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# Innovation Adoption in Robotics: Consumer Intentions to Use Autonomous Vehicles

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# Preface

This master thesis is one of a series of papers and reports published by the Center for Service Innovation (CSI). Centre for Service Innovation (CSI) is a coordinated effort by NHH to focus on the innovation challenges facing the service sector and involves 20 business and academic partners. It aims to increase the quality, efficiency and commercial success of service innovations and to enhance the innovation capabilities of its business and academic partners. CSI is funded through a significant eight-year grant from the Research Council of Norway and has recently obtained status as a Centre for Research-based Innovation (SFI).

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# Executive Summary

Fully autonomous vehicles (AVs) are due to be launched in the market within the next few years. These cars are designed to be capable of operating without a driver, apart from destination and navigation input, and are expected to have major positive impacts on the environment, traffic safety, mobility and productivity. Moreover, AVs may cause the car industry to switch from being a product consumers own to an on-demand service, and could lead to the entrance of new industry players.

However, little research exists on the mechanisms that lead consumers to intend to use AVs. The present study aims to expand the knowledge by developing a theoretical model to explain consumer intentions to adopt AVs. The model draws from established frameworks in the innovation adoption literature – the Theory of Planned Behavior, the Technology Acceptance Model, and the Diffusion of Innovations Model – and adds relevant extensions based on findings in research in motives for car use, research on consumer adoption of alternative fuel vehicles and research on consumer perception of product autonomy.

This conceptual model is tested through a cross-sectional survey (N=320). The results reveal that consumers mainly form their intentions based on attitude toward using AVs, as well as the perceived compatibility, usefulness and enjoyment of using AVs. In addition, perceived risk, self-identity, ease of use and personal norms play a role in shaping intentions. Overall, these constructs explain a high degree (79%) of the variance in intentions to use AVs. The thesis concludes with theoretical and managerial implications, along with suggestions for future research.

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# 1. Introduction

## 1.1 Topic and research question

Over the course of the past century, the automotive sector has contributed a flexible and affordable means of transportation for both people and goods, and worked as a catalyzer and facilitator of economic development to the extent that it has been called the most influential innovation of the 20th century (Thrun, 2010). Within the next few years, the industry is posed to go through its most radical transformation to date: a shift from manual to autonomous driving, in which vehicle sensors and computers replace the driver, making cars the first truly intelligent autonomous robots that people will be able to buy and use (Gill et al., 2015).

Autonomous driving technologies operate at different levels of autonomy (NHTSA, 2013). In this thesis, an autonomous vehicle (AV) is defined as a vehicle designed to operate without a driver, apart from destination and navigation input. While such vehicles may see deployment in many domains and for several purposes, this thesis focuses on the prospect of road-based autonomous vehicles for private consumers' personal transportation.

The transition to AVs is expected to have major impacts on the automotive sector: first, AVs that remove the human component to driving could save millions of lives by reducing both the number and severity of traffic accidents (Fagnant & Kockelman, 2015). Second, AVs are expected to have a big environmental impact through optimizing traffic and improving fuel economy (Fagnant & Kockelman, 2015). Third, AVs are predicted to reduce commute time and free up users' time in the vehicle, while simultaneously improving mobility for individuals who currently cannot drive (Fagnant & Kockelman, 2015; Silberg et al., 2012). Finally, AVs may help transition car ownership toward on-demand car services, and change the industry's design focus from optimizing the driving experience to creating experiences while driving (Shanker et al., 2013; Sullivan, 2015).

As AVs hold the potential to radically alter the automotive sector, as well as to provide several major improvements to individual users' lives and society at large, understanding the factors that will influence consumer adoption of AV technology is key. However, a review by Rosenzweig and Bartl (2015) of 399 published articles on autonomous driving found user acceptance to be the least studied aspect of the technology. Moreover, while some research exists on consumer attitude and behavior toward semi-autonomous driver assistance technologies (e.g. Höltl & Trommer, 2013; Huth & Gelau, 2013; Vlassenroot et al., 2011), little research has addressed fully-autonomous driving (Payre et al., 2014). With commercialization of AV technology expected over the coming years, research into which factors are likely to drive consumer adoption of AVs is important. As many of the benefits of AVs depend on active use of the technology, and large changes to ownership structures are expected, adoption of AVs is better measured in terms of the use of the technology rather than the acquisition of it. Thus, this thesis applies Rogers' (1983:176) definition of innovation adoption as a consumer's decision to make full use of an innovation. Since actual adoption naturally cannot be studied until AVs are made available in the market, consumers' intention to adopt the product are the focus of this study. Thus, the *research objective* of this thesis is to develop a model for the study of consumer intention to adopt AVs.

Behavioral intention is often predicted by utilizing multiattribute models, in particular the Theory of Reasoned Action (TRA: Fishbein & Ajzen, 1975) or its extended version, the Theory of Planned Behavior (TPB: Ajzen, 1985, 1991). These models have been utilized to predict a large range of behaviors including within the specific field of consumer decision-making processes (Armitage & Conner, 2001; Venkatesh et al., 2003), and offer a well-established theoretical foundation for volitional behaviors such as the private adoption of an innovation (Venkatesh & Brown, 2001).

However, in innovation adoption research, which to a high degree concerns the adoption of information systems or information technology, Davis (1989) Technology Acceptance Model (TAM) and Rogers' (1983) Diffusion of Innovations Model (DIM) represent the two leading schools of thought (Arts et al., 2011; Venkatesh et al., 2007). These models have been utilized to study consumer adoption intention and adoption behavior across a wide range of products and services (Arts et al., 2011; Venkatesh et al., 2007), including studies on consumer appreciation of product autonomy (Rijsdijk & Hultink, 2003) and consumer intention to use car innovations (Jansson, 2011; Petschnig et al., 2014).

As it has been argued that neither the TPB, the TAM or the DIM sufficiently consider the central influences on consumer adoption intention, yet all contain concepts that could serve to improve each other's explanatory power (cf. Bagozzi, 2007; Mathieson, 1991; Plouffe et al., 2001; Taylor & Todd, 1995; Venkatesh & Davis, 2000; Venkatesh et al., 2003), attempts to integrate the key insights of all three models are made in this thesis. Specifically, the proposed research model assesses consumers' intention to adopt AVs on basis of the influence of attitude, social norms and behavioral control as suggested by the TPB, while considering central belief structures proposed by the TAM and the DIM regarding the perceived usefulness, ease of use and compatibility of the innovation.

However, while these concepts have proven highly useful across a wide range of innovation adoption studies, several extensions may be relevant to study intention to use AVs. First, traditional innovation adoption models were developed for organizational contexts, which are associated almost exclusively with utilitarian information systems (van der Heijden, 2004). Consequently, traditional models may not cover certain non-utilitarian aspects relevant to the study of innovation adoption in a personal context. In addition to utilitarian or functional motives, findings from research in motives for car use reveal important motivations for private car use in terms of symbolic and hedonic benefits (e.g., Bergstad et al., 2011; Gardner & Abraham, 2007; Kent, 2014; Sandqvist and Kriström, 2001; Sheller, 2004; Steg et al., 2001; Steg, 2003, 2005; Stradling et al., 1999, 2000). Thus, consumers' intention to adopt AVs are proposed explored by including hedonic outcomes, in terms of perceived enjoyment, and symbolic outcomes, in terms of the innovation's ability to reflect and express one's self-identity.

Second, based on findings in research on consumer adoption of alternative fuel vehicles (e.g., Jansson, 2011; Petschnig et al., 2014), the role of consumers' personal norms is considered. Personal norms have been proposed as an extension to general models in the context of products with large expected environmental benefits (Jansson, 2011; Stern, 2001), and have later been found to have an important influence on consumers' intention to adopt alternative fuel vehicles (Petschnig et al.; 2014).

Third, this study lends from findings in research on consumer perceptions of product autonomy, where Rijsdijk and Hultink (2003) find that product autonomy has a significant, positive impact on perceived risk, which in turn negatively affects consumer appreciation of the product. As risk perceptions have been reported to be a major determinant of resistance toward innovations (Sheth, 1981), the influence of the perceived risk of using AVs is studied.

Based on the findings, an integrative research model is developed, where several relationships are hypothesized based on the TPB in terms of attitudinal influences, normative influences, and resource related influences. In addition, separate effects of motivational influences and automatic influences are proposed. Hence, the following *research question* is formulated for the present study:

*$RQ_1$*: Which attitudinal, motivational, resource related, automatic, and normative influences affect consumer intention to adopt AVs?

However, industry players are currently developing two fundamentally different types of AVs. Some developers have based their strategy on an incremental introduction of AV technology in addition to manual driving (e.g. Tesla and Mercedes), while others are attempting to develop fully computer-controlled vehicles without manual controls (e.g. Google). Hence, the AVs of the future may differ in terms of including a manual option or only having autonomous capabilities. While the former would only add possibilities to the consumer by providing autonomous drive when preferable, albeit at a certain cost, the latter completely redefines the driving experience. Thus, adoption intention may be based on different factors for the two variants of AVs, which leads to the second research question of this study:

*$RQ_2$*: Are there different drivers of adoption intention for AVs with a manual option compared to AVs without a manual option?

## 1.2 Theoretical and managerial contribution

### *Theoretical*

Previous research on the factors that affect consumer intention to adopt autonomous driving systems is scarce (Rosenzweig & Bartl, 2015), and concern mostly lower levels of automation (Payre et al., 2014). This thesis extends this research, and offers insight into consumers' intention to adopt fully-automated vehicles defined as AVs that require no human input other than a destination. Moreover, as tools to evaluate consumers' attitude toward AVs are lacking (Payre et al., 2014), this study is valuable in that it develops an integrative multi-attribute model based on well-established innovation adoption theories and relevant extensions. As such, it offers a model for future studies on consumer perceptions of autonomous vehicles and technologies.

Furthermore, as it lends from findings in research on motives for car use, research in consumer adoption of alternative fuel vehicles and consumer perceptions of product autonomy, the model may find further applications in these fields. For instance, it could be utilized to study the adoption of different transportation means or alternative fuel vehicles, where symbolic and hedonic dimensions have been pointed out as important areas for future research (Rezvani et al, 2014).

Moreover, as AVs effectively function as a chauffeuring service that frees the user of the task of driving, a link could be made to self-service innovation and studies on what influences customer adoption of such services. Likewise, the model could find uses in adoption studies in the rapidly expanding field of intelligent products, where it brings an alternative to the proposed model by Rijsdijk and Hultink (2003).

Regarding intelligent products, an important future research direction is to investigate consumer perceptions in pre-purchase situations, according to Rijsdijk et al. (2007). Similarly, some believe that research on predicting an innovation's adoption rate would be more valuable if data on the attributes of the innovation were gathered prior to, or concurrently with, individuals' decisions to adopt the innovation (Rogers, 1983:213; Tornatzky and Klein, 1981:5). This study may thus be of interest in that it gathers respondents' evaluations of the perceived characteristics of AVs prior to their commercial introduction. Future studies may test the same model in a post-commercialization stage, in order to compare the drivers of intention to adopt with the antecedents of actual adoption.

### *Managerial*

While cars today are built to maximizing the driver’s ability to operate the car, AVs could be designed around entirely different parameters. For instance, traditionally important factors, such as performance in terms of power and acceleration, may become less relevant in order to attract consumers (Silberg et al., 2013). Instead, the driving experience could be designed to maximize comfort, entertainment or productivity (Shanker et al., 2013; Sullivan, 2015). Moreover, as consumer preferences are shifting toward on-demand access of transportation over ownership (Crews, 2015; Sullivan, 2015), AVs may bring about major shifts in the automobile business model (Gill et al., 2015). Finally, completely new players are thought to be entering the industry, especially high-tech companies such as Google and Apple (CB Insights, 2015).

Thus, AVs may constitute the biggest transition in personal transportation since the invention of the car itself. It follows that insight into key drivers of adoption intention is important for managers in the industry in order to develop a product that fulfills consumer expectations and needs. Failure to understand these factors and develop products which deliver accordingly may lead to the decay of several established carmakers, and the rise of new entrants in the market who do appreciate the changed conditions (Crews, 2015). In other words, successful customer-experience innovation in the car industry is likely to depend on a thorough understanding of the factors which drive consumer adaption of AVs. Hence, the present study contributes by expanding the knowledge on the influences behind consumer intention to adopt AVs, and by providing product developers and marketing managers recommendations about aspects of AVs that should be emphasized to increase consumers’ intention to adopt the technology.

## 1.3 Thesis outline

Chapter 2 first offers a definition of the term AV as it is used in this thesis, followed by a brief description of the development of AVs. Next, the ways in which AVs are expected to have a major impact on society are presented, with emphasis on aspects related to energy, natural resources, and the environment.[1]

Chapter 3 presents a literature review on some of the most central theories on innovation adoption as well as a discussion of other potential drivers of AV adoption intention made relevant by related fields of study. These findings are then developed into a research model suited for the study of consumer intention to adopt AVs.

Chapter 4 outlines the hypotheses for the potential influences on adoption intention studied in this thesis.

Chapter 5 gives an overview of the method applied for the empirical study, including the procedure, sample and measures used.

Chapter 6 reports the analysis and results of the empirical study in terms of model validation and hypothesis testing.

Finally, Chapter 7 assesses the implications of the findings, evaluates the limitations of the study and offers potential directions for future research.

[1] As this thesis was written for a master's degree specialized in *Economics of Energy, Natural Resources and the Environment*, this section also serves the purpose of providing the academic relevance for the present study.

# 2. Autonomous Vehicles

## 2.1 A definition of autonomous vehicles

Consumer products are made increasingly smart by equipping them with IT and communication technologies. Along with increased information gathering and product-to-product communication, smart devices are progressively becoming capable of processing information and utilizing it to improve performance. As a result, products with the ability to autonomously make decisions are emerging (cf. Rijsdijk & Hultink, 2003), for instance in the form of robotic lawnmowers or vacuum cleaners. Within this field, autonomous vehicles (AVs) are expected by some to be the first truly intelligent autonomous robots that people will be able to buy and put to work within a few years (Gill et al., 2015). While autonomous vehicles are likely to be developed in several domains, including self-driving cars, trucks, buses, ships, trains, planes or drones, and for for several purposes, such as freight transport, delivery, agriculture, emergency response, law enforcement or military use, this thesis focuses on the prospect of road-based autonomous vehicles for private consumers' personal transportation.

Product autonomy can be described as the extent to which a product is capable of operating independently and in a goal-directed way without user intervention (Baber, 1996). Hence, it is useful to distinguish between different levels of vehicle automation. The U.S. National Highway Transportation Safety Administration (NHTSA, 2013) provides such a framework with five levels of vehicle automation, ranging from no automation at Level 0 to full self-driving automation at Level 4 (Table 1). For a comparison of different definitions, see Kyriakidis, 2015). In this thesis, an autonomous vehicle (AV) is defined in line with NHTSAs (2013) Level 4, as a vehicle that can drive itself from one location to another with no input from a driver. This does not necessarily exclude the possibility of human controlled driving, but renders it as merely an optional mode of operation.

## 2.2 The development of autonomous vehicles

Present-day vehicles are drastically different from their century-old predecessors, with major developments in areas such as control standardization, performance, reliability, comfort, safety, fuel economy, and, more recently, an onset of alternative energy propulsion systems. While all of these advances have contributed to a substantially improved driving experience, changes in the automotive sector have been

### Table 1: Levels of Vehicle Autonomy

| Level | Title | Description |
|---|---|---|
| Level 0 | No Automation | The driver is at all times in complete and sole control of the primary vehicle controls (steering, throttle, break and motive power), and must constantly monitor and ensure safe operation. |
| Level 1 | Function-specific Automation | The driver can cede limited authority over specific primary controls, but must constantly monitor and ensure safe operation. Examples include cruise control and electronic stability control. |
| Level 2 | Combined Function Automation | The driver can cede authority over multiple primary controls, but must constantly monitor and ensure safe operation and be ready to immediately resume control. For instance, adaptive cruise control and active lane centering working in unison. |
| Level 3 | Limited Self-Driving Automation | The driver can cede authority over all primary controls, and is not expected to constantly monitor and ensure safe operation. The driver still needs to be available for control, but with adequate transition time. |
| Level 4 | Full Self-Driving Automation | The vehicle is designed to operate without a driver, apart from destination and navigation input, and may operate both occupied and unoccupied. |

Source: NHTSA (2013)

largely incremental since the introduction of the Ford T-model in 1908 (Silberg et al., 2012). Within the next few years, however, the automotive industry is expected to go through a radical transformation to autonomous driving. AVs are expected to change not only the automotive industry, but even the way roads, infrastructure and cities function and are designed (Gill et al., 2015; Silberg et al., 2012). Logical progression of technology adoption rates implies that the shift to AVs may be fast, potentially reaching an 80 percent adoption rate within 20 years (Sullivan, 2015).

Already, new cars models offer different automated driving features, such as lane keeping systems and adaptive cruise control. Through such technologies, the driver is assisted, or even partially replaced, by a computer system in performing specific driving tasks. Such technologies constitute automation of Level 1 and 2 as defined by the NHTSA (2013). Yet, while several partial automation technologies are in the market, the development of fully autonomous systems is more challenging.

AV development initiatives date back several decades, with test projects and prototypes launched as early as the 1940s and 1950s. Most early attempts at creating autonomous driving required highly specialized infrastructure to function, and could not operate independently in normal circumstances (Shanker et. al., 2013). However, over the past decade the development of the hardware and software necessary to make vehicles autonomous while using existing infrastructure has come a long way.

Several of the technologies in development today were spurred by such initiatives as the US Defense Department's Defense Advanced Research Project Agency (DARPA) Grand

Challenge autonomous vehicle competitions. The Grand Challenges, held in 2004 (desert trail), 2005 (desert trail), and 2007 (urban course), brought innovators, universities and companies together to develop autonomous driving systems (Shanker et. al., 2013). The Grand Challenges have later been described as milestones in the robotics field, as they led to innovations in a range of core technologies for AVs and demonstrated their potential (Thrun, 2010).

Many semi-autonomous safety and convenience technologies, including adaptive cruise control and automated parking, were developed based on advances made due to the Grand Challenges. In turn, these features help pave the way for Level 3 or 4 automation in vehicles by advancing the technologies required for high level automation.

In autonomous operation, AVs use a combination of technologies – including cameras, radars, sensors, vehicle-to-vehicle and vehicle-to-infrastructure communication, GPS and map data – to monitor its surroundings (Shanker et. al., 2013; Silberg et al., 2012). Artificial-intelligence software, i.e. software that learns from experience and optimizes its own code, is used to assess the collected data, and determine the optimal path to the destination. The actual operation of the vehicle is achieved by using mechatronic units and actuators, allowing the car to accelerate, brake and steer as needed while complying with traffic rules and knowledge of exceptions, such as stopping at a green light if a pedestrian is in the road (Manyika et al., 2013, Shanker et. al., 2013; Silberg et al., 2012). Although some of these technologies still require further testing and validation to be considered reliable for autonomous systems (Silberg et al., 2012), the current technical issues are more related to software than hardware (Shanker et. al., 2013).

Based in part on technologies developed for the 2007 Grand Challenge iteration, Google started its Self-Driving Car Project in 2009. The Google project has so far completed more than one and a half million miles' worth of test driving, and lead to the development of a Level 4 AV prototype in late 2014 (Google, n/a). Several other high-tech companies are rumored to be working on AV technology, including Apple and Uber, and many established car manufacturers also envision fully autonomous cars in the future (CB Insights, 2015). For instance, Volvo plans to do a public road test in 2017 of its Intellisafe autopilot prototype AV (Volvo, n/a), and Mercedes-Benz has launched a system called Highway Pilot that could make trucks Level 3 autonomous on highways (Mercedes-Benz, 2015). Mercedes also recently unveiled its vision for future robotically steered cars, and Audi and BMW have indicated extended automation in coming car models (Carr, 2015). Tesla is another company which has publicly stated it is developing AV technology, and has already included advanced autopilot sensor technology in its latest production cars (Tesla, 2014), which now allow for autonomous driving in certain conditions under constant human vigilance. Through future software updates and adequate regulatory changes, these cars could become Level 3 autonomous. However, both Tesla and Google expect cars capable of Level 4 autonomous driving to be ready in the next 2 to 4-year time frame (Korosec, 2015). Furthermore, Tesla is working to create an automatic car charger (Bolton, 2015), which would allow an AV to operate completely without human input, save direction commands.

## 2.3 Potential impacts of autonomous vehicles

### *Environment*

One of the most anticipated effects of AVs, is that they will have an environmental impact on the automotive sector. Today, passenger cars and trucks pose a major challenge to efforts to reduce greenhouse gas (GHG) emissions and their climate changing effects. In the U.S., on-road vehicle emissions increased by nearly 25% between 1990-2011, and today contribute some 22% of total GHG emissions in the country (EPA, 2013). Reducing emissions from the automotive sector is important to abate climate change, and AVs could contribute substantially to this goal.

Specifically, AVs could reduce congestion by up to 60% through optimizing the traffic flow (Fagnant & Kockelman, 2015), as they are capable of running faster and more efficiently in dense traffic while keeping shorter distances between vehicles, thereby avoiding traffic jams (Silberg et al., 2013; Araujo et al, 2012). U.S. traffic jams are thought to cause 3.1 billion gallons of unnecessary fuel consumption every year (Schrank et al., 2015). Moreover, this number is expected to increase over the coming years, and could reach 4.5 billion gallons by 2020 according to some estimates (Schrank et al., 2012). Traffic jams have a big impact on local air quality as well, since much congestion occurs in urban areas.

Even in situations where traffic flows, AV fuel savings could reach 20% as they could travel in platoons with vehicles just a few meters or even inches apart to reduce air drag (Wright, 2015; Dumaine, 2012). Moreover, 30-40% of total gasoline use in heavily congested urban areas can stem from drivers searching for available parking lots (Mitchell et al., 2010; Shoup, 2005). However, AVs capable of unoccupied driving could self-park in optimal locations to reduce fuel consumption as they would not have to be within walking distance of the driver's destination (Bullis, 2011; Fagnant & Kockelman, 2015). Overall fuel savings could be as high as 30% compared to similar non-AVs (Shanker et. al., 2013).

Finally, as there are strong synergies between electric vehicles (EVs) and automated taxis or shared AVs, AVs are expected to use EV technology for most urban trips, which will result in cleaner and greener cities (Gill et al., 2015).

### *Ownership and resource use*

AVs are also expected to affect ownership and resource use in the car industry. On average, cars are utilized only about 4% of their lifetime (Thrun, 2010), and even at peak times only 12-16% of vehicles are typically used (Fagnant & Kockelman, 2015; Silberg et al., 2012). With cars representing one of the largest purchases consumers make (Lapersonne et al., 1995), as well as one of the highest annual expenses (Thrun, 2010), consumers increasingly look for different ways to have access to personal transportation. Services such as carsharing (e.g. Zipcar and Car2Go) and ridesharing (e.g. Uber and Lyft) have had great success in connecting people who need to use a car with people who, for an agreed fee, are willing to let others use their car (carsharing), or personally drive them in a taxi-like way (ridesharing). In fact, carsharing membership in Europe nearly tripled between 2006 and 2010 (Sessa et al., 2013).

In the U.S., the millennial generation buys fewer cars and display a preference for access and connectivity over ownership (Crews, 2015). In 2010, car sales to the customer group aged 21–34 were down 11 percentage points from 1985 (Sullivan, 2015). This can be seen as part of the growing consumer tendency to favor on-demand access to a service or good over ownership (Sullivan, 2015), sometimes referred to as the sharing economy. The sharing economy centers around using fewer resources more efficiently, and some believe AVs could become a main contributor to this by operating more efficiently and sustainably than current taxis or privately owned cars (Gill et al., 2015). Since AVs may not need a driver, they could be deployed on a short-term rental basis, possibly as an extension to current services such as Uber or Lyft. Reduced variable costs in the form of driver wages may also lead many taxi companies to adopt AVs. Thus, AVs could lead to a convergence of existing taxi, car-rental, and car-share business models (Gill et al., 2015; Shanker et al., 2013).

A simulation by OECD's International Transport Forum (OECD, 2015) suggests that one shared AV could serve an equal number of trips as 10 privately owned vehicles. Moreover, as the door-to-door style of transportation offered by cars seems to be a preferred mode of transport, for instance representing 87% of workers' commute in the U.S. (Thrun, 2010), developing infrastructure for shared AVs may be a better investment than new public transportation systems (Silberg et al., 2013). Sullivan (2015) notes that the increase in shared-vehicle business models could provide an inexpensive alternative to people who cannot afford the price premium of purchasing an AV. The cost of using shared AVs could be significantly lower than transportation with a driver, as in current buses or taxis (Shanker et al., 2013).

Thus, AVs may reduce the need for infrastructure capacity as they could co-operate to optimize road usage, and may even reduce the number of vehicles needed as car-sharing would be much simpler (Gill et al., 2015; Shanker et. al., 2013). Consequently, AVs may contribute to freeing up both natural resources that go into the production of cars, as well as the space they occupy, for instance by reducing urban areas currently dedicated to parking lots.

### *Mobility*

As AVs can operate without a driver, they will expand mobility for groups that currently are unable to drive. Thanks to features such as self-parking, door-to-door chauffeur services (Fagnant & Kockelman, 2015; Thrun, 2010), and automatic refueling (Bolton, 2015), the only requirements of using an AV may in time be the ability to enter the vehicle and set a destination. In terms of age groups, both individuals who are younger than the age limit for having a driver's license, and the elderly who are no longer capable or willing to drive could see expanded possibilities (Fagnant & Kockelman, 2015; Gill et al., 2015; Shanker et al, 2013). As an example, 14 percent of the population in Canada are registered disabled, and 25 percent of seniors above the age of 65 do not have a license (Gill et al., 2015). This share of the population is expected to double in numbers by 2050 (Goguen & Connoly, 2015).

Furthermore, people previously excluded from the driving population due to disability or visual impairment could now get access to personal vehicle transportation without depending on someone else to drive them (Araujo et al, 2012; Shanker et al, 2013; Gill et al., 2015). Likewise, temporary impairments, such as injury or intoxication (e.g. from alcohol or drug use) need not be an obstacle with AVs. Moreover, this should protect road users from dangers such as fatigued, impaired or intoxicated drivers (Araujo et al, 2012).

### *Traffic safety*

Over 90% of traffic accidents are caused by human error (NHTSA, 2008), and 40% of fatal crashes in the U.S. involve driver distraction, fatigue or intoxication through alcohol or drug use (NHTSA, 2012). Currently, using smartphones or being tired while driving are among the most dangerous behaviors in traffic (Aho, 2015). Driver distraction is an increasing problem, as a recent U.S. survey found that young drivers engage more than older drivers in distracting and potentially dangerous behaviors, including texting (Megna, 2015). Releasing the driver of the tasks of observing traffic and maneuvering the vehicle should thus have positive safety benefits.

Road traffic causes 1.24 million deaths and another 20 to 50 million injuries annually (WHO, 2013). The majority of these deaths occur in less developed regions, where the advent of AVs should be expected later than in the richest countries in the world. Yet, even in the U.S., around 2 million people are treated in emergency rooms, and around 30,000 lose their lives, each year due to traffic accidents (Silberg et al., 2012). Especially the youth are affected by traffic incidents, as crashes remain the primary cause of death for Americans aged 15 to 24 (CDC, 2011).

Out of 3500 London transport professionals, the majority believe automated vehicles would improve safety for all road users (Begg, 2014). According to Fagnant and Kockelman's (2015) estimations, a 10% market penetration of AVs could reduce crash and injury rates by 50%, versus non-AVs, while 90% market penetration should result in a 90% reduction. Thus, AVs that remove the human component to driving should drastically reduce both the number and severity of incidents.

### *Traffic efficiency*

AVs hold a great potential for improving traffic efficiency, which in turn is likely to cause both significant time saving for users, as well as large economic impacts for society. AVs are expected to run faster and more efficiently in dense traffic while keeping shorter distances between vehicles (Silberg et al., 2013; Araujo et al, 2012), thereby reducing congestion by up to 60% (Fagnant & Kockelman, 2015). As the average US commuter wastes on average 42 hours a year in traffic jams (Schrank et al., 2015), traffic flow improvements would bring significant time saving to users. Moreover, the potential for saving time is even greater as currently around 30-40% of traffic in urban areas is caused by drivers in search for a parking lot near their desired destination (Mitchell et al., 2010; Shoup, 2005). Thus AVs should save considerable amounts of user time, as they could be summoned to pick you up and drop you off as a door-to-door type of service (Thrun, 2010), self-park in optimal locations (Fagnant & Kockelman, 2015; Bullis, 2011), and automatically refuel or recharge (Bolton, 2015: Vorrath, 2015). Moreover, users could potentially make their AV drive errands for them, such as bringing their children to football practice or picking up their spouse (Gill et al., 2015).

In addition to saving time by reducing the time a user needs to be in the vehicle, AVs will free up the time previously spent on driving the car. Currently, U.S. drivers spend on average 6-7 hours per week behind the wheels (Swinburne & Fiftal, 2013). Having the car drive for you may change perceptions about spending time in a vehicle as it now becomes productive time (Fagnant & Kockelman, 2015), and could even make people tolerate longer commutes, as they can work while in transit (Gill et al., 2015). Some may even find it cost effective, time efficient and more flexible to base their office in a vehicle than a building (Gill et al., 2015). Alternatively, the freed up time could be spent on leisure, which should improve wellbeing (Araujo et al, 2012).

### *Driving experiences*

While cars today are built to maximizing drivers' ability to drive the car, AVs could be designed to maximize passengers' comfort (e.g. sporting a refrigerator for refreshments), entertainment (e.g. television and gaming equipment), or productivity (e.g. office or meeting room interior) (Shanker et al., 2013; Sullivan, 2015). Such new opportunities may increase the quality of the driving experience for many consumers, making it a comfortable, stress-free experience (Shanker et al., 2013; Sullivan, 2015). With expanded comfort, entertainment and productivity, it is expected that performance in terms of power and acceleration will become less important in order to attract consumers (Silberg et al., 2013). Moreover, drivers today are increasingly concerned about getting from one place to another as quickly, safely, and comfortably as possible, and are less in it for the experience of driving (Shanker et al., 2013).

As AVs allow the user to perform other activities than driving, car transport might switch from being centered around driving experiences to experiences while driving. In turn, expanded content offerings and connectivity are expected to substantially improve the value proposition of the car to many users, and become a principal way to monetize on the time they spend in cars (Shanker et al., 2013; Sullivan, 2015; Swinburne & Fiftal, 2013). Especially younger generations are likely to appreciate the new opportunities AVs bring, as Giffi et al. (Deloitte, 2014) found that 39% of young commuters travel by bus, train or taxi in order to multi-task while in transit, compared to 23% for other generations.

## 2.4 Consumer acceptance of AVs

Autonomous cars have the potential to bring about major transformations in society (Shanker et. al., 2013:17). Before that can happen, however, there are several obstacles that must be dealt with, including challenges related to technology (Shanker et al, 2013), security (Fagnant & Kockelman, 2015; Yeomans, 2014), infrastructure (Gill et al, 2015), telecommunications (Shanker et al., 2013; Anderson et al., 2014), regulations and legislation (Anderson et al., 2014; Khan et al., 2012), liability (Boeglin, 2015; Cohen, 2015) and ethical concerns (Bonnefon et al., 2015).

However, the success of AVs ultimately depends on consumers' decision to adopt the product. Several studies have investigated public opinion on AVs (see Appendix A for an overview). Findings in these studies indicate that consumers have positive opinions of AVs mainly because of their potential benefits in terms of saving or freeing up users' time, while mobility improvements and environmental benefits are also viewed as positive aspects (e.g., Bjørner, 2015; Bansal et al., 2015; Fraedrich & Lenz, 2014; Howard & Dai, 2013; JDPA, 2012, 2014; Schoettle & Sivak, 2014a, 2014b; Sciencewise, 2014; Silberg et al., 2013). Consumers report more mixed opinions, however, regarding questions over enjoyment while using AVs, AVs impact on personal finances, and especially safety, which is viewed as both a key benefit and main concern (e.g., Bansal et al., 2015; Fraedrich & Lenz, 2014; Howard & Dai, 2013; Kyriakidis et al., 2015; Schoettle & Sivak, 2014a, 2014b; Sciencewise, 2014; Silberg et al., 2013). Aspects that give rise to only negative opinions are mostly related to perceived risks or uncertainties with respect to control, cyber-security, liability and privacy (e.g., Bansal et al., 2015; Howard & Dai, 2013; Kyriakidis et al., 2015; Schoettle & Sivak, 2014a, 2014b).

However, while these studies provide valuable insight into issues that affect consumer opinion toward AVs, very little research exists on which dimensions affect consumer intention to adopt AVs (Payre et al., 2014; Rosenzweig & Bartl, 2015). Only one published study was found that sought to predict consumer intention to adopt fully automated vehicles. Payre et al. (2014) studied French consumers' intention to adopt AVs, and found that intention to use automated driving was partially ($R^2$ = 0.67) explained by attitude (β = 0.62), contextual acceptability (β = 0.24) and driving-related sensation-seeking (β = 0.07). However, this study assumed that the driver would always have to be responsible for the operation of the car and ready to take over controls if necessary. Thus, even less is known about consumers' intention to use AVs where no supervision is required whilst in autonomous driving mode.

Thus, this thesis seeks to expand the knowledge regarding factors that are likely to influence consumer adoption of AVs, particularly with respect to Level 4 automation (NTHSA, 2013) that requires no driver operation or supervision. Hence, the rest of this thesis develops a research model to study consumer intentions to adopt AVs, which is subsequently tested through a survey applied in a cross-sectional study.

# 3. Theoretical Perspectives and Research Model

Innovation adoption can be defined as a consumer's decision to make full use of an innovation (Rogers, 1983). As AVs are not yet available in the market, consumers' intention to adopt the product are studied in this thesis. Behavioral intention is often predicted by utilizing multiattribute models, in particular the Theory of Planned Behavior (TPB: Ajzen, 1985, 1991), which is an extended version of the Theory of Reasoned Action (TRA: Fishbein & Ajzen, 1975). These models have been utilized to predict a large range of behaviors, including within the specific field of consumer decision-making processes (Armitage & Conner, 2001; Venkatesh et al., 2003), and offer a well-established theoretical foundation for volitional behaviors such as the private adoption of an innovation (cf. Venkatesh & Brown, 2001).

Regarding innovation adoption research, which to a high degree concerns the adoption of information systems or information technology, Davis' (1986) Technology Acceptance Model (TAM) and Rogers' (1983) Diffusion of Innovations Model (DIM) represent the two leading schools of thought (Arts et al., 2011; Venkatesh et al., 2007). While autonomous cars pertain to a different product category, the functionality of intelligent, autonomous products mainly follows from computer technology (Rijsdijk et al., 2007), making theories from information systems research relevant to AV adoption.

Consequently, this chapter presents the TRA, the TPB, the TAM and the DIM, and discusses the relevance of their proposed constructs to the present study. The ensuing tentative model is then extended based on key findings from three research areas relevant to the topic: research in motives for car use, research on consumer adoption of alternative fuel vehicles and research on consumer perception of product autonomy.

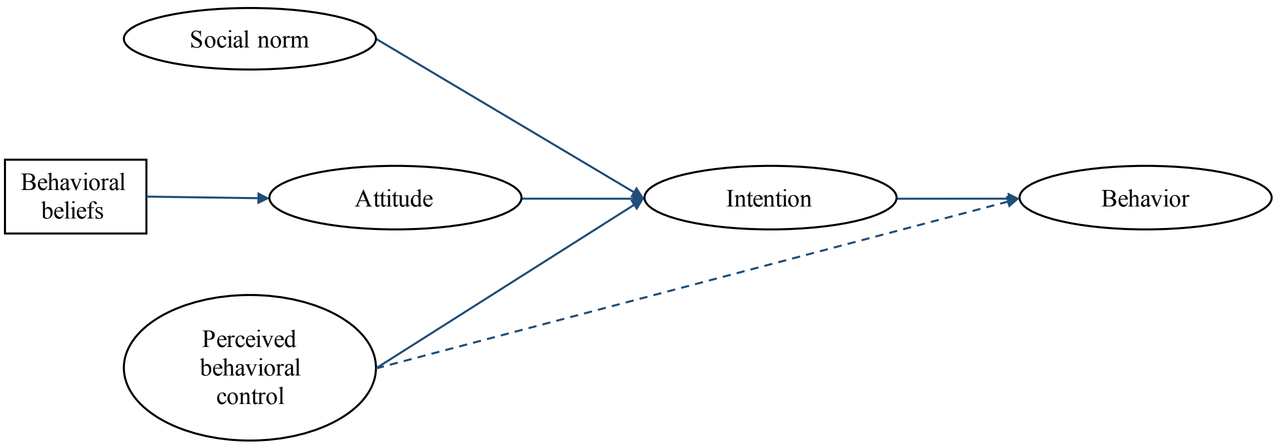
## 3.1 Innovation Adoption Theories

### 3.1.1 The Theory of Planned Behavior

The TPB (Ajzen, 1985, 1991) builds on the TRA (Fishbein & Ajzen, 1975), which explains the behavioral choice process through an individual's behavioral attitude, subjective norm, behavioral intention and actual behavior. Behavioral **intention** is defined as "the strength of one's intention to perform a specific behavior" (Fishbein & Ajzen, 1975:288), which is postulated to be determined by attitude and subjective norm. Subjective norm (in this thesis referred to as **social norm**) is defined as "the person's perception that most people who are important to him think he should or should not perform the behavior in question" (Fishbein & Ajzen, 1975:302). Behavioral **attitude** is defined as "an individual's positive or negative feelings about performing the target behavior" (Fishbein & Ajzen, 1975:216). Attitude is viewed to be formed by an individual's beliefs regarding the behavior, which in innovation adoption research pertains to consumers' beliefs about the innovation's attributes. In the TRA, social norm and attitude are viewed as direct antecedents of behavioral intention, while the influence of beliefs on intention are thought to be fully mediated by attitude.

In addition to the concepts proposed by the TRA, the TPB (Ajzen, 1985, 1991) adds another dimension labelled perceived behavioral control, which encompasses external and internal constraints on behavior. Ajzen (1991:183) defines **perceived behavioral control** as "people's perception of the ease or difficulty of performing the behavior of interest". Perceived behavioral control is thought to be directly linked to behavioral intention, as well as to behavior to the extent that it reflects actual behavioral control.

**Figure 1: The Theory of Planned Behavior**




### 3.1.2 The Technology Acceptance Model

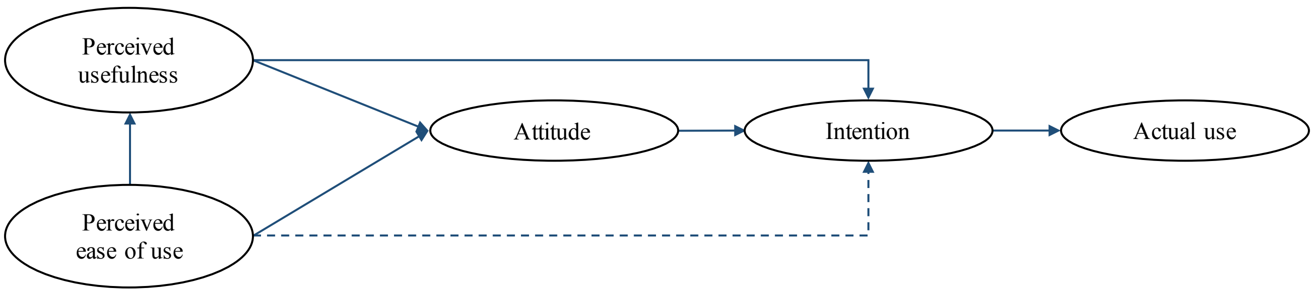
Building on the TRA, the TAM (Davis, 1986, 1989; Davis et al., 1989) was originally developed to predict the adoption of information and communication technology in organizations, but its concepts have later found use in a wide range of studies in the private consumer domain (e.g., Agarwal & Karahanna, 2000; Hong & Tam, 2006; Koufaris, 2002; Nysveen et al., 2005; Pavlou & Fygenson, 2006; van der Heijden, 2004).

The TAM consists of five elements: perceived usefulness, perceived ease of use, attitude toward use[2], intention to use, and actual usage. Described in a sequential process from attitude formation to adoption behavior, these factors explain how users come to accept and adopt a technology (Venkatesh et al., 2007). According to the TAM, attitude toward use is mainly formed based on a user's perception of the technology's usefulness and ease of use, which in turn influence adoption decisions and actual behavior (Davis, 1989; Kulviwat et al., 2007).

While attitude and behavioral intention are based on the TRA definitions (Fishbein & Ajzen, 1975), Davis (1989) defines **perceived usefulness** as "the degree to which a person believes that using a particular system would enhance his or her job performance" (p. 320), while **perceived ease of use** is defined as "the degree to which a person believes that using a particular system would be free of efforts" (p. 323). As ease of use may contribute to increased performance, it is thought to have a direct effect on usefulness.

Usefulness and ease of use correspond to the beliefs dimension in the TRA and TPB. Yet, unlike these models, the TAM views usefulness as a direct antecedent of behavioral intention, only partially mediated by attitude. Ease of use was originally understood to be fully mediated by attitude and usefulness, but has been found to influence behavioral intention directly in later research (e.g., Davis et al., 1989; Venkatesh & Davis, 1996).

**Figure 2: The Technology Acceptance Model**




## 3.1.3 The Diffusion of Innovations Model

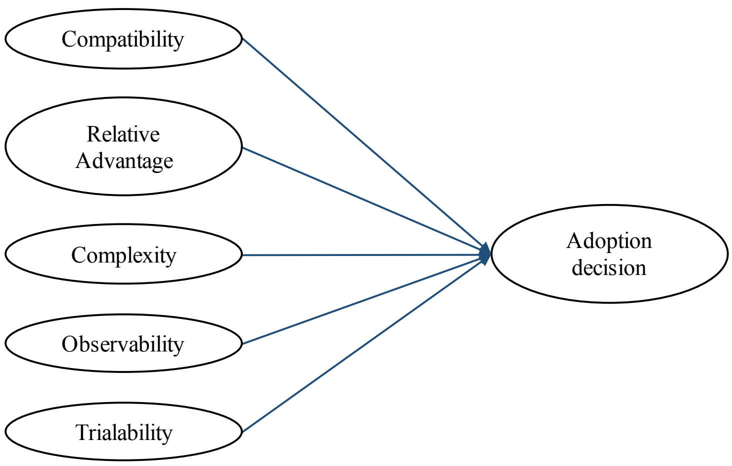
The DIM (Rogers, 1983) was originally developed in the early 1960s to explain how an innovation spreads over time through a social system (Wejnert, 2002; Rogers, 1983), and has proven useful in thousands of studies covering the adoption and diffusion of a wide range of innovations (Wejnert, 2002).

[2] While attitude was included in the original TAM (Davis, 1986), many later studies have dropped the construct from the model (e.g., Davis et al, 1992; van der Heijden, 2004; Venkatesh, 2000).

Understanding the diffusion of an innovation through society requires an understanding of individual consumers' adoption behavior. According to Rogers (1983), consumers' attitude toward an innovation is based in part on their perception of five innovation characteristics: relative advantage, compatibility, complexity, trialability, and observability. **Relative advantage** refers "the degree to which an innovation is perceived as being better than the idea it supersedes" (Rogers, 1983:213). **Compatibility** concerns "the degree to which an innovation is perceived as consistent with the existing values, past experiences, and needs of potential adopters" (Rogers, 1983:223). **Complexity** is "the degree to which an innovation is perceived as relatively difficult to understand and use" (Rogers, 1983:230). **Trialability** covers "the degree to which an innovation may be experimented with on a limited basis" (Rogers, 1983:231). Finally, **Observability** is "the degree to which the results of an innovation are visible to others" (Rogers, 1983:232).

In innovation adoption studies, these five product characteristics are typically tested as direct antecedents of adoption intention or adoption behavior (Arts et al., 2011). All constructs are thought to have positive effects on adoption, except for complexity, which negatively affects adoption.

**Figure 3: The Diffusion of Innovations Model**




## 3.2 Relevance and model development

As presented, the TPB[3], TAM and DIM offer different, yet partially overlapping frameworks for the study of innovation adoption. Hence, a comparison of the three theories, along with a discussion of the relevance of the introduced concepts, is here performed in order to

[3] For simplicity, the discussion refers only to the TPB and not the TRA, as the theories are similar except for the added perceived behavioral control dimension in the TPB (Ajzen, 1991).

establish a tentative model for the present study.

### *Attitude*

The TPB, TAM and DIM share the premise of beliefs or perceptions as key independent variables on intended behavior. While the TPB and TAM postulate that the impact of beliefs on intention are fully or partially mediated through attitude, studies based on the DIM tend to regard perceptions as direct antecedents to the adoption decision (cf. Arts et al., 2011). However, Rogers (1983) outlines that the adoption decision is based on the potential adopter's general attitude toward the innovation, which he postulates is formed by the five specific perceptions described in the DIM. Moreover, some studies find support for mediation of the DIM constructs through attitude (e.g., Karahanna et al., 1999; Taylor & Todd, 1995), including within the specific realm of car innovations (Petschnig et al, 2014). Thus, attitude is a relevant concept in all of the discussed theories.

In a meta-analysis of 87 studies, Sheppard et al. (1988) found strong support for attitude as a predictor of intention. Moreover, support for a positive effect of attitude toward new vehicle innovations on behavioral intention and actual adoption of such technologies has been found (e.g., Jansson, 2011; Moons & De Pelsmacker, 2012; Petschnig et al., 2014), including for autonomous driving technologies (Payre et al., 2014). Hence, attitude is included in the research model.

### *Social norms*

The TPB includes social norms as key antecedents of behavioral intention. Although not included in the TAM or DIM, the relevance of social norms as an antecedent of adoption intention has been revealed in innovation adoption studies based on both the TAM (Venkatesh & Davis, 2000) and the DIM (Karahanna et al., 1999). Moreover, social norms have been found to play a central role in the adoption of innovations in household contexts (Venkatesh & Brown, 2001). Similarly, social norms have been found to influence the adoption of car innovations (Jansson, 2011; Petschnig et al, 2014). Thus, this study includes social norm.

### *Behavioral control*

With regards to the TPB's dimension of perceived behavioral control, Ajzen (1985, 1991) differentiates between internal control factors pertaining to characteristics of the individual (e.g., will power and skill), and external factors that are situational in terms of the availability of resources needed to engage in a behavior (e.g., opportunity and money). While consumers may see good reasons for adopting AVs, their adoption intention may still be affected by whether they believe they will have the necessary means and resources to make full use of AVs. For instance, AV technology is expected to make vehicles more expensive (Fagnant & Kockelman, 2015), which may affect consumers' perception of behavioral control. Hence, perceived behavioral control is included in this thesis.

### *Ease of use and complexity*

Regarding the specific consumer perceptions of an innovation, perceived ease of use in the TAM and (the inverse of) complexity in the DIM are so akin that they have been viewed as identical in the literature (Moore & Benbasat, 1991; Plouffe et al., 2001), with ease of use being the preferred term for the concept (e.g., Moore & Benbasat, 1991; Venkatesh et al., 2003). Ease of use can be seen to correspond with the internal control factor of skill as it entails the match between a consumer's competence and the abilities required to use the innovation (Mathieson, 1991). As such, ease of use may be superfluous in a model that includes behavioral control. However, several researchers recommend that a distinction be made between internal control factors and externally based perceptions of control (e.g. Armitage & Connor, 1999; Terry & O'Leary, 1995). In particular, beliefs related to self-efficacy are proposed studied through a separate control dimension. While self-efficacy is not directly included in ease of use, it has previously been shown to be an antecedent of the construct (Venkatesh & Davis, 1996). Thus, perceived ease of use may be a valuable dimension to study in addition to perceived behavioral control.

Moreover, ease of use has been widely studied and empirically shown to be a factor influencing technology adoption in studies based on the TAM (e.g., Venkatesh, 1999; Venkatesh & Davis, 1996). In research based on the DIM, it has been found to be a generally significant predictor of both adoption intention and behavior (Arts et al., 2011; Moore & Benbasat, 1991), as well as an antecedent of attitude toward car innovations (Petschnig et al., 2014). Hence, this study includes perceived ease of use.

### *Usefulness and relative advantage*

Both usefulness and relative advantage have found strong support across a range of studies based on the TAM and the DIM as one of the most central predictors of intention to adopt (e.g., Arts et al., 2011; Plouffe et al., 2001; Venkatesh et al., 2003). As such, the concepts appear relevant for the present study, however, a high degree of similarity between the two has also been acknowledged in the literature (Davis et al., 1989; Moore and Benbasat, 1991; Plouffe et al., 2001; Venkatesh et al., 2003). It can be argued that the value to a consumer of an innovation lies in its ability to perform a function in a way that solves a problem better than the alternative, i.e. that it is useful in relative terms. Although this is not explicitly stated in the TAM (Davis, 1989; Davis et al., 1989), the usefulness construct was based on potential consumers perceived advantages and disadvantages, and are relative in nature (i.e. *enhance* performance). Furthermore, commonly applied measurement tools for the DIM utilize measures of relative advantage that are highly similar to the usefulness construct in the TAM (Moore and Benbasat, 1991; Plouffe et al., 2001). In addition, Kulviwat et al. (2007) tested the relationship between the two constructs, and found a correlation of 0.96. As such, the two constructs can be argued to cover highly similar concepts, albeit with slightly different measurement tools, which give minor differences in predictive power (Plouffe et al., 2001). While a conceptual distinction between perceived usefulness and relative advantage has been claimed (Kulviwat et al., 2007:1065), the two concepts are deemed sufficiently related, especially in terms of how they are operationalized in the literature, as to only include one construct in this thesis. Hence, this thesis covers this dimension using the TAM nomenclature of usefulness.

### *Observability and trialability*

While the TAM and the DIM are highly similar in terms of the abovementioned dimensions, the DIM includes three additional dimensions not found in the TAM. In terms of the observability and trialability constructs of the DIM, Tornatzky and Klein (1982) found the two concepts to not be consistently related to adoption in a meta-analysis. A recent meta-analysis by Arts et al. (2011) found only very small effects of the constructs on intention and adoption. One reason for this may be that one of the main effects of trialability and observability is to reduce uncertainty for the adopter (Rogers, 1983). Thus, while the opportunities for observation and trial may influence an innovation's rate of adoption as predicted by the DIM, their effect could be mediated through other variables, particularly uncertainty or risk (cf. Holak & Lehmann, 1990). Within the field of car adoption, a recent study on electrical vehicle adoption (Petschnig et al., 2014) found no significant effect for observability or trialability on attitude formation. Moreover, as AVs are not yet launched to market, opportunities for trial and observation are rather limited. Hence, while observability and trialability may in time become relevant factors to the successful spread of AVs, this thesis does not investigate the two concepts further.

### *Compatibility*

Finally, the DIM also proposes the inclusion of compatibility as a measure of the degree to which using an innovation fits with the existing values, needs, past experiences and lifestyle of potential adopters (Arts et al., 2011; Rogers, 1983). As such, compatibility can be regarded as a multidimensional concept covering both operational compatibility (i.e. regarding what people do) and normative or cognitive compatibility (i.e. concerning what people feel or think) (Karahanna et al., 1999; Tornatzky & Klein, 1982), of which mainly the operational aspect of compatibility has been studied in the information systems literature (Karahanna et al., 1999).

Several studies report difficulties in distinguishing between the effects of compatibility and relative advantage or usefulness empirically due to their high correlation (Arts et al., 2011; Karahanna et al., 1999; Moore & Benbasat, 1991; Tornatzky & Klein, 1982). As much of the innovation literature focuses on adoption of personal infrastructure technology in organizational contexts, a reason for this high correlation, according to Karahanna et al. (1999), may be that “task-centered beliefs that focus on the ability of the technology to facilitate one's job (i.e., perceived usefulness and operational compatibility beliefs) may be inextricably linked in the user's mind” (p. 193). This potential link has lead some to treat relative advantage and compatibility as one construct (e.g. Taylor & Todd, 1995). However, others argue that the two concepts should be included separately in spite of the high empirical correlation, due to a clear conceptual difference (Moore & Benbasat, 1991).

While the relationship between compatibility and usefulness may be different in a private adoption context and for a different product class, such as the AV, the content and operationalization of compatibility should still be assessed to ascertain a conceptual difference. According to Moore and Benbasat (1991), any reference to *needs* should be removed from the compatibility construct, as it could lead to confounding with usefulness. Regarding the remaining aspects, i.e. compatibility with the existing values, past experiences and lifestyle of potential adopters (Arts et al., 2011; Rogers, 1983), an interesting parallel can be drawn to automatic processes.

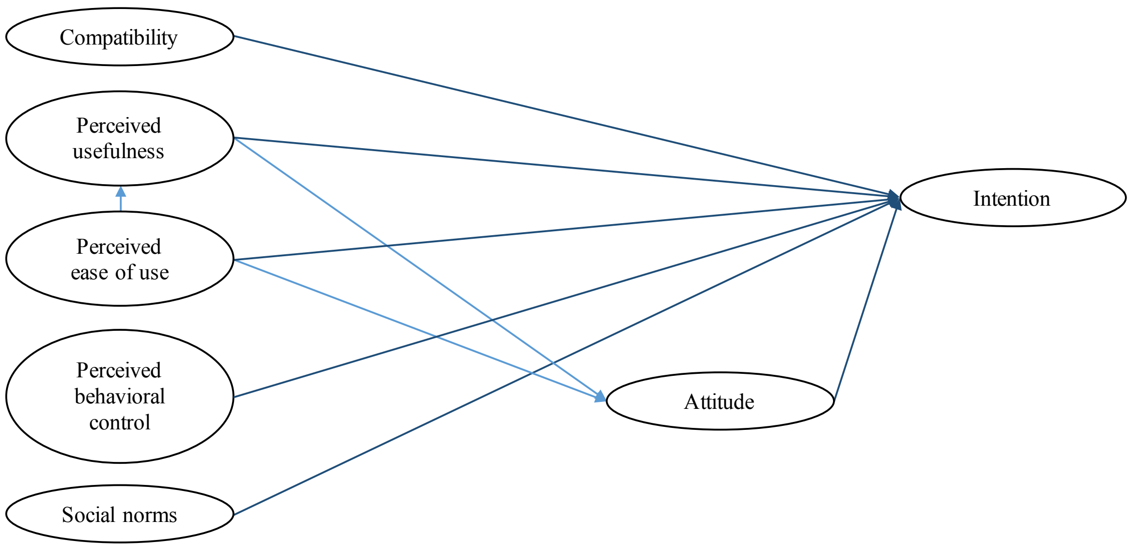
Automatic processes can be regarded as the ways in which future behavior is influenced by past behavior through a multitude of psychological factors that create consistency in response (Ouellette & Wood, 1998). Thus, frequent performance of a behavior in the past may lead to automatic repetition of the behavior in the future due to processes that occur non-deliberatively (Eagly & Chaiken, 1998). Studies based on the TPB that include past behavior as a proxy for automatic processes have repeatedly found independent effects of such processes on intention and behavior (e.g., Bagozzi & Kimmel, 1995; Beck & Ajzen, 1991; Ouellette & Wood, 1998). In turn, some emerging behavioral models, such as the Model of Goal-directed Behavior (Perugini & Bagozzi, 2001), propose the inclusion of automatic processes using past experience as an antecedent of intention (Perugini & Bagozzi, 2004). However, according to Ouellette and Wood (1998), past behavior may play a different role for novel behaviors – such as innovation adoption – than for routine behaviors, since “the initiation and execution of non-routine responses or responses in novel contexts require controlled processing” (p. 55). When people deliberately form conscious intentions to perform novel behaviors, Ouellette and Wood (1998:56) argue that past behavior is likely to be a contributing factor in that people generate intentions for future responses which are consistent with past behavior, due to self-perception processes or cognitive consistency pressures (Bern, 1972; Festinger, 1957). Thus, the influence of automatic processes on novel behaviors may require a measure of the *consistency* of the new behavior with past behavior. Regarding the novel behavior of innovation adoption, defined as a consumer's decision to make full use of an innovation (Rogers, 1983), compatibility can be argued to cover the perceived consistency of using the innovation with the potential adopters’ past behavior, as compatibility measures the perceived fit of the innovation with one’s past experiences, lifestyle and values (Arts et al., 2011; Rogers, 1983). Hence, compatibility can be conceptualized as an automatic influence, distinguishing it from the influence of perceived usefulness, which can be considered motivational (Davis et al., 1992; Nysveen et al, 2005; van der Heijden, 2004).

In a meta-study of research based on the DIM, Arts et al. (2011) found compatibility to be the most important predictor of adoption intention out of the original DIM constructs, as well as a significant predictor of behavior. Moreover, Plouffe et al. (2001) compared the predictive power of the DIM and the TAM and found that the inclusion of the DIM constructs improved the overall explanatory power regarding intention to adopt the innovation, with compatibility being the second most important construct after relative advantage. Concerning personal vehicle adoption, adopters of alternative fuel vehicles have been found to perceive such cars as more compatible than non-adopters (Jansson, 2011). Consequently, compatibility is included in the present research model.

### *Tentative model*

The above discussion identifies six constructs – i.e. perceived usefulness, perceived ease of use, compatibility, perceived behavioral control, social norms and attitude – as relevant antecedents of intention to adopt AVs. These constructs, along with the relationships postulated in the TPB, TAM, and DIM, are illustrated in Figure 4.

**Figure 4: Tentative Research Model**




## 3.3 Model extensions

However, most traditional models in the information systems literature, including the TAM (Davis et al., 1989) and the DIM (Moore & Benbasat, 1991), were developed for organizational contexts that are associated almost exclusively with utilitarian requisites (van der Heijden, 2004). This is reflected, for instance, in how the usefulness and relative advantage constructs focus on utilitarian aspects related to effectiveness, efficiency and productivity (Davis, 1989; Moore and Benbasat, 1991). While these theories are suited for adoption studies in organizational contexts, they may be in need of supplementary theories to address the adoption of innovations for personal use in daily life contexts (e.g., Hong & Tam, 2006; Nysveen et al., 2005; van der Heijden, 2004; Venkatesh & Brown, 2001). Moreover, as the innovation studied in this thesis pertains to a different product category than IT, extensions may also be necessary to cover potentially important aspects to the particular adoption decision in question.

Consequently, a review of literature related to the topic of AV adoption in a personal consumer context was performed to identify relevant extensions. As little prior research exists on intention to adopt AVs (cf. Rosenzweig & Bartl, 2015), this review included three related research areas: First, research in motives for car use was consulted to identify factors that promote car use in general. Then, research in consumer adoption of alternative fuel vehicles (AFVs) was reviewed to assess drivers of adoption intention within the car industry. Finally, as the above research covers human operated vehicles, research on consumer perceptions of product autonomy was investigated to identify factors that may be of particular importance to the adoption of machine operated vehicles.

### 3.3.1 Research in motives for car use

Research in motives for car use is dominated by social science researchers, and its reference disciplines include sociology, psychology, anthropology, and ethnography. While these studies confirm utilitarian functions of car use, they also highlight the relevance of non-utilitarian dimensions. Essentially, they reveal how consumers perceive using cars as attractive for other reasons than functional utility, specifically in that it fulfills important symbolic and hedonic functions (e.g., Bergstad et al., 2011; Gardner & Abraham, 2007; Kent, 2014; Sandqvist and Kriström, 2001; Sheller, 2004; Steg et al., 2001; Steg, 2003, 2005; Stradling et al., 1999, 2000). Identified in this research, are non-utilitarian factors related to hedonic dimensions of enjoyment, entertainment and sensation seeking; and symbolic dimensions of status, sociability, ego-formation and power, which serve as signals both to oneself and to one's peers. Symbolic and hedonic factors are found to strongly influence consumer's car use (Steg, 2005), and have been related to consumers' consideration sets for automobile purchases (Lapersonne et al., 1995). Furthermore, findings in studies on consumer opinion toward using autonomous driving systems, indicate that functional, symbolic and hedonic dimensions are relevant also with regards to automated driving (e.g., Bjørner, 2015; Fraedrich & Lenz, 2014; Howard & Dai, 2014; JDPA, 2012, 2014; Kyriakidis et al., 2015; Schoettle & Sivak, 2014a, 2014b; Sciencewise, 2014; Silberg et al., 2013; See also Appendix A).

Functional utility is included in the tentative model through usefulness, as this construct is focused on utilitarian aspects related to effectiveness, efficiency and productivity in the information systems literature (Davis, 1989; Moore and Benbasat, 1991). However, hedonic and symbolic factors are not included in theoretical models such as the TAM and DIM,[4] which have been criticized for overemphasizing functional values of technology acceptance, while understudying symbolic and hedonic values (Arbore et al., 2014). This is particularly relevant in a personal consumption context, as the personal value consumers perceive to gain from the attributes of a product or service can be understood in terms of fulfilling distinct underlying needs or motivations along functional, hedonic and symbolic dimensions (Keller,

[4] Rogers (1983) does mention symbolic factors as a potential source of relative advantage, but they are not included in standard measurement tools (e.g., Moore and Benbasat, 1991).

1993; Park et al., 1986), which have previously been found to influence consumer adoption in household contexts (e.g., Venkatesh & Brown, 2001). Hence, in addition to functional outcomes, symbolic and hedonic outcomes are deemed relevant to this study.

### Hedonic outcome

Research in consumer behavior describes hedonic outcomes as the pleasure resulting from the use or consumption of a product (Babin et al., 1994; Hirschman & Holbrook, 1982; Holbrook & Hirschman, 1982). A hedonic dimension was conceptualized as enjoyment and proposed as an extension to the TAM by Davis et al. (1992), who found that the explanatory power of the model was increased by adding the construct. **Perceived enjoyment** can be defined as the intrinsic reward derived through the use of a technology or service (Igbaria et al., 1996:129). In the field of research in motives for car use, aspects related to enjoyment have been identified as important motivations for car use (e.g., Bergstad et al., 2011; Sheller, 2004; Steg, 2005; Steg et al., 2001). Moreover, enjoyment has been found to be a significant antecedent of intention toward adopting alternative fuel vehicles (Moons & De Pelsmacker, 2012; Schuitema et al., 2013). Furthermore, Payre et al. (2014) found that consumers were more inclined to accept partial autonomous driving systems in tedious or unpleasant driving situations. Hence, a hedonic dimension measured through enjoyment is included in the research model.

### Symbolic outcome

Symbolic outcomes relate to how a product or service reflects on one's personal and social identities (Arbore et al., 2014). Personal identity accounts for how people see themselves as individuals, while social identity refers to how people define themselves in relationship to a group (Oyserman, 2009). Specific identity processes have been proposed as extensions to the TPB (e.g., Mannetti et al., 2002, Sparks & Shepherd, 1992), where findings suggest that people behave in ways that express and are congruent with their identity. Moreover, related constructs have been proposed as extensions to both the DIM (e.g., Moore & Benbasat, 1991) and the TAM (e.g., Venkatesh & Davis, 2000), where image is included as a concept that covers dimensions of prestige and status. In car studies, symbolic dimensions have been reported as significant antecedents of attitude and intention toward adopting alternative fuel vehicles (Petschnig et al., 2014; Schuitema et al., 2013).

However, the symbolic meaning of a product can extend beyond dimensions of status and prestige. For instance, the adoption of an innovation may be determined by a desire to find or express oneself and convey one's individuality (Bagozzi & Lee, 2002). Research in car use has found that owning and driving cars contribute to both the consumers' image and status (e.g., Bergstad et al., 2011; Sheller, 2004; Steg, 2005), and their ego-formation and sense of personal identity (e.g., Kent, 2014; Sheller, 2004; Stradling et al., 1999).

According to Escalas (2004), self-identifying possessions reflect the self both as a unique individual and as a group member, thus involving both personal and social identity. Concordantly, Arbore et al. (2014:94) define **perceived self-identity** as the symbolic meaning of an innovation, which measures the direct, symbolic determinant of intention to adopt. While measures of specific self-identity processes have been proposed as extensions to the TPB (e.g., Sparks & Shepherd, 1992), Arbore et al. (2014) implement a broader self-identity concept, covering the fit between the innovation and the self in terms of how well the innovation reflects and communicates one's social and personal identity. They find image to be an antecedent of self-identity, which improves the explanatory power of the model over including only the image construct (Arbore et al., 2014). Hence, the research model includes self-identity as a measure of the symbolic determinants of intention to adopt an AV.

### 3.3.2 Research in consumer adoption of alternative fuel vehicles

Findings from research in consumer adoption of alternative fueled vehicles (AFV) support the notion that consumer adoption decisions regarding car innovations are influenced by perceived benefits along functional, symbolic and hedonic dimensions (e.g., Graham-Rowe et al., 2012; Jansson, 2011; Moons & De Pelsmacker, 2012; Noppers, 2014; Petschnig et al., 2014; Schuitema et al., 2013; Skippon and Garwood, 2011). In addition, the role of social and personal norms is highlighted in connection with AFVs (Jansson, 2011; Petschnig et al., 2014).

Personal norm builds upon Schwartz's (1973, 1977) moral norm-activation theory of altruism, which holds that altruistic behavior occurs in response to personal norms that are activated in individuals who are aware of particular conditions' adverse consequences, and ascribe responsibility to the self in that they believe actions they can take may help avert those consequences (Stern, 2000). Thus, **personal norms** can be defined as a consumer's personal feelings of responsibility or moral obligation to perform, or refuse to perform, a certain behavior (cf. Ajzen, 1991). According to Ajzen (1991), "[personal] moral obligations would be expected to influence intention, in parallel with attitudes, subjective (social) norms and perceptions of behavioral control" (p. 199).

Personal norms have been found to increase the predictive power of the TPB in cases of unethical behaviors (Beck & Ajzen, 1991), including with regard to antisocial or socially controversial behaviors in traffic (Parker et al., 1995). As the use of cars has clear adverse social consequences in terms of environmentally degrading emissions (EPA, 2013), personal norms regarding the environment have been regarded relevant to the study of car innovation adoption (Jansson, 2011; Petschnig et al., 2014). Environmental personal norms concern norms that create predispositions to behave pro-environmentally (Stern, 2000). Petschnig et al. (2014) found environmental personal norms to be significant antecedents of intention to adopt alternative fuel vehicles, and similar concepts have been found to have a positive influence on the use of environmentally friendly travel modes (Hunecke et al., 2001; Nordlund & Garvill, 2003). As AVs are expected to contribute to abating car emissions (Fagnant & Kockelman, 2015), consumer adoption of AVs may be influenced by personal norms regarding the environment. Thus, personal norms are included in the research model.

### 3.3.3 Research on consumer perceptions of product autonomy

The main innovation of AVs lies in the vehicles ability to operate autonomously. Consequently, research in consumer perceptions of product autonomy is relevant to this study. Product autonomy can be described as the extent to which a product is capable of operating independently and in a goal-directed way without user intervention (Baber, 1996). Autonomous products in general have received some attention in the adoption literature (e.g., Rijsdijk & Hultink, 2003; Rijsdijk et al., 2007), where Rijsdijk and Hultink (2003) found that product autonomy has a positive impact on perceived risk. Risk, in turn, negatively affected consumer appreciation of the product.

**Perceived risk** can be defined as the potential realization of negative goals or the failure to satisfy positive goals (Moreau et al., 2001). A risk dimension has long been proposed as an extension to innovation adoption models (Ostlund, 1974), and risk perceptions have been reported to be a major determinant of resistance toward innovation (Sheth, 1981), as increased risk leads to lower diffusion rates and adoption levels of innovations (Rogers 1995; Sheth, 1981). A meta-study of research based on the DIM by Arts et al. (2011) found an uncertainty dimension that included risk to be a key predictor of adoption intention.[5] Moreover, risk has previously been related to consumers' consideration sets for automobile purchases (Lapersonne et al., 1995), and risk dimensions are connected to consumers' initial opinion toward

[5] Note that while Arts et al. (2011) study risk and uncertainty in combination, they may be conceptually different as other sources of uncertainty than risk have been reported in the literature (cf. Hoeffler, 2003).

AVs (e.g. Bansal et al., 2016; Fraedrich & Lenz, 2014; Howard & Dai, 2013; Kyriakidis et al., 2015; Schoettle & Sivak, 2014a, 2014b). Thus, risk is a relevant extension to the research model.

Ram and Sheth (1989) identified perceived risks of innovations along dimensions of economic risk, physical risk, social risk, and functional risk. These dimensions are relevant to AVs in terms of risks related to liability (Cohen, 2015), data privacy (Boeglin, 2015; Glancy, 2012), cyber-security attacks (Yeomans, 2014), and vehicle malfunction or traffic safety risks (Fagnant & Kockelman, 2015). However, while several risk dimensions have been discussed in relation to AVs, studies on consumer opinion on AVs report safety risks as the perceived risk dimension that creates the greatest consumer apprehension (e.g., Bansal et al., 2016; Bjørner, 2015; Kyriakidis et al., 2015; Schoettle & Sivak, 2014a, 2014b; Sciencewise, 2014; Seapine Software, 2014; Silberg et al., 2013). Hence, this thesis studies the impact of perceived physical risk in terms of personal safety while using an AV.

## 3.4 Research model

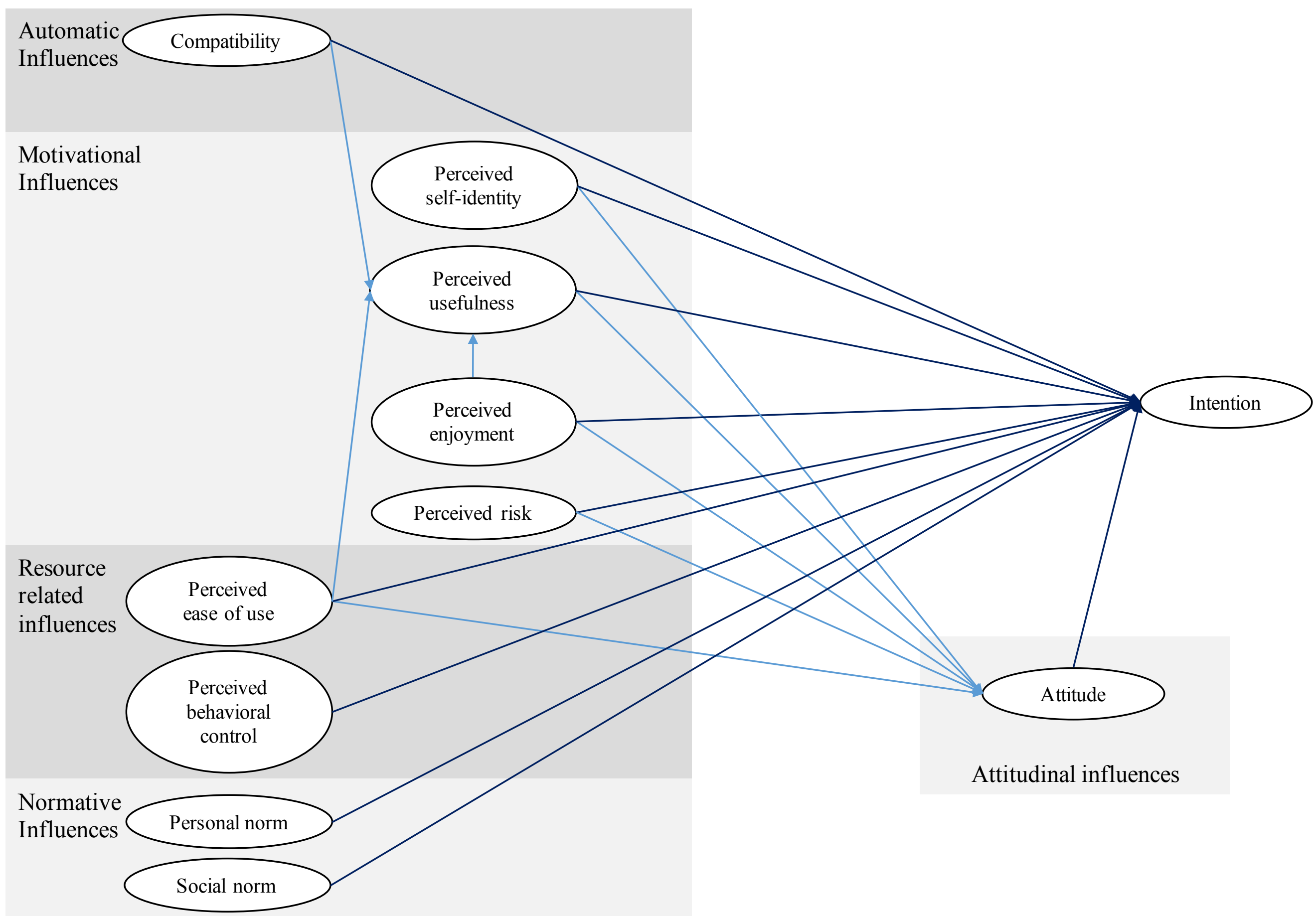
Based on the findings in this chapter, an integrative model is proposed for the study of consumers' intention to adopt AVs that combines six key constructs from three commonly applied theories in innovation adoption research – the TPB, TAM and DIM – with four specific extensions made relevant by findings in research in motives for car use, research on consumer adoption of alternative fuel vehicles, and research on consumer perception of product autonomy.

The result is a research model parallel to the TPB in that it predicts adoption intention based on social norms, attitude and behavioral control. However, it also includes central constructs in usefulness and ease of use from the TAM (which closely correspond to complexity and relative advantage in the DIM) and compatibility from the DIM, whose relevance and predictive power have been demonstrated in a range of innovation adoption studies. Moreover, the research model incorporates enjoyment, self-identity, risk and personal norms based on findings in the three research areas related to the specific topic of this thesis.

The final research model, including hypothesized paths (see Chapter 4), is illustrated in Figure 5. As proposed by the TPB, constructs are presented in terms of attitudinal influences, normative influences, and resource related influences. *Attitudinal influences* concern the direct influence of consumers' attitude toward AVs on their adoption intention, and relate to the attitude construct. *Resource related influences* deal with external and internal constraints on behavior, and are represented in this thesis by perceived behavioral control and perceived ease of use. *Normative influences* refer to the role played by perceived social pressure and moral obligations to adopt AVs on the formation of intention to adopt the product. Along with social norms from the TPB, personal norms are included as an additional normative construct in this thesis.

In addition, separate effects of motivational influences (cf. Nysveen et al, 2005) and automatic influences (cf. Perugini & Bagozzi, 2001, 2004) are proposed. *Motivational influences* entail the direct instrumentality of achieving a desired outcome, and are distinguished from attitudinal influences to allow for the proposal of individual effects of motivational influences on intention as well as the mediation of motivational factors through attitude. Motivational factors in this model are perceived usefulness, perceived risk, perceived self-identity and perceived enjoyment. *Automatic influences* cover how a consumer's automatic processes may influence intention, and are proposed studied through the compatibility construct.

**Figure 5: Research Model**



# 4. Hypotheses

## 4.1 Attitudinal influences

Attitudinal influences on intention are studied in the TPB and the original TAM, and are represented in this research through the attitude construct. An attitude toward a behavior concerns the degree to which an individual has a favorable or unfavorable evaluation of performing a specific behavior (Ajzen, 1991). As people generally want to behave in accordance with their attitudes (Fishbein & Ajzen, 1975), attitude exerts a positive influence on an individual's behavioral intention (Ajzen, 1991). Thus, the TPB and original TAM include attitude as a positive antecedent of behavioral intention. By defining innovation adoption as a consumer's decision to make full use of an innovation (Rogers, 1983), it follows that consumers' intention to adopt an innovation should be positively influenced by their attitude toward using the innovation. This relationship has previously been found with respect to adoption of new vehicle innovations (e.g., Jansson, 2011; Moons & De Pelsmacker, 2012; Petschnig et al., 2014), including for partially autonomous driving technologies (Payre et al., 2014). Thus, attitude is hypothesized to positively influence consumer's intention to adopt an AV.

*$H_1$: Attitude has a positive influence on intention.*

## 4.2 Motivational influences

Motivational influences are studied in the TAM and DIM, and are covered in this thesis by perceived self-identity, perceived usefulness, perceived risk and perceived enjoyment. In motivational research, extrinsic motivation and intrinsic motivation are suggested as the two main categories of motivators. Extrinsic motivation refers to the achievement of a particular goal or reward, while intrinsic motivation entails the satisfaction and pleasure derived from a specific behavior (Deci, 1975; Deci & Ryan, 1985; Vallerand, 1997). In the previous chapter, motivational factors for adopting an AV were theorized in terms of functional, symbolic and hedonic outcomes. Functional and symbolic outcomes mainly fall within the extrinsic motivator group, while hedonic outcomes pertain to intrinsic motivation.

A central component of several multiattribute behavioral models such as the TRA and TPB, is that an individual's evaluation of salient beliefs about a behavior directly impacts that person's general attitude toward the behavior (Fishbein & Ajzen, 1975). In other words, consumers tend to have a positive attitude toward adopting an innovation when the outcomes of using the innovation are positively evaluated. The rationale for this can be found in balance theory (Heider, 1946; Rosenberg, 1956), which proposes that people have a preference for balanced (i.e., coherent, consistent) cognitions (e.g., beliefs, attitudes, ideas) over imbalanced cognitions. Consequently, motivational factors are postulated in the TRA and the TPB to have indirect effects on intention via attitude, which are hypothesized in this thesis.

However, the TRA and TPB have been criticized for not addressing motivational processes (e.g. Bagozzi, 1992). One issue is that potential independent effects of salient beliefs on intention are not studied in the TRA and TPB, while such effects are theoretically justified and empirically grounded in alternative intention models (e.g., Bagozzi, 1982; Davis et al., 1989; Triandis, 1977, 1980). Furthermore, empirical evidence of direct effects of both extrinsic and intrinsic motivations on intention have been repeatedly found in the literature (e.g. Davis et al., 1989; Davis et al., 1992; Venkatesh & Davis, 1996).

One explanation for this may be that consumers see adopting a product as a way to achieving a desired outcome. If this outcome is deemed important or beneficial enough, the consumer may adopt the product regardless of their overall attitude toward the product (cf. Davis et al., 1989).[6] In general, goals have been shown to play an important role in the explanation of many behaviors, as these behaviors are chosen as means to goal achievement (Gollwitzer & Moskowitz, 1996).

Thus, to the extent that the outcomes of adopting an innovation are positively evaluated, motivations to achieve these outcomes may directly impact intention and adoption independently of attitude. The rationale for this rests in that consumers can form intentions to perform behaviors they see as a mean to achieving a desired outcome based on cognitive decision rules, without requiring a re-appraisal of how that outcome contributes to higher-level goals or purposes in one’s goal hierarchy, and therefore without necessarily activating the affect connected with achieving the outcome (Bagozzi, 1982). If affect is not completely activated, the consumer’s attitude would not be expected to fully capture the influence of outcome considerations on one's intention (Davis et al, 1989:986). Consequently, motivational influences reflect the direct instrumentality of extrinsic and intrinsic motivators on intention to use AVs. Hence, extrinsic and intrinsic motivations are hypothesized to directly impact intention in addition to potential indirect effect via attitude, as specified below.

[6] For instance, while one may perceive printing out articles as a negative behavior in general (e.g., due to environmental concerns), the increased convenience or improved readability of a paper copy may still cause one to choose print-outs over reading on a screen. Likewise, in spite of a negative attitude toward consuming coke (e.g., due to health concerns), the desire to enjoy a cool refreshment may still cause one to drink the beverage frequently.

### Perceived self-identity

Measuring the symbolic determinants of intention to adopt, perceived self-identity is an extrinsic motivation involving the innovations' ability to achieve the goals or rewards associated with promoting or enhancing one's identity. Consumers tend to behave in ways that are consistent with their identity (e.g., Mannetti et al., 2002, Sparks & Shepherd, 1992), which may be explained by cognitive consistency pressures (Festinger, 1957). In addition, the adoption of an innovation may be determined by a desire to find or express oneself and convey one's individuality (Bagozzi & Lee, 2002). Hence, to the extent that AVs can reflect and express consumers' identity, consumer intention to adopt AVs should be enhanced. Perceived self-identity has previously been shown to directly impact adoption intention in a personal innovation adoption context (Arbore et al., 2014), and can be hypothesized for AVs based on the findings in research in motives for car use (e.g., Bergstad et al., 2011; Steg, 2005; Stradling et al., 1999).

*$H_2$: Perceived self-identity has a positive influence on intention.*

Moreover, a consumer's overall appreciation of an innovation may be influenced by the extent to which the innovation is seen as congruent with that individual's identity. If the innovation is perceived to reflect and express one's identity, one's attitude toward using the innovation could be positively impacted as a positive evaluation of the outcome and a positive attitude represent cognitive consistency (Rosenberg, 1956). Symbolic outcomes have previously been reported to influence attitude (Karahanna et al., 1999), also with respect to attitude toward adopting car innovations (Petschnig et al., 2014). Thus, perceived self-identity is hypothesized to positively influence attitude.

*$H_3$: Perceived self-identity has a positive influence on attitude.*

### Perceived usefulness

Covering the positive functional outcome of an innovation, the perceived usefulness of an AV is also an extrinsic motivation, specifically in terms of increasing consumer's performance through freeing up time, increasing mobility and simplifying life. The perceived usefulness of a product is postulated in the TAM to positively influence intention independently of attitude through reasons of goal achievement or rewards (Davis et al., 1989). The direct impact of perceived usefulness on intention has repeatedly been shown in the innovation adoption literature (e.g., Davis et al., 1989; Agarwal & Karahanna, 2000; Hong & Tam, 2006; Nysveen et al., 2005; van der Heijden, 2004; Venkatesh & Davis, 2000). Moreover, functional outcomes have been reported to impact both car use (Steg, 2005) and adoption of car innovations (Jansson, 2011). Thus, perceived usefulness is hypothesized to positively influence consumer's intention to adopt an AV.

*$H_4$: Perceived usefulness has a positive influence on intention.*

The motivational influence of perceived usefulness may also be mediated through attitude. Based on the notion of balanced cognitions (Heider, 1946), a positive evaluation of an innovation in terms of high utility should positively influence one's attitude toward the use of that innovation. Perceived usefulness has been shown to influence attitude (e.g. Davis, 1989; Karahanna et al., 1999), which can also be hypothesized in the case of AVs, as consumers' beliefs about the functional outcomes of adopting car innovations have previously been reported to influence attitude (Petschnig et al., 2014).

*$H_5$: Perceived usefulness has a positive influence on attitude.*

### *Perceived risk*

Perceived risk can be seen to cover negative extrinsic motivation, as risk entails the potential realization of negative goals or failure to satisfy positive goals (Moreau et al., 2001). In other words, risk reduces the consumers' likelihood of achieving goals or rewards, and may directly contribute to negative outcomes. In general, people have been found to strongly prefer avoiding losses to acquiring gains, and such loss aversion mechanisms operate independently and with greater intensity than gains acquisition mechanisms (Kahneman & Tversky, 1984, 1992). Support for a direct negative effect of perceived risk on intention has previously been reported in the literature (Meuter et al., 2005), including in the realm of car innovations (Jansson, 2011). Thus, consumers' intention to use an AV is hypothesized to be negatively affected by perceived risk.

*$H_6$: Perceived risk has a negative influence on intention.*

Just like positive functional outcomes may positively impact attitude, the opposite could be argued for risk. In order to have cognitive consistency (Rosenberg, 1956), consumers who perceive a high risk of using an innovation may have a less positive overall attitude toward the use of that innovation. Perceived risk has previously been found to negatively affect attitude formation regarding autonomous products (e.g., Rijsdijk & Hultink, 2003). Therefore, perceived risk is hypothesized to negatively influence attitude toward using AVs.

*$H_7$: Perceived risk has a negative influence on attitude.*

### *Perceived enjoyment*

Dealing with the hedonic outcomes consumers expect to get from using the innovation, perceived enjoyment pertains to the intrinsic motivator group. Regardless of anticipated utility, the use of an innovation can be enjoyable in its own right, and enjoyment may positively influence intention independently of attitude due to the pleasure inherent in the activity of utilizing the innovation (Davis et al., 1992). Several studies reveal the direct influence of perceived enjoyment on adoption intention (e.g., Davis et al., 1992; Nysveen et al., 2005; van der Heijden, 2004), also with respect to intention to adopt car innovations (Moons & De Pelsmacker, 2012; Schuitema et al., 2013). Moreover, Payre et al. (2014) found that consumers were more inclined to accept partial autonomous driving systems in tedious or unpleasant driving situations. Hence, consumer's perceived enjoyment of using an AV is hypothesized to impact adoption intention.

*$H_8$: Perceived enjoyment has a positive influence on intention.*

As with the extrinsic motivators, the influence of intrinsic motivation may also be mediated through attitude. Based on cognitive coherence (Heider, 1946), the perceived enjoyment of using an AV should positively impact the overall attitude one has toward the technology. Partial mediation of perceived enjoyment via attitude has previously been found in the innovation literature (Nysveen et al., 2005), and can be hypothesized for AVs.

*$H_9$: Perceived enjoyment has a positive influence on attitude.*

In addition, Starbuck and Webster (1991) suggest that enjoyment contributes to extrinsic motivation. Later studies have revealed a direct influence of perceived enjoyment on perceived usefulness (e.g., Arbore et al., 2014; Hong & Tam, 2006). Related to the adoption of an AV, one of the key changes the innovation brings to the driving experience, is to free up the time that a user would otherwise spend on driving. Thus, if the user enjoys performing other activities than driving whilst in the car, the freed up time in the vehicle during autonomous drive could have greater value, which may increase perceived usefulness. Conversely, if the freed up time is seen to not be enjoyable (e.g., being boring or stressful), the perceived usefulness of the technology might be reduced. Integrating this into the model, it is hypothesized that perceived enjoyment will exert indirect effects via usefulness.

*$H_{10}$: Perceived enjoyment has a positive influence on perceived usefulness.*

## 4.3 Resource related influences

Resource related influences on intention are proposed in the TPB, and deal with perceptions of external and internal constraints on behavior (Ajzen, 1991), which are represented by perceived behavioral control and perceived ease of use in this thesis. Resource availability can facilitate or impede the actual achievement of the potential benefits to adopting an innovation. Consequently, perceptions regarding resources may affect the perceived feasibility of achieving a particular outcome, i.e. the expectancy of success (Atkinson, 1964), which may influence behavior.

### *Perceived behavioral control*

Perceived behavioral control covers factors that constrain or facilitate behavior, i.e. the consumer's perception of "the presence or absence of requisite resources and opportunities" (Ajzen & Madden 1986: 457), which in this thesis concerns whether consumers believe they will have the necessary resources to make use of an AV. While consumers may have good reasons for adopting an innovation, they may still perceive that they lack the necessary resources to make full use of it, leading to low adoption intention. Thus, perceived behavioral control is thought to directly influence intention (Ajzen, 1985). This relationship has previously been demonstrated in personal innovation adoption contexts (e.g., Nysveen et al., 2005), and can be hypothesized to impact AV adoption intention, particularly since the technology is expected to add significantly to the price of vehicles (Fagnant & Kockelman, 2015).

*$H_{11}$: Perceived behavioral control has a positive influence on intention.*

### *Perceived ease of use*

According to Mathieson (1991), perceived ease of use covers the match between a consumer's abilities and the skills required to make use of an innovation. As such, perceived ease of use also represents a resource related influence, and closely resembles the internal control dimension postulated by Ajzen (1985, 1991). In previous studies, perceived ease of use has repeatedly been shown to act as the mediator of several specific control beliefs while directly influencing intention (Venkatesh, 2000; Venkatesh & Davis, 1996). With respect to car research, adopters of alternative fuel vehicles have been found to view such cars as less complex than non-adopters (Jansson, 2011). Thus, the perception that an AV is easy to use is hypothesized to positively impact intention.

*$H_{12}$: Perceived ease of use has a positive influence on intention.*

In addition, a positive influence of perceived ease of use on attitude is postulated in the TAM. One explanation for this is that ease of use may be evaluated as a positive outcome in and on itself, as technology users aim to minimize their behavioral effort (Venkatesh, 2000). As such, perceived ease of use may positively impact attitude due to cognitive consistency mechanisms (Rosenberg, 1956), particularly to the extent that consumers consider the innovation in terms of not only ease of use, but whether it is easier to use than what it replaces. A direct influence of perceived ease of use on attitude has been shown in numerous innovation adoption studies (e.g., Davis, 1989; Karahanna et al., 1999; Nysveen et al., 2005), including studies on intention to adopt car innovations (Petschnig et al., 2014). Therefore, perceived ease of use is hypothesized to have a positive influence on attitude.

*$H_{13}$: Perceived ease of use has a positive influence on attitude.*

Furthermore, a second indirect effect of perceived ease of use is postulated in the TAM, where it is seen to have an indirect effect on intention via perceived usefulness. Although a consumer sees the potential to gain utility from an innovation, the attainment of that utility may rest on the consumer's perceived ability to make full use of the innovation (Venkatesh & Davis, 2000). Thus, depending on whether the innovation is perceived as being easy to use, the consumer may adjust their perception of the utility he or she individually expects to get from adopting the innovation. As such, ease of use has been shown to be an antecedent of perceived usefulness (e.g., Davis, 1989; Davis et al., 1989). Thus, perceived ease of use is hypothesized to have a positive influence on perceived usefulness.

*$H_{14}$: Perceived ease of use has a positive influence on perceived usefulness.*

## 4.4 Automatic influences

Compatibility is in this thesis conceptualized as an automatic influence regarding the the consistency of using the innovation with the past behavior of the potential adopter. Automatic processes have received much attention in the field of behavioral psychology, and are important as consumers tend to generate intentions that are consistent with their lifestyle and habits due to cognitive consistency pressures (Festinger, 1957). Automatic processes have been repeatedly found to have independent effects on intentions and behavior in studies of the TPB (e.g., Bagozzi, 1981; Bagozzi & Kimmel, 1995; Beck & Ajzen, 1991; Ouellette & Wood, 1998). With respect to intentions to perform novel behaviors, automatic processes are likely to be a contributing influence as people generate intentions for future responses which are consistent with past behavior (Ouellette & Wood, 1998:56). Thus, in the context of innovation adoption, i.e. the novel behavior of making full use of the innovation (Rogers, 1983), the compatibility construct may serve as a proxy for automatic processes, as it reflects the fit between the innovation and the potential adopter's past experiences, lifestyle and way of doing things.

As such, compatibility may influence AV adoption intention due to self-perception processes or cognitive consistency pressures (Bern, 1972; Festinger, 1957). Moreover, given the general human reluctance to change (Kahneman & Tversky, 1979), compatibility may influence adoption intentions as a compatible innovation requires little change to one's lifestyle and habits. In the innovation adoption literature based on the DIM, compatibility has been found to be among the strongest predictors of both intention and behavior (e.g., Arts et al., 2011; Plouffe et al., 2001). Thus, a positive influence of compatibility on intention is hypothesized for AVs.

*$H_{15}$: Perceived compatibility has a positive influence on intention.*

In addition, Holak and Lehmann (1990) argue that consumers who see the innovation as compatible with their lifestyle and past experiences are more likely to be familiar with earlier products in the same category, and thus have greater ability to recognize the potential advantage of an innovation over past offerings. This in turn could positively contribute to the perceived usefulness of the innovation to the consumer. Furthermore, an innovation's potential of bringing utility to potential adopters may depend on the extent to which the perceived necessary changes to their current habits and lifestyle are deemed acceptable (Rogers, 1983). Thus, if the innovation is seen to demand large alterations to the potential adopter's current life, perceived usefulness might decline. Empirical support for a direct positive influence of compatibility on perceived functional outcome has previously been found (Holak & Lehmann, 1990; Ostlund, 1973). Hence, compatibility is hypothesized to have a positive influence of on perceived usefulness.

*$H_{16}$: Compatibility has a positive influence on perceived usefulness.*

## 4.5 Normative influences

Normative influences on intention are studied in the TPB, and are include in this thesis through personal norms and social norms. Social norms concern an individual's perceived social pressure to perform, or refrain from performing, a behavior (Ajzen, 1991). When deciding on whether to perform a specific behavior, people are likely to consider and be influenced by the opinions of significant others (e.g., family, friends and colleagues) (Bearden & Etzel, 1982). Thus, social norms are postulated to have a direct impact on intention (Fishbein & Ajzen, 1975; Ajzen, 1991). Previous studies on adoption of innovations in private contexts have found that social norms play a central role (Venkatesh & Brown, 2001). Moreover, social norms have previously been found to significantly influence intention to adopt car innovations (Petschnig et al., 2014). Thus, social norms are hypothesized to have a direct impact on intention.

*$H_{17}$: Social norms have a positive influence on intention.*

Personal norms regard a person's feelings of moral obligations to perform a behavior (Ajzen, 1991). While not included in the TPB, Ajzen (1991:199) nonetheless theorizes that any effect of personal norms would run parallel to social norms and have a direct impact on intention, as an individual acts in accordance with perceived internal or external pressures. In general, consumers' behaviors can be affected by their own personal feelings of moral responsibility or obligation (Gorsuch & Ortberg, 1983; Schwartz, 1973, 1977), which is also the case with respect to traffic related behaviors (Parker et al., 1995). Within the field of car innovations research, personal norms regarding the environment have previously been found to positively influence adoption intention (Petschnig et al., 2014). As AVs are expected to contribute to abating car emissions (Fagnant & Kockelman, 2015), consumer adoption of AVs may be influenced by personal norms regarding the environment. Hence, personal norms are hypothesized to have a direct impact on intention.

*$H_{18}$: Personal norms have a positive influence on intention.*

# 5. Method

## 5.1 Data collection and sample

To test the hypotheses, an online survey was conducted among Norwegian consumers in the period between 15 April and 10 May 2016. The survey was distributed in two ways; first, an invitation to participate in the survey was sent by email to 3252 students at the Norwegian School of Economics, which yielded 234 (7.2%) respondents. Second, in order to get more robust findings (Brewer, 2000), the survey was distributed through social media to reach a wider population. This produced another 151 respondents, bringing the total number to 383. In addition, 95 people opened the survey, but were not registered in the sample as they did not provide a single answer.

**Table 2: Sample Demographics**

| | Full sample (N=320) | AM (N=160) | AO (N=160) |
|---|---|---|---|
| | % | % | % |
| **Gender** | | | |
| Male | 49.4 | 51.3 | 47.5 |
| Female | 50.6 | 48.8 | 52.5 |
| **Age** | | | |
| 18 - 24 | 48.4 | 43.8 | 53.1 |
| 25 - 29 | 37.8 | 40.6 | 35.0 |
| 30 - 39 | 8.8 | 9.4 | 8.1 |
| 40 - 49 | 2.2 | 2.5 | 1.9 |
| 50 - 59 | 1.9 | 1.9 | 1.9 |
| 60+ | .9 | 1.9 | .0 |
| **Education** | | | |
| Less than high school | .3 | .0 | .6 |
| High school graduate | 18.1 | 15.6 | 20.6 |
| Bachelor / 3 year degree | 48.1 | 46.3 | 50.0 |
| Master / 5 year degree | 32.2 | 38.1 | 26.3 |
| PhD / more than 5 year degree | 1.3 | .0 | 2.5 |
| **Nationality** | | | |
| Norwegian | 82.8 | 84.4 | 81.3 |
| Other | 17.2 | 15.6 | 18.8 |

AM = autonomous and manual, AO = autonomous only.

No compensation or prizes were offered for participation to avoid careless responses submitted for the purpose of attaining a reward. To further minimize careless responses, respondents with a completion time shorter than 180 seconds (N=24), as well as respondents who had given more than 9 successive identical responses (N=29), were eliminated from the final sample. Finally, respondents who had not completed the whole survey (N=10), most of whom had answered less than half of the questions, were removed. The final number of respondents was 320.

Sample characteristics for the full sample, as well as for the two groups used to study differences between intentions to use AVs with (AM) or without (AO) manual controls, are presented in Table 2. The nearly equal gender mix in the sample represents well the gender distribution among Norwegian consumers, but the education level is higher in the sample than the general population (cf. SSB, 2016a). In addition, with an average age between 25-29, the sample represents a younger population than would be representative for the country population (cf. SSB, 2016b). However, younger consumers are an interesting target group considering that the average age of passenger cars at the time of scrapping in 2015 was 18.4 years according to Statistics Norway (SSB, 2016c), and fully autonomous cars are still expected to be a few years away. Moreover, young consumers may be the first to adopt AVs as novices in a product category are more likely to adopt discontinuous innovations early (Moreau et al., 2001).

## 5.2 Research design and procedure

Several factors were considered in designing the survey to ensure the reliability of results, which can be threatened by systematic errors or biases, specifically in terms of observer bias and error, participant bias and error, and method bias (e.g., Brewer, 2000; Heffner, 2004; MacKenzie & Podsakoff, 2012; Viswanathan & Kayande, 2012).

Regarding observer bias and error, an online survey with structured, close-ended questions was used to collect data, thus limiting the risk of observer bias by avoiding the subjective interpretation linked with open-ended questions. Furthermore, all data was imported automatically into SPSS and Mplus 7, thereby removing the danger of data plotting errors associated with manual entry.

In terms of participant bias, a general concern for this type of research is social desirability bias (Maccoby & Maccoby, 1954), which refers to respondents' providing answers that may not hold true for them, but which they perceive to be the correct or socially acceptable answer to a question. Several steps were taken to diminish the potential for such bias in this study. First, in order to avoid answers that were deemed socially acceptable, anonymity of responses was guaranteed both in the invitations to participate and in the introduction text to the survey, and participants were not observed while answering the online survey. Moreover, to avoid researcher-desirable answers, participants were not informed about the true purpose of the survey (i.e., to unveil the drivers of adoption intention), but rather asked to simply provide their opinions on AVs by indicating how much they agreed with a set of statements.

Regarding participant error, a potential concern is that the newness of the innovation may imply that consumers have not yet fully acquired an understanding of AVs or formed opinions about them (Fraedrich & Lenz, 2014; Howard & Dai, 2013; Kyriakidis et al., 2015). If respondents lack experience in thinking about the topic, find the topic difficult to understand or see no personal relevance of the issue, systematic errors can occur (cf. MacKenzie & Podsakoff, 2012). Thus, an introductory text to the topic (see Appendix B) was displayed for a minimum of 10 seconds before the survey started to ensure that all respondents could more easily understand what an AV is and see its relevance to their personal lives.

Moreover, to study the second research question regarding whether there are differences between the mechanisms leading to intention to adopt AVs that have both autonomous and manual (AM) driving modes and AVs that solely have autonomous (autonomous only, AO) capabilities, a quasi-experimental setting was applied. In line with the recommendations by Heffner (2004) to avoid validity concerns in group selection, participants were automatically drawn at random into two even groups that were presented with different stimulus texts focused on one of the AV variants (i.e., AM or AO; see Appendix B), which was also displayed for a minimum of 10 seconds. In addition, participants were twice reminded about the type of AVs they were answering about (e.g., "What is your general impression of autonomous vehicles (AVs) that can be driven both manually and autonomously?").

Another potential source of participant error or method bias regards the respondents' ability to comprehend the meaning of questions and making judgments, which may be affected by issues of complex or abstract questions, item ambiguity or doubled-barreled questions (cf. MacKenzie & Podsakoff, 2012). All measures used in the survey were based on previously validated scales, and effort went into ensuring that all items were worded in a way that would not trigger any confusion for the respondent. In addition, five individuals from the target population were invited to read through both the topic introduction text and the survey items, and reported no difficulty in comprehending or relating to neither the topic nor the items.

Furthermore, in line with MacKenzie & Podsakoff (2012) recommendations to reduce common method bias due to similar scale attributes, the introduction to the survey (Appendix B) emphasized the importance of respondents answering all items to the best of their ability, even though some items might seem similar. In addition, items with different response formats were combined to reduce the risk of common method bias (Podsakoff et al., 2003). Thus, both Likert-type and semantic differential items were used.

Regarding the structure of the survey, different formats involve varying sources of method bias (for a discussion, see Viswanathan & Kayande, 2012). As the main focus of this research was to study relationships between constructs, sources of across-measure (i.e., between constructs) correlational systematic error were regarded as a greater concern than within-measure (i.e., between items of a construct) correlational systematic error. Hence, interspersion (i.e., intermixing) of items was avoided as it increases inter-construct correlation (Podsakoff et al., 2003), and, furthermore, may lead to confusion for the respondent (Viswanathan & Kayande, 2012). Rather, items of the same construct were placed contiguously.

However, items of different constructs were separated by one line, which may help reduce the potential for inflated correlations between constructs (Viswanathan & Kayande, 2012). As the survey consisted of relatively many items, perceived survey length might lead to reduced motivation to respond accurately (cf. Viswanathan & Kayande, 2012). Thus, a compromise between the number of items per page and the number of pages in the survey was sought by placing groups of two or three constructs on separate pages. Participants were not given the option of returning to a previous page. In addition, labeling of the constructs was avoided as it may lead to increased within-measure correlational systematic error (Viswanathan & Kayande, 2012). According to Viswanathan and Kayande (2012), this type of paginate structure with unlabeled constructs reduces the likelihood of invoking implicit theories. Nonetheless, steps were taken to minimize careless responses that might have resulted from participant fatigue (see Section 5.1).

## 5.3 Measures

The research model includes ten constructs, most of which have measurement items that are well-founded in the information systems research.[7]

Concerning *motivational influences*, the measures for **perceived self-identity** were taken from Arbore et al. (2014), but reworded in terms of using the innovation based on the

[7]An overview of the original measurement items that were adapted for this study can be found in Appendix C, while Table 4 (p. 52) shows the measures used in this study.

recommendation by Moore and Benbasat (1991). The **perceived usefulness** construct consisted of four items. Two general items were used, adapted from Davis et al. (1989) and Karahanna et al. (1999). However, as most usefulness scales have been developed for research on information systems adoption in organizational contexts, no scale seemed apt to reflect the particular functional outcomes of adopting AVs in a private context. Thus, two items were developed to adapt the scale to the research topic, with the aim of preserving the utilitarian nature of the scale. Based on the AV literature, two important functional benefits were identified related to saving or freeing up time and increasing mobility (Fagnant & Kockelman, 2015; Gill et al., 2015; Shanker et al., 2013). These factors have been found to be important both for general car use (e.g., Bergstad et al, 2011; Kent, 2014) and opinions toward AVs (e.g., Fraedrich & Lenz, 2014; Howard & Dai, 2014; Sciencewise, 2014). Thus two new items were developed; one to cover saved or freed up time ("using an AV would give me more time for other activities") and one to reflect increased mobility ("using an AV would enhance my mobility in situations where I cannot drive"). Four items were used to measure **perceived enjoyment**, with two items adapted from Hong and Tam (2006) and one item adapted from Nysveen et al. (2005), along with one item shared by both these research models. Items that were not worded in terms of using the innovation were rephrased (cf. Moore & Benbasat, 1991). In addition, the word "while" was inserted in two of the items, e.g., "I would be entertained while using an AV", so as to cover the whole experience of using an AV, which might involve both the experience of riding an AV as well as the experience of utilizing various forms of entertainment whilst being driven by the AV. The **perceived risk** items were nearly identical to the ones used by Wiedmann et al. (2011), but were rephrased in relative terms regarding the use of the innovation.

Regarding *automatic influences*, three items were used to represent **compatibility**, which were adapted from two items used by Meuter et al. (2005) and one item used by Petschnig et al. (2014). Based on the recommendation by Karahanna et al. (1999), the word "completely" was avoided. The resulting construct is a measure of compatibility with one's lifestyle, habits and ways of doing things, which closely relates it to automatic processes.

For *normative influences*, three items were used to measure **social norms** which were the same used by Hong and Tam (2006). **Personal norms** were measured using three items that were developed for this study inspired by the measures used by Jansson (2011) and Petschnig et al. (2014).

To cover *resource related influences*, **perceived behavioral control** was measured using three items that were based on the measure developed by Taylor and Todd (1995). Three items taken from Davis et al. (1989) were used for **perceived ease of use**.

In terms of *attitudinal influences*, **attitude** toward use was measured using four bipolar adjectives that cover different aspects of respondents' attitude. The items were taken from Bagozzi and Dholakia (2006) and Nysveen et al. (2005), and closely resemble those used by Davis (1989).

Finally, **intention** to use was measured using a two-item scale that was adapted from Hong and Tam (2006).

Except for attitude, all of the items were presented as statements that the participants would indicate their agreement with by using a 7-point Likert-type scale ranging from *strongly disagree* to *strongly agree*. Attitude toward use was measured using bipolar adjectives on 7-point Likert-type scales.

# 6. Analysis and Results

The collected data were analyzed using the statistical analytics software SPSS and structural equation modeling (SEM) in Mplus 7. As SEM is an extension of multiple regression analysis that allows for simultaneous investigation of relationships between several independent and dependent variables (Byrne, 2010), the assumptions of multivariate analysis were first tested as detailed below. Next, based on the recommended by Anderson and Gerbing (1988), a two-stage testing procedure was adopted: first, the measurement model for the constructs was estimated using confirmatory factor analysis (CFA); second, the structural relationships between the constructs were examined to evaluate the research model and test the research hypotheses.

## 6.1 Assumptions of multivariate analysis

In order to perform multivariate analysis, several assumptions should be met, including normality, homoscedasticity, linearity, and absence of autocorrelation (Field, 2009; Hair et. al., 2010).

First, normality refers to normal distribution of the residuals of variables (i.e., constructs). Substantial deviations from normality will affect the reliability of the t- and F-test, particularly for small samples, and may invalidate all resulting statistical tests (Hair et al., 2010). Hence, univariate normality of the latent constructs was assessed by the Kolmogorov-Smirnov statistics, which indicated normal distribution of seven of the constructs, and non-normal distribution for four of the constructs (see Appendix D). However, inspection of the constructs' skewness and kurtosis[8] (Appendix D) showed that all absolute values were below the threshold ($\leq 1$) recommended by Fields (2009). Moreover, on inspection of the residual histograms and Q-Q plots, all constructs were found to approximate normal distribution (Appendix E). Thus, while some of the constructs may be non-normal, the deviation can be considered small. As non-normality is less of a concern for large samples ($N > 200$) according to Hair et al. (2010), the low degree of univariate non-normality observed for some of the constructs can be considered non-critical for the current study given its relatively large sample ($N = 320$).[9]

[8] Skewness is a measure of the asymmetry and kurtosis is a measure of 'peakedness' of a distribution (Hair et al., 2010).
[9] SEM is usually performed using Maximum Likelihood (ML) estimation, which assumes that the data have not only univariate but multivariate normal distribution. Univariate normal distribution is a prerequisite, but no guarantee for multivariate normal distribution, yet is in most cases considered a sufficient indicator of normality (Hair et al., 2010). However, SEM

The next assumption is homoscedasticity, which entails the dependent variable exhibiting equal levels of variance across the range of predictor variables (Hair et al., 2010). To determine whether the data was homoscedastic, scatter plots of predicted versus residual values were examined for uneven distributions, indicating no clear violations of homoscedasticity (Appendix E). In addition, the Breusch-Pagan (Breusch & Pagan, 1979) and Koenker (Koenker & Bassett, 1982) statistical tests for heteroscedasticity were employed. Both tests had significant scores indicating that the null hypothesis of homoscedasticity could not be rejected (Appendix F). Hence, homoscedasticity was found acceptable.

Linearity is also assumed in multivariate analysis, and was examined by analyzing the residuals and partial regression plots for the independent variables (Hair et al., 2010). These plots are available in Appendix E, and show no signs of non-linear patterns, thus satisfying the assumption of linearity.

Autocorrelation refers to the correlation between the residuals of two observations in a model, which lead the variance and estimated standard errors to increase (Field, 2009). Applying the Durbin-Watson test on the data to assess autocorrelation produced a score of 1.305 (Appendix G), which is within the acceptable range between 1 and 3 (Field, 2009), thus indicating no issue with autocorrelation.

In addition, multicollinearity was assessed by inspecting the inter-construct correlations, non of which exceed the recommended 0.80 Pearson's r cut-off value for multicollinearity (Berry & Feldman, 1985; Field, 2009. See also Table 5). Furthermore, the tolerance values and variance inflation factors (VIF) were compared to the levels recommended by Hair et al. (2010), and showed acceptable scores for all constructs (tolerance = 0.45-0.76, VIF = 1.31-2.22. See Appendix G).

Finally, an assumption for SEM is that items representing latent constructs be reflective, i.e. affected by the same underlying concept (Chin, 1998). Applying the acid test proposed by Chin (1998:ix) of assessing whether a directional change in one item would make the other items change in a similar manner, indicated that all items were reflective. Thus, all constructs were treated as latent variables that included measured items, and were modeled as first-order factors.

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can also be executed using Robust Maximum Likelihood (MLR), which can provide more stable and precise robust standardized errors and other fit indices based on the Satorra-Bentler (S-B) $\chi 2$ if the data are multivariate non-normal (Byrne, 2010). Thus, MLR was run in Mplus 7 and compared to ML results, which showed only minor improvements in model fit and no change in explanatory power. Hence, ML was used as this is the standard method.

## 6.2 Analysis

### 6.2.1 Goodness-of-fit

To assess overall model fit, Mplus 7 was used to perform a confirmatory factor analysis (CFA) of the measurement model on the independent, mediating and dependent variables. A starting point for testing the goodness-of-fit (GOF) of the measurement model is typically its chi-square ($\chi^2$) value, which should preferably be low with insignificant *p*-values in SEM. However, chi-square statistics tend to be greater and more significant the larger the sample sizes and the more items are tested in a model (Bentler, 1990). Thus, as the research model is relatively complex and the sample is quite large (N = 320), it can be expected to get unsatisfactory chi-square statistics (Hair et al., 2010), which was indeed the case ($\chi^2 = 800.3$, $p < 0.05$). However, several other GOF measures have been developed to correct for the problems with the inherent bias in chi-square statistics against complex models and large samples. According to Hair et al. (2010:672), three to four such measures, which should include at least one absolute fit index and one incremental index, provides adequate evidence of model fit. Thus, three absolute fit indexes and two incremental indices were used to test the GOF of the research model, and were assessed based on the recommended values by Hair et al. (2010).

First, regarding the absolute fit indices, normed chi-square ($\chi^2/df$), which is the ratio of chi-square to the degrees of freedom, showed good fit ($\chi^2/df = 1.60$). The root mean square error of approximation (RMSEA), which attempts to correct for sample size and model complexity by including them in the calculation, was also satisfactory (RMSEA = 0.043). In addition, the standardized root mean residual (SRMR) showed good fit (SRMR = 0.031). Second, incremental indices were evaluated, with both the Tucker-Lewis index (TLI) that compares the normed chi-square of the null and specified model, and the comparative fit index (CFI), which is highly insensitive to model complexity, showing good fit (TLI = 0.974, CFI = 0.969). GOF values for the final measurement model are shown in Table 3 (see also Appendix H). [10]

However, while the overall fit seemed good, an examination of the modification indices for the various constructs showed potential problems with the perceived self-identity construct, where very high scores were found regarding item 3 and 4 (M.I. = 152.1), as well as item 1 and 2 (M.I. = 135.1). These pairs of items are worded rather similarly, which may

[10] Initial GOF values before including the correlated error terms for the pairs of PSI items (see Section 6.2.1) and removing PU3 (see Section 6.2.2) was: $\chi^2 = 974.0$ $p = 0.0000$, $\chi^2/df = 1.81$, RMSEA = 0.050, SRMR = 0.032, TLI = 0.956, CFI = 0.962.

**Table 3: Confirmatory Factor Analysis Results**

| Goodness-of-Fit Test | Abbreviation | Ranges indicating good fit* | Measurement model |
|---|---|---|---|
| Chi-square | $\chi^2$ | n.a. | 800.3 (p=0.0000) |
| Degrees of freedom | *df* | n.a. | 503 |
| Normed chi-square | $\chi^2/df$ | ≤ 2 | 1.60 |
| Root mean square error of approximation | RMSEA | < 0.05 | 0.043 |
| Standardized root mean residual | SRMR | < 0.05 | 0.031 |
| Tucker-Lewis Index | TLI | > 0.95 | 0.974 |
| Comparative fit index | CFI | > 0.95 | 0.969 |

*Based on thresholds cited in Hair et al. (2010).

justify specification of the correlated error terms (Byrne, 1998). Furthermore, as the self-identity construct consists of what may be perceived as two sub-dimensions in terms of personal identity and social identity (Arbore et al., 2014), the possibility exists that the construct is two-dimensional in the mind of the consumer. Introducing the correlated error terms for the two pairs of items (i.e., belonging to each potential sub-dimension) could thus also be theoretically justified, as it serves to make the potential bi-dimensionality explicit in the model. Thus, the correlated error terms were introduced, which significantly improved the model fit ($\Delta\chi^2$ = 142.6, $\Delta df = 2$, $p < 0.05$).[11] Hence, the measurement model fit met the first requirement for measurement model validity.

### 6.2.2 Construct validity

Construct validity refers to the extent to which a set of measured items actually reflects the theoretical latent construct those items were designed to capture (Hair et al., 2010), and is the second requirement for measurement model validity. The first condition for construct validity is convergent validity (i.e., internal consistency), which requires that a construct's items should converge or have in common a large proportion of variance so as to cover the same underlying concept. To test this, factor loadings for all items were first examined (see also Appendix I). According to Hair et al. (2010:709), standardized factor loading estimates should ideally be 0.7 or higher, and at least 0.5 or higher to be considered acceptable. All items scored

[11] Model fit was now $\chi^2$ = 831.4 $p$ = 0.0000, $\chi^2/df$ = 1.55, RMSEA = 0.041, SRMR = 0.032, TLI = 0.974, CFI = 0.970).

above the 0.5 threshold, but two of the factor loadings for the perceived usefulness construct were below 0.7. One of these items loaded only marginally weaker (PU1 = 0.69) than the recommended level, and was retained. However, the other item (PU3 = 0.55), which had been developed to cover aspects regarding mobility, loaded close to the lowest acceptable level. Moreover, an examination of item-to-total correlations (Appendix J) also showed a very low score for item PU3 (0.53), while all other items performed well (≥0.85). Item PU3 was therefore considered for exclusion.

One possibility for item PU3's low score is that mobility is considered a distinct dimension to usefulness by consumers, giving potential content validity problems for the measure. Some support for this can be found within research in motives for car use, as Steg (2005) found independence to emerge as a separate factor to instrumental motives for car use. Hence, item PU3 was dropped from the model as aspects related to mobility may be a discrete factor influencing AV adoption intention, thus threatening the face validity of the perceived usefulness construct. Removing item PU3 had insignificant effects on model fit ($\Delta\chi^2 = 31.1$, $\Delta df = 34$, $p < 0.05$).

As reported in Table 4, factor loadings of the retained items indicated acceptable convergent validity.[12] In addition, the constructs were tested in terms of Chronbach's alpha ($\alpha$), composite reliability (CR), and average variance extracted (AVE). Recommended values for these measures are $\alpha > 0.7$, CR > 0.7, and AVE > 0.5 (Fornell & Larcker, 1981; Nunnaly, 1978), which were exceeded for all constructs (Table 4), indicating good internal consistency.

The second condition for construct validity is discriminant validity, which concerns the degree to which the construct truly differs from other constructs (Hair et al., 2010). To assess discriminant validity, inter-constructs correlations provide a starting point. As shown in Table 4, non of the inter-construct correlations exceed the 0.80 cut-off value for multicollinearity recommended by Berry and Feldman (1985). Furthermore, Agarwal and Karahanna

[12] Introducing the correlated error terms for the two pairs of items in the self-identity construct only slightly changed the factor loadings by $\leq |0.05|$.

## Table 4: Items and Convergent Validity

| Construct | Item | Description | Loadings | α | CR | AVE |
|---|---|---|---|---|---|---|
| Perceived enjoyment | PE1 | I would find it enjoyable to use an AV. | 0.89 | 0.94 | 0.94 | 0.80 |
| | PE2 | I would be entertained while using an AV. | 0.87 | | | |
| | PE3 | I believe using an AV would be pleasurable. | 0.93 | | | |
| | PE4 | I would have fun while using an AV. | 0.89 | | | |
| Perceived self-identity | PSI1 | Using an AV would reflect my identity. | 0.94 | 0.97 | 0.96 | 0.85 |
| | PSI2 | Using an AV would reflect who I am. | 0.95 | | | |
| | PSI3 | Using an AV would express the personality that I want to communicate to others. | 0.91 | | | |
| | PSI4 | Using an AV would reflect the way that I want to present myself to others. | 0.90 | | | |
| Perceived usefulness* | PU1 | Using an AV would give me more time for other activities. | 0.69 | 0.83 | 0.83 | 0.62 |
| | PU2 | Using an AV would make my life easier. | 0.81 | | | |
| | *PU3*** | *Using an AV would enhance my mobility in situations where I cannot drive.* | *0.55*** | | | |
| | PU4 | I would find an AV useful in my daily life. | 0.86 | | | |
| Perceived risk | PR1 | Using an AV would make me more concerned about potential physical risks of driving. | 0.85 | 0.91 | 0.91 | 0.76 |
| | PR2 | While using an AV, I would be concerned that the risk of endangering my passengers, like family members, might be higher. | 0.92 | | | |
| | PR3 | While using an AV, I would have stronger security concerns in the case of an accident. | 0.85 | | | |
| Compatibil-ity | CO1 | Using an AV would be compatible with my lifestyle. | 0.91 | 0.95 | 0.95 | 0.87 |
| | CO2 | Using an AV would fit well with my habits. | 0.96 | | | |
| | CO3 | Using an AV would fit the way I do things. | 0.93 | | | |
| Perceived ease of use | PEOU1 | Learning to operate an AV would be easy for me. | 0.85 | 0.91 | 0.91 | 0.76 |
| | PEOU2 | I would find it easy to get an AV to do what I want it to do. | 0.82 | | | |
| | PEOU3 | I believe I would find an AV easy to use. | 0.96 | | | |
| Perceived behavioral control | PBC1 | When AVs are available, I believe I will afford to use one. | 0.81 | 0.89 | 0.89 | 0.73 |
| | PBC2 | When available, I believe I will have the necessary means and resources to use an AV. | 0.91 | | | |
| | PBC3 | When available, I will have the ability and opportunity to use an AV if I want to. | 0.85 | | | |
| Personal norm | PN1 | I would feel a moral obligation to use AVs due to their lower fuel con-sumption. | 0.96 | 0.97 | 0.97 | 0.92 |
| | PN2 | I would feel a moral obligation to use AVs due to their lower emissions. | 0.97 | | | |
| | PN3 | I would feel a moral obligation to use AVs as they are more environmen-tally friendly. | 0.96 | | | |
| Social norm | SN1 | People who influence my behavior would think I should use an AV. | 0.87 | 0.92 | 0.92 | 0.80 |
| | SN2 | People who are important to me would want me to use an AV. | 0.85 | | | |
| | SN3 | People whose opinions I value would prefer me to use an AV. | 0.96 | | | |
| Attitude | AT1 | Bad - Good | 0.86 | 0.93 | 0.93 | 0.78 |
| | AT2 | Harmful - Beneficial | 0.87 | | | |
| | AT3 | Foolish - Wise | 0.86 | | | |
| | AT4 | Negative - Positive | 0.95 | | | |
| Intention | INT1 | When available in the future, I intend to use an AV. | 0.95 | 0.94 | 0.94 | 0.89 |
| | INT2 | I intend to use an AV frequently in the future. | 0.94 | | | |

Values that indicate convergent validity (Hair et al., 2010): Loadings > 0.7, α > 0.7, CR >0.7, AVE > 0.5.

*. The factor loadings, α, CR and AVE of perceived usefulness are shown for the retained items.
**. Indicates dropped item.

(2000) state that all constructs should share more variance with their items than with other constructs for discriminant validity, which can be established by testing whether the square root of the AVE is larger than the correlations between constructs (Fornell & Larcker, 1981). As shown in Table 5, the diagonal values representing AVE square roots are all larger than the inter-construct correlations, which provides good evidence for acceptable discriminant validity (Fornell & Larcker, 1981; Hair et al., 2010). An even stricter test of comparing AVEs directly with inter-construct correlations (Fornell & Larcker, 1981), showed that only perceived usefulness has an AVE marginally lower than one of its correlation (AVE = 0.620, PU-CO correlation = 0.627). Thus, the constructs had solid discriminant validity.

**Table 5: AVE Square Roots and Inter-Construct Correlations**

| | PE | PSI | PU | PR | CO | PEOU | PBC | PN | SN | ATT | INT |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Perceived enjoyment (PE) | **.895** | | | | | | | | | | |
| Perceived self-identity (PSI) | .426** | **.923** | | | | | | | | | |
| Perceived usefulness (PU) | .574** | .392** | **.787** | | | | | | | | |
| Perceived risk (PR) | -.167** | -.189** | -.180** | **.874** | | | | | | | |
| Compatibility (CO) | .560** | .560** | .627** | -.243** | **.935** | | | | | | |
| Perceived ease of use (PEOU) | .364** | .267** | .376** | -.147** | .360** | **.877** | | | | | |
| Perceived behavioral control (PBC) | .141* | .229** | .249** | -.107 | .212** | .300** | **.857** | | | | |
| Personal norm (PN) | .258** | .135* | .204** | -.223** | .232** | .130* | .051 | **.959** | | | |
| Social norm (SN) | .332** | .338** | .392** | -.246** | .395** | .134* | .299** | .483** | **.894** | | |
| Attitude (ATT) | .453** | .392** | .502** | -.458** | .470** | .435** | .376** | .313** | .377** | **.884** | |
| Intention (INT) | .600** | .521** | .609** | -.382** | .671** | .401** | .342** | .359** | .475** | .737** | **.946** |

Bold numbers on the diagonal are the square root of each constructs AVE. Off diagonal numbers are the correlations among constructs. For discriminant validity, diagonal numbers should be larger than off diagonal numbers in the same row or column (Fornell & Larcker, 1981).

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

### 6.2.3 Common method variance

A risk with model testing is always the presence of common method bias, i.e. variance that is attributable to the measurement method instead of the constructs the measures represent (Bagozzi & Yi, 1991). While several procedural remedies for common method bias had been implemented as outlined in Chapter 5, no research design can guarantee against method bias. Therefore, statistical tools were employed to control for common method bias.

First, Harman's one-factor test was conducted to assess whether one factor accounted for the majority of the variance (cf. Podsakoff, 2003), which was not the case (see Appendix K). Second, the unmeasured latent method factor test was employed, as suggested by Podsakoff et al. (2003:898). The unmeasured factor accounted for only 9.7% of the total variance (see Appendix L). Based on comparable investigations (Carlson & Perrewe, 1999; Nysveen et al., 2005), this result indicates no serious threat caused by common method bias. Moreover, changes to standardized factor loadings were minor ($|\Delta| \leq 0.033$), and the change in model fit was insignificant ($\Delta\chi^2 = 0.23$, $\Delta df = 1$, $p < 0.05$. See Appendix I).

Hence, the statistical tools indicated that common method bias was not a threat to the analysis, which was completed without the common method variable.

### 6.2.4 Descriptive statistics

Table 6 reports the descriptive statistics for the constructs in terms of their mean, standard deviation, variance, skewness and kurtosis. Relatively low means are observed for perceived self-identity (2.78) and social norm (2.98), while perceived ease of use (5.13) has a relatively high mean. The strongest skewness is also found for perceived self-identity (0.591), while personal norm has the strongest kurtosis (-0.905). As previously mentioned (Section 6.1), all values are within the recommended threshold (i.e., with an absolute value < 1) (Fields, 2009).

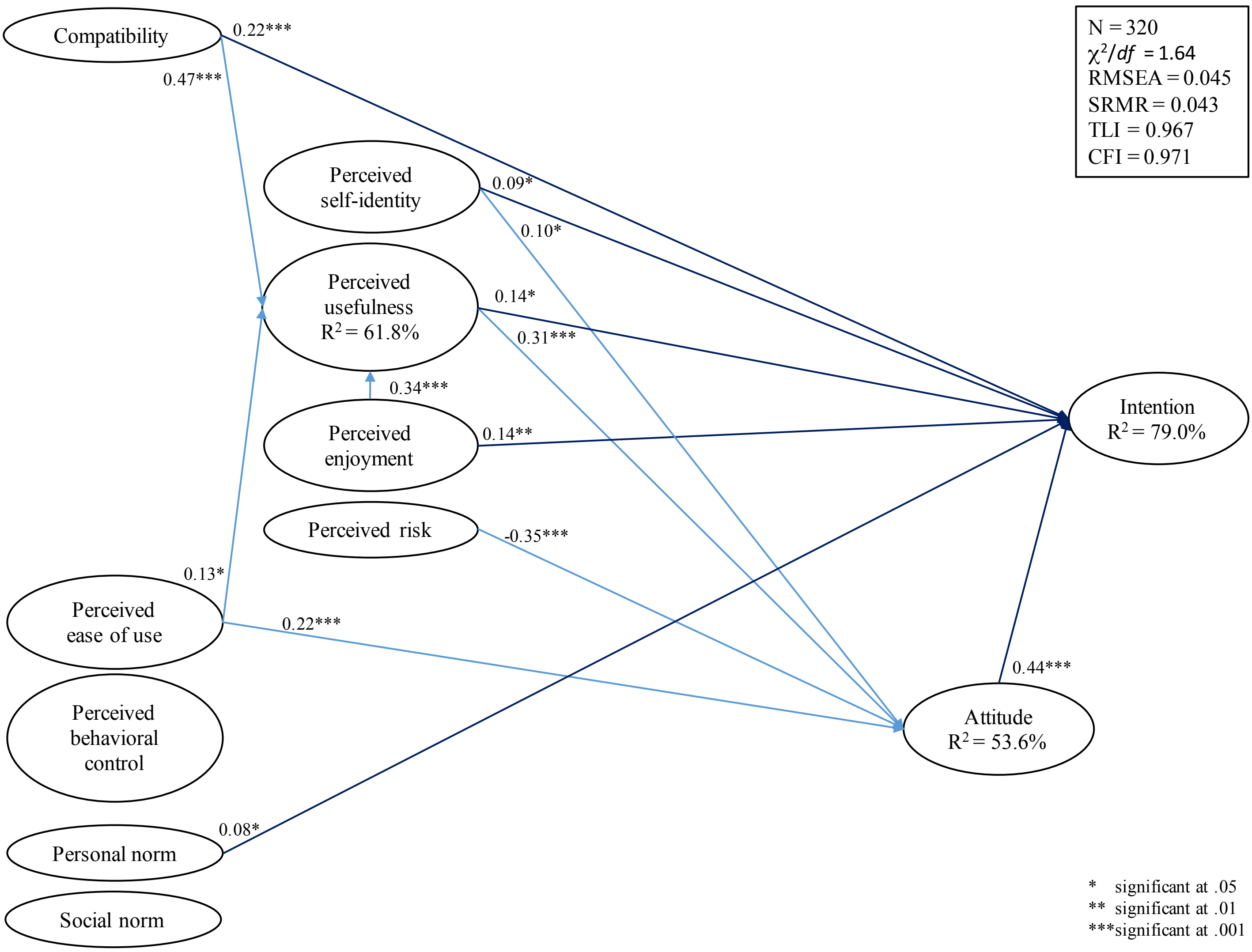
**Table 6: Descriptive Statistics**

| Construct | Mean | Std. Deviation | Variance | Skewness | Kurtosis |
|---|---|---|---|---|---|
| Perceived enjoyment | 4.59 | 1.47 | 2.17 | -.175 | -.762 |
| Perceived self-identity | 2.78 | 1.43 | 2.03 | .591 | -.481 |
| Perceived usefulness | 4.70 | 1.49 | 2.21 | -.289 | -.783 |
| Perceived risk | 4.55 | 1.62 | 2.61 | -.301 | -.791 |
| Compatibility | 4.10 | 1.60 | 2.56 | .042 | -.802 |
| Perceived ease of use | 5.13 | 1.26 | 1.59 | -.491 | -.213 |
| Perceived behavioral control | 3.50 | 1.41 | 2.00 | .253 | -.471 |
| Personal norm | 3.46 | 1.60 | 2.55 | .130 | -.905 |
| Social norm | 2.98 | 1.28 | 1.65 | .059 | -.768 |
| Attitude | 4.85 | 1.40 | 1.96 | -.335 | -.724 |
| Intention | 4.04 | 1.67 | 2.79 | -.003 | -.801 |

## 6.3 Results

Hypotheses were tested with structural equation modelling in Mplus 7, using the data from all respondents. In this structural model, the relationship between the five influences proposed in the research model (i.e., attitudinal influences, motivational influences, resource related influences, automatic influences and normative influences) and intention were investigated. In addition, the mediating effect of attitudinal influences on motivational influences, as well as the mediating effect of perceived usefulness on compatibility and perceived enjoyment, were tested. The results of this analysis are shown in Figure 6, which includes the standardized path coefficients for all significant paths and the explained variance of perceived usefulness, attitude and intention, along with a model fit summary. As anticipated based on the measurement model results, the structural model also showed good fit ($\chi^2$ = 839.3 $p$ = 0.0000, $\chi^2/df$ = 1.64, RMSEA = 0.045, SRMR = 0.043, TLI = 0.967, CFI = 0.971. See Appendix H).

**Figure 6: Structural Equation Modeling Results**



Moreover, the model explained a high share of the variance in intention to adopt (79%), which indicates that it covers well the underlying dimensions of consumer intention to adopt an AV.

### 6.3.1 Direct and indirect effects

To avoid confounding of results due to specific individual characteristics, gender, age, education and nationality were included in the analysis as control variables. Since none of the controls were significant (see Appendix M), they were dropped from the model.

Considering the individual determinants of intention, strong direct effects were found for attitude ($\beta = 0.44$, $p < 0.001$) and compatibility ($\beta = 0.22$, $p < 0.001$), with other significant effects of perceived enjoyment ($\beta = 0.14$, $p < 0.01$), perceived usefulness ($\beta = 0.14$, $p < 0.05$), perceived self-identity ($\beta = 0.09$, $p < 0.05$) and personal norms ($\beta = 0.08$, $p < 0.05$) were all significant predictors of intention to adopt an AV, supporting $H_1$, $H_2$, $H_4$, $H_8$, $H_{15}$ and $H_{18}$. Altogether, 79% of the variance in AV adoption intention was explained by these antecedents. However, no significant influence on intention was revealed for perceived behavioral control ($\beta = 0.06$, $p > 0.05$), perceived risk ($\beta = -0.05$, $p > 0.05$), perceived ease of use ($\beta = -0.04$, $p > 0.05$) or social norms ($\beta = 0.02$, $p > 0.05$), indicating that hypotheses $H_6$, $H_{11}$, $H_{12}$ and $H_{17}$ were not supported.

Regarding the determinants of attitude toward use, strong effects were found in the predicted direction for perceived risk ($\beta = -0.35$, $p < 0.001$), perceived usefulness ($\beta = 0.31$, $p < 0.001$) and perceived ease of use ($\beta = 0.22$, $p < 0.001$), in addition to significant effects of perceived self-identity ($\beta = 0.10$, $p < 0.05$), supporting $H_3$, $H_5$, $H_7$ and $H_{13}$. Yet, no significant influence of perceived enjoyment ($\beta = 0.08$, $p > 0.05$) on attitude was found, indicating that $H_9$ was not supported. Combined, these factors explained 54% of the variance in attitude toward use. In addition, regarding the hypothesized antecedents of perceived usefulness, strong effects were found for compatibility ($\beta = 0.47$, $p < 0.001$) and perceived enjoyment ($\beta = 0.34$, $p < 0.001$), along with significant effects for perceived ease of use ($\beta = 0.13$, $p < 0.05$). Thus support was found for $H_{10}$, $H_{14}$ and $H_{16}$, with the relationships jointly explaining 62% of the variance in perceived usefulness. Summarized results for all the hypothesis tests are shown in Table 7 (see also Appendix N).

## Table 7: Hypotheses Support

| Hypotheses | Relationship | Direction | β | *p* | Support |
|---|---|---|---|---|---|
| H1 | Attitude -> Intention | + | 0.44 | 0.000 | Yes |
| H2 | Perceived self-identity -> Intention | + | 0.09 | 0.022 | Yes |
| H3 | Perceived self-identity -> Attitude | + | 0.11 | 0.046 | Yes |
| H4 | Perceived usefulness -> Intention | + | 0.14 | 0.038 | Yes |
| H5 | Perceived usefulness -> Attitude | + | 0.31 | 0.000 | Yes |
| H6 | Perceived risk -> Intention | - | -0.05 | 0.223 | No |
| H7 | Perceived risk -> Attitude | - | -0.35 | 0.000 | Yes |
| H8 | Perceived enjoyment -> Intention | + | 0.14 | 0.003 | Yes |
| H9 | Perceived enjoyment -> Attitude | + | 0.08 | 0.191 | No |
| H10 | Perceived enjoyment -> Perceived usefulness | + | 0.34 | 0.000 | Yes |
| H11 | Perceived behavioral control -> Intention | + | 0.06 | 0.115 | No |
| H12 | Perceived ease of use -> Intention | + | -0.04 | 0.263 | No |
| H13 | Perceived ease of use -> Attitude | + | 0.22 | 0.000 | Yes |
| H14 | Perceived ease of use -> Perceived usefulness | + | 0.13 | 0.011 | Yes |
| H15 | Compatibility -> Intention | + | 0.22 | 0.000 | Yes |
| H16 | Compatibility -> Perceived usefulness | + | 0.47 | 0.000 | Yes |
| H17 | Social norms -> Intention | + | 0.02 | 0.594 | No |
| H18 | Personal norms -> Intention | + | 0.08 | 0.035 | Yes |

In addition, the total paths that take into consideration both the direct and indirect effects on intention were calculated for the different constructs using the same method as, e.g., Brakus et al. (2009). Table 8 shows each construct's total path on intention, along with the path coefficients for all tested direct effects on intention, attitude and perceived usefulness.

## Table 8: Constructs' Total Path on Intention

| Construct | Direct effects on: | | | Total path on intention |
|---|---|---|---|---|
| | INT | ATT | PU | |
| ATT | 0.44 | | | 0.44 |
| CO | 0.22 | | 0.47 | 0.35 |
| PU | 0.14 | 0.31 | | 0.28 |
| PE | 0.14 | n.s | 0.34 | 0.23 |
| PR | n.s. | -0.35 | | -0.15 |
| PSI | 0.09 | 0.10 | | 0.13 |
| PEOU | n.s. | 0.22 | 0.13 | 0.13 |
| PN | 0.08 | | | 0.08 |
| PBC | n.s. | | | n.s |
| SN | n.s. | | | n.s |

Numbers indicate path coefficients (β), while n.s. indicates non-significant paths

### 6.3.2 AV variant comparison

To answer RQ2 regarding whether there are different mechanisms behind adoption intention toward the two types of AVs (i.e. AVs with autonomous and manual (AM) versus autonomous only (AO) driving modes), group comparison methods for SEM were applied. As both groups consisted of respondents with highly similar sample characteristics (see Section 5.1), no control variables needed to be tested.

To test for configural invariance, i.e. that the same basic factor structure exists in both groups (Hair et al., 2010), model fit was assessed for both groups, and found to be reasonable (the least fit unconstrained model had $\chi^2 = 839.0$ $p = 0.0000$, $\chi^2/df = 1.64$, RMSEA = 0.063, SRMR = 0.057, TLI = 0.933, CFI = 0.942) given the number of items (35) and smaller sample size (N = 160 for each group).[13] The model with all parameters freely estimated in the two groups also had decent fit ($\chi^2 = 1707.6$ $p = 0.0000$, $\chi^2/df = 1.59$, RMSEA = 0.061, SRMR = 0.055, TLI = 0.941, CFI = 0.946). Next, metric invariance was tested to establish that the meaning of constructs was equivalent between the groups (Hair et al., 2010). This was performed by constraining all factor loadings, which resulted in an insignificant change in model fit ($\Delta\chi^2 = 5.98$, $\Delta df = 11$), indicating that constructs were understood similarly.

In order to check for potential differences in the mechanisms behind adoption intention, construct means for the two groups were first compared, with no significant differences found (see Appendix O). Next, potential differences in structural paths between the two groups were investigated by constraining the structural paths in the models one at the time.[14] As each of these constraints added one degree of freedom to the model, significant change in model fit would require $\Delta\chi^2 \geq 3.84$ (at $p < 0.05$), however the highest observed change was $\Delta\chi^2 = 2.55$ (see Appendix O). Hence, no significant differences in structural paths between the AM and AO groups were found.

In sum, these findings strongly support that there are no significant differences in the drivers of adoption intention for the two AV variants.

[13] All items used to capture latent constructs were identical for both groups.
[14] The implicit hypothesis tested here was that at least one structural path would be different between the AM and AO groups.

# 7. Discussion

The research model shows good fit and a high explanatory power of 79%. As such, the model compares well with the traditional DIM or TAM, which usually explain around 40% of the variance in adoption intention (cf. Arts et al., 2011; Venkatesh & Davis, 1999), as well as with earlier extended versions of such models (cf. Venkatesh et al., 2003). Furthermore, the results suggest that the model is good when compared with other research models on adoption intention toward car innovations, which typically explain only 20-55% of the variance in intention (e.g. Moons & De Pelsmacker, 2012; Noppers et al., 2014; Petschnig et al., 2014; Schuitema et al., 2013). Finally, the model explains considerably more of the variance in intention to adopt than previous research on consumers' intention to adopt autonomous driving technologies (Payre et al., 2014). Hence, the overall results indicate that the research model is suitable for studying consumers' intention to adopt AVs.

While previous research has shown that consumers' intention to adopt AVs is driven by attitude, contextual acceptability and driving-related sensation-seeking (Payre et al., 2014), the present research reveals several additional influences on adoption intention.

Regarding the first research question about the various influences on AV adoption intention hypothesized in this thesis, no support was found for the proposed direct impact of resource related influences on intention. However, perceived ease of use was found to have indirect effects via usefulness and attitude, as postulated by the TAM (Davis et al., 1989).

Some, albeit weak, support was found for the effect of normative influences on intention in terms of the direct influence of personal norms regarding the environment. Thus, the environmental impact of AVs seems relevant to consumers' adoption intention. However, it should be noted that the observed effect was weaker than what has been found in studies on intention to adopt other car innovations (Jansson, 2011; Petschnig et al., 2014), which may imply that the environmental benefits of AVs are less clear to consumers at this point in time than those offered by alternative fuel vehicles. Social influences had no significant effect, which could be due to the newness of the innovation, causing consumers to have no clear perception of other people's opinions regarding AVs.

Strong support exists for the effect of compatibility on intention, regarded in this thesis as an automatic influence, which indicates that the perceived fit of the innovation with the consumers' established lifestyle and habits directly influences their intention to make use of AVs in the future. This finding supports previous research that points out the importance of compatibility on adoption intention (Arts et al., 2014). Moreover, compatibility emerged as a strong predictor of usefulness (Holak & Lehmann, 1990), and as such also has an important indirect effect on attitude and intention.

Partial support was found for the direct impact of motivational influences on intention, as perceived self-identity, perceived usefulness and perceived enjoyment all have direct effects on intention, while perceived risk showed no direct impact on intention. This corroborates the finding that both extrinsic and intrinsic motivations directly influence intention (e.g. Davis et al., 1992; Venkatesh & Davis, 1996). Moreover, it indicates that functional, symbolic and hedonic motivations for car use (e.g., Bergstad et al., 2011; Gardner & Abraham, 2007; Kent, 2014; Sandqvist and Kriström, 2001; Sheller, 2004; Steg et al., 2001; Steg, 2003, 2005; Stradling et al., 1999, 2000) are also relevant in the context of AVs. In addition, all the motivational factors except perceived enjoyment were found to have significant influences on attitude toward using AVs. Together with perceived ease of use, the motivational influences explained 54% of the variation in consumers' attitude, which supports the traditional view that beliefs influence attitude and attitude influences intention (Fishbein & Ajzen, 1975). Furthermore, perceived enjoyment was found to be a strong predictor of perceived usefulness, which indicates that the finding by Hong and Tam (2006) and Arbore et al. (2014) may also be relevant in the context of car innovations. Together with the influence of compatibility and perceived ease of use, perceived enjoyment helped explain 62% of the variation in perceived usefulness.

Finally, strong support was also found for the impact of attitudinal influences on adoption intention. Attitude toward using AVs emerging as the strongest predictor of adoption intention supports the findings in previous research on adoption intention toward car innovations (Petschnig et al., 2014), including within the field of autonomous driving technologies (Payre et al., 2014).

With respect to the second research question, the results indicate that there are no significant differences in the mechanisms behind adoption intention nor the perceptions of the two different types of AVs, i.e., with (AM) or without (AO) the possibility to be driven manually. This may indicate that the option of manual driving is not a major concern for consumers, which would contradict earlier studies. Previous research has noted significant differences in consumer perceptions depending on a products level of automation (e.g., Rijsdijk & Hultink, 2003), and worries have been voiced elsewhere over loss of control or reduced driving pleasure if manual controls are not available (e.g. Bjørner, 2015; Kyriakidis et al., 2015; JDPA, 2012; Silberg et al., 2013). Thus, the insignificant differences between AM and AO found in this study should be interpreted with some caution, as it is also possible that, for instance, the autonomous capabilities described to both groups dominated respondents' attention to the extent that any priming effects were overshadowed. Nonetheless, the results offer an interesting contribution to the body of research regarding the need for manual controls in AVs.

## 7.1 Theoretical implications

As previous research on the factors that affect consumers' intention to adopt autonomous driving systems is scarce (Rosenzweig & Bartl, 2015), the results in this thesis contribute to the understanding of the factors that influence consumers' intention to make full use of AVs. Specifically, all included antecedents from the DIM or the TAM (i.e., compatibility, perceived usefulness, perceived ease of use and attitude) had significant direct or indirect effects on adoption intention toward AVs. However, neither perceived behavioral control nor social norms from the TPB were found to be significant predictors of consumers' intention to adopt AVs. In contrast, all the proposed extensions to the model taken from research in motives for car use, research on consumer adoption of alternative fuel vehicles and research on consumer perception of product autonomy (i.e., perceived enjoyment, perceived self-identity, perceived risk and personal norms) were found to have significant direct or indirect effects on adoption intention. Thus, the results indicate that considering rather untraditional antecedents of technology adoption is important in the context of consumer adoption of AVs.

Certain theoretical implications can be drawn from these results. First, in terms of the general theories that are frequently used in innovation adoption studies – the TPB, TAM and DIM – the results highlight the value of integrating different theoretical perspectives. Specifically, the findings imply that there is value to studying the direct effects of motivational influences, which are not considered in the TPB. While attitude toward use did mediate some of the effect of motivational influences, a considerable share of the impact was unmediated, indicating that consumers intend to adopt AVs for reasons of goal achievement or due to expected satisfaction from using the product. Thus, the results support previous studies that reveal the potential direct effects of motivational influences (e.g., Davis et al., 1989; Davis et al., 1992; Hong & Tam, 2006; Nysveen et al., 2005; van der Heijden, 2004; Venkatesh & Davis, 2000). Moreover, while much research based on the TAM and DIM do not measure attitude directly, the findings in this thesis show that including a measure for attitudinal influences can improve the explanatory power of the model (cf. Nysveen et al., 2005). In addition, the strong direct and indirect effects of compatibility found in this thesis indicate that the construct may cover aspects not included in the TPB or TAM. This result supports previous research which reveals that compatibility can significantly add to the explanatory power of a model compared with the TAM (Plouffe et al., 2001). While the conceptualization of compatibility as an automatic influence needs further research (see Section 7.3), findings in this thesis indicate that the fit between an innovation and the consumers' past experiences, habits and lifestyle can have effects beyond the influences traditionally argued to drive adoption intention. Furthermore, this study supports the notion that compatibility is an antecedent of perceived usefulness (Holak & Lehmann, 1990), which has not received much attention in the literature.

Second, the findings in this thesis lend support to previous research suggesting that general technology adoption models may need to be refined or expanded to capture the different usage contexts with respect to private innovation adoption (e.g. Hong & Tam, 2006; Nysveen et al., 2005; van der Heijden, 2004; Venkatesh & Brown, 2001). In particular, the results support previous findings that show how intrinsic motivation in terms of perceived enjoyment can be an important antecedent of intention (e.g., Davis et al., 1992; Nysveen et al., 2005; van der Heijden, 2004). Support is also found for a less explored relationship, as perceived enjoyment was found to be a strong antecedent of perceived usefulness (cf. Arbore et al., 2014; Hong & Tam, 2006; Starbuck & Webster, 1991). Moreover, the results show that perceived risk can be an important antecedent of attitude (cf. Rijsdijk & Hultink, 2003). In addition, perceived self-identity emerged with both direct and indirect effects on intention, supporting the findings by Arbore et al. (2014). However, the construct also showed signs of bi-dimensionality, suggesting future research is needed to uncover the structure of identity as an antecedent of adoption intention. Finally, the results support previous findings regarding personal norms with respect to the environment as a predictor of intention to adopt car technologies (Petschnig et al., 2014).

## 7.2 Managerial implications

The results of this study point out several implications for product developers and marketing managers with regard to aspects of AVs that should be emphasized to increase consumers' intention to adopt the technology.

The first conclusion that can be drawn from this study, is that motivational influences play a key role in forming adoption intention toward AVs, both through their direct impact on intention and through their indirect effects via attitude. Perceived **usefulness** has the strongest overall effect of the motivational influences, and is a relatively strong predictor of intention as well as a strong predictor of attitude. While this finding is perhaps not surprising, it nevertheless underlines the importance of AVs' potential to provide functional benefits in terms of freeing up consumers' time and simplifying their lives. Researchers have previously pointed out that AVs may change perceptions about spending time in a vehicle as it now becomes productive time (Fagnant & Kockelman, 2015), and could even make people tolerate longer commutes, as they can work while in transit (Gill et al., 2015). Thus, the industry should focus on the improved time efficiency of AVs compared to conventional cars by communicating how it saves and frees up time, as well as by designing AVs to make the time spent in autonomous drive productive for users.

Perceived **enjoyment** also emerges as a relatively strong direct predictor of intention, and is furthermore revealed to be a strong antecedent of perceived usefulness. Previous studies have shown that higher levels of automation lead drivers to engage more in non-driving activities such as entertainment (Carsten et al., 2012; Jamson et al., 2013). Thus, AVs may appeal to consumers as they allow their users to perform activities like using internet services and texting while in transit (Crews, 2015), and particularly consume video-based media (Swinburne & Fiftal, 2013). This implies that the industry should pay close attention to aspects of enjoyment, making the experience of using AVs entertaining and fun, both because it directly influences consumers' intention, but also because their perception of usefulness appears to be partly contingent on perceived enjoyment. No significant difference in perceptions was found regarding whether an AV comes equipped with manual controls, which suggests that perceived enjoyment relates more to the experiences while being driven than the joy of driving itself. Hence, these findings indicate that developing AVs as a platform for enjoyable experiences, for instance by including entertainment technologies and a stable internet connection, might positively affect consumer adoption.

Regarding perceived **self-identity**, both direct effects on intention and indirect effects via attitude are found. While these effects do not appear to be strong, they nevertheless suggest that developers and marketers of AVs need to consider how the shift from manual to autonomous driving serves as a symbolic signal to the self and to others. In particular, certain groups, such as automobile enthusiasts, may resist AVs due to a perceived loss of symbolic value (Boeglin, 2015).

Furthermore, perceived **risk** is revealed to have strong negative effects on attitude, through which it indirectly affects intention to adopt. Perceptions of risk should be taken seriously, as recent studies have found that vehicle safety is one of consumers' top reasons for purchasing a particular vehicle, with three of the top five technologies consumers most prefer in their next vehicle being related to collision protection (JDPA, 2013, 2015). While AVs are expected to significantly improve traffic safety (Fagnant & Kockelman, 2015), research has revealed that people perceive greater risk for more autonomous products (Rijsdijk & Hultink, 2003). In combination with the finding in this thesis, this accentuates the importance of communicating the safety benefits of AVs compared to conventional cars.

Second, the importance of attitudinal influences on intention is evident in that **attitude** toward use emerges as the single strongest predictor of intention to use AVs. This highlights the role of creating positive consumer attitudes toward AVs, which industry players should focus on in the initial phase of AV deployment as consumers may not yet have fully formed attitudes toward the technology. Perceived risk, perceived usefulness, perceived ease of use and perceived self-identity are all revealed to be significant antecedents of attitude in this study. In combination, these concepts explain more than half of the variation in attitude toward use, and as such outline key aspects to forming consumer attitudes regarding AVs.

Third, the impact of **compatibility**, theorized in this thesis as a proxy for automatic influences, is evident. Compatibility emerges as the second strongest direct antecedent of intention to adopt AVs, and is additionally a strong predictor of perceived usefulness, through which it has indirect effects on attitude and intention. Consequently, industry players should highlight the fit between AVs and the potential adopter's lifestyle and habits. For instance, previous research has shown that commute time can be a desirable component of people's daily lives, particularly as it provides transition time between work and home roles (Jain & Lyons, 2008; Redmond & Mokhtarian, 2001), however commuting can also give consumers an unpleasant mood and reduce life satisfaction (Krueger et al., 2008; Stutzer & Frey, 2008). Thus, AVs that free up the time in the car from the task of driving could allow for even more meaningful commute time, especially if they can release the driver of the task of operating the car in monotonous or stressful driving conditions (cf. Payre et al., 2014). Given the partial mediation of compatibility by usefulness, special attention should be given to communicating how AVs allow users to follow their daily routines, yet spend less time and effort on unattractive aspects such as finding parking lots.

Fourth, among resource related influences, perceived **ease of use** has indirect effects on intention via attitude and perceived usefulness. While not surprising, this finding does indicate that developers need to pay attention to the user-friendliness of AVs by providing compelling user-interfaces, for instance through mobile phone integration and apps that can easily summon the vehicle. Although **perceived behavioral control** was not found to have significant effects in line with the hypothesis, this could change when, for example, the cost of the technology becomes better know to consumers. Moreover, the construct is thought to have direct effects on adoption in the TPB, and may thus have influences beyond those studied in this thesis.

Finally, regarding normative influences, no effect is found for **social norms**. However, as the technology is not yet available in the market, aspects related to social norms may be difficult to relate to for consumers. Whereas the other constructs studied in this thesis require respondents to imagine what using an AV would be like, social norms add a level of abstraction to this process as it requires respondents' to envision what other people will think of the technology and how those opinions in turn will influence respondents' intention. Thus, the effects of social norms may be difficult to study before AVs are available in the marketplace and consumers get a better perception of what other people think about them. Nonetheless, given the potentially large benefits to society of AVs, social norms may well become a relevant factor in the future. In contrast, **personal norms** seem to already play a role through a direct, albeit fairly moderate, effect on intention. This indicates that the environmental benefits of AVs are relevant to consumers, but may not be fully understood. As people are becoming increasingly environmentally conscious, the demand for environmentally friendly vehicles is predicted to rise (Crews, 2015). Thus, the environmental benefits of AVs should be communicated to consumers to educate them on the full range of benefits AVs offer.

## 7.3 Future research

This study provides interesting results regarding the next generation of car buyers in Norway and similar countries, and thus provides valuable insights for industry players. While extensive effort was made to both design the study and test the findings to ensure the reliability and validity of the results (see Chapter 5 and 6), future studies could contribute to ascertain the results' generalizability and the models' potential boundary conditions. As discussed below, such studies could also consider testing the model on different populations, or by using different research designs. Moreover, this study uncovered certain theoretical areas that would benefit from more research in the future. Finally, while the research model already has a high explanatory power, several potential extensions to the model exist.

### 7.3.1 Research population and setting

Regarding the sample, respondents in this study were on average relatively young (i.e., in the 25-29 age group). Age was controlled for in the analysis, and has previously been shown to not affect intention to adopt AVs (Payre et al., 2014). However, future research could further elaborate on potential differences regarding the age of consumers, as the elderly who are no longer capable or willing to drive could see expanded possibilities due to AVs (Fagnant & Kockelman, 2015; Gill et al., 2015; Shanker et al, 2013). Senior consumers may form adoption intentions based on other mechanisms, e.g. seeing greater usefulness if they feel like navigating traffic is becoming more difficult to manage or, conversely, perceiving greater risk in delegating operation of the vehicle to a machine than would young consumers who are digital natives.

In addition, this study's respondents had a significantly higher level of education than the general population, and a large share of the sample were students at a business school. As some have voiced concerns over using students as respondents in research as students' perceptions of the phenomenon of interest may differ systematically from the target population in general (cf. Agarwal & Karahanna, 2000), replication studies on different samples may be valuable. However, such systematic differences are less likely to be present in this study's results as a considerable share of the sample was recruited outside of educational institutions. Furthermore, respondents' level of education was controlled for in the analysis, and did not show any significant effect on intention.

Finally, previous studies on consumer opinion toward AVs indicate that situational and cultural differences in perceptions may exist between consumers in various countries (e.g., Kyriakidis et al., 2015; Schoettle & Sivak, 2014a, 2014b). Nationality was controlled for, and found to be insignificant in this study. However, cultural aspects might still affect perceptions regarding AVs, particularly regarding the role of self-identity and normative influences on adoption intention, and differences between traffic systems may give rise to perception that are contingent on situational circumstances, especially in terms of the usefulness and risk of using an AV. Thus, future studies should test the model in other countries.

### 7.3.2 Research design

Regarding the research design, responses based on actual product interaction were not feasible for the present research, but such stimuli would make an interesting addition in future studies as, for instance, Jensen et al. (2013) showed that hands-on experience with alternative fuel vehicles could positively alter consumer's preferences and attitudes. Moreover, causal relationships tested in this study are based on theoretical justifications. While these have been widely accepted in the innovation adoption literature, and as such can be considered sound, future studies may provide additional insight by employing longitudinal or experimental designs that actively observe causality, particularly as AVs are made available in the market.

### 7.3.3 Theory development

This study validates several measures for established latent constructs, some of which are compound measures taken from different studies. In addition, a new set of items for personal norm regarding the environment is introduced. Given their good construct validity, these measures may be of use to future research. However, two constructs could benefit from further theoretical development.

First, high modification indices were found among the two sub-dimensions of self-identity (i.e., personal and social identities), which may indicate that consumers perceive these as more separated dimensions than what is theorized for the construct (cf. Arbore et al., 2014). Making the sub-dimensionality of the construct explicit in the model by introducing the correlated error terms for the two pairs of items was found to significantly improve model fit. While the construct as a whole has good convergent and discriminant validity, and, moreover, has been validated in previous research (Arbore et al., 2014; Escalas, 2004), the findings in this thesis may nonetheless imply that there are aspects to self-identity that are not fully understood, which should be studied further in future research. In particular, effort should be put into investigating whether personal and social identities conceptually belong to an overall self-identity construct, or whether they are separate, albeit closely related concepts.

Furthermore, the perceived usefulness construct had two items that did not fully satisfy the ideal level of 0.7 for the standardized factor loading estimate (cf. Hair et al., 2010), causing one item to be deleted. Although the retained items score satisfactorily in terms of construct validity, future research should nonetheless explore more items to refine the usefulness measure, and potentially find an even better approximation of the latent construct. [15] The three items kept in the final measurement model warrant inclusion in such exploratory studies, although the exact wording of item PU1 should be evaluated as it loaded marginally lower (0.69) than the ideal level. Regarding the dropped item pertaining to mobility (PU3), other variants should be included in future research to test whether the relatively low communality was due to poor

[15] See Table 4 (p. 52) for item wording of the retained and dropped items.

phrasing of the item, or whether mobility is a distinct concept to usefulness in the mind of the consumer, with potential separate direct or indirect influences on intention. Moreover, such studies could investigate whether there is a link between mobility and independence, which may be a distinct motive for car use (Steg, 2005).

In addition, this study lends support to two less frequently explored relationships, as perceived enjoyment was found to be an antecedent of perceived usefulness (cf. Arbore et al., 2014; Hong & Tam, 2006; Starbuck & Webster, 1991), and compatibility was found to be an antecedent of perceived usefulness (cf. Holak & Lehmann, 1990). While these relationships have not received much attention in the literature, the results in this study indicate that more research on the inter-relationships of different consumer beliefs could be beneficial.

Finally, compatibility is suggested in this thesis as a proxy for the effect of automatic processes on intention to perform novel behaviors, such as adopting an innovation (see Section 3.2), and labeled an automatic influence in the hypothesis section. While the impact of compatibility on intention was confirmed in this study, and a connection to automatic processes has intuitive appeal given the measurement items used, future studies should further investigate how suitable compatibility is as a proxy for automatic processes in the context of novel behaviors, particularly with respect to innovation adoption.

### 7.3.4 Potential model extensions

In addition to mobility, several other factors not covered in this thesis may be relevant to include in future studies. First, different risk dimensions have been related to AVs, especially in terms of risks related to liability (Cohen, 2015), data privacy (Boeglin, 2015; Glancy, 2012), cyber-security attacks (Yeomans, 2014), and vehicle malfunction and traffic safety (Fagnant & Kockelman, 2015). Thus, while the research model includes physical risks, several other risk dimensions might impact adoption intention, which could be explored in future studies.

Likewise, while this thesis studies personal norms concerning environmental aspects, other factors may influence personal norms. In particular, aspects pertaining to traffic safety may affect personal norms, as the use of cars has clear adverse social consequences in terms of accidents (NHTSA, 2008; WHO, 2013), and AVs are expected to improve traffic safety (Fagnant & Kockelman, 2015). Hence, future studies should explore the different dimensions of personal norms applicable to AV adoption intention.

Moreover, as AVs free the occupants from the task of driving, AVs could be designed in very different ways from traditional cars. Design has been shown to play an important role in attitude formation regarding other car innovations (Petschnig et al., 2014), and may be an important area to focus on for the industry in order to positively influence attitude and adoption. This is made even more relevant given the various functions an AV could be built to serve, e.g. outfitted for such functions as office work, entertainment, or sleeping.

Also, the car industry has already seen a range of new ownership models, with rapid growth in carsharing (e.g. Zipcar and Car2Go) and ridesharing (e.g. UberX and Lyft), which may become even more widespread with AVs. Future studies should consider how these different modes of acquisition (cf. Pham, 2013) may affect adoption of AVs.

## 7.4 Conclusion

Overall, the research model developed in this thesis showed good fit and explained a high degree (79%) of the variance in intention to adopt an AV. As such, it offers a promising framework for future studies on AV adoption intention. Likewise, as the model explained a considerably higher portion of the variance in adoption intention than has been the case for other models used to study the adoption of car innovations (e.g. Moons & De Pelsmacker, 2012; Noppers et al., 2014; Petschnig et al., 2014; Schuitema et al., 2013), the research model developed in this thesis may offer an interesting framework also for innovation adoption studies concerning other car technologies. Moreover, as AVs can be seen as part of a more general transition to wider use of intelligent products, the research model may find application in other product categories, including other types of robotics.

Positively perceived product autonomy can have public relations and branding benefits (Rijsdijk & Hultink, 2003), however innovations that are perceived to be disruptive or highly original can also be damaging to a company if consumers do not appreciate their functions (Min et al., 2006; Moldovan et al., 2011). As AVs may constitute the biggest transition in personal transportation since the invention of the car itself, insight into key drivers of adoption intention is vital for managers in the industry in order to develop and communicate a product that fulfills consumer expectations and needs. Failure to understand these influences may lead to the decay of several established carmakers, and the rise of new entrants in the market who do appreciate the changed conditions (Crews, 2015). The results from this study indicate that marketing managers should be particularly aware of motivational variables, such as perceived usefulness, perceived enjoyment, perceived self-identity and perceived risk, in addition to attitude toward use and the compatibility of AVs with consumers established lifestyle and habits.

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# Appendix A: Public Opinion on AVs - Benefits and Concerns

In order to identify key trends and relevant aspects to AV adoption, a review of studies on consumer opinions toward autonomous driving systems was conducted prior to developing the research model. This appendix presents the consulted reports, while key findings are integrated into the thesis. As several potentially interesting aspects were not covered in depth in the research model, this section is included also as a reference for future studies.

While not an exhaustive list of all studies to date, the identified reports cover both quantitative data obtained through surveys, as well as qualitative data from focus-groups, in-depth interviews and comment analysis of media and social media posts. Several questions could be raised over aspects such as the research design and data collection measures of many of the sources, as well over the representation of collected data – perhaps especially in the case of commercial actors. While the purpose of the section is to present an overview of identified findings and draw conclusions from the aggregate results, this limitation should nonetheless be kept in mind. Moreover, several of the studies pre-date the recent developments in the car industry (e.g. the launch of Tesla's Autopilot and Google public automated driving testing), and some studies include different levels of automation (e.g. level 3 and 4). Also note that several of the percentages referred to below have been rounded off to the nearest whole number, and some have been extracted from graphs – both of which may imply small inaccuracies.

## *Summary of Findings*

In the studies presented below, a range of factors are named. While the authors differ in choice of nomenclature, the concepts studied are in many cases highly similar. For comparison, attempts have been made to codify the terms according the concepts described in the articles. As the same term may have been used for different concepts in different texts, the coding may differ. For instance, *convenience* may entail either 'saved time' or 'freed time', depending on the description presented in the respective text.

The results (Table A.1), indicate that the main benefits consumers expect to come from AVs are in terms of saving and freeing up time and saving costs. Improving traffic safety is another main expected benefit, although several studies also find high concerns over safety aspects, which may give rise to apprehensions over not being able to control the vehicle.

**Table A.1: Summary of Findings**

| Category | Description | Benefit | Concern |
|---|---|---|---|
| Environment | Environmental sustainability, e.g. reduced emissions. | 7 | 1 |
| Safety | Safety aspects, e.g. risk of malfunction or collision | 11 | 14 |
| Control | Aspects related to not having control over the vehicle. | 0 | 10 |
| Security | E.g. risks of hacking or abuse of vehicle. | 0 | 8 |
| Liability | Legal liability issues, e.g. if an AV is involved in an accident. | 0 | 8 |
| Privacy | Concerns over personal data being collected and used. | 0 | 9 |
| Saved time | E.g. efficiency, less congestion, more reliable transport time. | 11 | 0 |
| Freed time | Freeing up time in the car for productivity/other activities. | 13 | 0 |
| Enjoyment | Aspects related to enjoyment, as in boredom, pleasure etc. | 6 | 5 |
| Mobility | Aspects related to mobility, inclusive transport etc. | 6 | 0 |
| Symbolism | E.g. status, social acceptance, expression of identity. | 0 | 2 |
| Cost | Purchase price or operating costs, e.g. fuel and insurance. | 10 | 6 |
| Social sustainability | E.g. issues with job losses and health effects. | 0 | 4 |
| Other | Factors that could not be grouped into the categories above. | 3 | 3 |

## Qualitative

### *Media comments content analysis*

**J.D. Power and Associates** (JDPA, 2012) performed analysis on social media activity regarding autonomous driving, and found opinions expressed online to be generally positive. The safety added from removing careless or distracted drivers, as well as the freed up time while travelling, were pointed out as perceived benefits by vehicle owners. Drivers would want the option for autonomy to increase enjoyment during times of “boring” driving, such as commuting to and from work, highway driving, going to the store or finding a parking space, but want to take control for pleasure driving or manual maneuvering. On the negative side, car enthusiasts viewed autonomous driving as involving loss of status, and would not wish to give up the pleasure of driving.

**Fraedrich & Lenz** (2014) qualitatively (and to an extent also quantitatively) assessed comments on articles related to AV technology from 12 online news portals selected to give a representative picture of the U.S. and German print media landscapes. In total, 636 comments were evaluated (314 from German media, 322 form U.S. media) and 1,060 statements codified. Results from the study include that the most positively perceived features of AVs or automated driving were: safety and system reliability (less human error), comfort and flexibility (time freed up to do other activities), progress (increased enjoyment), inclusive transport participation (expanded mobility to groups currently unable to drive), traffic optimization, and sustainability (lower emissions), cost savings (lower usage cost of transportation). While around two-thirds of statements on perceived features were positive views, certain negative aspects were also widespread: social consequences (including job losses, views on over-mechanization of society, and subsequent shifts in power), data abuse (privacy issues and system hacking), safety risks (malfunction), rise in costs (increased purchase price), and uncertainties (regarding how the technology would function).

**Sciencewise** (2014) performed an analysis of more than 2800 public comments published online in response to media coverage on AV technology. The most commonly cited benefits were: mobility (for groups who currently cannot drive), comfort and convenience (e.g. reducing stress and increasing productivity); safety (fewer accidents caused by human carelessness or distraction), easing congestion (e.g. more efficient traffic), decreased cost (running cost reductions); and environmental benefits. On the other hand, the main concerns expressed were: system vulnerability to abuse (e.g. hacking), privacy, safety, unwelcome lifestyle changes (including health issues from walking less, social equity issues as drivers would lose their jobs), waste of existing resources (e.g. reduced use of public transport infrastructure), and environmental concerns (due to e.g. increased willingness to commute, potentially more traffic and reduced use of public transport).

### *Focus groups and in-depth interviews*

In June 2013, **KPMG** (Silberg et al., 2013) performed a study of 32 people's perceptions of AV technology through 10 focus-group sessions in Los Angeles (CA), Chicago (IL), and Iselin (NJ). Participants were at least 21 years old, owned at least one vehicle, and had completed college or vocational school. The study found that both the place people lived and their gender influenced willingness to use AV technology. Men (with a median of 7.5 on a 1 to 10 scale) were less willing to use AVs than women (median 7.5). Moreover, participant's passion to drive negatively influenced willingness to use AVs. The report also noted that consumer's interest in AVs revolves around somewhat different factors than for general cars, centering more on handling, safety, innovation, and trust, and less on factors such as the engine, transmission, and styling. Participants were concerned over safety, as they lacked trust in the AVs' ability to operate safely, fearing what would happen if they could not control the vehicle in case of malfunction. There were also raised questions over liability, which was found to potentially influence willingness to use AVs negatively. Combined with a desire to not lose the ability to drive just for the fun of it, this made almost all participants to express a need for optional manual control. Shorter commute times and reduced traffic-related variability were among the benefits that would positively influence participants to use AVs.

In July and August 2015, **Bjørner** (2015) conducted 13 in-depth interviews with subjects who carried a driver's license, had no previous experience with semi-autonomous driving, and who drove at least 8,000km per year. Participants were shown different videos of four semi or fully autonomous vehicle scenarios: highway driving, reverse parallel parking, traffic congested city and a fully self-driving future scenario. The study found that trust regarding the safety of AV system and questions around a driver's control of the vehicle, were the main concerns that could negatively affect perceptions on AV technology, while the potential for increased mobility and freed up time were positively viewed.

## Quantitative

### *Academic research*

In spring 2013, **Howard and Dai** (2014) surveyed people's (N=107) opinion on AVs in Berkeley (CA). As part of the survey, participants were shown a 10-minute video after completing two out of five sections of the questionnaire. The results demonstrated that safety (79%), convenience (e.g. not having to find parking) (66%), amenities (such as being able to text message and multi-task while driving) (53%), mobility (50%) and, to a lesser extent, environment (28%) were the most attractive features of AVs. Conversely, liability (70%), cost (69%), control (52%), (social) equity (40%), privacy (35%) and safety concerns (32%) were the least attractive features. Just above 40% of the participants said they would wish to either purchase self-driving technology in their next vehicle or retrofit their current vehicle with such technology. An additional 40% were undecided, but open to the possibility. 81% of participants would be willing to use AV taxis, with 34% of respondents saying they would use them weekly.

**Schoettle and Sivak** (2014a) investigated public opinion in the U.S., the U.K., and Australia (N = 1533) about Level 4 AVs. Results showed that, on average for the three countries, 66% of the respondents had heard of such vehicles before and 57% had an overall positive opinion on them. Respondents were on average convinced that several benefits were likely to come from AVs, specifically in the form of better fuel economy (72%), improved safety (reduced number and severity of crashes) (71%), lower vehicle emissions (64%), and lower insurance rates (56%). Many respondents also believed less traffic congestion (48%) and shorter travel time (43%) would be likely consequences. However, respondents were also (‘moderately’ or ‘very’) concerned about issues regarding safety consequences of equipment failure or system failure (81%), legal liability (74%), system performance (e.g. performs in interacting with traffic, in bad weather or with unexpected situations) (70%), hacking and misuse (68%) and privacy (64%). The study notes significant differences between the countries, where U.S. respondents are more concerned overall about driving AVs (36% compared with 26% and 28% for the U.K. and Australia, respectively), as well as for several of the individual concern measures, particularly liability and privacy. A second study by Schoettle and Sivak (2014b) investigated the same aspects to public opinion in China, India, and Japan (N = 1722). Results from these three countries were in line with the results from the U.S., the U.K., and Australia (only better fuel economy and safety switched places), albeit with higher scores both in terms of likely benefits and concerns. However, larger inter-country differences were observed, as for instance more than 84% of the respondents in China and India, compared to only 43% in Japan, had positive opinions on AVs. In fact, results form Japan were closely aligned with results from the U.S., the U.K., and Australia in terms of how concerned consumers were, how likely they perceived benefits, as well as in terms of which features were viewed most positively or negatively. This could indicate that factors such as prior knowledge and economic development, perhaps especially in terms of transportation infrastructure, are interesting factors to look at in addition to cultural differences. Finally, Schoettle & Sivak (2014a, 2014b) also found that consumers would use the freed up time on activities related to entertainment (23% in U.S., the U.K., and Australia; and 35% for China, India, and Japan), sleep (7% and 9%) and work (5% and 7%). However, many said they would simply watch the road (41% and 33%) or would not be willing to drive an AV at all (22% and 15%).

In July 2014, **Kyriakidis et al.** (2015) carried out a study on public opinion on Level 4 automation among 4886 respondents in 109 countries through a crowd-sourcing internet survey. Results indicated that people with prior experience with semi-autonomous systems would be more inclined to using AVs, as respondents who used adaptive cruise control were willing to pay more for AVs, and would be more comfortable about riding without a steering wheel. Likewise, people who drove more were more willing to pay for an AV. There was also greater willingness to pay for fully-autonomous driving than for any level of semi-autonomous driving. Respondents expected that AVs would be driving on public roads by 2030 (median response). While responses indicated that fully automated driving (M = 3.49, SD = 1.41, on the scale from 1 = disagree strongly to 5 = agree strongly) would be somewhat less enjoyable than manual driving (M = 4.04, SD = 1.06), more than 30% of respondents strongly agreed that fully automated driving would be enjoyable. Perhaps connected to this, a high share of respondents would engage in different activities while riding an AV, such as listen to the radio (55%), eat (48%), talk with passengers (47%), observe (47%), make phone calls (46%), mailing (43%), watch movies (38%), read (37%) and rest (37%). Compared to a highly automated driving mode, full automation saw a sharp increase especially in the number of people who would be inclined to rest/sleep, watch movies, or read. On the negative side, people had concerns over AV technology in terms of software hacking and misuse (M = 3.9), legal issues (liability) (M = 3.8), safety risks (M = 3.7), and privacy (M = 3.5). Regarding privacy, people were mostly not very concerned about data transmission, except for sharing data with insurance companies or tax authorities. Respondents who scored higher on agreeableness were more comfortable about data sharing, while those who scored higher on neuroticism were less comfortable with this. Finally, no clear age or gender effects were observed.

**Bansal et al.** (2015) conducted a survey between October and December 2014 to explore 347 respondent's preferences concerning emerging vehicle and transport technologies. Due to overrepresentation of certain demographic groups, the results were scaled to represent the population of Austin, Texas where data was collected. 80% of respondents had heard of Google's AV, more than 70% of respondents would ride AVs on highways and in congested traffic, while only 46 % would want vehicles to drive themselves in the city. The average willingness to pay for Level 4 automation was \$7,253 – more than twice as much as the corresponding amount for Level 3 automation (\$3,300). The top benefits consumers perceived would come from Level 4 AVs were: fewer crashes (63%), better fuel economy (58%), lower emissions (48%), and less congestion (45%). According to the findings, consumers have concerns over: malfunction (50%), interaction with conventional vehicles (48%), affordability (38%), liability (36%), privacy (31%), and hacking (30%). Interestingly, for roughly 50% of the respondents, AV adoption rates seem to depend on the adoption rates of friends and neighbors: 19% of respondents said they would never adopt, 26% would adopt when 50% of their friends have adopted, 25% when 10% of friends, 30% as soon as possible). While riding an AV, respondents would wish to look out the window (77%), text or talk (74%), work (54%), sleep (52%), watch movies or play games (46%).

### *Company research*

A study from March 2012 by **J.D. Power and Associates** (JDPA, 2012), surveyed 17,400 vehicle owners interest and purchase intent for emerging automotive technologies. Respondents were particularly interested in technologies that improved safety and made them more productive, connected and entertained. Regarding autonomous driving, results showed that 37% of respondents would 'definitely' or 'probably' be interested in purchasing such technology. However, when respondents were informed that the estimated market price of the technology was $3000, the rate of positive responses dropped to 20%. Along with hesitations regarding price, respondents were also skeptical of releasing control of their vehicle, and wished to see the technology proven before adopting it. Respondents who were aged 18 to 37 (30%), living in urban areas (30%) or male (25%) had the highest interest in AV technology.

Follow-up studies (JDPA, 2014) conducted in 2013 and 2014 found similar results, and demonstrated a particularly high interest in semi-autonomous safety technologies such as emergency breaking and steering systems (49%) and low-speed collision avoidance systems (62%). Finally, the results indicated a slight increase in interest in fully autonomous driving technology (24% in 2014, up from 20% in 2012), driven by expectations over improved safety, less traffic and opportunities to pursue other activities while in a vehicle.

**TE Connectivity** (2013) had a survey done on opinions regarding autonomous vehicles based on 1,000 landline and cell phone interviews of U.S. adults conducted in May 2013. While almost 30% of respondents stated they would be comfortable in an autonomous vehicle, 70% would not yet feel comfortable with such technology. However, respondents deemed safety technologies (prioritized by 55%) the most important aspect to improve before AVs become widely available. Amongst the benefits respondents perceived, improved fuel efficiency ranked first (selected by 22%), followed by less traffic congestion (21%), relief of vehicle occupants from driving and navigation responsibilities (13%), enhanced productivity (11%), and higher speed limit (4%). Respondents' concerns mainly revolved around relinquishing full control (60%), with other concerns being relatively small. Additionally, men (34%) stated they would be comfortable in an AV more often than women (24%), and people aged 18-34 (38 percent) would likewise be more comfortable than 55-64 year olds (20 percent) and those aged 65 or older (18 percent).

A survey by **Continental AG** (Sommer, 2013) in Germany, China, Japan, and USA (N = 200 in each country) showed that between 41% (USA) and 70% (China) of respondents considered automated driving useful. Yet, the concept of automated driving also unnerved respondents, as between 42% (Japan) and 66% (USA) of respondents stated were rather scared by automated driving, and between 43% (Japan) and 74% (China) do not believe that AVs will function reliably. Respondents expressed an intention to use such technology more on long freeway journeys (67%) and in traffic jams (52%) than on rural roads (36%) and in city traffic (34%). Traffic jams and stop/start traffic were found to be the most stressful situation that occurs while driving, while long freeway trips were the least stressful, pointing toward a preference for AVs in either highly stressful or dull situations. As for the freed up time, respondents would prefer to listen to music or radio (45%), talk to other passengers (41%), make phone calls (34%), check or write e-mails (21%), read (20%) or surf online (18%).

**Carinsurance.com** (Smith, 2014) surveyed 2000 licensed motorists in the U.S., and found that 20% of respondents would be happy to switch to AVs, while the remaining 80% would not feel comfortable with the technology. 64% of respondents believed computers would make inferior quality decisions compared to humans, 75% believed they could drive better than a computer, and 75% said they would not trust a driverless car to take their children to school. However, when asked about a scenario in which AVs led to an 80% cut in insurance premiums, more than a third of respondents said they would ‘very likely’ buy an AV, and 90% would at least consider the possibility. Respondents would use the freed up time in an AV to text/talk with friends (26%), other (21%), read (21%), sleep (10%), watch movies (8%), play games (7%), and work (7%).

In January 2014, **Seapine Software** (2014) had a survey done on public perceptions on AV technology among 2039 U.S. adults. Results showed that 88% of respondents worried about riding an AV. In particular, 79% of respondents worried that the equipment in a driverless car could fail, for instance a software glitch in the breaking system. Other frequent concerns were related to liability (59%), hacking (52%), and privacy (37%).

Between June and July 2014, **Ipsos MORI** (Missel, 2014) carried out a study on perceptions of the importance of AVs for the car industry among British people (N = 1001) aged 16 to 75. Advanced (semi-autonomous) safety systems were favored by 50% of respondents, while only 18% found it important for the car industry to focus on AVs, compared to 41% who found it unimportant. Half (50%) of the respondents aged 55+ deemed the technology unimportant, while less than a third (30%) of respondents aged 16 to 24 found it unimportant.

Men (23%) were more likely to find AVs important than women (13%). The convenience AVs bring by improving traffic flow is pointed out as a positive influence on perceptions, and urban dwellers (23%), in particular from London (27%), were more likely to find AVs important. Moreover, AVs had greater appeal to respondents who were not interested in driving, indicating that those who enjoy driving are less likely to embrace AVs.

**NerdWallet** (Danise, 2015) conducted an online survey of 1,028 randomly selected Americans ages 18 and older in May 2015. Results showed a general skepticism towards driverless cars, with 76% of respondents unwilling to let their kids ride alone in one, 50% unwilling to pay more for a driverless car and, 46% who thought driverless cars would not be safe. While 28% of respondents would never buy a driverless car, 42% expected they would buy one within 4 years after availability. The features respondents would like about driverless cars included reduced insurance costs (35%), freed time from routine tasks (33%), improved safety (29%), and increased productivity (28%). Respondents worried, however, that driverless cars would be too expensive to buy (64%), unsafe (46%), reduce the fun of driving (35%), or have privacy issues (27%). Women (55%) worried more than men (37%) over safety, while men (44%) were more concerned than women (23%) that driverless cars would take the fun out of driving.

# Appendix B: Introduction and Priming

## I) Survey Introduction

This survey about autonomous vehicles is part of a master's thesis at the Norwegian School of Economics (Norges Handelshøyskole, NHH), and typically takes about 5-8 minutes to answer.

Methodological requirements may make some questions appear similar, but please answer all of them to the best of your ability. Participation is voluntary, and we appreciate that you take the time to answer the questions.

All your responses will be treated anonymously, and cannot be traced to you.

## II) Topic Introduction

Autonomous vehicles (AVs), also called self-driving cars, can drive themselves by combining advanced computers with cameras, radars and sensors. In 3-5 years, AVs will be able to take you where you want to go at the push of a button—no driving required. In an AV, you set the destination, and the car then drives there by itself while communicating with other AVs in order to optimize traffic and make the trip time efficient, fuel efficient and safe. Meanwhile, you can spend your time on other activities, such as reading, watching a movie or sleeping. When you leave the car, it finds a parking lot and parks by itself.

## III) Priming texts

**Priming for autonomous and manual (AM)**

In this survey, we are looking for your opinion on AVs that can be driven both manually (a human drives the car as in standard cars) and autonomously (the car drives itself). The driver can freely choose to switch between these modes whenever (s)he wants to, including during a trip.

**Priming for autonomous only (AO)**

In this survey, we are looking for your opinion on AVs that can only be driven autonomously (the car drives itself). The AV has no steering wheel or pedals, but the driver/passenger can give destination input and, if (s)he wishes, press a stop button that will quickly stop the car in a safe way.

# Appendix C: Adapted Measures

| Construct: | Source 1 | Source 2 |
|---|---|---|
| **Perceived enjoyment** | **Hong & Tam (2006)** | **Nysveen et al. (2005)** |
| | I expect that using MDS would be enjoyable. | I find "service" entertaining. |
| | I expect that using MDS would be pleasurable. | I find "service" pleasant. |
| | I expect to have fun using MDS. | I find "service" exiting. |
| | I expect that using MDS would be interesting. | I find "service" fun. |
| **Self-identity** | **Arbore et al. (2014)** | |
| | Having a mobile TV would reflect my identity. | |
| | Having a mobile TV would reflect who I am. | |
| | Having a mobile TV would express the personality that I want to communicate to others. | |
| | Having a mobile TV would reflect the way that I want to present myself to others. | |
| | Having a mobile TV suits me well. | |
| **Perceived usefulness** | **Davis et al. (1989)** | **Karahanna et al. (1999)** |
| | Using WriteOne would improve my performance in the MBA program. | If I were to adopt Windows, it would enable me to accomplish my tasks more quickly. |
| | Using WriteOne in the MBA program would increase my productivity. | If I were to adopt Windows, the quality of my work would improve. |
| | Using WriteOne would enhance my effectiveness in the MBA program. | If I were to adopt Windows, it would enhance my effectiveness on the job. |
| | I would find WriteOne useful in the MBA program. | If I were to adopt Windows, it would make my job easier. |
| **Perceived risk** | **Wiedmann et al. (2011)** | |
| | I am concerned about potential physical risks associated with an NGV. | |
| | One concern I have about purchasing an NGV is that the risk of endangering my passengers, like family members, might be too high. | |
| | I have security concerns in the case of an accident. | |
| **Compatibility** | **Meuter et al (2005)** | **Petschnig et al. (2014)** |
| | Using the SST is compatible with my lifestyle. | To use an AFV is in line with my beliefs. |
| | Using the SST is completely compatible with my needs. | AFVs fit well with my previous driving habits. |
| | The SST fits well with the way I like to get things done. | Using an AFV is completely compatible with my mobility needs. |
| | | An AFV suits me well. |
| | | The use of an AFV is in line with my everyday life. |

| Construct: | Source 1 | Source 2 |
|---|---|---|
| **Ease of use** | **Davis et al. (1989)** | |
| | Learning to operate WriteOne would be easy for me. | |
| | I would find it easy to get WriteOne to do what I want it to do. | |
| | It would be easy for me to become skillful at using WriteOne. | |
| | I would find WriteOne easy to use. | |
| **Perceived behavioral control** | **Taylor & Todd (1995)** | |
| | I have the resources, knowledge and ability to buy a VCR-Plus +TM: (unlikely/likely). | |
| | I have the resources, knowledge and ability to operate a VCR-Plus+TM: (unlikely/ likely). | |
| | I would be able to buy a VCR-Plus +TM: (unlikely/likely). | |
| | I would be able to operate a VCR-Plus + TM: (unlikely/likely). | |
| **Personal norm** | **Petschnig et al. (2014)** | **Jansson (2011)** |
| | I feel a moral obligation to abandon cars fueled by fossil fuels (e.g. gasoline, diesel) no matter what other people do. | I feel a moral obligation to conserve oil/petrol/diesel no matter what other people do. |
| | I feel guilty when wasting fossil fuels such as oil/petrol/diesel. | Personally, I feel that it is important to travel as little aspossible by car using oil/petrol/diesel. |
| | I feel a moral obligation not to use cars fueled by fossil fuels (e.g. gasoline, diesel). | I feel a moral obligation to use electricity or any other biofuel such as ethanol/bio-gas instead of fossil fuels such as oil/petrol/diesel. |
| | Personally, I feel that it is important to travel as little as possible by car using fossil fuels (e.g. gasoline, diesel). | People like me should do everything they can to decrease their use of fossil fuels such as oil/petrol/diesel. |
| | If I were to replace my car today I would feel a moral obligation to replace it for a car that is not fueled by fossil fuels (e.g. gasoline, diesel). | |
| **Social norm** | **Hong & Tam (2006)** | |
| | People who influence my behavior would think I should use MDS. | |
| | People who are important to me would want me to use MDS. | |
| | People whose opinions I value would prefer me to use MDS. | |
| **Attitude** | **Bagozzi & Dholakia (2006)** | **Nysveen et al. (2005); original source Davis (1989)** |
| | Foolish–wise | Bad/good |
| | Harmful–beneficial | Foolish/wise |
| | Bad–Good | Unfavorable/favorable |
| | Punishing–Rewarding | Negative/positive |
| **Intention** | **Hong & Tam (2006)** | |
| | I intend to use MDS in the future. | |
| | I expect that I would use MDS in the future. | |
| | I expect to use MDS frequently in the future. | |

# Appendix D: Indicators of Normality

| | Kolmogorov-Smirnov[a] | | |
|---|---|---|---|
| | Statistic | df | Sig. |
| Std. Residual Enjoyment | .051 | 320 | .043 |
| Std. Residual Self-identity | .048 | 320 | .077 |
| Std. Residual Usefulness | .031 | 320 | .200* |
| Std. Residual Risk | .036 | 320 | .200* |
| Std. Residual Compatibility | .036 | 320 | .200* |
| Std. Residual Ease of Use | .040 | 320 | .200* |
| Std. Residual Behavioral Control | .029 | 320 | .200* |
| Std. Residual Personal Norm | .066 | 320 | .002 |
| Std. Residual Social Norm | .068 | 320 | .001 |
| Std. Residual Attitude | .040 | 320 | .200* |
| Std. Residual Intention | .068 | 320 | .001 |

*. This is a lower bound of the true significance.

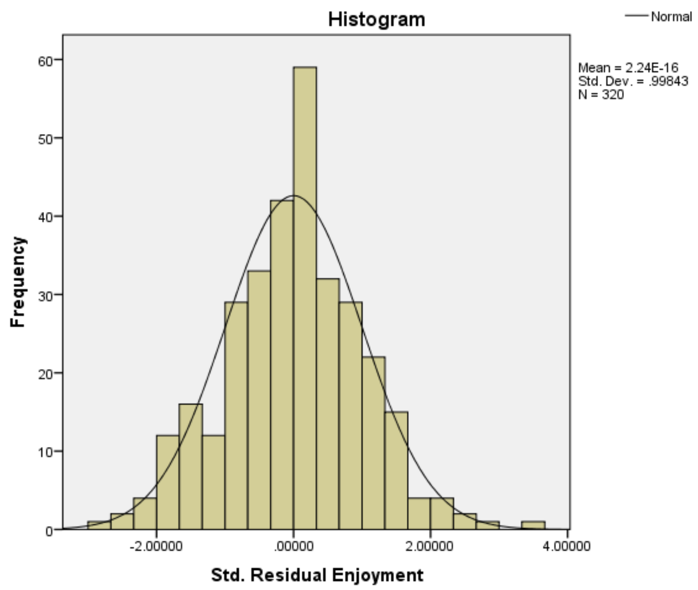
a. Lilliefors Significance Correction

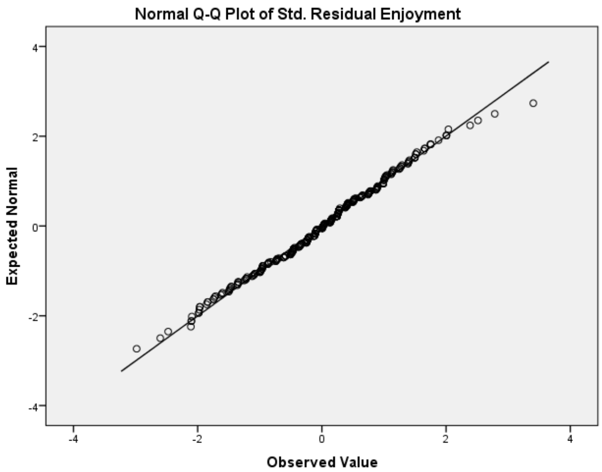
**Descriptive Statistics**

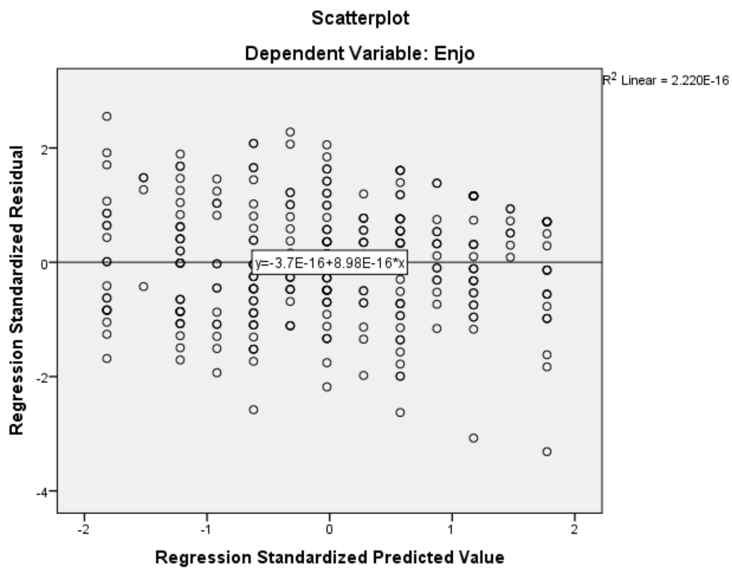
| | N | Mean | Std. Deviation | Skewness | | Kurtosis | |
|---|---|---|---|---|---|---|---|
| | Statistic | Statistic | Statistic | Statistic | Std. Error | Statistic | Std. Error |
| Perceived enjoyment | 320 | 4.5938 | 1.47 | -.175 | .136 | -.762 | .272 |
| Perceived self-identity | 320 | 2.7813 | 1.43 | .591 | .136 | -.481 | .272 |
| Perceived usefulness | 320 | 4.7042 | 1.49 | -.289 | .136 | -.783 | .272 |
| Perceived risk | 320 | 4.5500 | 1.62 | -.301 | .136 | -.791 | .272 |
| Compatibility | 320 | 4.1021 | 1.60 | .042 | .136 | -.802 | .272 |
| Perceived ease of use | 320 | 5.1333 | 1.26 | -.491 | .136 | -.213 | .272 |
| Perceived behavioral control | 320 | 3.4990 | 1.41 | .253 | .136 | -.471 | .272 |
| Personal norm | 320 | 3.4583 | 1.60 | .130 | .136 | -.905 | .272 |
| Social norm | 320 | 2.9760 | 1.28 | .059 | .136 | -.768 | .272 |
| Attitude | 320 | 4.8547 | 1.40 | -.335 | .136 | -.724 | .272 |
| Intention | 320 | 4.038 | 1.67 | -.003 | .136 | -.801 | .272 |

# Appendix E: Histograms, Q-Q and Scatter Plots

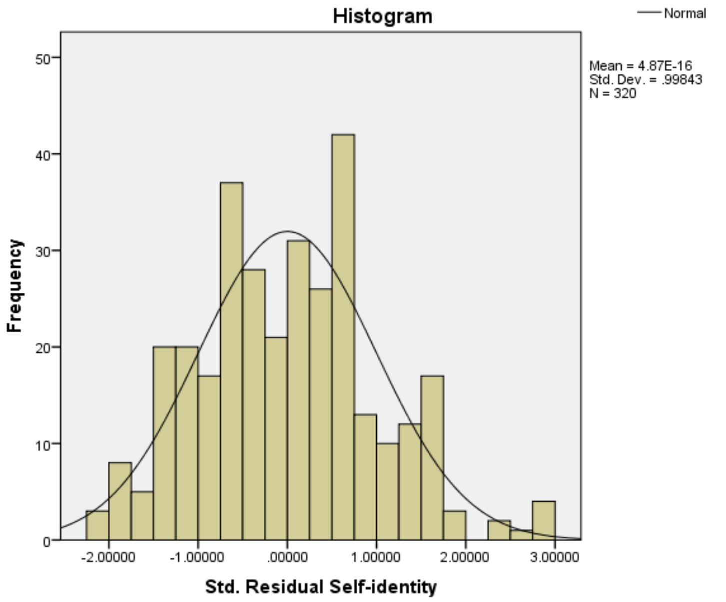
## *Perceived enjoyment*

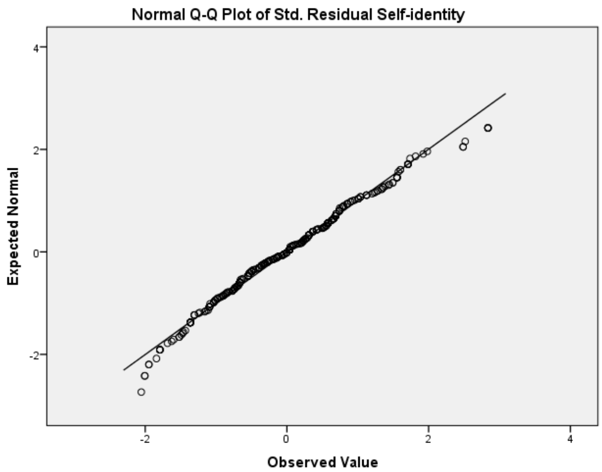


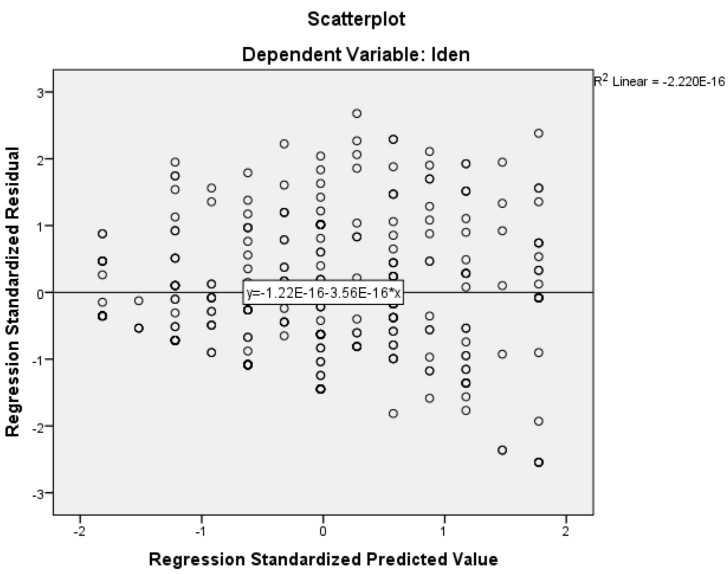



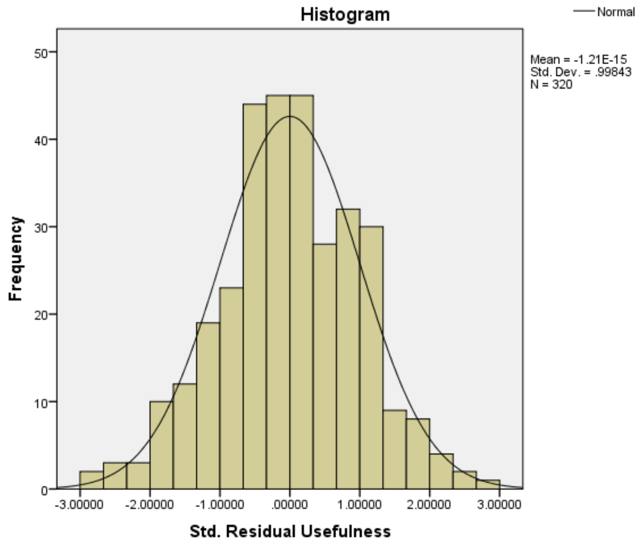
## *Perceived self-identity*

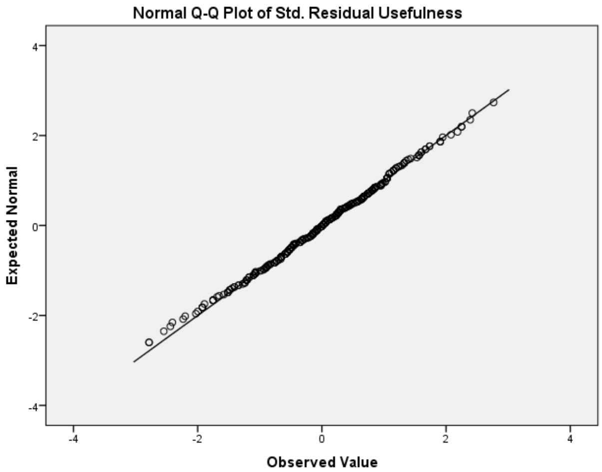


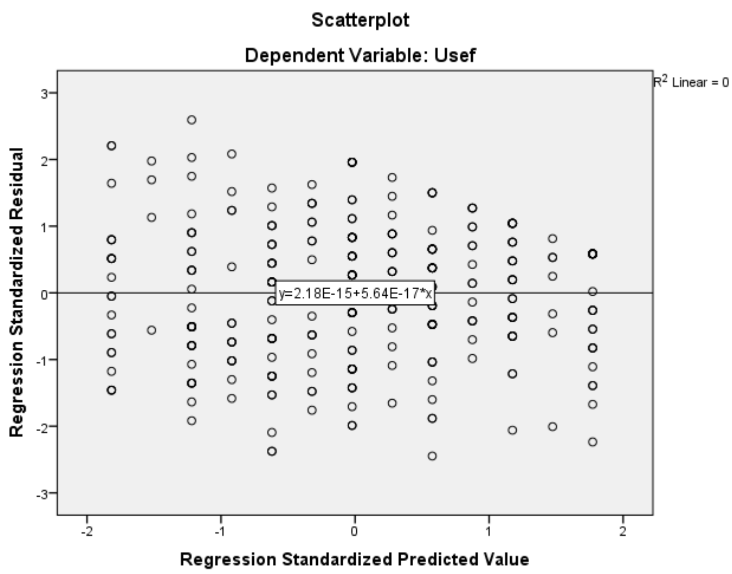



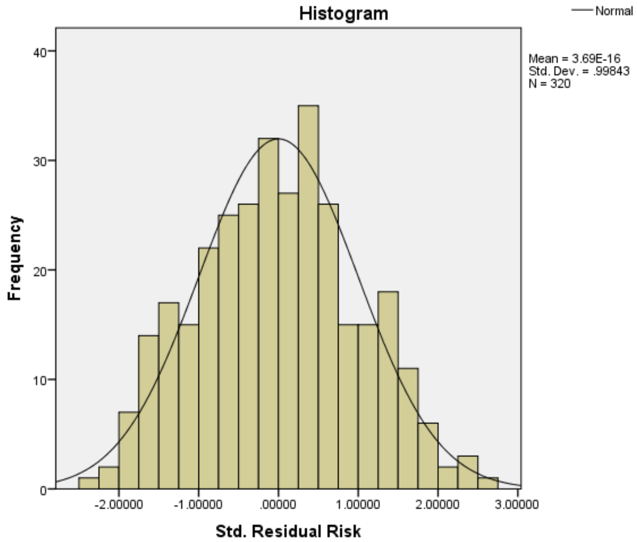
## *Perceived usefulness*

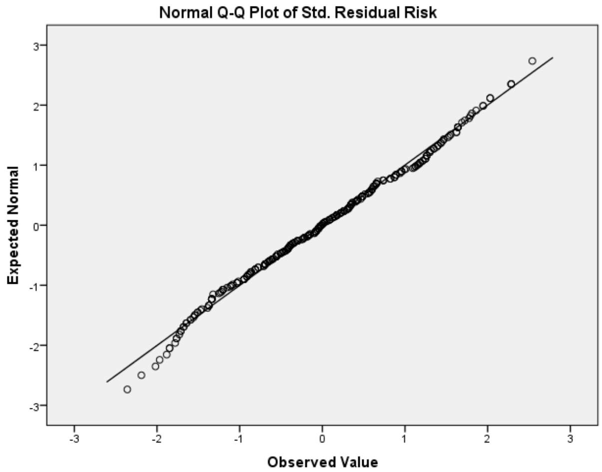


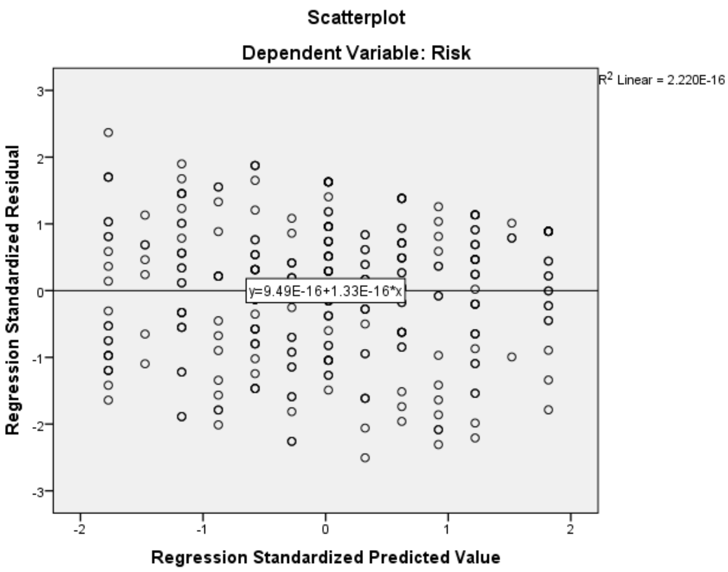



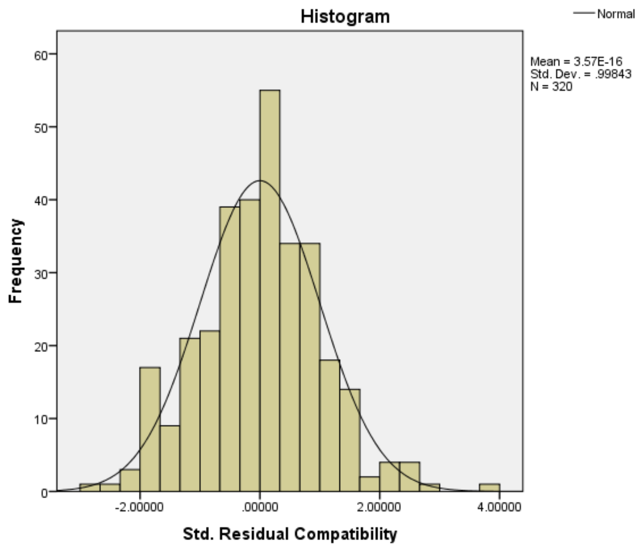
## *Perceived risk*

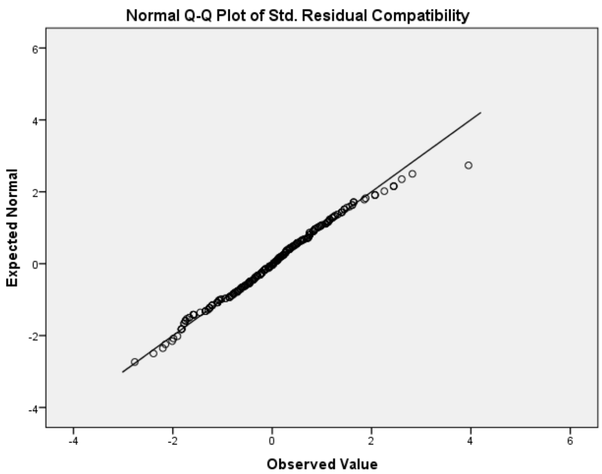


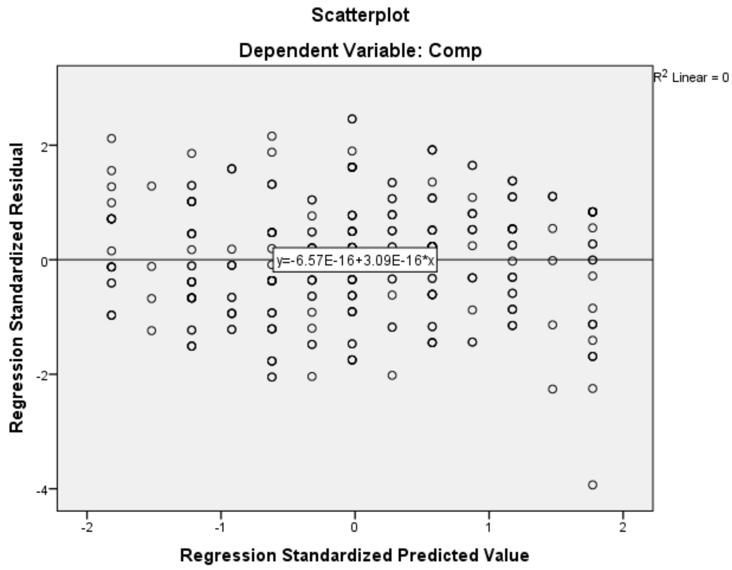



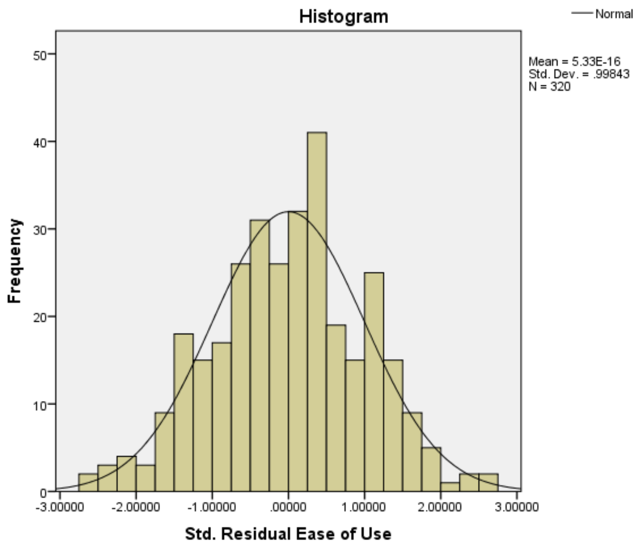
## *Compatibility*

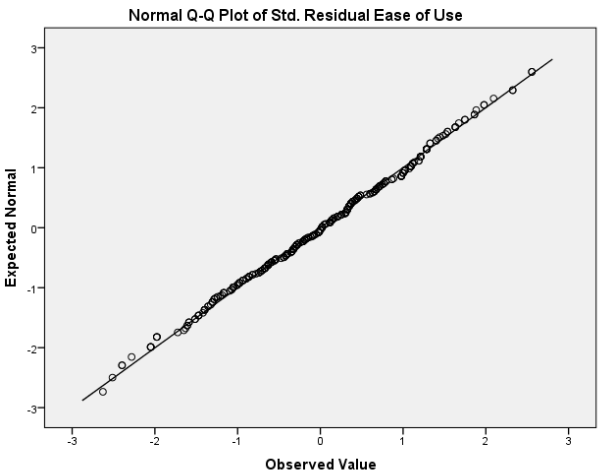


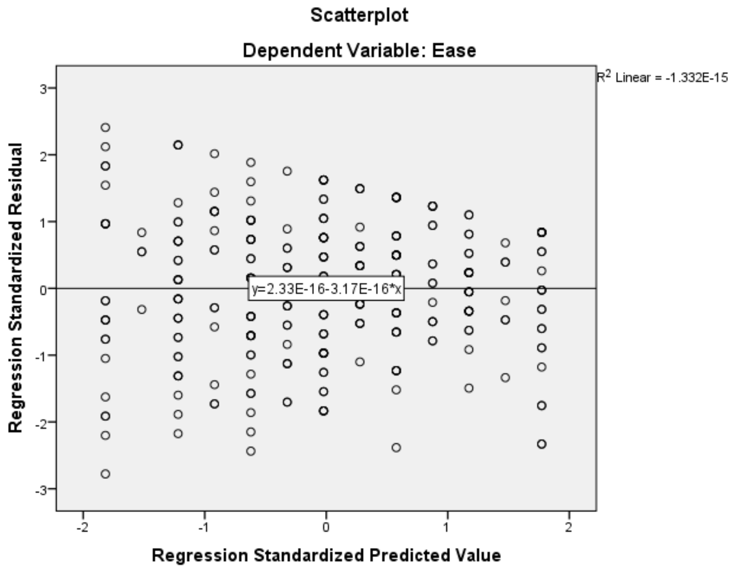



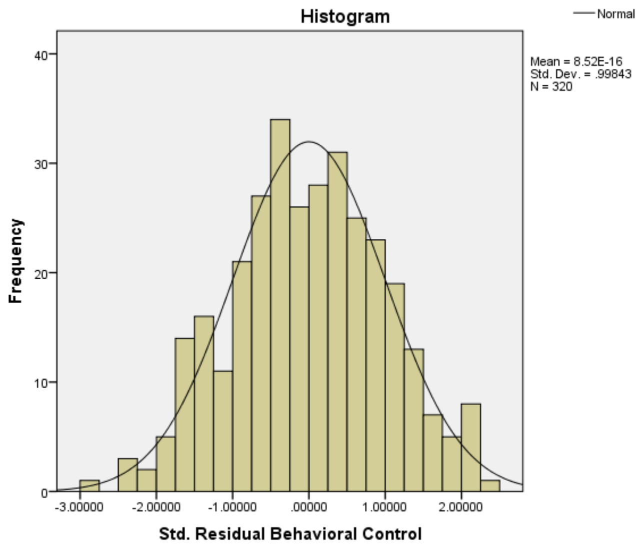
## *Perceived ease of use*

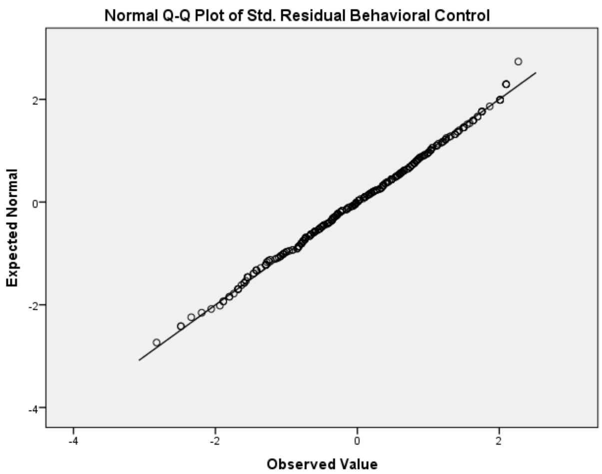


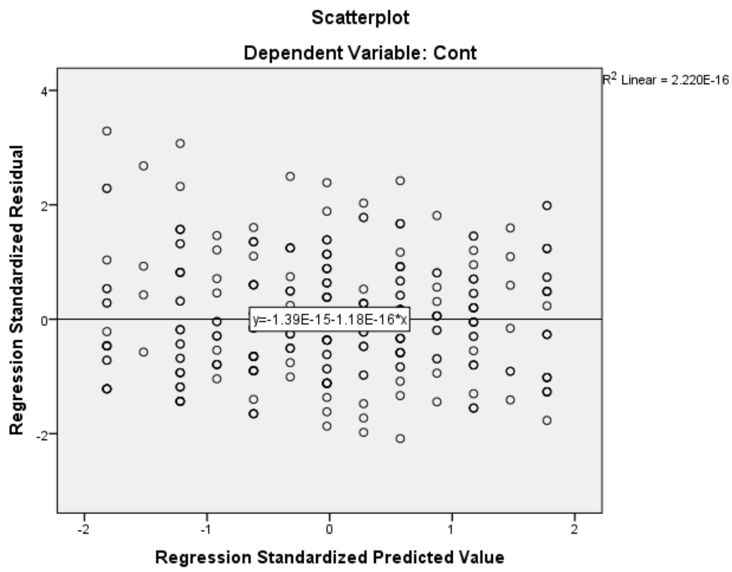



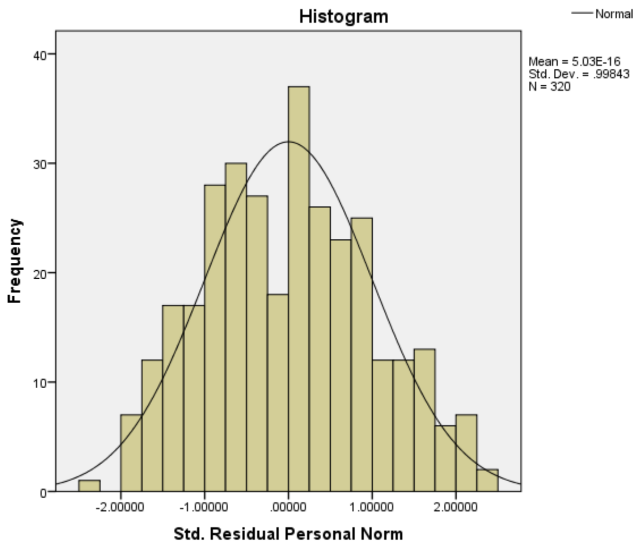
## *Perceived behavioral control*

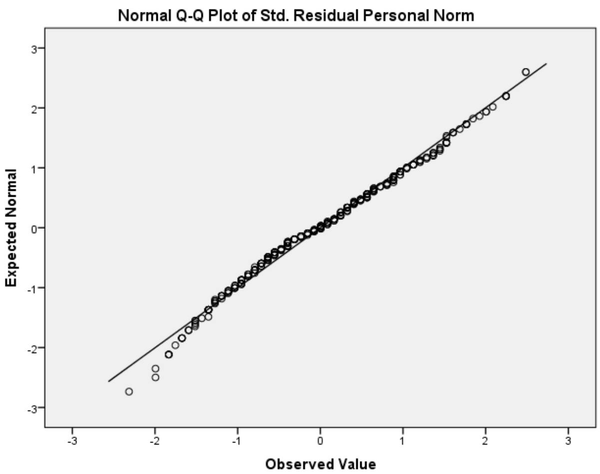


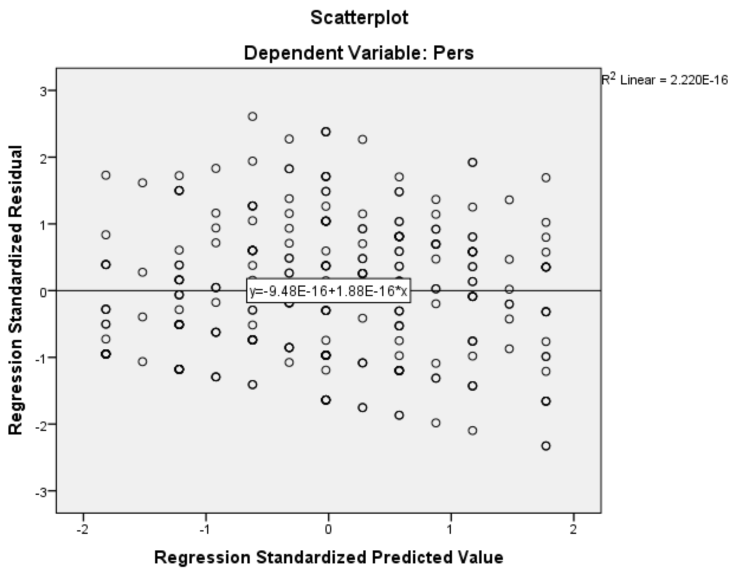



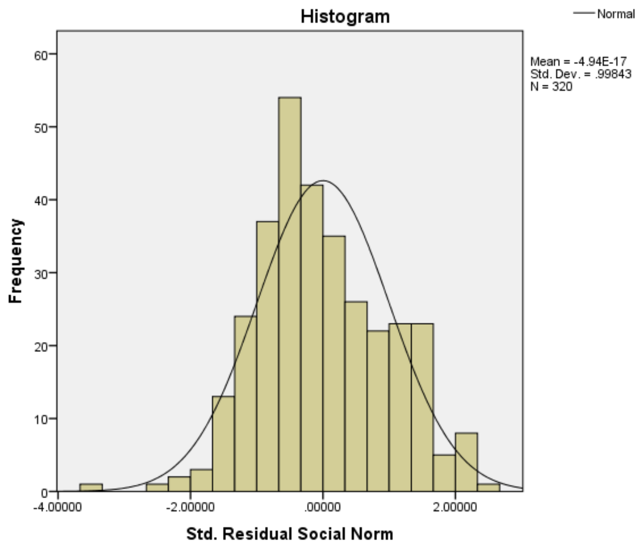
## *Personal Norm*

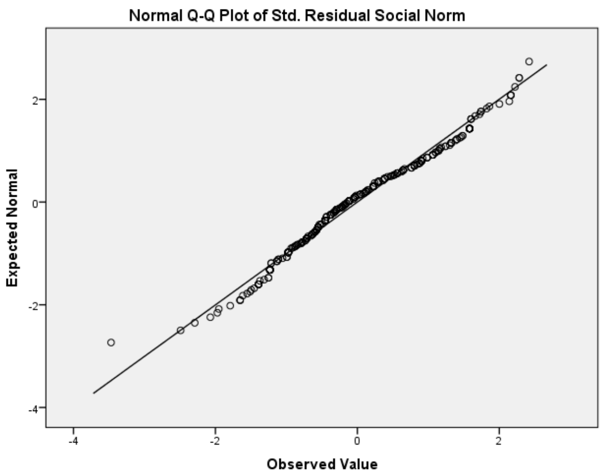


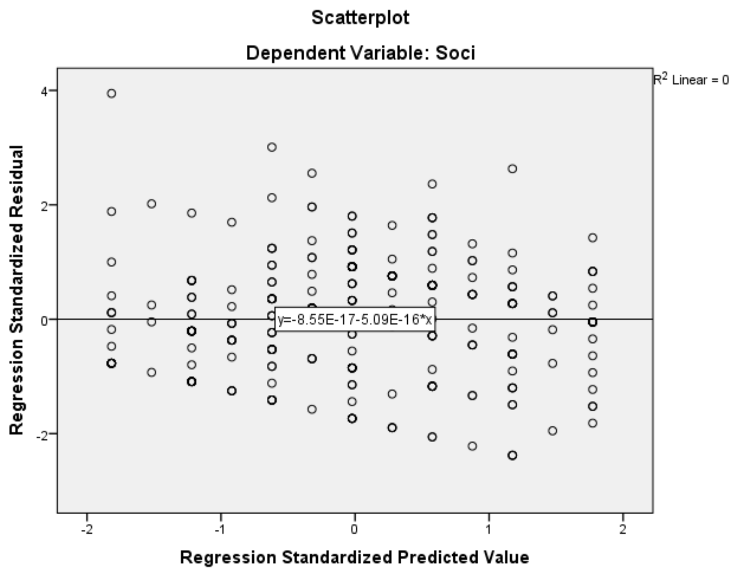



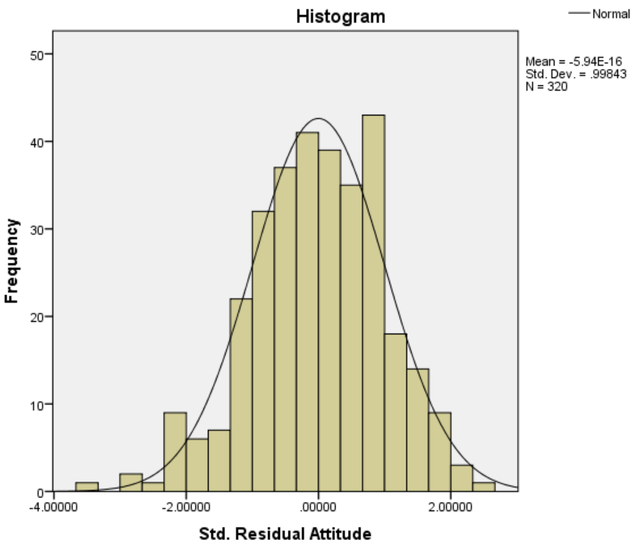
## *Social Norm*

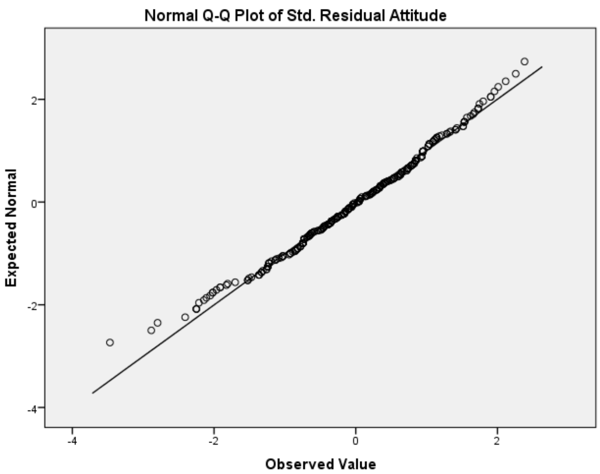

Histogram
Normal
Mean = -4.94E-17
Std. Dev. = .99843
N = 320
Frequency
Std. Residual Social Norm

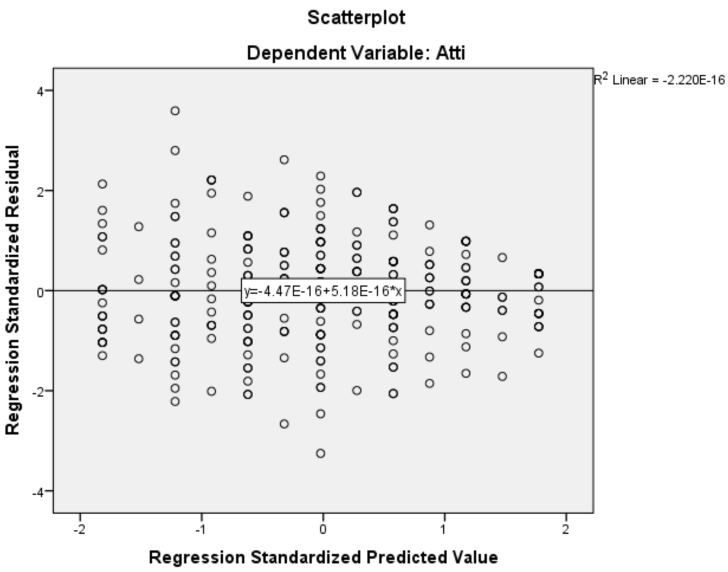

Normal Q-Q Plot of Std. Residual Social Norm
Expected Normal
Observed Value


Scatterplot
Dependent Variable: Soci
R2 Linear = 0
y=-8.55E-17-5.09E-16*x
Regression Standardized Residual
Regression Standardized Predicted Value

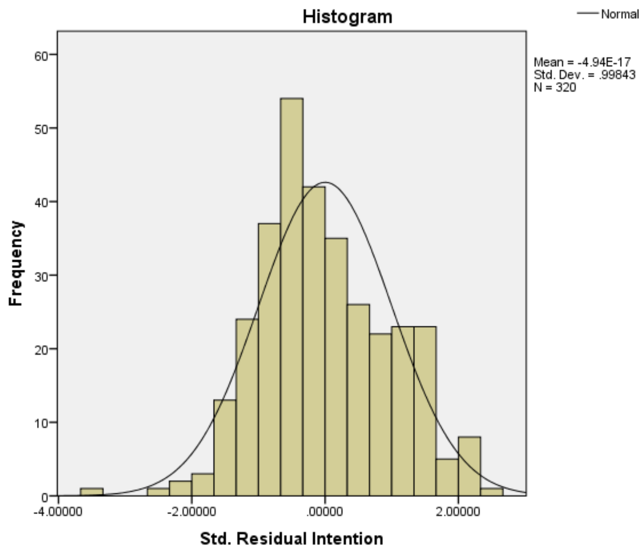
## *Attitude*

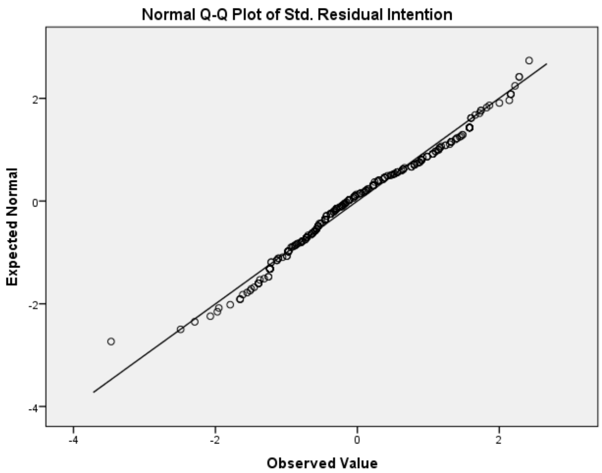

Histogram
Normal
Mean = -5.94E-16
Std. Dev. = .99843
N = 320
Frequency
Std. Residual Attitude

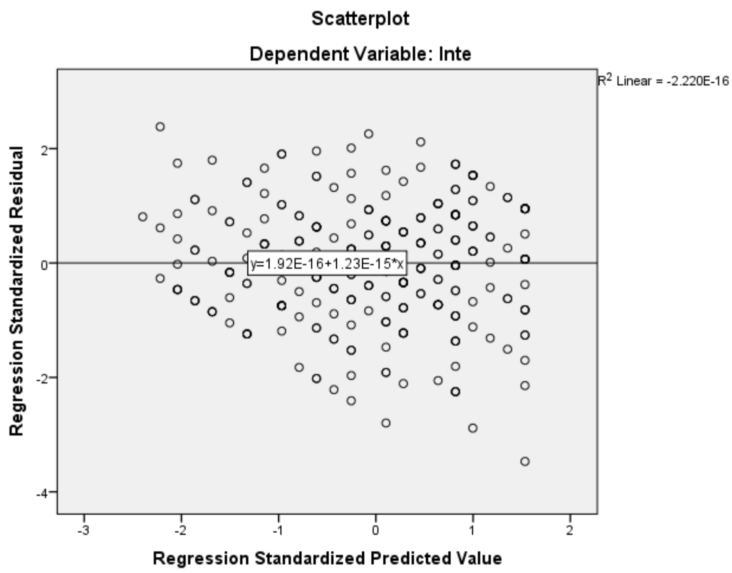

Normal Q-Q Plot of Std. Residual Attitude
Expected Normal
Observed Value


Scatterplot
Dependent Variable: Atti
R2 Linear = -2.220E-16
y=-4.47E-16+5.18E-16*x
Regression Standardized Residual
Regression Standardized Predicted Value

## *Intention*


Histogram
Normal
Mean = -4.94E-17
Std. Dev. = .99843
N = 320
Frequency
Std. Residual Intention


Normal Q-Q Plot of Std. Residual Intention
Expected Normal
Observed Value


Scatterplot
Dependent Variable: Inte
R2 Linear = -2.220E-16
y=1.92E-16+1.23E-15*x
Regression Standardized Residual
Regression Standardized Predicted Value

# Appendix F: Breusch-Pagan and Koenker tests

(Performed by running a macro in SPSS based on the code by Garcia-Granero (2002).)

```
Run MATRIX procedure:

 BP&K TESTS

 ==========

Regression SS
  35,2790

Residual SS
 719,5809

Total SS
 754,8598

R-squared
    ,0467

Sample size (N)
  320

Number of predictors (P)
   10

Breusch-Pagan test for Heteroscedasticity (CHI-
SQUARE df=P)
   17,639

Significance level of Chi-square df=P (H0:homosce-
dasticity)
    ,0614

Koenker test for Heteroscedasticity (CHI-
SQUARE df=P)
   14,955

Significance level of Chi-square df=P (H0:homosce-
dasticity)
    ,1337

------ END MATRIX -----
```

# Appendix G: Durbin-Watson, Tolerance and VIF tests

## *Durbin-Watson test for autocorrelation*

**Model Summary**[b]

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate | Durbin-Watson |
|---|---|---|---|---|---|
| 1 | .852[a] | .727 | .718 | .88804 | 1.305 |

a. Predictors: (Constant), Atti, Pers, Cont, Iden, Ease, Risk, Enjo, Soci, Usef, Comp
b. Dependent Variable: Inte

## *Tolerance and VIF tests for multicollinearity*

**Coefficients**[a]

| Model | | Collinearity Statistics | |
|---|---|---|---|
| | | Tolerance | VIF |
| 1 | Enjo | .554 | 1.803 |
| | Iden | .637 | 1.571 |
| | Usef | .485 | 2.063 |
| | Risk | .762 | 1.313 |
| | Comp | .450 | 2.223 |
| | Ease | .720 | 1.389 |
| | Cont | .763 | 1.310 |
| | Pers | .709 | 1.410 |
| | Soci | .590 | 1.695 |
| | Atti | .477 | 2.097 |

a. Dependent Variable: Inte

# Appendix H: GOF Results

## *Measurement Model Fit*

Chi-Square Test of Model Fit

| | |
|---|---|
| Value | 800.266 |
| Degrees of Freedom | 503 |
| P-Value | 0.0000 |

RMSEA (Root Mean Square Error Of Approximation)

| | | |
|---|---|---|
| Estimate | 0.043 | |
| 90 Percent C.I. | 0.037 | 0.048 |
| Probability RMSEA <= .05 | 0.983 | |

CFI/TLI

| | |
|---|---|
| CFI | 0.974 |
| TLI | 0.969 |

Chi-Square Test of Model Fit for the Baseline Model

| | |
|---|---|
| Value | 12040.509 |
| Degrees of Freedom | 595 |
| P-Value | 0.0000 |

SRMR (Standardized Root Mean Square Residual)

| | |
|---|---|
| Value | 0.031 |

## *Structural Model Fit*

Chi-Square Test of Model Fit

| | |
|---|---|
| Value | 839.314 |
| Degrees of Freedom | 512 |
| P-Value | 0.0000 |

RMSEA (Root Mean Square Error Of Approximation)

| | | |
|---|---|---|
| Estimate | 0.045 | |
| 90 Percent C.I. | 0.039 | 0.050 |
| Probability RMSEA <= .05 | 0.948 | |

CFI/TLI

| | |
|---|---|
| CFI | 0.971 |
| TLI | 0.967 |

Chi-Square Test of Model Fit for the Baseline Model

| | |
|---|---|
| Value | 12040.509 |
| Degrees of Freedom | 595 |
| P-Value | 0.0000 |

SRMR (Standardized Root Mean Square Residual)

| | |
|---|---|
| Value | 0.043 |

# Appendix I: Factor Loadings and Common Method

Original measurement model

| Chi-Square Test of Model Fit | | | | |
|---|---|---|---|---|
| | Value | | | 800.266 |
| | Degrees of Freedom | | | 503 |
| | P-Value | | | 0.000 |

STDYX Standardization

| | Estimate | S.E. | Est./S.E. | Two-Tailed P- Value |
|---|---|---|---|---|
| PU BY | | | | |
| PU1 | 0.685 | 0.035 | 19.379 | 0.000 |
| PU2 | 0.807 | 0.027 | 30.262 | 0.000 |
| PU4 | 0.859 | 0.023 | 37.783 | 0.000 |
| PR BY | | | | |
| PR1 | 0.853 | 0.020 | 43.628 | 0.000 |
| PR2 | 0.920 | 0.015 | 59.428 | 0.000 |
| PR3 | 0.848 | 0.020 | 43.070 | 0.000 |
| PEOU BY | | | | |
| PEOU1 | 0.847 | 0.019 | 43.862 | 0.000 |
| PEOU2 | 0.824 | 0.021 | 39.034 | 0.000 |
| PEOU3 | 0.954 | 0.013 | 71.272 | 0.000 |
| PE BY | | | | |
| PE1 | 0.888 | 0.014 | 63.152 | 0.000 |
| PE2 | 0.874 | 0.015 | 56.646 | 0.000 |
| PE3 | 0.925 | 0.011 | 84.816 | 0.000 |
| PE4 | 0.893 | 0.014 | 64.624 | 0.000 |
| CO BY | | | | |
| CO1 | 0.908 | 0.011 | 79.394 | 0.000 |
| CO2 | 0.961 | 0.007 | 135.441 | 0.000 |
| CO3 | 0.934 | 0.009 | 102.498 | 0.000 |
| PSI BY | | | | |
| PSI1 | 0.937 | 0.021 | 45.507 | 0.000 |
| PSI2 | 0.946 | 0.019 | 49.180 | 0.000 |
| PSI3 | 0.912 | 0.020 | 45.295 | 0.000 |
| PSI4 | 0.896 | 0.021 | 42.763 | 0.000 |
| PBC BY | | | | |
| PBC1 | 0.810 | 0.024 | 34.393 | 0.000 |
| PBC2 | 0.909 | 0.018 | 51.836 | 0.000 |
| PBC3 | 0.848 | 0.021 | 40.368 | 0.000 |
| PN BY | | | | |
| PN1 | 0.955 | 0.006 | 151.703 | 0.000 |
| PN2 | 0.965 | 0.006 | 173.479 | 0.000 |
| PN3 | 0.956 | 0.006 | 153.480 | 0.000 |
| SN BY | | | | |
| SN1 | 0.867 | 0.016 | 52.784 | 0.000 |
| SN2 | 0.852 | 0.018 | 47.037 | 0.000 |

Measurement model with common method factor

| Chi-Square Test of Model Fit | | | | |
|---|---|---|---|---|
| | Value | | | 800.491 |
| | Degrees of Freedom | | | 504 |
| | P-Value | | | 0.000 |

STDYX Standardization

| | Estimate | S.E. | Est./S.E. | Two-Tailed P-Value |
|---|---|---|---|---|
| PU BY | | | | |
| PU1 | 0.652 | 0.038 | 17.085 | 0.000 |
| PU2 | 0.781 | 0.029 | 26.892 | 0.000 |
| PU4 | 0.844 | 0.024 | 35.121 | 0.000 |
| PR BY | | | | |
| PR1 | 0.836 | 0.021 | 40.656 | 0.000 |
| PR2 | 0.902 | 0.016 | 54.994 | 0.000 |
| PR3 | 0.829 | 0.021 | 39.575 | 0.000 |
| PEOU BY | | | | |
| PEOU1 | 0.815 | 0.022 | 37.157 | 0.000 |
| PEOU2 | 0.796 | 0.023 | 33.899 | 0.000 |
| PEOU3 | 0.927 | 0.016 | 59.368 | 0.000 |
| PE BY | | | | |
| PE1 | 0.865 | 0.016 | 54.571 | 0.000 |
| PE2 | 0.852 | 0.017 | 49.738 | 0.000 |
| PE3 | 0.901 | 0.013 | 70.508 | 0.000 |
| PE4 | 0.874 | 0.015 | 57.570 | 0.000 |
| CO BY | | | | |
| CO1 | 0.888 | 0.013 | 68.006 | 0.000 |
| CO2 | 0.944 | 0.008 | 112.444 | 0.000 |
| CO3 | 0.915 | 0.011 | 86.499 | 0.000 |
| PSI BY | | | | |
| PSI1 | 0.911 | 0.022 | 40.854 | 0.000 |
| PSI2 | 0.919 | 0.021 | 43.968 | 0.000 |
| PSI3 | 0.891 | 0.021 | 41.652 | 0.000 |
| PSI4 | 0.873 | 0.022 | 39.115 | 0.000 |
| PBC BY | | | | |
| PBC1 | 0.788 | 0.025 | 31.297 | 0.000 |
| PBC2 | 0.885 | 0.019 | 45.512 | 0.000 |
| PBC3 | 0.824 | 0.023 | 36.127 | 0.000 |
| PN BY | | | | |
| PN1 | 0.936 | 0.008 | 118.989 | 0.000 |
| PN2 | 0.947 | 0.007 | 134.293 | 0.000 |
| PN3 | 0.938 | 0.008 | 121.969 | 0.000 |
| SN BY | | | | |
| SN1 | 0.836 | 0.019 | 44.119 | 0.000 |
| SN2 | 0.823 | 0.020 | 40.428 | 0.000 |

| | | | | |
|---|---|---|---|---|
| SN3 | 0.958 | 0.011 | 87.771 | 0.000 |
| | | | | |
| ATT | BY | | | |
| AT1 | 0.856 | 0.017 | 50.313 | 0.000 |
| AT2 | 0.872 | 0.016 | 55.859 | 0.000 |
| AT3 | 0.857 | 0.017 | 51.170 | 0.000 |
| AT4 | 0.945 | 0.009 | 101.220 | 0.000 |
| | | | | |
| INT | BY | | | |
| INT1 | 0.953 | 0.009 | 100.828 | 0.000 |
| INT2 | 0.938 | 0.010 | 91.281 | 0.000 |

| | | | | |
|---|---|---|---|---|
| SN3 | 0.933 | 0.013 | 73.667 | 0.000 |
| | | | | |
| ATT | BY | | | |
| AT1 | 0.831 | 0.019 | 44.515 | 0.000 |
| AT2 | 0.850 | 0.017 | 49.522 | 0.000 |
| AT3 | 0.831 | 0.019 | 44.310 | 0.000 |
| AT4 | 0.921 | 0.011 | 83.092 | 0.000 |
| | | | | |
| INT | BY | | | |
| INT1 | 0.946 | 0.006 | 159.958 | 0.000 |
| INT2 | 0.945 | 0.006 | 155.000 | 0.000 |

# Appendix J: Item-to-Total Correlations

**Correlations**

| | PE | PSI | PU | PR | CO | PEOU | PBC | PN | SN | ATT | INT |
|---|---|---|---|---|---|---|---|---|---|---|---|
| PE1 | $\mathbf{.911}^{**}$ | $.428^{**}$ | $.568^{**}$ | $-.214^{**}$ | $.557^{**}$ | $.384^{**}$ | $.178^{**}$ | $.268^{**}$ | $.335^{**}$ | $.473^{**}$ | $.613^{**}$ |
| PE2 | $\mathbf{.919}^{**}$ | $.348^{**}$ | $.488^{**}$ | $-.129^{*}$ | $.456^{**}$ | $.308^{**}$ | $.114^{*}$ | $.231^{**}$ | $.283^{**}$ | $.373^{**}$ | $.490^{**}$ |
| PE3 | $\mathbf{.932}^{**}$ | $.416^{**}$ | $.571^{**}$ | $-.170^{**}$ | $.543^{**}$ | $.406^{**}$ | $.154^{**}$ | $.247^{**}$ | $.315^{**}$ | $.457^{**}$ | $.590^{**}$ |
| PE4 | $\mathbf{.929}^{**}$ | $.382^{**}$ | $.495^{**}$ | $-.107$ | $.512^{**}$ | $.255^{**}$ | $.080$ | $.210^{**}$ | $.292^{**}$ | $.373^{**}$ | $.527^{**}$ |
| PSI1 | $.399^{**}$ | $\mathbf{.948}^{**}$ | $.357^{**}$ | $-.195^{**}$ | $.558^{**}$ | $.282^{**}$ | $.252^{**}$ | $.148^{**}$ | $.327^{**}$ | $.406^{**}$ | $.515^{**}$ |
| PSI2 | $.417^{**}$ | $\mathbf{.954}^{**}$ | $.371^{**}$ | $-.199^{**}$ | $.541^{**}$ | $.257^{**}$ | $.217^{**}$ | $.154^{**}$ | $.320^{**}$ | $.358^{**}$ | $.486^{**}$ |
| PSI3 | $.403^{**}$ | $\mathbf{.958}^{**}$ | $.391^{**}$ | $-.158^{**}$ | $.522^{**}$ | $.237^{**}$ | $.204^{**}$ | $.110$ | $.319^{**}$ | $.366^{**}$ | $.499^{**}$ |
| PSI4 | $.403^{**}$ | $\mathbf{.949}^{**}$ | $.375^{**}$ | $-.166^{**}$ | $.509^{**}$ | $.241^{**}$ | $.198^{**}$ | $.100$ | $.319^{**}$ | $.363^{**}$ | $.485^{**}$ |
| PU1 | $.404^{**}$ | $.276^{**}$ | $\mathbf{.845}^{**}$ | $-.120^{*}$ | $.452^{**}$ | $.281^{**}$ | $.223^{**}$ | $.125^{*}$ | $.269^{**}$ | $.370^{**}$ | $.406^{**}$ |
| PU2 | $.517^{**}$ | $.348^{**}$ | $\mathbf{.892}^{**}$ | $-.163^{**}$ | $.534^{**}$ | $.313^{**}$ | $.212^{**}$ | $.170^{**}$ | $.352^{**}$ | $.428^{**}$ | $.526^{**}$ |
| *PU3**** | $\mathit{.361}^{**}$ | $\mathit{.180}^{**}$ | $\mathit{.525}^{**}$ | $\mathit{-.111}^{*}$ | $\mathit{.312}^{**}$ | $\mathit{.222}^{**}$ | $\mathit{.114}^{*}$ | $\mathit{.139}^{*}$ | $\mathit{.241}^{**}$ | $\mathit{.304}^{**}$ | $\mathit{.338}^{**}$ |
| PU4 | $.567^{**}$ | $.394^{**}$ | $\mathbf{.862}^{**}$ | $-.183^{**}$ | $.640^{**}$ | $.381^{**}$ | $.212^{**}$ | $.234^{**}$ | $.395^{**}$ | $.505^{**}$ | $.646^{**}$ |
| PR1 | $-.118^{*}$ | $-.145^{**}$ | $-.166^{**}$ | $\mathbf{.912}^{**}$ | $-.218^{**}$ | $-.156^{**}$ | $-.074$ | $-.236^{**}$ | $-.208^{**}$ | $-.431^{**}$ | $-.337^{**}$ |
| PR2 | $-.202^{**}$ | $-.200^{**}$ | $-.196^{**}$ | $\mathbf{.933}^{**}$ | $-.264^{**}$ | $-.134^{*}$ | $-.159^{**}$ | $-.189^{**}$ | $-.246^{**}$ | $-.443^{**}$ | $-.390^{**}$ |
| PR3 | $-.139^{*}$ | $-.175^{**}$ | $-.132^{*}$ | $\mathbf{.908}^{**}$ | $-.185^{**}$ | $-.114^{*}$ | $-.062$ | $-.189^{**}$ | $-.225^{**}$ | $-.386^{**}$ | $-.324^{**}$ |
| CO1 | $.551^{**}$ | $.530^{**}$ | $.616^{**}$ | $-.194^{**}$ | $\mathbf{.947}^{**}$ | $.349^{**}$ | $.253^{**}$ | $.178^{**}$ | $.344^{**}$ | $.440^{**}$ | $.623^{**}$ |
| CO2 | $.536^{**}$ | $.523^{**}$ | $.606^{**}$ | $-.252^{**}$ | $\mathbf{.966}^{**}$ | $.341^{**}$ | $.189^{**}$ | $.266^{**}$ | $.415^{**}$ | $.454^{**}$ | $.660^{**}$ |
| CO3 | $.518^{**}$ | $.553^{**}$ | $.577^{**}$ | $-.251^{**}$ | $\mathbf{.956}^{**}$ | $.343^{**}$ | $.166^{**}$ | $.223^{**}$ | $.375^{**}$ | $.454^{**}$ | $.643^{**}$ |
| PEOU1 | $.306^{**}$ | $.216^{**}$ | $.345^{**}$ | $-.094$ | $.316^{**}$ | $\mathbf{.906}^{**}$ | $.260^{**}$ | $.088$ | $.109$ | $.386^{**}$ | $.353^{**}$ |
| PEOU2 | $.325^{**}$ | $.290^{**}$ | $.323^{**}$ | $-.141^{*}$ | $.338^{**}$ | $\mathbf{.906}^{**}$ | $.273^{**}$ | $.109$ | $.114^{*}$ | $.379^{**}$ | $.369^{**}$ |
| PEOU3 | $.372^{**}$ | $.227^{**}$ | $.369^{**}$ | $-.168^{**}$ | $.337^{**}$ | $\mathbf{.942}^{**}$ | $.291^{**}$ | $.160^{**}$ | $.148^{**}$ | $.435^{**}$ | $.382^{**}$ |
| PBC1 | $.125^{*}$ | $.232^{**}$ | $.251^{**}$ | $-.110$ | $.209^{**}$ | $.236^{**}$ | $\mathbf{.893}^{**}$ | $.076$ | $.273^{**}$ | $.328^{**}$ | $.335^{**}$ |
| PBC2 | $.130^{*}$ | $.214^{**}$ | $.238^{**}$ | $-.108$ | $.205^{**}$ | $.278^{**}$ | $\mathbf{.922}^{**}$ | $.076$ | $.307^{**}$ | $.368^{**}$ | $.322^{**}$ |
| PBC3 | $.129^{*}$ | $.177^{**}$ | $.187^{**}$ | $-.074$ | $.163^{**}$ | $.301^{**}$ | $\mathbf{.904}^{**}$ | $-.014$ | $.234^{**}$ | $.326^{**}$ | $.271^{**}$ |
| PN1 | $.240^{**}$ | $.156^{**}$ | $.216^{**}$ | $-.208^{**}$ | $.231^{**}$ | $.107$ | $.058$ | $\mathbf{.971}^{**}$ | $.478^{**}$ | $.314^{**}$ | $.363^{**}$ |
| PN2 | $.272^{**}$ | $.121^{*}$ | $.201^{**}$ | $-.210^{**}$ | $.222^{**}$ | $.141^{*}$ | $.037$ | $\mathbf{.975}^{**}$ | $.463^{**}$ | $.307^{**}$ | $.356^{**}$ |
| PN3 | $.242^{**}$ | $.117^{*}$ | $.180^{**}$ | $-.233^{**}$ | $.225^{**}$ | $.130^{*}$ | $.054$ | $\mathbf{.972}^{**}$ | $.468^{**}$ | $.294^{**}$ | $.328^{**}$ |
| SN1 | $.297^{**}$ | $.359^{**}$ | $.363^{**}$ | $-.253^{**}$ | $.370^{**}$ | $.137^{*}$ | $.278^{**}$ | $.383^{**}$ | $\mathbf{.919}^{**}$ | $.352^{**}$ | $.411^{**}$ |
| SN2 | $.329^{**}$ | $.288^{**}$ | $.381^{**}$ | $-.167^{**}$ | $.361^{**}$ | $.120^{*}$ | $.282^{**}$ | $.471^{**}$ | $\mathbf{.913}^{**}$ | $.337^{**}$ | $.477^{**}$ |
| SN3 | $.298^{**}$ | $.294^{**}$ | $.347^{**}$ | $-.266^{**}$ | $.368^{**}$ | $.116^{*}$ | $.273^{**}$ | $.489^{**}$ | $\mathbf{.952}^{**}$ | $.361^{**}$ | $.433^{**}$ |
| AT1 | $.459^{**}$ | $.344^{**}$ | $.483^{**}$ | $-.407^{**}$ | $.442^{**}$ | $.429^{**}$ | $.288^{**}$ | $.270^{**}$ | $.301^{**}$ | $\mathbf{.891}^{**}$ | $.684^{**}$ |
| AT2 | $.368^{**}$ | $.388^{**}$ | $.403^{**}$ | $-.436^{**}$ | $.397^{**}$ | $.375^{**}$ | $.347^{**}$ | $.273^{**}$ | $.331^{**}$ | $\mathbf{.919}^{**}$ | $.647^{**}$ |
| AT3 | $.380^{**}$ | $.337^{**}$ | $.451^{**}$ | $-.406^{**}$ | $.409^{**}$ | $.372^{**}$ | $.352^{**}$ | $.299^{**}$ | $.365^{**}$ | $\mathbf{.896}^{**}$ | $.635^{**}$ |
| AT4 | $.451^{**}$ | $.363^{**}$ | $.499^{**}$ | $-.423^{**}$ | $.468^{**}$ | $.415^{**}$ | $.382^{**}$ | $.302^{**}$ | $.380^{**}$ | $\mathbf{.944}^{**}$ | $.727^{**}$ |
| INT1 | $.583^{**}$ | $.510^{**}$ | $.607^{**}$ | $-.387^{**}$ | $.639^{**}$ | $.401^{**}$ | $.321^{**}$ | $.348^{**}$ | $.446^{**}$ | $.736^{**}$ | $\mathbf{.973}^{**}$ |
| INT2 | $.585^{**}$ | $.505^{**}$ | $.578^{**}$ | $-.356^{**}$ | $.667^{**}$ | $.380^{**}$ | $.344^{**}$ | $.350^{**}$ | $.478^{**}$ | $.698^{**}$ | $\mathbf{.973}^{**}$ |

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

***. Dropped item.

# Appendix K: Harman's One-factor Test

**Total Variance Explained**

| Component | Initial Eigenvalues | | | Extraction Sums of Squared Loadings | | |
|---|---|---|---|---|---|---|
| | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % |
| 1 | 13.022 | 37.205 | 37.205 | 13.022 | 37.205 | 37.205 |
| 2 | 3.308 | 9.452 | 46.658 | | | |
| 3 | 2.832 | 8.093 | 54.751 | | | |
| 4 | 2.404 | 6.868 | 61.619 | | | |
| 5 | 2.303 | 6.579 | 68.198 | | | |
| 6 | 1.685 | 4.813 | 73.011 | | | |
| 7 | 1.336 | 3.816 | 76.828 | | | |
| 8 | 1.242 | 3.548 | 80.376 | | | |
| 9 | 1.033 | 2.953 | 83.329 | | | |
| 10 | .880 | 2.513 | 85.842 | | | |
| 11 | .511 | 1.459 | 87.301 | | | |
| 12 | .398 | 1.137 | 88.438 | | | |
| 13 | .350 | 1.000 | 89.438 | | | |
| 14 | .334 | .953 | 90.391 | | | |
| 15 | .319 | .912 | 91.303 | | | |
| 16 | .289 | .825 | 92.128 | | | |
| 17 | .272 | .778 | 92.906 | | | |
| 18 | .248 | .709 | 93.615 | | | |
| 19 | .231 | .659 | 94.274 | | | |
| 20 | .218 | .621 | 94.895 | | | |
| 21 | .199 | .568 | 95.463 | | | |
| 22 | .190 | .543 | 96.006 | | | |
| 23 | .177 | .505 | 96.512 | | | |
| 24 | .169 | .482 | 96.993 | | | |
| 25 | .155 | .442 | 97.435 | | | |
| 26 | .142 | .406 | 97.841 | | | |
| 27 | .127 | .362 | 98.204 | | | |
| 28 | .111 | .316 | 98.520 | | | |
| 29 | .102 | .290 | 98.810 | | | |
| 30 | .090 | .257 | 99.066 | | | |
| 31 | .079 | .226 | 99.292 | | | |
| 32 | .072 | .207 | 99.499 | | | |
| 33 | .064 | .182 | 99.682 | | | |
| 34 | .059 | .167 | 99.849 | | | |
| 35 | .053 | .151 | 100.000 | | | |

Extraction Method: Principal Component Analysis.

# Appendix L: Unmeasured Latent Method Results

| | Estimate | S.E. | Est./S.E. | Two-Tailed P-Value |
|---|---|---|---|---|
| XX | BY | | | |
| PU1 | 0.311 | 0.024 | 12.985 | 0.000 |
| PU2 | 0.311 | 0.024 | 12.985 | 0.000 |
| PU4 | 0.311 | 0.024 | 12.985 | 0.000 |
| PR1 | 0.311 | 0.024 | 12.985 | 0.000 |
| PR2 | 0.311 | 0.024 | 12.985 | 0.000 |
| PR3 | 0.311 | 0.024 | 12.985 | 0.000 |
| PEOU1 | 0.311 | 0.024 | 12.985 | 0.000 |
| PEOU2 | 0.311 | 0.024 | 12.985 | 0.000 |
| PEOU3 | 0.311 | 0.024 | 12.985 | 0.000 |
| PE1 | 0.311 | 0.024 | 12.985 | 0.000 |
| PE2 | 0.311 | 0.024 | 12.985 | 0.000 |
| PE3 | 0.311 | 0.024 | 12.985 | 0.000 |
| PE4 | 0.311 | 0.024 | 12.985 | 0.000 |
| CO1 | 0.311 | 0.024 | 12.985 | 0.000 |
| CO2 | 0.311 | 0.024 | 12.985 | 0.000 |
| CO3 | 0.311 | 0.024 | 12.985 | 0.000 |
| PSI1 | 0.311 | 0.024 | 12.985 | 0.000 |
| PSI2 | 0.311 | 0.024 | 12.985 | 0.000 |
| PSI3 | 0.311 | 0.024 | 12.985 | 0.000 |
| PSI4 | 0.311 | 0.024 | 12.985 | 0.000 |
| PBC1 | 0.311 | 0.024 | 12.985 | 0.000 |
| PBC2 | 0.311 | 0.024 | 12.985 | 0.000 |
| PBC3 | 0.311 | 0.024 | 12.985 | 0.000 |
| PN1 | 0.311 | 0.024 | 12.985 | 0.000 |
| PN2 | 0.311 | 0.024 | 12.985 | 0.000 |
| PN3 | 0.311 | 0.024 | 12.985 | 0.000 |
| SN1 | 0.311 | 0.024 | 12.985 | 0.000 |
| SN2 | 0.311 | 0.024 | 12.985 | 0.000 |
| SN3 | 0.311 | 0.024 | 12.985 | 0.000 |
| AT1 | 0.311 | 0.024 | 12.985 | 0.000 |
| AT2 | 0.311 | 0.024 | 12.985 | 0.000 |
| AT3 | 0.311 | 0.024 | 12.985 | 0.000 |
| AT4 | 0.311 | 0.024 | 12.985 | 0.000 |

(Variance accounted for by the unmeasured latent variable is $0.311^2 = 0.0967 = 9.7\%$)

# Appendix M: Control Variables

Original Model:
Chi-Square Test of Model Fit

| | |
|---|---|
| Value | 839.314 |
| Degrees of Freedom | 512 |
| P-Value | 0.0000 |

Control Model:
Chi-Square Test of Model Fit

| | |
|---|---|
| Value | 1104.028 |
| Degrees of Freedom | 648 |
| P-Value | 0.0000 |

Insignificant effects of control variables:

| | Estimate | S.E. | Est./S.E. | Two-Tailed P-Value |
|---|---|---|---|---|
| INT | ON | | | |
| GEND | 0.137 | 0.109 | 1.258 | 0.208 |
| AGE | 0.009 | 0.055 | 0.155 | 0.876 |
| EDU | -0.013 | 0.074 | -0.171 | 0.864 |
| NAT | -0.096 | 0.144 | -0.666 | 0.506 |

# Appendix N: Structural Model Results

| STDYX Standardization | | | | |
|---|---|---|---|---|
| | Estimate | S.E. | Est./S.E. | Two-Tailed P-Value |
| PU | ON | | | |
| PEOU | 0.126 | 0.049 | 2.548 | 0.0110 |
| CO | 0.467 | 0.053 | 8.801 | 0.0000 |
| PE | 0.343 | 0.056 | 6.089 | 0.0000 |
| | | | | |
| ATT | ON | | | |
| PEOU | 0.215 | 0.05 | 4.345 | 0.0000 |
| PE | 0.083 | 0.064 | 1.292 | 0.1960 |
| PU | 0.307 | 0.069 | 4.467 | 0.0000 |
| PR | -0.351 | 0.044 | -7.986 | 0.0000 |
| PSI | 0.102 | 0.051 | 2.004 | 0.0450 |
| | | | | |
| INT | ON | | | |
| CO | 0.22 | 0.055 | 4.028 | 0.0000 |
| PEOU | -0.044 | 0.039 | -1.137 | 0.2560 |
| PE | 0.139 | 0.047 | 2.939 | 0.0030 |
| PU | 0.137 | 0.065 | 2.115 | 0.0340 |
| PR | -0.046 | 0.038 | -1.196 | 0.2320 |
| PSI | 0.088 | 0.041 | 2.141 | 0.0320 |
| PBC | 0.059 | 0.038 | 1.537 | 0.1240 |
| PN | 0.078 | 0.038 | 2.056 | 0.0400 |
| SN | 0.024 | 0.043 | 0.569 | 0.5700 |
| ATT | 0.441 | 0.05 | 8.905 | 0.0000 |
| (…) | | | | |
| R-SQUARE | | | | |
| Latent Variable | Estimate | S.E. | Est./S.E. | Two-Tailed P-Value |
| PU | 0.618 | 0.044 | 14.122 | 0.0000 |
| ATT | 0.536 | 0.043 | 12.45 | 0.0000 |
| INT | 0.79 | 0.026 | 30.893 | 0.0000 |

# Appendix O: Group Comparison

Means (STDY Standardization)

| Construct | Estimate | S.E. | Est./S.E. | Two-Tailed P-Value |
|---|---|---|---|---|
| PR | -0.023 | 0.115 | -0.201 | 0.841 |
| PEOU | 0.092 | 0.114 | 0.808 | 0.419 |
| PE | 0.005 | 0.119 | 0.043 | 0.965 |
| CO | -0.106 | 0.116 | -0.915 | 0.36 |
| PSI | 0.041 | 0.113 | 0.361 | 0.718 |
| PBC | -0.116 | 0.112 | -1.041 | 0.298 |
| PN | 0.16 | 0.113 | 1.413 | 0.158 |
| SN | 0.027 | 0.112 | 0.243 | 0.808 |

| Path Constraint | $\chi^2$ | $\Delta\chi^2$ | *df* |
|---|---|---|---|
| Baseline model | 1707.633 | | 1074 |
| PEOU->PU | 1708.503 | 0.87 | 1075 |
| CO->PU | 1708.519 | 0.02 | 1076 |
| PE->PU | 1708.795 | 0.28 | 1077 |
| PEOU->ATT | 1710.099 | 1.30 | 1078 |
| PE->ATT | 1710.152 | 0.05 | 1079 |
| PU->ATT | 1710.586 | 0.43 | 1080 |
| PR->ATT | 1711.326 | 0.74 | 1081 |
| PSI->ATT | 1711.326 | 0.00 | 1082 |
| CO->INT | 1712.903 | 1.58 | 1083 |
| PEOU->INT | 1714.257 | 1.35 | 1084 |
| PE->INT | 1715.355 | 1.10 | 1085 |
| PU->INT | 1715.449 | 0.09 | 1086 |
| PR->INT | 1717.737 | 2.29 | 1087 |
| PSI->INT | 1720.288 | 2.55 | 1088 |
| PBC->INT | 1720.323 | 0.04 | 1089 |
| PN->INT | 1721.065 | 0.74 | 1090 |
| SN->INT | 1721.151 | 0.09 | 1091 |
| ATT->INT | 1721.204 | 0.05 | 1092 |