Insurance is a self-reinforcing mechanism for improving security and safety, while still allowing companies room to innovate (Schneier, 2018). As a whole, user-friendly legislation clarifying responsibility, liability disputes, manufacturing and commercialisation procedures, educational programme prerequisites and creating a generic regulatory framework of operation should be in place before the implementation of CAVs (Nikitas *et al.* 2019) and should focus, with special care, on privacy and cyber security issues.

4.4.6 Safety

Safety is a core prerequisite to any IoT device and thus critical for the acceptance of CAVs. The elite respondents clearly highlighted that cyber security threats and privacy breaches would be viewed as inadequate safety provision by most end-users. Since safety has been the prime reason for introducing the CAVs in the first place and is the most critical criterion for their perceived success (Hulse *et al.* 2018, Papadoulis *et al.* 2019) and privacy and cyber security have clear links with safety perceptions (Taeihagh and Lim, 2019), prioritising CAV cyber security and privacy solutions that address safety concerns would be a decisive step towards the right direction. In this way, CAV users can develop a sufficiently positive perception to trust and use CAV services.

Ensuring the safety of CAVs, according to Koopman and Wagner (2017), requires a multi-disciplinary approach from all the involved stakeholders across all the levels of functional hierarchy including activities looking to support: hardware and software fault tolerance; resilient machine learning; cooperation with human-driven vehicles; validation systems for operation in highly unstructured environments; and appropriate regulatory approaches. In regard to the edge cases, the most well-known solution is probably prototyping, where researchers and developers can simulate unsafe situations arising from cyber security and privacy threats to explore crisis management solutions (Brugali *et al.* 2014).

Moreover, to improve the safety of the CAVs, it is essential to enhance prompt, transparent and forthright communication between CAV manufacturers and stakeholders. Manufacturers should notify relevant stakeholders when and where flaws exist, their severity, contents of the update, and instructions for each role. Updates may be exclusively communication about workarounds, warnings, unsafe conditions, labelling or instructions for use. To CAV manufacturers, the outstanding safety feature can differentiate their brand and build greater customer loyalty.

Chapter 5. Quantitative Research Stage

5.1 Introduction

After the in-depth elite interview phases, six main themes reflecting and affecting potential CAV public acceptance factors around cyber security and privacy emerged thanks to the field experts' responses. The author could thus survey public opinion to test the derived model that was inspired by the first stage research and theoretical framework. This chapter consists of three parts. The first part introduces the methodology of the quantitative research. The second part presents the preliminary analysis of the online survey data obtained from the public. The third part gives the explanation and interpretation of results obtained from the online survey.

5.2 Quantitative research methodology: online survey

Survey research design can be classified as cross-sectional and longitudinal based on the time dimension. In this research, the survey data will be collected at one point in time from the representatives of the population thereby making this survey research cross-sectional. A critical requirement for the cross-sectional survey research is that the hypothesis with the propounded theoretical framework must be clearly defined.

5.2.1 Theoretical framework and hypothesis development

Survey research design can be classified as cross-sectional and longitudinal based on the time dimension. In this research, the survey data will be collected at one point in time from the representatives of the population thereby making this survey research cross-sectional. A critical requirement for the cross-sectional survey research is that the hypothesis with the propounded theoretical framework must be clearly defined.

As detailed in Chapter 2, several theoretical frameworks on modelling attitude in relation to behavioural prediction have been develop since 1960s and 70s such as Theory of Reasoned Action (TRA) (Fishbein and Ajzen, 1975) and Technology Acceptance Model (TAM) (Davis, 1989). It is believed that Fishbein and Ajzen's Theory of Planned Behaviour (Fishbein and Ajzen, 1975) are the first researchers who started the attitude/behaviour field of research. In the 1980s, Davis developed TAM based on Fishbein and Ajzen's model to investigate the rationale behind the workers not using the ITs that were provided to them which made TAM one of the most influential models in examining the acceptance of innovations.

This study proposed an extension model based on the TAM. In particular, the present model has included three additional contrasts into the TAM which was inspired from the qualitative research and the literature in order to test the public attitude and acceptance in the context of CAVs. In Davis's explanation, one of the main purposes of TAM is to explain the factors that influence computer acceptance in general and understanding users' behaviour across technologies (Davis, Bagozzi, and Warshaw, 1989). Given that computer acceptance model should evolve with the society changes, and because different types of technology might need to be applied in an acceptance theory differently, the extended TAM with the acceptance themes derived from the elite interviews was developed. In summary, the constructs of the models are *perceived usefulness* (PU), *perceived ease of use* (PEOU), *attitude toward using* (ATU), *intention to use* (IOU), *self-efficacy* (SE), *perceived risks* (PR), and *facilitating conditions* (FC). Figure 5-1 depicts the proposed extended TAM model for this study.

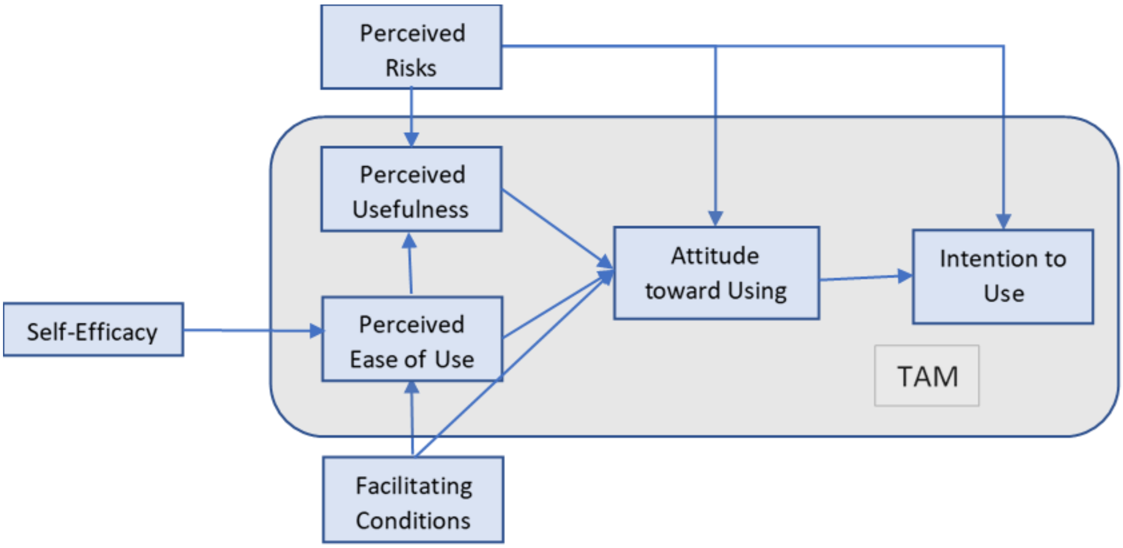

Figure 5-1 Proposed extension of TAM

TAM is a causal model that consists of four constructs, PU, PEOU, ATU and IOU. PU and PEOU are considered the key factors that influence public acceptance of the technology (Davis *et al.,* 1989). In light of the extensive literature review, 21 hypotheses in regard to the proposed model were formulated. These main constructs and their relationships development are presented in the following sections.

5.2.1.1 Perceived usefulness (PU)

Perceived usefulness (PU) is defined as "the degree to which an individual believes that using a particular system would enhance his or her job performance" (Davis, 1989). More specifically, this construct emphasizes the importance of the function and usefulness to the user, or the extent that user believe a certain technology would contribute to the productivity of a task.

In the context of this study, PU was used to examine people's belief on the benefits that CAVs could potentially bring to their life. As shown in Table 5-1 , four items for this construct were adopted.

It is worth mentioning that there is no consensus on the cultural dimensions point of view. Social presence theory suggest that the collectivistic society tend to undervalue the usefulness of a certain technology (Straub, Keil, and Brenner, 1997), whereas social cognitive theory (SCT) research has suggested the opposite (Oyibo and Vassileva, 2020). Collectivistic society stresses on communal objectives, goals and common ideas shared among the people while individualistic society upholds personal achievements, ideals and goals. The multigroup SEM intended to examine the difference between collectivistic (China residents) and individualistic (UK residents) on the influence of PU.

Item label	Operationalization of theoretical constructs
PU_1	The use of CAVs allows me free my hand so that I can do other activities in transit.
PU_2	The use of CAVs reduces the hassle for parking.
PU_3	The use of CAVs increase the effectiveness and reduce the time when traveling.
PU_4	The use of CAVs reduce traffic congestion

Table 5-1 Operationalization of PU

In the original TAM assumption, PU is directly linked with PEOU and ATU, where PEOU has a direct positive effect on PU, PU has a direct positive effect on ATU. Same assumption on the proposed model to test its validity has been formulated.

5.2.1.2 Perceived ease of use (PEOU)

Perceived ease of use (PEOU) is "the degree to which a person believes that using a particular system would be free of effort" (Davis *et al.,* 1989). Prior research indicated that PEOU positively influence PU and ATU in various context. For instance, in the context of autonomous electric buses (AEBs) (Herrenkind, *et al.*, 2019), public transport mobile payment acceptance (Di Pietro *et al.*, 2015), and autonomous vehicles acceptance (Zhang *et al.,* 2020).

PEOU is based on three items as shown in Table 5-2 where participants were asked about their feeling of the future CAVs when operating CAVs. They were measured by the five-point Likert scale.

In the original TAM assumption, PEOU is a form of intrinsic motivation factor that predict the ATU which directly influence the IOU. PEOU was also assumed to have a direct positive impact on PU, as Davis *et al.,* (1989) reasoned in their work, "Increased PEOU contributes to improved performance". The author argues that Davis's assumption on the relationship between PEOU and PU was based on the participants actual experiential feedback after using the certain technology, and it perhaps implies that PEOU positively influences PU in that certain scenario only. For this study, people who have been surveyed were those with no prior experience with CAVs thereby relying on the Davis' assumption would not suffice. However, since it is a claim that has been validated by many studies, this study has given the same assumption to be tested by its empirical data.

Item label	**Operationalization of theoretical constructs**
PEOU_1	I think CAVs can be easy to access and use.
PEOU _2	The use CAVs is easy for me because it does not require a licence.
PEOU _3	Controlling CAVs is simple and not require much effort.

Table 5-2 Operationalization of PEOU

5.2.1.3 Attitude toward using (ATU)

According to Davis (1989), attitude toward using (ATU) is defined as "the degree of a person's positive or negative feelings about performing the target behaviour". In consistence with TAM theory, where PU and PEOU would determine ATU, the adoption for a certain innovation is ultimately a decision-making process (Rogers, 1962), where the adoption or rejection decision is made followed by the attitude of the user (Gregan-Paxton and John, 1997).

Davis' TAM has positioned ATU to be the outcome of PU and ATU, in other words, if the product is perceived to be useful and easy to operate by the user, then user would have a positive attitude about that technology. This study has postulated the same causal effect and formulated four items measuring ATU (as shown in Table 5-3).

Item label	Operationalization of theoretical constructs
ATU_1	CAVs should substitute conventional cars soon.
ATU _2	I find the use of CAVs would be advantageous to safety.
ATU _3	I find the use of CAVs would be meaningful to the environment.
ATU _4	The use of CAVs is a good idea on minimize my transportation cost.

Table 5-3 Operationalization of ATU

5.2.1.4 Intention to use (IOU)

IOU is defined as "the degree to which a person has formulated conscious plans to perform, or not perform some specified future behaviour" (Davis, 1989). IOU in TAM is equivalent to behaviour intention (BI) in TRA and TRB that it indicates a plan or intention towards the upcoming behaviour of the user. ATU has a direct positive influence on IOU and so does PU, implying the relationships of these three factors in this study in line with TAM. This study has postulated the same causal effect and formulated four items measuring IOU (as shown in Table 5-4).

Item label	Operationalization of theoretical constructs
IOU_1	I intend to use CAVs even I need to get a training certificate.
IOU_2	I am willing to use CAVs and learn how to protect my personal and travel data.
IOU_3	I am willing to use CAVs and be responsible for my behaviour when using the CAV.
IOU_4	I am willing to participate in CAV trials, related awareness campaigns, and workshops.

Table 5-4 Operationalization of IOU

5.2.1.5 Self-efficacy (SE)

Self-Efficacy (SE) is defined as the "in one's capabilities to organise and execute the courses of action required to produce given attainments" (Bandura, 2010). It is believed to be "the foundation of human motivation" (Bandura, 2010). SE is a component made by Bandura's social cognitive theory in 1986 and has had a huge impact. The logic of SE in relation to the behaviour is refers to the self-evaluation on individual's performance where it "informs and alters their environments and their self-beliefs, which in turn inform and alter their subsequent performances" (Multon, Brown, and Lent, 1991).

The selection of SE was inspired by TPB's measurement contrast where SE is defined by individual's self-assessed confidence in performing a task (Ajzen, 1991). The integration of TPB and TAM has been successfully integrated to examine adoption intentions (Awa, Ojiabo, and Emecheta, 2015; Nasri and Charfeddine, 2012). In the context of this study, SE is used as an exogenous variable which directly influences PEOU, and it is measured by participants' confidence in their awareness on CAV related knowledge that was developed from the first stage of study (as shown in Table 5-5).

Item label	**Operationalization of theoretical constructs**
SE _1	I am confident with my existing knowledge about advantages of CAVs.
SE _2	I am confident with my existing knowledge about disadvantages of CAVs.
SE _3	I am confident with my existing knowledge about CAV related basic data protection practice.
SE _4	I am confident with my existing knowledge about CAV related basic cyber security practice

Table 5-5 Operationalization of SE

5.2.1.6 Perceived risks (PR)

Another external factor the author has chosen is perceived risk (PR) as has been found that many pieces of research have examined perceived risk and perceived benefit as corresponding to the wiliness to pay (Wang *et al.,* 2012) and the acceptance of the technology (Groot, 2018). PR was first proposed in 1960 in the context of consumer behaviour (Bauer, 1960) where Bauer studied the factors influencing consumer's purchasing decision making on people from different social and economic class. Cunningham's (1967) has classified PR into two categories, uncertainty and consequences. Uncertainty focuses more on perceived uncertainty by the user, and consequences focus on the user's evaluation of future loss. This study has adopted the PR definition from Engel, Kollat and Blackwell (1973) that has positioned PR as "external search and alternative evaluation".

In the IT acceptance field of research, it was established that perceived risk, such as perceived system disturbance and perceived system reliability, significantly influence PU and ATU (Chen *et al.,* 2019). Therefore, in line with the literature findings, direct relationship between PR and PU, ATU have been postulated.

As shown in Table 5-6, for the proposed model, four items were included in PR to collect respondent's feelings on CAV related risks that was informed by the first stage of study and adapted from several literatures (Liu, Nikitas, and Parkinson, 2020; Parkinson *et al.,* 2017; Taeihagh and Lim, 2019). PR in the survey consists of cyber security risks, privacy risks of CAVs.

Item label	**Operationalization of theoretical constructs**
PR_1	I am concerned about the interior cameras and usage logs will track when and where I have gone.
PR _2	I am concerned about cyber security issues of CAVs.
PR _3	I am concerned about privacy issues of CAVs.

PR _4	I am concerned about legislation issues around CAVs' cyber security and privacy.

Table 5-6 Operationalization of PR

5.2.1.7 Facilitating condition (FC)

Facilitating conditions (FC) refer to the "perceived enablers or barriers in the environment that influence a person's perception of ease or difficulty of performing a task" (Teo, 2010). FC is one of the core components of TPB. In the context of this study, FC means the facilitating support people desire from external environment in response to the CAV associated cyber security and privacy risks. Specifically, support from the government sectors, mobility services and car manufacturers. These supports have been cited in prior research such as smart cities (Khatoun and Zeadally, 2017) and healthcare information systems adoption (Hsu, Lee, and Su, 2013). As shown in Table 5-7, three items are selected for FC, these items selection were inspired by Thompson et al. (1991).

One of the main reasons our proposed model introduced FC is because new technologies are susceptible or prone to threats (Kavanagh, 2019) and organizational and technological support in place would give users the confidence of using the certain technology (Hsu *et al.,* 2013). Additionally, in IT acceptance and adoption point of view, the amount of support available directly influences the IT adoption (Taylor and Todd, 1995) as FC would be more salient given that most of the user would have no experience on CAVs.

Studies that have been conducted using the combination of TPB and TAM model have found that FC significantly influences ATT and PEOU (Terzis and Economides, 2011). In other words, the supports would influence user's perception and their attitude on the use of the technology. For example, adequate support from the desired organisation would increase the user's knowledge on the engagement of the technology and serve to promote positive attitude toward it. The proposed model has adopted the same relationships from the prior literature.

Item label	Operationalization of theoretical constructs
FC_1	Government is providing help on protecting my personal data when I am using CAVs.
FC_2	Mobility service providers are providing help on protecting my personal data when I am using CAVs.
FC_3	Car manufacturers are providing help on protecting my personal data when I am using CAVs.

Table 5-7 Operationalization of FC

5.2.2 Hypothesis development finalisation

In summary, the theoretical framework was presented to understand the construct and the measurement items of the proposed model that are expected to influence the adoption and the acceptance of CAVs. The proposed model and theories are rooted on TAM and inspired by TPB. The selected factors reflect integrated individual (SE, PU, PEOU) and organisational (PR, FC) dimension (As shown in Table 5-8). Exactly 21 Hypotheses were formulated and presented in Table 5-9.

Researchers has successfully adapted TAM to the mobility context, including investigating public acceptance towards CAVs (Panagiotopoulos and Dimitrakopoulos, 2018; Rahman *et al.*, 2017). Thus, this study tests the model by examining public acceptance of CAVs using the empirical data collected from UK and China residents.

Construct	Definition	Source
PU	"the degree to which an individual believes that using a particular system would enhance his or her job performance"	(Davis *et al.,* 1989)
PEOU	"the degree to which a person believes that using a particular system would be free of effort"	(Davis *et al.,* 1989)

ATU	"the degree of a person's positive or negative feelings about performing the target behaviour"	(Davis *et al.,* 1989)
IOU	"the degree to which a person has formulated conscious plans to perform, or not perform some specified future behaviour"	(Davis *et al.,* 1989)
SE	"in one's capabilities to organise and execute the courses of action required to produce given attainments"	(Bandura, 2010)
PR	"external search and alternative evaluation"	(Bauer, 1960; Engel *et al.,* 1973)
FC	"perceived enablers or barriers in the environment that influence a person's perception of ease or difficulty of performing a task"	(Teo, 2010)

Table 5-8 Operational Definitions of the Terms

Hypothesis #	Direct effects
H1a	Perceived risk has a negative effect on perceived usefulness;
H1b	Perceived usefulness has a positive effect on attitude toward using;
H1c	Perceived risk has a negative effect on attitude toward using;
H1d	Perceived ease of use has a positive effect on attitude toward using;
H1e	Self-efficacy has a positive effect on Perceived ease of use.
H1f	Facilitating condition has a positive effect on attitude toward using;
H1g	Facilitating condition has a positive effect on perceived ease of use;
H1h	Perceived risk has a negative effect on intention to use.
Hypothesis #	Mediated effects
H2a	Perceived ease of use mediates the positive relationship between self-efficacy and attitude toward using;
H2b	Attitude toward using mediates the negative relationship between perceived risk and intention to use;
H2c	Perceived usefulness mediates the negative relationship between perceived risk and attitude toward using.

Hypothesis #	Multigroup effects for UK and China resident
H3a	The negative relationship between perceived risk and attitude toward using is stronger for the China resident than the UK resident;
H3b	The negative relationship between perceived risk and intention to use is stronger for the China resident than the UK resident.
Hypothesis #	Multigroup effects for UK gender group
H4a	The positive relationship between perceived ease to use and attitude toward using is stronger for females than males in the UK sample;
H4b	The negative relationship between perceived risk and attitude toward using is stronger for females than males in the UK sample;
Hypothesis #	Multigroup effects for China gender group
H5a	The negative relationship between perceived risk and attitude toward using is stronger for females than males in China sample;
H5b	The positive relationship between attitude toward using and intention to use is stronger for females than males in China sample.
Hypothesis #	Multigroup effects for Millennials and GenX
H6a	The positive relationship between perceived ease to use and attitude toward using is stronger for the millennials than generation X;
H6b	The negative relationship between perceived risk and attitude toward using is stronger for the millennials than generation X;
H6c	The positive relationship between self-efficacy and perceived ease to use is stronger for the millennials than generation X;
H6d	The negative relationship between perceived risk and intention to use is stronger for the millennials than generation X.

Table 5-9 Hypotheses

5.2.3 Questionnaire design

In this study, a questionnaire was developed to collect data for the model testing. The online survey content is provided in Appendix B. All questions covered in the model constructs are included in the Likert-scale questions which include both 3 scale[11] such as yes, maybe, no and 5 scale responses such as strongly disagree, somewhat disagree, neither agree nor disagree, somewhat agree, strongly agree. Each item in the questionnaire were chosen carefully from the previous literature that have been proven to be valid and reliable. Except from the items that has been discussed in the previous section which mostly used 5-point rating scale, standardised demographic data was developed too, including country of residency, age, gender, education and occupation. Additionally, individual's information relating to the current transportation use, including whether they obtained a driving licence, means of transport for commuting in the city, whether they liked to share cars with others were also collected.

The questionnaire design has followed the general framework suggested by Pinsonneault and Kraemer (1993). The nature of our survey is set on explanations. That is, it is answering questions based on the hypothesised causal effects between variables. It does so by answering what is the existent causal relationships as well as explaining why the relationship exists (Pinsonneault and Kraemer, 1993). As for the study, the questionnaire design poses the questions on the TAM causal relationships stand in the context of CAV acceptance and the reasons behind it. Also, the study queries how FC, PR and SE influence the variables in the traditional TAM model and investigate the reason behind.

Some suggestions were adopted in the questionnaire design stage based on best practice literature. For instance, straightforward questions were incorporated into the questionnaire to prevent a 'missing data' issue that normally happens in the data analysis stage, in line with Kline (2015) best strategy advice.

When comparing people's attitudes across countries, some challenges in the questionnaire design needing to be tackled include questionnaire translation and sample selection. People would respond to the same question differently in the cross-national survey, regardless of their social class, gender or religious identities. It is more challenging to control response style in a cross-country survey due to cultural differences. The

[11] For items FC_1, FC_2 and FC_3, Response options: yes, maybe, no

questionnaire was designed in English, and then the author has translated it into the Chinese language since the questionnaire is simple and straightforward, the author did not face any difficulties in the translation process.

5.2.4 Pilot testing

The pilot study also called pre-testing consists of a small-scale survey testing that aims at curing mistakes associated with the data collection. Mistakes may include misunderstanding of the questions or vagueness at testing questions (Grimm, 2010). Pilot testing is important because once the official data collection is started, occurrence of mistakes will create credibility issues around reliability and validity of the research process.

For this study, 13 people were invited including undergraduate students, PhD researchers and academics to answer the questionnaire and give feedback on a shared google spread sheet. All the feedbacks were carefully considered and revised accordingly under supervision. The final questionnaire was developed and published in the online survey tool Qualtrics.

5.2.5 Sampling procedure and data collection

The population of this study include UK and China adult residents. As mentioned in section 1.4, both UK and China have supporting environment for public road testing without interruption or intervention. Furthermore, both two countries have comparable information and communication technology (ICT) adoption levels. Purposive sampling was adopted under the non-probability sampling approach. Compared to probability sampling that has the advantage of claiming the representative nature of a sample and at the same time avoid selection bias (Saunders, Lewis, and Thornhill, 2009), non-probability sampling does not involve random selection and it is cheap and can collect a large sample in a short time (Faber and Fonseca, 2014). The non- probability sampling is normally prone to selection bias; however, the author argues that most of the sampling methods are purposive in nature as the researcher has to have a research question before data collection, which means that data will be collected and directed by a purposive plan.

The survey respondent recruitment process involved: calls for participation issued by the author and supervisors' network (email), recommendations from that network and social media (i.e., LinkedIn and Twitter), handout print brochures on street corners. All respondents were directed to the online Qualtrics by using QR code scanning or by clicking the provided web link. As the questionnaire is computer based, it gives the opportunity to collect large amount of data targeted to a large sample size. Additionally, it is economical, sustainable and effective as internet technologies have removed the barriers on printing and posting questionnaires. Data was collected from 11th of February to 25th of April 2020. For the data collected in the UK, about 80% of the data was collected before UK Covid-19 national lockdown while 20% of the data was collected during the UK Covid-19 national lockdown (23rd of March to 25th of April 2020). The data collected in China was gathered during the pandemic period, as the Covid-19 pandemic gained momentum in China in January 2020. As the nature of the research topic is not considered context-sensitive, the author believes the quality and reliability of the data collected have relatively low influence on this research, and the data reliability is further examined in Chapter 5.

Sample size is an important element in both data collection and data analysis. It is particularly more important in this study as a lot of model reliable estimate parameters are sensitive to sample sizes (Jackson, 2003). In terms of sample size for explanatory survey studies, it was suggested to be "sufficient to test categories in the theoretical framework with statistical power" (Pinsonneault and Kraemer, 1993). Therefore, SEM's sample size requirement needed to be met. These is no consensus on the ideal sample size for SEM as most of the relevant literature studies have given a vague description of "a large sample size". Kline (2011) has suggested that the typical sample sizes in SEM studies are N = 200-300 and the large sample size is N = 5000.

5.2.6 Data analysis

To select the data analysis method, one important element needs to be considered, the research question. As this study intended to answer the questions about what factors affect public acceptance of CAVs, and to what degree these factors influence each other, it is essential to select the most suitable approach to the data analytic that can respond to the questions. In principle, public acceptance is not simply affected by manifest variables or indicator variables (i.e., age, gender, price), but also by latent variables (i.e., PEOU, PU, IOU). Moreover, this study tries to investigate the relationships between those factors implying that causal relationships needed to be tested. Therefore, due to the nature of this study, Structural Equation Modelling (SEM) was adopted to conduct the data analysis.

As shown in Table 5-10, SEM is the second generation of multivariate analysis method that was developed since 1990. It was used to examine casual assumptions and further give informational conclusions.

	Exploratory	**Confirmatory**
First generation **(1900-1990)**	Exploratory Factor Analysis (EFA) Cluster Analysis Multidimensional Scaling (MDS)	Analysis of variance (ANOVA) Logistic Regression Multiple Regression
Second generation **(1900-)**	Structural Equation Model (SEM) -Partial Least Square (PLS)	Structural Equation Model (SEM) - Covariance based confirmatory factor analysis (CFA)

Table 5-10 Multivariate analysis methods

First generation multivariate methods are used to measure mostly the correlation between the constructs; the primary goal is “merely prediction (Bollen and Pearl, 2013)”, however it has no causal explanation. With incorporation of estimated parameters, SEM allow simultaneous analysis of all latent variables that have interplay effect on one other. The advantage of SEM over first generation multivariate analysis methods is that the insight is more reliable than single variable formulated regressions. This study has adopted both EFA for primary data analysis and SEM-CFA analysis, it is discussed in detail in session 5.2.7, 5.2.8 and 5.2.9.

"Computing polyserial or polychromic correlations are complicated and requires special software, such as PRELIS[12] in LISREL[13]" (Kline, 2015). Polyserial or polychromic correlations tests the correlation between two continuous variables where one of the variables remains unobserved while the other variable is measured directly. IBM SPSS Statistics 26 was used for data cleaning and primary data analysis, and SEM was conducted using IBM SPSS Amos 26 graphics. SPSS is a statistical software produced by IBM which offers advanced statistical analysis, it is used in various research areas for basic to complex statistical data analysis. Furthermore, SPSS Amos is designed for SEM where the researcher can gain a holistic insight on the causal networks of effects.

5.2.7 Exploratory factor analysis (EFA)

Exploratory Factor Analysis (EFA) is one of the two categories of the factor analysis group and it is one type of the first-generation multivariate analysis methods, as mentioned in Table 5-10. This analysis approach does not require to specify the number of factors and the results generated by EFA could be various, therefore, EFA is unrestricted measurement model. In general, EFA is used to discover the main characteristics or patterns of the dataset. EFA can be performed in SPSS using datasets at interval lever, distributed in bell curve (standardised variables).

Because EFA can have unrestricted numbers of parameters than observations, the exact numbers of latent factors cannot be identified through EFA. Since EFA is an exploratory technique, there is no expected distribution of loadings; hence, it is not possible to test

[12] PRELIS is a preliminary program for preparing data to be analysed by LISREL.

[13] LISREL stand for linear structural relations, it is a statistical program package particularly designed to estimate SEMs.

statistically whether factor loadings are the same across cultural groups. However, using a rotation method allows EFA to rescale pattern coefficients and result in emphasising the factors with high loading to close to 1 or -1 and low loadings to close to 0. In SPSS, researchers need to manually set a particular rotation method. Popular rotation methods include orthogonal rotation (i.e., varimax rotation, equamax rotation) and oblique rotation (i.e., promax rotation). Promax rotation was chosen for this study because it is the most widely used oblique rotation method which allows for correlating factors. Furthermore, promax is specifically useful for the large data set as it can be calculated quickly than a direct oblimin rotation (IBM, 2020).

It is recommended to begin model generation from conducting EFA to identify potential factors (i.e., number of factors, type of factors) in a plausible model (Costello and Osborne, 2005). The general idea is that after EFA, CFA can be used in the sample that was not used in CFA (Kline, 2015) because after constraining the indicators from EFA in CFA, model might not be able to be identified. (Jöreskog, 1969). However, some argue that in EFA is a necessary step to determine the underlying factor structure before CFA (Suhr, 2006). There is no general consensus on whether EFA should be conducted before CFA, and what is the right practices of the two methods (Crowley and Fan, 1997).

As for this study, both EFA and CFA were conducted. Firstly, given that this research is new and about emerging technologies, there are not enough empirical studies in the literature to inform on the appropriate theoretical framework as such EFA is suitable for this study to identify the latent factors. However, as the questionnaire was designed based on a strong conceptual underpinning (TAM) and the author has also extended the TAM model by adding three other factors CFA becomes essential to confirm the model. Therefore, as much as the study does not have a strong underlying theory that supports the dimensionality of the model contrast, it is a logical path to conduct EFA before CFA.

5.2.8 Confirmatory factor analysis (CFA)

Confirmatory factor analysis (CFA) is another category of factor analysis where the researchers must specify the number of the factors and the identity of the factors. Thus, unlike EFA, restricted measurement models are analysed in CFA (Kline, 2011). It is one of the most primary used techniques for conducting measurement-related researchers.

The rationale of the factor analysis is that the observed covariance among the common variance within one latent variable depart appreciably from 0. For example, in this study,

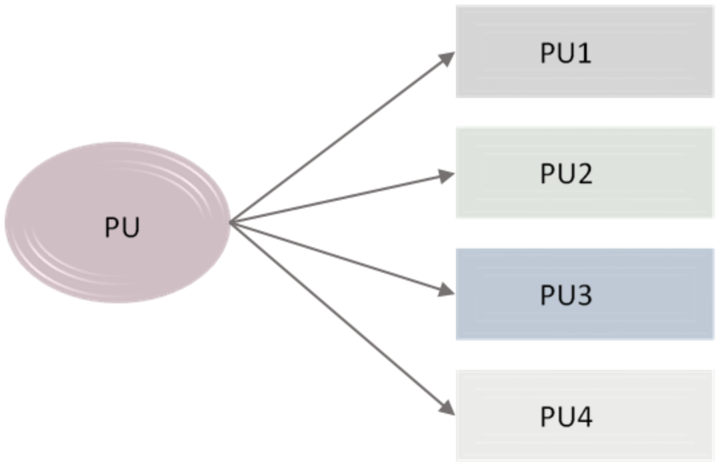

Figure 5-2 PU measurement models as DAG

the latent variable PU is the common cause of four observed variables (items) PU1-PU4, therefore, PU d-separates PU1-PU4 as shown in Figure 5-2.

In this case, the conditional independences implied by Figure 5-2 can be listed as:

$$PU1 \perp PU2 \mid PU;\ PU1 \perp PU3 \mid PU;\ PU1 \perp PU4 \mid PU$$

$$PU2 \perp PU3 \mid PU;\ PU2 \perp PU4 \mid PU;\ PU3 \perp PU4 \mid PU$$

Moreover, Figure 5-2 also implies:

$\rho^{14}_{PU1PU2 \cdot PU} = \rho_{PU1PU3 \cdot PU} = \rho_{PU1PU4 \cdot PU} = \rho_{PU2PU3 \cdot PU} = \rho_{PU3PU4 \cdot PU} = 0$

Another form of measurement model in this study pertains to the existence of correlated error between the indicators (items) within the same latent variables. Presented next, Figure 5-3 is the example of SE d-separates SE1-SE4 as causal directed acyclic graphs (DAG) with SE1 and SE2 with correlated errors.

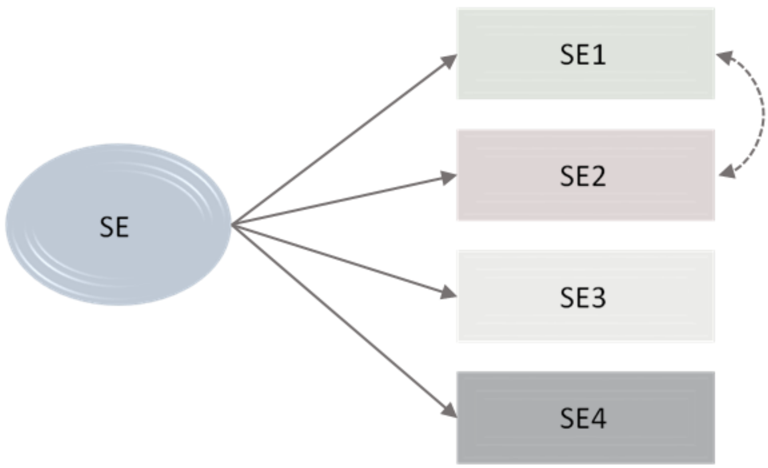

Figure 5-3 SE measurement models as DAG

In comparison with PU measurement model, SE implies fewer conditional independences because the shared error between SE1 and SE1 (a common cause of SE1 and SE2) is not a substantive latent variable and it cannot appear in any conditioning set. Figure 5-3 implies:

$$SE1 \perp SE3 \mid SE;\ SE1 \perp SE4 \mid SE;\ SE2 \perp SE3 \mid SE$$

$$SE2 \perp SE4 \mid SE;\ SE3 \perp SE4 \mid SE$$

5.2.9 Structural equation modelling (SEM)

Structural equation modelling (SEM) is widely used in behaviour science. It consists of a broad array of models from linear regression to measurement models to simultaneous equations. In other words, SEM can be seen as a combination of factor analysis, regression

[14] ρ represents the population correlation.

analysis or path analysis. SEM itself is an estimation approach rather than a particular model and it is often drawn as path diagrams.

There are several advantages SEM has over regression and path analysis. In brief, regression analysis estimates the relationship between one dependent variable and one or more independent variable. It is also good in data exploration and the conclusion are mostly about correlations. Regression analysis is an empirical model that is based on empirical observations not on the theory.

The biggest drawback that causes a rigid researcher not to choose regression analysis when investigating public perception is that ordinary regression cannot draw causal conclusions. Furthermore, the findings followed by regression analysis can only belong to the environment where the experiments are conducted. However, SEM allows the research process to develop complex path models with direct and indirect effects which allows the researcher to interpret accurately on model causal mechanisms. In this way, other researchers can imitate the method to do similar research or improve the whole method. In addition, Nunkoo and Ramkissoon (2012) had ranked SEM over regression analysis as shown in Table 5-11. Behavioural research is in general complex with several variables or factors influencing one another simultaneously, therefore, a multivariate statistical analysis such as SEM is capable and suitable to perform comprehensive human factor research.

	Advantages	**Limitations**
1	modelling of measurement errors and unexplained variances;	difficulty in choosing and using SEM software packages;
2	simultaneous testing of relationships;	complexity and ambiguity;
3	ability to link micro- and macro-perspectives;	limited use in exploratory research;
4	best-fitting model and theory development.	inability to model ‘truly’ categorical variables.

Table 5-11 The advantages of SEM over regression analysis (Nunkoo and Ramkissoon, 2012)

Path analysis is a series of regressions applied sequentially to data, same as regression analysis, it contains only observed variables and it is assumed that all variables are measured with no measurement error. The advantages that SEM has over path analysis is that path analysis cannot measure latent variables and it has a limited set of assumptions (more restrictive) than SEM. This explains why most of the studies in behavioural science are conducted using SEM rather than Path analysis.

5.3 Quantitative survey results

As this research followed Creswell and Clark's (2017) triangulation mixed-methods approach, this chapter offers a detailed account of the results generated by the quantitative part of the research that aims to investigate the factors that may affect CAV acceptance based on Davis' (1989) TAM model. First, the data screening results are presented. Second, the EFA results are introduced. By exploratory factor analysis (EFA), the initial latent factors throughout a wide range of variables are extracted. Following this, confirmatory factor analysis (CFA) determined the factor structure from the initial extracted model in EFA. Ultimately, a structural equation modelling (SEM) result tested the fit and the interactions between the hypothesised model and the latent factor obtained from CFA.

5.3.1 Data Screening

In this section, case screening and variable screening are evaluated based on statistical screening methods which include the descriptive statistics, outlier analysis, the missing data check and discordant responses which directly linked to EFA, CFA analysis and bias check.

5.3.1.1 Missing data

Missing data is the incomplete data in the dataset where the variable or a question was not captured during the data collection process. Missing data is the most common problem that occurs in a survey, and it affects the subsequent data analysis process. It was first introduced by Rubin (1976), who proposed that missingness mechanisms can be classified using typology, namely missing completely at random (MCAR), missing at random (MAR) and missing not at random (MNAR).

Hair *et al.* (2018) and Rubin (1976) had pointed out the critical role of missing data played in the data analysis process because most statistical instruments cannot be incorporated on an incomplete dataset. SPSS AMOS version 26 was chosen for the data analysis in this study. When missing data is encountered, it assumes that the typology of the dataset is MAR, then it estimates the maximum likelihood of the parameter by its full information maximum likelihood (FIML). When CFA and SEM run in AMOS, with missing data, the χ^2, modifications indices and usual fit indices cannot be computed due to lack of numbers of data points.

In addition to the problem mentioned above, missing data may also introduce bias issues. As most public acceptance studies estimate causal effects on variables, incomplete observed data consist of missing data that if used in the analysis would lead to incorrect or biased outcomes on the estimation of quantities of interest (e.g., causal effect) (Edwards, Cole, and Westreich, 2015; Rubin, 1976).

Opinion varies on the threshold for the number of missing data. In educational and psychological studies, it is commonly agreed that 15% to 20% of missing data in the data set is acceptable (Enders, 2003). A lower threshold of up to 5% is assigned to be a rate that can result in a 'fairly accurate' estimation (Schafer, 1999).

There are several techniques for handling missing data, including the mean replacement method, median replacement method, maximum likelihood method, and Don Rubin's expectation-maximisation (EM). It is a common practice in statistical software packages to set default values for handling missing data (Schumacker and Lomax, 2004). The EM algorithm is an acceptable approach used to remedy the situation.

The initial data screening conducted in the IBM SPSS Statistics 26. There are less than 4% of missing data were detected in the dataset. The proportion of the missing data is within the limit of the strict threshold, and then the author imputed the missing data using the mean substitution method as suggested by Schumacker and Lomax (2004), that is regarded as the best approach for a small number of missing values in a dataset. After the initial data screening, 1162 full data left for analysis, as shown in Table 5-12.

	N Valid	Missing	Mean[15]	Std. Deviation
Location	1162	0		
Employment	1162	0	3.02	2.322
Age	1162	0	3.59	1.968
DrivingLicence	1162	0	1.17	0.378
Gender	1162	0	1.50	0.545
Education	1162	0	4.82	1.440
JobField	1162	0	7.59	5.669
Transport2Work	1162	0	3.53	2.339
ATU_1	1162	0	3.12	1.162
ATU_2	1162	0	3.16	1.272
ATU_3	1162	0	3.23	1.251
ATU_4	1162	0	3.13	1.237
PU_1	1162	0	3.95	1.212
PU_2	1162	0	3.94	1.165
PU_3	1162	0	3.98	1.132
PU_4	1162	0	4.01	1.150

[15] For the items created in this research, the mean values do not have any meanings because of ordinal scale used. In other words, mean cannot be found in Likert scale questions and is only essential for detecting outliers.

PEOU_1	1162	0	2.79	1.302
PEOU_2	1162	0	2.78	1.302
PEOU_3	1162	0	2.02	1.154
PR_1	1162	0	2.45	1.250
PR_2	1162	0	2.11	1.222
PR_3	1162	0	2.21	1.240
PR_4	1162	0	1.98	1.137
PR_5	1162	0	1.92	1.115
IOU_1	1162	0	4.21	1.007
IOU_2	1162	0	4.27	0.980
IOU_3	1162	0	4.05	1.106
IOU_4	1162	0	3.84	1.179
FC_1	1162	0	1.81	0.749
FC_2	1162	0	1.64	0.743
FC_3	1162	0	1.60	0.763
SE_1	1162	0	3.35	1.238
SE_2	1162	0	3.12	1.180
SE_3	1162	0	3.11	1.241
SE_4	1162	0	3.13	1.247
SlvNLaunch	1162	0	4.07	1.100

Table 5-12 Missing data screening

5.3.1.2 Outliers

The next step is to examine data outliers or out-of-range data commonly caused by discordant responses in the survey type of data. In essence, it is the observations that are far different from the well-structured dataset (Blunch, 2012), it can happen on either the endogenous or exogenous latent variables (Schumacker and Lomax, 2004).

Additionally, in SEM, the best practice is to check both types of outliers, individual variables in the raw data set and the outliers for the model, in other words, univariate outlier and multivariate outliers. A univariate outlier is an abnormal data point that exists on one variable (or 'item' in SEM). A multivariate outlier is a data point with an abnormal combination of scores on more than one variable.

Checking both types of outliers are especially crucial in SEM analysis as it can affect the sample profile (e.g., mean, standard deviation, and correlation coefficient) and the outcome of the estimation (e.g., observation errors, data entry errors, and instrument errors).

Outliers are typically considered as errors that should be remedied before proceeding to data analysis. Wilcox and Keselman (2012) had introduced several robust techniques to detect outliers, including minimum volume ellipsoid estimator, projection method, boxplot, MAD-median rule.

This study used boxplot to detect univariate outliers because it is easy and effective to visualise outliers. As the boxplot displayed in the Figure 5-4, four continuous variables are plotted; *employment, age, education* and *transport to work* (Transport2Work). Extreme cases in the employment variable were visited, unengaged responses who had chosen "retired" together with "18-25", "26-34", "35-44" in the age variable were manually deleted. At the same time, the responses who are under 18 years old were deleted. Similarly, responses who have selected "Unable to work" but not selected "Other" in "Transport2Work" question were also deleted.

Outliers cannot be detected horizontally in Likert-scales questions, because the 5-points Likert scale have only options of 1 to 5 which cannot represent outlier behaviour. The standard deviation of overall Likert scale questions was calculated to detect the unengaged responses. Responses scores of '3, 3, 3, 3, …' or '1, 2, 3, 4, 5, 1, 2, …' would be suspected as unengaged respondents (Gaskin, 2016).

Some reverse-coded and some same direction coded questions were deliberately set in the questionnaire design stages to cross-check valid responses and detect the responses with a certain pattern. For the first scenario, "a reason that could make me avoid the use of a CAV is that I need to get a training certificate specifically for driverless cars." and the question "I am willing to take a test that will give me a training certificate for driverless cars" are two reverse-coded questions. If the responses scored in the same scale (e.g., both questions scored in agree side) then this response will be considered unengaged responses and will be removed from the dataset. For the second scenario, "a reason that could make me avoid the use of a CAV is that cyber security is a concern" and the question "I am concerned about problems that relate to the cyber security issues of driverless cars" are two same direction questions. If the responses scored in a different scale (e.g., scored the first question in disagree side and the second question in the agree side) then these responses will be removed as the author considers that the respondent did not understand the question correctly.

As a result, 23 responses with a standard deviation lower than 0.7 got deleted. Until this stage of data screening, 1162 out of 1214 responses are left for future analysis (see Table 5-12).

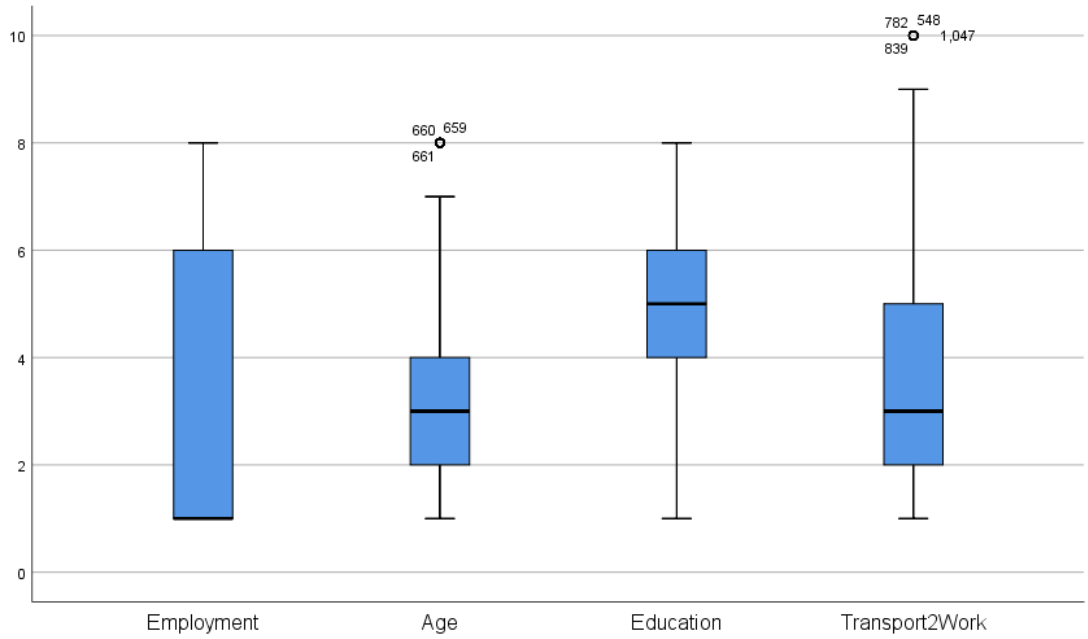

Figure 5-4 Boxplot of four continuous variables

5.3.1.3 Normality

Normality assumption testing is considered an essential step for multivariate analysis because it may affect the reliability and the validity of the research outcome. Maximum likelihood is the default estimation method in SEM, which assumes multivariate normality of the latent variables and indicators.

In theory, for continuous outcome variables, a normal distribution is required. However, in reality, no variables are strictly normal (Blunch, 2012). Because it is often impractical to get normally distributed dataset in the real world, and most of the empirical distribution is often departures from strict normality (Micceri, 1989). Several techniques have been developed to detect the violation of multivariate normality, including: graphical methods (e.g., histogram, normal probability plot, quantile-quantile plot) and Bayesian tests (Spiegelhalter, 1980).

5.3.1.4 Skewness and kurtosis

Lund and Lund (2010) recommend that adopting numerical methods such as skewness and kurtosis as graphical methods is a good approach. Therefore, in this study, a skewness and kurtosis check were adopted for the normality test.

Skewness or Pearson's moment coefficient of skewness refers to a measure of the asymmetry of the distribution. A positive skew indicates that most values are lower than the mean, and vice versa. The larger the absolute value of the skewness measure, the more asymmetric the distribution.

Kurtosis refers to the "tailedness" or "peakiness" of the distribution. Negative kurtosis indicates lighter tails and a flatter peak, and a positive kurtosis indicates the opposite. Skewness and kurtosis generally appear together in a dataset, which means that skewed distribution is generally either leptokurtic or platykurtic (Kline, 2015).

Variable	Missing	Skewness	Std. Error of Skewness	Kurtosis	Std. Error of Kurtosis
Age	0	1.342	0.071	0.505	0.142
DrivingLicence	0	1.707	0.071	0.914	0.142
Education	0	-0.908	0.071	0.686	0.142
Employment	0	0.456	0.071	-1.548	0.142
Gender	0	0.510	0.071	-0.278	0.142
JobField	0	0.162	0.071	-1.595	0.142
Location	0	0.249	0.071	1.941	0.142
Transport2Work	0	1.084	0.071	0.375	0.142
ATU_1	0	0.043	0.071	-0.666	0.142
ATU_2	0	-0.085	0.071	-0.999	0.142
ATU_3	0	-0.512	0.071	0.089	0.142
ATU_4	0	-0.993	0.071	0.020	0.142
ATU_5	0	0.283	0.071	-0.948	0.142
FC_1	0	-1.375	0.071	0.167	0.142
FC_2	0	0.321	0.071	-1.135	0.142
FC_3	0	0.662	0.071	-0.895	0.142
FC_4	0	0.783	0.071	-0.843	0.142
IOU_1	0	0.971	0.071	0.069	0.142
IOU_2	0	-1.302	0.071	1.321	0.142
IOU_3	0	-1.415	0.071	1.731	0.142
IOU_4	0	-1.060	0.071	0.458	0.142
IOU_5	0	-0.758	0.071	-0.248	0.142
PEOU_1	0	-0.691	0.071	-0.325	0.142
PEOU_2	0	0.218	0.071	-0.965	0.142
PEOU_3	0	1.032	0.071	0.012	0.142
PR_1	0	0.210	0.071	-1.047	0.142

PR_2	0	1.030	0.071	0.331	0.142
PR_3	0	0.503	0.071	-0.667	0.142
PR_4	0	0.883	0.071	-0.165	0.142
PR_5	0	-0.742	0.071	-0.428	0.142
PR_6	0	-1.020	0.071	0.253	0.142
PR_7	0	-1.130	0.071	0.547	0.142
PU_1	0	-0.025	0.071	-0.902	0.142
PU_2	0	-0.953	0.071	0.080	0.142
PU_3	0	-0.981	0.071	0.158	0.142
PU_4	0	-1.029	0.071	0.247	0.142
SE_1	0	-0.295	0.071	-0.775	0.142
SE_2	0	-0.097	0.071	-0.614	0.142
SE_3	0	-0.054	0.071	-0.849	0.142
SE_4	0	-0.112	0.071	-0.869	0.142
SlvNLaunch	0	-1.074	0.071	0.451	0.142

Table 5-13 Skewness and Kurtosis

There is no official cut-off threshold for the level of measurement in terms of skewness and kurtosis. As a general rule of thumb, a strict clear-cut standard for skewness is ±1. There is less consensus about kurtosis as it can range from 8.0 to 20.0 and still be considered as "severe" kurtosis (Kline, 2015).

Presented in Table 5-13 is the skewness and kurtosis of the dataset. It is observed that a mild skewed distribution exists for the indicators of latent factors IOU, and FC. These skewness values range from -1.4 and 1.4. While this does violate strict rules of normality, it is within the tolerance limit as suggested by Byrne (2013), George and Mallery (2010), and Kline (2011) who recommended ±2 as the threshold for normality. In terms of skewness a fairly mesokurtic distribution is observed.

5.3.1.5 Linearity and homoscedasticity

As SEM is an extension of the general linear model (GLM) (Kaplan, 2008), linearity assumption testing is a must for SEM. Linearity assumption averts that the linear relationships between endogenous η (i.e., dependent variables) and exogenous ξ (i.e., independent variables) latent variables.

Testing linearity methods includes the formal linearity test that is based on the cumulative sum (CUSUM) statistic (Page, 1954) and the Kolmogorov-Smirnov test. In SPSS, the ANOVA test is accessible and rigorous for the linearity test. In this study, a curve estimation technique is adopted to test the linearity as the author aimed to see more information about the data in the output tables. The estimation for all the relationships in the model is shown in Appendix C and determines that all relationships were sufficiently linear to be tested using the covariance-based SEM algorithm (e.g., AMOS).

Homoscedasticity assumption validates that the variable's residual (e.g., standard error, variance) is consistent for all variables. As it is mentioned in section 5.3.1.3, normality distribution in actual studies is rare; Kline (2015) believes that homoscedasticity is a myth because Keselman et al. (1998) had proven a mean variance ratio of 8:1 across different groups.

The homoscedasticity assumption needs to be to eliminate biases to the right extent (Lewis-Beck, 1995). The variable residual scatter plot for all the relationships in the model is shown in Appendix D, a consistent pattern was found in each regression, so it is apparent that they are homoscedastic.

5.3.2 Profile of respondents

The target sample for this study was people living in the UK and China who are above 17 years old. A total of 1214 responses were received, and 1162 responses were retained after preliminary data analysis. These included 656 participants living in China and 506 participants living in the UK (See Table 5-14).

	Frequency	%
China	656	56.5
UK	506	43.5
Total	1162	100.0

Table 5-14 Respondent's location

Table 5-15 presents the gender category information. Most of the respondents (59.1%) were male. For the rest of the respondents, 38.1% were female, 2.2% preferred not to reveal their gender, and 0.6% selected other gender.

	China		**UK**	
	Frequency	%	Frequency	%
Male	302	46	299	59.1
Female	347	52.9	193	38.1
Prefer not to say	7	1.1	11	2.2
Other	0	0	3	0.6
Total	656	100	506	100

Table 5-15 Respondent's gender

The below Table 5-16 presents the age category information. Most of the respondents (69.1%) were aged 18-34. Among the rest of the respondents, 8.8% were aged 35-44, 6.1% were aged 45-54, 2.2% were aged 55-64, 1.5% were at 65+, and 12.4% preferred not to reveal their age.

	China		UK	
	Frequency	%	Frequency	%
18-25	204	31.1	216	42.7
26-34	296	45.1	87	17.2
35-44	71	10.8	31	6.1
45-54	53	8.1	18	3.6
55-64	14	2.1	11	2.2
65+	13	2.0	4	0.8
Prefer not to say	5	0.8	139	27.5
Total	656	100.0	506	100.0

Table 5-16 Respondent's age

Table 5-17 presents the education category information. A majority (68.8%) of the respondents has a higher education qualification, which consists of people with a bachelor's degree (36.8%), a master's degree (23%), and a doctorate degree (8.9%). The rest 31.3% does not have a higher education qualification.

	China		UK	
	Frequency	%	Frequency	%
Less than high school	37	5.6	8	1.6
High school or equivalent (e.g., GED)	59	9.0	28	5.5
Professional Qualification/Certification	6	0.9	4	0.8
College	110	16.8	111	21.9
Bachelor's degree (e.g., BA, BS)	262	39.9	166	32.8
Master's degree (e.g., MA, MS, MEd)	159	24.2	109	21.5
Doctorate (e.g., PhD, EdD)	23	3.5	80	15.8
Total	656	100.0	506	100.0

Table 5-17 Respondent's education

Table 5-18 presents the employment status of the respondents. A majority of the respondents were employed full time (53%), student (19.6%) and self-employed (15.1%). The rest 12.3%, were employed part-time (3.4%), unemployed (5.5%), retired (4.7%) and unable to work (0.3%).

	China		UK	
	Frequency	%	Frequency	%
Employed full time	414	63.1	203	40.1
Employed part-time	6	0.9	34	6.7
Unemployed and currently looking for work	14	2.1	10	2.0
Unemployed and not currently looking for work	15	2.3	3	0.6
Self-employed	73	11.1	103	20.4
Student	110	16.8	118	23.3
Retired	24	3.7	31	6.1
Unable to work	0	0	4	0.8
Total	656	100.0	506	100.0

Table 5-18 Respondent's employment status

Table 5-19 presents the occupation field of the respondents.

	China		UK	
	Frequency	%	Frequency	%
Student	93	14.2	196	38.7
Public sector	49	7.5	22	4.3
Private sector	44	6.7	42	8.3
Agriculture, forestry & fishing mining, energy and water supply	19	2.9	3	0.6
Manufacturing	49	7.5	21	4.2
Construction	29	4.4	20	4.0
Wholesale, retail & repair of motor vehicles	16	2.4	3	0.6
Transport & logistics	10	1.5	14	2.8
Accommodation & food services	8	1.2	5	1.0

Information & communication, financial & insurance activities	71	10.8	30	5.9
Real estate activities professional, scientific & technical activities	11	1.7	11	2.2
Administrative & support services	27	4.1	17	3.4
Public admin & defence; social security	15	2.3	2	0.4
Education	113	17.2	78	15.4
Human health & social work activities	22	3.4	4	0.8
Other	80	12.2	38	7.5
Total	656	100.0	506	100

Table 5-19 Respondent's occupation field

Table 5-20 presents the respondents' means of travel to work. Out of all respondents 36.5% drive to work, 21% use public transport, 20.7% by foot, 4.8% use shared vehicles, 13% cycle, 2.2% by taxi, less than 2% use motorbike and other means of transport.

	China		**UK**	
	Frequency	%	Frequency	%
Walking	100	15.2	141	27.9
Cycling	110	16.8	40	7.9
Car / Van (driving)	267	40.7	157	31.0
Car / Van (as a passenger)	40	6.1	16	3.2
Taxi/Uber	19	2.9	7	1.4
Bus	56	8.5	68	13.4
Train	4	0.6	41	8.1
Motorbike	3	0.5	4	0.8
Underground / Metro	47	7.2	28	5.5
Other	10	1.5	4	0.8
Total	656	100.0	506	100.0

Table 5-20 Respondents' means of travel to work

Table 5-21 presents the data on driving license holding of the respondents. Most of the respondents (82.7%) hold a driving license, 17.3% of the respondents do not possess a driving license.

	China		UK	
	Frequency	%	Frequency	%
Yes	558	85.1	403	79.6
No	98	14.9	103	20.4
Total	656	100.0	506	100.0

Table 5-21 Data on driving licence holding

The collected data about the respondent's profile information allows to understand the impact of socio-demographic characteristics on the following data collection process, for instance, one of the research questions is looking at how gender influence the attitudes towards CAVs differently between male and female. Moreover, it was found in the literature that people's attitudes and decision-making are hugely influenced by their socio-demographical characteristics (Simsekoglu & Klöckner, 2019).

5.3.3 Exploratory factor analysis (EFA) results

The traditional factor analysis refers to exploratory factor analysis (EFA). In the SEM context, EFA is always conducted as a primary analysis for building the fundamental logic and structure of the model (Hoyle, 2012). Although EFA does not belong to the SEM family it analyses models in an unrestricted method (Kline, 2015). It is still considered an essential step because EFA would give the researcher a cleaner structural and potential latent variable to be used in a plausible model (Costello and Osborne, 2005). Moreover, EFA is more recommended to the researcher when a theoretical model is not yet established (Jöreskog, 1969).

The Kaiser-Mayer-Olkin (KMO) criterion for 0.825, and the Bartlett's test was $p = 0.000$ (Table 5-22). The latent factor was chosen based on eigenvalue greater than 0.9. In the end, seven factors were identified by using 27 items. Factor loading, as shown in Table 5-24, indicate the relationships between the observed variables and the latent factors (Schumacker and Lomax, 2004).

KMO Measure of Sampling Adequacy.		.825
Bartlett's Test of Sphericity	Approx. χ^2	14313.751
	df	351

	Sig.	.000

Table 5-22 EFA, KMO and Bartlett's Test

KMO test is one of the indicators about the adequacy of each variable in the EFA model. The KMO test allows to ensure that the variables that have been chosen for the model are suitable to run the factor analysis. The interpretation of KMO is straightforward, the closer to 0 means that there are widespread correlations (large partial correlations) in comparison to the total correlations. In other words, there is a small proportion of variance in the chosen variables that are caused by underlying factors, whereby the variable the author has set out cannot fully measure the intended concept. Therefore, as a rule of thumb, the KMO value closer to 1, the better. Table 5-23 shows Kaiser (1970)'s evaluation of KMO value. Our KMO value 0.825 showed meritorious adequacy for factor analysis.

0.00 to 0.49	Unacceptable
0.50 to 0.59	Miserable
0.60 to 0.69	Mediocre
0.70 to 0.79	Middling
0.80 to 0.89	Meritorious
0.90 to 1.00	Marvelous

Table 5-23 Kaiser (1970)'s KMO index evaluation

Bartlett's test of sphericity checks if the correlation matrix (or Pearson's R) is the identity matrix. If the result is significant ($p < 0.05$), it means that the correlation matrix is different from the identity matrix. In other words, chosen variables are related to each other to an adequate level to run a meaningful EFA. The Bartlett's test was significant $p = 0.000$, therefore it indicates that the chosen variable is usable for the EFA.

	SE	PR	IOU	ATU	PU	FC	PEOU
SE_3	0.904						
SE_4	0.889						
SE_2	0.803						
SE_1	0.767						
PR_3		0.915					
PR_4		0.898					
PR_2		0.721					
PR_1		0.668					
IOU_3			0.893				
IOU_2			0.796				
IOU_4			0.760				
IOU_1			0.707				
ATU_3				0.946			
ATU_2				0.889			
ATU_4				0.707			
ATU_1				0.559			
PU_1					0.813		
PU_3					0.796		
PU_4					0.772		
PU_2					0.768		
FC_2						0.883	
FC_3						0.881	
FC_1						0.712	
PEOU_1							0.767
PEOU_3							0.731
PEOU_2							0.680

Table 5-24 EFA, factor loadings

Rotation is often an essential step for factor analysis as it gives a clearer differentiation between factors and it also aids in providing the explanation. The rotation method used is the Promax (oblique) with Kaiser Normalization (Rotation converged in 6 iterations) as this study has a large dataset.

These seven factors explained 66.6% of the total variance as shown in Table 5-25. Each factor that was extracted from the sample explains a percentage of the total variance explained which is the percentage sum of variances. If the cumulated percentage is low that would mean that the factors would not be worthy to be included into the model.

Seven factors explained 66% of the variance which is valid as it is over the 60 percent cut off suggested by Hair et al. (1998).

	Total	**% of Variance**	**Cumulative %**
1	5.316	20.448	20.448
2	3.97	15.269	35.717
3	2.379	9.151	44.868
4	1.926	7.409	52.277
5	1.58	6.078	58.356
6	1.215	4.673	63.029
7	0.926	3.562	66.591

Table 5-25 EFA, total variance explained

Each item's communality (or common variance) is shown in Table 5-26. This indicates the amount of variance shared with other variables. The general cut off is > 0.4 irrespective of sample size as suggested by Stevens (2012). The average communality of the present sample is 0.66, which is excellent considering the large sample size.

	Initial	**Extraction**
	Initial	Extraction
ATU_1	1	0.524
ATU_2	1	0.79
ATU_3	1	0.799
ATU_4	1	0.533

PU_1	1	0.57
PU_2	1	0.607
PU_3	1	0.701
PU_4	1	0.652
PEOU_1	1	0.586
PEOU_2	1	0.524
PEOU_3	1	0.635
PR_1	1	0.551
PR_2	1	0.674
PR_3	1	0.774
PR_4	1	0.786
IOU_1	1	0.617
IOU_2	1	0.658
IOU_3	1	0.731
IOU_4	1	0.602
FC_1	1	0.497
FC_2	1	0.798
FC_3	1	0.791
SE_1	1	0.7
SE_2	1	0.623
SE_3	1	0.808
SE_4	1	0.782

Table 5-26 EFA, communalities

5.3.3.1 Convergent validity and discriminant validity

Campbell and Fiske (1959) had proposed convergent validity and discriminant validity to assess the construct validity of a model. These two tests aim to check whether the proposed measures are truly consistent with the measures in theory. These two steps of validity tests are necessary for excellent construct validity.

Convergent validity is defined as the degree of confidence the researcher have that a factor is well measured by its items implying that the variables within the single factor are highly correlated. Factor loadings are evidence for convergent validity. In general, the bigger the sample size, the lower the required loading. Since the factor loadings of the study are fairly high even at a large sample size, the structure showed an excellent construct validity.

Discriminant validity refers to a degree to which different factors are unrelated to each other. One common method to examine discriminant validity is the factor correlation matrix denoting that the correlation between factors should be less than 0.7. As shown in Table 5-27, the off-diagonal values in the factor correlation matrix are low, thus our factors extraction are distinct and uncorrelated.

Factor	SE	PR	IOU	ATU	PU	FC	PEOU
SE	1	-0.088	0.287	0.187	0.284	-0.068	-0.007
PR	-0.088	1	-0.307	0.038	-0.154	0.133	0.461
IOU	0.287	-0.307	1	0.214	0.38	-0.089	-0.124
ATU	0.187	0.038	0.214	1	0.475	0.166	0.268
PU	0.284	-0.154	0.38	0.475	1	-0.035	0.022
FC	-0.068	0.133	-0.089	0.166	-0.035	1	0.107
PEOU	-0.007	0.461	-0.124	0.268	0.022	0.107	1

Table 5-27 EFA, factor correlation matrix

5.3.3.2 Reliability: Cronbach’s α

Cronbach’s alpha, or coefficient alpha is a reliability measure named after its developer Lee Cronbach (1951). In theory, reliability measures single factor’s internal consistency and the acceptable values of Cronbach’s α is above 0.7 and lower than 0.9 (Streiner, 2003). If one factor has fewer items, the Cronbach’s α is reduced (Nunnally, 1994). In contrast, if the alpha value is over 0.9, there might be redundancy in items. As shown in Table 5-28, six of our extracted factors have a Cronbach’s α above 0.7 and factor seven slightly under 0.7 due to low item number (3 items included).

Factor	Cronbach's Alpha
SE	0.87
PR	0.84
IOU	0.81
ATU	0.82
PU	0.80
FC	0.77
PEOU	0.62

Table 5-28 EFA, Cronbach's α

5.3.4 Confirmatory factor analysis (CFA) results

In exploratory factor analysis (EFA), a theoretical model was found that fits the present dataset. Once the initial model is setup, confirmatory factor analysis (CFA) will determine the factor structure of our dataset. The model extracted from EFA was used to measure the model fit and validity as the primary rationale for CFA to further confirm the validity of the hypothesized model (Schumacker and Lomax, 2004).

5.3.4.1 CFA measurement model

As can be shown in Figure 5-5, a seven-factor model was specified with 26 indicator variables. The author has appropriately modified the model by covaried error terms within the same factor (e.g., $\varepsilon 1 \Leftrightarrow \varepsilon 4$, $\varepsilon 2 \Leftrightarrow \varepsilon 3$,$\varepsilon 7 \Leftrightarrow \varepsilon 8$, $\varepsilon 9 \Leftrightarrow \varepsilon 11$, $\varepsilon 14 \Leftrightarrow \varepsilon 15$)[16]. The CFA was conducted from the sample of 1162 participants. The latent factors are presented by the ellipses, the observed variables are presented by the rectangles, and the estimated measurement error of each item are presented by small circles. The single headed arrow indicates the relationship between the latent factors and observed variables. The double headed arrow that links the measurement errors together means that two errors are correlated. The errors might be caused by two reasons: (a) the variables are both part of the same global instruments, or (b) the same measure is being duplicated. The author revisited the items that got error terms correlated to other variable's error term and determined reason (a) as what caused the error correlation in our model. For instance, PR_4 and PR_1 is both related to cyber security risk which belongs to the latent factor Perceived Risk.

For the hypothesized CFA model (Figure 5-5 and Figure 5-6), each observed variable is hypothesized to measure only one single factor, the latent factors are believed not to be correlated, and some of the measurement error variance within one single factor can be

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[16] ε representing the measurement residuals.

correlated. In terms of the variable names from Figure 5-6, the measurement equations are as follows:

$Cybersecurity\ =\ Perceived\ Risk\ +\ \varepsilon 1$
$Privacy\ =\ Perceived\ Risk\ +\ \varepsilon 2$
$Hacking\ =\ Perceived\ Risk\ +\ \varepsilon 3$
$Tracking\ =\ Perceived\ Risk\ +\ \varepsilon 4$
$Privacy\ Awareness\ = Self - efficacy\ +\ \varepsilon 5$
$Cybersecurity\ Awareness = Self - efficacy\ +\ \varepsilon 6$
$CAV\ advantages\ Awareness = Self - efficacy\ +\ \varepsilon 7$
$CAV\ disadvantages\ Awareness = Self - efficacy\ +\ \varepsilon 8$
$Use\ responsibly\ =\ Intention\ to\ Use\ +\ \varepsilon 9$
$Upskill\ and\ Use =\ Intention\ to\ Use\ +\ \varepsilon 10$
$Workshop\ and\ Trial =\ Intention\ to\ Use\ +\ \varepsilon 11$
$Use\ with\ Licence =\ Intention\ to\ Use\ +\ \varepsilon 12$
$Eco - friendly\ =\ Attitude\ towards\ Usage\ +\ \varepsilon 13$
$Safe =\ Attitude\ towards\ Usage\ +\ \varepsilon 14$
$Cheap =\ Attitude\ towards\ Usage\ +\ \varepsilon 15$
$Replace\ Car =\ Attitude\ towards\ Usage\ +\ \varepsilon 16$
$Hands\ off\ =\ Perceived\ Usefulness\ +\ \varepsilon 17$
$Time\ Efficent =\ Perceived\ Usefulness\ +\ \varepsilon 18$
$Traffic\ Improve =\ Perceived\ Usefulness\ +\ \varepsilon 19$
$Parking\ =\ Perceived\ Usefulness\ +\ \varepsilon 20$
$MSP =\ Facilitating\ Condition\ +\ \varepsilon 21$
$Manufacturer =\ Facilitating\ Condition\ +\ \varepsilon 22$
$Data\ Ownership =\ Facilitating\ Condition\ +\ \varepsilon 23$
$Easy\ operation =\ Perceivd\ Ease - of - Use\ +\ \varepsilon 24$
$Edge\ Cases =\ Perceivd\ Ease - of - Use\ +\ \varepsilon 25$
$Licence =\ Perceivd\ Ease - of - Use\ +\ \varepsilon 26$

To conclude, EFA was conducted to explore whether the cluster of the questionnaire items was assigned to the proposed factor. The EFA results indicate that the seven underlying factors were supported. These factors are *perceived risks, facilitating conditions, self-efficacy, perceived usefulness, perceived ease of use, attitude towards using* and *intention to use*.

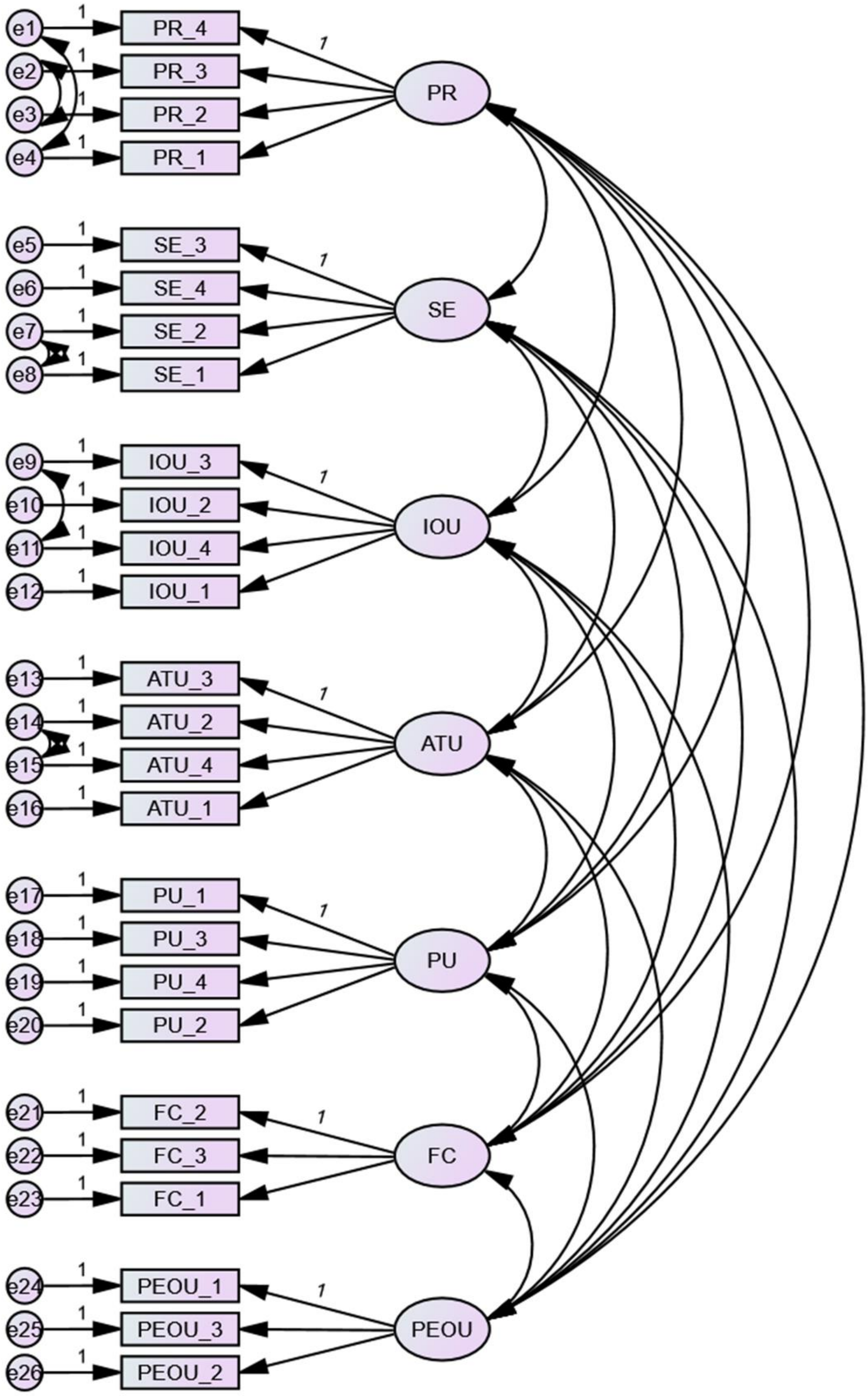

Figure 5-5 Hypothesised CFA model derived from EFA

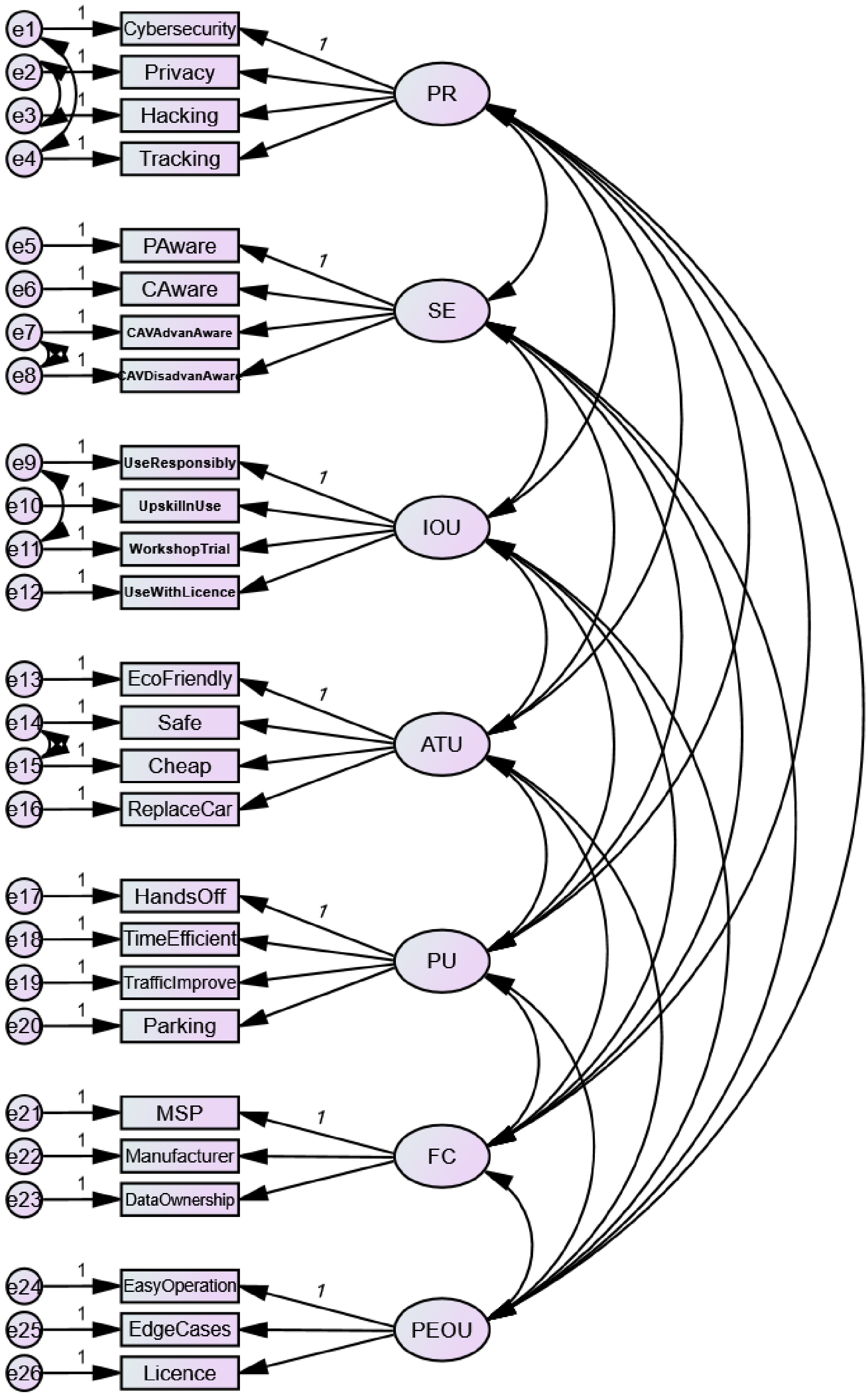

Figure 5-6 Hypothesised CFA model derived from EFA with item label

5.3.4.2 CFA model fit

The proposed CFA model was introduced in the section 5.3.4.1 using diagrams where factors and items are named by the abbreviation of the variable. This selection presents the CFA model fit. There are some commonly reported fit statistic criteria that are listed in the Table 5-29.

These criteria are based on the relationships between the observed variables and model-implied variance-covariance matrices (Schumacker and Lomax, 2004). Reported in the Table 5-30, in the model analysis, the author chose the maximum likelihood chi-square estimation method which is also the default method in AMOS. As reported in Table 5-30, factor loadings, latent variable correlation and some selected fit indices are presented. In the CFA model, a χ^2 of 998 with 273 degree of freedom is significant as χ^2 is inflated due to large sample size, so this information was ignored since it was considered of with limited value. Therefore, RMSEA is used as the main measure of model fit (suggested by Blunch (2012)). GFI=0.94, this means 94% of items is predicted by the reproduced variance-covariance matrices. The CFI = 0.95, SRMR = 0.072, RMSEA = 0.048, PCLOSE = 0.87 which is deemed an acceptably good fit.

Measure	Name	Description	Cut-off for good fit
χ2/*df* (CMIN/*df*)	Model Chi-Square/Degree of freedom	CMIN/*df* is a statistic directly testing the similarity between the sample covariance matrix and the estimated variance matrix (Li, Huang, and Feng, 2020).	the closer the value is to 1, the better the model fitting is; <3 good; < 5 sometimes permissible
***p* value**	p value for the model		> 0.05
CFI	Bentler Comparative Fit Index	The Bentler CFI is an incremental fit index that is also a goodness-of-fit statistic (Bentler, 1990).	CFI > 0.95 great; > 0.90 traditional; > 0.80 sometime permissible
GFI	Goodness-of-fit index	GFI is the proportion of variance accounted for by the estimated population covariance. Analogous to R^2. GFI favours parsimony.	GFI ≥ 0.95 AGFI ≥0.90
RMSEA	Root Mean Square Error of Approximation	A parsimony-adjusted index. Values closer to 0 represent a good fit.	RMSEA < 0.05 good; 0.05-0.1 moderate; >0.1 bad
SRMR	Standardized Root Mean Square Residual	The square-root of the difference between the residuals of the sample covariance matrix and the hypothesized model. If items vary in range (i.e., some items are 1-5, others 1-7) then RMR is hard to interpret, better to use SRMR.	SRMR < 0.08
AVE	Average Value Explained	The average of the R^2s for items within a factor.	AVE > 0.5

Table 5-29 CFA model fit criteria

	λ	Measurement error variances:	Correlation of independent variables:	
PR_4	1.00	0.37	PR, SE	-0.086
PR_3	1.10	0.42	PR, IOU	-0.277
PR_2	0.99	0.59	PR, ATU	0.074
PR_1	0.82	0.94	PR, PU	-0.122
SE_3	1.00	0.19	PR, FC	0.1
SE_4	0.96	0.30	PR, PEOU	0.44
SE_2	0.59	0.92	SE, IOU	0.238
SE_1	0.70	0.87	SE, ATU	0.195
IOU_3	1.00	0.69	SE, PU	0.246
IOU_2	1.06	0.36	SE, FC	-0.053
IOU_4	0.87	0.98	SE, PEOU	-0.084
IOU_1	1.05	0.42	IOU, ATU	0.181
ATU_3	1.00	0.50	IOU, PU	0.251
ATU_2	1.13	0.25	IOU, FC	-0.048
ATU_4	0.79	0.87	IOU, PEOU	-0.154
ATU_1	0.66	0.88	ATU, PU	0.39
PU_1	1.00	0.94	ATU, FC	0.144
PU_3	1.26	0.44	ATU, PEOU	0.216
PU_4	1.16	0.62	PU, FC	-0.013
PU_2	1.12	0.70	PU, PEOU	-0.038
FC_2	1.00	0.12	FC, PEOU	0.087
FC_3	0.99	0.16		
FC_1	0.56	0.43		
PEOU_1	1.00	1.21		
PEOU_3	1.16	0.67		
PEOU_2	1.07	1.13		

Selected fit Indices:	
χ2	998
df	273
χ2/*df*	3.65
p	0.00
RMSEA	0.048
CFI	0.95
GFI	0.94
SRMR	0.072
PCLOSE	0.87

Table 5-30 CFA, Standardised estimates and selected fit indices

5.3.4.3 CFA model validity and reliability

For CFA models, precise tests of convergent validity and discriminant validity are required. Raykov (2004) and Hancock and Mueller (2013) had proved that coefficients H (maximal reliability H) is the indicator of the CFA reliability, and it is believed that the reflective measurements are generally better than Cronbach's α. The construct validity and reliability can be measured using composite reliability (CR), average variance extracted (AVE), maximum shared squared variance (MSV) and average shared variance (ASV). Described in the Table 5-31 are empirical checks when exam CFA model construct validity.

CR	> 0.6
AVE	> 0.5
MSV	< AVE
MaxR(H) (maximum reliability)	> CR

Table 5-31 Convergent validity and discriminant validity cut-off

Based on the results presented in Table 5-32, the 7-factor CFA model, the CR ranges from 0.7 to 0.9 while the AVE ranges from 0.4 to 0.7. The diagonal values (in bold) ranges from 0.61 to 0.78 which is higher than most AVE values. PEOU appears having a low AVE value, however, AVE of 0.4 is acceptable if the CR is higher than 0.6, as suggested by Fornell and Larcker (1981). These results show that the CFA model has adequate convergent validity and discriminant validity.

	PR	**SE**	**IOU**	**ATU**	**PU**	**FC**	**PEOU**
CR	0.	0.9	0.8	0.9	0.8	0.8	0.7
AVE	0.	0.7	0.6	0.6	0.6	0.6	0.4
MSV	0.	0.1	0.3	0.3	0.3	0	0.5
MaxR	0.	0.9	0.85	0.94	0.85	0.91	0.66
PR	**0.**	-	-	0.08*	-	0.16*	0.66*
SE		**0.7**	0.28*	0.16*	0.29*	-	-
IOU			**0.7**	0.24*	0.47*	-	-
ATU				**0.76**	0.52*	0.21*	0.30*
PU					**0.71**	-	-
FC						**0.76**	0.19*

PEOU	**0.61**

Significance of Correlations: † *p* < 0.100, * *p* < 0.050, ** *p* < 0.010, * *p* < 0.001**

Table 5-32 CFA, model validity measures

5.3.4.4 CFA measurement invariance

A measurement invariance test aims to make sure the consistency of the measurement across different groups. For example, does perceived risk imply the same thing to China's residents and UK residents? Only if the measurement invariance is established, findings between Chinese residents and UK residents can be unambiguous and trustworthy.

To achieve measurement invariance, there are three levels of measurements needed namely: (1) configural invariance; (2) metric invariance; and (3) scalar invariance. Vandenberg and Lance (2000) had reported that too many publications failed to evaluate all three aspects of measurement invariance which could introduce measurement bias. A constrained baseline approach was selected as it is easy to conduct using AMOS.

The least restrictive level of measurement is configural invariance. It aims to test whether the CFA model still fits when the whole dataset splits into different groups. Metric invariance is also known as pattern invariance or weak invariance and it is tested in a similar way as configural invariance. Scalar invariance is also known as strong invariance or strict invariance that is the highest level of measurement invariance which assumes metric invariance. Instead of placing factor constrain on the variance, scalar invariance places invariance constraints on the measurement intercepts. If scalar invariance holds across for all the group, it means that there is controllable ambiguity in the explanation of group differences in means.

5.3.4.4.1 CFA measurement invariance: China and UK group

Firstly, the dataset was divided into hypothesized group, Chinese residents and UK residents. Then an initial CFA model ran again on each group. Finally, check to see if the resultant model fit holds. Table 5-33 gives the sample correlations for the China and UK groups which indicate the correlations between the factor ATU and SE, PU and SE, FC and ATU tend to be higher among the China-based sample, whereas FC and IOU, PEOU and SE, PEOU and FC tend to be higher among the UK sample. Table 5-34 gives the model fit results; it shows that the model achieved has configural invariance.

Correlations for the China resident (n = 656)							
	PR	SE	IOU	ATU	PU	FC	PEOU
PR	1.00	-0.02	-0.42	0.08	-0.17	0.12	0.69
SE		1.00	0.32	0.32	0.34	0.22	-0.02
IOU			1.00	0.25	0.49	-0.05	-0.29
ATU				1.00	0.53	0.20	0.29
PU					1.00	0.10	-0.04
FC						1.00	0.12
PEOU							1.00
Correlations for the China resident (n = 506)							
	PR	SE	IOU	ATU	PU	FC	PEOU
PR	1.00	-0.10	-0.35	-0.01	-0.16	0.16	0.61
SE		1.00	0.20	0.00	0.19	-0.30	-0.21
IOU			1.00	0.27	0.44	-0.15	-0.33
ATU				1.00	0.60	0.09	0.30
PU					1.00	-0.10	-0.11
FC						1.00	0.32
PEOU							1.00

Table 5-33 Descriptive statistics for the China and UK samples

Measure	**CMIN**	***df***	**CMIN/*df***	***df***	**SRMR**	**RMSEA**	**PClose**
Estimate	1420.48	546	2.602	0.94	0.056	0.037	1
Threshold	--	--	Between 1-3	>0.95	<0.08	<0.06	>0.05
Interpretation	--	--	Excellent	Acceptable	Excellent	Excellent	Excellent

Table 5-34 CFA, model fit measures for the China-UK invariance group

For the metric invariance test, the factor constraint of 1 was imposed on the first item of each factor. Then the χ^2 difference test was compared between the unconstrained and constrained models. As shown in Table 5-35, the change in χ^2 is non-significant (*p* = 0.401), thus, the model that specifies metric invariance is retained.

	χ2	***df***	***p*-value**
Unconstrained model	1373.697	546	

Fully constrained model	1389.412	561	
Number of groups		2	
Δ	15.715	15	0.401

Table 5-35 CFA, metric invariance statistics for the China and UK samples

Finally, the scalar invariance hypothesis was tested. The error variance was restrained for each of the indicators to 1.0 across the groups to access scalar invariance. As reported in Table 5-36, the hypothesis is rejected with *p* = 0.000. Failure on scalar invariance indicates of potential measurement bias, which make logical sense in our model given that the author spit the dataset by country and cultural norms. Further, developmental differences play a big role in survey participants' understanding on the same survey question.

Model	**χ2**	**CMIN**	***P***	**NFI**	**IFI**	**RFI**	**TLI**
				D1	D2	r1	r2
Measureme nt intercepts	26	141.4 55	0.0 00	0.0 09	0.0 1	0.0 05	0.0 06

Table 5-36 CFA, model comparison assuming model unconstrained to be correct (China and UK samples)

5.3.4.4.2 CFA measurement invariance: UK gender group

The UK dataset was then split into two groups, male and female. This step aims to check measurement invariance in the UK gender group. A three step measurement invariance test was repeated and found that the UK gender group met configural and metric invariance, but rejected the scalar invariance (shown in Table 5-37, Table 5-38, Table 5-39, and Table 5-40).

Correlations for the Male UK resident (n = 299)							
	PR	SE	IOU	ATU	PU	FC	PEOU
PR	1	-0.059	-0.349	-0.009	-0.127	0.125	0.679
SE		1	0.221	0	0.132	-0.271	-0.178
IOU			1	0.329	0.46	-0.056	-0.382
ATU				1	0.584	0.084	0.273
PU					1	-0.057	-0.044
FC						1	0.276
PEOU							1
Correlations for the Female UK resident (n = 193)							
	PR	SE	IOU	ATU	PU	FC	PEOU

PR	1	-0.122	-0.222	0.039	-0.118	0.119	0.471
SE		1	0.075	-0.046	0.203	-0.348	-0.303
IOU			1	0.155	0.294	-0.125	0.021
ATU				1	0.626	0.087	0.386
PU					1	-0.104	-0.094
FC						1	0.235
PEOU							1

Table 5-37 Descriptive statistics for the UK gender groups

Measure	**CMIN**	***df***	**CMIN/*df***	**CFI**	**SRMR**	**RMSEA**	**PClose**
Estimate	1006.13	546	1.84	0.90	0.06	0.04	1
Threshold	--	--	Between 1-3	>0.95	<0.08	<0.06	>0.05
Interpretation	--	--	Excellent	Acceptable	Excellent	Excellent	Excellent

Table 5-38 Model fit measures for the UK gender invariance group

	χ2	***df***	***p*-value**
Unconstrained model	1006.12	546	
Fully constrained model	1039.45	572	
Number of groups		2	
Δ	33.315	26	0.153

Table 5-39 CFA, metric invariance statistics for the UK gender group

Model	**χ2**	**CMIN**	***P***
Measurement intercepts	26	57.514	0.000

Table 5-40 CFA, model comparison assuming model unconstrained to be correct (UK gender group)

5.3.4.4.3 CFA measurement invariance: China's gender group

After testing the gender group measurement invariance, the same test was repeated on China's gender group and found the same results as shown in Table 5-41, Table 5-42, Table 5-43 and Table 5-44.

Correlations for the Male China resident (n = 302)

	PR	SE	IOU	ATU	PU	FC	PEOU
PR	1	-0.047	-0.375	0.107	-0.16	0.054	0.636
SE		1	0.377	0.345	0.365	0.259	-0.033
IOU			1	0.193	0.477	0.008	-0.159
ATU				1	0.529	0.24	0.34

PU					1	0.151	0.011
FC						1	0.029
PEOU							1
Correlations for the Female China resident (n = 347)							
	PR	SE	IOU	ATU	PU	FC	PEOU
PR	1	0.017	-0.442	0.08	-0.159	0.183	0.737
SE		1	0.251	0.295	0.292	0.188	-0.003
IOU			1	0.289	0.463	-0.136	-0.38
ATU				1	0.509	0.135	0.27
PU					1	0.037	-0.076
FC						1	0.226
PEOU							1

Table 5-41 Descriptive statistics for the China gender group

Measure	CMIN	*df*	CMIN/*df*	CFI	SRMR	RMSEA	PClose
Estimate	1142.18	546	2.09	0.90	0.07	0.04	1
Threshold	--	--	Between 1-3	>0.95	<0.08	<0.06	>0.05
Interpretation	--	--	Excellent	Acceptable	Excellent	Excellent	Excellent

Table 5-42 Model fit measures for the China gender invariance group

	χ2	*df*	*p*-value
Unconstrained model	1142.18	546	
Fully constrained model	1184.8	579	
Number of groups		2	
Δ	42.62	33	0.122

Table 5-43 CFA, metric invariance statistics for the China gender group

Model	χ2	CMIN	*P*
Measurement intercepts	26	60.461	0

Table 5-44 CFA, model comparison assuming model unconstrained to be correct (China gender group)

5.3.4.4.4 CFA measurement invariance: age group

Age group were also conducted. A strong measurement invariance was tested across two groups: Millennials and the Generation X group. It is widely believed that Millennials are the people who born from mid-1980s to early 2000s (Rauch, 2019). Generation X or Gen X are the people who born as early as 1960 to mid-1980s (or sometimes 1965 to 1980) (Bevan-Dye, 2017). Both two generations experienced web

1.0 and now live in the web 2.0 world. Generation X was not brought up with the internet and digital technologies but have learnt how to use them as grown-ups (Prensky, 2001). In contrast, millennials are “digital natives” as they have been raised in a digital world (Rauch, 2019).

Millennials tend to have different technology behaviour in comparison to Generation X. For instance, motivations on technology acceptance (Calvo-Porral and Pesqueira-Sanchez, 2019), engagement with the technology (Owens *et al.*, 2015), and attitudes towards new technology (Chivu-Draghia and Antoce, 2016; Lee *et al.*, 2017) vary from Gen X’s.

Respondents who are not older than 35 years have been grouped together as millennials, and respondents age 36 or older have been grouped into Gen X. The author went through all three steps of measuring invariance test, and found that configural invariance (Table 5-46) and metric invariance (Table 5-47) can be established, thus scalar invariance (Table 5-48) got rejected. It is worth mentioning here that a clearly different factor correlation profile was seen between millennials and Generation X from Table 5-45. This will be discussed later in the Chapter 6.

Correlations for the Millennials (n = 803)							
	PR	SE	IOU	ATU	PU	FC	PEOU
PR	1	-0.108	-0.44	0.055	-0.162	0.163	0.624
SE		1	0.231	0.078	0.241	-0.074	-0.178
IOU			1	0.213	0.468	-0.117	-0.298
ATU				1	0.462	0.219	0.328
PU					1	-0.079	-0.056
FC						1	0.199
PEOU							1
Correlations for the Gen X (n = 215)							
	PR	SE	IOU	ATU	PU	FC	PEOU
PR	1	-0.025	-0.327	0.173	-0.161	0.065	0.729
SE		1	0.469	0.366	0.458	-0.135	-0.054
IOU			1	0.359	0.554	-0.091	-0.251
ATU				1	0.628	0.093	0.233
PU					1	-0.014	-0.065
FC						1	0.136
PEOU							1

Table 5-45 Descriptive statistics for the age groups

Measure	CMIN	*df*	CMIN/*df*	CFI	SRMR	RMSEA	PClose
Estimate	1230.88	546	2.25	0.94	0.05	0.04	1
Threshold	--	--	Between 1-3	>0.95	<0.08	<0.06	>0.05
Interpretation	--	--	Excellent	Acceptable	Excellent	Excellent	Excellent

Table 5-46 Model fit measures for the age invariance group

	χ2	*df*	*p*-value
Unconstrained model	1230.879	546	
Fully constrained model	1316.765	672	
Number of groups		2	
Δ	85.886	126	0.998

Table 5-47 CFA, metric invariance statistics for the age group

Model	χ2	CMIN	*P*
Measurement intercepts	17	31.11	0.019

Table 5-48 CFA, model comparison assuming model unconstrained to be correct (Age group)

5.3.4.4.5 CFA Measurement Invariance: Δ CFI

Based on the measurement invariance results just presented, tests were performed on the aforementioned types of invariance groups, that are, (1) China-based resident and UK-based resident; (2) UK male and UK female (3) Chinese male and Chinese female; (4) Millennials and Generation X. All these groups have established configural invariance and metric invariance, but none of them fulfills the criteria of scalar invariance. The reason why measurement invariance is so important is that multi-group CFA is concerned with the measurement consistency; in other words, the author needed to make sure if the data across different groups reflected them understanding the same question in the same way, so that these could be measured concurrently. A constrained baseline approach was used as it is one of the most popular approaches in testing measurement invariance. However, it was found that Type I error normally gets inflated (Stark, Chernyshenko, and Drasgow, 2006), and it is better to use Bonferroni-corrected LR, CFI or RMSEA test in large sample (e.g., ≤0.01 for Δ CFI and ≤.015 for Δ RMSEA) (Kline, 2015). Cheung and Rensvold (2002) found that CFI was relatively unaffected by the number of items per factor, so for large sample it seems a better indicator for measurement invariance. Thus, given the above-mentioned reason that χ^2 test is strongly influenced by sample size, the author revisited the multi-groups, and checked their change in CFI and RMSEA for the previously rejected scalar invariance test. As Table 5-49 shows, Δ CFI and Δ RMSEA [17]were all fitted within acceptable threshold. In summary, no violation of measurement invariance assumption was found in the model sample and as such the author can confidently propose a multi-group model.

China vs. UK	**CFI**	**SRMEA**
Unconstrained	0.94	0.037
Constrained	0.932	0.039
Δ	0.008	0.002
UK male vs. UK female	CFI	SRMEA
Unconstrained	0.903	0.065
Constrained	0.901	0.066
Δ	0.002	0.001
China male vs. China female	CFI	SRMEA
Unconstrained	0.903	0.041
Constrained	0.907	0.041
Δ	0.004	0
Millennials vs. GenX	CFI	SRMEA
Unconstrained	0.943	0.035
Constrained	0.938	0.036
Δ	0.005	0.001

Table 5-49 CFI and RMSEA for measurement invariance test

5.3.5 Structural equation modelling (SEM) results

After CFA specified and confirmed the model, the author compared the direct, indirect, mediation effects among the latent factors. SPSS AMOS 26 was adopted for SEM. A hypothesized structural model is shown in Figure 5-7. This study employs a macro-micro approach to test the hypothesis. In the first analytical step, the causal effect between latent factors was examined. In the second step, country, age, and gender level differences on

[17] Δ is the absolute differences of the fit indices between unconstrained and constrained model.

causal links between individual factors were examined, in order to explore how above-mentioned dimensions' influence attitude formation.

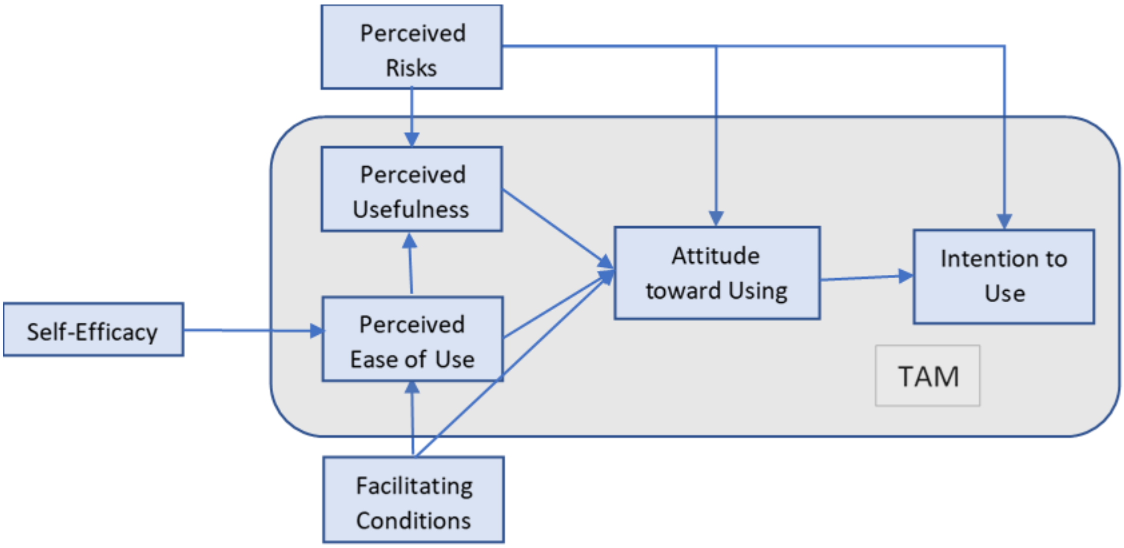

Figure 5-7 Proposed structural model of public attitude towards CAVs and direct effects assumption

5.3.5.1 Influential outliers test

A practice that was recommended by Aguinis, Gottfredson, and Joo (2013), presents the Cook’s D (gCD) plot as essential in the regard of influential outlier test. Therefore, the author ran cook's distance analysis to determine if any multivariate influential outliers existed. As shown in Figure 5-8, all respondents data were examined by their preassigned ID and got the plotting of cook’s distance. For the first test, IOU was used as dependent variable (DV), PR, ATU and PU as dependent variable. As a result, there was no case in which a cook's distance greater than 1 was observed. This means that there are no record responses has a big influence on the regression between IOU and PR, ATU PU. Similarly, a cook’s distance analysis was conducted on ATU as the dependent variable, PR, PU and PEOU as the independent variables. As shown in Figure 5-9, no influential outliers need to be cleared out.

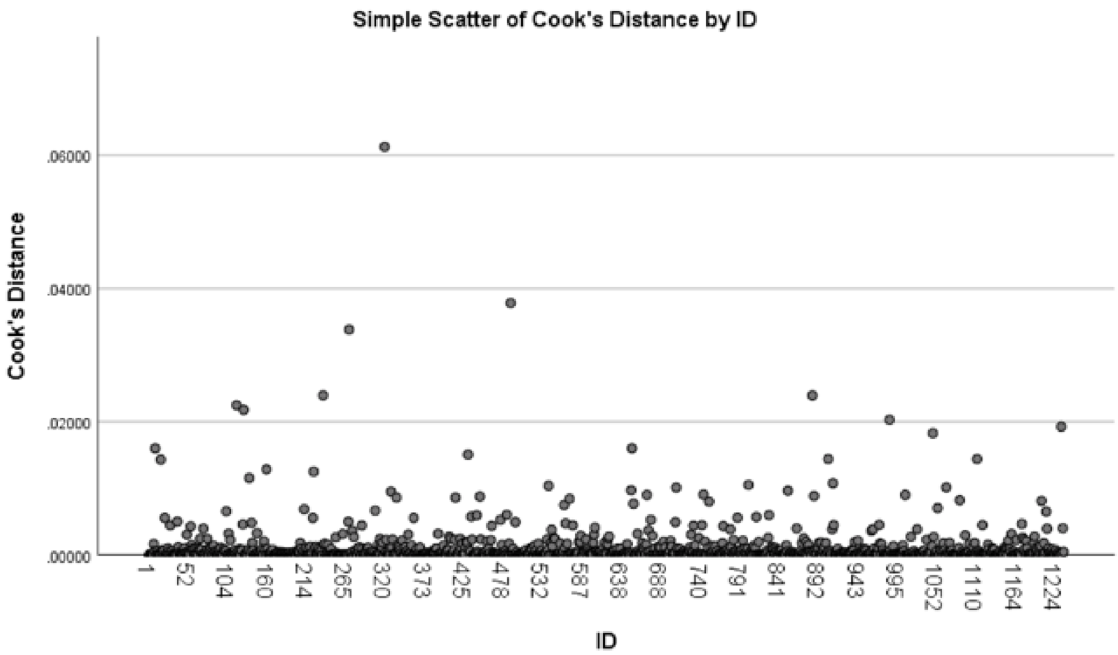

Figure 5-8 Cook’s distance analysis for multivariate influential outliers’ test: IOU as DV

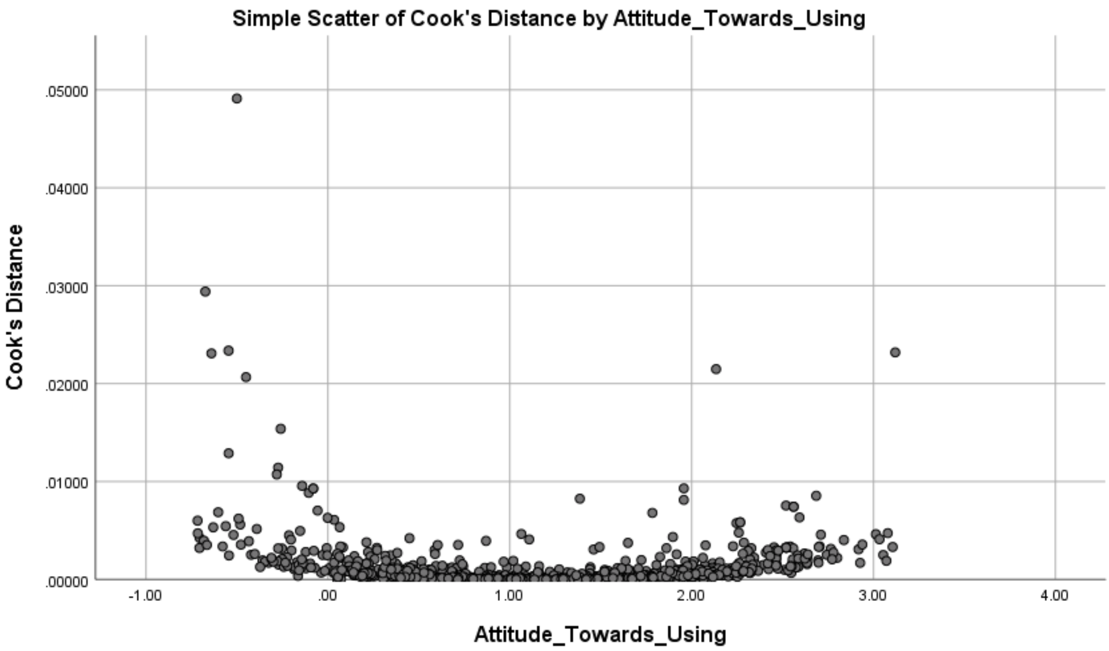

Figure 5-9 Cook's distance analysis for multivariate influential outliers' test: ATU as DV

5.3.5.2 Multicollinearity

The next step is to examine the multicollinearity. Violation of multicollinearity variables could inflate type II error rate as suggest by Grewal, Cote, and Baumgartner (2004) because two independent variables might measure the same contract. AMOS offers options to check variance inflation factors (VIFs) and tolerance values for the multicollinearity test. The author examined variable inflation for both predictors on the dependent variables: IOU and ATU (as shown in Table 5-50) as well as the observed variables. It is evident that all VIFs value are less than 10, and the values of tolerance are all greater than 0.1.

Coefficients[a]

	Tolerance	VIF
Model		
PR	0.35	2.859
PU	0.597	1.674
PEOU	0.223	4.487
ATU	0.75	1.334
SE	0.695	1.438
FC	0.796	1.257

a. Dependent Variable: IOU		
Coefficients[b]		
	Tolerance	VIF
Model		
PR	0.352	2.838
PU	0.652	1.534
PEOU	0.227	4.413
SE	0.709	1.411
FC	0.884	1.132
b. Dependent Variable: ATU		

Table 5-50 SEM, multicollinearity test

5.3.5.3 Causal model hypothesis: direct and indirect effect

As in all social and behavioural sciences, the vague nature of the causal research that are studies by the nature of the context (e.g., intelligence, preference, social status, attitude, literacy), there are no generally acceptable measuring instruments that exist (Blunch, 2012). Likewise, TAM was selected as the base model for describing public attitudes towards CAVs as it is a technology acceptance theory that has been mostly studied and examined. In order to adapt this general technology acceptance theory on CAV acceptance, the following hypothesis was proposed to verify the direct effects and the mediation effect within the model. In the end, a multi-group analysis was conducted.

As mentioned in Section 5.2.2, eight direct effect hypotheses were proposed (see Table 5-51). Figure 5-11 summarises the direct path coefficients and their significance levels. After the model construct (see Figure 5-10) was identified, three mediated effects were further proposed as presented in Table 5-52.

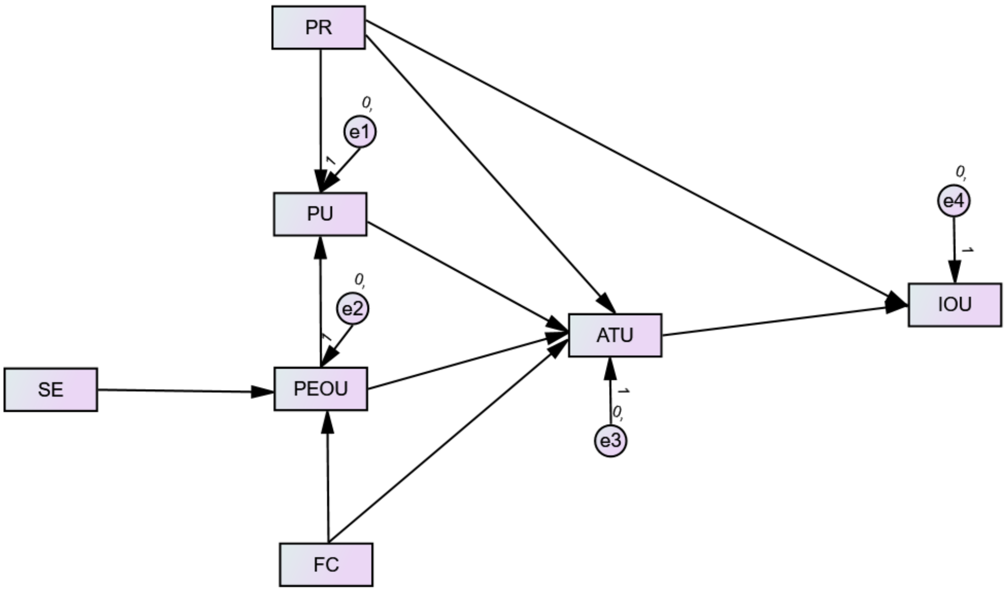

Figure 5-10 The structure model in AMOS

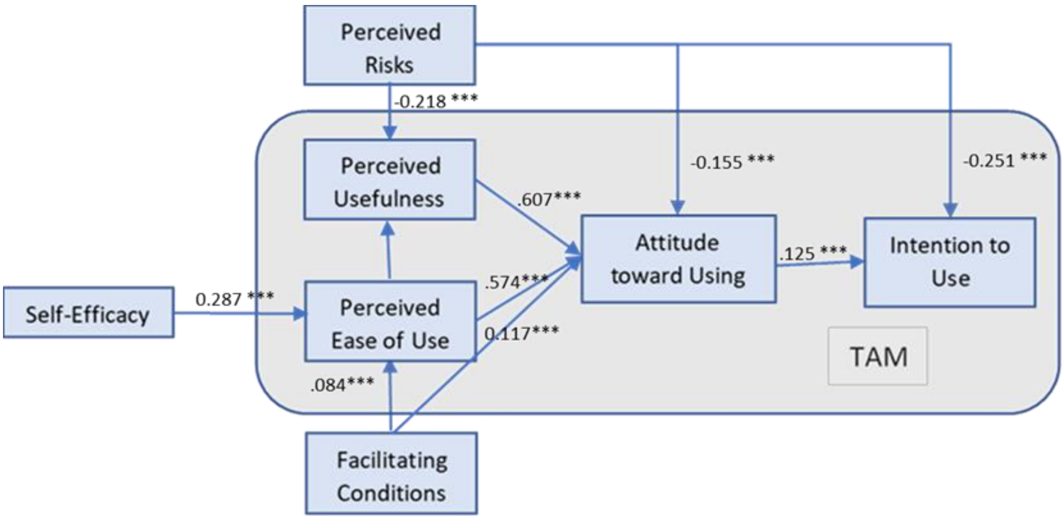

Figure 5-11 Results of the structural equation model

Hypothesis #	Direct effects
H1a	Perceived risk has a negative effect on perceived usefulness;
H1b	Perceived usefulness has a positive effect on attitude toward using;

H1c	Perceived risk has a negative effect on attitude toward using;
H1d	Perceived ease of use has a positive effect on attitude toward using;
H1e	Self-efficacy has a positive effect on perceived ease of use;
H1f	Facilitating condition has a positive effect on attitude toward using;
H1g	Facilitating condition has a positive effect on perceived ease of use;
H1h	Perceived risk has a negative effect on intention to use.

Table 5-51 SEM, hypothesises on direct effects

Hypothesis #	Mediated effects
H2a	Perceived ease of use mediates the positive relationship between self-efficacy and attitude toward using;
H2b	Attitude toward using mediates the negative relationship between perceived risk and intention to use;
H2c	Perceived usefulness mediates the negative relationship between perceived risk and attitude toward using;

Table 5-52 SEM, hypothesises on mediated effects

As can be shown in Table 5-53, all of the direct effects were supported, and two out of three mediated effects were supported.

Hypothesis #	Causal direct graphs	Expression	Path coefficient	Results
Direct effects				
H1a	$PR \overset{-}{\rightarrow} PU$	$PR \not\perp\!\!\!\perp$[18] PU	β = -0.218 ***	support
H1b	$PU \overset{+}{\rightarrow} ATU$	$PU \not\perp\!\!\!\perp ATU$	β = 0.607 ***	support
H1c	$PR \overset{-}{\rightarrow} ATU$	$PR \not\perp\!\!\!\perp ATU$	β = -0.155 ***	support
H1d	$PEOU \overset{+}{\rightarrow} ATU$	$PEOU \not\perp\!\!\!\perp ATU$	β = 0.574 ***	support
H1e	$SE \overset{+}{\rightarrow} PEOU$	$SE \not\perp\!\!\!\perp PEOU$	β = 0.287 ***	support
H1f	$FC \overset{+}{\rightarrow} ATU$	$FC \not\perp\!\!\!\perp ATU$	β = 0.117 ***	support
H1g	$FC \overset{+}{\rightarrow} PEOU$	$FC \not\perp\!\!\!\perp PEOU$	β = 0.084 **	support
H1h	$PR \overset{-}{\rightarrow} IOU$	$PR \not\perp\!\!\!\perp IOU$	β = -0.251 ***	support
Mediated Effects				
H2a	$SE \rightarrow PEOU \rightarrow ATU$	$SE \not\perp\!\!\!\perp ATU$	β = -0.017 *P*= 0.169	reject

[18] $\not\perp\!\!\!\perp$ means statistically dependent. In this expression, it means PR and PU are dependent to each other.

		$\mathrm{PR} \perp$ [19]$\mathrm{PU} \mid \mathrm{PEOU}$		
H2b	$\mathrm{PR} \rightarrow \mathrm{ATU} \rightarrow \mathrm{IOU}$	$\mathrm{PR} \not\perp \mathrm{IOU}$ $\mathrm{PR} \perp \mathrm{IOU} \mid \mathrm{ATU}$	β = -0.011 *P* = 0.026 *	support
H2c	$\mathrm{PR} \rightarrow \mathrm{PU} \rightarrow \mathrm{ATU}$	$\mathrm{PR} \not\perp \mathrm{ATU}$ $\mathrm{PR} \perp \mathrm{ATU} \mid \mathrm{PU}$	β = -0.132 *P* = 0.001***	support

Table 5-53 SEM, direct and mediated effect result summary

Perceived risk was found to have a significant negative effect on perceived usefulness (**β** = -0. 218 ***) [20], attitude towards using (**β** = -0.155 ***) and intention to use (**β** = -0.251 ***). Self-efficacy was found to have a significant positive effect on perceived ease to use (**β** = 0.287 ***). Furthermore, the author has also tested the conventional theory of TAM and perceived usefulness was found to have a significant positive effect on attitude toward using (**β** = 0.4 ***). Perceived ease of use has a significant positive effect on attitude toward using. These are consistent with the TAM model. In summary, the abovementioned findings yield strong evidence for confirming the direct hypotheses.

In terms of mediation effect, the bootstrapping technique was applied to test the indirect effect. Bootstrapping is famous for dealing with non-normal data and additionally, it becomes very handy on testing the significance of indirect and total effect (Hancock and Liu, 2012). The author has multiplied the paths that constitute the effect and observed its significance to determine whether the effects hold. As a result, H2a hypothesis was rejected due to insignificant *p*-value and other two hypothesizes were supported. The results indicate that perceived usefulness mediates the negative relationship on perceived risk to attitude toward using. For a descriptive record of the detailed upper and lower bound on the 90% confidence interval, see Appendix E.

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[19] ⊥ means statistically independent. In this expression, it means PR and PU are statistically independent. PEOU is the sole intervening variable between PR and PU, and deactivating PEOU blocks causal coordination between this pair of variables.

[20] β stands for beta weight. It represents the standardised partial regression coefficients. In path analysis, it is interpreted as standardised regression coefficients that control for correlated causes. Simply put, β means the causal paths between factors.

5.3.5.4 Causal model hypothesis: multigroup effect

For the CFA measurement invariance, four types of multigroup analysis were proposed, namely, the Chinese and the UK resident group, the UK gender group, the Chinese gender group, millennials and the GenX group. A multigroup analysis was put in a different session because the author not only needed to analyse the measurement model, but also analyse the causal model. Firstly, the causal model shown in Figure 5-10 was derived. Then the author divided this model by different groups and examined each groups' model measurement fit. In the end each model was tested with constrained regression weights which are assumed identical across two groups.

The models still hold after these were split into groups. The full sets of measurement fit results of these four groups can be found in Appendix F. Therefore, ten hypotheses are proposed, as shown in Table 5-54.

Hypothesis #	Multigroup effects for China resident and UK resident
H3a	The negative relationship between perceived risk and attitude toward using is stronger for the China resident than the UK resident;
H3b	The negative relationship between perceived risk and intention to use is stronger for the China resident than the UK resident;
Hypothesis #	**Multigroup effects for UK gender group**
H4a	The positive relationship between perceived ease to use and attitude toward using is stronger for females than males in the UK sample;
H4b	The negative relationship between perceived risk and attitude toward using is stronger for females than males in the UK sample;
Hypothesis #	**Multigroup effects for China gender group**
H5a	The negative relationship between perceived risk and attitude toward using is stronger for females than males in China sample;
H5b	The positive relationship between attitude toward using and intention to use is stronger for females than males in China sample;
Hypothesis #	**Multigroup effects for Millennials and GenX**
H6a	The positive relationship between perceived ease to use and attitude toward using is stronger for the millennials than generation X;
H6b	The negative relationship between perceived risk and attitude toward using is stronger for the millennials than generation X;

H6c	The positive relationship between self-efficacy and perceived ease to use is stronger for the millennials than generation X
H6d	The negative relationship between perceived risk and intention to use is stronger for the millennials than generation X

Table 5-54 SEM, hypothesises on multigroup effects

The hypothesis around China and the UK was inspired by Hofstede's cultural model which was one of the most used theories in cross-cultural research. Table 5-55 (Hofstede, 2011) gives a summary on the Hofstede model. For H3a and H3b, the negative power of perceived risk on attitude toward using and intention to use is stronger on Chinese residents, as according to Hofstede's uncertainty avoidance theory, China has a strong culture acceptance of conformity. In other words, Chinese respondents are less risk tolerant. Therefore, it was assumed that perceived risk would have a stronger negative effect for China residents than UK residents.

Dimensions	**Defemination**
Power Distance	related to the different solutions to the basic problem of human inequality.
Uncertainty Avoidance	related to the level of stress in a society in the face of an unknown future.
Individualism vs. Collectivism	related to the integration of individuals into primary groups.
Masculinity vs. Femininity	related to the division of emotional roles between women and men.
Long Term vs. Short Term Orientation	related to the choice of focus for people's efforts: the future or the present and past.
Indulgence vs. Restraint	related to the gratification versus control of basic human desires related to enjoying life.

Table 5-55 Hofstede model

In terms of country-based gender group hypothesis, H4b and H5a were motivated by the risk behaviour theory "men are more inclined to take risk than women" (Harris and Jenkins, 2006). H4a and H5b were suggested by the literature that had examined the gender difference in TAM and it was found that perceived ease to use has a stronger effect on intention to use and attitude toward using on females than males (Venkatesh and Morris, 2000; Yuen and Ma, 2002).

Millennials are believed to express a stronger relationship over the factors as opposed to the GenX. This is because millennials have been labelled as tech-savvy, thus it can be assumed that they are more sensitive to the relationships between self-efficacy, perceived risk on attitude and behaviour intention.

To test the group difference, a plugin was used that was developed by Gaskin and Lim (2018). It has adopted the widely accepted χ^2 difference approach to test the multigroup effects. The algorithm performs an array of χ^2 significant testing across two groups first, then a statistically significant test on χ^2 difference is applied in order to compute the significance of the p-value. The threshold for a negligible difference is the p-value of the Δ **β** is less than 0.05. As it shown in Table 5-56, seven out of ten hypotheses were supported. H3A and H4b did not test group difference and H6a was rejected as although the significant Δ **β** across groups was found but failed to predict the direction. It was assumed that the positive relationship between perceived ease to use and intention to use is stronger on millennials than on GenX, but the result found here indicates the opposite.

In summary, for the proposed causal structural model, the direct effects, mediated effects, and multigroup effects were all examined. The model results indicate good model fit which led to meaningful findings. The next chapter will discuss findings in detail and interpret the results in an in-depth way.

Hypothesis #	Causal direct graphs	Expression	β	Δ β	Results
Multigroup Effects: China and the UK resident group (CN vs. UK)					
H3a	PR $\overset{-}{\rightarrow}$ ATU	PR ∡ ATU	CN β = -0.167** UK β = -0.244***	0.077	no difference
H3b	PR $\overset{-}{\rightarrow}$ IOU	PR ∡ IOU	CN β = -0.148* UK β = -0.347***	0.199*	Support
Multigroup Effects: UK gender group (M vs. F)					
H4a	PEOU $\overset{+}{\rightarrow}$ ATU	PEOU ∡ ATU	M β = 0.197** F β = 0.371**	0.330*	Support
H4b	PR $\overset{-}{\rightarrow}$ ATU	PR ∡ ATU	M β = -0.399** F β = - -0.343*	0.055	no difference
Multigroup Effects: China gender group (M vs. F)					
H5a	PR $\overset{-}{\rightarrow}$ ATU	PR ∡ ATU	M β = -0.267** F β = -0.432***	0.165*	Support
H5b	ATU $\overset{+}{\rightarrow}$ IOU	ATU ∡ IOU	M β = 0.167** F β = 0.310***	0.143*	Support
Multigroup Effects: millennials and GenX group (M vs. G)					
H6a	PEOU $\overset{+}{\rightarrow}$ IOU	PEOU ∡ IOU	M β = 0.213* G β = 0.792***	0.579*	Reject
H6b	PR $\overset{-}{\rightarrow}$ ATU	PR ∡ ATU	M β = -0.170*** G β = 0.057	0.227*	Support
H6c	SE $\overset{+}{\rightarrow}$ PEOU	SE ∡ PEOU	M β = 0.283*** G β = 0.141*	0.142*	Support
H6d	PR $\overset{-}{\rightarrow}$ IOU	PR ∡ IOU	M β = -0.385*** G β = -0.096	0.481*	Support

Table 5-56 SEM, multigroup effects result summary

5.4 Quantitative survey discussion

This subsection will further elaborate and explain the findings from the survey results that encounter the cyber security and privacy factors but go well beyond those. It aims to relate and connect the quantitative results obtained from the elites whose decision would affect CAV's implementation. It is a discussion that seeks to develop a model that could potentially generalise CAV acceptance. All constructs in the quantitative model are the key predictors of CAV acceptance, which inspired and extended from the classic TAM model.

5.4.1 Validation of extended TAM

The exogenous variables perceived risks (PR), perceived usefulness (PU), perceived ease of use (PEOU) and facilitating conditions (FC) appeared to be significant direct determinants of the endogenous variables attitude toward using (ATU) and intention to use (IOU). In essence, the empirical results support the hypothesis of the original TAM model. Particularly, the perceived risks of CAVs, the perceived usefulness of CAVs, the perceived ease-of-use of the CAVs and the facilitating conditions of CAVs have been found to directly affect the end users' acceptance of CAVs.

The path coefficient of the factors influencing the public acceptance within the proposed graphical conceptual models are shown in Figure 5-11. The factor loadings indicate that all of the hypotheses were supported. Table 5-57 presented overall standardised regression weights (β weights) of the direct effect.

			β	***P***
PEOU	<------	SE	.287	***
PEOU	<------	FC	.084	**
PU	<------	PEOU	.096	.106

PU	<------	PR	-.218	***
ATU	<------	PEOU	.574	***
ATU	<------	PU	.607	***
ATU	<------	PR	-.155	***
ATU	<------	FC	.117	***
IOU	<------	ATU	.125	***
IOU	<------	PR	-.251	***

*** $p < 0.050$, ** $p < 0.010$, *** $p < 0.001$**

Table 5-57 Standardized regression weights

A standardised regression weight equals the correlation. The beta weight shows how much the dependent variable increases when the independent variable is increased by one standard deviation. In alignment with TAM, PU (**β** = 0.607 ***) and PEOU (**β** = 0.574 ***) were found to have a significant positive influence on attitude toward using CAVs (H1b, H1d). Facilitating conditions of CAVs were found to have a significant positive influence on attitude toward using CAVs (**β** = 0.117 ***) (H1f); however, the data fails to support the direct relationship assumption between FC and PEOU (β = 0.084 not significant). In other words, the hypothesis of facilitating conditions positively influencing perceived ease of use for the CAV context is not supported (H1g). Additionally, PR was found to have significant negative influence on perceived usefulness of CAVs (**β** = -0.218 ***), attitude toward using CAVs (**β** = -0.155 ***) and intention to use CAVs (**β** = -0.251 ***) (H1a, H1c and H1h). Moreover, SE (**β** = 0.287 ***) was found to have a significant positive influence on perceived ease of using CAVs (H1e).

As for the mediating effects, the results revealed that the PU significantly mediated the negative relation between perceived risks (PR) and ATU (H2c). This implies that PR causes those who have low PU to have lower ATU. Similarly, an increase in PR will likely decrease the PU, which will in turn decrease the likelihood of IOU. Transferring this to the context of this study, if an individual's perceived higher risks are associated with CAVs, it will reduce their perceived benefit of CAV uptake and usage which will in turn lead to a negative attitude toward CAVs (Horst, Kuttschreuter, and Gutteling, 2007). Similarly, H2b indicates that ATU mediates the effect PR has on IOU. Accordingly, CAV associated risks perceived by the users affect their intention to use CAVs based on their attitudes towards CAVs. Therefore, cyber security and privacy concerns could negatively influence attitude toward CAVs. As such addressing cyber security and privacy risks in CAVs is essential for CAV acceptance.

The proposed model achieved partial mediation among PR → PU → ATU (H2c) and PR → ATU → IOU (H2d). This is because PR → ATU and PR → IOU are also significant. Particularly, in H2c, PR explains some unique amount of variance for ATU that is not also explained by PU. However, regarding the overall effect, the PU explains a significant amount of variance that PR has on ATU.

The mediating role of perceived ease of use (PEOU) between self-efficacy (SE) and attitude toward using (ATU) could not be verified (H2a), regardless, SE was found to positively influence PEOU (H1e). This means that higher CAV self-efficacy contributes to higher CAV PEOU, but PEOU does not mediate the positive relationship between SE and ATU (because there is no overall effect to mediate).

5.4.2 Implications based on original TAM model

The relationships within the original TAM were also tested in this study. For direct effects, the findings reveal that the direct causality between perceived usefulness (PU) and perceived ease of use (PEOU) could not be verified. Davis (1989) stated that "perceived ease of use is hypothesised to have a significant direct effect on perceived usefulness, since all things being equal, a system which is easier to use will result in increased job performance (i.e., greater usefulness) to the user." But the results in this study did not follow Davis' assumption. The not statistically significant results could imply that the respondents who acknowledged CAV's ease of use not necessarily recognised the benefits and usefulness of CAVs.

In line with Davis' (1989) TAM model, both PEOU and PU are determinants of ATU. Additionally, results also revealed that the perceived usefulness has stronger effect on attitude toward using than the perceived ease of use. These findings are supported by

Davis (1989), Herrenkind, et al. (2019) and Adams et al. (1992). One possible reason could be the practical side of the CAV (usefulness) being perceived as a more important factor than the characteristic of CAVs (ease of use). Perhaps a CAV is a transportation tool to the user, with its operational barriers being considered easy enough by the user, therefore, the benefits of CAV in relation to traditional cars (i.e., safety) are more persuasive in the attitude forming process.

The positive association between attitude toward using with the intention to use is confirmed in this study. This is the causal link of TAM that has been examined in numerous research (Ajzen and Fishbein, 1980; Davis, 1989; Panagiotopoulos and Dimitrakopoulos, 2018; Venkatesh, Morris, Davis, and Davis, 2003). The result implies that public perceptions on CAVs affects the acceptance and the adoption of CAVs. Thus, to introduce CAV to the market or users, an effective intervention method in improving public attitude is necessary.

5.4.3 Self-efficacy (SE)

This research found a positive association between the self-efficacy (SE) of the end user and perceived ease of use (PEOU). Consistent with existing literature, this study affirms that the self-confidence on CAV related knowledge positively influences the perceived ease of use. The literature suggests that individuals who have higher SE are more likely to use a new technology (Compeau and Higgins, 1995). Similarly, individuals with low SE are less likely to use the technology (Igbaria and Iivari, 1995). However, this relationship has not been investigated in the CAV context with SEM. In other research contexts, SE was proved to have a strong influence on PEOU (Abdullah, Ward, and Ahmed, 2016; Jin, 2014). Chen et al. (2019) found a positive relationship between SE and PEOU in the context of cloud telehealth systems.

SE in the context of this study focuses on whether individuals believe they can accomplish basic cyber security and privacy protection practice. As such, SE is a judgement of one’s level of CAV understanding and its associated risk management knowledge. It is important to note that this causal relationship between SE and PEOU does not imply that individuals with high confidence on their ability would perform the desired behaviour in the real life. Rather, high SE does not necessarily guarantee high-performing CAV related capabilities.

In this regard, Figure 5-12 shows four potential scenarios for self-reported scenarios and the real-world scenarios. For instance, for individuals with higher SE, their perceived ease of using CAVs tends to be higher. Whereas in the real-world scenario, their skills or knowledge might be low (low skill), and therefore, they might not be able to perform the tasks in a desired way (low performance), whereby their self-reported measures do not match the real-world behaviour. This study is not intended to explore whether user's real-world behaviour is consistent with the self-reported behaviour, instead, self-reported measures are particularly useful to understand what triggers user's intention of using CAVs without any real-world CAV experience.

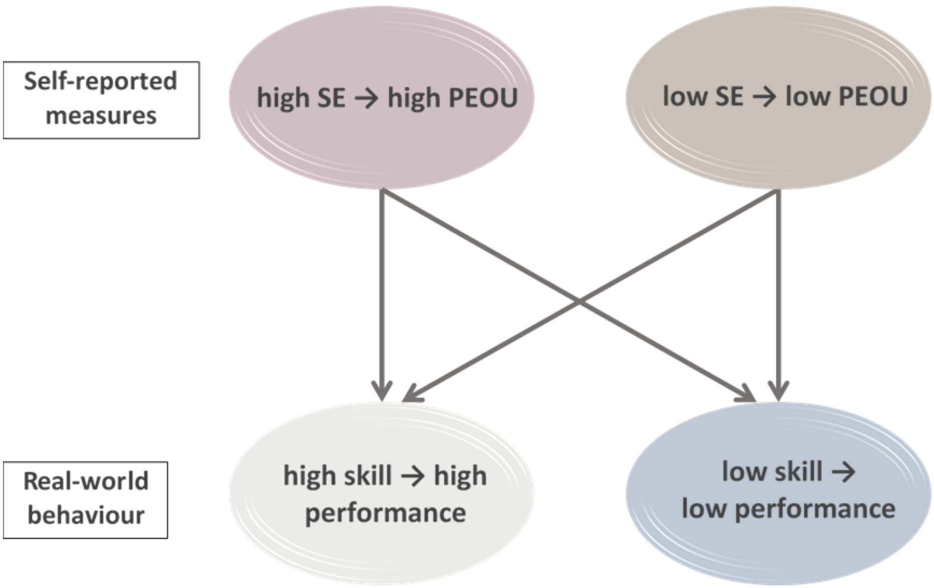

Figure 5-12 Schematic representation of the self-reported SE-PEOU and real-world skill-performance

The results suggest that individual's self-efficacy on CAV knowledge, and specifically knowledge regarding cyber security and privacy practices, indicate a higher user PEOU where higher PEOU, in the classic TAM model, signifies a more positive attitude toward using (ATU). As such, the intentions of the users to use the CAV would also be enhanced only if CAV's benefits and its associated risks can be disseminated to the users effectively and objectively in order to improve self-efficacy of the user.

In accordance with the elite interview findings, CAV education on privacy and cyber security (and beyond) is at the core of improving people's awareness and knowledge about CAVs. As mentioned in section 4.4.2, user awareness of CAVs and its related risks including cyber security risks and privacy risks is one of the essential outcomes that can be achieved via education.

5.4.4 Perceived risks (PR)

Cyber security risk encompasses the element of risk perception that may arise through system failure or hacker attacks in the new vehicle technology acceptance (Viereckl *et al.,* 2015). Privacy as a concept proceeds on the principle of distrust toward sharing data (Schmidt *et al.*, 2016) and threat of identity theft (Jordan *et al.*, 2013).

Notably, perceived risks (PR) differ from the actual risk. In particular, perceived risk can be an exaggeration or underestimation of the actual risk. Perceived risks are a psychological reaction measured by human cognitive skills, unlike actual risks that is measured by probabilities and mathematics and perceived risks rarely represent the actual risks (Slovic, 2010). Bruce Schneier (2006) listed five general pathologies that define individual's risk perception patterns:

a. People exaggerate spectacular but rare risks and downplay common risks.
b. People have trouble estimating risks for anything not exactly like their normal situation.
c. Personified risks are perceived to be greater than anonymous risks.
d. People underestimate risks they willingly take and overestimate risks in situations they cannot control.
e. People overestimate risks that are being talked about and remain an object of public scrutiny.

Since perceived risk are not equal to actual risk, the question which arises is whether perceived risk is something worth investigating. As such, it is essential to understand people's risk perception in relation to CAV acceptance. Also, it is important to investigate what influences the mismatch between risk perception and the actual risk. Further, how to reduce the gap between perceived risks and the actual risks as discussed below.

Perceived risks are mainly formed by media and word-of-mouth (WOM) (Jalilvand, 2017; Mutz, 1989). In cognitive development theory (Fischer, 1980), the development of conceptual resources depends on the information provided by the product. Similarly, public risk perception on CAVs is principally influenced by the media (e.g., TV, newspaper, internet) in modern society. Risk perception of CAVs is determined by media input since because the majority of the people in the society are not conversant with the CAV concepts as of yet. The available information about CAV associated risks would influence the perception of the CAV itself.

Thus, media would directly influence risk perception of the consumer. Negative media coverage will most likely give negative sensory input to public's risk perception and vice versa. Due to lack of experience with CAVs, the public may not be able to acquire objective and holistic information about CAVs, which may therefore cause information asymmetry (IA).

In economics risk management research, information asymmetry highly influences decision making. IA refers to a situation where the involved party have different types or different quantity of information which failed to understand accurately the information that is shared (Sceral, Erkoyuncu, and Shehab, 2018). This concept was originally developed in economics and can subsequently be applied in studies that involve exchange of information. In the context of this study, media plays a major role in causing mismatch of perceived risk and the actual risk and it may subsequently influence end user's decision-making process with asymmetric information.

The media forms and shapes public's views thereby informing the contextual environment for end users' decisions on CAV acceptance. If the media releases incorrect, unreliable, or inaccurate information the public risk perception of CAV could be misevaluated. When the public's past experience of using CAV is absent then the users would rely on new information to define their perception and understanding of CAVs.

Perceived risks in the CAV context are understudied; few empirical studies have examined the cyber security and privacy risks associated with CAV acceptance. In social science research, individuals connect high risks with negative consequences (Slovic and Peters, 2006). This indicates that people would negatively respond to risks in the risk adaptation process. For example, it was found that perceived risk is one of the determinant factors on acceptance of IoT devices that is susceptible to cyber security and privacy threat (Horst *et al.,* 2007). They are also affected by risk characteristics, which they are not necessarily aware of, but act as hidden drivers in favour of or against a specific technology (Alhakami and Slovic, 1994; Joffe, 2003).

The study results reveal that the PR, specifically perceived cyber security and privacy risks of CAVs, negatively influence perceived usefulness of CAVs (H1a), as well as the attitude toward using CAVs (H1d). This is consistent with many studies that examine PR under different context (for instance, Groot, 2018; e.g., Chen *et al.,* 2019).

From the elite interviews, some experts state that "people do not care about cyber security and privacy; what people care about is only safety." Empirical data shows that people care about cyber security and privacy risks, however, most of them do not understand what cyber security and privacy are and how hazardous they can be. Research has proved that disinformation can be weaponized (Raman *et al.*, 2020).

In accordance with the elite interview results, increasing public awareness about cyber security and privacy threats and the upskilling of the end users would eliminate the gap between perceived risk and the actual risk. Ultimately, prioritising cyber security, privacy and safety from the product-development process phase is the decisive step for reducing CAV associated risk, and consequently lead to positive attitudes towards CAVs.

From another point of view, media is a crucial link in the propagation of information, and it should be countable and reliable. Fundamentally, established policy and legislation may be the keys in mitigating cyber security risks and privacy threat. This point will be discussed later in the facilitating condition (FC) section.

5.4.5 Facilitating conditions (FC)

Facilitating conditions (FC) in the study refers to the perceived data protection supports in the external CAV environment. In the literature section, FC was found to have a significant positive association with attitude toward using (ATU) in the context of pre-service teachers' technology acceptance and perceived ease of use (PEOU) in the context of Web Course Tools (WebCT) acceptance. The cause-effect between FC and ATU is confirmed in this study and the direct causality between FC and PEOU. Particularly, this result implies that respondents generally should have a positive attitude if the CAV related resources (i.e., data being protected by the trusted governing body) are perceived as adequate by the users and the increased facilitating resources are likely led to higher user's PEOU. Karahanna and Straub (1999) found an insignificant relationship between FC and PEOU in the context of e-mail adoption where FC such as the availability of training and support for the use of IT had no impact on PEOU or PU of the e-mail adoption. One possible reason for this insignificant path could be the measurement of FC in this research context reflected only one aspect of FC (Thompson *et al.*, 1991).

As mentioned earlier, the relationship between FC and attitude toward using (ATU) is positive and significant. This finding suggests that the enhancement of the positive attitude toward CAVs can be accomplished by providing adequate cyber security and privacy protection. Backed by the inferences of the qualitative study, it remains a collective responsibility of the stakeholders such as the automotive manufacturers, mobility service providers and legal entities to protect users from cyber threat and privacy breaches.

The proposed impact of FC on PEOU was also supported by the model. Particularly, FC in this study refers to facilitating resources in protecting users from cyber security and privacy threat. The inference indicates that individuals perceive CAV's ease to use based on the facilitating conditions available to them. Suggestions on this manner is to utilise the power of trusted voices (e.g., public authorities). Research has found that people would change their attitudes in an uncritical manner under the influence of the prestige of authority and numbers (Sherif, 1936).

As for the implementation aspect of facilitating end user against cyber-attacks and privacy breaches Government, CAV manufactures and the third-party service providers should introduce security standards that would affirm the cyber safety and privacy of the end users. Additionally, the end users should be enlightened to enable them exercise caution to avoid errors that may expose them to cyber threats and privacy breaches. For instance, the enlightenment mechanisms can come through organised campaigns, workshops, test drives and highlighting the cyber and privacy protection features via marketing and advertising. Technically, there should be comprehensive remedial mechanisms meaning to mitigate risks once attacks or breaches occur. This requires that CAV manufacturers and service providers should be ready to implement strong cyber security and privacy features by design into the CAV systems.

The author is convinced that providing facilitating conditions that are perceived to be important to the CAV user would help building institutional trust on CAVs. Leviathan trust (institutional trust) is the highest in the existing trust relationships architecture[21], where the government or a centralised authority are counted for resolving any disputes (Werbach, 2018) and is proved to increase using intention by other studies (Fang *et al.,* 2014; Guo, Lin, and Li, 2020).

5.4.6 Theoretical implications of the multi-group analysis

It is assumed by this study that individual’s attitudes towards CAV adoption are shaped by social-political values and cultural identity or background. As previous sections discussed, public acceptance of CAVs is influenced by the individual’s perceived usefulness, ease of use, self-efficacy and facilitating conditions. The objective of the multi-group analysis is to explore whether or not one’s gender, age and cultural background enhances or weakens the relationship between perceived CAVs characteristics and attitudes.

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[21] Werbach (2018) proposed a trust architecture in the network security context, consisting of four architectures, namely peer-to-peer trust, Leviathan trust, intermediary trust, and blockchain security system enabled trust.

According to Fishbein's (1963) attitude theory and McGuire's (1973) attitude change theory, one's attitude is formed on their acquired knowledge and the evaluation of the characteristics of the object. This type of attitude formation is classified as a bottom-up approach. For instance, when the attitude object is CAV adoption, public attitude formation may start from learning about the benefits of CAVs, the risks of CAVs, their difference from non-autonomous vehicles, their cost to purchase or hire. The overall characteristics of CAVs help to formulate and shape the attitudes as perceived by the public.

In contrary to the bottom-up approach, the top-down formation of attitude (Scholderer, Bredahl, and Frewer, 2000) refers to an individual's attitude that is rooted from how a particular value system (general attitude) would guide the deriving attitude formation for a particular object (Katz, 1960).

When discussing attitudes towards technology acceptance, it has been widely held that the bottom-up approach can be predicted by the top-down approach of the attitude formation (for example, Bredahl, 2001; Frewer, Shepherd, and Sparks, 1994). This means that individuals who carry a particular value system will impact one's attitude toward the characteristic of the object. For instance, individuals born and raised in the same generation share similar experiences and tend to exhibit a set of shared value systems (Mannheim, 1970). When it comes to attitudes towards technology, millennials for example, the "digital native" generation tends to embrace technology (Au-Yong-Oliveira *et al.*, 2018) (top-down). In this regard, millennials tend to perceive that technology is easy to use which results in positive attitudes towards technology (bottom-up).

5.4.7 Cyber security and privacy risk perception differences between UK and China

The proposed hypothesis was intended to examine two issues:

> Does the perceived risk negatively affect attitude differently between UK and China? (H3a);

Does the perceived risk negatively affect intention to use differently between UK and China? (H3b).

Accordingly, the two results indicate that PR negatively influences ATU and IOU. PR does not have a different influence on attitude across the UK and China, but it has greater influence on behavioural intention in China's dataset. The above findings underline the need to address issues in risk perception based on the theories of attitude formation in CAV acceptance.

The negative influence of PR on ATU is not statistically significant across UK and China (H3a). This means that the relationship between perceived ease to use and attitude toward using is not significantly different for China and the UK. This finding from the Chinese sample departs from the principle of uncertainty avoidance outlined in the Hofstede's theory. A plausible explanation could be that most of the respondents in the Chinese sample are millennials who are less risk averse. Illustratively, the Chinese millennials born after the 1980s experience less levels of stress in the society in the face of an unknown future, unlike Hofstede's sample where most of the participants examined were born in the 1960s. This is due to China's rapid economic growth in 1980s, as shown in Figure 5-13 (IMF, 2019). Many studies have evidenced that risk perception and wealth are closely correlated (Guiso and Paiella, 2008; Pratt and Zeckhauser, 1996). When the environment is difficult and individuals suffer from hardship such people would be less risk-averse and vice versa. Therefore, millennials born and raised in a stable and economically developing period in China; those who did not suffer from domestic wars or poverty, compared to Generation X, tend to have higher willingness to take risks. Essentially, the willingness to take risks is not necessarily equal to actual risk tolerance (or ability to take risk) which is discussed in detail in section 5.4.9.

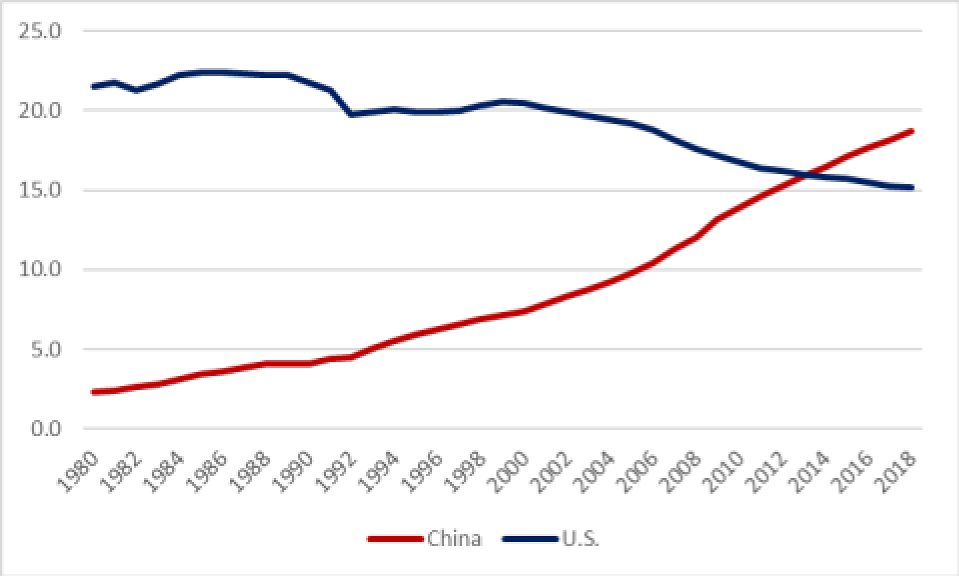

Figure 5-13 U.S. and Chinese GDP (PPP Basis) as a Share of Global Total: 1980-2018 (%)

Findings support the hypothesis H3b where the negative effect between the perceived risk and intention to use is stronger for Chinese residents than the UK residents. This is perhaps due to the uncertainty avoidance cultural dimension. According to Hofstede (1980), individuals with lower uncertainty avoidance cultural values, for example, UK residents, tend to have a greater risk tolerance and a stronger tendency to take risks. Similarly, as mentioned in Chapter 3, the Chinese culture is less risk tolerant as compared to Western cultures, therefore, these results echo Hofstede's cultural value assumption regarding uncertainty avoidance.

A similar association also appears in the TPB research (Dinev *et al.*, 2009; Tarhini *et al.*, 2017) around the moderating effect of uncertainty avoidance in the relationship between the subjective norm and behaviour intention. The proposed effect is that the subjective norm has a stronger impact on behaviour intention for those with high uncertainty avoidance cultural value. Accordingly, individuals with high uncertainty avoidance like the Chinese are highly influenced by their perceived risks associated with CAVs (based on the information disseminated by the media) as they are more wary of using CAVs.

Another reason might be the influence from China's one-child policy (OCP) that was introduced in 1979. Cameron et al. (2013) found people born under the OCP are more risk averse in financial investment however, this finding was not statistically significant.

Nevertheless, according to Brown (2014)'s longitudinal research, an only child exhibits a lower risk tolerance. Hence, to approach individuals with lower risk tolerance. It is instructive to combine factors such the high uncertainty avoidance cultural value and policymakers should promote the use of CAVs via credible news sources. Moreover, the promotion of CAVs should highlight the confidence on CAV's cyber security and privacy capacities as the end user would be more concerned and aware of the cyber risks and privacy issues in this digital era.

Gaining and retaining trust from the end user would be the first step for the successful introduction of CAVs. Governments, automotive manufacturers, and third-party service providers are charged with the responsibility of ensuring end-user's cyber safety and privacy. This involves the joint effort from the hardware vendors, software engineers, telecommunications providers, automotive vendors and the industry policy makers.

5.4.8 Gender differences: case of UK and China

5.4.8.1 UK gender differences

The proposed hypothesis intended to examine two issues:

> Does the perceived ease of use positively affect attitude differently between male and female respondents in the UK group? (H4a);
>
> Does the perceived risk negatively affect attitude differently between male and female respondents in the UK group? (H4b).

The results indicate that the positive relationship between perceived ease to use and attitude to use is stronger for females than males in the UK sample. Several studies examined the gender differences in the relative influence of the TAM constructs on PEOU-IOU and PU-IOU relationships. For example, Venkatesh and Morris (2000) revealed that perceived ease of use influences behavioural intention to use a system more strongly for females than it has influenced males. This is because females were found to have higher computer anxiety than males (Morrow-Bradley and Elliott, 1986). Since computer anxiety is a known determinant of perceived ease of use (Venkatesh and Morris, 2000), higher computer anxiety can be expected to lead to lower perceived ease of use and in turn weaken the relationship between PEOU and its associated constructs.

Research established that gender influences perceptions and the usage of the technology (Goh and Sun, 2014). Liu and Guo (2017) confirmed that females are comparatively more satisfied with the increased ease of use of the information technologies and devices as opposed to males. In this study, it has been confirmed by the UK dataset that perceived ease of use is more prominent to females than males and plays a bigger role in forming their attitudes regarding the use of CAVs. Based on these results, one could argue that highlighting the practical characteristics of CAVs when advertising or promoting CAVs could potentially attract more female end users than male ones. Further, female users might react more positively to information that connotes ease of use of CAVs as opposed to their male counterparts.

The negative relationship between perceived risk and attitude toward using is similar for females and males in the UK sample. Various studies have reported females to be more sensitive to risks and have a lower risk tolerance as compared to men (Gustafsod, 1998). Similarly, the inference established that white people perceived lower risks as opposed to the people of colour (Finucane *et al.*, 2000). However, this study could not support such a finding from the UK dataset group. This finding contributes to the existing literature on gender differences reflecting cyber security and privacy risks in CAV acceptance research. Male and female respondents from the UK showed that perceived risks have in both cases a similar influence on the attitude toward using a CAV. This implies that cyber security and privacy concerns affect their attitude toward using CAVs equally. Regulation, legislation and policy in terms of data protection measures are needed to address cyber security and privacy issues associated with CAVs. As such, in the process of promoting CAVs, sufficient emphasis should be placed on cyber security and privacy of CAVs as this would help to inspire and develop positive attitudes among male and female populations in the UK towards embracing the new technology.

5.4.8.2 China gender differences

The proposed hypothesis was intended to examine two issues:

> Do the perceived risks negatively affect attitude differently between male and female respondents in the China group? (H5a);
>
> Does attitude positively affect intention to use differently between male and female respondents in the China group? (H5b).

Xu and Fan (2019) found a significant relationship between individual's risk perception and gender risk perception in the autonomous vehicle's context through a web-based survey in China. Risk perception in this specific study consists of perceptions of road safety, personal information safety (privacy) and car safety.

The negative relationship between perceived risk and attitude toward using is stronger for females than males in the Chinese sample of the present work. This finding is consistent with the traditional literature that women have higher levels of risks and concerns than males (Finucane *et al.,* 2000; Gustafsod, 1998; Hulse *et al.,* 2018). Therefore, decision makers should understand that promoting the option of having control over the user's personal data and cyber safety could potentially convince more females to have a positive attitude toward CAVs as opposed to the males.

The positive relationship between attitude toward using and intention to use is stronger in females than males in the Chinese sample. This finding implies that females with positive attitude toward CAVs are more likely to use CAVs in the future as compared to males. This finding is consistent with TPB and gender research in various research contexts (e.g., Bagheri and Pihie, 2014; Fakhrudin, Karyanto, and Ramli, 2018). Combining the previous finding that females are more sensitive to cyber security and privacy risks of CAVs in the Chinese sample, the important role of PR in attitude formation is more critical, as the attitude will in turn directly influence female's intention of using CAVs. Perceived cyber security and privacy risks can be considered to be a strong predictor of female’s CAV acceptance as evidenced by the Chinese dataset.

For a similar supposition of PR-ATU, UK male and female groups differ from the Chinese male and female groups. This could arise because of the differences in gender effects across UK and China. According to Hofstede (1980), UK tends to be a feminine society where social gender roles are less distinct, and the gender value of the society insists on gender equality. A feminine society refers to a community where gender roles overlap and both men and women are expected to display congruent traits of modesty, tenderness, compromise, consensus etc. China is considered a masculine-leaning society, where it has bigger and clearer gender differences in terms of social gender roles. These two different society dimensions result in different upbringing between males and females. Evidenced by this study, smaller gender differences, like those evidenced in the UK society, make attitudes on CAVs more uniform. In contrast, due to relatively bigger gender differences, the Chinese group showed a heterogeneity on the attitude forming process consistent with the distinct gender roles observable in a masculinity society; females tend to have greater difficulties to accept CAVs than men when evaluating risks as high.

Another plausible reason for the difference in results between the Chinese and the UK gender groups over PR-ATU relationships might be over-confidence and under-confidence issues in a self-reporting survey process. The Chinese gender group results suggest female’s perceptions are more sensitive to cyber security, privacy risks, it is, however, unclear whether the function of overconfidence in the male or the under-confidence in females interfered with the results. There is significant evidence in the body of knowledge that in a masculine-leaning society, females tend to have a relatively modest self-representation style as compared to males (Kosakowska-Berezecka *et al.*, 2017; Wells *et al.*, 1977). Similarly, a substantial amount of literature evidence outlines that overconfidence issues are more revealing in masculine cultures (Sanchez-Franco, 2006). This explains why gender effects were different between UK and China.

5.4.9 Generation differences between millennials and GenX

The proposed hypothesis was intended to examine four issues:

Does the perceived ease of use's positive effect on intention to use differ between millennials and the GenX? (H6a);

Does the perceived risk's negative effect on attitudes differ between millennials and the GenX? (H6b);

Does the self-efficacy's positive effect on perceived ease of use differ between millennials and the GenX? (H6c);

Does the perceived risk's negative effect on intention to use differ between millennials and the GenX? (H6d).

Results from this study show the positive relationship between perceived ease of use and attitude toward using is stronger for the generation X than millennials. This was opposite to the postulated hypothesis on this relationship. One plausible explanation for this is that, in comparison to millennials, GenX focus on the practical factors over technologies (Calvo-Porral & Pesqueira-Sanchez, 2019). Hence, the operational characteristics of CAVs could potentially trigger more GenX developing positive attitudes towards CAVs. As such, effort should be directed towards promoting ease of use to appeal to the GenX groups, thereby achieve greater CAV adoption.

The negative relationship between perceived risk and attitude toward using is stronger for the millennials than GenX. Similarly, the negative relationship between perceived risk and intention to use is stronger for the millennials than GenX (H6b, H6d). This result highlighted the risk averse characteristics of millennials something that is consistent with most of the literature (Erlam, Smythe, and Wright-St Clair, 2018; Struckell, 2019). It was believed that some big events millennials experienced such as 9/11, terrorism, financial crisis contributed to the formation of their risk perception (Kessler, 2016). These events were central to inform and guide the psyche of the millennials and the GenX. It is essential to outline that the millennials are more educated as compared to their predecessors (Burkus, 2010; Desy, Reed, and Wolanskyj, 2017). According to DOI theory, early adopters tend to be younger in age and more educated (Rogers, E. M., 2010). Therefore, the early adopters of CAVs are highly likely to be many of the millennials. Given the above prediction, if the CAV stakeholders aim to target millennials as early adopters, they should not neglect the cyber security and privacy issue because these are the strong determiners of CAV acceptance that are deemed particularly critical for the millennials.

On the other hand, considering millennials do not hold vast portions of wealth or financial resources at present, it would be unlikely that they would form the initial customer base for the CAVs when they first enter the market (Steverman and Tanzi, 2020). As such, the author suggests that the subscription-based and shared service-based market entry strategy should be adopted to enable millennials and GenZ[22] prospective consumers to access CAVs more freely because they would be the early adopters.

It is expected that self-efficacy has a stronger influence on perceived ease of use for the millennials group than the GenX group. Millennials are regarded as “technologically savvy” because they have lived all their lives in the midst of rapid technological developments that allow them to accustom better to new technologies including CAVs. GenX being relatively older than the Millennials would be more reserved to approach the new technology; they could possibly approach CAVs with more caution, confusion or trepidation.

Combining the H6a result with the H6c result, implies that GenX values more the ease-of-use factor of CAVs but have less confidence in their ability to operate CAVs when compared to Millennials. This arises because GenX is comparatively less tech savvy as opposed to the Millennials rendering it difficult for them to learn how to use new technologies such as the CAVs. In this case, it is of the utmost importance to develop novel

[22] Generally, GenZ refers to people born from 1995 to 2010.

human machine interface tools that would enable easy to operate models in complex human-machine interaction scenarios.

Another plausible reason could be the element of overconfidence in the self-reported survey. The traditional view is that overconfidence is more pronounced in younger people (Palmer, 2014), however, a number of researchers have proved the opposite to be true (Prims and Moore, 2017; Rorty, 1982).

5.5 Synthesising the key lessons of the two research stages

From the coverage of the literature in chapter 2 and the qualitative research findings in chapter 4, a basic conceptual framework was established around cyber security and privacy themes that needed to be addressed prior to a full-scale launch of CAVs. Chapter 5 presented the quantitative results that modelled the causal relationships of CAV acceptance and how these can be generalised on different target audience of CAV users. The key findings from the two-phased research that has endeavoured to address the research questions are listed as follows:

1. Addressing cyber security issues and privacy issues in CAVs are ranked as significant by both the field experts and the general public. Millennials who would form the largest target audience of CAV users, showed a clearly high-risk sensitivity to cyber security and privacy risks of CAVs;
2. Building trust could be done through creation of awareness through campaigns, workshops, advertisement and test drives and via education and training;
3. Media is the major player in influencing public opinion since it informs the public to either build their confidence or disparage their trust and subsequent perception regarding CAVs;

4. TAM is validated by this research. Perceived usefulness, perceived ease of use, and attitude toward using CAVs have been proved to be key determinants of the intention to use CAVs;
5. People with higher self-efficacy are more likely to use the CAV and self-efficacy can be improved by education;
6. The extension that integrated to the TAM constructs, components such as self-efficacy, facilitating conditions and perceived risks that were inspired by the themes of awareness and education, legislation and safety respectively, have proven to be reliable predictors of CAV acceptance;
7. This study has proved that age-related and culture related factors are relevant aspects for the acceptance of CAVs;
8. Hofstede's cultural dimension model was not fully relevant to the sample in this study. The Chinese sample departs from the principle of uncertainty avoidance outlined in the Hofstede's theory;
9. From the organisational perspective, providing the end-users with adequate cyber security and privacy protection would enhance their positive attitude toward CAVs. This involves the joint effort from the stakeholders such as the automotive manufacturers, mobility service providers and legal entities. The stakeholder's efforts would increase the prospects of protecting end users from cyber-attack and privacy breaches;
10. From the elite interviews, field experts expressed an urge for the general public to hold cyber security and privacy risks in high regard as they believe the public lacks the requisite awareness on the matter. The quantitative results revealed moderate awareness to cyber security and privacy issues of CAVs.

Figure 5-14 shows the final process model with the combined framework identified in the qualitative elite interview phase and the structural model proposed in quantitative survey research. As such, the final framework aims to frame the human factors and the organisational factors in the resultant model.

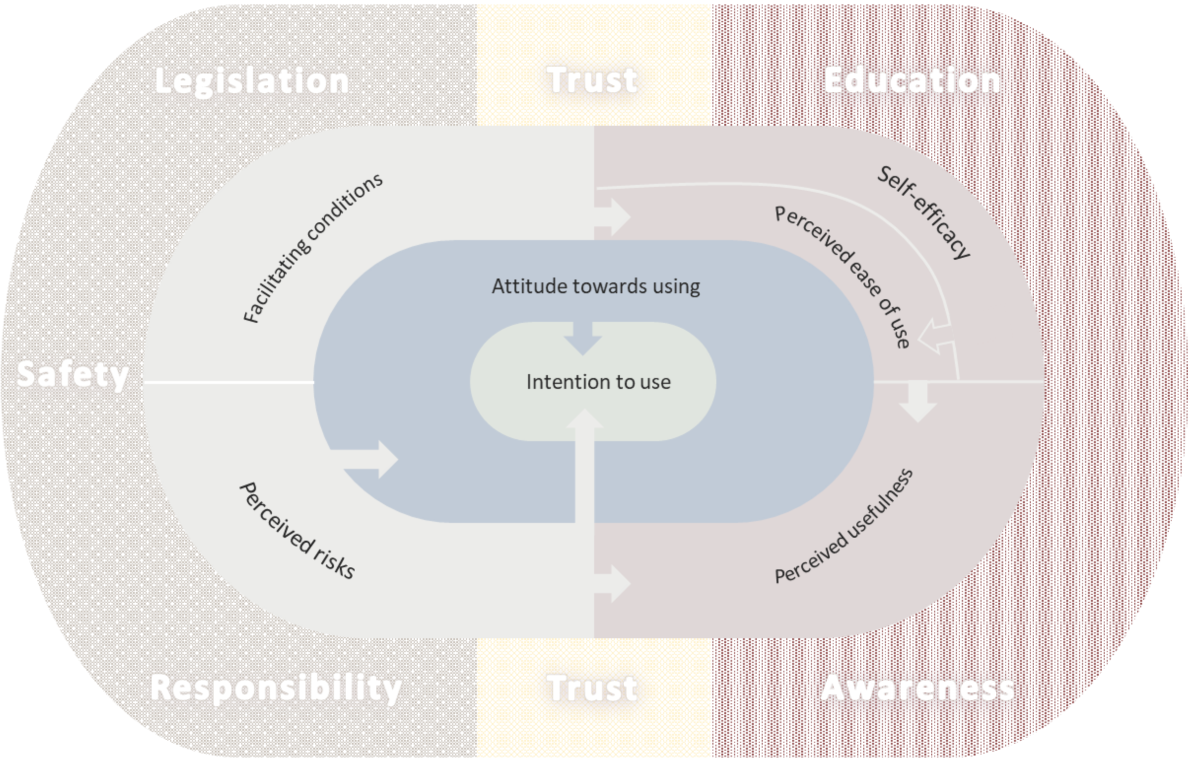

Figure 5-14 CAV acceptance framework

As seen above, public's risk perception has a direct influence on the attitude toward using CAVs and the intention to use CAVs. In this study, the cyber security and privacy concerns were examined on the risk perception basis. Users' safety may be compromised as a result of cyber-attack or related data breaches. The results from both research phases indicate that ensuring CAV's cyber security and privacy that is user friendly, requires joint efforts from the government, policy makers, CAV manufacturers and third-party service providers.

The author suggests that government intervention remains the ultimate avenue to achieve the users' ultimate cyber safety and privacy protection. From the technical aspect (left side of Figure 5-14), in terms of cyber and privacy protection, legislation, industry standards and liabilities need to be clearly specified. If CAV's cyber security and privacy business model continues like in the current unregulated market system, where the users bear the consequences of cyber-attack and the privacy breach, CAVs may fail in the long run. Consequently, CAVs' safety advantages over conventional cars will be negated. From the human factor aspect (right side of Figure 5-14), awareness and education are the keys to improve public's awareness and skillsets in preventing human factor related cyber security and privacy losses. Accordingly, trust is built through the relationships between users and the specific systems (Borsci *et al.*, 2018). In the context of this study, trust (middle part of Figure 5-14) before using CAVs can be built through user's knowledge of CAVs, perceived CAVs' system characteristics and the facilitations available to the user. The author argues that the government has a fundamental role in the introduction, acceptance and long-term establishment of CAVs.

As highlighted in one of the key findings, media currently plays a major role in shaping public attitudes towards CAVs and as such the knowledge about CAVs will concurrently be shaped by the media. However, from a security perspective, misinformation and fake news diffused via social media have made it possible to manipulate the public (Raman *et al.,* 2020). Thus, it is imperative to contemplate social media regulation. Many governments around the world have started to introduce policies that regulate social media namely Germany's NetzDG law in 2018, Australia's Sharing of Abhorrent Violent Material Act in 2019, China's cyber-police act amongst others. UK government official media regulator Ofcom has planned to regulate social media companies with the anticipation of the Online Safety Bill expected to be ready by 2021 [23]. Additionally, Bruce Schneier, one of the world's top technology theorists proposes the enforcement of existing antitrust laws on social media monopolies (i.e., Google and Facebook) as an effective way to decentralise their influential power (Schneier, 2021).

As shown by this study, public's risk perception strongly influences people's intention to use CAVs. However, this does not imply that the public has adequate cyber security and privacy knowledge regarding the consequences of the cyber security and privacy breaches or the basic practice in protecting themselves from cyber-attacks and personal data leaks. This problem can be broken down into two issues. Firstly, if the end users raised their

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[23] UK Home Office. (2020, December 15). *UK leads the way in a 'new age of accountability' for social media* [Press release]. https://www.gov.uk/government/news/uk-leads-the-way-in-a-new-age-of-accountability-for-social-media

awareness regarding cyber risks and privacy breaches that exist and improve their knowledge about the potential impact on their personal and proprietary security they would be best placed to mitigate and remedy those risks. Additionally, they will be more cautious and make safer choices. Secondly, a successful education requires the cooperation of the educator and the learner. In the context of CAVs, cyber security and privacy education can fail if the user is not properly trained according to high standards in a way that allows him or her to understand and take on their portion of responsibility. Therefore, awareness must be raised, which in turn would enable a successful education on the public's responsible CAV behaviour when using CAVs.

If education fails, two major possible scenarios are likely to happen on CAVs. The first scenario could arise where people may capitalise on CAVs defects, weaknesses in cyber security and privacy risks thereby diminishing prospects of CAVs acceptance. More specifically, end users are not only the bearers of the cost purchased products and services, but also bearers of its associated risks. However, should there be security and privacy breaches as suggested by the extended TAM model proposed in this research, end-users would form a negative attitude toward CAVs thereby adversely informing their prospects of CAV acceptance. The second possible scenario is that if CAV acceptance is compromised or fails, then its introduction and long-term viability will also fail because of the climate of fear that could force prospective end users to question the controllable consequences of cyber-attacks and privacy breaches. In essence, according to the proposed model, the perceived risks associated with CAVs will directly influence people's attitude toward CAV and intention to use. The potential dangers caused by cyber security and privacy breaches are huge concerns among CAV stakeholders. Thus, it is imperative to set forth the regulation and legislation to CAV companies requiring them to produce and provide standard CAVs and services, that promote and raise public's cyber security and privacy awareness and education.

Finally, based on the final model the contributions, limitations of this research and future research recommendations are presented in the conclusion chapter.

Chapter 6. Conclusion

6.1 Introduction

The previous two chapters presented the qualitative elite interview, the quantitative survey, and developed the final CAV implementation framework that draws together the results and recommendations from the two studies. This chapter starts with a summary of the research's objectives and findings. Then, it concludes this thesis by highlighting the contribution of the research to the body of knowledge, identifies the existing limitations and gives suggestions for future areas of research stemming from this study.

6.2 Research overview

The aim of this study was to develop a theoretical and empirical understanding of attitudes towards CAV acceptance with a particular focus on the elements of cyber security and privacy. Based on the literature reviewed and identification of research gas as presented in detail in Chapter 2, the aim, objectives and research questions were identified as follows:

Aim: Developing a theoretical and empirical understanding of attitudes towards CAV acceptance with a particular focus on the agendas of cyber security and privacy.

Research objectives and questions:

- Identifying and contextualising the diverse dimensions of CAV related cyber security and privacy breaches for the end-users from the lens of CAV experts;

    1. What types of CAV associated risks may the user face in terms of cyber security and privacy?

2. What are the key expressions of cyber security and privacy issues?
3. What can be done to mitigate these risks?

- Modelling the factors influencing public attitudes towards CAV acceptance;

4. What is the suitable technology acceptance model that can be used as the conceptual framework to examine CAV acceptance?
5. What are the factors affecting CAV acceptance and in what way they do so?
6. To what extent do the determining factors influencing CAV acceptance vary or concur in different cultural/gender/generational contexts?

- Proposing policy recommendations for mitigating cyber security and privacy concerns and advancing public acceptance for CAVs.

7. What can policy makers do to safeguard CAVs cyber security and privacy?
8. What can end users do to safeguard their cyber security and privacy?
9. What can stakeholders do to ensure the acceptance and better diffusion of CAVs?

The methods used and the key findings answering the research questions are briefly summarised in Table 6-1.

Research Questions	Summary of findings	Methods
RQ1: CAV user is prone to what types of risks associated with CAV?	CAVs are more prone to data exploitation and vulnerable to cyber-attacks than any of their predecessors increasing the risks of privacy breaches and cyber security violations for their users.	Literature review Semi-structured elite interview with field experts from academia, industry, and policymaking
RQ2: What are the factors affecting CAV acceptance and in what way they do so?	Awareness, user and vendor education, safety, responsibility, legislation, and trust are all critical issues that need to be addressed prior to a full-scale launch of CAVs.	
RQ3: What recommendations are available to mitigate these risks.	Addressing cyber security and privacy risks in CAVs requires inter-institutional cooperation, awareness campaigns and trials for trust-building purposes and mandatory educational training and licensing for manufacturers and end-users.	
RQ4: What is the suitable technology acceptance model that can be used as the	Based on the review of the literature, most of the empirical research from different contexts of technology arrived at similar findings that proved TAM as being the most robust and reliable in predicting interrelationships between factors and behaviour intention. Derived from the TAM and the interview results, it is believed that the extended TAM that consists of	Literature review Qualitative results

conceptual framework to examine CAV acceptance?	three extended constructs - perceived risks, self-efficacy, and facilitating conditions is the most suitable conceptual framework to examine CAV acceptance.	Online survey with general public
RQ5: What factors influence public's CAV acceptance and what is the relationships between them?	Based on the quantitative findings, perceived usefulness, perceived ease of use, attitude toward using, perceived risks, self-efficacy, and facilitating conditions have been proved to be key determinants of the intention to use CAVs. The causal relationship of the proposed model has been validated through a survey of 1162 respondents from the UK and China.	
RQ6: To what extent do the determining factors influencing CAV acceptance vary or concur in different cultural/gender/generational contexts?	This study has proved that culture related factors, gender-related factors and generational related factors are relevant aspects for the acceptance of CAVs. However, Hofstede's cultural dimension model was not fully relevant to the sample in this study.	

RQ7: What can policy makers do to safeguard CAVs cyber security and privacy?	Addressing cyber security issues and privacy issues in CAVs, set forth the regulation and legislation to CAV companies, regulate the media, promote, invest and raise public's cyber security and privacy awareness and education would help to accelerate the emergence and the widespread use of CAVs.	Combine the results from qualitative and quantitative studies
RQ8: What can end users do to safeguard their cyber security and privacy when using CAVs?	End users need to be aware, educated and empowered with two-way HMI communication and engagement platforms that would allow them to understand and address better risks (and perhaps in-real time) associated cyber security and privacy threats. Cyber security and privacy skill shortage should be dealt with pro-actively and users need to be genuinely involved into these efforts.	
RQ9: What can stakeholders do to ensure the acceptance and better diffusion of CAVs?	Balanced and fair responsibility-sharing, providing and facilitating the end-users with adequate cyber security and privacy protection. Increase the communication between CAV industry and the policymakers. The subscription-based and service-based market entry strategy should be adopted to enable more millennials and GenZ prospective consumers to become the early adopters of CAVs.	

Table 6-1 Summary of research questions, methods used and key findings.

This two-strand sequential mixed method research consists of a qualitative elite interview phase and a quantitative survey phase. The quantitative research development was largely informed by the elite interview result and the literature. Thematic analysis was employed in analysing interview results in order to gain a deeper understanding from the field experts on the emerging CAV technologies. Structural equation modelling was adopted in analysing the quantitative survey in order to establish a causal model that can be generalised for the CAV acceptance context. This study finally provides a well-justified CAV acceptance framework, which combines the results identified in the elite interview and the survey. The CAV acceptance framework is intended to include the types of anticipated issues that should be addressed before the introduction of CAV, in order to ensure the diffusion of CAVs in a way that will be truly acceptable by the general public and they will not create more problems than the ones capable of solving, especially when it comes to cyber security and privacy. Although this framework is derived for and address specifically the CAVs context, it is expected to be relevant to other new technologies acceptance that involve human participation; therefore, the present model can inform eventually other more generic studies that deal with a number of other cyber physical systems.

6.3 Contribution of the research

This section provides the theoretical, practical and methodological implications of this study.

6.3.1 Theoretical implications

The core contribution of this study is to develop a conceptual framework that allows for better understanding of attitudes towards CAV acceptance with a specific focus on the agendas of cyber security and privacy. The literature review on the innovation and technology acceptance theory contributes to the future technology acceptance research design. Additionally, this study has taken into consideration the elements of gender related, age related and cultural related issues and their impact on CAV acceptance.

The extensive literature review and research design in Chapter 2 and Chapter 3 discussed the emergent vulnerabilities of CAVs and the existing models relating to the broader area of technology acceptance. It was found that there was a significantly small or limited body of work relating to the nexus of acceptance and policy per se. The human factors research for CAVs are mainly focused on their development phases, implementation including policy and practice, challenges and user characteristics, user opinions on CAVs referring to law and liability, public acceptability, attitudes, awareness, willingness to use, willingness to pay, and their fit with other road users like pedestrian and cyclists. Research on CAVs' network security vulnerabilities and privacy, breaches or risks through the lens of human factors is limited to date.

This study provides theoretical contributions of the existing literature on CAV acceptance in relation to the privacy and cyber security agendas. The main findings of this study, namely the thematic framework and the CAV acceptance model, act as complementary frameworks that make it more generalisable to a broader innovation acceptance research area. More specifically, the qualitative research focused on collecting interview data from the field experts in CAV industry, academia, policy making entities, cyber security firms, has been exploratory, contributing to the interdisciplinary research design of the CAV diffusion research field.

The quantitative research contributes both to theory testing and theory development. This empirical research tested and confirmed the causal relationship of TAM in the context of CAV acceptance. A new model was also developed by adding three new latent factors to the TAM model and these factors were identified as determinants of CAV acceptance when considering cyber security and privacy issues.

Additionally, this study offers cultural, gender and generational perspectives to explore relationships between perceived CAVs characteristics and attitudes. It emphasises the role of perceived cyber security and privacy risks in influencing CAV acceptance that were particularly challenging for Millennials. The nature of the sample used in this study also contribute to the theory in a unique way as most studies that have adopted TAM focus on western cultures, and there is lack of developing countries representation in testing such models (Teo and Noyes, 2008). Findings from this study proved that a model like TAM is also valid for the Chinese culture context.

The final contribution to theory made by this research is that this is an attempt to test the attitude toward an innovation that has not yet entered the market; that is to say that people who have been surveyed were those with no prior experience with CAVs. As most TAM studies typically have surveyed people who have a certain level of exposure to the particular technology, this research validated the model for an attitude object relatively unknown and certainly untested from the majority of the respondents.

6.3.2 Practical implications

The qualitative phase of this study provided a useful framework that consisted of six themes which should be addressed for the policy, planning, design and manufacturing of CAVs before their full-scale launch. Particularly, the six-theme conceptual framework adds to the dialogue about what the priorities should be on CAV cyber security and privacy policy development. This framework may be tested, improved and extended to a broader IOT application research.

The empirical findings have strategic implications that are relevant for the CAV manufacturers and software developers to remain vigilant against the weak cyber security and privacy design that may compromise the overall product. As such, they need to prioritise CAV's cyber security and privacy in the product design process. For policy makers, it highlights the urge when crafting the regulatory regime to foster the widespread use of CAVs, ensure working with a wide range of stakeholders to balance the cyber security and privacy concerns thereby advancing caution for the CAV industries and their innovation. For the public sector (i.e., Departments and Ministries of Transport), they must continue to be advocates of CAV introduction at the first instance in trials and living labs, to close the existing gap in public's lack of awareness regarding cyber security and privacy risks. The transport sector should actively retrain and upskill the public by offering workshops and campaigns. CAV vendors should work on providing information making these vehicles easy to operate, convenient, safe and useful for end users. The shared use subscription business model on CAV sales would help to propel its sales thereby boost CAV market competitiveness or position thereby endearing it to the users. For the potential consumers and end users, they should be aware of the cyber security and privacy risks in the digital era and as such actively attend training that are offered by the public sector or their organisations.

Although technology acceptance is researched in various contexts, the final model tends to cover a wide range of problems, thereby limiting the use of those stakeholders attempting to implement their inventions into their decision-making process. The final integrated model proposed by this study presented in detail some specific factors that need to be considered in decision-making and further explored.

In terms of the perceived characteristics of CAVs, for example PEOU and PU, the results show that perceived usefulness contributes the strongest to intention to use CAVs. The positive relationship between perceived ease to use and attitude to use is stronger for females in the UK and the GenX. In this context, to attract more CAV users, promoting the usefulness of CAV is key. The respondents in this study have acknowledged the useful features that CAV could provide, like freeing drivers hands, saving time on the road, improved traffic efficiency and less concern with parking lots. Furthermore, 'the ease to use' characteristic is particularly in favour of generation X, it is therefore important for the developers to design the system in a way that is user friendly and easy to operate.

Self-efficacy has a positive effect on perceived ease of use which was also found to be less influential among GenX. Therefore, training and education should be provided to the users on all levels of CAV operation skills and CAV related cyber and privacy safeguarding skills. For the current situation on how people source for cyber security protection, there exists a gap on official authoritative sources where the public may get adequate cyber security training (Rader and Wash, 2015). Public sector should focus on the nationwide public cyber security training; policymakers should work together with the CAV industries in user's education on this matter. Training and education work effectively in boosting users' self-confidence in the use of technology which in turn increases their possibility to use.

Perceived cyber security and privacy risks, facilitating conditions have also been found to be an important determinant construct in the attitude shaping process referring to CAV. This finding suggests the CAV software developers, as well as third party service providers need to pay attention on the cyber security design and privacy design of the system. From the cyber security side, it has been acknowledged by the respondents that they are concerned of location correlation cyber-attack. From the privacy side, public's concerns include fear of their location being tracked or their identity being accessed without their consent or authorisation. As such it is necessary for the developers to design the privacy features in a manner that would restrict an unauthorised access of users' location or data that may be stolen.

Trust bridges the gap between users' perceived CAV characteristics and their attitude and intention to use. Trust would be developed once the positive characteristics of CAVs are established such as the security of CAVs (both physical security and cyber security) and the available facilitating conditions of CAVs have been affirmed by the users. Backed up with the quantitative study results it is apparent that public acceptance depends on trust. Media is an instrumental player in influencing public opinion by espousing and scrutinizing new technologies and whose results may either break or build public trust towards those technologies. Similarly, disinformation and fake news diffused via social media has made it possible to manipulate the public. Thus, the public sector must put a closer look on making sure that the social media provide more accurate information. This would possibly help ensuring that the news about the early implementation phase of CAVs are not inaccurate, manipulative or misleading.

6.3.3 Methodological implications

This study contributes to the research methodology by utilising thematic analysis in analysing field experts' attitudes and by subsequently developing a thematic framework. Further, this study contributes to the technology acceptance area of research by using a three-step structural equation modelling approach. More specifically, exploratory factor analysis was applied to integrate qualitative results with the theory-based model. The proposed model was then confirmed using confirmative factor analysis. Lastly, a structural equation modelling technique was adopted to analyse the causal effect between the factors.

When researchers study future technology acceptance research, a small qualitative sample might not generalise the result to other types of technology acceptance. Whereas when researchers using quantitative methods examine a large population sample, the in-depth understanding of one important finding might be diminished. Hence, the combination of interview and survey data would give a more comprehensive understanding of the research questions than the single method. This study has approved the use of such a combination by accommodating both elites and the public's voices. Not only the research method is generalisable to future research, the findings have provided a transport technology acceptance model that can also be adapt and tested in other transport scenarios.

The existing literature on CAVs is primarily focused on technical, computer and engineering issues. There is a significantly smaller body of work referring to the nexus of acceptance and policy per se; there is no study that has researched or analysed qualitative data by reflecting on the views of CAV experts about CAVs' cyber security vulnerabilities and privacy breach risks. This work utilised elite interview thereby contributing to the existing field of CAVs' literature uniquely. The in-depth interviews with members of the scientific, political, economic, or social elites provide valuable insights that could be critical to the exploration of a research topic may not be obvious to the general public. Moreover, the use of elite interviews is beneficial for the policy and planning of CAVs as the emphasis of the research was on privacy and cyber security issues that may be unfamiliar for the average future end-user. The general public is still not adequately exposed to the privacy and cyber security specifics of CAVs, despite some media coverage, and might not have adequate knowledge, answers or sufficient understanding on the subject.

As discussed in Chapter 3, a big proportion of AV acceptance studies were found to have an unclear theoretical framework which subsequently introduced bias in the research process. In other words, a fair number of the AV acceptance studies have methodological quality concerns. Drawing from the above reasons, this study has combined expert insights and a theory based conceptual framework to develop a CAV acceptance model.

The nature of the sample used in this study contributes to the methodological implications. The sample comprises of voices from both field experts and general public the latter from two very different cultures.

There is a limited literature that demonstrated the use of multi-group analysis (MGA) in SEM. This research is among a few studies that utilised the multi-group analysis technique in analysing the moderation effects of the structural model. The result indicates that this technique is useful in understanding the model constructs in depth. Moreover, this study has successfully demonstrated that MGA can be used in examining the effects of different cultures, gender, and age groups on CAV acceptance.

Finally, a sequential mixed method approach (Creswell, 2008; Creswell and Plano Clark, 2007; Creswell and Tashakkori, 2007) was used for data analysis. The qualitative research phase employed a thematic analysis approach looking in-depth at the factors that reflect and affect CAV acceptance related to privacy and cyber security agendas. The quantitative phase adopted a quantitative modelling approach to examine the extended TAM framework that aims to investigate factors leading to users' adoption of CAVs. Few past studies have utilised both qualitative and quantitative research together (Tashakkori and Teddlie, 1998). Though a number of prior TAM studies utilised a quantitative data analysis approach, a search of the literature did not reveal TAM studies using a mixed-method approach. Therefore, by utilising a sequential mixed method approach for data analysis, this dissertation added value to the literature by linking theory building to empirical evidence. Furthermore, as mixed method research is a systematic approach that considers the diverse agenda of a broad subject, hence, this is a rare but successful attempt using the mixed method in understanding CAV acceptance related research.

6.4 Reflections and limitations

While the first phase of study is a rigorous qualitative work, that followed a systematic data collection and analysis approach in line with best practice in qualitative research the author acknowledges that there are limitations in the author's study. Braun and Clarke (2006) argue that a strong thematic analysis does not necessarily focus on following procedures "correctly, accurately, or reliably" or achieving a perfect consensus between coders. Rather, it focuses on the researcher's reflective and thoughtful engagement with both the data and the analytic process. In general, the researcher agrees with Braun and Clarke that there is no single way of analysing the data, because it is impossible for any researcher to avoid ontological, epistemological and paradigmatic assumptions. Coding will always reflect the researcher's philosophical standpoint and research values, while reliability measures only confirm that the analyst, coded the data in a meticulous way that was confirmed and validated by her supervisors overseeing efforts and approved by a prestigious journal that published the qualitative study (Liu, Nikitas, and Parkinson, 2020).

The author has adopted the Braun and Clarke's six-step thematic analysis approach which seeks to develop a fluid and recursive frame which is different from the rigid and structured frame that the traditional codebook approach typically uses. But at the same time, the use of a consistent interview guide and reliability measures to improve the coherence and validity of the study provide an extra layer of validity to the research. This was a systematic, intensive and insightful interpretative approach that reduced to a considerable degree inconsistencies and potential individual researcher biases. As a whole the work actively combined two schools of qualitative thought following the line of conduct of previous well-established and regarded qualitative work (Nikitas *et al.,* 2018, Nikitas *et al.,* 2019).

It should not be ignored that elite interviews do not necessarily represent the acceptance of users per se; distinctive differences of opinions are bound to exist between the two groups. What the elite interviewees think does not make it the case so the reader should be aware of the difference between our data set and the phenomena studied. The author also acknowledges that the elite voices reported from industry, academia and policy speak their own truth and are not privileged to report the unbiased universal reality. It should be recognised that most of the respondents being employed in senior positions in jobs heavily involved in one way or another with CAV-related agendas could make some of their opinions more prone to bias favouring CAVs. Furthermore, it should be acknowledged that the interview guide might not have been able to capture, despite the researcher's best efforts, all the diverse dimensions of these multi-faceted phenomena examined meaning that some areas could still be relatively unexplored.

The small participation of female respondents although representative of the male-dominated field of CAVs may also generate some bias. Moreover, this study focused primarily on elites from the UK. The sample size (i.e., the small number of participants) and the qualitative nature of the study per se might restrict the generalisability of the qualitative findings to a much broader context.

As for the quantitative research, there might be a range of other demographical factors that have not been considered by this research which may potentially influence the relationship differently between the constructs. For instance, a respondent's education level was found to influence self-efficacy (Schunk, 1995); this was not recorded in the present study.

This research has adopted a self-reported survey method in the data collection process. The self-reported measurement might not be able to fully reflect user's real-life experience or behaviour. Like most data collection methods, self-reported assessment tends to be subject to response bias. For instance, respondents might over or under evaluate their self-efficacy in this study due to their personal characteristics or cultural dynamics. Future research could mitigate or eliminate this issue by collecting longitudinal data on the same sample over time or use survey techniques in combination with experimentation or observation to validate the behavioural consistency of the respondents. However, it is rather natural and common to find behaviour inconsistency in humans, so it is therefore important for the researcher to clearly understand one's research aim, and carefully choose an appropriate research method.

Although this study incorporated three extra diverse factors in addition to the original TAM model, there is still abundant room for investigating other factors that may have strong influence on the CAV acceptance such as the price evaluation (Herrenkind *et al.,* 2019) or the willingness to pay (Hohenberger *et al.,* 2017) in the context of autonomous vehicles. The reason as to why this research neglected price considerations is because, for all service-based technologies, price is always a strong factor that influences peoples' decision to use. However, the author argues that the key issue is not to investigate how much the user is willing to pay but rather the type of billing models that are likely to be accepted by the users. For example, personal contract purchase (PCP) (McElvaney, Lunn, and McGowan, 2018), mortgage (Taltavull *et al.,* 2011) helps to increase affordability. Future research can focus on developing a billing model that is suitable for a CAV widespread diffusion, whether or not it can be subscription-based billing model, one off payment model, or a bundle payment model.

6.5 Future research

To the best knowledge of the author, this is the first study to focus on cyber security and privacy concerns over CAV acceptance, and compared the attitudes towards CAVs in the UK and China. There are several numbers of future research ideas that could be inspired by this study as detailed below.

Firstly, future research should consider gauging responses from a more balanced international sample. In this regard, the study should test and compare the context of different countries, geographic regions and evaluate the country-specific characteristics of the issues associated with CAVs. The present focus on user acceptance makes it necessary to extend the research focus, beyond elites and their perceptions of privacy and cyber security and explore public opinions. Despite their limited engagement with CAVs the average future user may have different notions to report on this topic.

Furthermore, the quantitative research looked to explore through the means of a quantitative survey, based on the themes discussed and contextualised herein, the general public attitudes towards CAV acceptance with a special focus on the privacy and cyber security issues. Future research could potentially focus on other risky aspects of CAV and investigate public attitudes towards them. Additionally, effort can be made to qualify the quantitative results themes in order to examine public attitude association.

Moreover, it is recommended that future research employs a longitudinal design to investigate how public attitudes could influence behaviour intention in the actual life. Discussion can also open up around the self-reported behaviour and the real-life behaviour differences, as well as the factors that do influence such differences.

Future research could also consider utilising other available theories in understanding CAV acceptance. By applying different models and theories on CAV acceptance research can help understand this issue at higher levels and assist the transition to a fairer, safer and more sustainable CAV-centric mobility paradigm.

Finally, further research could focus on using a different research design method in reasoning users' acceptance with real life experience. For instance, using experiment design to survey participants who have real life experience on using and operating CAVs and using simulation and observation to understand users' incident response under cyber attach and privacy breaches scenarios.

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Appendix A. Interview Guide

Hi___, Thanks for coming to talk to me today, I hope this interview will be pleasant and interesting for both of us. As you know, this interview is about the experts ‘insights of cybersecurity and privacy in connected and autonomous vehicles.

I need to check out a few things with you before we get started. This interview will be anonymised and be confidential. It will be used for the purposes of this research study only. You can withdraw at any point during the interview. This work will be audio recorded and transcribed for precision purposes. Is that okay with you?

1	What information will CAVs collect from the user?
2	Will CAVs provide a sufficient level of privacy?
3	What classifies as a breach of privacy for the CAV environment?
4	What can CAV manufacturers do to ensure personal space and privacy?
5	How important is privacy for CAV users and CAV manufacturers?
6	What are the measures that could help the user achieve a ‘more private’ CAV environment?
7	How can the user help with the task of safeguarding one’s privacy when using a CAV?
8	How do you define cyber security?
9	What does cyber security mean to ordinary people?
10	What an attacker can do to a car if he/she was able to communicate on CAV’s internal network maliciously?
11	What is the current state of cyber security and what are the trends for the future regarding cyber security in CAVs?
12	Does the industry and other stakeholders understand how cyber threats evolve and how to anticipate them? What do you (or suggest to) do to avoid them?
13	What should be done before we introduce CAVs into the market?
14	Will engineers/technology providers/regulators be able to solve most modern cyber security problems in AVs?

15	Who exactly is responsible for these problems?
16	How can the user help with the task of safeguarding one’s cyber security when using a CAV?
17	How CAV acceptance could be undermined by cyber security and privacy flaws?
18	How can we maintain or inspire trust?
19	What are the common cyber security and privacy mistakes users make?
20	What skills should the user of CAVs have from a cyber security and privacy point of view?
21	What type of education should be provided to CAVs users?
22	What is the role/responsibilities of end-user for CAVs?
23	Who should provide user education for CAVs and how?
24	What is the advice we give to end-users? To what extent do you think they can understand it?
25	How can we promote user responsibility?

Appendix B. Online Survey

<u>Factors that might affect end-users adopting CAVs</u>

Introduction:

Life in the future: How Do You Want the Future Driverless Car to Be?

Connected and Autonomous Vehicle (CAV), also known as a driverless car, self-driving car, driverless car, robo-car, or robotic car, is a vehicle that is capable of sensing its environment and moving safely with little or no human input.

We are conducting a study looking into public attitudes towards connected and autonomous vehicles (CAVs). This will help us to identify problems and opportunities and propose solutions that could make future CAVs design more user centred.

Frequently asked questions

Who is conducting the research?

This research is being carried out by Na Liu, as part of her research project at the University of Huddersfield. The study is under the supervision of Dr Alexandros Nikitas.

How long will the survey be open for?

The survey will be open for responses until 5 pm GMT on 25th April 2020.

How long will it take?

It is anticipated that you would be able to reply with your opinion in 10 minutes or less.

Will my answers be confidential?

Your responses will be fully anonymous. Neither will you be contacted by anyone who does not work at the University of Huddersfield, and you will only be contacted if you provide permission.

Who can I contact if I have any questions?

If you require any further information, please contact na.liu@hud.ac.uk

I. Demographic Questions

Q1.1 What is your age?

- ◯ 18-25
- ◯ 26-34
- ◯ 35-44
- ◯ 45-54
- ◯ 55-64
- ◯ 65+
- ◯ Prefer not to say

Q1.2 What is your nationality?

[ ]

Q1.3 Do you hold a driving license?

- ◯ Yes
- ◯ No

Q1.4 To which gender identity do you most identify?

- ◯ Male
- ◯ Female
- ◯ Prefer not to say
- ◯ Other [ ]

Q1.5 What is the highest degree or level of education you have completed?

- ◯ Less than high school
- ◯ High school or equivalent (e.g., GED)
- ◯ Professional Qualification/Certification
- ◯ College
- ◯ Bachelor's degree (e.g., BA, BS)
- ◯ Master's degree (e.g., MA, MS, MEd)
- ◯ Doctorate (e.g., PhD, EdD)

Q1.6 What is your current employment status?

- ◯ Employed full time
- ◯ Employed part-time
- ◯ Unemployed and currently looking for work
- ◯ Unemployed and currently not looking for work
- ◯ Self-employed
- ◯ Student
- ◯ Retired
- ◯ Unable to work

Q1.7 What is your occupation/profession?

- ◯ Student
- ◯ Public sector
- ◯ Private sector
- ◯ Agriculture, forestry & fishing, mining, energy and water supply
- ◯ Manufacturing
- ◯ Construction
- ◯ Wholesale, retail & repair of motor vehicles
- ◯ Transport & logistics
- ◯ Accommodation & food services
- ◯ Information & communication, financial & insurance activities
- ◯ Real estate activities professional, scientific & technical activities
- ◯ Administrative & support services
- ◯ Public admin & defense; social security
- ◯ Education
- ◯ Human health & social work activities
- ◯ Other ________

Q1.8 What is your most usual means of travelling to school/work/most frequent destination?

- ◯ Walking
- ◯ Cycling
- ◯ Car/Van (driving)
- ◯ Car/Van (as a passenger)
- ◯ Taxi/Uber
- ◯ Bus
- ◯ Train
- ◯ Motorbike
- ◯ Underground/Metro
- ◯ Other ________

II. CAVs benefits and its associated risks

Q2.1 An important reason for me to use a CAV/driverless car is that it can…

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
I find the use of CAVs would be advantageous to safety.	○	○	○	○	○
The use of CAVs is a good idea on minimize my transportation cost.	○	○	○	○	○
I find the use of CAVs would be meaningful to the environment.	○	○	○	○	○
I think CAVs can be easy to access and use.	○	○	○	○	○
The use CAVs is easy for me because it does not require a licence.	○	○	○	○	○
Controlling CAVs is simple and not require much effort.	○	○	○	○	○
The use of CAVs reduces the hassle for parking.	○	○	○	○	○
The use of CAVs increase the effectiveness and reduce the time when traveling.	○	○	○	○	○
The use of CAVs allows me free my hand so that I can do other activities in transit.	○	○	○	○	○
The use of CAVs reduce traffic congestion.	○	○	○	○	○

Q2.2 An important reason for me to use a CAV/driverless car is that…

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
I do not trust this technology.	○	○	○	○	○
I am concerned about privacy issues of CAVs.	○	○	○	○	○
I am concerned about legislation issues around CAVs' cyber security and privacy.	○	○	○	○	○
I need to get a training certificate specifically for driverless cars.	○	○	○	○	○
I enjoy driving.	○	○	○	○	○
I am concerned about the interior cameras and usage logs will track when and where I have gone.	○	○	○	○	○
I do not know what to do if the car lost control.	○	○	○	○	○
I am concerned about cyber security issues of CAVs. *	○	○	○	○	○

*Cyber security is how individuals and organisations reduce the risk of hacking.

Q2.3 I am concerned about problems that relate to the...

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
Privacy issues of driverless cars.	○	○	○	○	○
Cyber security issues of driverless cars.	○	○	○	○	○
Legislation of driverless cars.	○	○	○	○	○

III. Facilitating Conditions

Q3.1 Who do you expect to have significant control of your personal data? (E.g., travel data)

	Yes	Maybe	No
Government is providing help on protecting my personal data when I am using CAVs.	○	○	○
Mobility service providers are providing help on protecting my personal data when I am using CAVs.	○	○	○
Car manufacturers are providing help on protecting my personal data when I am using CAVs.	○	○	○

IV. Self-efficacy

Q4.1 To what extent are you confident with your existing knowledge about:

	Not confident at all	Not confident	Somewhat confident	Slightly confident	Very confident
Advantages of driverless cars	○	○	○	○	○
Driverless cars related basic data protection practice	○	○	○	○	○
Driverless cars related basic cyber security practice	○	○	○	○	○

Q4.2 How important is for you to have adequate knowledge when it comes to CAVs/driverless cars?

○ Not important at all

○ Slightly important

○ Moderately important

○ Very important

○ Extremely important

V. Attitude and intention

Q5.1 CAVs/driverless cars should substitute conventional cars soon.

- ◯ Strongly disagree
- ◯ Somewhat disagree
- ◯ Neither agree nor disagree
- ◯ Somewhat agree
- ◯ Strongly agree

Q5.2 I am willing to...

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
I am willing to use CAVs and learn how to protect my personal and travel data.	◯	◯	◯	◯	◯
I am willing to use CAVs and be responsible for my behaviour when using the CAV.	◯	◯	◯	◯	◯
I intend to use CAVs even I need to get a training certificate	◯	◯	◯	◯	◯
I am willing to participate in CAV trials, related awareness campaigns, and workshops.	◯	◯	◯	◯	◯

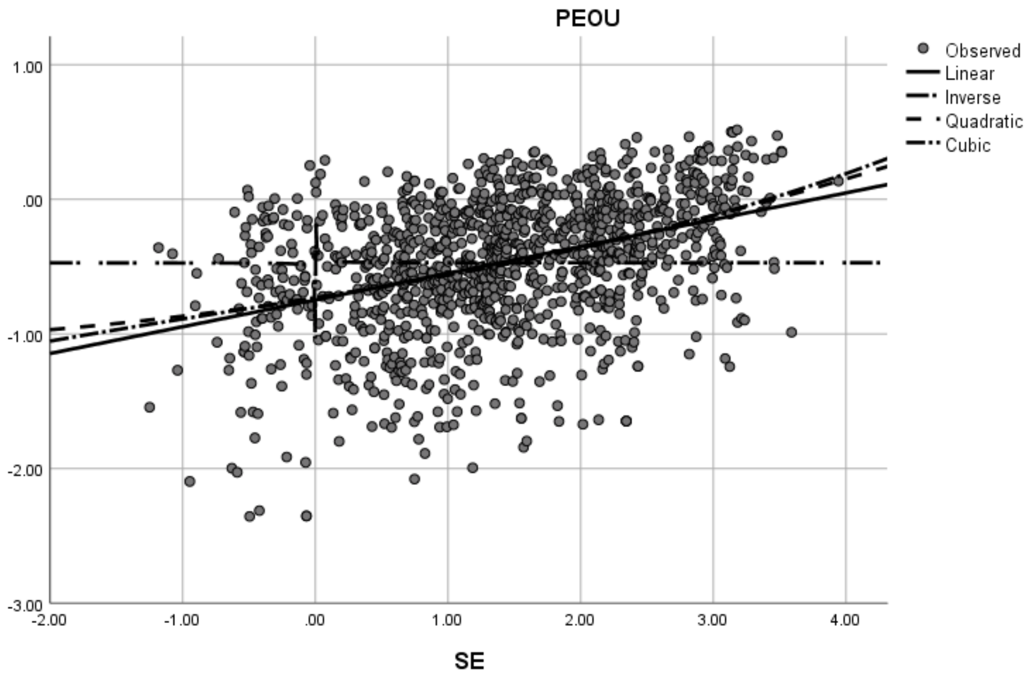
VI. And finally, is there anything you would like to add? *(please write any additional comments below)*

Appendix C. Curve Estimation

Model Summary and Parameter Estimates

Dependent Variable: PEOU									
Equation	Model Summary					Parameter Estimates			
	R^2	F	*df*1	*df*2	Sig.	Constant	β1	β2	β3
Linear	0.155	213.455	1	1160	0	-0.748	0.199		
Inverse	0.002	2.133	1	1160	0.144	-0.472	0.001		
Quadratic	0.157	107.914	2	1159	0	-0.733	0.152	0.017	
Cubic	0.157	71.916	3	1158	0	-0.73	0.161	0.006	0.003

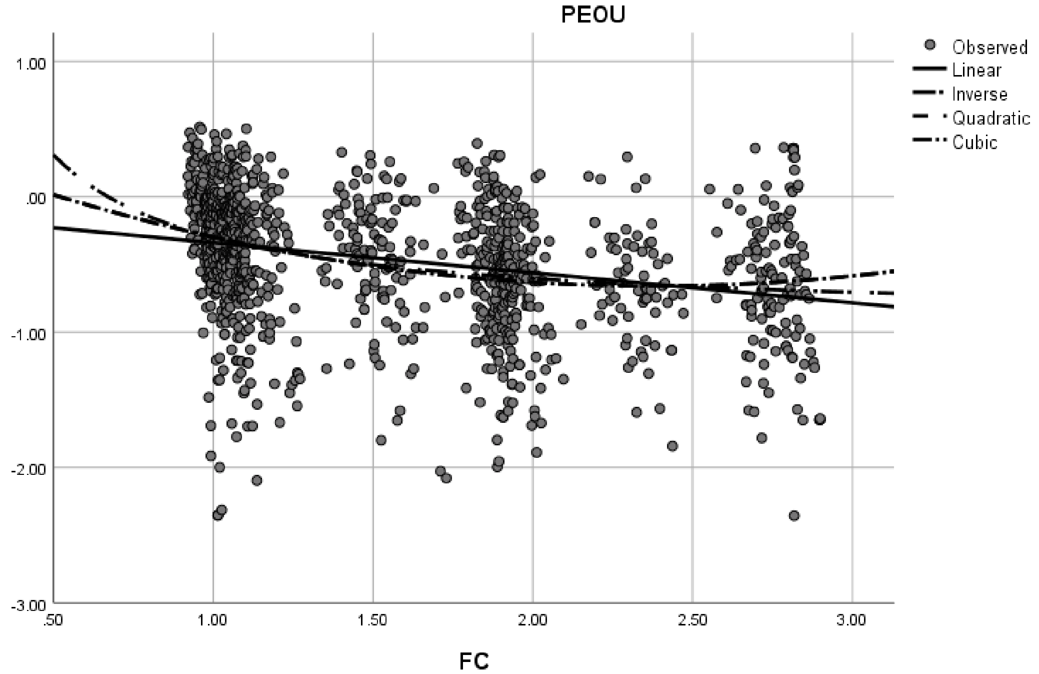
The independent variable is SE.



Model Summary and Parameter Estimates

Dependent Variable: PEOU									
Equation	Model Summary					Parameter Estimates			
	R^2	F	*df*1	*df*2	Sig.	Constant	β1	β2	β3
Linear	0.074	92.147	1	1160	0	-0.119	-0.222		
Inverse	0.089	113.189	1	1160	0	-0.909	0.609		
Quadratic	0.089	56.47	2	1159	0	0.421	-0.909	0.191	
Cubic	0.089	56.47	2	1159	0	0.421	-0.909	0.191	0

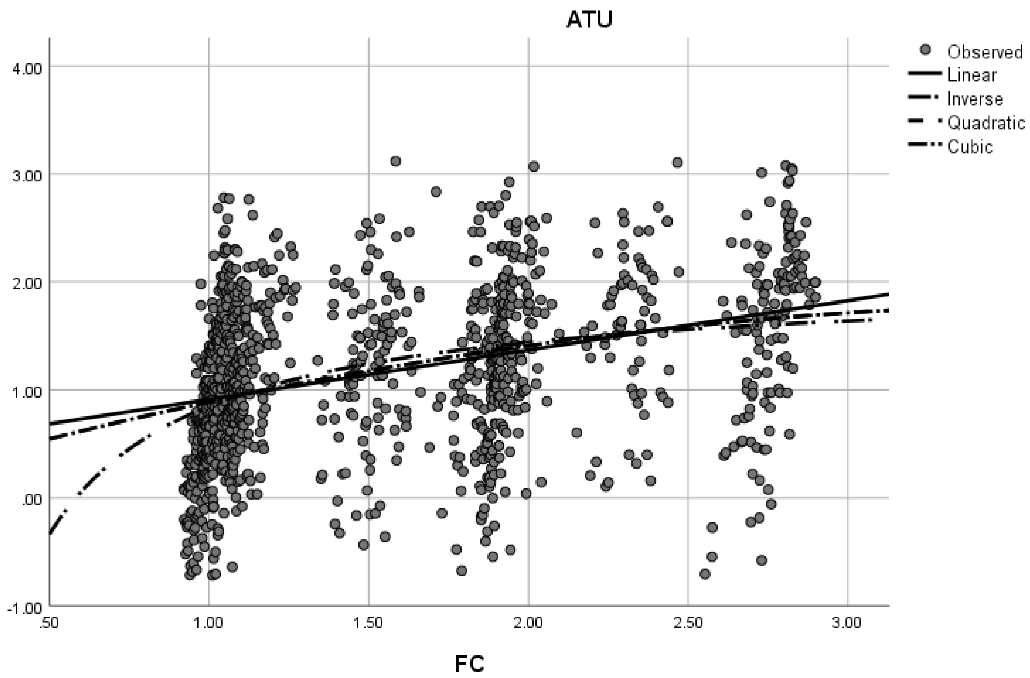
The independent variable is FC.



Model Summary and Parameter Estimates

Dependent Variable: ATU									
Equation	Model Summary					Parameter Estimates			
	R^2	F	*df*1	*df*2	Sig.	Constant	β1	β2	β3
Linear	0.128	170.344	1	1160	0	0.457	0.457		
Inverse	0.138	185.336	1	1160	0	2.034	-1.185		
Quadratic	0.13	86.653	2	1159	0	0.148	0.85	-0.109	
Cubic	0.13	86.653	2	1159	0	0.148	0.85	-0.109	0

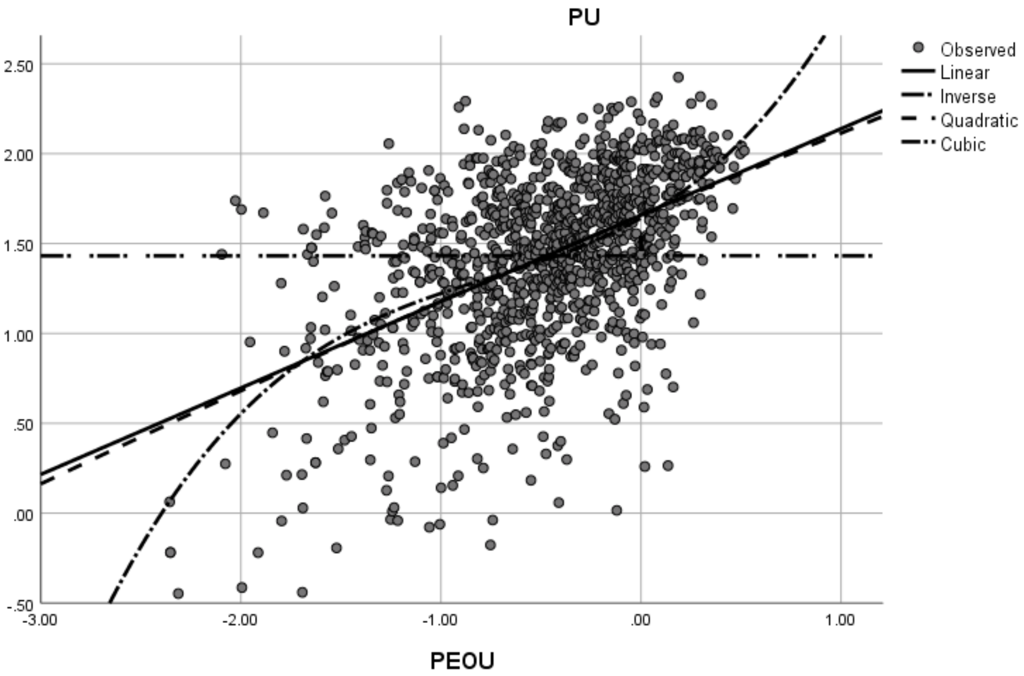
The independent variable is FC.



Model Summary and Parameter Estimates

Dependent Variable: PU									
Equation	Model Summary					Parameter Estimates			
	R^2	F	*df*1	*df* 2	Sig.	Constant	β1	β2	β3
Linear	0.254	395.628	1	1160	0	1.658	0.481		
Inverse	0.001	0.708	1	1160	0.4	1.432	9.97E-05		
Quadratic	0.254	197.701	2	1159	0	1.657	0.468	-0.01	
Cubic	0.263	137.998	3	1158	0	1.642	0.625	0.372	0.166

The independent variable is PEOU.

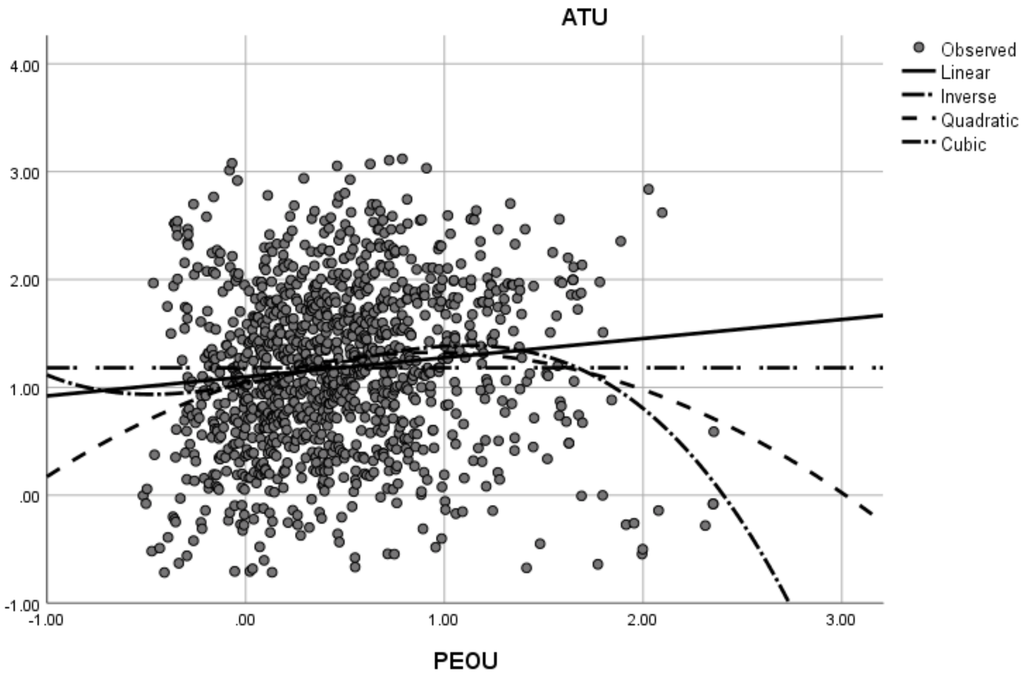


Model Summary and Parameter Estimates

Dependent Variable: ATU

Equation	Model Summary					Parameter Estimates			
	R^2	F	*df*1	*df* 2	Sig.	Constant	β1	β2	β3
Linear	0.013	15.121	1	1160	0	1.098	0.177		
Inverse	0	0.107	1	1160	0.743	1.181	6.36E-05		
Quadratic	0.032	19.247	2	1159	0	1.053	0.575	-0.306	
Cubic	0.038	15.401	3	1158	0	1.033	0.36	0.215	-0.226

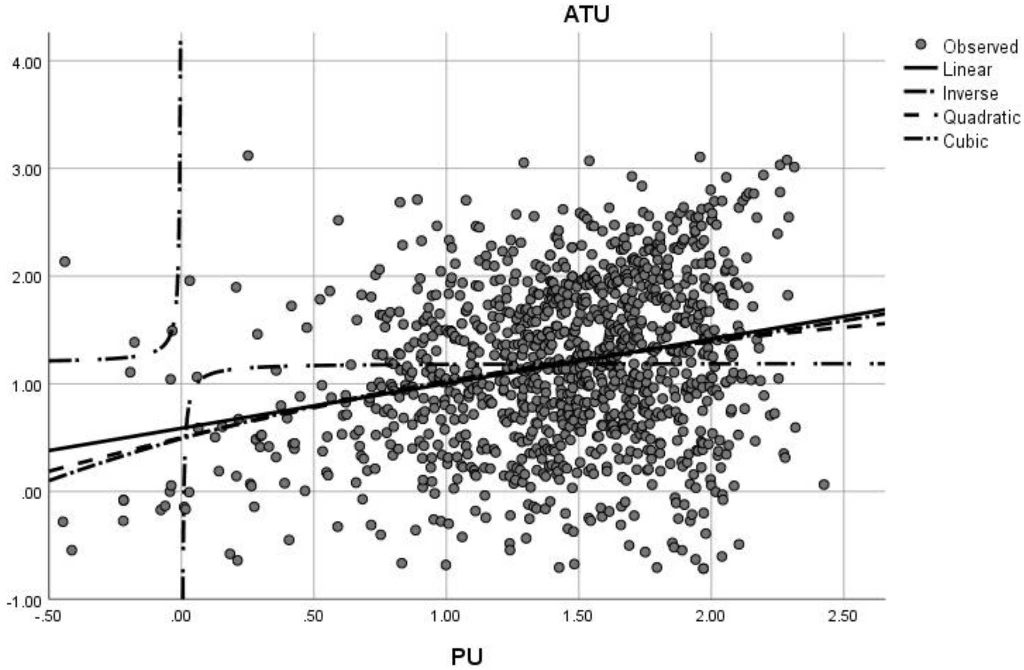
The independent variable is PEOU.



Model Summary and Parameter Estimates

Dependent Variable: ATU									
Equation	Model Summary					Parameter Estimates			
	R^2	F	*df*1	*df*2	Sig.	Constant	β1	β2	β3
Linear	0.064	79.389	1	1160	0	0.587	0.415		
Inverse	0.003	4.019	1	1160	0.045	1.191	-0.011		
Quadratic	0.065	40.303	2	1159	0	0.501	0.589	-0.072	
Cubic	0.065	26.895	3	1158	0	0.491	0.682	-0.183	0.034

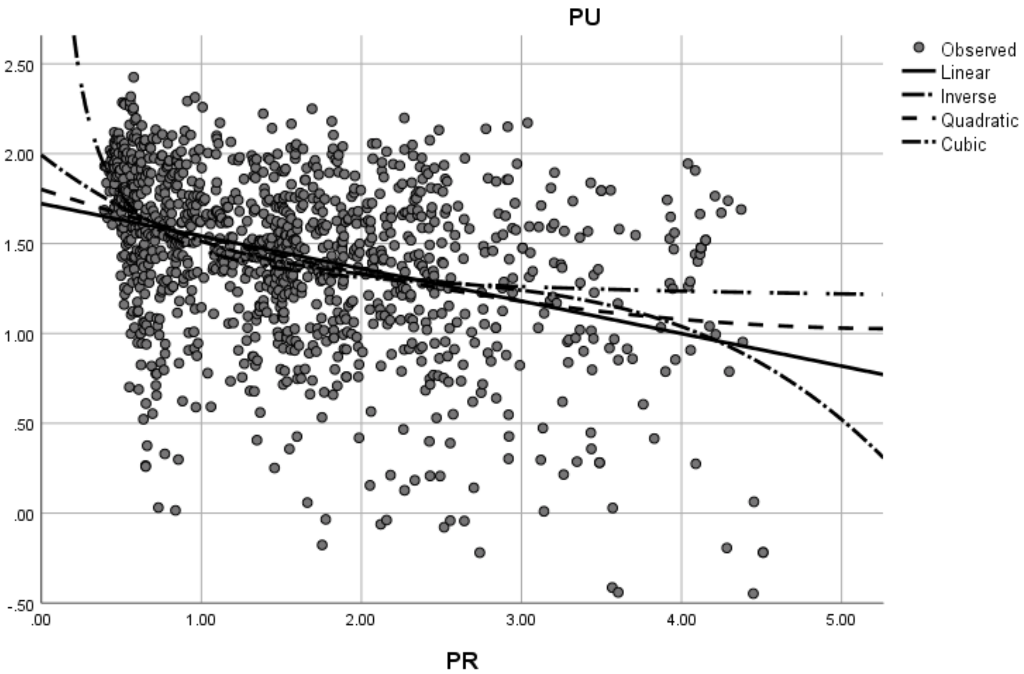
The independent variable is PU.



Model Summary and Parameter Estimates

Dependent Variable: PU									
Equation	Model Summary					Parameter Estimates			
	R^2	F	*df*1	*df*2	Sig.	Constant	β1	β2	β3
Linear	0.127	169.463	1	1160	0	1.722	-0.181		
Inverse	0.129	171.774	1	1160	0	1.159	0.305		
Quadratic	0.131	87.353	2	1159	0	1.801	-0.287	0.027	
Cubic	0.137	61.117	3	1158	0	1.993	-0.696	0.25	-0.034

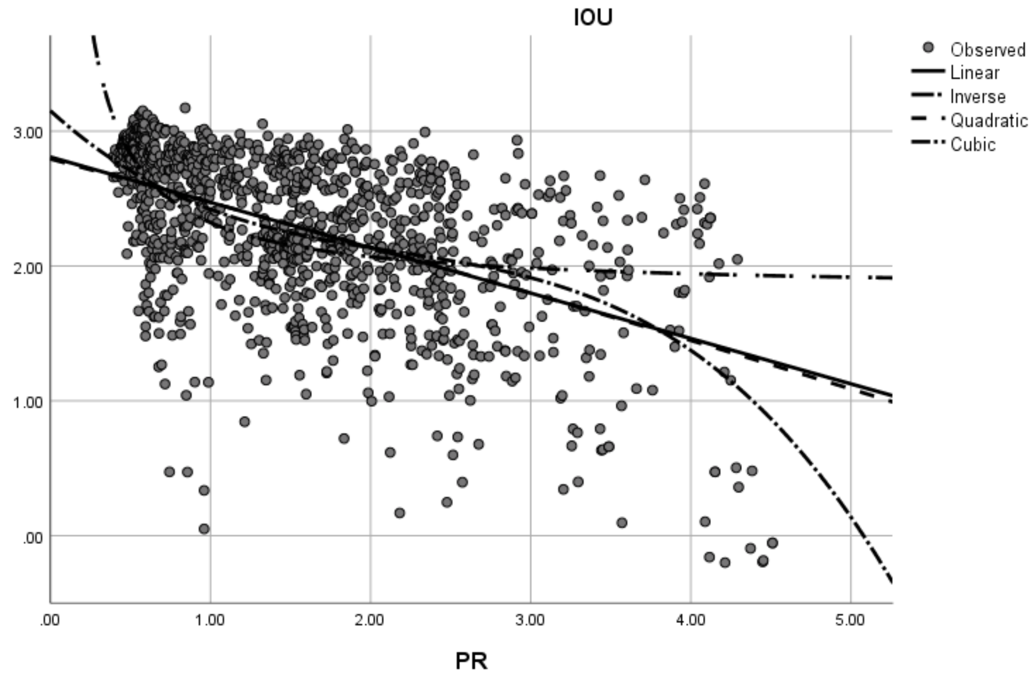
The independent variable is PR.



Model Summary and Parameter Estimates

Dependent Variable: IOU									
Equation	Model Summary					Parameter Estimates			
	R^2	F	*df*1	*df*2	Sig.	Constant	β1	β2	β3
Linear	0.278	445.742	1	1160	0	2.808	-0.337		
Inverse	0.223	332.756	1	1160	0	1.816	0.506		
Quadratic	0.278	222.758	2	1159	0	2.794	-0.317	-0.005	
Cubic	0.29	157.777	3	1158	0	3.152	-1.081	0.413	-0.064

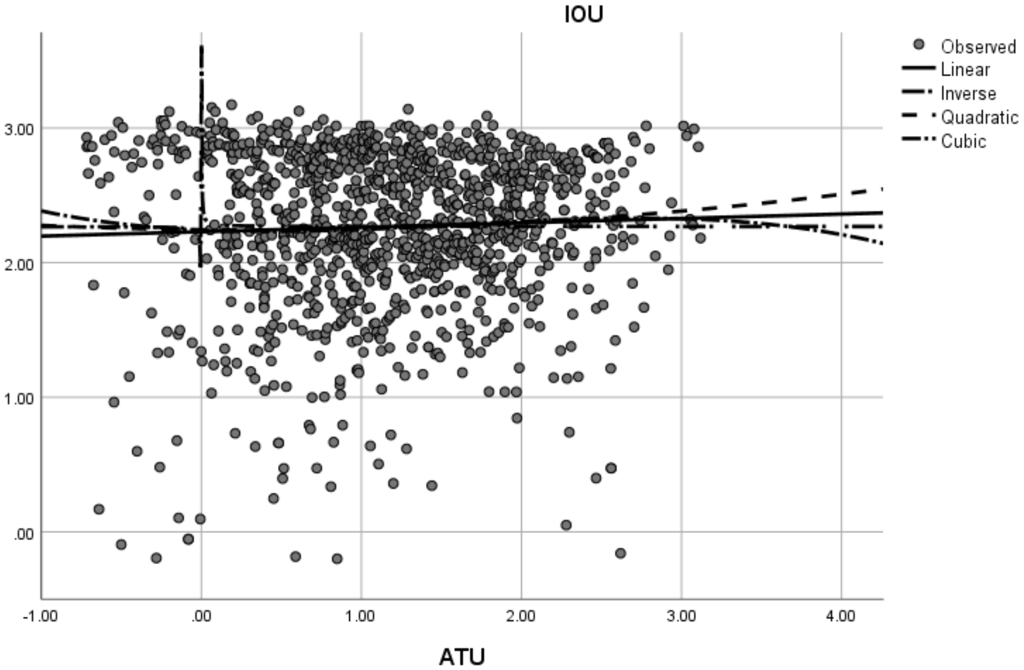
The independent variable is PR.



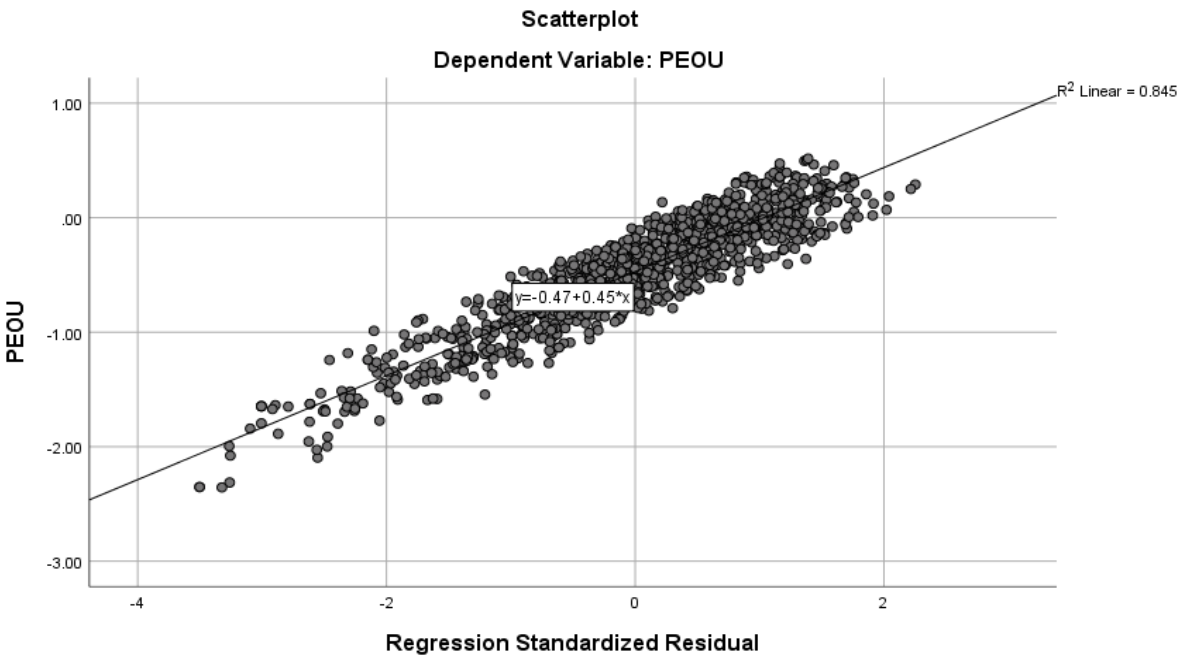
Model Summary and Parameter Estimates

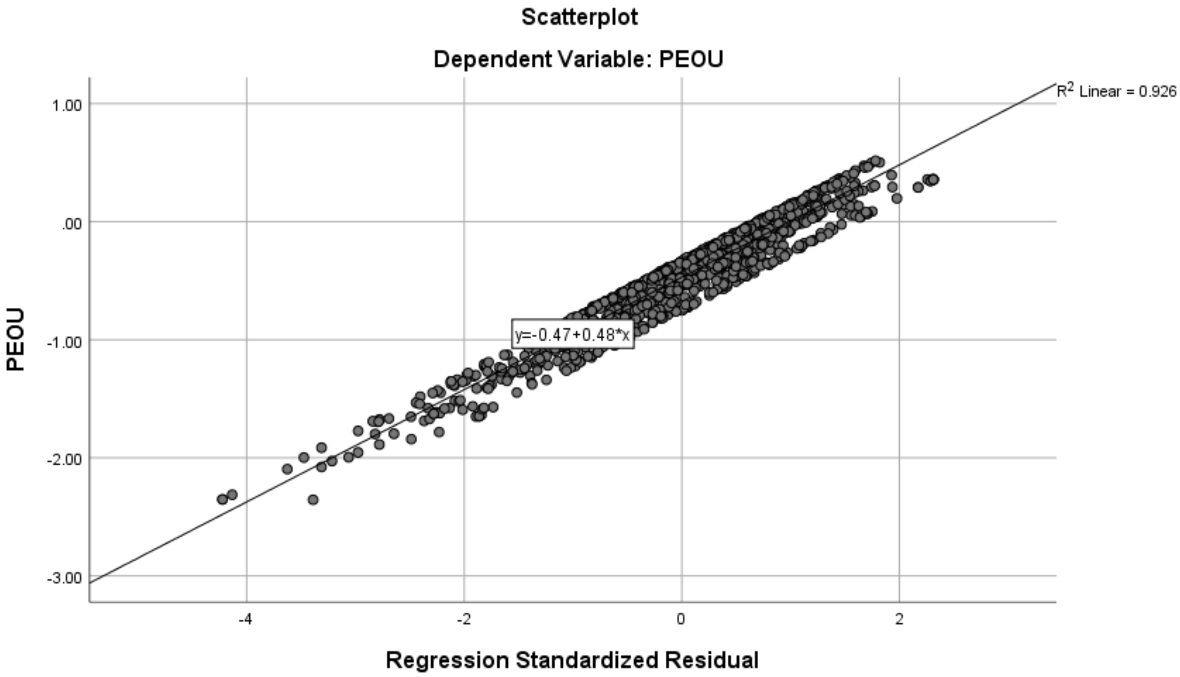
Dependent Variable: IOU									
Equation	Model Summary					Parameter Estimates			
	R^2	F	*df*1	*df*2	Sig.	Constant	β1	β2	β3
Linear	0.002	2.111	1	1160	0.147	2.23	0.033		
Inverse	0.002	2.21	1	1160	0.137	2.268	0.001		
Quadratic	0.002	1.395	2	1159	0.248	2.244	-0.013	0.02	
Cubic	0.003	1.085	3	1158	0.355	2.241	-0.052	0.074	-0.016

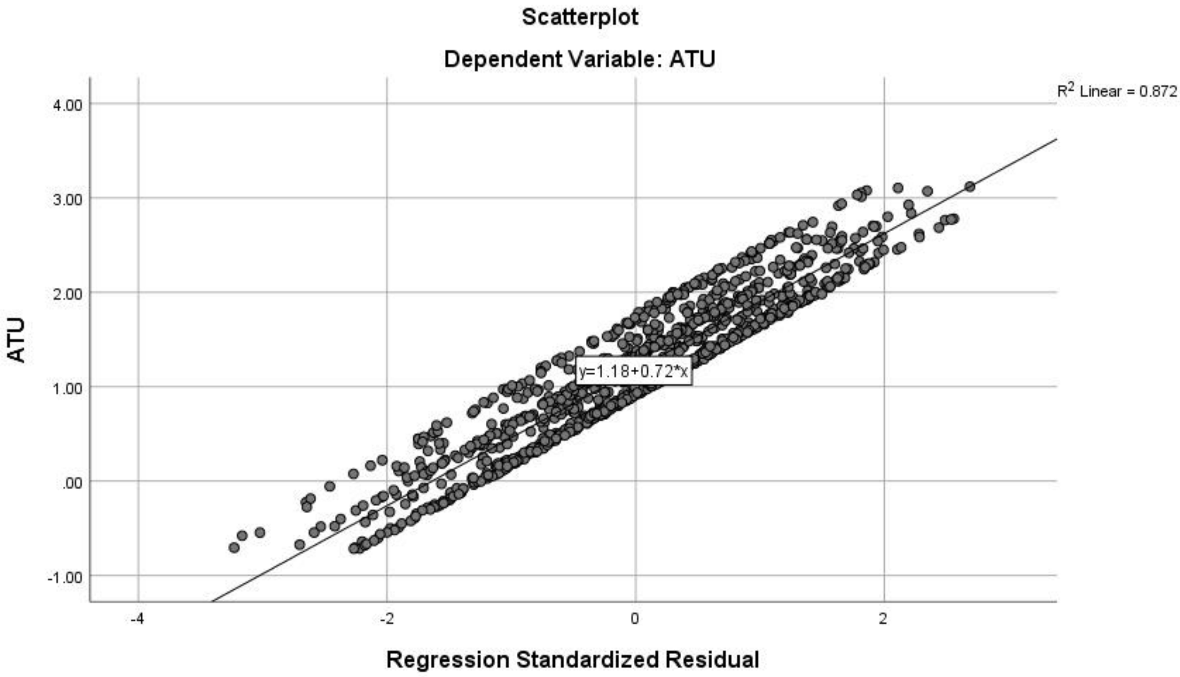
The independent variable is ATU.

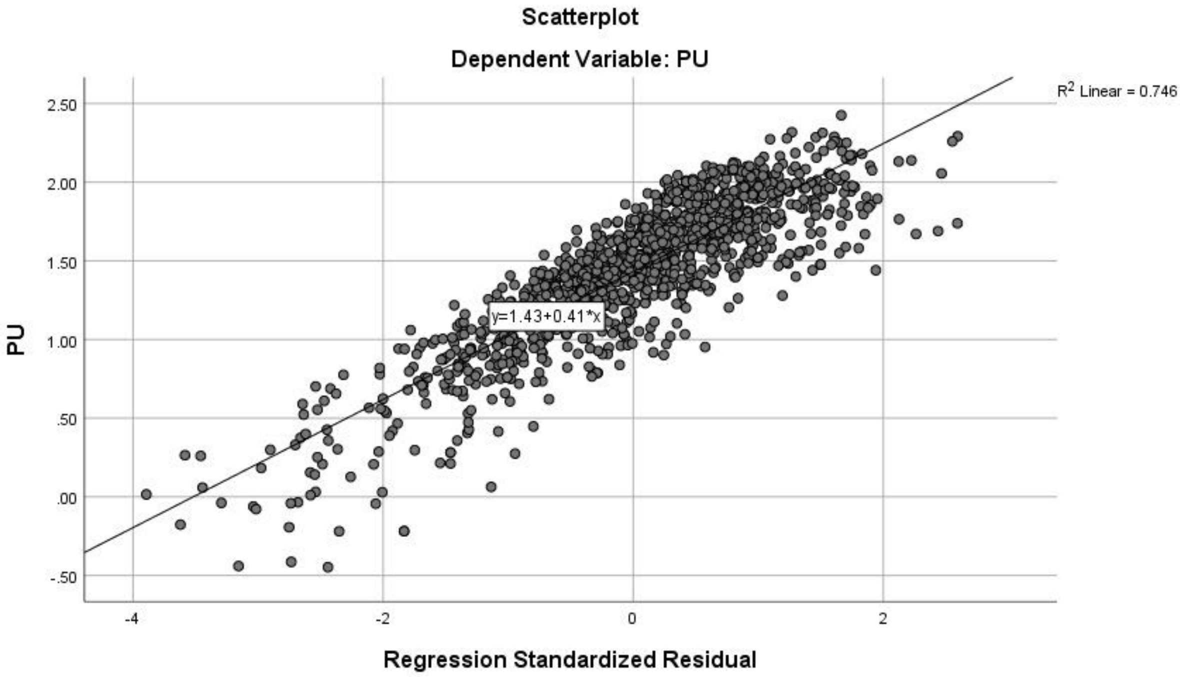


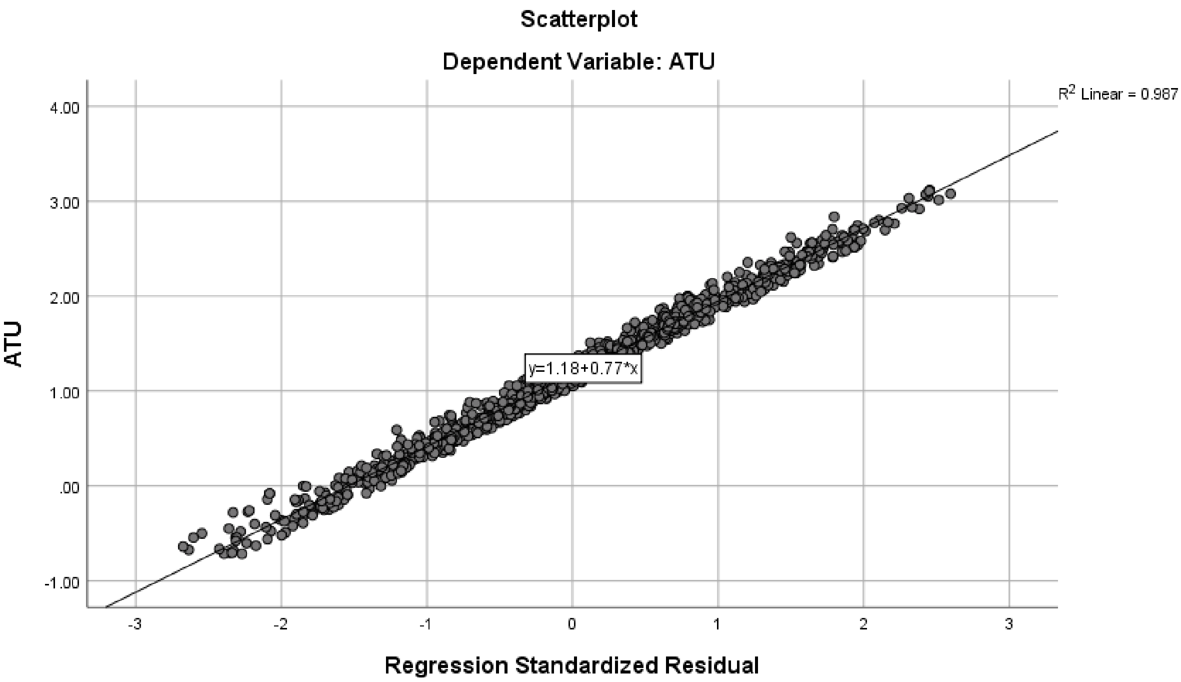
Appendix D. Homoscedasticity

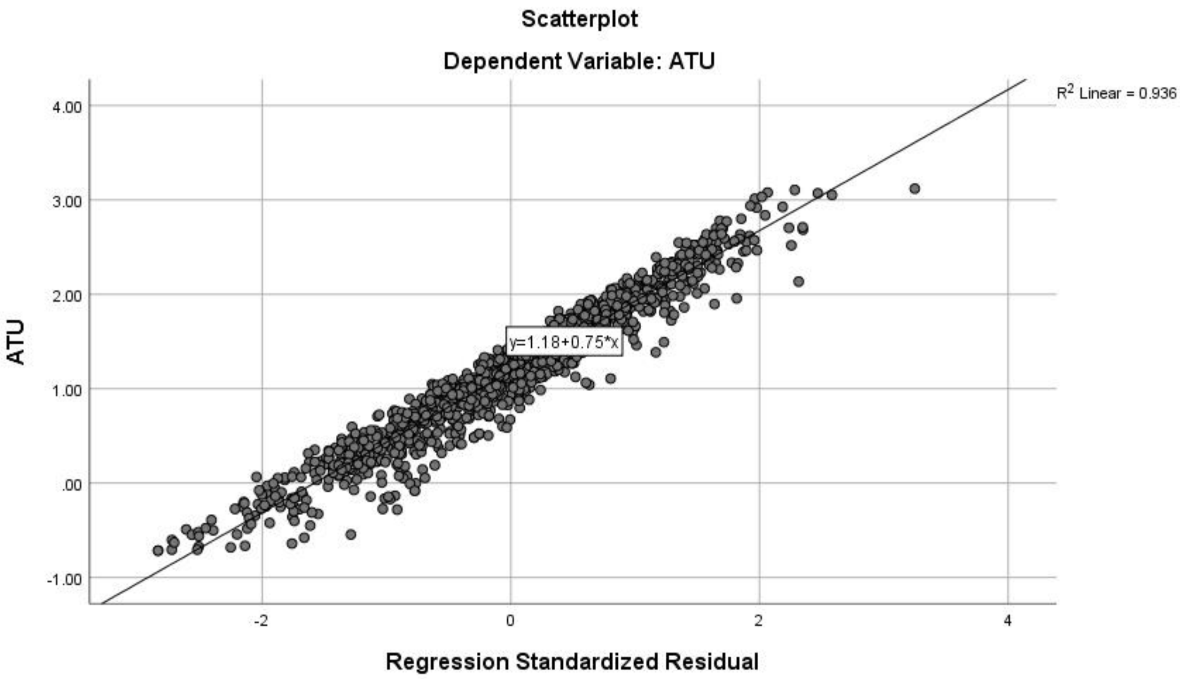


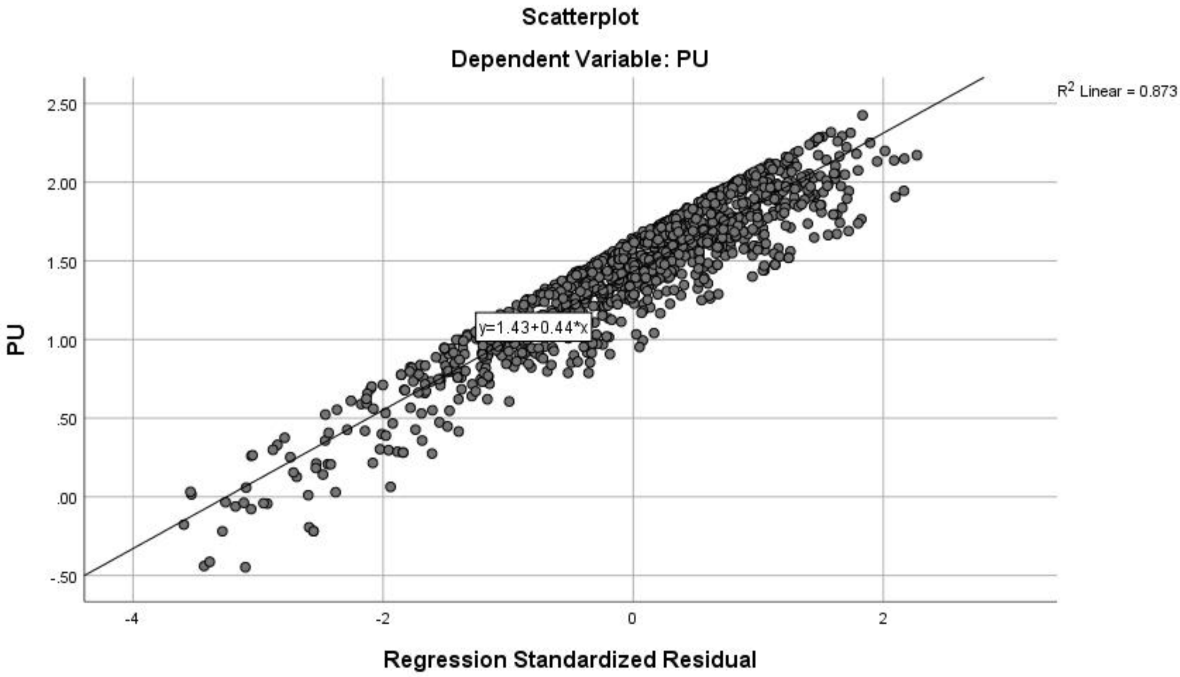


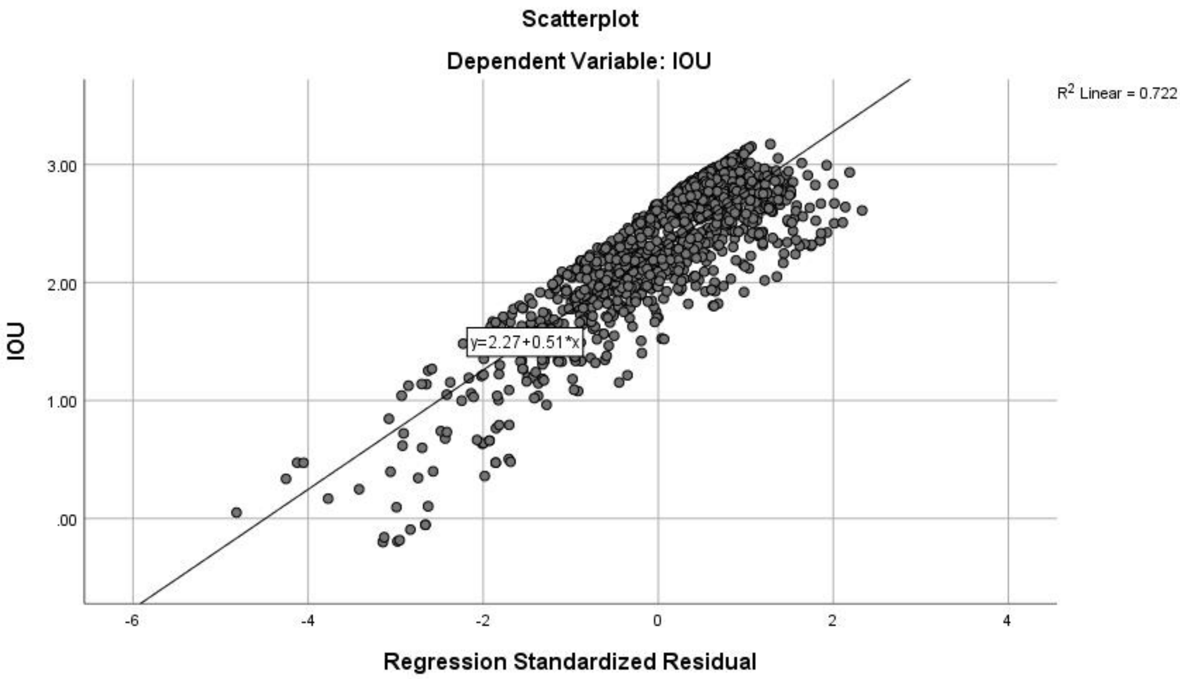

Scatterplot
Dependent Variable: ATU
R² Linear = 0.872
y=1.18+0.72*x
ATU
4.00
3.00
2.00
1.00
.00
-1.00
-4
-2
0
2
Regression Standardized Residual

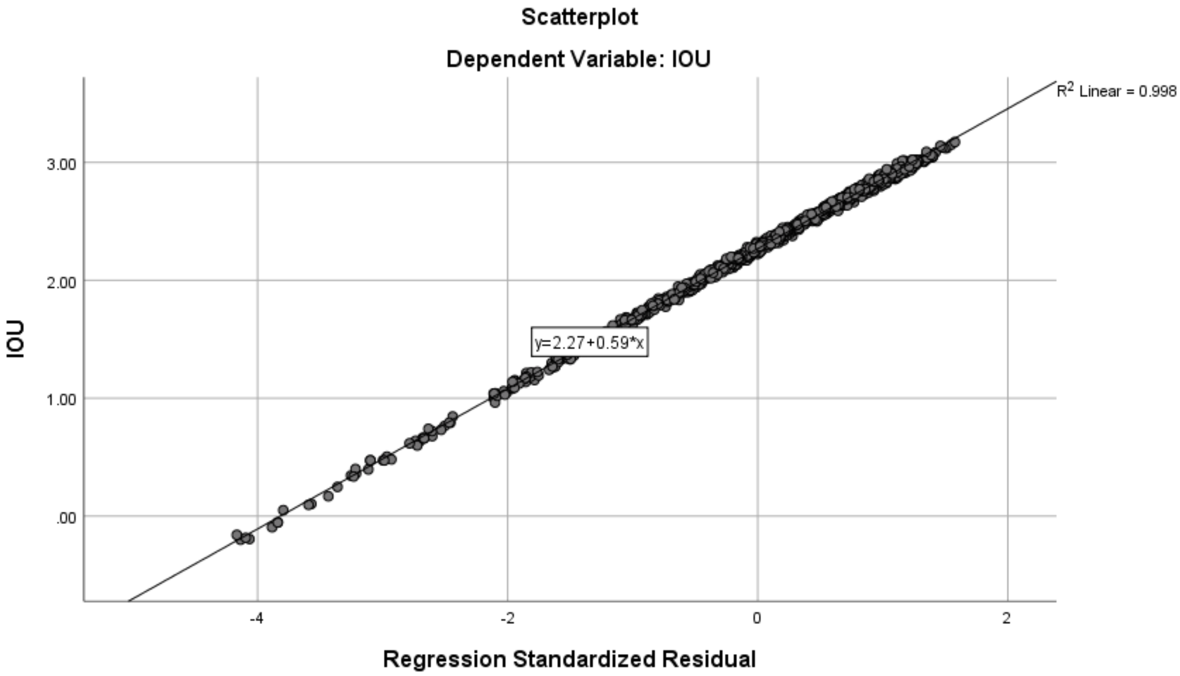

Scatterplot
Dependent Variable: PU
R² Linear = 0.746
y=1.43+0.41*x
PU
2.50
2.00
1.50
1.00
.50
.00
-.50
-4
-2
0
2
Regression Standardized Residual


Scatterplot
Dependent Variable: ATU
R2 Linear = 0.987
y=1.18+0.77*x
ATU
4.00
3.00
2.00
1.00
.00
-1.00
-3
-2
-1
0
1
2
3
Regression Standardized Residual


Scatterplot
Dependent Variable: ATU
R2 Linear = 0.936
y=1.18+0.75*x
ATU
4.00
3.00
2.00
1.00
.00
-1.00
-2
0
2
4
Regression Standardized Residual


Scatterplot
Dependent Variable: PU
R² Linear = 0.873
y=1.43+0.44*x
PU
Regression Standardized Residual


Scatterplot
Dependent Variable: IOU
R² Linear = 0.722
y=2.27+0.51*x
IOU
Regression Standardized Residual



Scatterplot
Dependent Variable: IOU
R2 Linear = 0.998
3.00
2.00
1.00
.00
IOU
y=2.27+0.59*x
-4
-2
0
2
Regression Standardized Residual

Appendix E. Bias Corrected Percentile Method on Examine Mediated Effects

H2a	**Estimate**	**Lower**	**Upper**	**P**
A x B	-0.017	-0.044	0.008	0.169
H2b	Estimate	Lower	Upper	P
A x B	-0.011	-0.035	-0.001	0.026
H2c	Estimate	Lower	Upper	P
A x B	-0.132	-0.202	-0.068	0.001
H2d	Estimate	Lower	Upper	P
A x B	-0.052	-0.096	-0.025	0.001

Appendix F. Model Fit Measures for Multigroup Effects

Measure	China and UK residents	UK gender group	China gender group	Millennials and GenX	Threshold
CMIN	7.79	7.79	7.17	5.91	--
DF	2	2	2	2	--
CMIN/DF	3.89	3.89	3.59	2.96	Excellent: 1-3 Acceptable: 3-5
CFI	1	1	1	1	>0.95
SRMR	0.006	0.006	0.008	0.001	<0.08
RMSEA	0	0	0	0	<0.06
PClose	0.882	0.882	0.922	0.972	>0.05