RESEARCH

Patrick Planing

Innovation Acceptance

The Case of Advanced Driver-Assistance Systems

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Patrick Planing
Stuttgart, Germany

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Patrick Planing

Abstract

Advanced Driver-Assistance Systems (ADAS) provide the opportunity to increase road safety and driving comfort. Yet, the analysis of the European market shows that ADAS are still niche products with low customer awareness and marginal market penetration rates. The overall aim of this study is to explain which factors are decisive for the customer's acceptance of Advanced Driver-Assistance Systems (ADAS) in order to help the industry and legislation to market this technology. The academic discussion is still far from reaching a common agreement on a universally applicable model for the acceptance of technological innovations and so far no acceptance research has been conducted in the specific context of ADAS.

Reviewing existing empirical work on comparable innovations, the author derived potential acceptance constructs, which together with the results of thirty-two semi-structured interviews have constituted the basis for a survey instrument that was consequently administered to a sample of over 400 participants (of which 387 were accepted responses) from the target population.
The resulting regression model shows that *Perceived Safety and Comfort Benefits* are most decisive for the acceptance of ADAS, while *Desire to Exert Control* was found to most strongly support resistance to this technology. In other words, a strong personal motivation to exert power significantly reduces the acceptance of ADAS. The analysis of group differences, furthermore, revealed that females and younger individuals are significantly more likely to buy driver-assistance systems than males and senior individuals. Most importantly, past experience was found to act as a major background variable for the acceptance of ADAS.

These findings contribute not only to the academic field, but also have several implications for the industry and the legislative authorities. The industry should focus its attention on the direct communication of potential safety and comfort benefits at the point of sale. Since the results generally show that first experiences strongly support the acceptance of this technology, both industry and legislation should aim for increasing initial usage of this technology by providing test drive opportunities or governmental incentives for initial usage. Furthermore it is promising to develop target-group oriented marketing measures specifically in regard to female and younger car drivers, as these groups will act as early adopters in the case of driver-assistance systems.

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List of Abbreviations

ABS	Anti-Lock Brake System
ACC	Adaptive Cruise Control
ADAS	Advanced Driver-Assistance Systems
AGFI	Adjusted Goodness-of-Fit Index
AMOS	Analysis of Moment Structures
CAS	Collision Avoidance Systems
CFA	Confirmatory Factor Analysis
CFI	Comparative Fit Index
EFA	Exploratory Factor Analysis
EPC	Expected Parameter Change
ESP	Electronic Stability Program
GFI	Goodness-of-Fit Index
IFI	Incremental Fit Index
ITTC	Item-to-Total-Correlation
MANOVA	Multivariate Analysis of Variance
MRA	Multiple Regression Analysis
NNFI	Non-Normed Fit Index
PBC	Perceived Behavioural Control
PEU	Perceived Ease of Use
PLUM	Polytomous Logit Universal Models
PPS	Pedestrian Protection Systems
PU	Perceived Usefulness
RFI	Relative Fit Model
RMSEA	Root Mean Squared Error of Approximation
SEM	Structural Equation Modelling
SPSS	Statistical Package for the Social Sciences
TAM	Technology Acceptance Model
TPB	Theory of Planned Behaviour
TRA	Theory of Reasoned Action
UTAUT	United Theory of Acceptance and Use of Technology
VIF	Variance Inflation Factor

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Chapter 1: Introduction

1.1 Chapter Objectives

The main purpose of this first chapter is to provide a comprehensive introduction to the research topic and the objectives of the present thesis. The chapter starts with an explanation of the research context, the acceptance of Advanced Driver-Assistance Systems. Next, the research aims and objectives are outlined and initial hypotheses are proposed, serving as a starting point and justification for the research. Thereafter the relevant stakeholders, involved in or affected by this research, will be highlighted. Finally, the chapter will end with a brief explanation of the thesis structure

1.2 Research Introduction

Innovative driver-assistance systems have the potential to change the way of personal transportation by increasing safety and efficiency. To some extent, they already have accomplished this. Today most cars are equipped with ABS (anti-lock brake system) and ESP (Electronic Stability Program), which can be considered as early driver-assistance systems. More complex innovations like distance, lane or parking assistance, which are commonly called Advanced Driver Assistance Systems (ADAS), have not yet reached market acceptance despite their technical maturity and proven usefulness.

In 2010, the car industry spent approximately € 48 billion on Research & Development of innovative technologies, which is an increase of more than 15 percent compared to the previous year (Bratzel and Tellermann, 2011, p.113). Many innovations, however, do not meet customer needs and are thus abandoned before they reach the market (Story, O'Malley and Hart, 2011, p.952). The main barriers towards market penetration are no longer only technology-based but rather based on the lack of acceptance of potential customers. End-users are increasingly overwhelmed by the rapid proliferation of technological advancements and thus are more likely to be resistant to change (MacVaugh and Schiavone, 2010, p.198; Nabih, Bloetn and Poiesz, 1997, p.47). From an objective point of view, the decision as to whether or not to adopt an innovation should depend mainly on its usefulness compared to the technology it is substituting. However, customers are not always rational, objective and utility-maximising: instead, they tend to base their decisions on other more subjective

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beliefs about the technology in question (MacVaugh and Schiavone, 2010, p.199). Different areas of technological development have shown that reasonable innovations do fail in the market or take longer than expected to reach acceptance despite their proven usefulness (Rogers, 2003, pp.1–10). Thus, learning about the reasons and root causes of beliefs that lead towards the acceptance of innovations by potential end-users is a necessary prerequisite for developing new technologies, as in the case of driver-assistance systems.

1.3 Research Aims and Objectives

The overall aim of this study is to explain the individual psychological factors that lead to either acceptance or resistance of Advanced Driver-Assistance Systems (ADAS) on the German market and thus help the industry to market this new technology.

In particular, the research objectives are formulated as follows:

1) Identification of psychological factors that explain the individual acceptance or resistance decision towards ADAS

2) Development of a predictive model towards the acceptance of ADAS that permits organisations to successfully market this technology.

1.4 Initial Hypotheses

The fact that Advanced Driver-Assistance Systems are rejected by many individuals despite their proven usefulness in increasing road safety has led the author to develop three initial hypotheses about the potential causal relationships behind this apparent paradox. Based on more than five years' working experience in the automotive industry, the author has recognised a set of characteristics that might have an effect on the acceptance of ADAS technology in the given research context.

First, driving an automobile creates a primary benefit for an individual in the form of transportation, but might also create secondary benefits in the form of thrill, sensory stimulation or exertion of power. The author has recognised that ADAS technology is perceived as potentially reducing these ancillary driving benefits through an increased rate of automation. Thus, initial hypothesis 1 follows:

H_{i1}: The more ADAS is perceived as reducing ancillary driving benefits, such as thrill, sensory stimulation or exertion of power, the less individuals will intend to use this technology.

Second, the author has recognised that the perceived usefulness of ADAS technology is largely dependent on the estimated likelihood of making a hazardous driver error. Individuals with strong confidence in their own driving skills tend to place a lower value on the potential safety benefits of ADAS technology. Thus, initial hypothesis 2 follows:
H_{i2}: The greater the confidence in their own driving skills, the less individuals will intend to use this technology.

Finally, the author noticed strong concerns about the reliability of Advanced Driver-Assistance Systems in daily usage. In particular, the fear of malfunctions, leading to hazardous driving situations, might create an additional reason for resistance towards this technology. Thus, initial hypothesis 3 follows:
H_{i3}: The greater the concerns about potential malfunctions of ADAS technology, the less individuals will intend to use this technology.

These hypotheses can be regarded as initial, or working, hypotheses in the sense that they are not based on primary or secondary research, but only on experience and logical reasoning. In the following, these hypotheses will subsequently be supplemented, modified and tested based on the results of the literature review and primary research.

1.5 Research Questions and Gaps in Knowledge

In order to address the defined research objectives, the author reviewed a range of secondary literature to consider the existing state of knowledge and to identify potential gaps for which primary research will be conducted. This analysis revealed that there is no existing empirical study on the psychological factors which determine the consumer acceptance of Advanced Driver-Assistance Systems. Based on this gap of knowledge, this research should provide sufficient evidence to answer the main research questions, namely which psychological factors influence consumer acceptance of ADAS and which factor contributes most or least to the acceptance decision. Table 1 provides an overview of the research questions and the associated gaps in knowledge. Next to this, the intended research strategies as well as the potential data sources are listed in each row.

Table 1: Research questions and gaps in knowledge

Research Question		Gaps in Knowledge	Research Strategy	Data Sources
1	Which factors influence the acceptance of ADAS?	Factors influencing acceptance behaviour in the case of ADAS	Literature Review, Qualitative research, Chapter 3&5	Books and articles, interviews with car drivers at the point of sale
2	How can these factors be arranged in a model, explaining the acceptance behaviour of customers towards ADAS?	A predictive model towards the acceptance of ADAS technology	Quantitative research, regression model, group difference tests, Chapter 6	Data from the representative survey on the German market

The research questions outlined in the above table provide the basic guideline for developing the research methods of the present thesis. In the next step, the context and subject of the research will be defined in more detail and will be justified based on the research objectives.

1.6 Rationale for Industry and Location Focus

The focus of this research is the automobile industry and within this industry the Advanced Driver-Assistance Systems (ADAS), increasingly offered as optional equipment in modern cars. This research context was chosen for two reasons. First, the automotive industry is, in general, an innovation-driven industry in which competitiveness is heavily determined by innovativeness and continuous improvement. Accordingly, automobile companies have invested billions into research and development of innovations like driver-assistance systems with the belief that these systems will reach market maturity soon (OECD, 2008). Yet, many of these companies now face the classical dilemma that their innovations, despite technical maturity and proven usefulness, are not accepted by the potential customers. This situation yields a promising field for the application of innovation acceptance research.

Second, from the theoretical perspective of innovation acceptance research, the context of ADAS combines some very unique aspects:

(1) ADAS are part of a highly emotional product, the automobile.
(2) ADAS are aimed at regulating the driving task, which is known to have a special role in the self-identity of consumers
(3) ADAS represent, at least in part, a preventive investment, which, like insurance or contraceptives, do not posses a direct short-term benefit for the customer.

For this reasons, the beliefs towards the acceptance of ADAS are expected to differ substantially from other cases of consumer goods. Consequently, this unique context offers promising insights into the field of innovation acceptance from a new perspective.

Germany is chosen as the location of interest for the present research. This decision is due to several purposes. Since the author works for a German car manufacturer, the focus on the German market increases the possibility of gaining access to potential car customers that serve as objects of study in the present research. This choice also provides further advantages. With 67 percent of the German population owning a car and an above-average percentage of luxury cars on the roads, Germany clearly offers a great opportunity for reaching an acceptable sample size (European Commision – Eurobarometer, 2006, p.6).

It has to be acknowledged that there are some important limitations regarding the selected research context. First, the very uniqueness of the ADAS technology discussed above may limit the applicability of the findings to other innovations. Second, the novelty of this innovation to the customers may raise problems, since people who are not aware of a new technology are not likely to develop beliefs towards it. Thus, it might not be possible to elicit readily accessible beliefs towards this new technology in the chosen sample (Keeling, 1999, p.167). Finally, the focus on German automobile customers may limit the generality of the findings, since multiple authors have reported a significant effect of cultural differences on the acceptance of innovations (see Bagozzi, 2007, p.247; Zakour, 2004, p.156; Fishbein and Ajzen, 2010, p.224). This geographical limitation, however, can be by partly resolved by discussing the findings from a cross-cultural perspective, which will be part of the last Chapter of this thesis. Consequently, while the research context is limited to the German market, the results of this study will also benefit the global industry and international governmental institutions.

1.7 Stakeholder Analysis

It is important to acknowledge the different stakeholder groups who are interested in the results of the present research and to specify what interests these groups have in relation to the research objectives. In sum, the author identified three groups of stakeholder: the Academic Community, the Industry and the Government.

Interests of the Academic Community

From a theoretical point of view this piece of research is aimed at advancing the scientific model for innovation acceptance. Based on Fishbein's and Ajzen's (2010) Theory of Planned Behaviour (TPB), this study develops a conceptual framework in the context of ADAS usage. While the TPB model only delivers a broad framework, further research is necessary to develop an understanding of the underlying sets of salient beliefs that eventually initiate the behaviour of individuals in a given context (Sattabusaya, 2008, p.51). Currently only a minority of innovation acceptance studies have considered salient beliefs as origins of intention. Ajzen and Fishbein (2010, p.206) remarked that "of the multitude of studies conducted in the context of our theory, only a minority have assessed beliefs; most rely on direct measures of the three major components to predict intentions and behaviour". Moreover, relatively few studies so far have looked at background variables (such as gender, age or socioeconomic status) in relation to the behaviour-relevant beliefs (Elliott and FU, 2008, p.50; Fishbein and Ajzen, 2010, p.252; Venkatesh et al., 2003, p.469). By studying the interrelation of background factors, the origins of salient beliefs that serve as the cognitive foundation for a behaviour of interest can be identified (Fishbein and Ajzen, 2010, p.253). Previous studies that have considered underlying beliefs have shown that these sets of beliefs vary significantly, depending on the very context of the behaviour in question. Therefore "future researchers should continue to test the validity of the TPB model to understand the complex interplay among attitudes, norms and identity processes in the different consumer contexts" (Smith et al., 2008, p.329).

Consequently, applying research in the framework of the TPB model to the context of ADAS not only promises insights in the respective field of study but might also help to advance the understanding of the behavioural model itself.

Most innovation acceptance studies of recent years have focused on health issues, like the use of contraceptives. The few studies that focused on consumer technology acceptance mainly investigated IT innovations, such as mobile commerce and electronic banking. Very few researchers have yet studied the motivation to adopt highly emotional innovations, such as cars or laptop computers, which are expected to have a very different set of modal beliefs (Rogers, 2003, p.116). From the perspective of the academic community, the context of ADAS combines some very unique aspects that could alter the belief sets included in behavioural acceptance models significantly.

Interests of the Industry

Despite their obvious importance and their economic implications for the automobile industry, Advanced Driver-Assistance Systems have so far not reached the focus of commercial research. Only a few studies have been published so far in the context of ADAS, mainly focussing on absolute user intention and demographic variables. From the perspective of the industry, this research will provide a scientific approach to the practical question of why product innovations take longer than expected to be accepted by the market. Especially for the automobile industry, investing billions each year into the development of product innovations like driver-assistance systems, profound knowledge of customer behaviour in terms of innovation acceptance is essential for effective product development as well as for an effective adjustment of the marketing-mix (Bratzel and Tellermann, 2011, p.113). The overall interest of the industry in research on the acceptance of ADAS technology is therefore twofold. First, a predictive model, taking into account background variables such as age and gender, will help the industry to adjust the marketing strategy in order to address potential reasons for customer rejection. Second, the knowledge of which factors have the strongest influence on consumer acceptance in the case of ADAS technology will help the industry to develop this technology further in order to better meet customer needs.

Interests of the Governmental Institutions

Generally, most governments follow the aim to increase road safety, which is often accompanied by initiatives to foster safety technology development and market penetration. In order to foster the market spread of ADAS technology, for instance, the European Commission has initiated the *eSafety* project, which is aimed at "accelerating the development, deployment and use of so-called 'intelligent integrated safety systems'" (Kosch et al., 2012, p.358). Based on this project, national level campaigns are initiated in order to increase awareness and acceptance of ADAS technology by end-users. The German branch of this campaign, which is called *Bester Beifahrer* ("best co-driver"), acts as a local level change agent and informs car customers about the potential benefits of modern driving-assistance systems. Similar initiatives can be found in many countries. Whether or not these initiatives will be successful in increasing the market share of ADAS is not yet known.

It is obvious that a profound understanding of the reasons and root causes for the acceptance of driver-assistance systems will help governmental institutions to develop more efficient and effective legislative action towards their ultimate goal to increase road safety. Consequently, governmental institutions are an important stakeholder in the present research project.

Summary

Table 2 gives an overview of the results of the stakeholder analysis of the present research.

Table 2: Stakeholder analysis

Stakeholder	**Interest**
Academic Community	Advancement of behaviour model for innovation acceptance
Industry	Understanding the decisive factors which explain consumer acceptance or non-acceptance of ADAS technology, helping to better market this technology
Governmental Institutions	Understanding critical success factors for the acceptance of ADAS as a safety technology, helping legislation to foster the development towards safer road traffic

1.8 Thesis Structure

So far the research objectives, initial hypotheses and the research questions, together with identified gaps in knowledge, have been provided. This information outlines the main academic and personal influences that formed the basis of this research as well as the justification for undertaking this research.

The structure and content of this thesis begins with **Chapter 2**, which provides the key concepts about Advanced Driver-Assistance Systems. A basic understanding of the main functionalities and technological concepts is a prerequisite for understanding which advantages, but also which disadvantages or risks are related to this technology. The chapter is completed by outlining the current market situation for this technology in Europe as well as the legislative situation.

Chapter 3 outlines the key foundations, definitions and important terms related to innovation acceptance. The key concepts and models for innovation acceptance by relevant authors in the field are described in detail, but also evaluated critically. These psychological constructs form the underpinning theory and concepts upon which the rest of the research is based. By reviewing past empirical work, the author will derive potential acceptance constructs in different fields and will discuss their applicability in the case of ADAS.

Chapter 4 considers philosophical approaches, methodological choices and the most appropriate research design. The post-positivistic research philosophy as well as the triangulation of methods, combining qualitative and quantitative methodology, is justified.

Chapter 5 provides information about how qualitative research should be conducted in general and how in particular the interviews for the present research were designed and administered. The qualitative data analysis of the full interview transcripts is outlined in detail and the final findings are presented using a concept mapping approach.

Chapter 6 outlines the general concept of quantitative research and explains how the questionnaire is developed from the combined results of the qualitative phase and the literature review. The operationalisation of question items, as well as the decision on the appropriate sample size and sampling method, is presented in detail. Descriptive statistics of the survey results are provided, along with tests of representativeness and normality. A correlation analysis is employed to test for potential associations between variables. Next, the question items are tested for group differences in order to identify significant differences based on background variables, such as age or gender. Finally, a regression model is fitted to the data, which forms the basis of the final conceptual model described in the last chapter.

Chapter 7 provides a discussion of the findings and introduces the final conceptual model. Recommendations for each stakeholder group are proposed based on the key findings. Finally the contributions to knowledge are illustrated in detail.

1.9 Chapter Conclusion

This chapter has provided an introduction to the research topic and a description of the research aims and objectives. Together with the rationale and justification of the research objectives, this chapter has laid out the foundation for the entire thesis. The chapter concluded with a stakeholder analysis and a brief description of the thesis structure.

Chapter 2: Background

2.1 Chapter Objectives

In this chapter, the technological context of the present research, namely Advanced Driver-Assistance Systems, will be described in more detail. Since this thesis will not focus on the technological aspects of ADAS, only a brief introduction on available systems and functionalities will be given. Potential advantages of ADAS will be discussed in more detail, together with potential risks of employing this technology. Next, an overview of the current market situation for driver-assistance systems in Europe is provided which shows the current state of diffusion of this technology. Finally, the chapter will close with a brief insight into the German car industry, explaining the relative importance of ADAS technology for this industry sector.

2.2 ADAS Technology

What is now called ADAS (Advanced Driver-Assistance Systems) can be considered as the collection of systems and subsystems on the way to fully autonomous driving. Industry experts agree that the rapid development of recent years will inevitably lead towards "intelligent" cars, detecting dangerous situations and acting autonomously to avoid accidents (European Commission for Information Society and Media, 2007). Already available ADAS concepts include among others Adaptive Cruise Control, Blind Spot Monitoring, Lane Departure Warning and Lane Change Assistance (Brookhuis, de Waard and Janssen, 2001, p.247). The basic aim of these assistance systems is "to help prevent driver errors, give warnings and provide support in performance of driving tasks" (Smith et al., 2008, p.341). Statistically, more than ninety percent of all road accidents are caused by human error, while an examination of accidents' most prevailing factors shows, perhaps not surprisingly, that the two most common reasons for accidents are loss of control over the vehicle and failing to avoid a vehicle (vehicle collision) (Bekiaris and Stevens, 2005, p.283; Brookhuis, de Waard and Janssen, 2001, p.245). Next to increased safety, most of these systems also offer a comfort benefit for the driver by taking over driving tasks and thereby reducing the driving strain. Traditionally, Advanced Driver-Assistance Systems are often categorized into safety systems, aimed at preventing accidents, and comfort systems, aimed at reducing the driving strain. This categori-

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sation is, however, rather artificial since most systems on the market provide both effects to some extent (Happe and Lütz, 2008, p.18). From a technical point of view, systems associated with ADAS can generally be allocated to three major categories: Longitudinal Support Systems, Lateral Support Systems and Assessment of Driver Vigilance System. Chart 1 provides a closer look at these categories and the major systems currently available in the respective categories.

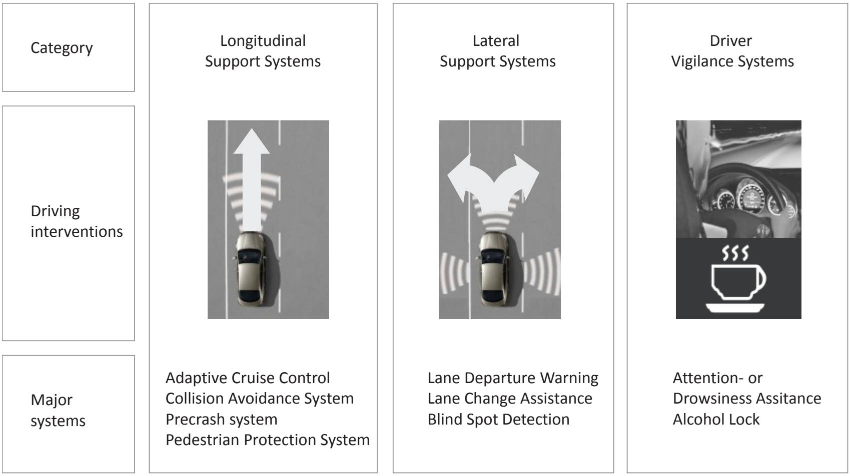

Chart 1: Overview of Advanced Driver-Assistance Systems, Source: Own drawing based on Papadakis (2007, pp.15–16)

Longitudinal support systems were the first available Advanced Driver-Assistance Systems on the market. As early as 1995, Mitsubishi introduced the Preview Distance Control, which can be considered the first Adaptive Cruise Control System (Mitsubishi Motors, 2008, p.1). Other car makers followed soon, making Adaptive Cruise Control (ACC) the most widespread available ADAS on the market today. ACC can be seen as an extension of conventional cruise control systems. In contrast to conventional cruise control systems, ACC, however, not only maintains the driver-set vehicle speed, but also adjusts the vehicle's speed to that of a preceding vehicle, thus keeping the exact distance to the car in front (Bekiaris, 2011, p.60).

Collision Avoidance Systems (CAS) use a similar technology to that applied by ACC in order to monitor the roadway in front of a vehicle and warn the driver when a potential collision risk to an object ahead of the vehicle exists. Active Collision Avoidance Systems additionally initiate an emergency breaking process if a collision is judged as unavoidable (Krems, Risser and Barnard, 2011, p.16). A further extension of the forward road monitoring technology is the protection of so called *vulnerable road users*. Usually, these systems are aimed at protecting pedestrians from being involved in a car collision. Unlike the radar based ACC and CAS systems, Pedestrian Protection Systems (PPS) generally need a forward looking camera to identify potential vulnerable subjects in the vehicles pathway (Bekiaris, 2011, p.76).

Lateral support systems made their way into the car market considerably later than longitudinal systems, with the first lane-keeping support offered by Nissan in 2001 (Society of Automotive Engineers of Japan, 2011, p.1). Lane-keeping and warning systems are aimed to support the driver's lane keeping task. When a significant deviation from the expected vehicle trajectory is detected, these systems either warn the driver or steer the vehicle automatically back into the lane (Krems, Risser and Barnard, 2011, p.12). Other lateral support systems are designed to support the driver's abilities to change lanes. Blind Spot Monitoring Systems and Lane Change Assistance use various technologies to detect vehicles and objects in adjacent lanes, such as a fast approaching and potentially overtaking vehicle in the next lane. These systems either warn the driver that an intended lane change is unsafe or actively prevent the vehicle from changing lanes (Bekiaris, 2011, p.54).

Driver vigilance monitoring, finally, is aimed at detecting situations in which the driver's alertness is diminished, as a consequence of stress, fatigue or alcohol abuse. Most of the currently available systems in this field, such as the drowsiness alert offered by Mercedes-Benz, use already available information by several sensors (steering wheel positions, maintained speed, overall driving time, day time or daylight) in order to detect the driver's alertness. When a complex algorithm detects driver impairment, an alarm is given (Krems, Risser and Barnard, 2011, p.19). In order to detect alcohol abuse, Volvo was first to introduce a breathalyzer-based system which is connected to the vehicle's ignition. The system is aimed at preventing drunk drivers to start their vehicle when a critical alcohol level is exceeded (The American Beverage Institute, 2011, p.3).

2.3 Advantages of ADAS Technology

Providing support in critical driving situations, ADAS technology promises a significant decrease in road accidents. Due to the marginal market share of ADAS today, its potential future impacts can only be estimated. A study funded by the European Commission recently reported that the three percent of vehicles currently equipped with Longitudinal Support Systems prevent up to 4,000 accidents each year, while the 0.6% of cars equipped with Lateral Support Systems prevent about 1,500 accidents a year (European Commission for Information Society and Media, 2007, p.6).
German traffic researcher Johann Gwehenberger (2010, p.1) predicts that given a 100% equipment rate of ADAS in Europe, more than half of all serious accidents could be prevented. Considering that every year more than 40,000 lives are lost in European traffic, creating a direct and indirect economic loss of 180 billion EUR (Evgueni Pogorelov, 2007), it is not particularly surprising that the EU strongly supports the diffusion of ADAS technology. Next to the prevailing safety benefits and the increase in driving comfort, these systems could also provide cleaner and more efficient transport in the near future. Currently, researchers integrate the existing systems with online information and GPS signals, thus being able to judge the most efficient driving route and driving speed. Such systems could, for instance, identify a red traffic sign well before the driver is able to see it and reduce speed accordingly. Thinking this idea further, traffic signs might one day no longer be necessary, eliminating delays and waste of resources (European Commission for Information Society and Media, 2007, p.6).

2.4 Risks Associated with ADAS Technology

Even though there is clear evidence that ADAS technology provides major social and economic benefits, it must be acknowledged that these systems also entail some risks (European Commission for Information Society and Media, 2007, p.4).

ADAS can fail and, in general, there are two types of fault: random and systematic. Examples of random faults include communications interference and unexpected component failures, while systematic faults are related to software failures or overall failures in the design of the system (Bekiaris and Stevens, 2005, p.283). Moreover, it has been discovered that, whilst driver assistance

systems are aimed at reducing driving strain, they can also create stress by requiring performance of new tasks, for example, programming the navigation system or learning how to use the Adaptive Cruise Control (Smith et al., 2008, p.341). This touches another critical aspect regarding the ADAS technology: The lack of user-knowledge. Drivers usually receive little or no training about how to use a new system compared with, for example, personnel within a company. In most cases the maximum training consists of a user manual, which is often completely ignored (Bekiaris and Stevens, 2005, p.284). While the cognitive expenses necessary to learn how to operate the new systems are usually significant, the lack of training increases the risks of faulty operation, which might lead to ineffectiveness or even to serious traffic incidents.
Moreover, several studies have found evidence that excessive reliance on automated systems such as ADAS could deteriorate the driving performance. One important argument for supporting this claim is that while more and more normal driving operations are performed automatically, abnormal conditions have to be dealt with manually. Unfortunately, as a result of automation, experiences with these situations are limited and thus reactions could be sub-optimal. Increasing automation also has the effect that driver attention is shifted away from the driving task to a monitoring task. In general, studies have shown that prolonged periods of passive monitoring induce high levels of workload, despite the fact that information-processing requirements for these tasks are rather low in themselves. This shift also increases the danger of complacency, which is known to have a negative effect on alertness and reaction time (Brookhuis, de Waard and Janssen, 2001, pp.247–251; Papadakis, 2007, pp.21–22).

Shifting responsibility from humans to machines also raises ethical and legal implications. The question of technology paternalism in modern traffic was discussed as early as 1968 within the Vienna Convention on Road Traffic. In chapter
II, Article 13, the protocol expressly states that: *Every driver of a vehicle shall in all circumstances have his vehicle under control so as to be at all times in a position to perform all manoeuvres required of him* (United Nations Conference on Road Traffic, 1968, p.15). Whether or not future driver-assistance systems directed at partly autonomous driving are in compliance with this regulation is widely discussed by industry experts (ADAC, 2010, p.1; Berz, 2002, p.3; Etzold, 2002, p.1).The general notion, however, is that as long as the responsi-

bility is not completely shifted to the system and as long as the driver has the continuing ability to shut down or override the driving manoeuvre, driver assistance systems are in full accordance with this convention.

In sum, it has to be acknowledged that there are serious risks involved in ADAS technology. Even though most scientific studies in the field report that the advantages of ADAS far outweigh the disadvantages, there is still some uncertainty involved. This insight is a necessary condition for avoiding an uncritical "pro-innovation bias". According to Rogers (2003, p.106) "the pro-innovations-bias is the implication in diffusion research that an innovation should be diffused and adopted by all members of a social system, that it should be diffused more rapidly, and that the innovation should be neither reinvented nor rejected." Consequently, it is important to be aware that for many individuals, it might be perfectly reasonable not to adopt ADAS.

2.5 Market Situation of ADAS in Europe

In the next step, the current level of ADAS market penetration will be discussed with a focus on the relevant target group of the present study, the German automobile market. Despite their potential, most intelligent driver-assistance systems have not yet reached the market – neither in Germany nor elsewhere.
A recent study of the German Road Safety Council (DVR) revealed that only between 12 and 35 percent of car drivers in Germany are aware of certain Advanced Driver-Assistance Systems. In terms of equipment rates, however, the result is even more worrying. Only between 1 and 3 percent of cars are currently equipped with any of these innovations (German Road Safety Council e.V., 2010, p.1). Chart 2 gives an overview of the results from this study.

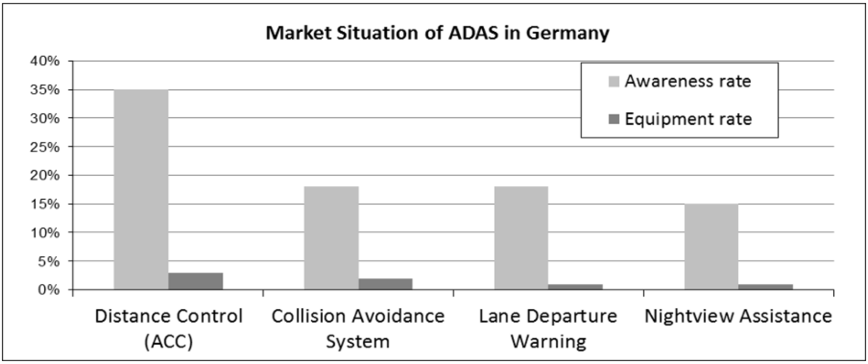

Chart 2: Market situation of ADAS in Germany, Source: Own drawing based on German Road Safety Council e.V. (DVR) (2010)

Equipment rates for other European countries are not available to date, but are expected to be on the same level or below. Due to the absence of definite numbers, the European Commission Working Group for the Implementation of ADAS estimated the penetration rates of ADAS innovations in Europe in a recent publication to be below 5 percent (European Union eSafety Forum, 2010, p.19). The study, however, remarked that penetration rates vary markedly between car categories. Safety innovations tend to start from the top end of the market, in luxury cars, and take a long time to 'trickle down' to the mass market. Currently most of these innovative systems are only available in the top-end luxury automobiles, which is a major barrier to further market penetration (European Commission for Information Society and Media, 2007, p.6). This development is comparable to the introduction of ABS and ESP technology, which were initially also restricted to luxury class vehicles. In terms of increasing acceptance rates, however, the comparison to the early assistance systems, ABS and ESP, shows a significant difference. While ABS and ESP have achieved s-shaped acceptance rates towards full acceptance (as predicted by current diffusion literature: see Rogers, 2003), ADAS still lacks the initial breakthrough that marks the start point of the increasing adoption curve (see Chart 3).

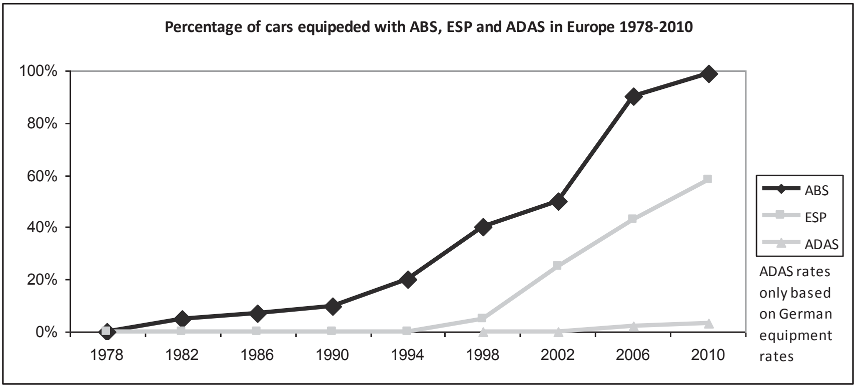

Chart 3: Equipment rates of ABS, ESP and ADAS, Source: German Road Safety Council e.V. (2005); Gottschalk and Kalmbach (2008); Happe and Lütz (2009); Kraus and Stephan (2010)

From the current perspective, it is thus questionable whether or not the Advanced Driving Assistance Systems will have the same market success as their preceding car innovation systems, ABS and ESP. According to Rogers (2003), perfect s-shaped acceptance rates that lead towards full acceptance (as in the case of ABS and ESP) are rather rare, and especially in the field of high-tech innovations, many innovations never actually gain any relevant market share. It is worth noticing that ABS became mandatory in Europe by 2004, while ESP will be mandatory from 2012 onwards (European Commission, 2007). Legislation thus stepped in when the adoption curve was already approaching full adoption in the European market. The question of whether or not Advanced Driver-Assistance Systems will one day be mandatory in Europe thus largely depends on how the adoption curve for ADAS will develop in future. Legislation can foster the development of technological diffusion but it cannot prescribe a certain development on its own. If ADAS is not accepted by the market, it is rather unlikely that legislation will be able to oblige its population to use this technology. The European Commission Working Group for the Implementation of Safety Systems in Cars developed two different scenarios for the future development of ADAS: First, the *Business as Usual Scenario*, with unchanged conditions, and second, the *Implementation Support Scenario*, which presumes legislative action in the form of financial or fiscal incentives and additional national support programs to increase the public awareness of ADAS. Table 3 shows the expected market development figures of both scenarios.

Table 3: ADAS market development scenarios, Source: European Union eSafety Forum, 2010, p.19

Business as Usual Scenario	**% new cars equipped**		
	2010	**2015**	**2020**
Obstacle & collision warning	< 5%	5% - 20%	20% - 50%
Emergency braking	< 5%	5% - 20%	20% - 50%
Blind spot monitoring	< 5%	5% - 20%	5% - 20%
Adaptive headlights	5% - 20%	20% - 50%	20% - 50%
Lane departure warning	< 5%	5% - 20%	20% - 50%
Implementation Support Scenario	**% new cars equipped**		
	2010	**2015**	**2020**
Obstacle & collision warning	< 5%	20% - 50%	50% - 80%
Emergency braking	< 5%	20% - 50%	50% - 80%
Blind spot monitoring	< 5%	5% - 20%	20% - 50%
Adaptive headlights	5% - 20%	20% - 50%	50% - 80%
Lane departure warning	< 5%	20% - 50%	80% - 100%

In conclusion, the current market for ADAS technology is still at a very early phase with a supply that is limited to a small model range (mainly luxury cars), a significant lack of customer awareness and a marginal market spread. Whether the rather optimistic market scenarios of the European Commission working group will come into reality will mainly depend on the acceptance of this technology by end-users in the respective markets.

2.6 The Importance of ADAS for the German Automobile Industry

This final part of the background chapter will focus on the special role of product innovations in the German car industry and will explain why driver-assistance technologies are of particular relevance to this industry sector. In the first step, an overview of the German automobile industry will be provided by identifying the key players and their current position on the world automobile market.

The German Automobile Industry

In terms of domestic car production Germany ranks third in the world, following the United States and China, with a total annual car production of almost six million cars. More than twice this number, almost 13 million cars are produced by German automobile companies worldwide (VDA, 2012). This makes the automotive industry the largest industry sector in Germany and with more than 700.000 direct employees one of the country's biggest employers (Germany Trade and Invest, 2010, p.3). Chart 4 shows the domestic production of the world's biggest car producing countries.

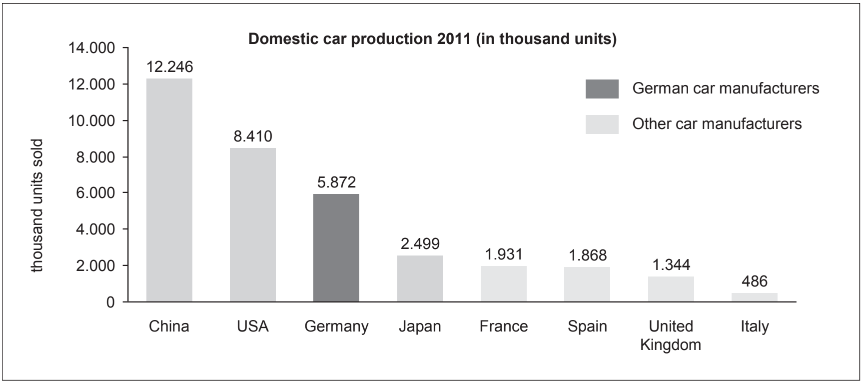

Chart 4: Domestic car production 2011, Source: VDA (2012)

Generally, Germany is renowned for its production of top-range luxury vehicles, but looking at the domestic car production reveals that, in terms of car categories produced, luxury cars represent less than five percent of the overall production volume. Most cars of the domestic production are in the medium and compact segment, with a considerable volume of off-road and upper medium vehicles. Chart 5 shows the segmentation of the German car production by car category.

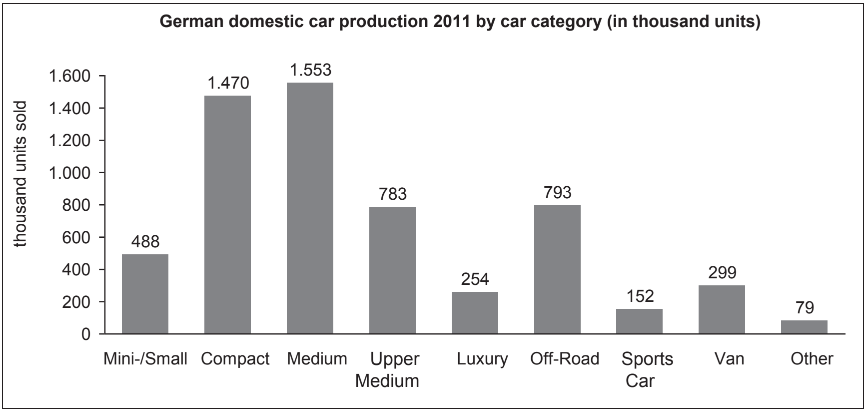

Chart 5: German domestic car production by car category, Source: VDA (2012)

As a result of an increasing market consolidation over the last decades, only three major German car manufacturers remained as independent corporations:

- Volkswagen (compromising the brands VW, Audi, Seat, Skoda, Bentley, Bugatti, Lamborghini and recently Porsche)
- Daimler (compromising the brands Mercedes-Benz and Smart)
- BMW (compromising the brands BMW, Mini and Rolls Royce).

It should be noted that the brand Opel/ Vauxhall, even though generally regarded as a German car brand, is actually part of the General Motors (GM) group and is consequently not considered as a German car manufacturer. In terms of production volume only Volkswagen ranks among the world's largest car manufacturers. Daimler and BMW have a considerably lower overall production volume, mainly due to their specific focus on premium brands (Center of Automotive Management, 2012b, p.22). Chart 6 shows the number of automobiles sold worldwide per car manufacturer in 2011.

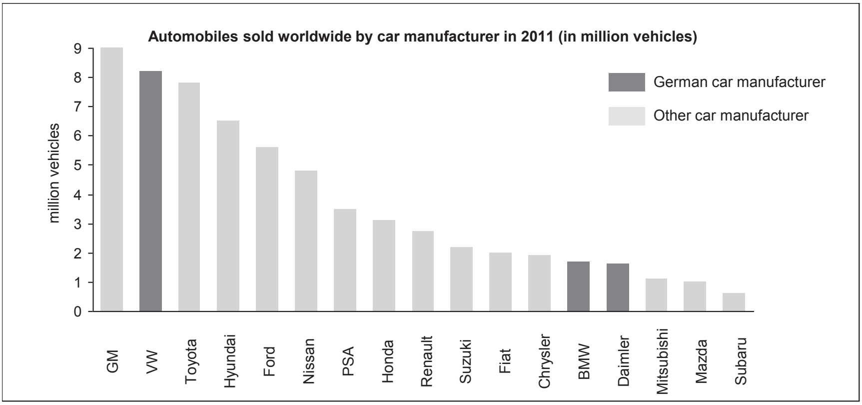

Chart 6: Automobiles sold per manufacturer, Source: Center of Automotive Management (2012b, p.22)

The Role of Innovations in the German Automobile Industry

Germany's automotive sector is the country's most innovative industry sector and accounts for more than one third of the total R&D expenditures within the German industry (Germany Trade and Invest, 2010, p.3). As a result of this, German car manufacturers also rank relatively high in the worldwide comparison of R&D spending per car manufacturer. Regarding individual companies, VW has had the highest R&D spending among all car makers with a total expenditure in excess of seven billion Euros in 2011. Daimler and BMW also invest heavily into the development of new technologies with an R&D spending of about four billion Euros each in 2011. When considering the relatively low rank in overall production volume of these two companies (see Chart 6), these figures are even more striking (Center of Automotive Management 2012b, pp.47). Chart 7 shows the Research & Development spending per car manufacturer in the year 2011.

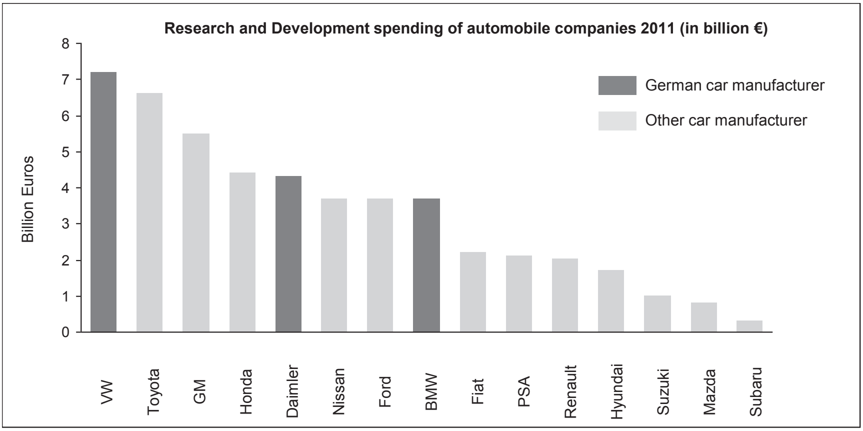

Chart 7: R&D spending per car manufacturer in 2011, Source: Center of Automotive Management (2012b, pp.47)

In the next step, the innovation output of car companies will be compared in order to determine whether the high R&D spending of German car manufacturers also translate into tangible product innovations. In an attempt to compare the innovation output of the worldwide car manufacturers a recent study determined the number of innovations presented within the year 2011 per car manufacturer. In this study innovations were defined as any publicly presented development in cars which provides a customer benefit and is perceived as new by the public (Center of Automotive Management, 2012a). While it certainly has to be acknowledged that a simple counting of innovations neglects the relative importance of innovations, this study nevertheless provided an interesting insight. The analysis revealed that, measured by innovation output, all three German car makers rank among the top five of car manufacturers worldwide. Consequently, the heavy investments of German car companies in R&D transfers directly into a comparably high innovation output, as measured by tangible product innovations. Chart 8 shows the number of innovations presented per car manufacturer in 2011.

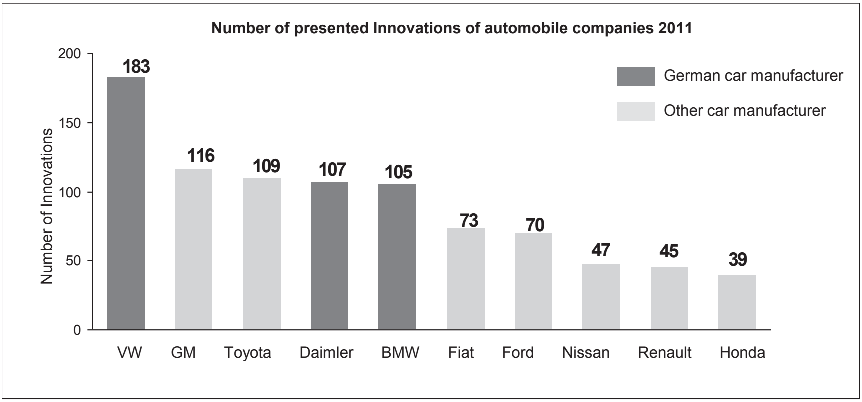

Chart 8: Number of innovations presented per car manufacturer in 2011, Source: Center of Automotive Management (2012a, p.91)

Finally, the focus of the innovation output analysis will be further narrowed down by looking only at innovations in the field of driver-assistance systems. This analysis reveals that, in terms of driver-assistance innovations, the three German car makers rank highest among all car manufacturers worldwide. Chart 9 shows the number of innovations in the field of driver-assistance systems, which were presented by car manufacturers in 2011.

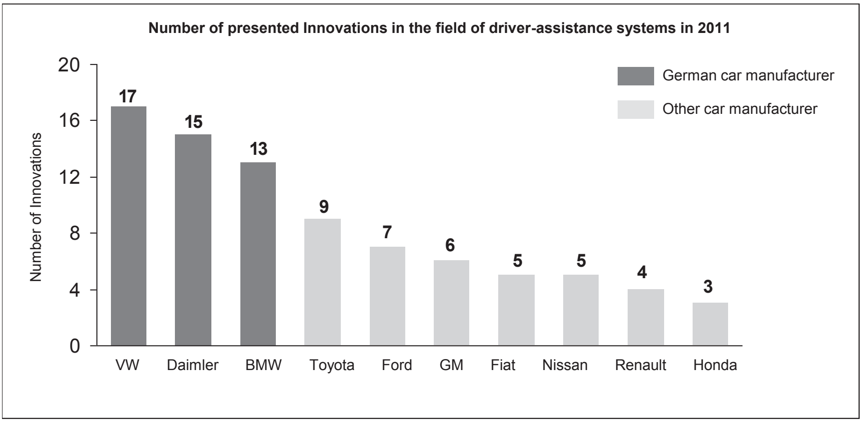

Chart 9: Number of driver-assistance innovations presented per car manufacturer in 2011, Source: Center of Automotive Management (2012a, p.50)

Conclusion

In sum, this industry sector analysis demonstrated the importance of the German automobile industry for the domestic economic welfare and its relatively strong position in terms of the worldwide car production. With more than 15 billion Euros in R&D expenditures, the three major German car manufacturers account for a large proportion of the worldwide research in the field of automotive technologies. These investments have enabled the German car makers to present 395 product innovations in the year 2011 alone, more than any other country's industry sector. While other car makers score higher on production volume, the German car makers capitalise strongly on their innovativeness to position their products in the premium segment. Especially in the field of safety and comfort innovations, such as driver-assistance systems, the German car makers have presented more product innovations than any other country's car producers.

2.7 Chapter Conclusion

The present chapter has provided an overview of currently available driver-assistance systems and has critically discussed the potential benefits and potential risks associated with this technology. In sum, the discussion showed that the benefits clearly outweigh the risks, at least from an objective point of view. On an individual level, the decision can, however, be substantially different. An analysis of the current market situation of ADAS showed that Advanced Driver-Assistance Systems are currently still niche products with low customer awareness and marginal market penetration rates. The chapter ended with an overview of the German car industry, which invests more into the development of driver-assistance technology than any other country's industry sector.

Chapter 3: Literature Review

3.1 Chapter Objectives

This chapter is aimed at providing a framework and a rationale for the collection of empirical data and for relating the empirical results to previous findings in the field of innovation acceptance. Most importantly, this chapter should:

- provide an overview of the key theories in the field,
- discover the important variables relevant to the topic,
- synthesize different results and develop a new perspective,
- identify relationships between ideas and practices, and
- provide an understanding of the structure of the subject.

As explained in the previous chapter, this research aims to provide a contribution to knowledge. Without establishing the state of previous research, however, it is impossible to demonstrate how the present research advances the knowledge in the field. Thus, this literature review is also aimed at locating the present research into the context of current advancements in innovation acceptance literature.

3.2 Literature Review Design

Conducting a literature review is a means of gaining insight into a particular field of study, including theories, main contributors, key variables, methods and history (Randolph, 2009, p.2). According to Fox and Bayat (2008) a literature review also helps to delimit the research problem, to identify recommendations for further research and to gain methodological insights. The literature review also helps to distinguish what has been done already and what needs to be done in future research. This is especially important in a field that produces a considerable amount of research papers, as in the field of innovation acceptance. The general process of conducting a literature review is not too different from the process of conducting primary research. The main components are a rationale for the review, research questions or hypotheses, a plan for collecting the data, a plan for analysing the data and finally a plan for presenting the data (Randolph, 2009, p.4).

The common starting point for a literature review is to select the units of review. This means explicitly determining the criteria for inclusion and exclusion of

P. Planing, *Innovation Acceptance,* DOI 10.1007/978-3-658-05005-4_3,

articles and books that should be reviewed (Randolph, 2009, p.6). The present review started with the standard books in the field of innovation acceptance, such as Rogers' "Diffusion of Innovations" with its different editions from 1962 until 2003. In order to develop selective criteria for further review of literature, empirical studies in the field of innovation acceptance were reviewed for methodological and bibliographic citations. It became apparent that regularly cited standard articles, such as Venkatesh and Davis (2000), should be included in the review. Moreover, it was striking that most of the empirical studies in this initial review not only relied on the concepts developed by Rogers (2003), but also included concepts developed in the field of social psychology, such as the Theory of Reasoned Action. Consequently, these concepts and their related books, such as "Predicting and changing behaviour" by Fishbein and Ajzen (2010), were also included in the literature review.

Due to the vast amount of empirical research in the field of innovation acceptance, some rather strict selection criteria had to be defined for the inclusion of empirical articles. Based on the research objectives, articles were included if they met the following criteria:

- The study focused on the acceptance of a product or service in the field of advanced technology (innovations in the field of health, education or organisations were thus intentionally neglected).
- The study reported significant results, employed standard validity tests and documented means and standard deviations.
- The study reported on the methodology employed, especially on the theories and models used for developing the constructs.
- The study reported on the sample size used.
- The study was not conducted prior to 2001.
- The study was written in English.

In the next step, a qualitative synthesis of the empirical articles meeting these criteria was developed by comparing and contrasting the results of the individual studies and generating categories and core concepts. Consequently, the final result of this chapter is a table, containing the common synthesized concepts and results from all innovation acceptance articles reviewed in the process of this literature review.

3.3 Defining Innovation

Even though the creation of new ideas had been studied in many disciplines before, it is widely believed that the term ‘innovation’ was introduced to the world of economics by Peter Schumpeter in 1939. In his description of the capitalistic market, he defined Innovation as "doing things differently in the realm of economic life" (Schumpeter, 1939, p.84). For Schumpeter, innovation can occur in five ways (Schumpeter, 1939, pp.90–93):

- by the introduction of new goods,
- by new methods of production,
- by the opening of new markets,
- by the conquest of new sources of supply and,
- by carrying out a new organization of any industry.

Since Schumpeter, innovation has been studied in many disciplines and has been defined from different perspectives (Damanpour and Schneider, 2006, p.215). Academic discussion is still some way from reaching a common agreement to describe innovation. Depending on the particular research issue, different criteria are employed to characterise what is meant by the term *innovation* (Herzog, 2011, p.9). One reason for the fact that there is not an established single definition of the term *innovation* is that innovation is of interest to practitioners and researchers across a wide range of business and management disciplines. Literature focusing on innovations can be found in human resource management, operations management, entrepreneurship, research and development, information technology, engineering and product design, and marketing and strategy. Consequently, each of these different disciplines proposes different definitions for innovation (Baregheh, Rowley and Sambrook, 2009, p.1324). Whilst there are some overlaps between the various definitions of the term *innovation*, the proliferation and diversity of definitions lead to a situation in which there is no clear and authoritative definition that can be accounted for (Baregheh, Rowley and Sambrook, 2009, p.1324). Table 4 provides a compilation of popular definitions for the term *innovation*.

Table 4: Definitions of Innovation in chronological order

Definition	Author
"The act of introducing something new"	The American Heritage Dictionary
"The process whereby new and improved products, processes, materials, and services are developed and transferred to a plant and/or market where they are appropriate"	White and Bruton (2011, p.19)
"The use of new technological knowledge, and/or new market knowledge, employed within a business model that can deliver a new product and/or service to customers who will purchase at a price that will provide profits"	Kaplan and Warren (2010, p.41)
"A significant positive change"	Berkun (2010, p.17)
"Change that creates a new dimension of performance"	Drucker (2007, p.51)
"An innovation is an idea, practice, or object that is perceived as new by an individual or other unit of adoption."	Rogers (2003, p.12)
"… the transformation of knowledge into new products, processes, and services — involves more than just science and technology. It involves discerning and meeting the needs of the customers"	Porter and Stern (1999, p.12)
"Innovation consist of the generation of a new idea and its implementation into a new product, process, or service, leading to the dynamic growth of the national economy and the increase of employment as well as to a creation of pure profit for the innovative business enterprise"	Urabe (1988, p.3)
"Innovation is any thought, behaviour or thing that is new because it is qualitatively different from existing forms"	Barnett (1953, pp.7–8)
"The introduction of new goods (…), new methods of production (…), the opening of new markets (…), the conquest of new sources of supply (…) and the carrying out of a new organization of any industry"	Schumpeter (1939, p.84)

Reviewing these definitions, it becomes obvious that a new idea by itself is not yet an innovation; it could merely be regarded as a concept or a thought. The process of converting these thoughts into tangible new artefacts (usually a product, a service or a process) is usually called invention. The later activities that lead to an invention becoming a success in the marketplace or in a society as a whole represent exploitation. It is, however, the complete process that represents innovation (Trott, 2010, p.14).

There is no doubt that a general definition covering all these aspects of innovation in a multidisciplinary manner would be beneficial to the field of economics (Adams, Bessant and Phelps, 2006, p.22). In an attempt to arrive at a single comprehensive definition, Baregheh, Rowley and Sambrook (2009) recommend defining innovation as a process and including various dimensions for every process step. Their basic definition reads as follows: "Innovation is the multi-stage process whereby organizations transform ideas into new or improved products, services or processes, in order to advance, compete and differentiate themselves successfully in their marketplace" (Baregheh, Rowley and Sambrook, 2009, p.1333). The authors acknowledge that, depending on the context, the term *transformation* may need to be replaced with *creation*, *generation* or *adoption.* Also, many innovation processes may not originate from an *organization* but rather from a *social system, employees* or an *individual*. To make up for these variations, multiple dimensions are necessary for every step in the process definition. It is hard to imagine a definition that covers all these dimensions in one comprehensive and articulate manner. Consequently, Baregheh, Rowley and Sambrook (2009, p.1333) argue in favour of a diagrammatic definition of the term *innovation* instead of a pure textual definition. Chart 10 shows a graphical approach to the definition of *Innovation*.

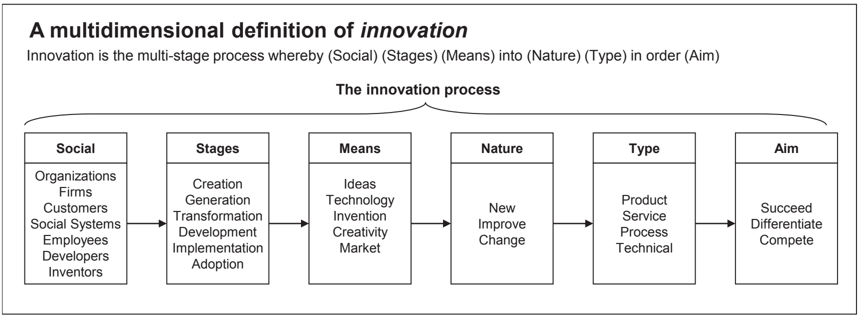

Chart 10: Multidimensional definition of innovation, Source: Own drawing, based on (Baregheh, Rowley and Sambrook, 2009, p.1333)

Since the main interest of the present research is the acceptance of a new technology, a process definition of innovation, like the one by Baregheh, Rowley and Sambrook (2009, p.1333) is not applicable in this case. The acceptance of an innovation itself is only one partial process within the overall "innovation process": thus, the term "acceptance of an innovation" would not make any sense in this perspective. Consequently, for the purpose of the present research, an object-based definition will be employed. Based on the multidimensional, graphical approach developed by Baregheh, Rowley and Sambrook (2009, p.1333), the author thus developed a definition that incorporates the three object-related dimensions: (1) the object of an innovation, (2) the attribute, which describes the novelty character of this object and (3) the social dimension, describing the unit of adoption. The reviewed definitions of the term *Innovations* delivered the potential items for each of these three dimensions by splitting the definitions accordingly.

Table 5 gives the results of this three-dimensional analysis of definitions.

Table 5: Developing a definition of innovation

Object		**Novelty attribute**		**Social adoption unit**	
Term	**Reference**	**Term**	**Reference**	**Term**	**Reference**
knowledge	Kaplan and Warren (2010, p.41)	significant change	Berkun (2010, p.17)	customers	Kaplan and Warren (2010, p.41); Porter and Stern (1999, p.12)
idea, practice, or object	Rogers (2003, p.12)	perceived as new	Rogers (2003, p.12)	individual or other unit of adoption	Rogers (2003, p.12)
product, process, or service	Porter and Stern (1999, p.12)	qualitatively different from existing forms	Barnett (1953, pp.7–8)		
thought, behaviour or thing	Barnett (1953, pp.7–8)	new	Schumpeter (1939, p.84); Porter and Stern (1999, p.12)		
goods	Schumpeter (1939, p.84)				

Regarding the object dimension, two different aspects are relevant for the definition of *innovation* in the present context. An object could either be a ***product***, referring to any object aimed at commercialization or an ***idea***, referring to any thoughts or knowledge, aimed at diffusion within a society. Reviewing the dif-

ferent attributes for novelty, it becomes apparent that an object can either be *new* or *significantly different* to existing objects in order to be considered an innovation. An important aspect, developed by Rogers (2003, p.12), is that an innovation should be considered as new or significantly different from the perspective of the adoption unit (those, who will eventually adopt it). Concerning this adoption unit, finally, it is important to acknowledge that the adoption decision can be made can be made either by an individual, by an organisation or by a society. Thus the final definition for the term *Innovation* reads as follows:
Innovation is any product or idea, which is perceived as new or significantly different by an individual or other unit of adoption.
Whenever used throughout this document, the term *innovation* will consequently refer to this definition.

3.4 Defining Acceptance, Adoption, Resistance and Diffusion

Since the present research focuses on the *acceptanc*e of an innovation the terms associated with the acceptance or rejection decision have to be defined in the next step.

Acceptance
Before discussing the application of the term *acceptance* in the field of economics, this Chapter will first focus on its general usage in linguistics and its origins. The first approach to the term *acceptance* is derived from its general applications in linguistics. The Oxford Dictionary proposes three basic definitions for the term *acceptance*:

- "The action of consenting to receive or undertake something offered".
- "The process or fact of being received as adequate, valid, or suitable".
- "The agreement with or belief in an idea or explanation" (Oxford Dictionaries, 2011).

According to the Oxford Dictionary, the word's origin's date back to the mid-16th century, based on the Old French word *accepter*. The Mirriam-Webster Dictionary dates the first occurrence of the term *Acceptance* to the year 1574 (Mirriam-Webster Dictionary, 2011).
In the area of social science, however, the term *acceptance* took much longer to be of any interest to researchers. Its usage increased in the late 1970s and 1980s,

with studies focusing on consumer resistance towards new means of communication, such as videotext, or political programmes (Küpper, 2005, p.126). The impact of the introduction of new technologies into personal lives and the workplace has since become an increasing interest of social science researchers. This process established the term *Acceptance* in such diverse fields as politics, philosophy, law, religion and linguistics (Lucke, 1995, p.10).

In the field of economics, the term *Acceptance* is mainly used in the field of organisation theory and marketing. Organisational acceptance research mainly focuses on the implementation of guidelines and the acceptance of new organisational structures (see Rycroft-Malone and Bucknall, 2010, p.147 ff.). In the field of marketing, research is focused on the acceptance of new product or service innovations and is either trying to explain the current market situation or trying to predict a future development (see Cui, Bao and Chan, 2009 and Seeman and Gibson, 2009).

Dillon (2001, p.1) defines acceptance as the "demonstrable willingness within a user group to employ […] for the tasks it is designed". This definition makes an emphasis on the actual ("demonstrable") acceptance behaviour, rather than focussing only on self-reported intention of use (Wu, 2009, p.10). Even though it is important to acknowledge the difference between the intention to use an innovation and the actual usage of it, authors widely agree that there is a direct correlation between these two variables (Fishbein and Ajzen, 2010, p.39). Due to the fact that a measurement of actual usage is not feasible in many cases, most authors thus rely on a measurement of the *Intention to Use* instead (see Hrubes, Ajzen and Daigle, 2001; Jaensirisak, 2002 and Sparks and Shepherd, 2002). Since the present study focuses on the intention to use a technology, rather than on the actual usage of it, acceptance will accordingly be defined as the *Intention to Use a Technology*.

Adoption and Rejection

Adoption is often used as a synonym for acceptance in the consumer behaviour context and many researcher use both terms without distinction (see Carlsson et al., 2006; Pedersen, 2005; Yang, 2005). Rogers (2003, p.21) defines adoption as the "decision to make full use of an innovation as the best course of action available". Following the same line of reasoning, *Rejection* is defined as the "decision not to adopt an innovation" (Rogers, 2003, p.21). It is worthwhile noticing that Rogers uses this definition to point to a single decision, which "can be reversed at a later point" (Rogers, 2003, p.21). In his view, the terms *Adoption* and *Rejection* represent the outcome of a decision process of a single individual. This notion represents a clear distinction from the term *Acceptance*, which is a more general "agreement with or belief in an idea or explanation" (Oxford Dictionaries, 2011). While *Adoption* and *Rejection* thus denote the individual decision as to whether or not to use an innovation, *Acceptance* can be described as the continued usage of it. Consequently, some authors argue that researchers should conduct a separate analysis of the perceptions related to adoption and the perceptions related to acceptance (Hernandez, Jimenez and Martin, 2009, p.1233). Research has found that determinants of continued usage of a technology system are often different from those of initial adoption (Wu, 2009, p.12). Measuring the differences between initial adoption and continuous acceptance, however, requires multiple measurements at different points in time. Because of this, only a few authors so far have gone down this path (see Hong, Thong and Tam, 2006 as a rare example).

Since the present study focuses on the intention to use a technology, rather than on the actual usage of it, a distinction between the terms *adoption* and *acceptance* would not provide any benefit. Consequently, for the purpose of the present study, the terms *adoption* and *acceptance* are used as synonyms representing the *intention of an individual to use an innovation*.

Diffusion

Rogers (Rogers, 2003, p.5) defines *diffusion* as a "process in which an innovation is communicated through certain channels over time among the members of a social system". For Rogers, the term *diffusion* implies social change, meaning that some alteration occurs in the structure and function of a social system. When a new idea is invented, diffused and adopted or rejected by a society, this leads to certain consequences and social change (Rogers, 2003, p.6). Basically there are two types of diffusion: spontaneous unplanned spread of ideas, for example caused by a political revolution, and the planned and facilitated spread of new concepts, which can occur through governmental policy or marketing efforts. The interest of the present piece of research is clearly the latter type of diffusion, which could be described as *a process in which an innovation is promoted and accepted over time among customers.*

3.5 History of Acceptance Research

"There is nothing more difficult to plan, more doubtful of success, nor more dangerous to carry through than the creation of a new order of things"
Machiavelli, 1513

The roots of diffusion research extend back to the beginnings of social science in Europe. In the history of religion, as well as in some aspects of culture and folklore, much attention was devoted to the diffusion of new ideas and beliefs within a society (Katz, 1999, p.144). However, it took until the early 20th century for diffusion research to make its way into the scientific tradition. Being one of the forefathers of sociology and social psychology, French lawyer Gabriel Tarde was the first to observe and analyse how new ideas flourished within French society at around 1900. In his influential book "Laws of Imitation" Tarde (1903) dealt with the central question of compatibility: that is, the goodness of fit between the attributes of a diffusing item and the social and psychological attributes of the potential adopter (Katz, 1999, p.150).
One reason why innovation acceptance took so long to be established as a distinct research field was the very lack of commonalities between the many different fields of diffusion studies, ranging from agriculture to linguistics, medicine or psychology. It was only when Everett Rogers (1962) combined the diffusion studies in an interdisciplinary manner and thus developed a common framework that diffusion research was accepted as a research field of its own. Since then, the scope of innovation acceptance research has broadened as more and more disciplines became involved. Early studies mainly focused on rural sociology, investigating the spread of new farming techniques, but soon scholarly interest tailed off somewhat to other disciplines such as communication, public health and marketing. Since around 1990, the number of diffusion studies strongly increased, with many focusing on the rapid spread of new communication technologies like the internet and mobile applications (Rogers, 2003, p.83).

Despite these important pieces of work, scientific research in the field of innovation acceptance is still in an early phase and far from consensus regarding central questions of individual behaviour in the innovation acceptance process (Keeling, 1999, p.59; Silva, 2007, p.256; Venkatesh et al., 2003, p.427).

3.6 The Diffusion Paradigm

The widespread success of Everett Rogers' book the "Diffusion of Innovations" created a framework for future research, which today is known as the *diffusion paradigm* (Dearing, 2008). Although Rogers (2003) based this framework on many early diffusion studies, the Ryan and Gross (1943) investigation of the diffusion of hybrid seed corn in Ohio has influenced the methodology and theoretical framework of innovation acceptance studies more than any other study until now. In this detailed field study it became apparent that a certain diffusion process develops because potential customers do not adopt an innovation directly after it becomes available to them, but only with a – varying – time gap. These different time lags build the fundament for the categorisation of adopters as (1) innovators, (2) early adopters, (3) early majority, (4) late majority and (5) laggards (Rogers, 2003, pp.22–23). Plotting the adoption of an innovation over time on a frequency basis will result in a normal, bell-shaped curve or – if the numbers of adopters are cumulated over time – in an S-Shaped curve of adoption (Rogers, 2003, p.272). Chart 11 gives an overview of Roger's Diffusion Process.

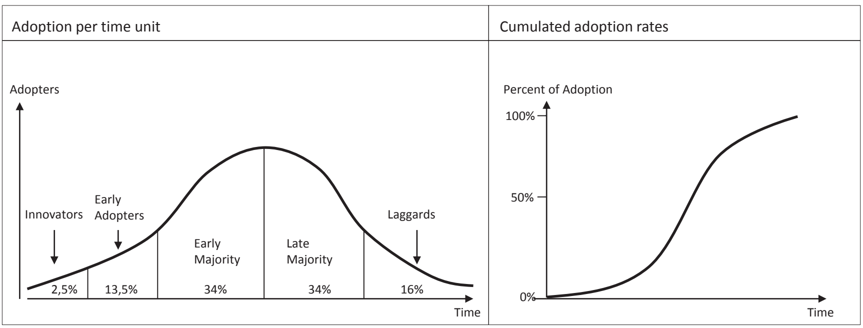

Chart 11: Roger's Diffusion Process, Source: Own drawing based on Rogers (2003, pp.11,281)

Recognizing that adoption is based on a hierarchical mental process, scholars in many disciplines have developed divergent phase models of innovation acceptance. Even though the terminology and the categorisation of process-steps vary throughout these models, there is a common basic structure in most of them: the innovation-diffusion process is essentially an information-seeking and information-processing activity in which an individual is motivated to reduce uncertainty about the advantages and disadvantages of the innovation (Binsack, 2003, p.9). The most basic phases of this process are: (1) Knowledge, (2) Persuasion, (3) Decision, (4) Implementation and (5) Confirmation (Rogers, 2003, p.170). Chart 12 gives an overview of Roger's Adoption Process Model.

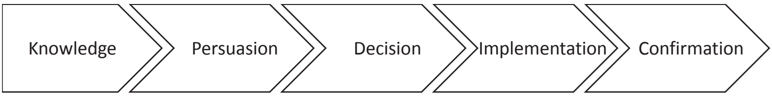

Chart 12: Roger's Adoption Process Model, Source: Own drawing based on Rogers (2003, p.170)

In the knowledge stage, the individual usually plays a relatively passive role when being exposed to new information about an innovation. However, some individuals do intentionally expose themselves to ideas that are compliant with their interests, needs and existing attitudes (Rogers, 2003, p.171). At the persuasion stage, the individual forms a favourable or unfavourable attitude towards the innovation. Attitude in this context is best described as "a latent disposition or tendency to respond to some degree favorable or unfavorable to a psychological object" (Fishbein and Ajzen, 2010, p.76). Other authors emphasize especially the learned and experiential aspects of attitudes (see Keeling, 1999, p.168 for an overview of definitions of attitude). In developing a favourable or unfavourable attitude towards an innovation, an individual may need to mentally apply the new idea to an anticipated future situation before deciding whether or not to try it (Rogers, 2003, p.175). The persuasion and decision stages are usually the main interest of innovation acceptance studies, although recently the consequences of innovation have gained increased attention (Rogers, 2003, p.442).

The question of why certain innovations spread more quickly than others and why some innovations fail is one of the major concerns in the field of innovation diffusion research today (Gottschalk and Kalmbach, 2005, p.221). According to Rogers (2003, p.221), the rate of adoption is influenced by a

multitude of factors, which can be characterised as (1) product-related influences (2) consumer-related influences and (3) external influences.
Performing a meta-study of 1,500 diffusion studies, Rogers (1995) found that the perceived attributes of an innovation are the most important explanation for the rate of adoption and that "most of the variance in the rate of adoption of innovations, from 49 to 87 percent, is explained by only five attribute categories: (1) relative advantage, (2) compatibility, (3) complexity, (4) trialability, and (5) observability" (Rogers, 2003, p.222). Relative advantage can be interpreted as technological, economical, social or emotional advantage. As Bagozzi and Lee (1999, p.218) argue, perceived advantage can also be seen as a result of anticipated positive consequences towards a personal goal. Compatibility is the degree to which an innovation is perceived as being consistent with the existing values, past experiences, and needs of potential adopters (Rogers, 2003, p.15). Complexity in this context determines the cognitive efforts a potential adopter anticipates to be necessary in order to make full use of an innovation. In other words, complexity is the perceived difficulty of an innovation by the end-user. Trialability is the degree to which an innovation may be experimented with on a preliminary basis. The Ryan and Gross (Ryan and Gross, 1943) hybrid seed corn study, for instance, found that most farmers did not adopt an innovation until they had tried it on an experimental basis (Rogers, 2003, p.271). Finally, observability is the degree to which the use and the consequences of an innovation are visible to others (Rogers, 2003, p.16).

These original five attributes of innovations, also known as the Rogers criteria, form the standard classification scheme for describing the perceived attributes of innovations in universal terms (Rogers, 1995, p.208). However, in addition to these five universal characteristics, scholars in the field have continuously added other attributes, usually based on a given context of research (Bagozzi and Lee, 1999, p.218). In a literature review, Adams (2002, pp.75–79) identified fifty-two innovation attributes, with many of them being virtual synonyms. He blamed this result on the fact that innovations are researched in a variety of scientific fields and language develops differentially in many disciplines.

Next to the innovation attributes, Rogers (2003, p.221) found that much of the remaining variance in the rate of adoption was explained by four other variables: Firstly, the type of innovation-decision, which can either be an optional decision, made by an individual independently of others, a collective innovation decision, made by consensus within a social system, or an authority decision, made by relatively few individuals who possess power, status or technical experience (Rogers, 2003, pp.28–29). Secondly, the communication channels used for facilitating the spread of the innovation (Rogers, 2003, p.35). Thirdly, the nature of the social system, meaning the cultural values and relationships in a given society, which can either facilitate or impede the diffusion of innovations (Rogers, 2003, p.26), and finally (4) the extent of promotion efforts by a Change Agent, who is "influencing clients' innovation-decisions in a direction deemed desirable by a change agency"(Rogers, 2003, p.369). Chart 13 illustrates the model described by the Rogers Diffusion Paradigm.

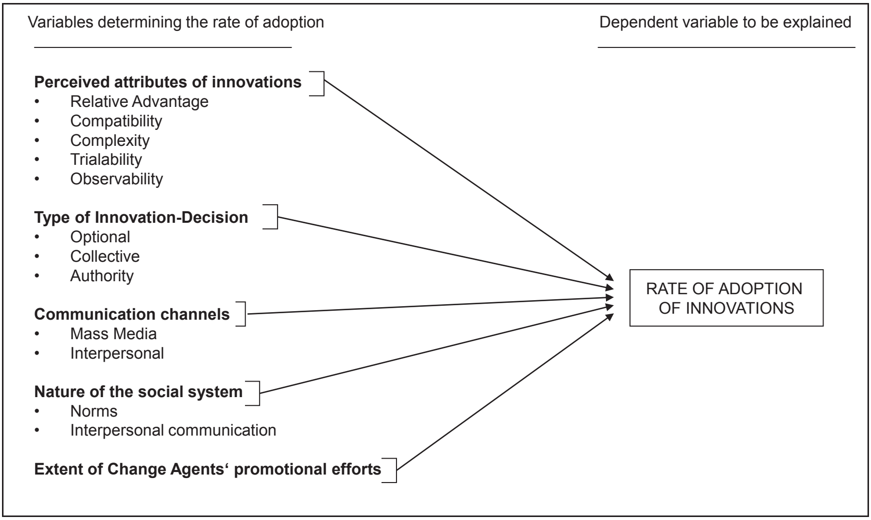

Chart 13: The Rogers Diffusion Paradigm, Source: Own drawing based on Rogers (2003, p.222)

Due to its relative simplicity and universality, the Diffusion Paradigm has found widespread acceptance in contemporary literature on innovation acceptance. At the same time, however, this simplicity and universality of the theoretical model has raised criticism among researchers (Dethloff, 2004, p.29).

3.7 Criticism of the Diffusion Paradigm

The simplicity of the innovation-decision phase model has raised questions since, there are no rational sharp distinctions between the phases; nor is there any empirical evidence for the existence of individual phases within this mental progress. Rogers (2003, p.195) argues that "stages may be useful as a means of simplifying a complex reality, so as to provide a basis for understanding human behaviour change".

Critics have also argued that the five perceived attributes of an innovation are not empirically confirmed to be sufficiently independent. A recent empirical study revealed that the interdependencies among Rogers' attributes are so strong that they result in an extremely poor fit with empirical data if they are completely ignored, as in Rogers original model (van Rijnsoever et al., 2009, pp.419-420). Other critics argue that relative advantage is a multidimensional attribute and thus difficult to operationalise. Depending on the context, economical, social or technical aspects may be more important to consider as a relative advantage in a specific context (Dethloff, 2004, p.29). Additionally, there is a lack of standardised operationalisations for the independent and dependent variables, leaving much room for interpretation when applying the model (Nabih, Bloetn and Poiesz, 1997, p.191). In conclusion, the attributes proposed by the Diffusion Paradigm are found to be difficult to use under different innovation acceptance contexts.
It is maybe because of these shortcomings that very little empirical work has been done in the framework of the *diffusion paradigm*. In order to develop a predictive instrument towards the rate of adoption of an innovation, empirical studies in the field of innovation acceptance make use of behaviour models from the field of psychology, such as the Technology Acceptance model (TAM) or the Theory of Planned Behaviour (TPB). Both of these models originate from the Theory of Reasoned Action (TRA), which will be the focus of the next section.

3.8 The Theory of Reasoned Action

The Theory of Reasoned Action or TRA was developed from Fishbein's (Fishbein, 1967) Theory of Attitude, which in its original formulation was largely adapted from Dulany's (1968) theory of propositional control (Fishbein and Ajzen, 2010, p.17). In general, the model aims at predicting individual behaviour by postulating that human behaviour is based on the systematic use of available information through the formation of beliefs. Ajzen and Fishbein (Fishbein and Ajzen, 2010) propose that behaviour is determined by intention, which in turn is determined by two fundamental factors: the attitude towards the behaviour and the subjective norms. Attitudes are basically the positive or negative evaluations of the behaviour in question, while norms represent the perceived social pressure to engage or not engage in the behaviour in question (Fishbein and Ajzen, 2010, p.21). Developing this model further, Ajzen (Ajzen, 2002) introduced a third factor, Perceived Behavioural Control (PBC), representing the beliefs of a subject that he or she is able to perform the behaviour in question or that he or she has actual control over performing the behaviour. This addition was necessary because the TRA has lacked the ability to deal with the behaviour of individuals under non-volitional control (Sattabusaya, 2008, p.48). The revised model is referred to as the Theory of Planned Behaviour (TPB).

The TRA and the TPB can be considered together here, since from a theoretical point of view, the TRA simply examines a special case of the TPB – that is, a case of planned behaviour in which there is sufficient PBC (Greve, 2001, p.442).
As noted above, the three components of the model are based on beliefs towards the behaviour. Attitudes are believed to develop automatically and inevitably as new beliefs are formed about an object. Specifically, people are assumed to have pre-existing evaluations of certain attributes of an innovation that become linked to this object in the process of belief formation. Depending on the strength of these beliefs and the evaluations of the innovation’s attributes, the overall attitude towards the object is formed. Thus, in future, the attitude object will automatically activate the summated evaluative response: that is, the overall attitude towards the object (Fishbein and Ajzen, 2010, pp.96–97). People can, of course, form many different beliefs about an object, but it is assumed that only a relatively small number determine the attitude at any given moment. Only salient beliefs (i.e. beliefs about the object that come readily to mind) serve as the predominant determinants of the attitude (Swartz and Douglas, 2009, p.26).

This so called Expectancy-Value Model of Attitude can be written as

$$A = \Sigma\, b_i\, e_i$$

Where A is the attitude towards an object, b_i is the strength of the belief that the object has attribute i, and e_i is the evaluation of the attribute i.
The Subjective Norm component represents the perceived social pressure to perform or not to perform a given behaviour. This social pressure is generally associated with two normative components: Injunctive Norms, which represent the perceptions concerning what should be done, and Descriptive Norms, which represent the perceptions that others are or are not performing the behaviour in question (Fishbein and Ajzen, 2010, p.130). When an individual forms an injunctive norm, the normative prescriptions of various individuals and groups are taken into account. However, similar to the attitude formation, only salient or readily accessible referents will influence the person's injunctive norm (Aboelmaged, 2010, p.396). Yet, knowing what a referent prescribes may put little or no pressure on a person to carry out the behaviour unless that person is motivated to comply with the referent in question. Therefore, analogous to the Expectancy-Value Model, the measure of the overall injunctive norm can be written as:

$$N_1 = \Sigma\, n_i\, m_i$$

Where N_1 is the injunctive norm, n_i is the injunctive normative belief about referent *i*, m_i is the motivation to comply with referent *i*, and the sum is over the total number of salient referents (Fishbein and Ajzen, 2010, p.137). Alongside this, the Descriptive Norm component can be seen as a singular factor. It is based on the insight that human behaviour is influenced by the perceived behaviour of others, be it their past behaviour, their current behaviour or their anticipated future behaviour. Although it is usually possible to identify a single social norm construct that incorporates both injunctive and descriptive aspects of perceived normative pressure, it is important to include measures of both injunctive and descriptive norms when normative beliefs need to be assessed in more detail (Hagger and Chatzisarantis, 2005, p.524).

The third factor within this theory, Perceived Behavioural Control, refers to people's general expectations regarding the degree to which they are capable of performing a given behaviour (Fishbein and Ajzen, 2010, p.169). This factor takes into account the availability of information, knowledge and other resources required to perform the behaviour as well as possible barriers that may have to be overcome (Aboelmaged, 2010, p.396). Whether these resources are internal or external is not of importance in this context. Again, readily accessible beliefs regarding these external and internal control factors are assumed to determine the overall level of perceived behavioural control. These beliefs may be based in part on past experience with the behaviour. In cases where a new, or innovative, behavioural object is about to be concerned, these beliefs will usually be influenced by second-hand information and observation of others already performing the behaviour in question (Sattabusaya, 2008, p.48).

Two types of control beliefs will influence the overall Perceived Behavioural Control and thus intention towards behaviour: the likelihood that a given control factor will be present (belief strength) and the extent to which its presence would facilitate or constrain performance of the behaviour (power of the factor) (Fishbein and Ajzen, 2010, p.177). This could be written as:

$$PBC = \Sigma\, c_i\, p_i$$

Where c_i is the belief that control factor i will be present; p_i is the power of factor i to facilitate or constrain performance of the behaviour, and the sum is over the number of salient control beliefs (Fishbein and Ajzen, 2010, p.170)

The beliefs discussed so far are not predetermined; rather, they are accumulated over time through experiences and interaction with the real world and by the individual’s own inferences based on the given set of information. Differences in individual beliefs must therefore be the result of different learning experiences throughout a lifetime. These real life experiences, in turn, are likely to vary as a function of personal characteristics, social and cultural factors and exposure to media and other sources of information (Venkatesh et al., 2003, p.469). As a result, demographic, cultural or socioeconomic characteristics, such as gender, age, religion or income, are often found to be associated with differences in behaviour. However, these variations in personal characteristics do not cause differences in behaviour and by themselves they cannot explain these differences. Rather, they provide a segmentation of the given population along certain dimensions and reveal differences in behaviour among different subgroups. By exploring why behaviour differs among segments of the population, we can deepen our understanding of behaviour's underlying determinants (Fishbein and Ajzen, 2010, p.234).

In sum, these personal characteristics can generally be seen as background factors in the TPB model. As the number of background factors that could be considered is virtually unlimited, the scope of personal characteristics has to be adapted closely to the behaviour in question.

Chart 14 illustrates the TPB model as described by Ajzen & Fishbein

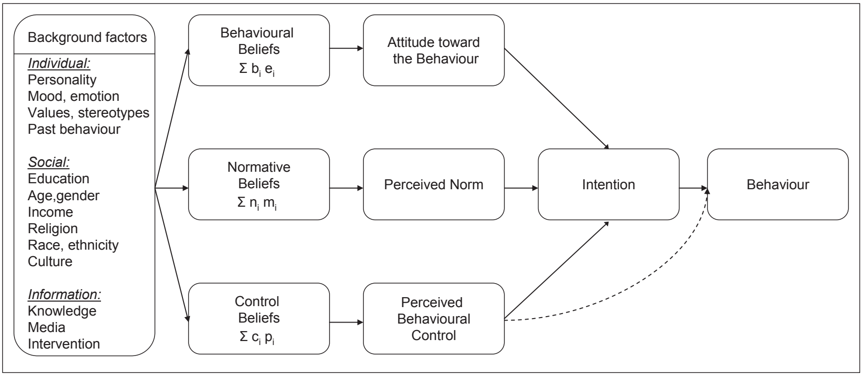

Chart 14: The TPB model, Source: Own drawing based on Ajzen & Fishbein (2010)

Being heavily employed in contemporary social psychology, the model developed by Ajzen and Fishbein has proved to be successful in many behavioural domains. Especially in the field of innovation acceptance, the TPB model became the most widely used theoretical framework for researchers (Venkatesh et al., 2003, p.427). In a meta-analysis based on 185 independent studies (Armitage and Conner, 2001), the TPB was found to account, on average, for 39% of the variance in intentions. Given the fact that before the introduction of these models most studies accounted for, at most, 10% of the variance in behaviour, this was a definite advancement (Ajzen and Fishbein, 2004, p.432). Other, more behaviour specific meta-studies even exceeded these results. On average, if the measures of the theory's construct comply with the principle of compatibility, are reliable, and have convergent and discriminate validity, the theory can account for about 50% to 60% of the observed variance in intentions towards a specific behaviour (Fishbein and Ajzen, 2010, p.283).

Considering that even carefully assessed predictor variables contain random errors of measurement, successful research based on the TPB model tends to approach the theoretical limits of predictive validity.

Nevertheless, it has been argued that there is potential room for improvement. Some investigators have suggested that it may be possible to further improve the predictiveness of the TPB model by adding more predictors to the model (Sattabusaya, 2008, p.51). Examples such as “Attitudes towards uncertainty” (Braithwaite, Sutton and Steggles, 2002, pp.761–764), “Trust in Salesperson’s expertise” (Teo, 2009, p.274), “Stress Coping Strategies” (Cui, Bao and Chan, 2009, p.113) and “Self-Identity”(Smith et al., 2008, p.314) have been proposed as possible additions. Empirically, however, most of these variables can be regarded as background factors, since the majority of their variance is moderated by behavioural, normative and control beliefs (Fishbein and Ajzen, 2010, p.293). Other additional factors might only be particularly useful in some instances. “Moral Concerns”, for instance, will play only a minor role in the purchase of prevalent consumer goods such as toothpaste or biscuits (Sparks and Shepherd, 2002, p.318). Yet none of the additional factors developed so far has fulfilled the criterion of adding significant additional and unique variance to the explanation of intention towards behaviour.

3.9 Criticism of the Theory of Reasoned Action

Despite its persistence and increasing popularity, criticism of the TPB has emerged from a theoretical as well as from a methodological point of view.

One of the major critiques of the TPB is that not all behaviours are logical or rational. In fact, “it would be hard to argue that behaviours that impair one’s health or well-being,[..] such as drunk driving, are either goal-related or rational” (Gibbons et al., 1998, p.1164). However, whether a given behaviour is rational or not is not of any particular importance in the context of the TPB model. It is assumed that in the course of their lives, people form various kind of behavioural, normative and control beliefs, some of which might be perfectly correct, based on logical trains of thought, while others might be inaccurate, misinterpreting or biased by wishful thinking or other self-serving motives (Fishbein and Ajzen, 2010, p.303). No matter how unfounded or biased people’s beliefs may be, their attitudes, subjective norms and perceptions of behavioural control are assumed to follow reasonably from these beliefs to produce a corresponding behavioural intention, and ultimately to result in behaviour that is consistent with the overall tenor of the beliefs (Bamberg, Ajzen and Schmidt, 2003, p.176).

Another basic criticism is that the three factors are not independent. Several studies have argued that subjective norms have a crucial effect on attitude (Teo, 2009, p.276). This is not particularly surprising, since, as a general rule, people who are important to someone will encourage them to perform behaviours that produce positive outcomes and to avoid behaviours that are likely to lead to negative outcomes (Fishbein and Ajzen, 2010, p.204). It is thus important to recognize that although the components are conceptually distinct, empirically there is likely to be at least some overlap among these factors.

One major critique on a more theoretical level is that, at least in principle, a good theory should be able to be rejected. Meta-analysis has revealed studies with an explained variance of the three factors ranging from 14% to 92% for behavioural intentions and a low variance was usually not blamed on the theory but rather explained by a poor operationalisation of the variables or the lack of additional, behaviour-specific factors. The fact that such results are not used to reject the model in question has raised criticisms that the theory is infallible by definition (Ogden, 2003, p.425). Ajzen and Fishbein (Ajzen and Fishbein, 2004, p.431), on the contrary, argue that there is nothing inherently wrong with the model when one of the three factors has no significant contribution to the prediction of intention. Rather, such a result signals that the factor in question has no relevance for intention in this specific behaviour case. If all three factors (i.e., attitude, subjective norm and perceived behavioural control) would fail to predict intention, however, the TPB would be disconfirmed (Ajzen and Fishbein, 2004, p.431). This case, however, has not been reported so far by any TPB study.

Much of the criticism of the methodology applied in the context of the TPB model is quite common to empirical research. For instance, Ogden (Ogden, 2003, p.426) questioned whether the answers given in a questionnaire will reveal pre-existing states of mind rather than ones that have been generated by completing this questionnaire. Especially when the individual has none or only limited experience with the behaviour in question, the risk of generating new beliefs is rather high. From a behaviourist perspective, it is thus dangerous to attempt to measure attitudes and intention about the use of a new product (i.e. car navigation) when people neither have any experience of using this product, nor have experience of using the technology this product is based on (in this case automobiles) (Keeling, 1999, p.167). It is also known that structural models cannot confirm any causal logical chains in a definite way. Thus empirical studies claiming to test the TRA/TPB model are sometimes labelled "pseudo-empirical" (Greve, 2001, p.442; Silva, 2007, p.257). This critique is quite common for any causal model and can usually be avoided by defining a valid and reasonable logical chain. Definite certainty about its underlying causal relationships, however, will never be achieved by empirical research (Nutt and Wilson, 2010, p.547).

In sum, the TPB model has, despite its criticisms on theoretical as well as on methodological grounds, proven to be a valid prediction model for behaviour in general. Its applications in the field of innovation acceptance are promising, since the validity of the model in this behavioural category was confirmed by virtually all studies conducted in this category so far (see Dwivedi, Lal and D. Williams, 2009; Hashim, 2008; Kwong and Park, 2008; Omar and Owusu-Frimpong, 2007; Pelling and White, 2009; Ramayah et al., 2009 Pavlou and Fygenson, 2006).

3.10 The Technology Acceptance Model

The Technology Acceptance Model (TAM) is an adaptation of the Theory of Reasoned Action specifically tailored to innovation acceptance in the context of using computer information systems in the workplace (Jaensirisak, 2002, p.199). The overall aim of the TAM is to explain the determinants of computer acceptance in universal terms and thus explain user behaviour across a broad range of end-user computing technologies and user populations (Davis, Bagozzi and Warshaw, 1989, p.985).

The TAM is widely used in contemporary science. Bagozzi (2007, p.244) stated that there are already more than 700 citations of the original paper of Davis, Bagozzi and Warshaw. The usefulness of TAM was validated by several empirical meta-studies considering the model as a "robust, powerful, and parsimonious "(Venkatesh and Davis, 2000, p.187) tool for predicting and explaining user acceptance of an innovation. The most distinctive feature of the TAM is the use of a salient belief set, which is called Perceived Usefulness (PU) and Perceived

Ease of Use (PEU). Davis, Bagozzi & Warshaw (1989, p.320) claim that these two constructs are the essential elements in determining the user's attitude towards a technology. In this regard, they defined PU as “the degree to which a person believes that using a particular system would enhance his or her job performance” (Davis, Bagozzi and Warshaw, 1989, p.320), and PEU as “the degree to which a person believes that using a particular system would be free of effort” (Davis, Bagozzi and Warshaw, 1989, p.985). In essence, perceived ease-of-use (PEU) reduces uncertainty about the cause-effect relationship involved in the innovation’s capacity to solve an individual's problem, while perceived usefulness (PU) describes the anticipated positive effect of using this IT System.

The theory further implies that behavioural intention to use an information system is determined by attitude toward using a system and PU, while Attitude, in turn, is directly determined by PU and PEU (Sattabusaya, 2008, p.53). This can be explained by suggesting that if someone believes that a system is easy to use, this will also have a positive effect on attitude and the motivation to overcome obstacles towards the use of such a system. Thus PEU has also positive effects on PU.

Chart 15 gives an overview of the TAM model in its original formulation.

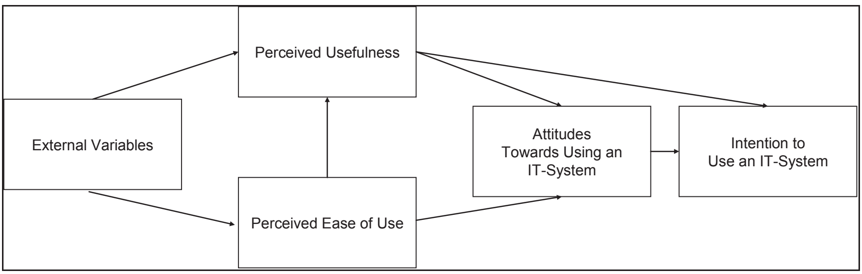

Chart 15: The TAM model in its original formulation, Source: Own drawing based on Davis, Bagozzi & Warshaw (1989, p.320)

Venkatesh and Davis (2000) extended the original TAM model to explain perceived usefulness and usage intentions in terms of social influence and cognitive instrumental processes. The extended model, referred to as TAM2, was validated with several meta-studies, outperforming the original model in most cases (Kwong and Park, 2008, p.1470). Other authors added several more constructs to the model, like compatibility with existing beliefs and prior experience (Karahanna, Agarwal and Angst, 2006, p.787), perceived risks (Sattabusaya, 2008, p.58), psychological attachment (Alrafi, 2007, p.49) and perceived enjoyment of using an IT System (Chtourou and Souiden, 2010, p.337). However, like additions to the TPB model discussed before, additions to the TAM model tend to reduce the universality of the model and thus tend to reduce the possible range of its application.

3.11 Criticism of the Technology Acceptance Model

In contrast to the TPB, one of the major drawbacks of the TAM certainly is that it focuses exclusively on the acceptance of IT-systems (Aboelmaged, 2010, p.397; Venkatesh and Davis, 2000). Since the TAM was developed in the context of new Information Systems (IS) usage in the workplace, several authors question the ability of the model to predict end-user acceptance of technology in a private user setting. Chen et al. (2007, p.356), for instance, argue that the central constructs of the TAM model, PU and PEU, are different from the diverse needs relevant in the voluntary consumer context. Others argue that utilitarian motives, represented by PU and PEU, are not sufficient to explain consumer behaviour toward a product and thus claim that a hedonic construct towards the usage of technology would be more beneficial for the model (Chtourou and Souiden, 2010, p.337). More than any other single factor, however, the lack of a social pressure construct has raised much critique, since it is a widely accepted fact that individual decision-making is heavily influenced by peer group pressure (Bagozzi, 2007, p.247). Despite this critique, the TAM has demonstrated a high level of predictiveness in many IT contexts, ranging from the employment of personal computers in the workplace to telemedicine acceptance by professionals (Aboelmaged, 2010, p.397).

3.12 Current Trends in Innovation Acceptance Research

Although the TPB and the TAM have been widely applied to examine the adoption and acceptance of technology, neither has been found to provide consistently acceptable explanations or predictions of any behavioural context (Venkatesh et al., 2003, p.426). This may be due to the various factors that actually influence the adoption of technology, such as the type of technology, users' behavioural beliefs and the very context of the research (Chen and Mort, 2007, p.356). Consequently, a growing body of research has focused on developing the models further by extending them with several new constructs, as discussed before.

Recently, however, some researchers have also tried to integrate the existing models to examine technology adoption by employing the complementary and explanatory power of the models taken together. In an attempt to recognize the strengths and weaknesses of different technology acceptance models developed so far, Venkatesh et al. (2003) incorporated Rogers' Innovation Diffusion Theory, the TRA and the TPB as well as the TAM and several other specialized innovation acceptance models into one unified model, which was consequently referred to as the United Theory of Acceptance and Use of Technology (UTAUT). The possible constructs were reduced by means of significance and unique explained variance, with four main variables, alongside four main moderators, remaining in the unified model. According to the UTAUT, intention to use a technology posits three direct determinants: (1) performance expectancy, (2) effort expectancy and (3) social influence, while usage behaviour has two direct determinants, (1) intention and (2) facilitating conditions. Significant moderating influences were found from experience, voluntariness, gender and age (Venkatesh et al., 2003, pp.468–470). Chart 16 gives an overview of the UTAUT model.

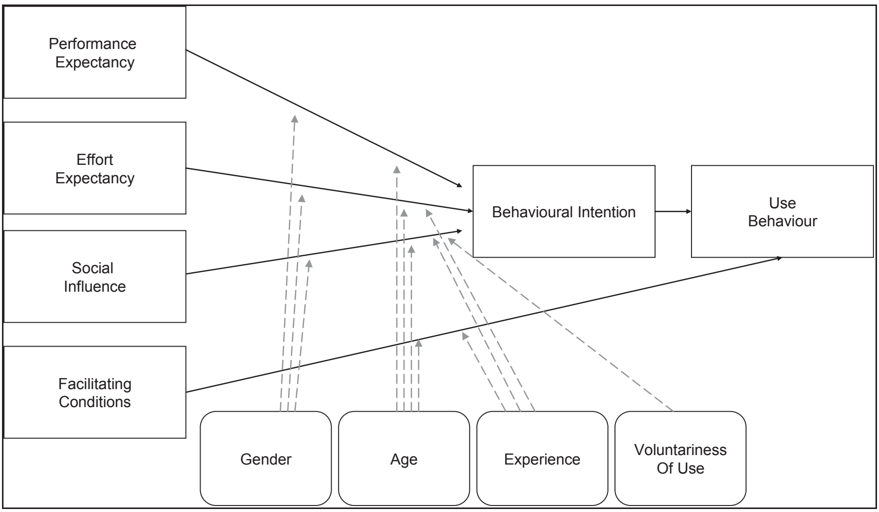

Chart 16: The UTAUT model, Source: Own Drawing based on Venkatesh et al. (2003)

Vankatesh et al. (2003, pp.425–426) tested the UTAUT in direct comparison to the original models discussed so far and found it to outperform the individual models significantly in terms of predictiveness, using the same data set. Despite this success, the UTAUT has not yet supplanted the TPB and the TAM in contemporary innovation acceptance research and other researchers have not yet reached a conclusion about its usefulness under other than theoretical considerations (Bagozzi, 2007, p.245).

A different approach was recently advocated by MacVaugh and Schiavone (2010). The authors argue that it might be more promising to focus on the non-adoption of innovations instead of analysing successful introductions of new technologies. Their investigation of the limits to innovation can be seen as a framework for explaining resistance rather than acceptance. Based on a historic literature review, the authors argue that resistance occurs in different domains, which can be described as a macro-dimension (market/industry), a meso-dimension (social system) and a micro-dimension (individual). The review of different cases of technology non-adoption led the authors to expose patterns of non-adoption, which are mainly attributed to the technology itself, the social structure and the learning abilities. Their complete model for technology resistance can be seen in Chart 17.

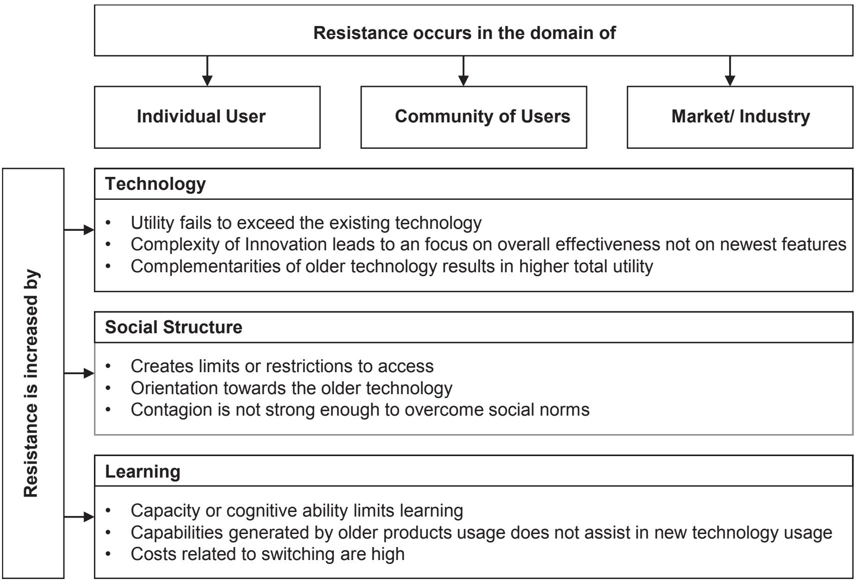

Chart 17: Resistance model of MacVaugh and Schiavone, Source: Own drawing, based on MacVaugh and Schiavone (2010, p.208).

So far, there are no empirical verifications of the model proposed by MacVaugh and Schiavone (2010). The authors do not provide information about how the proposed variables could be measured and operationalised: thus, so far, this model can be rather seen as a conceptual framework for further research.

Despite the conceptual frameworks proposed by Venkatesh et al. (2003) and MacVaugh and Schiavone (2010), the vast majority of papers currently published in the field of innovation acceptance rely on the original behavioural models developed by Fishbein and Ajzen (2010) and Davis, Bagozzi and Warshaw (1989). It can be observed, however, that instead of using these behavioural models in their original formulation, researchers have increasingly modified the models to fit specific needs. Most authors extend the TPB model with context-specific factors, such as *Perceived Risk* or *Perceived Trust*. Others combine elements of the TAM and the TPB in order to arrive at a more comprehensive acceptance model. It is likely that future research in the field of innovation acceptance will follow this trend and will increasingly use context-specific factors in the framework of the TPB and TAM model. Table 6 gives an overview of contemporary acceptance research and the underlying models that were employed by the authors.

Table 6: Contemporary research in the field of innovation acceptance

Study	**Behavioural model employed**
Nasri and Charfeddine (2012)	Combined TPB and TAM model, extended with the factors *Governmental Support* and *Technology Support*
Chong, Chan and Ooi (2012)	TAM model, extended with the factors *Trust*, *Cost* and *Social Influence*
Un Jan and Contreras (2011)	TAM model, extended with the factors *Compatibility* and *Subjective Norm*
Pai and Tu (2011)	UTAUT model, extended with the factor *Task-Technology Fit*
Yang et al. (2011)	TAM model, extended with the factors *Content* and *Interaction*
Lin, Fofanah and Liang (2011)	TAM model, extended with the factors *Information*

	System Quality and *Information Quality*
Lymperopoulos, Chaniotakis and Rigopoulou (2010)	TPB model, extended with the factors *Trust* and *Consumer Pessimism*
Aboelmaged (2010)	Combined TPB and TAM model
Chtourou and Souiden (2010)	TAM model, extended with the factor *Fun*
Crespo, del Bosque and de a los Salmones (2009)	TAM model, extended with the factor *Perceived Risk*
Zhang, Reithel and Li (2009)	TPB model, extended with the factor *Perceived Security Protection Mechanism*
Zolait, Mattila and Sulaiman (2009)	TPB model, extended with Rogers' innovation acceptance process
Ramayah et al. (2009)	TPB model
Seeman and Gibson (2009)	Combined TPB and TAM model

In correspondence to these findings, the author will use divergent sources of information to construct a behavioural model for ADAS acceptance based on the original works of Ajzen and Fishbein (1980). In order to develop relevant factors for this model, the findings of comparable innovation acceptance studies will be analysed in the next step.

3.13 Review of Empirical Innovation Acceptance Studies

The first step in any exploratory study is reviewing secondary literature that addresses a similar research question. As discussed in Chapter Two, research in the field of innovation acceptance is quite popular, with an increasing rate of empirical studies published in relevant journals each year (Rogers, 2003, p.83). Out of these studies, ranging from health innovations to pre-school education methods, the author selected forty-nine studies, which focus on high-tech innovations comparable to the interest of the present research (see paragraph 0 for the selection criteria of empirical studies). Even though some of these studies have a focus on related technologies, such as mobile parking services, none of the publications examines the acceptance of ADAS. Despite this fact, there are some important inferences that can be drawn from these studies, which could be highly relevant for the context of ADAS. In order to compare the research approach as well as the results of these studies, the author decided to summarize key aspects and bring together the results of the selected studies in tabular form. Key aspects from the perspective of the present research are the subject of study, the geographic location of interest, the methods of data collection, the sample size and the statistical tests employed for data interpretation and reliability analysis. Moreover, the author extracted the factors used to explain acceptance behaviour and the associated background factors. Most importantly, the main findings of each study were summarised briefly. The key question to be answered for each study was ‘which factor contributes most to the explanation of acceptance behaviour in the respective field of study?’. Table 7, finally, shows the key aspects of each study summarised following the outlined procedure.

Table 7: Results from Empirical Innovation Acceptance Studies

Author / Date	Research Context	(Psychological) constructs used to explain technology acceptance	Sample	Data collection	Stat. tests employed	Main findings
Huang and Hsieh, 2012	e-book readers	Relative advantage Compatibility Complexity Procedural switching costs Financial switching costs Relational switching costs	395 e-book customers	Online with telephone follow-up	Confirmatory Factor Analysis, GFI, NFI, RMSEA, SEM with AMOS	Innovative attributes (relative advantage, compatibility and complexity) directly affect the acceptance behaviour. Complexity is a key antecedent to switching costs. Financial switching costs are not influential for usage of e-books.
Nasri and Charfeddine, 2012	Internet banking	Perceived ease of use Perceived usefulness Security and privacy Self efficacy Government support Technology support	284 bank account owners	One-to-one interview	SEM with LISREL, GFI, NFI, RMSEA,	Intention to adopt Internet banking can be predicted by attitudinal factors (Perceived Usefulness, Perceived Ease of Use,Security and Privacy), subjective norms and by perceived behavioural control factors (self efficacy, government support and technology support).
Chong, Chan and Ooi, 2012	Mobile commerce	Trust Cost Social Influence Variety of Services Perceived Usefulness Perceived Ease of Use	172 Malaysian and 222 Chinese consumers	Written survey	Hierarchical regression analysis, Cronbach's alpha	The TAM predictors (Perceived Usefulness, Perceived Ease of Use, and Trialability) have no significant relationships with consumer intention. Instead, social factors such as trust and social influence play a significant role in m-commerce adoption
Un Jan and Contreras, 2011	University administration software	Perceived usefulness Subjective norm Compatibility Perceived ease of use Attitude toward use	89 students	Written questionnaire	Cronbach alpha, Correlation analysis, T-Test	Perceived Usefulness influences the attitude toward technology. Perceived Usefulness influences the behavioural intention. Subjective norms influence the attitude towards technology. Attitude influences the intention to use technology.
Pai and Tu, 2011	CRM Systems	Performance Expectancy Effort Expectancy Social Influence Facilitating Condition Task-Technology Fit	271 employees of two service companies	Written questionnaire	Confirmatory Factor Analysis, GFI, NFI, RMSEA, SEM with AMOS	Performance expectancy has no influence on behavioural intention. Effort expectancy has a positive influence on behavioural intention. Social expectancy has shown positive effects on user behaviour. Task-technology fit positively affects behavioural intention .
Yang et al., 2011	Digital Learning Systems	Perceived usefulness Perceived ease of use Attitude toward use Content Interaction	120 university students	Online questionnaire	Confirmatory Factor Analysis, GFI, NFI, RMSEA, SEM	Both Perceived usefulness and Perceived ease of use significantly and positively affect attitude toward digital learning . Contents and interaction service have a direct influence on perceived ease of use
Lin, Fofanah and Liang, 2011	e-Government	Attitude toward behaviour Perceived usefulness Perceived ease of use Information system quality Information quality	167 citizens	E-Mail questionnaire	SEM with LISREL, GFI, NFI, RMSEA,	Information quality and perceived ease of use positively influence the perceived usefulness (PU). However, PU does not have a strong impact on behavioural Intentions.
Gerpot, 2011	Mobile internet	Relative advantage Compatibility Lack of complexity Communicability Trialability	525 effective and 540 potential users	E-Mail survey	Bivariate correlation, multivariate OLS regression analyses	Perceived Relative Functional Advantage and Communicability of mobile internet offers are significantly positively related and their trialability is significantly negatively correlated with mobile internet acceptance.

Author / Date	Research Context	(Psychological) constructs used to explain technology acceptance	Sample	Data collection	Stat. tests employed	Main findings
Aboelmaged, 2010	e-procurement	Perceived Usefulness Perceived Ease of Use Attitude Subjective Norm Perceived Behavioural Control Intention	316 companies	Written questionnaire	GFI, AGFI, CFI, NFI, RFI, RMSEA	Attitude is main determinant of intention Perceived Usefulness and Subjective Norm further determine intention.
Chiu, Fang and Tseng, 2010	Interactive multimedia kiosks for convenience retailing	Optimism Innovativeness Insecurity Discomfort Performance expectancy Effort expectancy Social influence Facilitating conditions Technology Readiness Use intention	387 students	Written questionnaire	R_2 ΔR_2, variance inflation factor (VIF)	Performance expectancy, effort expectancy, facilitating conditions and social influence impact intention. Perceptions of these factors vary significantly between potential versus early users.
Chtourou and Souiden, 2010	Mobile Devices	Perceived Ease of Use Perceived Usefulness Fun Attitude	367 users of mobile devices	Written questionnaire	RMSEA, GFI, TLI, CFI	Usefulness and Ease of Use are confirmed to be important predictors of Attitude. Further, the importance of considering fun as an determinant of Attitude is confirmed.
Tsai, Chin and Chen, 2010	Nutraceuticals	Attitude Subjective Norm Intention Salesperson's Expertise Trust Belief	334 drugstore customers	Written questionnaire (Email)	RMSEA, GFI, AGFI, CFI, Cronbach's alpha, Average Variance Extracted (AVE)	Attitudes and Subjective Norm are predictors of intention, with Attitudes being a stronger predictor than Subjective Norm. Salesperson's Expertise has a positive influence on Intention. Trust beliefs had an indirect influence on consumer's intention through Attitude.
Dwivedi, Lal and D. Williams, 2009	Broadband internet	Age Gender Utilitarian outcomes Hedonic outcomes Self-efficacy Facilitating conditions	358 persons	Written questionnaire	t-test for demographics, regression analysis	All constructs, apart from hedonic outcomes, significantly influence intention.
Hahn and Kim, 2009	Online apparel shopping	Consumer Trust Perceived Confidence of Shopping Online Online Information Search Intention	261 student	Written questionnaire	R_2 ΔR_2, , GFI, AGFI, RFI, RMR	Consumer Trust is a significant predictor of Perceived Confidence and Online Information Search Intention. Online Information Search Intention is a significant predictor of Intention to buy online.
Pelling and White, 2009	Social Networking Websites	Attitude Subjective Norm Perceived Behavioural Control Self-identity Belongingness	233 university students	Written questionnaire	R_2 ΔR_2	Attitude and subjective norm significantly predicted intention. Intention significantly predicting behaviour.Self-identity, but not belongingness, significantly contributed to the prediction of intention.
Ramayah et al., 2009	Internet tax filing	Attitude Subjective Norm Perceived Behavioural	125 taxpaying employees	Written questionnaire	Cronbach's alpha, KMO measure of sampling, Bartlett's Test of Sphericity	Perceived Behavioural Control and Subjective Norm were positively related to intention. In terms of the impact, Perceived Behavioural Control was the most influential factor.

Author / Date	Research Context	(Psychological) constructs used to explain technology acceptance	Sample	Data collection	Stat. tests employed	Main findings
Seeman and Gibson, 2009	Electronic Medical Records	Perceived Ease of Use Perceived Usefulness PCB Perceived Social Influence Attitudes	102 members of faculty	Written questionnaire	R_2	Best explanatory power is obtained by a linear combination of the variables associated with TPB and TAM. However, TPB has a higher explanatory power than TAM.
Cui, Bao and Chan, 2009	3G Phones	Perceived Ease of Use Perceived Usefulness Fun Coping Strategies Attitude	228 persons of the general public	Written questionnaire	Cronbach's alpha, Wilk's lambda	Coping strategies have significant influence on consumers' product beliefs, which in turn mediate the effects of coping strategies on consumers' attitude.
Khalifa and Shen, 2008	Mobile Commerce	Attitude Subjective Norm Perceived Behavioural Control Ease of Use Trialability Observability Communication Knowledge	202	Written questionnaire	Composite reliability measures (r), average variance extracted (AVE),	Knowledge is increased by trialability and communication but not by observability. Subjective Norms have strongest influence on intention to use.
Königstorfer, 2008	Mobile parking service	Innovativeness Mobility Contact to Change Agents External Influences Self-Efficacy Perceived Ease of Use Self-Identity Fun Perceived Usefulness Attitude Social Influence Intention	186 persons in Germany and 170 persons in Austria	Personal interviews	R_2 ΔR_2, Liklehood-Ratio-Test, chi-square difference test, Goodness-of-Fit-test	Perceived Usefulness together with Self-Identity have the strongest influence on intention. Social Influence strongly determines Attitude and Intention. Innovativeness increases Perceived Usefulness.
Hashim, 2008	Web-Based Training	Perceived Ease-of-Use, Perceived Comfortableness Perceived Usefulness Perceived Support	261 employees	Written questionnaire personally administered	Factor analysis	Perceived Ease-of-Use, Perceived Comfortableness and Perceived Usefulness are all significantly related to Attitude. Strongest relationship between Perceived Usefulness and Attitude.
Kwong and Park, 2008	Digital music services	Perceived Ease of Use Perceived Usefulness Attitude Subjective Norm Perceived Behavioural Control Perceived Service Quality	217 students	Online questionnaire	GFI, AGFI, CFI, IFI, TLI, RMSEA	Attitude, Subjective Norm and Perceived Behavioural Control have a positive effect on intention. Perceived Ease of Use and Perceived Usefulness have a positive influence on attitude.
Bouwman et al., 2007	Mobile Services	Barriers towards use Attitude Current Use Entertainment character Flexibility Intended future use	484 persons	Email questionnaire		No overall predictiveness achieved. Entertainment character has a positive influence on intended future use
Kim, Chan and Gupta, 2007	Mobile Internet	Perceived Usefulness Fun Technical Quality Costs Intention	161 persons	Online questionnaire		Perceived Usefulness is the strongest determinant of intention. Cost has the most negative influence on intention. Fun has the most positive influence on intention.

Author / Date	Research Context	(Psychological) constructs used to explain technology acceptance	Sample	Data collection	Stat. tests employed	Main findings
Park, Yang and Lehto, 2007	Mobile Phones	Expected Benefit Expected Cognitive Expenses Social Influence Perceived Ease of Use Attitude, Intention	221 persons	Online questionnaire	Cronbach's Alpha, GFI, CFI, RMSEA	Expected Benefit and Social Influence have a positive influence on attitude. Expected Cognitive Expenses have a negative influence on attitude.
Omar and Owusu-Frimpong, 2007	Life Insurance	Attitude Subjective Norm Intention	240 persons	Written questionnaire	Cronbach's Alpha, T-tests	Intention is mainly determined by Subjective Norm.
Carlsson et al., 2006	Mobile devices and services	Expected Convenience Expected Costs Social Influence Perceived Ease of Use Attitude, Intention Use	157 persons	Email questionnaire	Cronbach's alpha,	Expected Convenience strengthens, while Expected Costs weaken intention. Attitude strengthens intention.
Fang et al., 2006	Mobile applications	Perceived Usefulness Perceived Ease of Use Playful approach Safety concerns Intention	101 persons	Email and written questionnaire	R_2 ΔR_2 T-Tests	Perceived Usefulness and Perceived Ease of Use strengthen intention (not in the case of games). Playful approach increases the intention to play games.
Hong, Thong and Tam, 2006	Mobile Internet	Perceived Usefulness Perceived Ease of Use Satisfaction with status quo Intention	1826 citizens of Hong Kong	Online questionnaire	GFI, AGFI, NFI, NNFI, CFI, RMSR	Perceived Usefulness and Perceived Ease of Use strengthen intention. Satisfaction with status quo has a rather weak influence on intention.
Koivumäki, Ristola and Kesti, 2006	Mobile Services	Perceived Usefulness Perceived Ease of Use Internal Resources External Resources Satisfaction with status quo, Intention	196 persons	Field Experiment and written questionnaire		Perceived Usefulness has the strongest influence on intention. External Resources are an important determinant of Intention.
Mahatanankoon, Wen and Lim, 2006	Mobile devices	Reliability of Service Perceived Usefulness Perceived Ease of Use Trustworthiness Attitude Intention	212 students owning a smartphone	Online questionnaire		Reliability of Service strengthens Perceived Usefulness, Perceived Ease of Use and Trustworthiness. Perceived Ease of Use has a stronger influence on Attitude than Perceived Ease of Use.
Wang, Lin and Luarn, 2006	Mobile Services	Self-Efficacy Financial Resources Perceived Usefulness Perceived Ease of Use Trustworthiness Intention	258 participants of a trade fair	Written questionnaire	$\chi 2$/d.f., GFI, AGFI, NFI, NNFI, CFI, RMSR, SRMSR, RMSEA	Perceived Usefulness, Trustworthiness and Financial Resources have the strongest influence on intention. Self-Efficacy increases Perceived Ease of Use. Perceived Ease of Use increases Perceived Usefulness and Trustworthiness.
Spence and Townsend, 2006	Genetically Modified Food	Moral Norms Emotional Involvement PCB Intention Behaviour Self-Identity Attitude Subjective Norms	99 participants	Written questionnaire	T-tests, Cronbach's alpha.	All TPB components significantly predicted behavioural intentions, with attitudes toward being the strongest predictor. Self-identity and emotional involvement were also found to be significant predictors of behavioural intentions but moral norms were not.

Author / Date	Research Context	(Psychological) constructs used to explain technology acceptance	Sample	Data collection	Stat. tests employed	Main findings
Bruner II and Kumar, 2005	Mobile Internet	Perceived Ease of Use Perceived Usefulness Fun Visual predisposition Type of device Attitude Intention	212 Students	Experiment followed by a written questionnaire	CFI, IFI, NNFI, RMR,RMSEA	Attitude is influenced more by Fun than by Usefulness. Perceived Ease of Use increases Perceived Usefulness and Fun.
Luarn and Lin, 2005	Mobile Banking	Perceived Ease of Use Perceived Usefulness Trustworthiness Self-Efficacy Costs Intention	180 participants of a trade fair	Written questionnaire		Perceived Ease of Use, Perceived Usefulness and Trustworthiness are major determinants of intention. Perceived Ease of Use increases Perceived Usefulness and Trustworthiness.
Pedersen, 2005	Mobile Internet	Perceived Ease of Use Perceived Usefulness External Factors Subjective Norms PCB, Attitude Intention Use	228 persons	Online questionnaire	$\chi 2$/df, NFI, CFI, IFI, RMSEA	Perceived Behavioural Control has a stronger influence on intention to use than Attitude and Subjective Norms. Perceived Usefulness is the strongest determinant of Attitude.
Wu and Wang, 2005	Mobile Commerce	Risk Costs Compatibility Perceived Usefulness Perceived Ease of Use Intention Use	310 persons	Combined online and written questionnaire	GFI, AGFI, NFI, NNFI, CFI, RMSR	Intention is a strong predictor for actual use. Compatibility and Perceived Usefulness are the strongest determinants of Intention. Perceived Ease of Use has no influence on intention.
Yang, 2005	Mobile Commerce	Individual characteristics Perceived Usefulness Perceived Ease of Use Attitude	866 students	Written questionnaire	R_2, ΔR_2, Cronbach's alpha	Perceived Usefulness positively influences Attitude and Perceived Ease of Use. Perceived Ease of Use has no influence on intention.
Fusilier and Durlabhji, 2005	Internet Usage	Perceived Ease of Use Perceived Usefulness Attitude Subjective Norm PCB Intention	269 college students	Written questionnaire	R_2, ΔR_2	User experience did significantly interact with components of the TPB and the TAM model, suggesting that it has a complex influence on internet user intentions.
Gruner t and Ramus, 2005	Internet Food Purchasing	Attitude Subjective Norm PCB Perceived Difficulty Risk Aversion Food-Related Lifestyle Wired Lifestyle	na	na	na	Perceived Benefits and Disadvantages, beliefs about others' reactions, beliefs about availability of resources, and beliefs about personal abilities strongly influence Intention.
Kleijnen, Wetzels and de Ruyter, 2004	Mobile Banking	Perceived Ease of Use Perceived Usefulness Costs System Quality Social Norms Attitude Intention	105 persons with mobile internet access	Written questionnaire	R_2 ΔR_2, Cronbach's alpha.	Usefulness and Perceived Ease of Use are the only determinants of Attitude Social Norms and Attitude are the only determinants of intention.
Pedersen and Nysveen, 2003	Mobile Parking	Perceived Ease of Use Perceived Usefulness Attitude	459 individuals	Combined online and written questionnaire	confirmatory factor analysis, NFI, RFI, IFI, CFI, RMSEA	Usefulness and Attitude have a positive influence on Intention . Usefulness and Perceived Ease of Use have a positive influence on Attitude.

Author / Date	Research Context	(Psychological) constructs used to explain technology acceptance	Sample	Data collection	Stat. tests employed	Main findings
Teo and Pok, 2003	Smart Phones	Relative Advantage Perceived Ease of Use Image Compatibility Risk Subjective Norms PCB Intention	1012 with 587 asked via Newsgroup and Forums and 425 asked via mail	Internet Questionnaire	GFI,AGFI, NFI RMSEA, RMR	Perceived Behavioural Control has no influence on intention. Relative Advantage and Image strengthen intention while perceived risks reduce intention.
Hung, Ku and Chang, 2002	Mobile internet services	Attitude Subjective Norm Perceived Behavioural Control Perceived Ease of Use Perceived Usefulness Innovation affinity	267 individuals	Written questionnaire		Attitude and Subjective Norm positively influence intention. Perceived Behavioural Control has no influence. Attitude is mainly determined by Usefulness.
Jaensirisak, 2002	Road User Charging	General Attitudes Personal Characteristics Effectiveness Perceives Current Situation Perceived Attributes Acceptability Intention	830 persons of the general public	Written questionnaire	Likelihood ratio test, chi-square difference test	The acceptability of road user charging is influenced by perceptions of benefits to self and to society and by the system features of the charging scheme.
Sparks and Shepherd, 2002	Genetically Modified Food	Attitude Subjective Norm Perceived Behavioral Control Perceived moral obligation. Intention	61 persons of the general public	Written questionnaire, personally administered in a second step	R_2 ΔR_2	Salient Beliefs representing Attitudes, Subjective Norms, and Perceptions of Behavioural Control were significant determinants of intentions, Independent predictive effect of perceived moral obligation on behavioural intentions.
Braithwaite, Sutton and Steggles, 2002	Testing technology for hereditary cancer	Attitude Subjective Norm Perceived Behavioral Control Attitude Towards Uncertainty Intention	124 persons (breast cancer), 168 persons (colon cancer)	Written questionnaire	R_2 ΔR_2, chi-square difference test	The TPB components and Attitude Towards Uncertainty are the strongest predictors of intention. Attitude Towards Uncertainty moderates Intention.
Hrubes, Ajzen and Daigle, 2001	Hunting behaviour	Attitude Subjective Norm Perceived Behavioral Control Intention Behaviour	395 outdoor recreationists	Written questionnaire	R_2 ΔR_2	Attitudes toward hunting, subjective norms, and perceptions of behavioural control were significant determinants of intentions. These predictors correlated highly with sets of underlying beliefs. Background factors were largely mediated by the components of the TPB.
Li, 2001	Tertiary education program	Country-of Origin (COO) (Australia, UK, USA) Attitude Subjective Norm Perceived Behavioural Control Intention Behaviour	633 year 12 students	Written questionnaire in the normal class setting	RMSEA, RMR, Cronbach's alpha, chi-square difference test	Attitudes, Subjective Norms and Perceptions of Behavioural Control were significant determinants of intentions, irrespective of the Country of Origin (COO) of an education program.

The above summary of the main aspects from contemporary research in the field of acceptance research reveals a number of similarities among the reviewed studies. First of all, there is a clear focus on computer-related technologies as a research subject. The most common research subjects are mobile phone related services and online commerce systems. In terms of geographic location, there are no clear commonalities apparent among the reviewed studies. Acceptance research takes place on every continent, and in lesser-developed countries, such as Nigeria or Tunisia, as much as in well-developed countries, such as the USA or the UK. In terms of applied methodology, most of the studies rely on the application of a survey instrument, in written or online form. Only two of the studies have employed personal interviews and a further two have combined a field experiment with a written questionnaire. The resulting questionnaire data was analysed using a range of statistical tests. Most of the authors employed a structural equation model or regression model and estimated the predictive power of the model using a measurement of R-squared and further model-fit estimates such as RMSEA.

Recapitulating the chapter objectives, the most important reason for conducting this review of empirical studies was to elicit potential determinants of acceptance behaviour. Thus, the extracted factors, which were employed by the authors to predict the acceptance behaviour in the respective context of study, deserve the most attention and will consequently be discussed in detail in the next step.

3.14 Main Findings and Implications of Reviewed Studies

Each reviewed study used between three and fourteen predictors to explain acceptance behaviour. It is particularly interesting that most studies relied on either the TPB or the TAM model, as a basis, and extended the models with several novel predictors that were suspected to be important in the relevant research subject. Chart 18 shows a summary of the applied psychological constructs in the 49 studies reviewed. For this chart, only constructs that were used in more than three studies were considered.

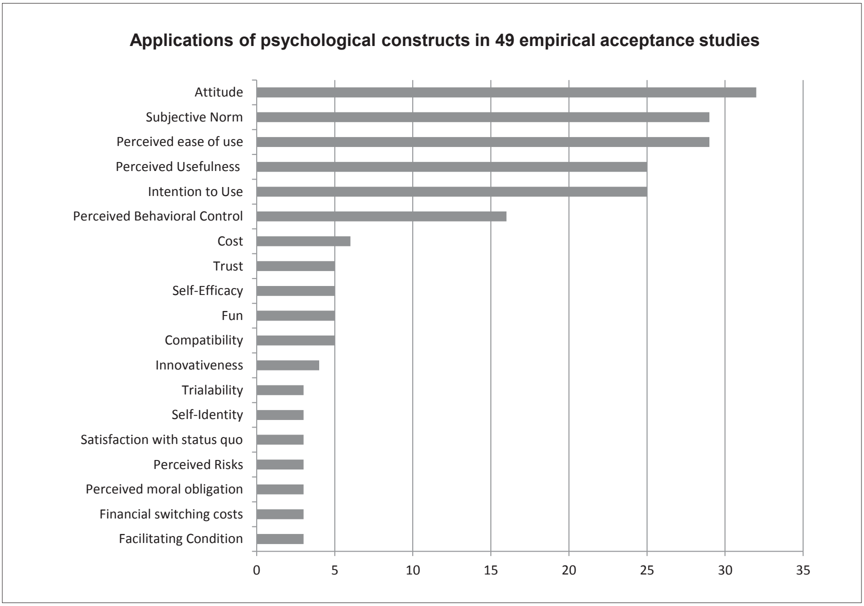

Chart 18: Applications of psychological constructs in empirical acceptance studies

It is important to acknowledge, however, that the above overview only gives the frequency of applied constructs, disregarding the outcome of the respective studies. Most studies revealed that one or more of the employed predictors did not significantly contribute to the prediction of acceptance behaviour. The results vary markedly from one study to the next, so that only major tendencies across all studies can be reported.

Generally, attitudes and subjective norms, which are at the core of the TPB model, as well as Perceived Ease of Use and Perceived Usability, which are at the core of the TAM model, were consistently found to be the main determinants of product acceptance. Since these factors were already discussed in the previous theoretical chapter as major determinants of acceptance behaviour, this is not particularly surprising. A closer look at the research findings, however, revealed that below the surface of these core factors, a multitude of further motives were found to be involved in the innovation acceptance decision, which deserve more attention.

One common result of this review is that generally the acceptance of innovations involves paradoxical effects, meaning that motives that support acceptance and motives that support resistance are both prevalent in the consumer's belief set. One such motive for resistance, especially in the field of private consumer behaviour, is the technologies' effect on non-functional motives, such as perceived enjoyment. Further examples of resistance motives are the perceived risks of a new technology and the technology's effect on personal freedom of choice. Generally, satisfaction with the status quo leads to increased reluctance towards change and thus towards innovation resistance. Factors supporting the acceptance decision were found in the area of social norms. Increased peer pressure based on the perceived spread of a new technology in the peer group or based on moral obligations tends to support the acceptance decision. The general attitude towards new technologies and past experiences with a technology were also reported to be decisive factors for technology acceptance by many authors.

Since these factors are the major contribution of this review to the further research progress, the implications of each psychological determinant for the present research subject will be discussed in the next step.

Paradoxical Effects

Comparing the findings of empirical studies in the area of technology, it becomes obvious that acceptance and resistance co-exist in consumers' evaluations. New technologies often involve paradoxical effects, which end-users are actually quite aware of (Heiskanen et al., 2007, p.501). On the one hand, consumers generally appreciate the comfort or safety benefits that these systems offer, while on the other hand consumers have serious concerns about the reliability of these systems and the influence they have on their daily life (Brookhuis, de Waard and Janssen, 2001, pp.247–251). It is expected that in the context of ADAS, consumers will correspondingly form positive and negative evaluations at the same time. Thus, it is a necessary precondition to investigate motives for both acceptance and resistance in order to fully understand the adoption process of ADAS.

Non-Functional Motives

One important aspect of resistance towards innovations is the technologies' effect on non-functional motives. Acceptance studies in the field of online shopping behaviour consistently report that the shopping task provides more to the customer than the simple purchase and replacement of goods (Keeling, 1999, p.129). Various social and personal motives, such as self-gratification and sensory stimulation, are involved in the shopping process in addition to the acquiring of a good or service. In general, non-functional motives, like enjoyment and entertainment, have been found to be more influential than the pure utility function (Wonga et al., 2012, p.240).

Based on an empirical study, Chtourou et al. (2010, p.340) have reported, consistent with other work, that enjoyment mediates the effect of usefulness on the attitude towards a new technology. In other words, if the usefulness of a product does not generate amusement for the consumer, then even a high utility will have only a limited impact on the decision to adopt a new technology. As an example, a useful system that is very slow might fail in satisfying the user not because it is useless but because it is irritating and annoying (Chtourou and Souiden, 2010, p.341).

When transferring these findings to the context of ADAS it becomes apparent that customer motives in the case of personal transport reach far beyond only driving from A to B. Driving enjoyment and the general entertainment factor of driving might play an important role in the motives of many customers and thus might influence the acceptance decision towards ADAS.

Perceived Risks of Technology

Perceived risk as opposed to objective risks serve as a major motive for technology resistance. It is acknowledged that some activities are perceived as being more hazardous than others. A failure in a part of a bicycle, for example, is perceived as being less hazardous than the failure in a part on a plane (Bekiaris and Stevens, 2005, p.284). When a new technology is associated with potential hazards to one's well-being, it comes as no surprise that this fact might have a negative influence on the acceptance decision. Most studies in the field of technology acceptance indicate that perceived risks differ substantially from objective risks (see Wu and Wang, 2005 and Grunert and Ramus, 2005). In general, perceived risk affect the adoption decision when circumstances of the decision create feelings of uncertainty, psychological discomfort and anxiety (Sattabusaya, 2008, p.58). In the case of ADAS, technology is aimed at supporting or substituting manual tasks. Perceived risks are thus dependent on the extent to which the consumers believe that potential system failures are more likely than own driving errors. Recent studies indicate that most drivers consider themselves at least as better drivers than average with respect to safe behaviour (Brookhuis, de Waard and Janssen, 2001, p.251). At the same time, information about the potential reliability of ADAS technology is very low in the public (German Road Safety Council e.V. (DVR), 2010). Nabih et al. (1997, p.52) postulate that a lack of understanding of the product's functionality may create "fear effects" which lead to extreme resistance towards the technology. Customers might thus be more likely to trust in their own capabilities instead of handing over these tasks to a device. As a result, perceived risks might act as a major motive for resistance towards innovation in this specific case.

Loss of Control, Autonomy and Empowerment
Another related motive for resistance is the technologies' effect on control, autonomy and empowerment. In general, handing over control to a device is evaluated as a negative aspect of technology (Brookhuis, de Waard and Janssen, 2001, p.247). Mick and Fournier (1998, p.125) argue that on a personal level, people are concerned that smart technologies might one day "take over" their lives, substituting their own responsibilities and leading to a loss of individual choice and the freedom to follow one's impulses. In a highly planned and organized world, people want to preserve their zones free of management. Smart technologies can improve life, but at the same time they come at the cost of giving up control and decision freedom. In the context of ADAS, this effect might be particularly important, since automobiles are, in general, an expression of personal freedom. If ADAS technology is perceived as restricting the free choice of travel route, travel speed or driving style, this fact might act as a motive for resistance towards the technology.

Satisfaction with Status Quo
While perceived risks often create active resistance towards new technology, many innovation acceptance studies indicate that passive resistance occurs as well, mainly caused by satisfaction with the status quo (see Hong, Thong and Tam, 2006; Koivumäki, Ristola and Kesti, 2006 and Bamberg, Ajzen and Schmidt, 2003). By using some products repeatedly over a long period of time, consumers form habits and routines. In general, they aim to preserve these habits and strive for consistency and status quo rather than to continuously search for and embrace new behaviours (Bagozzi and Phillips, 1982, p.219). According to Sheth (1981, p.275) this might even be "the single most powerful

determinant in generating resistance". Based on an empirical study, Bamberg et al. (2003, p.176) concluded that habits are even a stronger predictor of behaviour than the TPB Model in some behavioural categories (the study investigated the choice of transport options). Generally, strong attitudes toward existing objects usually increase the resistance to change and may prevent consumers from being open to innovations. In this case, further processing of information about an innovation may require a new openness to change or even a change in one's attitudes toward the habitual target (Hee-Woong and Kankanhalli 2009, p.567). However 'changing people's customs is an even more delicate responsibility than surgery in many cases' (Rogers, 2003, p.436).
The introduction of ADAS technology requires a change in driving habits. Since driving is, as noted before, generally a rather emotional activity with strong attributes towards specific behaviours, the impact of resistance towards change is expected to be significant in this context.

Perceived Installed Customer Base

Another attribute that is important in the context of many acceptance studies is the perceived installed customer base. In general, humans base their decisions as to whether or not to adopt a new behaviour on the perceived number of relevant others who are or are not already performing the specific behaviour (Fishbein and Ajzen, 2010, p.130). Especially in the field of consumer innovations, the perceived customer base was found to have a relevant impact on the acceptance decision. The perceived market share of an innovation can serve as a signal of product quality to potential adopters, who may infer the quality and utility of a product from the number of existing adopters (Song, Parry and Kawakami, 2009, p.304). While for highly visible innovations, perceived market share may be almost equal to, or sometimes even exceeding, the real market share, for nonvisible innovations, in contrast, the perceived installed base of customers might be much smaller than it actually is. Since in the case of ADAS, the adoption of the technology is not directly visible to others, the perceived installed customer base will potentially be a restricting factor for technology diffusion unless communication efforts (e.g. an "ADAS" badge on the back of a car) are established.

Linguistic Attributes

The name of a new product is another important aspect influencing the individual decision-making. Usually new products are labelled with novel, often rather technical, attributes. The name given to an innovation often affects its perceived compatibility, and therefore its rate of adoption. According to Rogers (2003, p.250), inadequate attention has been paid to what innovations are called by potential adopters, and as a result, many serious mistakes have been made. Past research suggested that adding novel linguistic attributes to a product is likely to improve its product evaluation in the mindset of potential customers. However, more recent studies indicate that positive effects of novel attributes are likely to be obtained only in the case of relatively low-complexity products, such as refrigerators and washing machines, in the case of high-complexity products, such as computers or automobiles, the addition of novel linguistic attributes can actually reduce product evaluation because of learning-cost inferences made about these attributes (Mukherjee and Hoyer, 2001, p.470). In the field of ADAS a vast amount of highly technical acronyms and abbreviations are offered to the customer (such as ESP, ABS, ACC etc.), who often draws his or her first conclusions about the possible utility of these systems from the name alone (European Commisson esafety initiative, 2007, p.4). Thus the current linguistic attributes used for this technology are another possible motive for resistance in the case of ADAS.

Subjective Norms / Peer Pressure

According to many studies, understanding the relationships between users may be more critical than factors relating to the product itself (see Khalifa and Shen, 2008; Omar and Owusu-Frimpong, 2007; Park, Yang and Lehto, 2007). Rogers (2003, p.245) argues that individuals do not evaluate an innovation solely on the basis of its performance as judged by objective attributes. Rather, they decide whether or not to adopt the product on the basis of the subjective evaluations of the innovation conveyed to them by others like themselves (peers). These findings are in accordance with the original TRA model proposed by Fishbein and Aizen (2010), which postulated that behaviour is only determined by attitude and subjective norms, where Subjective Norms are defined as "perceived social pressure to perform or not to perform a given behaviour" (Fishbein and Ajzen, 2010, p.130). Even though the majority of acceptance studies (27 out of 49, see Chart 18) report a major effect of subjective norms, it must be acknowledged that in some contexts, subjective norms were not found to significantly influence the adoption process (see Karahanna, Agarwal and Angst, 2006, p.213; Omar and Owusu-Frimpong, 2007, p.967; Swartz and Douglas, 2009, p.36). The level of influence of subjective norms or peer pressure on the adoption decision in the case of ADAS is thus difficult to estimate from literature research alone. However, based on that fact, that especially in the area of consumer goods, subjective norms are rather important, it is expected to find some impact of peer pressure on the decision to use ADAS technology.

Self-Identity

Several researchers have addressed the concept of self-identity for predicting innovation acceptance (see Königstorfer, 2008; Pelling and White, 2009; Spence and Townsend, 2006). The concept of self-identity is a set of socially constructed roles reflecting the extent to which individuals see themselves as fulfilling the criteria for particular societal roles (Pelling and White, 2009, p.756). In other words, self-identity reflects the extent to which engaging in a behaviour is important to an individual's self-concept. On the basis of past research, Conner and Armitage (1998) argued that it is reasonable to assume that there are certain behaviours for which self-identity is an important determinant for innovation acceptance. Empirical research confirmed that self-identity impacts intentions to engage in behaviours that are performed relatively frequently (e.g., food choices), and those performed relatively infrequently (e.g., consumption of luxury goods); however, it is expected to have a stronger impact on the latter (Smith et al., 2008, p.215). Since the purchase of ADAS technology is linked to the purchase of a new car, which is a rather rare act for most people, it is expected that the self-identity of consumers plays a major role in the acceptance process.

Perceived Moral Obligation

A number of studies have incorporated moral concerns as a potential motive for innovation acceptance (see Bradley, 2007; Spence and Townsend, 2006). According to Sparks and Shepherd (2002, p.300), this is congruent with positions in other disciplines that would argue for the importance of morals in social and personal actions. Additionally, the rising tide of ethical consumerism means that moral issues are likely to be present in many instances of consumer behaviour. Perceived moral obligations are thus expected to be an important determinant of innovation acceptance in the consumer product context (Sattabusaya, 2008, p.51). Generally, moral norms are defined as personal norms regarding what is right and what is wrong (Spence and Townsend, 2006, p.658). As opposed to laws and regulations, moral obligations are completely subjective and solely based on the subjective impression of what ought to be done or not done. Especially in the context of food innovations (e.g. fair-trade coffee), moral concerns have been found to be an important motive for acceptance (see Bradley, 2007; Spence and Townsend, 2006). Whether or not moral concerns have an influence on the adoption decision towards ADAS technology is unknown. It is expected, however, that the overall positive influence of these systems on road safety might have a positive moral influence on the purchase decision.

Past Experiences

According to Rogers (2003, p.15) past experiences determine the degree of compatibility of an innovation with existing ideas, values and practices. The compatibility in turn is a major determinant for the adoption decision. Ajzen and Fishbein (2010, p.289) report correspondingly that "including past behaviour as an additional predictor has consistently been found to produce a substantial increase in the amount of explained variance in later behaviour". In some contexts, past behaviour was even found to be the single most important determinant of the adoption process (see Fusilier and Durlabhji, 2005). It remains unclear whether past experience is a motive in its own right or whether it is part of the attitude component as discussed above (Keeling, 1999, p.168). However, transferring these findings to the context of ADAS, it becomes obvious that past experience with similar technologies might have a significant influence on the future adoption decision. If, for instance, a customer has purchased an early driver assistance system, such as ESP, which he believes has saved his life in a critical driving situation, this would certainly have a positive influence on the decision to adopt the more advanced ADAS technology.

Innovativeness

Rogers and Shoemaker (1971) defined innovativeness as "the degree to which an individual is relatively earlier in adopting new ideas than other members of his social system" (p. 27). Others define innovativeness as the relative affinity to test new products or technologies (Königstorfer, 2008, p.42). Even though only a minority of studies employ this concept, those that do emphasize the "role individual innovativeness plays in shaping technology acceptance" (Chiu, Fang and Tseng, 2010, p.454). Since driver-assistance systems are part of a highly emotional product, namely cars, it is expected that general innovativeness plays a significant role towards the acceptance of this technology.

Emotional Involvement

One determinant of technology acceptance that has mainly been found in a consumer context is emotional involvement with the behavioural or product category. According to Chtourou et al. (2010, p.340), the impact of emotions goes beyond the consumption of hedonic products and extends to the adoption of technological products, such as mobile phones or computers. Emotional involvement is generally defined as "the extent to which the individual is engaged with (or disinterested in) the behaviour at hand" (Spence and Townsend, 2006, p.659). In other words, emotional involvement represents the level of perceived personal importance and/or interest evoked by a certain technology. This emotional engagement with a new technology or the broad category of its application has been found to positively impact the decision to adopt a new product offered in this field. Transferring these results to the context of ADAS, it is expected that consumers who are generally more emotionally attached to cars are more likely to adopt ADAS technology. On the contrary, however, it could be argued that automobile enthusiasts might be more reluctant to adopt a technology that is aimed at substituting driving tasks and thus a reciprocal causal relationship could also hold true.

Conclusion

In conclusion, the discussed studies have delivered a comprehensive list of potential determinants which have been proven useful in their respective contexts of research. It has to be acknowledged that most of these studies have focussed on the use of technological innovations that are significantly different in many aspects from the use of ADAS. Due to the lack of scientific work in the context of ADAS, the next chapter will focus on studies conducted by commercial and governmental entities in the field of driver-assistance systems.

3.15 Review of Commercial Innovation Acceptance Studies

By extending the literature review to non-scientific publications, several studies in the context of ADAS conducted by governmental authorities and the industry are available for drawing conclusions. It should be acknowledged that most studies in the commercial field only survey the overall level of ADAS usage and the level of ADAS awareness without an attempt to assess the underlying reasons for these results. Some of these studies, however, are especially noteworthy and allow for generalisations to be drawn, since they are based on a relatively large and representative sample size.

Performing a representative market study, Oliver Wymann (2007, p.9) found several reasons for resistance towards ADAS along the innovation acceptance process. In the knowledge stage, the plethora of available innovations, the perceived complexity of the innovation's usage and the multitude of confusing terms used for these innovations tend to reduce the acceptance rate. In the decision stage the main problems according to this study are budget restrains (mainly due to uptrading of car models) and the different benefit perceptions along different customer segments (mainly due to customer polarisation). Another industry study by one of the leading suppliers of ADAS components asked a representative sample of German end-users to agree or disagree with a set of eight possible advantages and shortcomings of ADAS (Happe and Lütz, 2008, p.14). While around sixty percent of end-users agreed that ADAS would provide "more safety", around thirty percent reported that they feared that ADAS might result in "unconcentrated driving" or "distraction". Interestingly, another almost thirty percent did not find any disadvantage of the four listed to hinder them from using an ADAS (Happe and Lütz, 2008, p.14). It was not disclosed, however, how these eight advantages and disadvantages were selected and the limitation to these eight factors certainly influenced the decision making of respondents. The complete results of this study are displayed in Chart 19.

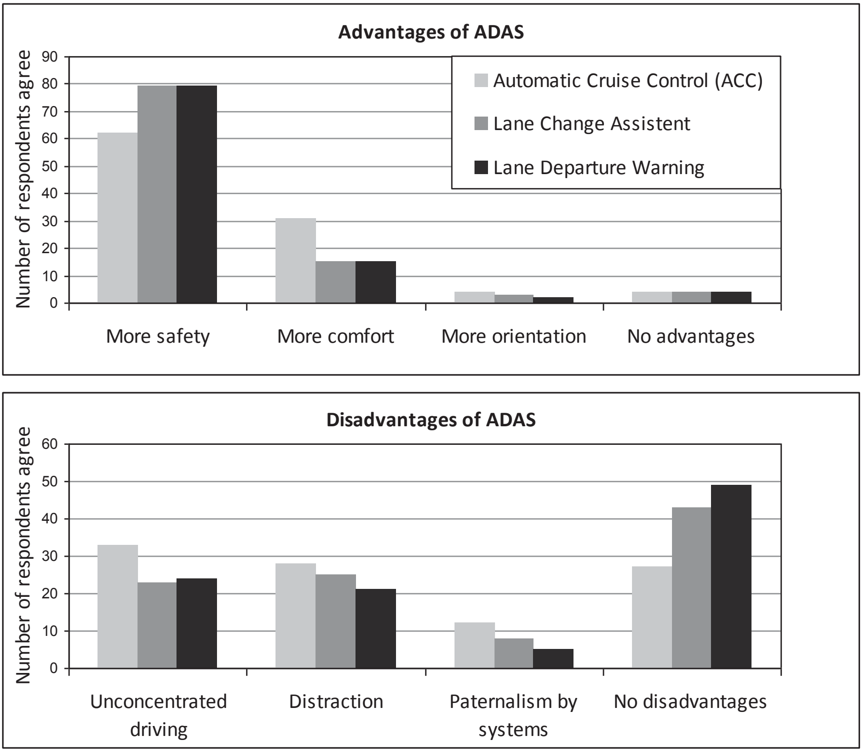

Chart 19: Perceived advantages and disadvantages of ADAS on the German market, Source: Own drawing based on Happe and Lütz (2008, p.14)

The most comprehensive study in the context of ADAS, however, was conducted on behalf of the European Commission as part of the Eurobarometer research. The study covered representative samples of all twenty-five member states of the European Union, with a total of 24,815 citizens being interviewed face to face about their perception of intelligent vehicle system (European Commision - Eurobarometer, 2006, p.3). In conclusion, this empirically strong study revealed seven core reasons for resistance towards ADAS. ADAS was perceived as being: too expensive (fifty-one percent), too unreliable (twenty-four percent), reducing drivers' alertness by creating an artificial feeling of being protected (twenty-three percent), too expensive to service (twenty-two percent), creating too much visual and sound warning (nineteen percent), being too difficult to understand (twelve percent) and undermining drivers' freedom (eleven percent) (European Commision – Eurobarometer, 2006, p.47). Capturing a vast amount of demographic data (including driving habits), this study also analysed the user segments in accordance with perceptions towards ADAS usage. One of the major findings was that "males and those who have a higher level of education as well as those who drive a lot and have bought a new car – the categories that are also likely to belong to the group of potential users of intelligent vehicle systems – tend to consider these systems more useful" (European Commision - Eurobarometer, 2006, p.56). Those who indicated that they drove a small car or a second-hand car were, however, slightly less likely to consider these systems worth having in their car (European Commision - Eurobarometer, 2006, p.56). In other words, the group that appears to have limited access to these systems also appreciates them less, while individuals with easier access to this technology tend to have more positive attitudes towards them. Chart 14 gives an overview of the reasons for resistance towards ADAS elicited in this study.

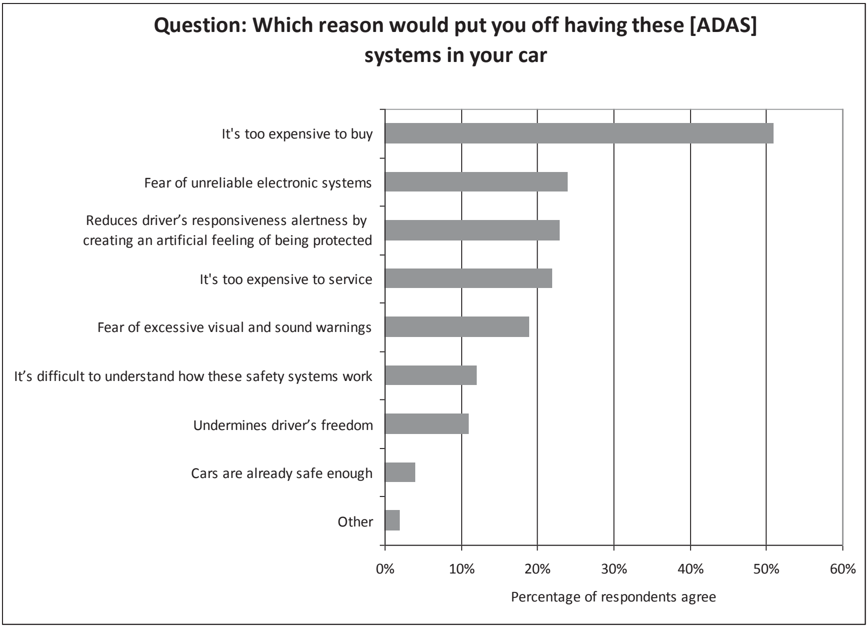

Chart 20: Reasons for resistance towards ADAS, Source: Own drawing based on European Commission - Eurobarometer (2006, p.47)

In sum, the commercial studies discussed so far have provided a first representative overview of potential determinants of ADAS acceptance. It has to be acknowledged, however, that these studies have only asked for predetermined beliefs towards ADAS acceptance, while none of the studies has revealed the process of how these potential beliefs were elicited beforehand. From a scientific point of view, these studies have also failed to explain the causal relationships of individual beliefs and thus failed to create an explanatory and predictive behavioural construct towards the end-user acceptance of ADAS.

3.16 Implications from the Literature Review

Scientific as well as commercial studies have contributed important aspects for understanding individual innovation acceptance behaviour. In order to use these findings for the later stages of the present research, it is necessary to concentrate and integrate these findings in a clearly arranged manner. Each of the innovation acceptance studies reviewed so far has applied or developed concepts in order to explain the acceptance behaviour. Some of these concepts, such as attitude or perceived social pressure, appear regularly, while others, such as moral concerns, were only found to be relevant in a few studies. Thus it was necessary to generate a list of potential core concepts derived from the literature. This set was developed by:

1) Extracting the main findings from the considered acceptance studies;
2) Grouping similar concepts from different authors;
3) Grouping concepts with different wordings but the same meaning.

In sum, a list of fifteen core concepts resulted, which are expected to explain most of innovation acceptance behaviour in any given context. The relevance of these concepts for the present research was judged by:

1) Elaborating their relevance in the literature, based on the number of applications;
2) Assessing the explained variance in innovation acceptance behaviour, which was attributed to these concepts in the reviewed studies;
3) Evaluating the potential relevance for the subject of driver-assistance systems based on logical reasoning.

Using this process, the set of seventeen core concepts was again grouped from the top tiers, which are expected to have very high influence on acceptance behaviour, to the lowest rank, which are expected to have only a minor influence on acceptance behaviour. The following table gives an overview of the results matrix.

Table 8: Acceptance factors derived from secondary research

Concept (alphabetic order)	**Short description**	**Significance of the concept** (Based on applications of the concept in the literature and the explained variance in innovation acceptance behaviour that was attributed to the concept in the reviewed studies)		**Reference** (Original reference and applications)
Attitude	A learned orientation, or disposition, providing a tendency to respond favourably or unfavourably to an object (Gross, 1992, p.515).	Very high	Attitudes towards an innovation were consistently found to be a major explanation for its acceptance.	Fishbein and Ajzen, 2010, multiple applications
Behavioural Control	People's perceptions of their ability to perform a given behaviour, i.e. adopting a certain innovation (Fishbein and Ajzen, 2010, p.21).	Low	Even though this concept is widely employed in acceptance research as part of the TPB model, its ability to explain the acceptance behaviour was in most cases found to be insignificant.	Fishbein and Ajzen, 2010, multiple applications
Emotional involvement	The extent to which an individual is engaged with (or disinterested in) the adoption object (Spence and Townsend, 2006, p.659).	Context specific	Rarely applied in innovation acceptance literature, this concept was only found to be significant in consumer product acceptance.	Chtourou and Souiden, 2010; Spence and Townsend, 2006
Innovativeness	"The degree to which an individual is relatively earlier in adopting new ideas than other members of his social system" (Rogers and Shoemaker, 1971, p.27).	High	Widely applied in empirical research, this concept is generally treated as a background variable (like age, gender or socio-economic status). Two studies, however, also used this concept as a predictor for attitude towards an innovation.	Chiu, Fang and Tseng, 2010; Königstorfer, 2008; Rogers, 2003
Linguistic Attributes	Novell attributes and names given to an innovation.	Low	Despite the fact that this concept is often discussed in the literature on a theoretical level, there is too little empirical material to judge the significance of this concept.	European Commisson esafety initiative, 2007; Mukherjee and Hoyer, 2001; Rogers, 2003
Loss of control, autonomy and empowerment	The degree to which an innovation substitutes personal responsibilities and leads to a loss of individual choices.	Context specific	This factor was only applied in the area of technological innovations that are aimed at substituting manual tasks. In these cases, however, the concept was found to be significant.	Brookhuis, de Waard and Janssen, 2001; Mick and Fournier, 1998
Non-functional motives	Personal motives that are not related to the basic function of an innovation, such as self-gratification, enjoyment or sensory stimulation.	High	Non functional motives were generally found important in consumer product innovation acceptance.	Bruner II and Kumar, 2005; Chtourou and Souiden, 2010; Cui, Bao and Chan, 2009; Kim, Chan and Gupta, 2007
Past Experiences	Past experiences determine the degree of compatibility of an innovation with existing ideas, values and practices (Rogers, 2003, p.15).	Moderate	This concept was found to be a significant factor for acceptance in some studies, others could not report any impact.	Fishbein and Ajzen, 2010; Fusilier and Durlabhji, 2005; Rogers, 2003
Perceived Ease of Use	The degree to which a person believes that using a particular system would be free of effort (Davis, Bagozzi and Warshaw, 1989, p.985).	Very high	Virtually all studies applying the TAM model report that this concept has a significant influence on attitude, which in turn significantly influences the acceptance of innovations.	Davis, Bagozzi and Warshaw, 1989, multiple applications

Concept (alphabetic order)	**Short description**	**Significance of the concept** (Based on applications of the concept in the literature and the explained variance in innovation acceptance behaviour that was attributed to the concept in the reviewed studies)		**Reference** (Original reference and applications)
Perceived installed customer base	Perceived number of relevant others who have or have not already adopted a specific innovation (Fishbein and Ajzen, 2010, p.130).	High	Especially in the field of consumer innovations, this concept was found to have a relevant impact on the acceptance decision.	Fishbein and Ajzen, 2010; Song, Parry and Kawakami, 2009
Perceived Moral Obligation	Personal norms regarding what is right and what is wrong (Spence and Townsend, 2006, p.658).	Context specific	Even though the rising tide of ethical consumerism means that moral issues are likely to be present in many instances of consumer behaviour, empirical studies could only report significance of this concept in some product categories so far (e.g. food).	Bradley, 2007; Sattabusaya, 2008; Spence and Townsend, 2006
Perceived risks	The perception that the adoption of a certain innovation involves risks and thus creates feelings of uncertainty, psychological discomfort and anxiety (Sattabusaya, 2008, p.58).	Context specific	This concept has only been reported significant for some technological innovations like mobile banking, thus its significance is likely to be context dependent.	Grunert and Ramus, 2005; Wu and Wang, 2005
Perceived Usefulness	The degree to which a person believes that using a particular system would enhance his or her job performance (Davis, Bagozzi and Warshaw, 1989, p.320).	Very high	Virtually all studies applying the TAM model report that this concept has a significant influence on attitude, which in turn significantly influences the acceptance of innovations.	Davis, Bagozzi and Warshaw, 1989, multiple applications
Satisfaction with status quo	By using some products repeatedly over a long period of time, consumers form habits and routines, which they like to preserve (Bagozzi and Phillips, 1982, p.219).	Context specific	Several studies found this concept being the strongest predictor for acceptance behaviour; others, however, reported only minor impacts.	Bamberg, Ajzen and Schmidt, 2003; Hong, Thong and Tam, 2006; Koivumäki, Ristola and Kesti, 2006
Self-Identity	Self-identity is a set of socially constructed roles reflecting the extent to which individuals see themselves as fulfilling the criteria for particular societal roles (Pelling and White, 2009, p.756).	High	Even though rarely applied, this concept was consistently reported to be a significant predictor.	Königstorfer, 2008; Pelling and White, 2009; Spence and Townsend, 2006
Social Norms	Perceived social pressure to adopt or not to adopt a certain innovation (Fishbein and Ajzen, 2010, p.21).	Very high	A widely applied and integral part of the TPB model, this concept was consistently found to be a significant predictor.	Fishbein and Ajzen, 2010, multiple applications
Trust	The reasonable expectation (confidence) of an individual that the adoption of an innovation will be beneficial for him or her.	Context specific	Only a minority of studies, mainly in the field of high-tech innovations such as mobile banking, considered trust as a factor influencing the acceptance behaviour. Yet, those studies reported a strong significance of this factor.	Hahn and Kim, 2009; Luarn and Lin, 2005; Mahatanankoon, Wen and Lim, 2006; Tsai, Chin and Chen, 2010; Wang, Lin and Luarn, 2006

As expected, the concepts derived from the Theory of Planned Behaviour (TPB) and from the Technology Acceptance Model (TAM) were judged highest in terms of their potential predictiveness towards the acceptance behaviour. Other concepts received varying results depending on the context in which they were applied. It remains to be clarified whether or not these concepts will be relevant in the specific context of ADAS acceptance. Consequently, it is imperative for the author to conduct primary research in the context of ADAS in order to verify and revise the results presented so far.

3.17 Chapter Conclusion

The present chapter has provided a substantial contribution to the current research and laid out the foundation for the further empirical research phase. In the absence of widely-agreed definitions for the relevant terms of the present thesis, this chapter started by providing an overview of available definitions for the terms *Innovation*, *Adoption* and *Rejection*. Subsequently, the differences and similarities of definitions and the specific components of the term *Innovation* were discussed in order to develop a new definition which is most comprehensive yet applicable to the present research context. In the next step, the author provided an overview and a critical evaluation of available models for explaining the acceptance of innovations. Contemporary empirical work employing these models was consequently reviewed and the core elements were integrated into a tabular overview. Based on this academic work, the author developed a compendium of potential determinants of innovation acceptance and discussed their potential application in the case of ADAS. The chapter ended with a list of potential determinants of innovation acceptance, providing a first conceptual framework for further research.

Chapter 4: Research Approach

4.1 Chapter Objectives

The present chapter is aimed at specifying the methods and procedures for collecting and analysing data within the empirical part of the research project. In a first step, this chapter will discuss the author's philosophical approach towards the research questions. Based on the author's epistemology in alignment with the research problem, appropriate methodologies for data collection will be discussed. Finally, a research design will be proposed and justified, including multiple research steps and incorporating different methodological approaches.

4.2 Understanding Epistemological and Ontological Considerations

In order to investigate the reality of research problems, a philosophical approach for research has to be adopted. Different philosophies imply different ways of finding a solution to a theoretical problem. Applying different approaches to the solution of the same problem, however, might generate different results (Sattabusaya, 2008, p.88). In general one has to distinguish between the philosophy's ontology, meaning the theory of being, focusing on the beliefs about the real world which is being researched, and the epistemology, meaning the knowledge that is required and seen by the researcher (Alrafi, 2007, pp.101–102). The research methodology in this context refers to how we do logical and empirical work (Lee, 2004, p.5). It is often argued that research methods carry with them an inherent cluster of epistemological and ontological commitments, such that the decision for one research method inevitably selects a specific science model and worldview. Research methods, however, are versatile instruments and do not necessarily indicate an assumption about knowledge and the nature of social reality (Bryman and Bell, 2007, p.631). In contrast, it is more promising to define the epistemological and ontological positions as a starting point for making methodological decisions. According to Easterby-Smith, Thorpe & Jackson (2008, p.56), there are at least three reasons why an understanding of philosophical factors is a necessary prerequisite for defining an appropriate research design:

1) It helps to clarify what kind of evidence is required and how this evidence is to be gathered and interpreted in order to answer the research question.

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2) It helps to recognise which research design will be most appropriate to answer the research questions and which limitations this design inherits.
3) It helps the researcher to identify or even create designs that are outside his or her past experience and to adopt these designs according to the constraints of different subject or knowledge structures.

The starting point for identifying a philosophical position is the researcher's ontology. Ontological views are mainly divided into two opposing schools of thought, which can be traced back to the philosophers Heraclitus and Parmenides. While the Heraclitean approach views the world as changing and emergent, Parmenides places an emphasis on a permanent and unchanging reality. Followers of Parmenides see reality as being composed of clearly formed entities with identifiable properties, which can be represented by signs and language. In contrast, Heracliteans place an emphasis on formlessness, interpenetration and the limitations of truth-seeking due to an ever-changing environment. The Parmenidean ontology of *being* clearly dominates in Western thought; however, recently, notions of an increased orientation towards a Heraclitean ontology of *becoming* are noticeable (Gray, 2011, p.7). Today, ontological schools of thought are usually divided into *realism* and *relativism*. Realism builds on Parmenides' thoughts and emphasises that the world is concrete, external and independent from scientists and their activities. Relativists, on the other hand, argue that the development of scientific laws is always influenced by the protagonists, their position and their resources, and thus the truth of scientific laws is never independent from the process of its discovery (Easterby-Smith, Thorpe and Jackson, 2008, p.61). Between these extreme positions, researchers have recently developed a new paradigm, the so-called *critical realism*. Critical realism can be seen as a compromise between both positions and claims that a reality can exist independently from our knowledge of it, but also recognises that concepts in social sciences are human constructions and are thus subjective (Bryman and Bell, 2007, p.62).

4.3 Major Philosophical Paradigms in Social Research

Epistemologies are general sets of assumptions about the most appropriate ways of generating knowledge about the nature of the world (Easterby-Smith, Thorpe and Jackson, 2008, p.62). It is obvious that epistemological decisions are generally, if implicitly, based on the worldview of the researcher, or in other words, on his or her ontological school of thought. Rooted in different worldviews, epistemological approaches also have two opposing extreme positions: *Positivism* and *Interpretivism* (Carson, 2001, p.5).

The positivistic research paradigm argues that the study of human behaviour should be conducted in the same way as studies are conducted in the natural sciences. It is based on the principle that reality is independent of the observer and exists regardless of whether one is aware of it. Thus the positivist takes a rational approach to understanding the world that is always external and objective (Sattabusaya, 2008, p.89). "Positivism holds that an accurate and value free knowledge of things is possible. It holds out the possibility that human beings, their actions and institutions can be studied as objectively as the natural world" (Fisher, p.19). In a positivist approach, the theory to be tested is generally deductive. Firstly hypotheses are developed by the researcher and then they are used to test the theory in order to prove it or dismiss it. In positivism, objective knowledge can be gained from direct experience or observation, the only available source of knowledge for science (Alrafi, 2007, p.122).

Interpretivists, on the other hand, believe that reality can only be discovered through an understanding of the multiple social constructs of meaning and knowledge. Interpretivism puts an emphasis on the belief that knowledge can only be gained through understanding the social construction of the world (Alrafi, 2007, p.123). According to Klein and Myers (Klein and Myers, 1999, p.69), research can be classified as interpretive if "it is assumed that our knowledge of reality is gained through social construction such as language, consciousness, shared meanings, documents and other artefacts". In interpretive research, the scientists do not predefine dependent and independent variables: instead, they focus on the complexity of human sense-making as the situation emerges and try to understand how people invent structures to explain phenomena around them (Easterby-Smith, Thorpe and Jackson, 2008, p.63).

Followers of both philosophies view their paradigms as the ideal approach for research. Over the last decades, however, a number of further paradigms have been developed, each situated between these two extreme positions. The most well known is the so called *Postpositivism*, which acknowledges that scientists actively construct scientific knowledge rather than passively noting laws that are found in nature (Crotty, 2009, p.31). A further step towards interpretivism represents the school of *Critical Theorists / Critical Realists*, which emphasises the understanding of the (objective) world through subjective meanings. Table 9 shows the major philosophical paradigms in social research and their associated ontology, epistemology and methodologies.

Table 9: Major philosophical paradigms in social research, Source: Based on Guba and Lincoln (2009, p.193)

	Positivism	**Post-Positivism**	**Critical Theory**	**Interpretivism**
Ontology	Naïve realism – "real" reality	Critical realism – "real" reality but only imperfectly	Historical realism – reality is virtual and shaped by society	Relativism – local and specific constructed reality
Epistemology	Objectivist: findings are true	Modified objectivist, critical tradition – findings probably true	Subjectivist – value-mediated findings	Subjectivist – created findings
Methodology	Experimental/ manipulative: verification of hypotheses, mainly quantitative methods	Experimental/ manipulative – critical multiplism, falsification of hypotheses, may include qualitative methods	Dialogic/dialectical	Hermeneutical/dialectical

According to Easterby-Smith, Thorpe & Jackson (2008, p.71), the major strength of the positivist paradigm is that it generally provides a fast and economical method for generating evidence in a wide range of situations. At the same time, the positivistic approach suffers from inflexibility and has been found to be "not very effective in understanding processes or the significance that people attach to actions"(Easterby-Smith, Thorpe and Jackson, 2008, p.71). Since positivists usually focus their approach on empirical data, there is a risk of ignoring important nuances and/or explanations that lie outside of the conceptual framework being employed (Neergaard and Ulhøi, 2007, p.105). Postpositivism emerged as a reaction to these disadvantages, while still putting an emphasis on the importance of empirical, thus "value-free", data for problem solving

(McNabb, 2010, p.19). This rather new approach links the observer to that being observed, acknowledging that there are no objective things standing apart from human subjectivity. Objectivity is seen as an ideal by Postpositivists; however, given the multiplicity of causes and effects and the problem of social meaning, it requires a critical community of interpreters to arrive at a most objective interpretation of reality (Yolles, 2006, p.74). This worldview also has methodological implications. When objectivity can never be entirely achieved, relying on many divergent sources of information decreases the potential to arrive at misinterpretations of reality (Guba, 1990, p.21). It needs to be acknowledge that there are no right/ wrong or better/worse paradigms. However, since these philosophical paradigms are incommensurable and widely incompatible, it is important to clearly state which school of thought underlies the reasoning of one's scientific work (Okasha, 2002).

4.4 Justification of Postpositivistic Research Approach

As outlined in the previous chapter, the researcher's decision on the evidence needed to solve a particular research question inevitably carries along a certain set of philosophical assumptions. While the author beliefs in the existence of a reality which is concrete, external and independent from the observer, the author also acknowledges that reality can never be fully known, since the efforts to understand reality are limited by human beings' sensory and intellectual limitations.

Recalling the research objectives of the present research, it is the central aim of this thesis to develop an understanding of which psychological factors influence the decision-making towards the acceptance of driver-assistance systems. The author beliefs that there is no single and thus entirely objective answer to this question, since both, the individual decision-making of consumers, as well as researcher's interpretation of it is based on human subjectivity. The knowledge that will be developed throughout this thesis is consequently a human construct and generally based on observations and perceptions. Because perception and observation are fallible, the researcher's constructions are generally imperfect which may affect the neutrality of this work. The author, however, strongly believes that it is the responsibility of the researcher to put aside personal biases and beliefs and strive to be objective, neutral and ensure that the findings fit with the existing knowledge base. The best approach for achieving objectivity is to triangulate across multiple fallible perspectives in order to derive a combined, thus less biased perspective on the research question. Transferred to the research questions this means that the author will develop different measurements of the psychological constructs involved in the acceptance of driver-assistance systems. Since all measurements are fallible, multiple measures and observations, which may possess different types of error, will reduce the overall error of measurement and thus deliver a more objective and neutral result.

In regard to the discussion of philosophical paradigms outlined in the previous chapter, this research position can be best described as following the post-positivist paradigm. As noted before, this also causes several methodological implications, which will be discussed in the next step.

4.5 Methodological Considerations

After determining the philosophical approach, the next step is to identify the appropriate methodologies that will be employed in order to answer the research questions. Methodology can be defined as "the logic of the application of scientific methods for investigation of phenomena" (Mouton and Marais, 1988, p.16). There are various classifications of methodologies; the most common, however, is the distinction into quantitative and qualitative methodologies (Bryman, 2006b, p.1). Quantitative methodology is usually associated with inferences based on large numbers of dataset observations and statistical analysis, while qualitative methodology bases inferences on relatively few datasets and puts an emphasis on causal-process observations (Gerring, 2012, p.362). Both methodological approaches will be discussed in more detail in the next step.

4.6 Quantitative Research in Social Science

Quantitative research is generally associated with applying methods and procedures of the natural sciences to the social sciences. The main idea is that there are regular patterns in human and organisational behaviour, but these are difficult to detect because of the number of factors and variables which might produce the observed result. Consequently, multiple factors need to be measured simultaneously to examine the potential underlying relationships. Since this process involves making approximations of reality, relatively large samples are usually required (Easterby-Smith, Thorpe and Jackson, 2008, p.90).

Even though the quantitative approach can be associated with a number of different data collection methods, the main methods of data collection, which are also used as a classification for this research approach, are surveys and experiments. Due to the need for large sample sizes in sociology, the survey has emerged as the most popular method of data collection in this research field (Bryman, 2006b, p.11).

Addressing a research problem with quantitative methods usually means generating hypotheses that derive from general theories about the research object. These hypotheses are expectations about potential causal relationships between psychological concepts, whereby their degrees of variation and co-variation maybe measured (Bryman, 2006b, p.18). Consequently,quantitative methods require the use of standardised measures to fit the divergent views of people into a limited number of predetermined response categories to which numbers are assigned (Patton, 2005, p.46). Usually this is accomplished by conducting a survey, based on a questionnaire with a number of multiple-choice questions, each asking the respondent to choose an answer on a fixed-point scale.

The review of existing innovation acceptance studies has revealed that surveys were used in most of the cases as exclusive research methods (see Table 7). All of these studies applied standardised quantitative models (e.g. the TRA/TPB model) for predicting the acceptance of technological innovations. In accordance with this, the present research will employ a survey method to develop a quantitative model of acceptance behaviour.

4.7 Qualitative Research in Social Science

Qualitative research mainly originated from the intellectual field of sociology, "a science which attempts the interpretive understanding of social action in order to arrive at a causal explanation of its course and effects" (Weber, 1947, p.90, quoted in Bryman, 2006b, p.57). Qualitative research has become a fashionable term, being used for any method other than a survey. The main distinction of qualitative research, in contrast to quantitative research, however, is that it produces data that are freely defined by the subject rather than structured in advance by the researcher (Dey, 1998, p.15). While quantitative methods reduce data to scales and numbers, qualitative methodologies allow for an interpretation of the rich and complex reality of the world (Mayring, 2002a, p.10).

A fundamental characteristic of qualitative research is its approach to view actions from the perspective of the people who are being studied. This implies that the researcher has to develop a sound understanding of his target population, usually achieved by persistent participant observation. Yet, other methods, most importantly in-depth, unstructured interviews and group discussion, also proved to be successful in generating the necessary empathy to see the world through the eyes of those being studied (Bryman, 2006b, pp.61–62).

Since this study is aimed at uncovering the beliefs that lead to technology adoption or rejection, direct observation is not feasible. Even if the observer would be present at the point of sale, he or she would not be able to draw any conclusion on action motives from observation alone. Neither focus groups nor any other sort of group discussion are particular useful in this context, since those methods tend to reveal the salient beliefs of dominant individuals that lead the discussion and might therefore give a biased view of the readily accessible beliefs represented in a population (Fishbein and Ajzen, 2010, p.103).

Personal interviews, finally, enable the researcher to elicit personal motivations, attitudes and beliefs pertaining to a particular topic (Flick, 2010, p.156). The strengths of interviews as a qualitative research method fit with the research objectives stated. Consequently the author decided to use in-depth personal interviews as a qualitative research method for the present study.

4.8 Mixed Methods Approaches

In a purist's view, qualitative and quantitative research methods, including their associated methods, cannot and should not be mixed. Over the last decades, however, support for a mixed method approach to research has emerged, and can now be considered as a paradigm in its own right (Johnson and Onwuegbuzie, 2004, p.14). This new paradigm recognises that both qualitative and quantitative methods offer different strengths and weaknesses. Both methods constitute alternative, but not necessarily mutually exclusive, strategies for research. A mixed methods approach thus could "bridge the schism between quantitative and qualitative research" (Johnson and Onwuegbuzie, 2004, p.15) and lead to an advancement in science (Sattabusaya, 2008, p.91). At the same time, however, criticism of the mixing of methods has emerged. The main arguments against mixed methods are that research methods inevitably carry epistemological commitments which are often incompatible and that qualitative and quantitative research are two distinct paradigms on their own (Bryman and Bell, 2007, p.643). While this apparent conflict is not yet completely resolved, there is common agreement that the purpose of mixing different methodologies must be made clear by the researcher, as well as the intended process of combining different approaches (Bryman, 2007, p.8).

In principle, there are various ways of combining divergent methodological approaches and it is important to acknowledge that there is no one mixed methods methodology (Bazeley, 2002, p.2). One of the most common forms of mixed methods is triangulation. In social science, triangulation means the mixing of data or methods so that diverse viewpoints or standpoints cast light upon a topic. Triangulation can thus be defined as "an approach in which multiple observers, theoretical perspectives, sources of data, and methodologies are combined" (Denzin, 1970, p.310, cited in Bryman, 2006b, p.131). The basic intent of triangulation is to use two or more aspects of research to strengthen the design and thus to increase the ability to interpret the findings (Thurmond, 2001, p.253). Mixing data types is often thought to help in validating the claims that might arise from an initial study, while the mixing of methods, e.g. mixing survey and interview methods, is a more profound form of triangulation. (Olsen, 2004, p.3).

One idea of triangulation is to employ more than one method of investigation, for instance quantitative and qualitative research methods. Generally, quantitative and qualitative research may be perceived as different ways of examining the same research problem (Bryman, 2006b, p.131). Thus, a combination of both promises a better understanding due to the different perspectives on the research problem. Next to the methods triangulation, researchers can also combine more than one type of data or more than one type of data analysis technique. Table 10 gives an overview of the different triangulation methods and their characteristics.

Table 10: Types of triangulation, Source: based on Thurmond (2001, p.253)

Triangulation Type	Characteristic	Example
Data Source Triangulation	Data sources for investigation vary based on time, space or person	Repeat a survey in different locations
Investigator Triangulation	Using more than one observer, interviewer, coder or data analyst	Using two different researchers analysing the same data set
Methods Triangulation (within-method)	More than one data collection procedures from the same design approach	Using a survey and secondary data for quantitative analysis
Methods Triangulation (between- or across-method)	Employing both qualitative and quantitative data collection methods	Using interviews and a survey
Data-Analysis Triangulation	Combination of two or more methods of analysing data	Using different statistical-techniques to determine similarities or validate data

Next to triangulation, mixed methods can also be applied for explanation. This means that one method is used to explain the findings resulting from another. The reciprocal of this is exploration. This means that one method is used to identify units of research, which are investigated with a second method (Bryman, 2006a, p.98).

So far, most studies in the context of innovation acceptance literature apply a rather positivistic approach, eliciting dependent and independent variables by employing questionnaire-based empirical research. Recently, however, studies applying a mixed method approach have increased in number (Lee, Kozar and Larsen, 2003, p.753). Many of these studies reported that applying this paradigm helped them to gain a deeper insight and a better understanding of behaviour than either paradigm could have provided separately (Hwa, 2006, p.129). This idea is also increasingly supported by behavioural theorists. In one of their latest publications, Ajzen & Fishbein (2010) recommended basing the application of their model on extensive formative research, applying free-response interviews to elicit salient beliefs and thus employing a mixed methods approach towards the exploration of innovation acceptance. In correspondence to these findings, this study will be incorporating the strengths of both methodological approaches by applying a methods triangulation of qualitative and quantitative methodologies.

4.9 Defining a Research Design

A research design is defined as "... a set of advance decisions that makes up the master plan specifying the methods and procedures for collecting and analyzing the needed information"(Burns and Bush, 2002, p.120). Primarily, a research design helps to align the planned methodology to the research problems in accordance with the research philosophy chosen for a given study (Sattabusaya, 2008, p.93). Thus, it can be seen as a detailed construction plan used to guide a research study towards its objectives. The most crucial decision in creating this plan is the choice of an appropriate research approach, since this determines how the information will be obtained (Kumar, Aaker and Day, 2002, p.67). As discussed in the previous chapters, the choice of a research approach depends widely on the nature of the research and the philosophical approach towards problem solving. This includes not only the choice of specific data collection methods but also the data analysis, research tactics and most importantly the continuous safeguarding that all pieces of the research fit together and deliver what should be delivered according to the research objectives (Kumar, Aaker and Day, 2002, p.67). Robson (2009, p.81) argues that all aspects of research design are interrelated and thus should be kept balanced to ensure that the interaction of different methods and approaches will support the research objectives.

In order to develop the most appropriate research design for the present research objectives, different aspects have to be considered. In accordance with the research philosophy stated in the previous chapter, the author will follow a post-positivistic approach, which aims at complete objectivity but acknowledges that psychological constructs are based on human subjectivity. Qualitative research methods offer a deep understanding of individuals’ beliefs, but have the disadvantage that they are usually limited to a non-representative sample and thus increased subjectivity. This means that the findings cannot be generalised for the chosen population. Quantitative methods, on the other hand, have the advantage of a huge sample size, which comes at the cost of reducing individual beliefs to predefined answer sets. As a consequence of this, and in alignment with the research philosophy, a methods triangulation of quantitative and qualitative research methods will be necessary to approach the research problem in the most appropriate way.

It is important to acknowledge, however, that even though quantitative and qualitative methods may provide mutually reinforcing results, the possibility of discrepant findings also exists. (Bryman, 2006b, p.133). Generally, discrepancies are not a sign of a flawed research design, but instead can be beneficial in their own right. Investigating the differences in the results may lead the researcher to probe certain issues in greater depth, which may lead to fruitful areas of inquiry in their own right (Bryman, 2006b, p.133). For the present research, triangulation will lead to a multi-stage process in which data from secondary research and qualitative research will build the foundation for a standardised, quantitative research. This approach diminishes differences between the data sets, since the quantitative stage can only produce data within the merits of the results from the qualitative stage. Yet, initial results or hypotheses from the qualitative stage might be refuted due the analysis of the quantitative data.

The decision on a mixed-methods approach raises further important methodological issues. The first question to be addressed is the process of combining methods and thus in the present case whether quantitative and qualitative data will be collected simultaneously or sequentially. Second, the question of focus arises. Robson (2006b, p.128) remarks that even though methods triangulation means giving quantitative and qualitative methods comparable weight, most researchers rely mostly on one approach, but support their findings with a method using the other approach. Third, and probably most important, is the question of which function the mixing of methods has in the research progress – triangulation, exploration or explanation (Bryman, 2006a, p.98). The approach of the present research towards these key questions is summarized in Table 11.

Table 11: Decisions on the mixed-methods approach

Key questions of mixing methods	Research decision
Are qualitative and quantitative data collected simultaneously or sequentially?	Qualitative data will be collected before quantitative data. Thus a sequential mixed-methods approach will be employed.
Which method has priority?	In the case of discrepancies in findings, only findings that were confirmed by the quantitative stage will be accepted as real; thus, the quantitative stage has a priority function.
What is the function of the integration of methods?	The qualitative research phase will have both an explorative function, supporting the development of the quantitative research instruments, and an explanatory function, helping to interpret the results of the quantitative research instrument.

To conclude, the basic research design will include three steps. In the first step the literature review will deliver the basic psychological and behavioural models as well as potential determinants of innovation acceptance from previous studies in different technological contexts. In the second step qualitative interviews will be employed to elicit individual beliefs that are related to the acceptance of ADAS. These determinants will be matched against the determinants that evolved from the literature review.

The resulting list of potential determinants of innovation acceptance will constitute the main content of the questionnaire. For each construct, a set of items will be developed based on the interview results and the literature review of comparable questionnaire formulations. Finally, scales will be developed for each item and the questionnaire will be administered to a small sample for a pre-test. After necessary corrections, the final questionnaire will be administrated to a representative sample of potential car customers in Germany. The resulting data will be analysed using statistical methods. Finally, the quantitative results will be interpreted by integrating the findings from the qualitative stage. Chart 21 gives an overview of the intended research process.

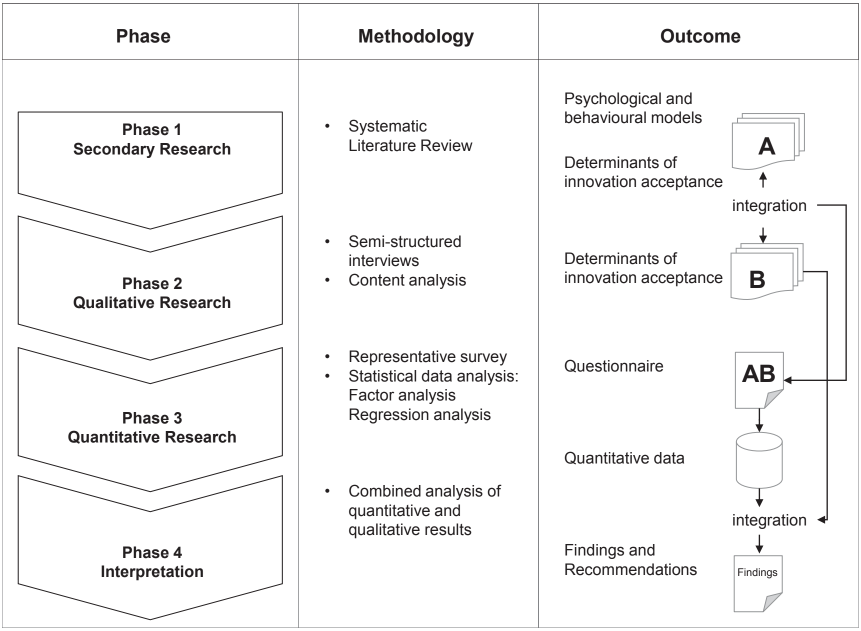

Chart 21: Intended research process, Source: Own drawing

4.10 Chapter Conclusion

The aim of the present chapter was to develop a well-defined research process for collecting empirical data. Starting with a discussion of different philosophical viewpoints, the author's postpositivistic epistemological position was acknowledged and justified based on the research questions of the present thesis. The author discussed the differences between quantitative and qualitative methods as well the current developments towards a mixed-methods paradigm. By sequentially aligning qualitative and quantitative methods in a mixed-methods approach, the proposed research design of the present thesis will integrate the results of both methods in two ways. First, the qualitative phase will provide an explorative approach to the subjective belief sets of individuals in the case of ADAS acceptance, supporting the development of a quantitative questionnaire in the next step. Second, the results from the qualitative stage will be used to interpret findings from the questionnaire data, and consequently also have an explanatory function. In sum, the presented research design provides a strong methodological foundation and a detailed guideline for the remainder of the present research and thus fulfils the objectives of the present chapter.

Chapter 5: Qualitative Research Approach

5.1 Chapter Objectives

According to the research design, the overall aim of this chapter is to develop concepts that are involved in the individual belief formation towards the use of Advanced Driver-Assistance Systems. These concepts constitute the basis for the construction of a quantitative questionnaire; thus, they should be:

- As complete as possible, covering all sorts of affective and cognitive, conscious and unconscious, favourable and unfavourable beliefs towards ADAS technology;
- Clearly described, mutually exclusive and exhaustive, with as little overlap as possible;
- Directly based on the interview response with a clear and reproducible reference.

It is clearly not the objective of this particular chapter to report on the significance and impact of these concepts or on their potential interrelation and cause-and-effect relationship. Rather, this chapter aims at a holistic collection of potential individual beliefs towards the acceptance decision, which can at a later stage be used in order to construct an explanative model based on representative empirical results.

5.2 Interview Types

The general aim of an interview is to reconstruct subjective theories, or in other words, to elicit the complex stock of knowledge an individual has about the topic under study (Flick, 2010, p.156). Unlike standardised surveys, which generate quantitative, measurable results, interviews generally deliver an extensive amount of verbal data or transcribed text. Another distinctive feature of interviews is that they have to be conducted in person, usually in a one-to-one setting. According to Webb (2002, p.71) interviews can be classified by their degree of structure and directness. Structure represents the amount of freedom that the interviewer has to change the content or order of questions, while directness refers to the amount of awareness the respondent has about the nature and purpose of the study. Completely structured or completely unstructured interviews are rather rare; most interviews involve some kind of structure around which the

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interviewer has considerable freedom to follow the thoughts of the interviewee (Robson, 2009, p.279).

Qualitative research has developed a number of specialised interview types, each with different characteristics and objectives. In research scenarios that focus on specialist knowledge, the *Expert Interview* is used to develop insights on a specific topic. In research scenarios interested in biographic aspects, the *Narrative Interview*, developed by Schütze (1983), is used to motivate the respondent to explain his or her thoughts in a storytelling form. The *Problem Centred Interview*, developed by Witzel (1982), combines a relatively strict contextual focus with a relatively open questioning approach. An overview of the different characteristics of interview types can be found in Table 12.

Table 12: Characteristics of interview types, Source: Based on Flick (2010, p.212)

Criteria	**Standardised Interview**	**Semi-Standardised Interview**	**Expert Interview**	**Narrative Interview**	**Problem-Centred Interview**
Openness to the interviewee's subjective view by:	Structured questions	Open questions	Limited because only interested in the expert, not the person	Non-influencing of narratives once started	Object and process orientation, room for narratives
Structuring (e.g. deepening) the issue by:	Structured questions	Hypothesis-directed questions, Confrontational questions	Interview guide as instrument for structuring	Generative narrative questions, Narrative questioning at the end	Interview guide as basis for turns and ending unproductive presentations
Domain of application	Confirming hypotheses	Reconstruction of subjective theories	Expert knowledge in institutions	Biographical courses	Socially or biographically relevant problems
Problems in conducting the method	Missing the subjective view of participants	Extensive methodological input, problems of interpretations	Role diffusion of the interviewee, blocking by the expert	Unilateral interview situation, problematic to develop pressure	Unsystematic change from narrative to question-answer schema
Limitations of the method	Assumption of knowing objective features of the object is questionable	Introducing structure, need to adopt the method to the issue and the interviewee	Interpretability of expert knowledge	Assumed analogy of experience and narrative, reducing the object to what can be recounted	Problem orientation, unsystematic combination of most diverse partial elements

Generally, the most appropriate way to choose an interview type for a given research topic is to start with the research objectives and develop an interview form that enables the researcher to fulfil these objectives most efficiently (Flick, 2010, p.211).

5.3 Decision on Interview Type

One of the aims in this part of the qualitative research is to collect salient beliefs pertaining to the use of ADAS technology. Literature research indicates that some questions will be necessary to elicit readily accessible beliefs towards a technology (Keeling, 1999, p.16). Thus, a completely unstructured interview will not be applicable in this case. At the same time, it is expected that the acceptance or resistance decision towards ADAS technology involves multiple complex and interconnected aspects of subjective and emotional elements. Consequently, the respondents as well as the interviewer should be as free as possible to follow their thoughts. An open discussion increases the possibility of revealing subliminal and subconscious beliefs, which respondents might not have been aware of beforehand.

Based on the literature review the author concludes that semi-structured interviews provide the best research solution for the given research objectives, leaving it to the interviewer to elaborate the respondent's answers and to vary the sequence of questions. In terms of directness, the interviews will honestly convey the main purpose of the research in advance, thus being rather direct by openly approaching the research topic. Chart 22 shows the two-dimensional characteristics-model of interviewing and classifies the chosen interview-type.

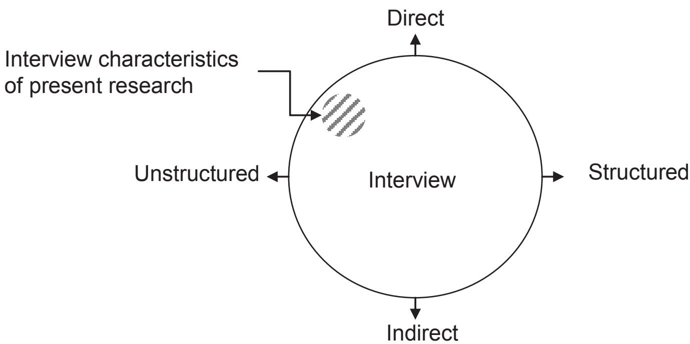


Chart 22: Interview characteristics, Source: Own drawing, based on Flick (2010, p.156)

This interview type will provide the following advantages in regard to the research objectives for the present study:

- Rather open questions concerning the advantages and disadvantages associated with ADAS technology will lead to a mutual discussion that helps to elicit subconscious beliefs
- The possibility of rephrasing and asking follow-up questions on a response will help the interviewer to focus on the relevant topics in relation to the research objectives
- By applying prompts and other techniques of active listening, the interviewer can assist the interviewees to fully develop their own trains of thought (Flick, 2010, p.172).
- By establishing an open dialogue, the interviewer creates mutual trust and thus the interviewee is expected to answer more openly, honestly and precisely than on a standard interview scheme (Mayring, 2002b, p.69).

5.4 Interview Design

In general, interviews should not be conducted with an *a priori* theoretical schema in mind. Hirschman (1986) argues that the researcher should be "interested in learning the group's construction of reality and how possessions, purchasing, apparel, automobiles and leisure time activities fit into that reality". The interviewer has to be aware that in a mutual interactive interview the values and beliefs of the interviewer may be projected on the respondent. Thus, when designing semi-structured interviews, it is important to concentrate on the research objectives and how these objectives can be achieved, avoiding any researcher bias.

According to Robson (2009, p.274) the basic contents of an interview are a set of items (usually questions), often with alternative subsequent items depending on the responses obtained. Furthermore, an interview design should contain a proposed sequence for the questions (which in a semi-structured interview may be subject to change) and suggestions for so-called probes and prompts. A probe is a method to get interviewees to expand on a response where the interviewer beliefs that they have more to say. There are various techniques for constructing probes. Mostly applied are short periods of silence or a short “mmhhmm” to stimulate another response. Alternatively, the interviewer might be prepared with probe sentences in advance (Zikmund and Babin, 2007, p.354).

As a starting point, it is important to make a short self-introduction. As a warm-up and motivator for the following interview, the interviewer should tell the respondent something about himself – his background and the reason for his interest in the area of enquiry. Flick remarks that it is essential to create a good atmosphere in this early phase of the interview and to give room to allow the interviewees to open up (Flick, 2010, p.172). According to Robson (2009, p.279) the interviewer should further use the introduction phase to:

- Explain the purpose and nature of the research
- Explain why the interviewee was selected for the interview
- Give the interviewee assurance the all responses will remain anonymous.

Following this initial phase, the topic is usually introduced by an open question followed by more theory-driven, hypotheses-directed questions (Flick, 2010, p.157). These questions are aimed at making the interviewer's implicit knowledge (derived from scientific literature about the research subject) more explicit by testing assumptions. In semi-structured interviews, "interviewers have their shopping list of topics and want to get responses to them, but they have considerable freedom in the sequence of questions, in their exact wording, and in the amount of time and attention given to different topics"(Robson, 2009, p.279). Researchers have the possibility to deepen their understanding of interesting aspects and develop a certain structure around their research problem. By responding to thoughts, emotions and beliefs, the interviewer also creates empathy with the interviewee, which helps to maintain an open and honest atmosphere during the interview (Mayring, 2002a, p.69).

It is common to have some more structured parts, for example to obtain some standard factual biographical material at the beginning or at the end of the interview. A strategy suggested by Robson (2009, p.279) was followed by providing the interviewer with a series of cards, each with another topic and the associated questions to it. Responses to all questions were immediately judged by the interviewer for being sufficiently elaborate and the interviewer deepened his understanding by asking follow-up questions as needed. It is important, however, that these questions do not unintentionally lead the interviewee in a certain direction but only give the interviewee the chance to follow his or her thoughts. Generally, theoretical concepts should not be developed during the interview;

instead, the interviewer should discover the life world of the interviewee (Flick, 2010, p.172).

5.5 Development of the Interviewer Questions

For the purpose of the present research, the interviews were aimed at eliciting pre-existing evaluations and beliefs that are persistent in the interviewee's subconscious decision-making process towards the acceptance of ADAS. The simplest and most direct procedure to achieve this goal is by asking respondents to name the advantages and disadvantages they associate with the technology in question. The first five to nine beliefs disclosed are readily accessible in memory and are therefore likely to serve as the primary determinants of attitudes towards the behaviour under investigation (Fishbein and Ajzen, 2010, p.100). In a second step, the interviewers prepared a list of more specific questions, each aimed at a feature of Driver Assistance-Systems, such as Lane-Keeping or Automated Cruise Control. These questions were asked if the conversation has not touched this topic so far during the interview (alternative subsequent items). Finally, as recommended by Flick (2010, p.157), the interview ended up with confrontational questions, each centred at the interviewee's reaction to the possibility of completely autonomous driving or legislative enforcement of ADAS usage. Autonomous driving represents an extreme form of a driver-assistance system. Thus it is expected that the prospect of giving up complete control raises extreme reactions, which might inspire further discussion. Also the prospect of legislative enforcement of ADAS usage might raise scepticism about the usefulness of driver assistance systems, especially for those respondents who indicated that they would not consider buying such a system.

Even though the exact formulation of questions might be subject to change in semi-structured interviews, some important aspects concerning the question quality have to be considered beforehand. First of all, it is important that the requirements imposed by each question must be in accordance to the respondent's capabilities (Zikmund and Babin, 2007, p.353). Any form of imposition and stress can negatively influence the interview atmosphere and thus can decrease the respondent's motivation. Moreover, the interviewer must be aware of the effects of choosing the right question wording. Generally, questions should be asked using everyday language and formulations that are not too complex (Faulbaum, Prüfer and Rexroth, 2009, pp.58–63).

Chart 23 gives an overview of the final interview design that was followed in the curse of the present research:

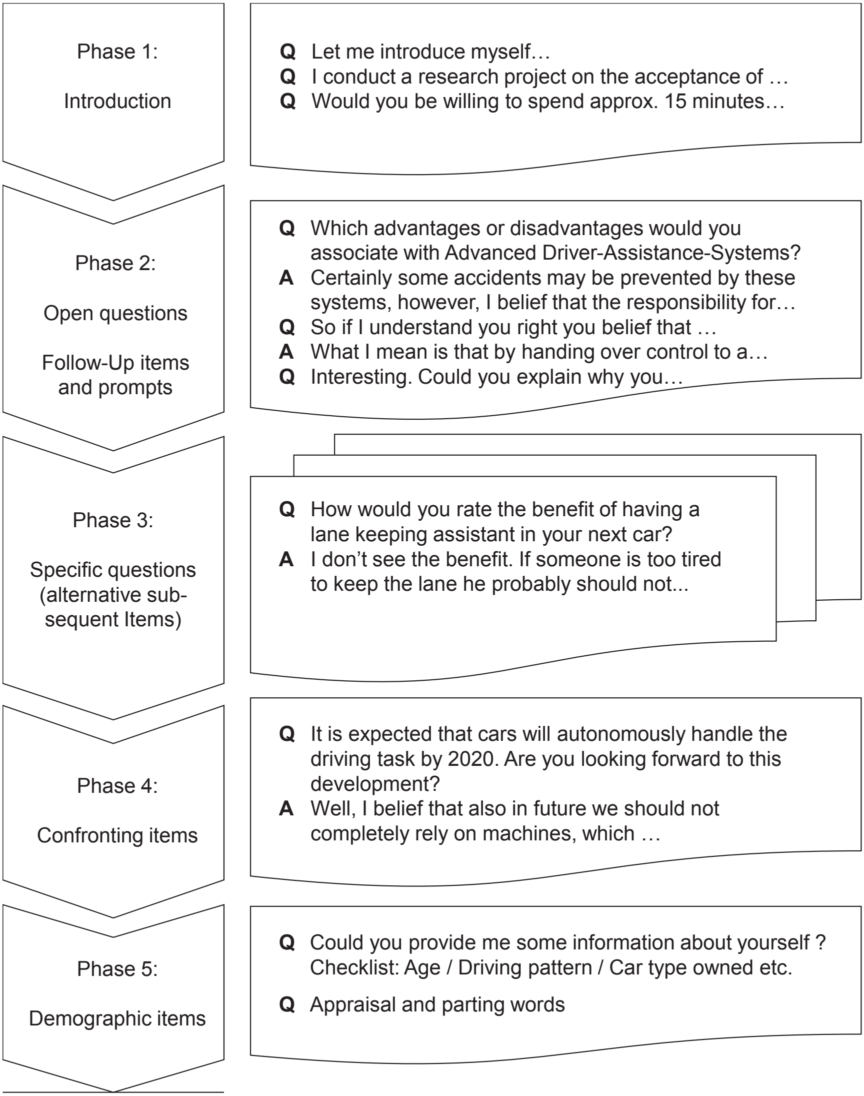


Chart 23: Interview Design Phase Model, Source: Own drawing

The given interview design was pre-tested in interview situations with a group of students. The advantage of pre-testing is that the interview process and content can be elaborated in a more relaxed atmosphere and the interviewers can become accustomed to the situation (Chenail, 2011, p.257). The final interviews were conducted independently by the author and two research assistants in June 2011. Flick (2010, p.391) argues that by having different interviewers conducting the same interview scheme, objectivity can be increased and potential interviewer bias can be reduced.

5.6 Development of the Interviewer Guide

Especially when having different interviewers, a standardised interviewer guide has to be developed in order to ensure a consistent administration of the interviews in any case. Even though standardised, an interviewer guide for semi-structured interviews is "much less specific than the notion of a structured interview schedule" (Bryman and Bell, 2007, p.482). Instead it is usually a list of memory prompts or areas to be covered, giving the interviewer the maximum possibility to follow the participant's thoughts, while offering enough structure to guide the interviewers along the topics that have to be addressed. Based on this, an interviewer guide was developed containing the relevant lead questions and items, the question objectives and their references. The complete interviewer guide can be found in Table 13.

Table 13: Interview guide

Category/ Item	Objective	Reference
1 Introduction		
• Explaining the background of the present research project	Connecting to the interviewee. Creating awareness and attention. Creating the necessary empathy for conducting the interview	Flick, 2010, p.172; Mayring, 2002a, p.69.
• Explaining the reason for the present interview and the approximate required interview duration – 15 minutes	Clarification of interview objectives	Lamnek and Krell, 2010, p.307
• Explaining information on consent form, especially: o participation is voluntary o the interview can be stopped at any time o all personal information will be kept confidential o the interview will be taped and later transcribed o the transcript will remain anonymous o The results of this interview will be published as part of a PhD thesis	Compliance with the ethical standards of scientific research	Robson, 2009, p.279
• Asking for consent to conduct the interview	Approval for conducting the interview	
• Explaining what Advanced Driver-Assistance Systems (ADAS) are, naming some examples, such as Lane Departure Assistance, Automatic Cruise Control or Blind Spot Monitoring.	Assuring that the respondent is aware of what the interviewer wants to ask him about (Corresponding to the Problem-Centered Interview).	Flick, 2010, p.161
• Asking for the level of experience with Driver-Assistance Systems. Have these systems already been purchased or experienced on other cars (rental car etc.)? Are these systems known from advertising or other information sources?	Elicit the individual's status in Rogers' phase model of innovation acceptance (1) Knowledge, (2) Persuasion, (3) Decision, (4) Implementation, (5) Confirmation.	Rogers, 2003, p.170
2 Open questions		
• Please list advantages and/or disadvantages of Driver-Assistance Systems in your opinion?	Elicit the readily accessible beliefs regarding Advanced Driver-Assistance Systems. The respondent should have sufficient time to deeply reflect on this question. If necessary, prompts should be applied to further elaborate on this question until all potential beliefs are elicited.	Fishbein and Ajzen, 2010, pp.96–97
• What are your expectations concerning the functionality of these systems?	Additional question to further reflect about the advantages of ADAS	Fishbein and Ajzen, 2010, p.289; Rogers, 2003, p.15
• Do you see risks using these systems?	Additional question to further reflect about the disadvantages of ADAS	
If the respondent has already used these systems: • Have your expectations concerning ADAS been fulfilled in the past? • Have you made positive and / or negative experiences with Driver-Assistance Systems in the past?	The influence of past experiences on the acceptance of this technology	Sattabusaya, 2008, p.58

3 Specific questions		
• Which Driver-Assistance System would you consider to buy next and why?	Basis for the following question-sequence.	
The following question-sequence should be applied for each assistance system the respondent has named so far.	Deepen the understanding of one specific assistance-system	
• Which specific advantages do you see in using this system?	Elicit the individual beliefs towards the specific system	
• Would you pay a price premium for having this system in your next car?	Elicit the relevance of costs of the acceptance decision	
• In which situations would you expect this system to be beneficial for you?	Reflection on the perceived usefulness of Advanced Driver-Assistance Systems in different driving situations.	Davis, Bagozzi and Warshaw, 1989, p.320
• How would you feel driving with this system?	Elicit affective responses in relation to Advanced Driver-Assistance System usage	Chtourou and Souiden, 2010, p.340
• Would you drive differently when this system is activated?	Influence of Advanced Driver-Assistance Systems on driving behaviour	
4 Confronting questions		Flick, 2010, p.157
• It is expected that cars will autonomously handle the driving task by 2020. Are you looking forward to this development?	Autonomous driving represents an extreme form of driver-assistance system development. It is expected that the prospect of giving up complete control will raise extreme reactions, which might inspire a further discussion	
• Since 2012, Electronic Stability Program (ESP) is mandatory for all new cars in the EU. Other assistance systems may become mandatory soon, too. What do you think of this development?	The prospect of legislative enforcement might raise scepticism about the usefulness of driver assistance systems, especially for respondents who would not consider buying such a system. Thus this question might also inspire a further discussion on the usefulness of ADAS.	
• Studies confirm that more than 50 percent of all accidents could be prevented with ADAS. Don't you believe that this could be a beneficial development for the society?	This question confronts the respondent with the moral concern of creating a benefit for the common public by using these systems. Thus it is expected that the respondent will reflect on whether or not he or she sees a moral obligation to use such a system.	
5 Demographic items		
Questions: • Type of car • Used/ New-car customer • Car age • Annual distance travelled by car Documentation: • Date of interview • Place of interview • Participant gender		
6 Appraisal for participation		

5.7 Defining a Recording Concept

Since the given interview design was expected to result in a considerable amount of verbal content, the need for an efficient documentation system has emerged. The interview responses have to be recorded in a way that enables the researcher to analyse the content at any later point of the project without any loss of meaning (Flick, 2010, p.294). Consequently the author decided to use an audio-taping system, digitally recording the interview discussion and allowing for a loss-free reproduction of the interview audio track at any time. The author consciously refrained from taping any visual data, since literature suggests that compared to audio taping, video taping has an irritating effect on respondents and thus might impede them from opening up (Lamnek, 2005, p.393). An additional protocol was kept for the documentation of observed behavioural changes and emphases made and for remembering the main topics discussed so far in order to choose the right subsequent questions.

5.8 Defining a Sample Size

According to Marshall (1996, p.523) "an appropriate sample size for a qualitative study is one that adequately answers the research questions". In principle there are different ways of deriving a group of interview participants. In statistical or probability sampling, individuals are put together according to certain (e.g. demographic) criteria in order to arrive at a sample that represents the research object's typicality as well as possible (Flick, 2010, p.117). In contemporary qualitative research, nonprobability sampling, however, has become more and more common. In theoretical sampling, the most common form of nonprobability sampling, decisions about choosing and putting research objects together are made in the process of collecting and interpreting data. The process of data collection is controlled by the emerging theory (Patton and Patton, 2002, p.230). Usually certain individuals are selected according to their expected level of new insights for the developing theory (Flick, 2010, p.118). The qualitative literature recognizes that some respondents are richer informants than others and that these people are more likely to provide an insight and an understanding for the researcher (Marshall, 1996, p.523). The criteria that define a valuable participant from the perspective of the research objectives have to be estimated *a priori*, based on the literature, and are refined in the course of the ongoing interviews.

The overall size of the sample is also defined by criteria in relation to the emerging theory. An *a priori* estimation of the number of participants needed to reach saturation in a qualitative study is almost impossible, since it depends on various factors such as the scope of the study, the nature of the topic, the quality of the data and the research method (Robson, 2009, p.199). Usually the key question is how promising the next case is and how relevant it might be for developing the theory. Based on Glaser and Strauss (1967, p.45) this criterion is named "theoretical saturation". According to this theory, the number of participants needed for interviews usually becomes evident as the study progresses, as new beliefs, categories and values stop emerging and thus data saturation is achieved (Robson, 2009, p.199). This requires a flexible research design and an iterative approach to sampling. In general, the qualitative literature suggests that the sample variation is more important than the overall sample size (Kleining, 2007, p.200). Consequently, a small well-chosen sample might be more appropriate than large-scale random sampling for the purpose of the present study at this point of the research.

5.9 Interview Participants

In order to find individuals providing an insight and an understanding for the research objectives, the author decided to visit automobile dealerships of different car brands in different cities. This approach provides the advantage that mainly car drivers, who are in the decision phase towards the purchase of a new automobile, will be part of the sample. It is expected that new car shoppers will have more elaborated beliefs towards the potential equipment of their next car and thus are more valuable as interview partners. It is further expected that these individuals are more open to give their opinions on ADAS technology in the atmosphere of an automobile dealership. Moreover, waiting times are quite common in this environment, so it was expected that respondents would have the necessary time to take part in the interviews.

In order to increase the sample heterogeneity, different car dealerships in different cities were selected and interviews were conducted at different times of the day. It was expected that customers of car brands that already offer a wide range of ADAS equipment have already formed more beliefs about this technology. Thus, following a market analysis, dealerships of the brands Mercedes-Benz, Audi, Volkswagen and BMW were chosen as interview spots. Most of these dealerships, however, also offered lower priced brands such as Smart, Mini or

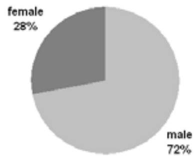
Skoda, whose customers were consequently also part of the research. The local dealership management of these branches supported the research by offering office space for the interviews. Consequently it was possible to conduct the interviews in office spaces usually dedicated to sales conversations and thereby generate an atmosphere as close as possible to the situation when a new car is sold. It was expected that this atmosphere would help the interviewees to most openly reflect on the possibility of having driver assistance systems as extra equipment in their next car. In order to further increase the heterogeneity of the sample, some interviews were also conducted on a university campus. Students are expected to have less experience with ADAS technology but are generally expected to have a higher level of affinity towards innovations (Waycotta et al., 2010, p.1208). Thus their individual beliefs might be valuable for the later stages of the present research.

All interviewees were asked to consent to a fifteen-minute interview, which was an estimated average duration. One of the shortcomings of non-standardised interviews is that an *a priori* estimation of the overall interview duration is not possible. Literature suggests an average duration of approximately twenty minutes, which might change considerably depending on the context and interview setting (Lamnek and Krell, 2010, p.307). In the course of the present research project the interview duration was tested during the pilot phase and the result – between fifteen and twenty minutes – was used for the final consent information for all respondents. In sum, thirty-two interviews were conducted, nine of which took place at a Mercedes-Benz and Smart dealership, eight at a BMW and Mini dealership, seven at a VW and Skoda dealership and, finally, eight at the Pforzheim University campus. There were no further selection criteria on gender, age or social status of the participants. It turned out, however, that males were over-represented with a three to one ratio, which is attributed to the fact that two-thirds of car owners in Germany are male (ACE, 2010). The distribution of car segments among the interviewees (categorized into small-, medium- and large-sized cars) was equally balanced in the sample. Chart 24 shows the distribution of selected demographic variables within the chosen interview sample.

Selected demographic variables of interview participants

Interview Location:	Interview Participants	Sample Percentage
Mercedes-Benz and Smart dealership	9	28%
BMW and Mini dealership	8	25%
Volkswagen and Skoda dealership	7	22%
Pforzheim University Campus	8	25%

Gender distribution:



Car-Segment distribution:

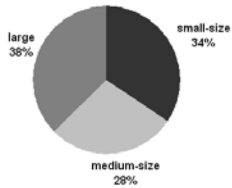


Chart 24: Demographic distribution of interview participants, Source: Own drawing.

It has to be acknowledged that the theoretical sampling approach applied in the present research also conveys some risks. Generally, this approach has the limitation that the sample might be biased due to the pre-selection of participants. In order to minimise this threat, the author visited different car dealerships, in different locations, at different times and chose participants within the selected location at random.

5.10 Transcription

Transcription means the conversion of spoken material into textual data, which in general implies a reduction of audio/visual data into a written form (Höld, 2009, p.657; Mayring, 2002a, p.89). This process is necessary for virtually all analysis techniques in qualitative research and lays the foundation for the further elaboration of the material (Kowal and O´Connell, 2009, p.438). A transcript enables the researcher to develop a reproducible interpretation which is later available for critical appraisal and thus offers a high level of methodical validity (Lamnek and Krell, 2010, p.356). Even though there are no widely accepted standards for transcription, certain general rules have emerged persistently in the literature (Robson, 2009, p.456). In general, transcription aims at the maximum exactness in classifying and presenting statements. In qualitative research, however, the question of appropriateness for the given research process has become more important. In order to judge the appropriateness of a transcription method, a variety of criteria were developed, such as manageability, readability, learnability and interpretability. Some of the most important general guidelines for generating transcriptions include leaving enough space in the left and right margins for notes, using line numbers for reference and employing standardised conventions for the whole text (Flick, 2010, pp.300–305). Consequently, ample space was left in the margins to permit the author to annotate the transcripts.

For the purpose of the present research, the interviews were first recorded on tape, and along with field notes made during the interview, were later transcribed into written verbal data. Nonverbal aspects, such as pauses, pitch or facial expressions, were neglected for the transcription, since this surplus of information was judged as not appropriate for the later analysis in regard to the research objectives. Moreover, the interviews were transcribed in German standard orthography, meaning that verbal colloquial expressions were transformed into written standard German expressions. The sequence of dialogue items was transcribed line-by-line in descending order, representing the chronology of the interview. The change of speaker from interviewer to interviewee was clearly marked and transcribed into a new passage. In sum, the resulting transcription convention is in line with Flick, who denotes that "a transcription system should be easy to write, easy to read, easy to learn and easy to search" (Flick, 2010, p.300).
The amount of verbal data produced in this way is expected to be substantial, thus methods of reduction will be necessary. The first step for simplification of material or data is to select the part of data that covers the topic relevant for the research objective. Thus, for most interviews, the author reduced Phase 1 (Introduction) from the transcript if it was not directly directed at the research objectives. Also, any off-topic conversation, not related to ADAS usage, was reduced, leaving a richer content for further analysis.

Using these techniques, the overall volume of transcripts can be reduced without changing the underlying meaning of the text. It has to be acknowledged, however, that any reduction of the volume of text affects what finally constitutes data for the purpose of the research and thus may have an influence on the research findings (Dey, 1998, p.16).

5.11 Qualitative Data Analysis

The aim of qualitative data analysis is to describe the world as it is perceived by different observers (Dey, 1998, p.36). Robson (2009, p.456) remarks that "there is no clear and accepted single set of conventions for analysis [of qualitative data] corresponding to those observed with quantitative data". However, there are ways in which qualitative data can be dealt with systematically.

Three basic methodologies of content analysis are suggested by the literature, which have to be regarded as supplementary rather than competing strategies:

Summarizing Content Analysis
In Summarizing Content Analysis, the text is paraphrased and less relevant passages and paraphrases with the same meaning are skipped (first reduction). Then similar paraphrases are grouped and summarized (second reduction). The result of this content analysis is a text on a higher level of abstraction.

Explicative Content Analysis
Explicative Content Analysis is aimed at clarifying unclear, diffuse or ambiguous passages by involving text from either inside the text (narrow context analysis) or from external material (wide context analysis). On this basis, explicating paraphrases are formulated and tested,

Structuring Content Analysis
Finally, the paraphrased text can be restructured in such a way that the internal structure of the text helps in explaining the phenomenon under study (Flick, 2010, p.326).

Since the first reduction as part of the Summarizing Content Analysis had already been performed during the transcription process, the analysis continues with the second part, the grouping and summarizing of similar paraphrases. After a first familiarization with the text, the main task is to translate the key ideas into more abstract concepts, which will become the labels for the underlying phenomena in the text. This process is known as open coding – the categories are allowed to emerge from the detailed analysis of the text (Flick, 2010, p.307). In a second step, the distinct categories will be tested for any logical connection using mind-map techniques, which is known as axial coding (Flick, 2010, p.310).

The procedure of coding in the context of Grounded Theory was developed by Glaser and Strauss (1967) in order to integrate data collection and sampling into the data interpretation phase. In general, coding leads to the development of theories through a process of abstraction. Even though there are different approaches to coding, such as “open coding”, “axial coding” and “selective coding”, in practice there are no clear distinctions between these methods. Basically coding approaches can be seen as different ways of handling textual material between which the research may move back and forth if necessary and which can be combined (Flick, 2010, p.307). In general, the process of text interpretation begins with open coding, whereas the need for axial and selective coding emerges during the procedure.

Open Coding

In open coding, codes are developed and attached to parts of the texts or to single words in a first step. These codes can either be formulated as closely as possible to the text or, if possible, based on relevant literature on the topic. Codes that are rephrasing parts of the text are called *in-vivo codes*, while codes based on literature are called *constructed codes* (Flick, 2010, p.309). In a second step, codes are categorized by grouping them around phenomena discovered in the data. The resulting categories are again linked to codes, which are now more abstract than those in the first step. The result of open coding should be a list of the codes and categories attached to the text (Flick, 2010, p.308).

Axial Coding

After identifying a number of relevant categories and codes, the next step is to develop a differentiated picture of their relation to the research topic. In general, axial coding is aimed at revealing the relations and dependability between categories and codes (Strauss and Corbin, 1998, p.127). The key question here is which category or code causes a phenomenon and which category or code is the consequence of a phenomenon. The result of axial coding is a structure of the hierarchy and relations of the categories relevant to the research question (Flick, 2010, p.311).

Selective Coding

In a third step, selective coding continues axial coding on a higher level of abstraction. This step focuses on potential core concepts or core variables and compares and contrasts these to other groups and foci. The result of selective coding should be one central category and one central phenomenon. This core category is developed in its dimensions and features and should then be linked to all other categories. Finally, the theory is developed in more detail and checked against the data (Flick, 2010, p.310).

According to Dey (1998, p.30), qualitative data analysis is a circular process. Description lays the basis for analysis, but analysis in turn lays the basis for further description. From initial description, the process continuous with breaking down and classifying the data and then aims to connect the concepts developed so far in order to provide a basis for a new description. The process of coding should then continue until theoretical saturation occurs, meaning that further coding, enrichment of categories etc. no longer promise any new insights into the topic (Flick, 2010, p.312).

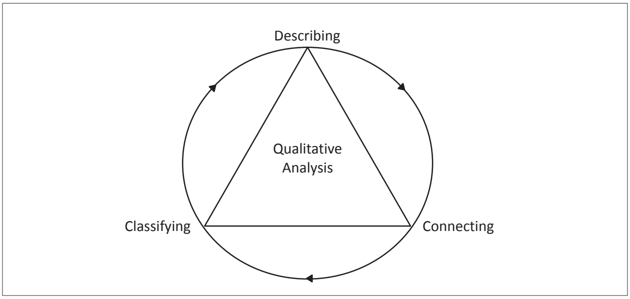


Chart 25: Circular process of data analysis in qualitative research, Source: Own Drawing based on Dey (1998, p.31)

5.12 Content Analysis of the Interview Transcripts

Following the process described by Dey (1998), data analysis of the present material started with an initial familiarization of the text. During this first reading the author marked any relevant parts of the text with regard to ADAS acceptance by underlining them. In a second step, initial *in vivo* codes were developed from the underlined parts, directly based on the content. Since the interviews were conducted in German, these initial *in vivo* codes were also based on German standard expressions. In a second step, the author had to transfer these *in vivo* codes into constructed codes in English, consciously bringing the results to a slightly higher level of abstraction. Since these codes had to be clearly distinguishable and differentiated from each other, they were constantly developed further during the process of analysis. Existing code groups had to be extended or completely changed, while new ones had to be created in the course of this process. In order to have a clear reference, an ascending number was assigned to each code in a side column. Table 14 gives an example of the data analysing process.

Interview transcript:	**In Vivo Code**	**Constructed Code**	**Code #**
What are the disadvantages of Advanced Driver-Assistance Systems in your opinion?			
The additional costs are certainly an issue here. Malfunctions are another topic; however, I have to admit that in my experience I have not yet had any trouble with that so far.	Additional costs	Price	4
	Malfunctions	Risk of Failure	11
	My Experiences	Past Experienc-es	1

Table 14: Example of initial data analysis

Since the development of constructed codes is based on the interpretive understanding of the written transcripts, it is generally influenced by the researcher's position towards the research object. In order to increase the objectivity of the interpretation, the development of codes was conducted independently by the author and two research assistants following the open coding method outlined before. As expected, the resulting constructed codes from the interview transcripts varied slightly in quantity and wording. In a first step, codes with similar meaning but divergent wording were grouped and the most unambiguous wording was chosen as the final code label. In the second step, each of the remaining codes, resulting from only one of the two analyses, was included in order to derive the most comprehensive code list of the transcripts. In sum, 54 codes emerged from the process of open coding which consequently formed the basis for the further analysis.

There is no clear agreed approach as to how to present the results of coding and the structure of volumes of non-standard data derived from qualitative research (Easterby-Smith, Thorpe and Jackson, 2008, p.175). For the present research, a model developed by Miles and Huberman (2009) is applied, which is aimed at capturing the complexity of all sorts of qualitative data in a wide variety of circumstances. The core element of this approach is a matrix format, which displays the constructs (i.e. the beliefs derived from content analyses) on one axis and the responses on the other. The characteristics of responses displayed on the second axis depend on the research question, and thus have to be developed beforehand. The main advantage of this model is the clear visualisation of results, which can lead beyond a simple configuration to sort data into an understanding of causal linkages. In conclusion, a matrix was developed showing the codes on the first row and their mentioning in each interview on the following rows. The interview numbers appear column by column, while the code appearance in each interview was noted line by line. As noted above, each code was allocated an ascending number (#1,#2,#3 etc.) as a clear reference. The author decided to use Microsoft Excel database software, which fulfils all requirements of this part of the analysis. Due to the predefined reference for each code and each interview, the allocation of codes in the matrix can easily be traced to the relevant interview passages. Table 15 gives an example of the raw database matrix.

Code	**Code #**	**I1**	**I2**	**I3**	**I4**	**I5**	**I6**	**I7**	**I8**	**I9**	**I10**	**I11**	**…**
Perceived Usefulness	7												
Risk of Failure	11												
Trust in Technology	21												
Safety Benefit	17												
Comfort Benefit	19												

Table 15: Example Raw Data Matrix

In the next step, axial and selective coding was applied to check for any hierarchical structure within the extrapolated codes. Similar codes were grouped into logical entities. For instance, the codes Good Feeling, Unsafe Feeling, Uneasy Feeling and Coolness were grouped into one unit, since all of these concepts include some affective elements referring to feelings and emotions. In the next step, a higher-level code was developed, referring to the mutual meaning of the group of codes. This was either one of the codes itself, meaning that there was already a superior code within the group that represented a category, or alternatively a new, higher-ranked code had to be developed, which completely covers the meaning of the group's codes. In the example mentioned above, a new code

"Emotions" was defined to cover the implicit meaning of all four codes in the group. Table 16 shows the example Group "Emotions".

Category	Code	#	I1	I2	I3	I4	I5	I6	I7	I8	
Emotions	Good Feeling	23									
	Unsafe Feeling	47									
	Uneasy Feeling	41									
	Coolness	56									

Table 16: Example Category Grouping Matrix

The process of grouping was applied until all codes that had been developed from the data were allocated to a logical concept category. The final category system consists of ten higher ranked categories and fifty-four secondary codes. Chart 26 gives an overview of the process steps involved in the development of the category system.

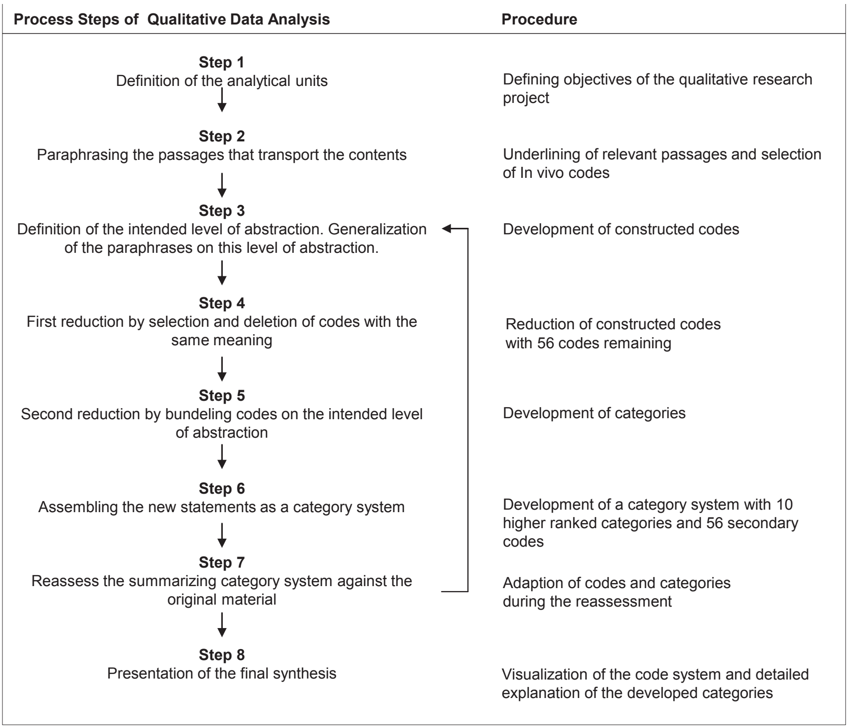


Chart 26: Data analysis process, Source: Own drawing based on Flick (2010, p.326)

5.13 Content Analysis Results

The results were finally visualised in matrix form with the resulting categories in the first row, the codes and code numbers in the second and third rows and the interview results in the subsequent rows. The interview results represent the number of code appearances in each interview. Instead of numeric results, the author decided to use symbols, which simplify the matrix and increases readability and interpretability. Every mentioning of a code in the given interview is represented by a filled slot. Since no individual code was mentioned more than four times in any interview, four empty slots are provided for each code/ interview combination. Four empty slots represents no mentioning of the code in the given interview, one coloured slot means that the concept was addressed once, two slots filled means the concept came up twice, three slots filled means the concept was brought up three times and four slots filled, finally, means that the concept has been mentioned four times during the interview.

This visualisation approach enables the researcher to get a general idea of the interview results and to develop hypotheses about the potential impacts and the potential interrelation of different codes and categories. Table 17 shows the complete result matrix and the symbolic representation of the results.

Category	Code	Code ID	I1	I2	I3	I4	I5	I6	I7	I8	I9	I10	I11	I12	I13	I14	I15	I16	I17	I18	I19	I20	I21	I22	I23	I24	I25	I26	I27	I28	I29	I30	I31	I32
Emotions	Good Feeling	#23		1								1	1	1	1		1					1	1	1	1		1			1				
	Unsafe Feeling	#47																	1				1		1	1								
	Uneasy Feeling	#41										1						1	1															
	Coolness	#39																							1									
Enjoyment of Driving	Enjoyment of Driving	#27			1	1	1				1	2			1	1	2	1		1			1	1		1	1	1			2			1
	Conformity with Driving Style	#25		2		3			1																			1						
Loss of Control	Loss of Control	#6	3	3	2	1					1	2	1		1	1	1		1	1	1	1		1	2			1			1	1		
	Irreplaceability of Human Driver	#13	1	1	1	3	2	2	3						1		1	1						1	2						1			1
	Technological Paternalism	#34						1																		1		2			1			1
	Dependency on Systems	#49																		1														
Past Experiences	Past Experiences	#1	1	2	1	1	1	2	1		1			1	1		2	1	1		3	2		3	2	3		3	1	1			1	1
	Familiarisation with Technology	#24		1						1																								
	Lack of Knowledge	#38										1	1	1		1				1														
Perceived Ease of Use	Ease of Use	#42										1			1			1				1											1	
	Customisation with System	#53																					1	1			1						1	
Perceived Risks	Risk of Failure	#11	1	1	1	3	1	3	1		1	2	2		2	1	1		1	2			1	4	1	3	1				2		1	
	Technical Immaturity	#10	1		4	1	3	1					1		1		1	1		1	3		1	4	4	3						1	2	1
	Fear of Excessive Warnings	#32					2	1	2				1		1		1	1	1	1					2								1	1
	Responsibility	#5	2		1			2			1															1					1		1	
	Artificial Feeling of Being Protected	#28			1	1			1			1								1			2		1	1								
	Risk of Decreased Driving Skills	#29			1						1						2			1							1	1			1			
	Risk of Distraction	#48																		2	1				1	2	1							1
	Uncertainty in Driving Situations	#26		1						1														1	2		1				1			
	Risk of Becoming Careless	#12	1					1	2								1							1										
	Reliability	#22		2												1					1							1			1			
	Increased Driving Complexity	#31				1				1	1									1														1
	Risk of Wrong Operation of System	#52																					1											
Perceived Usefulness	Comfort Benefit	#19	1			1	1			1		2	1		2	1	3	1				1		1		2	2	1	3	1	1		1	
	Reduction of Driving Strain	#35								1															1		1			1	2		1	1
	Perceived Usefulness	#7	4	2	2	3	3	2	2		1		1	1		1	4	1		2			3	1	1	4	1			1	1		1	1
	Technical Gadget	#9	1		1		2	1	2		1													1		2	1						1	
	Ability to Support Driving	#15	1							1		1					1	1	1		1		1		1	1			1					
	Technological Proliferation	#20	1	1		1					2		1													1								
	Safety Benefit	#17	1	1			1		1				1	2	2	1	1	2			1		2	2		2	2	3		2	1	1	1	3
	Support for Highway Driving	#40										1										1				1	2			1				
	Support for Elderly	#50																				1			1			1			1		1	1
	Support for City Driving	#45																	1	1					1									
	Increased Traffic Law Conformity	#46																											3					
	Support for Handicapped Persons	#44																										1					1	
	Possibility of Drunk- or Tired-Driving	#54																					1											
	Risk of Human Error	#16	1	2			1			1												1	1		1	1	1		1	1		1		1
	Usefulness for Job-related Driving	#2																						1										
Resources	Price	#4	4	2	2		1		1			1					1						3		1	1	1		1			1	1	
	Value for Money	#18	1	1	2				1																									
	Limited Availability	#3	1							1							1																	
	Risk of Increased Repair Costs	#36									1																					1		
Subjective Norms	Subjective Technological Standard	#37															2	1		1												1		
	Social Obligation	#8	1				1			1																								
	Social Influence	#33					1																											
	Societal Need due to Increase in Traffic	#51																				1												
Trust	Trust in Technology	#21	1		1	2	1	1				1				1	2	1	1	3	2	3	1	2	2	2	1	2		2	1			1
	Trust in Own Driving Skills	#43			1								1			1				1	1					1								
	Trust in Computer	#14	1		1																												1	
	Trust in Brands	#30				1																			1									

Symbol explanations:	No mentioning of the Code in this interview	Code was mentioned once during this interview	Code was mentioned twice during this interview	Code was mentioned three times during this interview	Code was mentioned four times during this interview

Table 17: Content Analysis Results Matrix

The visualisation scheme makes it apparent that some of the codes appeared constantly in almost every interview, while others only came up once or twice. The codes that were mentioned in more than half of the interviews are: Enjoyment of Driving, Loss of Control, Past Experiences, Risk of Failure, Technical Immaturity, Comfort Benefit, Perceived Usefulness, Safety Benefit and Trust in Technology. In sum, these nine codes represent more than half of all mentioned concepts. Eight codes, on the other hand, were only brought up once.

It has to be acknowledged, however, that conclusions from the relative frequency of occurrences cannot be drawn from this qualitative analysis alone. Rather, according to the chapter objectives, this study is aimed at eliciting prevalent beliefs towards the acceptance of ADAS, which can later be used to construct a standardised survey. Consequently, it is necessary to evaluate whether the concepts developed so far are satisfying the requirements to be used in this regard.

5.14 Quality Criteria of Qualitative Research

In order to evaluate the level of confidence that may be associated with the present research results, a set of quality criteria have to be established beforehand. Increasingly popular among social science researchers, qualitative research has been heavily criticised for not being assessable by standardised, external means. Quality criteria are well known and widely agreed in quantitative research. For qualitative research, however, that is not yet the case (Bryman, Becker and Sempik, 2008, p.262). Recognizing the very wide range of methods that this term covers, Dale (2006, p.79) argues that it might not be possible to establish comparable fixed sets of criteria that can be universally employed in every type of qualitative research. Yet, developing quality criteria for qualitative research has become increasingly popular in recent years. Criteriology, a designated research area aimed at developing criteria for judging the quality of qualitative research studies, has generated a number of publications proposing divergent evaluation criteria (Seale, 2002, p.102). Most authors start by outlining conceptions of validity and reliability in the quantitative tradition, transferring some fundamental aspects to the field of qualitative research (see Golafshani, 2003 as an example). The central conceptions of quality, generally discussed as validity and reliability, are transferred into the field of qualitative research by generating aspects that establish the trustworthiness of a research report. Reliability is translated into dependability, which can be achieved via an auditing procedure, involving the researchers' documentation of data, methods and decision-making during a project, as well as its end product (Flick, 2010, p.396). Internal validity is transferred to neutrality, and is achieved by basing the findings on the subjects and conditions of the inquiry, rather than on the eventually biased researcher perception. Additionally, researchers should aim to maximize the truth value, accomplishable by "prolonged engagement in the field, persistent observation and triangulation exercises, as well as exposure of the research report to criticism by a disinterested peer reviewer" (Seale, 2002, p.104). External validity, finally, translates into applicability. Providing a detailed, rich description of the study, the author should give readers sufficient information to be able to judge the applicability of findings to other settings (Seale, 2002, pp.104–105). Consequently, based on Lincoln and Guba (2007, p.290), five basic requirements have to be fulfilled by qualitative research reports:

1. ***Trustworthiness/Credibility:*** How can one establish confidence in the truth of the findings resulting from a particular inquiry?

2. ***Applicability:*** Are the findings of a particular survey applicable in other contexts or with other subjects?

3. ***Consistency:*** Would the findings be repeated if the inquiry were replicated with the same (or similar) subjects in the same (or similar) context?

4. ***Neutrality:*** Are the findings of a survey determined by the subjects and conditions of the inquiry or rather by the biases, motivations, interests or perspectives of the inquirer?

5. ***Transparency:*** Are the research methods, procedures and actions described in a way that enables an external auditor to assess the work?

Trustworthiness/Credibility

As noted by (Seale, 2002), prolonged engagement in the field and persistent observation of subjects in the research area can foster the trustworthiness of qualitative research reports. The author of the present study has spent more than five years in the automobile industry, constantly being exposed to car customers as part of his daily work. Conducting hundreds of interviews on customer satisfaction, the author has gained confidence in interviewing techniques as well as experience in data analysis. The research results will be discussed in the course of several research conferences and a synthesis of this chapter will be published as a part of a book on entrepreneurial communication (see publication list), allowing for an open discussion of the findings.

Applicability

The development of concepts and categories is described in detail and enables the reader to judge whether or not a particular concept might be transferable to another context. Furthermore, the results of the present study are comparable to the results from other inquiries in different areas of technological product innovation. Consequently, knowledge from this study can be transferred and checked against results from other fields of acceptance behaviour.

Consistency

Consistency is obtained if any repetition of the qualitative interviews in a similar setting with similar participants leads to similar findings. In order to ensure this, the author aimed for maximum sample heterogeneity within the chosen interview participants by interviewing different car drivers at different dealerships at different times. In sum, it is thus expected that an acceptable level of consistency was obtained by the present interview methodology.

Neutrality

In order to increase neutrality, the author decided to carry out the qualitative phase together with two research assistants from Pforzheim University. The interviews were each conducted either by one of the research assistants or by the author himself. Comparability of interview administration was ensured by using a predefined interviewer's guide and by having a mutual pre-testing phase of the interviews. Data analysis was conducted by the research assistants and the author independently, but applying a similar methodology. By comparing the results from both analyses (the research assistants performed their analysis together) the author could use triangulation to ensure that the results are free from researcher bias.

Transparency

Transparency is one fundamental aspect that is involved in any kind of quality criteria. Without transparency, quality assessment would be not possible. Transparency is a crucial requirement at a number of different points during the research process: not only when keeping respondents informed about the research objectives but also at the end, when reporting the full details of how the study was conducted and the data was analysed (Dale, 2006, p.79). In order to increase the transparency of the present research, the author thus specified and documented the multiple processes from data gathering to data presentation at a very detailed level, ensuring a clear and comprehensible thread for the reader.

Conclusion

In the absence of standardised, objective quality criteria, trustworthiness of the present research was evaluated by assessing the research report's level of Credibility, Applicability, Consistency, Neutrality and Transparency. The author used different techniques to ensure that the research methodology applied met these criteria, such as using different interviewers and documenting the data analysis process to a very detailed level. Based on this evaluation, the present qualitative study can be regarded as a credible source of knowledge, acknowledging some minor tentative assumptions in the field of consistency.

5.15 Implications from Qualitative Research

The implications from this part of the research are substantial from the viewpoint that they allow for an insight in the manifold and complex constitution of conscious and subconscious beliefs influencing the acceptance decision towards ADAS technology. In sum, ten clearly defined categories have emerged from the interview transcript as the result of content analysis. These categories and their subordinate concepts are supposed to serve as the main determinants for the acceptance decision of individuals towards ADAS technology. Thus a further elaboration of these categories delivers a meaningful contribution for the explanation of acceptance behaviour in this context.

Emotions

During the interviews it became apparent that ADAS technology causes affective responses, which arise intuitively without an immediate rational explanation. It is important to acknowledge that these affective responses expressed positive as well as negative feelings or emotions. Interviewees reported that they expect a "good feeling" (code #23) when driving with ADAS, while others reported that they expect an "unsafe feeling" (code #47) or an "uneasy feeling" (code #41). Two respondents expressed positive as well as negative emotions during the same interview, a paradox that occurs because in some situations (e.g. parking) these systems might create a good feeling, while in others (e.g. highway driving), these systems are perceived as "spooky" (code #47 in interview 23). In conclusion, emotions have repeatedly emerged as an important affective concept from the interviews, which can have a positive and/or negative impact on the innovation acceptance decision of ADAS.

Enjoyment of Driving

An aspect mentioned by more than half of all respondents is "perceived enjoyment of driving an automobile" (Code #27). Enjoyment in this context refers to various personal motives other than transportation, such as sensory stimulation, excitement or self-expression. Advanced Driver-Assistance Systems are perceived as supplanting manual driving tasks that respondents prefer to fulfil themselves. In most cases respondents commented that they "enjoy driving too much to use these assistance systems" (Code #27 in interview 16). It also became evident that individuals want to preserve their own driving style, which they suspect ADAS not to be compatible with: "especially for sportive drivers, ADAS might not be especially useful" (Code #25 in interview 4). In conclusion, the perceived enjoyment of driving has occurred as one of the major reasons for resistance towards ADAS in this interview phase.

Loss of Control

Respondents reported very directly that with the usage of ADAS they "fear losing control over the vehicle" (Code #6 in interview 17). More than half of all interviewees expressed this fear, which is motivated by the belief that such systems are "taking away personal freedom" (Code #34 in interview 29) and thus creating a form of technological paternalism. Moreover, respondents remarked that assistance systems "cannot replace the human driver" (Code #13 in interview 23) and expressed the wish to remain in control of the automobile in any situation. In conclusion, the prospect of handing over control to an assistance system has consistently emerged as a major reason for resistance towards ADAS.

Past Experiences

During the interviews it became apparent that drivers with no knowledge and no experience of ADAS were more sceptical towards this technology, while drivers who already had first experiences with these systems had a more positive attitude towards them. It is not particularly surprising that past experiences with a technology strongly impact the attitude towards this technology. Additionally, however, it also became apparent that personal experiences have a significant impact on the acceptance decision. Multiple respondents remarked that they had experienced critical driving situations in the past: “it happened to me that I went off the lane after a long drive […] so I would definitely pay a price premium to have a Lane-Assistance System in my next car ” (Code #1 in interview 22). These critical experiences influenced the perceived need for driving assistance, thus leading to a more positive attitude towards ADAS. In conclusion, past experiences are expected to have a significant impact on the decision as to whether or not to use a new technology.

Perceived Ease of Use

The expected cognitive expenses necessary to use a driver assistance-system were mainly brought up by respondents who already had first experiences with ADAS. They remarked that they liked the easy operation of these systems: “You just switch it on and nothing else – I like the usability” (Code #42 in interview 1). Respondents with little or no experience rather remarked that they expected to be able to use these systems with little strain after a short period of customisation: “At first I might be irritated but I believe that’s a matter of becoming accustomed to it” (Code #53 in interview 22). In conclusion, Perceived Ease of Use was brought up rather seldom by respondents and if so, the interviewees consistently reported that they had experienced or expected a rather easy usage of these systems.

Perceived Risks

Throughout the interviews, almost every respondent remarked that he or she expected risks associated with ADAS. The most common risk mentioned by the interviewees was a critical system failure leading to a hazardous situation: “I believe that these systems will malfunction one day or do not work the way they should” (Code #11 in interview 21). This perception was intensified by the belief that these systems are technologically immature or not yet safe enough: “These systems are marketed too early: [they] should be tested more thoroughly” (Code #10 in interview 24). Alongside this, respondents feared distraction by excessive warning noises and flashing signals (Code #32) and increased driving strain (Code #31). Another serious concern expressed by the interviewees was that these systems create an artificial feeling of being protected. This can be attributed to the fact that using ADAS might lead to the belief that driver attention is no longer necessary: “If the car is doing too much automatically, the driver might fall asleep sometime” (Code #28 in interview 21).

Further to this, respondents expressed the fear of diminishing driving skills due to the use of ADAS: “The disadvantage of parking assistance is that you unlearn how to park by yourself” (Code #29 in interview 15). In conclusion, there is a multitude of anticipated risks that are involved in the belief formation towards the acceptance of ADAS technology. Taken together, these risks are expected to serve as a major reason for resistance towards this innovation.

Perceived Usefulness

The usefulness of ADAS technology was discussed in every interview conducted. Most respondents named specific product features, such as lane keeping or automatic parking, which they considered useful: “Traffic signs are recognised automatically. That’s useful” (Code #7 in interview 21). Perceived Usefulness in this regard mainly refers to an expected benefit towards an individual goal. The interviews revealed that in the context of ADAS this benefit could be a:

- Comfort Benefit (Code #19), which was mainly associated with a reduction in driving strain: “Using parking assistance, I don’t have to wrench my head anymore” (Code #19 in interview 15)
- Safety Benefit (Code #17), which mainly refers to the perceived increase in driving safety: “Using blind spot monitoring, I can probably realize dangerous situations much faster” (Code #17 in interview 31).

Safety Benefit was frequently linked to the belief that human errors do occur and could possible be prevented by these systems: “On a long drive it can always happen that you become inattentive […]” (Code #16 in interview 25). Additionally respondents saw specific benefits for different target groups, such as:

- elderly (Code #50),
- handicapped (Code #44),
- professional drivers (Code #2) or
- drunk drivers (Code #54).

A minority of respondents reported that they did not see a benefit in at least some of these systems: “Lane keeping is a feature which I rather regard as a technical gadget” (Code #9 in interview 5). In conclusion, the perceived usefulness of ADAS strongly depends on the personal motives and goals, generally either related to increased comfort, increased safety or both. In sum, this concept is expected to be a major determinant for innovation acceptance in the context of ADAS.

Resources

Another important aspect elicited from the interviews is the perceived expectation of resources necessary to obtain and use Advanced Driver-Assistance Systems. The additional price for such systems was mentioned by almost half of the interviewees as a reason for non-adoption of this technology: “These systems are probably very expensive” (Code #4 in interview 22). It is remarkable that respondents often did not know the exact costs of these systems but instead anticipated an additional cost, based on their expectations. The non-availability of these material resources then acts as a reason for resistance: “I have no money for this” (Code #4 in interview 21). Additionally, two respondents anticipated high repair and maintenance costs for these systems (Code #36). Perceived non-availability of these systems also occurred because respondents believed that they are either not offered in their car category or not offered by their car brand: “I drive old cars – for those you cannot get these systems” (Code #3 in interview 8). In conclusion, the perceived requirements of material- and non-material resources acts as a motive for resistance towards the acceptance of ADAS for at least half of the individuals interviewed at this stage.

Subjective Norms

Subjective Norms have a manifold influence on human behaviour and on the acceptance of innovation in particular. On the one hand, respondents remarked that they perceived ADAS to be a common technological standard with which they wanted to comply: “these systems are standard equipment already. I wouldn’t buy a car without them” (Code #37 in interview S15). The perceived installed customer base acts as a descriptive norm in this case, meaning that individuals want to comply with what they perceive the public is considering reasonable. On the other hand, some respondents perceived a moral obligation to use ADAS: “Personally I don’t see the benefit. If the accident rates are lowered by these systems, however, everybody would benefit” (Code #8 in interview 1). If ADAS is perceived as serving the common good, this belief can establish a moral norm, which respondents want to comply with. Direct influence of a peer group or individuals, which the literature refers to as injunctive norms, was only reported by one interviewee: “I have been told that these systems are too sensitive in every usage […]" (Code #33 in interview 5). It is remarkable that injunctive norms, even though widely recognized in the literature, played only a minor role in this interview phase. Either the influence of peer groups is rather low in the context of ADAS, or respondents were influenced by these norms on a subconscious level, which could not be revealed in the course of these interviews.

Trust in New Technologies / Trust in Own Driving Skills

The interviews revealed that trust is an important, although ambivalent, influence factor for innovation acceptance. On the one hand, trust in technology serves as a major motive for the acceptance of ADAS: "I trust in these systems because I feel confident that they work" (Code #21 in interview 26). On the other hand, the absence of trust in technology serves as a major motive for resistance: "I don't believe you should rely on technology too much" (Code #21 in interview 18). Since ADAS is aimed at substituting manual driving tasks, respondents weighed the level of trust in technology against the level of trust in their own driving skills: "I trust my own eyes more than this computer screen […]" (Code #43 in interview 3). In order to recognise these two aspects, the author decided to split this concept into *Trust in Own Driving Skills* and *Trust in New Technologies*. *Trust in New Technologies* is a factor considered in most innovation acceptance studies as *General Innovativeness*. The author will consequently use this wording for the concept.

5.16 Summary of Results

Ten core concepts have been developed from this qualitative phase as potential influence factors for acceptance behaviour in the context of ADAS. Based on the interview results, the factors that are expected to constitute the main reasons for resistance towards ADAS are *Enjoyment of Driving*, *Loss of Control* and *Perceived Risks*. *Perceived Usefulness*, on the other hand, has emerged as the strongest factor supporting the acceptance of this technology. Finally, *Past Experiences* and *Trust* were also found to be important influence factors for the acceptance of ADAS, albeit with ambiguous effects.

Recapitulating the chapter objectives, these concepts are clearly described, mutually exclusive, exhaustive and directly based on the interview responses with a clear and reproducible reference. Even though it is not the objective of this chapter to report on the significance and impact of these concepts, initial hypotheses can be developed from the present interviews. The significance of these concepts for the respondents can be estimated based on the number of occurrences during the interview phase (see Table 17). Additionally the interview results allow for an evaluation of whether the concepts tend to support acceptance, resistance or both in the context of ADAS. Table 18 shows the acceptance factors, their significance and their effect on the acceptance decision.

Table 18: Acceptance factors derived from qualitative interviews

Concept (alphabetic order)	**Short description**	**Importance of the concept** (Based on the frequency of occurrences in the interviews)		**Effect of the concept** (Whether the concept tends to lead towards acceptance or towards resistance of ADAS)		**Typical quotations**	**Reference**
Emotions	Affective responses, referring to feelings and emotions which come up intuitively without an immediate rational explanation.	Average	Slightly less than half of all respondents expressed emotions or feelings in relation to ADAS during the interview.	Acceptance and/or resistance	The affective responses expressed positive as well as negative feelings towards ADAS. Positive emotions are, however, predominating.	“I feel much better and safer with these systems” “As a passenger I would clearly feel much more unsafe […]”	Code #23, interview 12 Code #47, interview 24
Enjoyment of Driving	Enjoyment refers to various personal motives other than transportation (non-functional motives), such as sensory stimulation, excitement or self-expression.	High	This concept was mentioned by more than half of all respondents.	Resistance	Advanced Driver-Assistance Systems are perceived as supplanting manual driving tasks, which respondents prefer to fulfil themselves.	“I enjoy driving too much to use these assistance systems”	Code #27, interview 16
Loss of Control	Loss of Control expresses the belief that ADAS is taking away personal freedom and thus creating a form of technological paternalism.	High	This concept was mentioned by about two thirds of the respondents, some of whom brought it up multiple times.	Resistance	The prospect of handing over control to an assistance system has consistently emerged as a major reason for resistance towards ADAS.	“Fear of losing control over the vehicle” “Taking away personal freedom”	Code #6, interview 17 Code #34, interview 29
Past Experien-ces	Past Experiences refers to experiences with ADAS technology as well as to personal experiences for instance in critical driving situations.	High	Past Experiences were found to have a significant impact on the decision as to whether or not to use ADAS technology.	Acceptance and/or resistance	Generally, having first experiences with ADAS increases the acceptance of this technology and vice versa. Additionally, having experienced critical driving situations in the past was found to support the acceptance of ADAS.	“I have ACC on my car and I don’t want to miss this anymore” “	Code #1, Interview 6 Code #1, interview 22

Perceived Ease of Use	Expected cognitive expenses necessary to use a driver- assistance system.	Low	Perceived Ease of Use was brought up rather seldom by respondents and if so, the interviewees consistently reported that they had experienced or expected a rather easy usage of these systems.	Acceptance	Respondents who already had first experiences with ADAS remarked that they liked the easy operation of these systems.	"You just switch it on and nothing else – I like the usability"	Code #42, interview 10
Perceived Risks	Anticipated negative consequences of adopting ADAS. Most commonly: Critical system failure, distraction, diminishing driving skills and the artificial feeling of being protected.	High	Almost every respondent remarked that he or she expected risks associated with ADAS throughout the interviews: thus the influence of this factor is expected to be rather high.	Resistance	The multitude of anticipated risks associated with ADAS serve as a major barrier for the acceptance of this technology.	"I believe that these systems malfunction one day" "If the car is doing too much automatically, the driver might fall asleep some time."	Code #11, interview 21 Code #28, interview 21
Perceived Usefulness	Anticipated positive consequences of adopting ADAS. Most commonly: Comfort and safety benefit.	High	The usefulness of ADAS technology was discussed in every interview: thus, the influence of this factor is expected to be rather high.	Acceptance	Perceived usefulness of ADAS strongly depends on the personal motives and goals, usually either related to increased comfort, increased safety or both. These motives were found to be in line with ADAS features for most respondents.	"Traffic signs are recognized automatically. That's useful." "Using blind spot monitoring I can probably realize dangerous situations much faster"	Code #7, interview 21 Code #17, interview 31
Resources	Perceived expectation of resources necessary to obtain and use Advanced Driver-Assistance Systems.	Average	The resources needed to obtain and use ADAS were mentioned by about half of the individuals interviewed.	Resistance	The perceived requirement of material- and non-material resources acts as a motive for resistance towards the usage of ADAS.	"These systems are probably very expensive" "I drive old cars – for those you cannot get these systems."	Code #4, interview 22 Code #3, interview 8
Subjective Norms	Perceived social pressure to adopt or not to adopt a certain innovation.	Low	The perceived installed customer base (descriptive norm) and direct social pressure (injunctive norm) have played only a minor role in this interview phase.	Acceptance and/or resistance	If respondents perceive ADAS to be a common technological standard, they want to comply with it (descriptive norm). Direct influence of a peer group can lead to either acceptance or rejection (injunctive norm).	"These systems are standard equipment already. I wouldn't buy a car without them" "I have been told that these systems are too sensitive in every usage […]"	Code #37, interview 15 Code #33, interview 5

Trust in own driving skills	The reasonable expectation (confidence) of the respondents to posses the necessary driving skills.	Low	Even though it was only mentioned by six respondents *Trust in own driving skills* could be an important subconscious influence factor of ADAS acceptance	Resistance	Trust in own driving skills has led to resistance towards ADAS technology	"I trust my own eyes more than this computer screen [..]"	Code #43, interview 3
Trust in New Technologies	The reasonable expectation (confidence) of the respondents that new technology will be beneficial.	High	Trust in New Technologies has emerged as an important factor mentioned by almost two thirds of the respondents.	Acceptance	Trust in technology serves as a major motive for the acceptance of ADAS. The absence of trust, on the other hand, serves as a major motive for resistance	"I trust in these systems because I feel confident that they work" "I don't believe you should rely on technology too much"	Code #21, interview 26 Code #21, interview 18

5.17 Visualisation of Results

In the next step, the results presented so far are visualized by employing *concept mapping*, a tool increasingly employed in qualitative research in order to develop and to clarify theory (Maxwell, 2009, p.47). Originally developed by Miles and Huberman (2009), concept mapping has been developed to fit different purposes and is used by social science researchers in different contextual areas. The common idea is to develop a map-like pattern by "arranging and connecting a set of ideas that is relevant to the research topic" (Hesse-Biber and Leavy, 2011, p.188). For the purpose of the present research, categories are expressed with circles, which are arranged around the main research objective, the intention to use ADAS. The circle size depends on the estimated significance of the particular concept developed from the number of occurrences during the interviews (see Table 18). Lines connecting the circles represent hypotheses for potential causal relationships. Finally, positive and/or negative symbols illustrate whether concepts were found to support or impede the acceptance of ADAS. A "+" symbol indicates that the concept is expected to support the acceptance of ADAS, while a "-" symbol indicates that the concept is expected to lead to resistance towards ADAS. The combination "+/-" indicates that the concept was found to have ambiguous effects on the acceptance decision. The codes, which were developed from the interview transcripts, are attached to their respective concept category. In conclusion, this visualisation scheme provides a comprehensive, yet perspicuous overview of the research results obtained by the qualitative interviews.

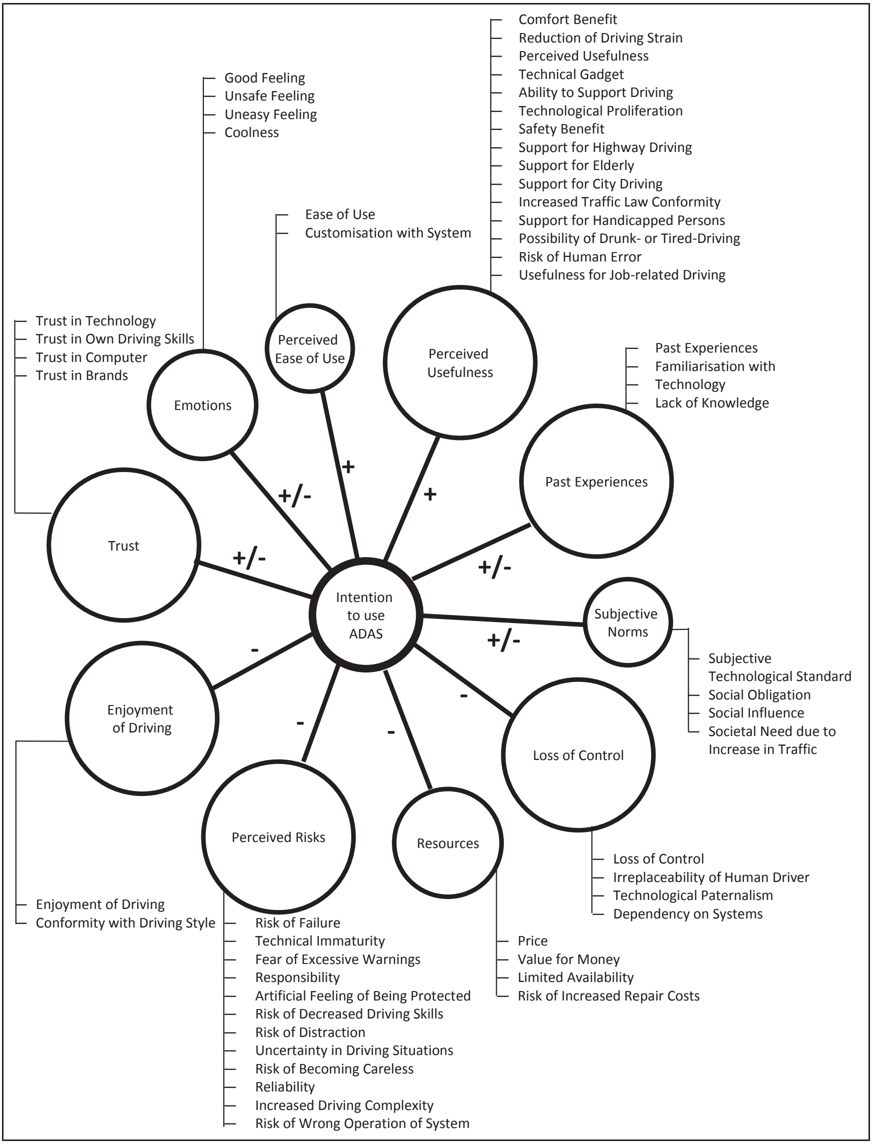


Chart 27: Visualisation of qualitative research results, Source: Own Drawing

5.18 Comparison of Results with Previous Empirical Studies

Comparing the findings of this qualitative stage to the results derived from literature review (see Chapter 3), it becomes apparent that considerable differences exist between what has been found in this study and what was found in previous innovation acceptance studies. An analysis of overlaps and differences between this qualitative study and the results from literature review will thus help to draw conclusions on the relevant factors that should consequently be used in the quantitative phase.

A direct comparison of the concept list from interview data and the concept list from the literature review shows that five out of the ten concepts from the interview analysis directly match the findings from literature research and will consequently be used to develop hypotheses for the further research steps. These concepts are: *Enjoyment of Driving, Loss of Control*, *Perceived Risks*, *Perceived Usefulness* and *Trust*.

Despite these similarities, the results from the qualitative research and the results from the literature review revealed some fundamental differences. *Subjective Norms* were mentioned only rarely during the interviews, while this factor was found to be a major determinant for innovation acceptance behaviour in the literature. Due to the possibility that *Subjective Norms* influence behaviour on a strongly subconscious level, which the interviews might not have been able to reveal, the author decided to use this concept in the quantitative stage, despite the low occurrences during the interviews.

Emotions were brought up relativly frequently by respondents during the interviews, while most empirical research has not included affective responses as causes of action. This is, most possibly, due to the fact that the majority of empirical studies is based on the on the Theory of Reasoned Action (TRA). This psychological model is founded on Ajzen and Fishbein’s (2010) paradigm, which suggests that human behaviour is based on beliefs, which are developed over time, rather than on affective impulses. In this regard, affective responses are a result rather than a cause of behaviour. Based on the massive empirical evidence for this paradigm, the author decided that affective responses would be dismissed for hypothesis development.

Perceived Ease of Use was brought up rather infrequently by respondents, while virtually all empirical studies applying the TAM model report that this concept has a significant influence on acceptance behaviour (see Chapter 3). To explain this paradox, it is necessary to have a closer look at the few interview responses that were received on this topic in the course of the interviews. Respondents consistently reported that they had experienced or expected rather easy usage of ADAS. Thus, it can be concluded that the extent to which *Perceived Ease of Use* impacts acceptance behaviour is strongly dependent on the technology or product category in question. In the case of ADAS, inferences about potential learning expenditures were found to be almost nonexistent. Consequently, *Perceived Ease of Use* is expected to have only a minor influence on the acceptance of ADAS. This factor was accordingly omitted from the hypothesis development.

Resources, most importantly price, were brought up in a fraction of the interviews as a factor impeding acceptance. Empirical studies, however, have generally found no proof for a causal relationship between the availability of resources and the intention to accept an innovation. Even though the availability of resources is part of the TPB model (as part of a concept called *Perceived Behavioural Control*), its ability to explain the acceptance behaviour has been found to be insignificant in most empirical studies (see Chapter 3). Consequently, this factor will be dismissed for hypothesis development.

Finally, *Past Experience* was derived from the literature as well as from the interview data as an influence factor of innovation acceptance. However, the author decided to dismiss this concept, since most empirical work indicates that Past Experience is not a predictor of acceptance behaviour but should rather be treated as a background factor. People having experience with an innovation generally have a stronger intention to use this innovation, since they are situated further on the Rogers (2003) acceptance process model (usually they have already accepted the innovation). Thus, including *Past Experience* into the hypotheses will not add to the explanative power of the final model. Consequently, Past Experience is omitted from the hypotheses model and will be treated as an ancillary background factor.

Table 19 shows the comparison of concepts derived from the qualitative interviews and those elicited from the literature review and the resulting decision on the further process.

Table 19: Comparison of results from interviews with results from literature research

Concept (alphabetical order)	**Short description**	**Significance of the concept derived from interviews** (Based on the frequency of occurrences in the interviews)		**Significance of the concept derived from literature review** (Based on applications of the concept in literature and the explained variance in innovation acceptance behaviour that was attributed to the concept in the reviewed studies)		**Decision on the concept** (whether or not the concept will be subsequently used to develop hypothesis for quantitative research)	
Emotions	Affective responses, referring to feelings and emotions which come up intuitively without an immediate rational explanation	Average	Slightly less than half of all respondents expressed emotions or feelings in relation to ADAS during the interview	Low	Most empirical research is based on the Theory of Reasoned Action, which does not include affective responses as causes of action. Emotional involvement with a product category, however, was found to support the acceptance decision	Dismiss	Even though *Affective Responses* were brought up during the interviews, the author follows the reasoning of Ajzen and Fishbein (2010), who emphasize that human behaviour is based on beliefs, which are developed over time, rather than on affective impulses. In this view, affective responses are rather a result than a cause of behaviour. Consequently, affective responses are dismissed for hypothesis development.
Enjoyment of Driving	Enjoyment refers to various personal motives other than transportation (non-functional motives), such as sensory stimulation, excitement or self-expression	High	This concept was mentioned by more than half of all respondents	High	Non-functional motives, such as enjoyment of driving, were generally found to be important in research on consumer product acceptance	Continue	*Enjoyment of Driving* was brought up regularly during the interviews. Empirical research in the field of consumer products confirms that non-functional motives are important in virtually any consumer related product category. Consequently, this concept will be included in the quantitative stage.
Control	Control expresses the belief that ADAS is taking away personal freedom and thus creating a form of technological paternalism	High	This concept was mentioned by about two thirds of the respondents, some of whom brought it up multiple times	Context-Specific	This factor was only applied in the area of technological innovations that are aimed at substituting manual tasks. In these cases, however, the concept was found to be significant	Continue	*Control* was found to be an important factor in both interviews and empirical research in the field of technological innovations. Consequently, this concept will be included in the quantitative stage.
Past Experiences	Past Experiences refers to experiences with ADAS technology as well as to personal experiences for instance in critical driving situations	High	Past Experiences were found to have a significant impact on the decision as to whether or not to use ADAS technology	Moderate	This concept was found to be a significant factor for acceptance in some studies, others could not report any impact	Dismiss	Experience with the product category or the technology of interest was found to be an important determinant in literature as well as during the interviews. This causal relationship, however, is almost tautological and is also confirmed by Roger's Innovation Acceptance Process. Thus, the concept was dismissed for hypothesis development.

Concept (alphabetical order)	**Short description**	**Significance of the concept derived from interviews** (Based on the frequency of occurrences in the interviews)		**Significance of the concept derived from literature review** (Based on applications of the concept in literature and the explained variance in innovation acceptance behaviour that was attributed to the concept in the reviewed studies)		**Decision on the concept** (whether or not the concept will be subsequently used to develop hypothesis for quantitative research)	
Perceived Ease of Use	Expected cognitive expenses necessary to use a driver assistance-system	Low	Perceived Ease of Use was brought up rather seldom by respondents and if so, the interviewees consistently reported that they had experienced or expected a rather easy usage of these systems	High	Virtually all studies applying the TAM model report that this concept has a significant influence on attitude, which in turn significantly influences the acceptance of innovations	Dismiss	*Perceived Ease of Use* was found to be a relevant factor for many technological innovations in empirical studies. The interviews revealed, however, that in the case of ADAS learning efforts are generally not regarded to be relevant. Consequently, this concept will be dismissed for hypothesis development.
Perceived Risks	Anticipated negative consequences of adopting ADAS. Most commonly: Critical system failure, distraction, diminishing driving skills and the artificial feeling of being protected	High	Almost every respondent remarked that he or she expected risks associated with ADAS throughout the interviews: thus, the influence of this factor is expected to be rather high	Context-Specific	This concept has only been reported to be significant for some technological innovations like mobile banking: thus, its significance is likely to be context dependent	Continue	*Perceived Risks* were found to be an important factor in both, interviews and empirical research in the field of technological innovations. Consequently, this concept will be included in the quantitative stage.
Perceived Usefulness	Anticipated positive consequences of adopting ADAS. Most commonly: Comfort and safety benefits	High	The usefulness of ADAS technology was discussed in every interview: thus, the influence of this factor is expected to be rather high	High	Virtually all studies applying the TAM model report that this concept has a significant influence on attitude, which in turn significantly influences the acceptance of innovations	Continue	*Perceived Usefulness* was found to be an important factor in both interviews and empirical research. Consequently, this concept will be included in the quantitative stage.
Resources	Perceived expectation of resources necessary to obtain and use Advanced Driver-Assistance Systems	Average	The resources needed to obtain and use ADAS were mentioned by about half of the individuals interviewed	Low	Even though the availability of resources necessary to adopt an innovation are part of the TPB model, its ability to explain the acceptance behaviour was in most cases found to be insignificant	Continue	*Resources*, most importantly price, were brought up during the interviews as a factor impeding acceptance. Empirical studies, however, have generally found no proof for this relationship (see Table 7). It can be concluded that cost may only play a role for the acceptance of some particular innovations. Since costs were mentioned during the interviews on ADAS technology, costs will be included for the present hypothesis model.

Concept (alphabetical order)	**Short description**	**Significance of the concept derived from interviews** (Based on the frequency of occurrences in the interviews)		**Significance of the concept derived from literature review** (Based on applications of the concept in literature and the explained variance in innovation acceptance behaviour that was attributed to the concept in the reviewed studies)		**Decision on the concept** (whether or not the concept will be subsequently used to develop hypothesis for quantitative research)	
Subjective Norms	Perceived social pressure to adopt or not to adopt a certain innovation.	Low	The perceived installed customer base (descriptive norm) and direct social pressure (injunctive norm) have played only a minor role in this interview phase	High	A widely applied and integral part of the TPB model, this concept was consistently found to be a significant predictor	Continue	*Subjective Norms* were rarely mentioned during the interviews. In empirical research, however, this factor was found to be a major determinant for the acceptance behaviour. Due to the possibility that *Subjective Norms* influence behaviour on a more subconscious level, which the interviews might not have been able to reveal, the author decided to test this model in the qualitative stage, despite the rather low occurrence in the interview results.
Trust	The reasonable expectation (confidence) of the respondent that the system will behave in a beneficial way	High	Trust has emerged as an important factor mentioned by almost two thirds of the respondents	Context-Specific	This concept has only been reported to be significant for some technological innovations like mobile banking, and thus its significance is likely to be context dependent	Continue	*Trust* was found to be an important factor in both interviews and empirical research in the field of technological innovations. Consequently, this concept will be included in the quantitative stage.

5.19 Integrating Behavioural Models

In order to develop behavioural hypotheses from these concepts, it is necessary to recall the behavioural models reviewed in the literature review (see Chapter 2). From an empirical point of view, it is difficult to judge the efficiency of the different behavioural models as predictive tools for innovation acceptance. Meta-studies which applied the TPB and the TAM model to the same data set have found that the "theory of planned behaviour explains acceptance [..] beyond that which is explained by TAM alone" (Seeman and Gibson, 2009, p.25). However, other meta-studies have revealed a rather similar predictive efficacy of TPB and TAM (Fusilier and Durlabhji, 2005, p.234). From a more theoretical point of view, the models differ mainly in the degree of generality. The TAM uses only two main constructs, *Perceived Ease of Use* and *Perceived Usefulness*, as the core determinants of use decisions. The TPB, on the other hand, employs beliefs that are specific to the very context under investigation.

In contrast to the TAM, which uses the same constructs for each context, the TPB thus requires conducting a pilot study to identify relevant behavioural beliefs, referent groups and control variables in every context and for each study (Hwa, 2006, p.102). Moreover, unlike the TPB, the TAM does not explicitly include any social pressure variable, which, as discussed above, might be an important influential variable in the context of consumer goods. The UTAUT is an attempt to incorporate both models, but has not yet proved to be a predictive model outperforming the singular applications of the TPB and the TAM. Moreover, operationalisation of UTAUT variables is difficult, since the multitude of constructs lack a standard operationalisation-scheme comparable to the original models (Bagozzi, 2007, p.245). In terms of numbers of applications in contemporary innovation acceptance research, the TAM and TPB are employed almost equally, with only a minority of researchers deciding to use the UTAUT model.

In conclusion, Ajzen and Fishbein's TPB model offers the possibility to combine the results from the qualitative research with a quantitative approach and thus best fits within the chosen research approach. In accordance with the research philosophy discussed in the previous chapter, the employment of the TPB model will satisfy a postpositivistic approach and will base the empirical research on a model that is scientifically robust and empirically proven. Thus, the TPB model will be the model of choice for the further hypothesis development.

Ajzen and Fishbein (1980) propose that behaviour is determined by *Intention,* which in turn is determined by two fundamental factors, the *Attitude* towards the behaviour and the *Subjective Norms*. According to Rogers (2003) it is the persuasion stage when the individual forms a favourable or unfavourable attitude towards the innovation. This phase is followed by the decision and, finally, the implementation phase. Both models thus propose that the acceptance of an innovation is preceded by a positive intention to use the technology in question.

Demographic variables such as age and gender are treated as background variables in the TPB model as well as in other behavioural models such as the UTAUT model. Thus, demographic variables can be an explanation for model factors but are not part of the model themselves.

Chart 28 shows the basic behavioural model of ADAS acceptance.

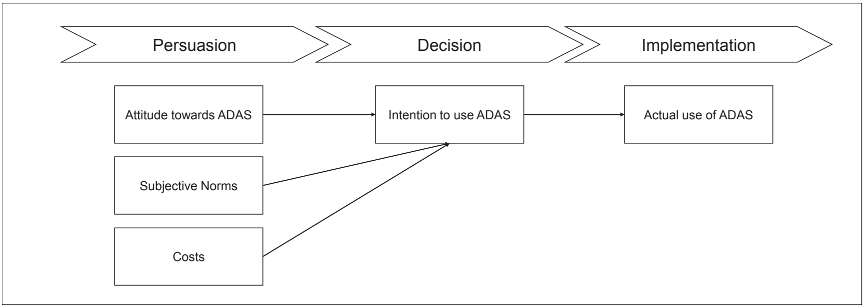


Chart 28: Basic behavioural model, Source: Own drawing based on Rogers (2003) and Fishbein and Ajzen (2010)

As a consequence of this behavioural model, all causal hypotheses will be directed at the *Intention to Use ADA*S, as an affected construct. By determining the intention to use ADAS within the target group, the author will derive at the most exact approximation of the future actual usage of this technology.

5.20 Hypothesis Refinement

Based on the combined analysis of interview data and empirical research, the initial hypotheses, set up before, are now revisited. The analysis resulted in seven core concepts, which are expected to impact the individual acceptance or resistance decision towards Advanced Driver-Assistance Systems. These seven concepts widely confirm the initial hypotheses, but with some minor refinements and supplements.

Initial hypotheses H_{i1} was confirmed, since ancillary driving benefits were found to be a major factor influencing the acceptance of ADAS. The hypothesis, however, will consequently be split into two, with one resulting hypothesis referring to the general enjoyment of driving and one to the desire to exert control. Hypothesis H_{i2} was confirmed by the analysis, as was Hypothesis H_{i3} (both were only slightly reworded, based on the interview results). Three new predictors resulted from the analysis, which were not included in the initial hypotheses, namely *Perceived Usefulness*, *Perceived Installed Customer Base* and *Perceived Costs*. These concepts will consequently be included in the hypotheses model.

The refined hypotheses are as follows:

Enjoyment of Driving
Enjoyment of driving, which refers to various personal motives other than transportation, such as sensory stimulation, excitement, independence or self-expression, was found to be a major reason for resistance towards ADAS. Advanced Driver-Assistance Systems are perceived as supplanting manual driving tasks which respondents prefer to conduct themselves. Thus, it follows that:

H_1: The greater the enjoyment of driving, the lesser the intention to use Advanced Driver Assistance Systems.

Desire to Exert Control
The interviews revealed the concern that ADAS are taking away personal freedom and thus create a form of technological paternalism. Respondents expressed the wish to remain in control of the automobile in any situation. Thus, it follows that:

H_2: The greater the desire to exert control, the lesser the intention to use Advanced Driver Assistance Systems.

Perceived Risks
Throughout the interviews, almost every respondent remarked that he or she expected risks associated with ADAS. The most common risks mentioned by the interviewees were related to safety considerations. Taken together, these risks are expected to serve as a major reason for resistance towards this innovation. Thus, it follows that:

H_3: The greater the perceived risks associated with Advanced Driver Assistance Systems, the lesser the intention to use Advanced Driver Assistance Systems.

Perceived Usefulness

The interviews revealed that the anticipated positive consequences of adopting ADAS, which were mainly attributed to comfort and safety benefits, were the strongest factors supporting the acceptance. Thus, it follows that:

H_4: The greater the perceived usefulness of Advanced Driver Assistance Systems, the stronger the intention to use Advanced Driver Assistance Systems.

Trust in Own Driving Skills

Trust is defined as the reasonable expectation (confidence) of an individual that the adoption of an innovation will be beneficial for him or her. Generally, the literature found empirical evidence that trust in technology supports the acceptance of high-tech innovations. The interviews, however, also revealed that trust is an ambivalent influence factor for innovation acceptance in the case of ADAS. Since ADAS are aimed at substituting manual driving tasks, respondents weighted the level of trust in technology against the level of trust in their own driving skills. To support this thesis, it follows that:

H_5: The greater the confidence in one's own driving capabilities, the lesser the intention to use Advanced Driver Assistance Systems.

General Innovativeness

Even though innovativeness is often regarded as a background factor (such as age or gender), the interviews revealed that the general attitude towards new technologies (or general innovativeness) serves as a major factor influencing the attitude towards ADAS. To support this thesis, it follows that:

H_6: The more individuals trust in new technology, the stronger the intention to use Advanced Driver Assistance Systems.

Perceived Installed Customer Base

Rogers (2003, p.245) argues that individuals do not evaluate an innovation solely on the basis of its performance as judged by objective attributes. Rather, they decide whether or not to adopt the product on the basis of the subjective evaluations of the innovation conveyed to them by others like themselves (peers). During the interviews, respondents remarked that they perceive ADAS to be a common technological standard. The perceived installed customer base acts as a descriptive norm in this case, meaning that individuals want to comply with what they perceive that the public considers reasonable. Thus, it follows that:

H_7: The greater the perceived installed customer base of Advanced Driver Assistance Systems, the stronger the intention to use these Systems.

Perceived Costs
Costs were found in many interviews as a factor impeding acceptance of ADAS technology. Consequently, it follows that:

H_8: The greater the perceived costs of Advanced Driver Assistance Systems, the lesser the intention to use Advanced Driver Assistance Systems.

In the next chapter, these eight hypotheses will be used as a basis for developing a questionnaire aimed at eliciting the underlying interdependencies between the variables and thus develop a conceptual model towards the acceptance of ADAS.

5.21 Chapter Conclusion

Recapitulating the chapter objectives, the overall aim of this chapter was to develop concepts that are involved in the individual belief formation towards the use of Advanced Driver-Assistance Systems. Based on fifty-four initial codes, which were extracted from the interview transcripts, ten main categories could be developed as potential concepts towards this objective. A combined analysis of the interview results and the results from literature research was conducted in order to increase the validity of the concepts. In sum, eight refined hypotheses were derived as a basis for the next research phase. Chart 29 gives an overview of the model of hypotheses that was developed as the result of this chapter.

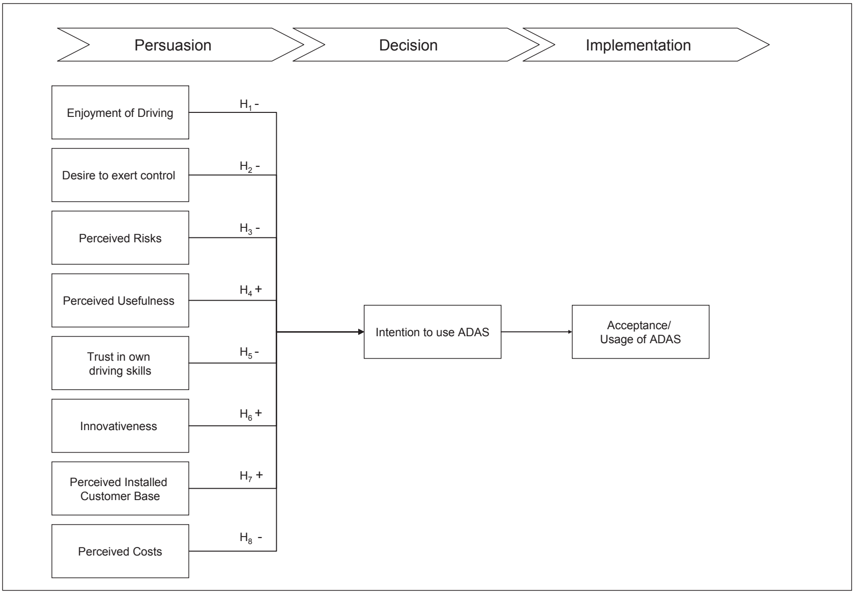


Chart 29: Model of Hypotheses for ADAS acceptance, Source: Own drawing

Chapter 6: Quantitative Research Approach

6.1 Chapter Objectives

The overall aim of this chapter is to either confirm or reject the hypotheses developed in the previous chapter with a maximum level of confidence and to develop a conceptual model for the acceptance of ADAS technology. The resulting conceptual model should be based on:

- A sufficiently large and representative sample of the target group;
- A valid operationalisation and measurement of the chosen concepts in the form of a questionnaire;
- Valid descriptive scales, which fit with the research object but do not bias the result in any direction;
- A comprehensive analysis of the survey results, applying appropriate statistical tests.

In order to achieve these objectives, the available methods for data collection and appropriate sampling methods will be discussed in the first step. Next, items and scales will be developed in order to operationalise the research hypotheses and to construct a research questionnaire, which is consequently administered to a representative sample of the target population. The resulting data will finally be interpreted by applying appropriate statistical tests and procedures in order to arrive at a conceptual model of ADAS acceptance.

6.2 Survey Types

Questionnaires are one of the traditional data collection methods designed to elicit standard information from a large number of subjects (Hwa, 2006, p.130). Even though there is no widely accepted, concise definition of the term *survey*, Robson (2009, p.230) argues that the typical central features of a survey are:

- The use of a fixed, standardised design for all respondents
- The collection of a small amount of data from a relatively large number of individuals
- The selection of representative samples of individuals from a known population.

P. Planing, *Innovation Acceptance,* DOI 10.1007/978-3-658-05005-4_6,

The relative popularity of surveys is not only due to their relatively low cost and their time efficiency, but also because surveys provide the sort of data which can be easily understood by a broad audience in a scientific field and thus deliver a convincing argument for the research findings (Robson, 2009, p.232). Another important advantage of a survey is that it allows for the collection of a great amount of data about an individual respondent at one time. At the same time, surveys can be employed in virtually any setting, whether among teenagers, seniors, IT experts or car owners (Kumar, Aaker and Day, 2002, p.209). Robson (2009, p.233) states that surveys "provide a relatively simple and straightforward approach to the study of attitudes, values, beliefs and motives". This clearly fits well with the research objectives of the present study.

Yet, surveys also convey some risks in regard to the research objectives. Self-completion surveys typically have a low response rate. As the characteristics of non-respondents are not known, this generally imposes a threat to the representativity of the sample (Robson, 2009, p.233). Moreover, in written surveys, it is difficult to detect respondents who do not treat the exercise seriously and thus bias the results in any direction (Robson, 2009, p.233).

Next to these general advantages and disadvantages of self-completion surveys, it is worthwhile to have a closer look at the different types of survey methods. The decision on a data collection method is a critical point in the research process and should thus be based on an appraisal of relevant factors in regard to the research objectives (Kumar, Aaker and Day, 2002, p.215). There are as many survey methods as there are different kinds of communication technologies. With the rapid proliferation of communication processes, the number of survey methods has also increased in recent years (Kumar, Aaker and Day, 2002, p.209). Most common in marketing research are surveys using mail, fax or email. Online-based surveys are, however, becoming more and more important. Table 20 gives an overview of the basic survey methods and their general advantages and disadvantages for application in practice.

Table 20: Characteristics of survey methods,
Source: Based on Easterby-Smith (2002, pp.216–235); Thorpe and Jackson (2008, pp.219–225) and Robson (2009, p.233)

Method	**Characteristics**	**Advantages**	**Disadvantages**
Mail survey	Administered through the mail	• Access to widely dispersed samples and samples that cannot be reached via fax or online	• Relatively high costs • Relatively time consuming • Slow data collection • Mailing addresses needed
Fax survey	Administered via fax	• Relatively low costs • Fast data collection • Can be administered to corporate fax accounts	• Sample limited to fax owners • Return costs for the respondent might decrease response rate • No enclosed incentives possible
E-Mail survey	Administered via e-mail	• Relatively low costs • Email addresses can be purchased very cheaply	• Limited to e-mail users • Difficult to determine the sampling variables and their target proportions • Sending unauthorised emails can raise ethical and legal issues • Relatively low response rate
Web-based survey	Administered online	• Relatively low costs • Flexible Design • Automated data encoding • International audience • Perceived anonymity	• Difficulty to attract respondents to the web page • Sample limited to web users • Exclusion of individuals who are not attracted to the webpage

In terms of efficiency and accuracy, the web-based survey outperforms all other sorts of surveys. Its biggest benefit is the automated data generation, which makes encoding (a potential error cause) dispensable. Thus, the author decided to employ this survey method. In order to utilise the advantages of this survey type, however, it is necessary to develop strategies to circumvent the risks associated with this specific type of questionnaire. Risks related to the sample limitation are diminishing, since over 80 percent of households in Germany already have internet access (Zweiter Deutscher Rundfunk (ZDF), 2011, p.1). However, the risk of sample bias due to the exclusion of individuals who are not attracted to the web page imposes a relevant threat to the representativity of the sample. In order to minimise this risk, individuals will be attracted to the web page via different channels. This approach will increase the sample heterogeneity and will therefore help to increase the representativity of the sample.

6.3 Questionnaire Design

Despite the obvious advantages of questionnaires, their design is probably one of the most challenging tasks when conducting social science research. Since the researcher is usually not present when the respondent fills out the survey, the exact question wording, the question sequence and the survey layout are crucial elements that determine whether the responses given are the answer to what was asked or to something completely different (Bradburn, Sudman and Wansink, 2004, p.4; Robson, 2009, p.245). Most generally, Robson (2009, p.242) states that a good survey should:

- Provide a valid measure of the research question,
- Get the co-operation of respondents,
- Elicit accurate information.

Survey questions should thus be designed in order to help achieve the goals of the research and, in particular, to answer the research questions (Kumar, Aaker and Day, 2002, p.275; Robson, 2009, p.241). The researcher's task in this process is to link the research questions to the survey questions. Even though there are no established and widely-accepted procedures that will lead consistently to a good questionnaire, a vast amount of rules and procedures, which should be considered before actually writing questions, have been developed in order to guide researchers through this process (Brace, 2008, p.105; Kumar, Aaker and Day, 2002, p.275).

Robson (Robson, 2009, p.245) and Kumar, Aaker and Day (2002, pp.283–284) agree that the most important rules to create effective questions are:

- Keep the language simple
- Keep the questions short
- Avoid double-barrelled questions
- Avoid leading questions
- Ensure that the question wording means the same thing to all respondents.

Next to these basic guidelines, a number of other factors have to be considered when designing a questionnaire. The appearance of the questionnaire, especially the first impression, is vital for a high response rate (Kumar, Aaker and Day, 2002, p.186; Robson, 2009, p.249). It has to be emphasized that next to the wording, the sequence of questions is the most important factor in facilitating recall and motivating more accurate responses (Kumar, Aaker and Day, 2002, p.275). Thus, initial questions should be easy and interesting (Kumar, Aaker and Day, 2002, p.286). Middle questions should cover the more difficult areas. The last questions should again be more interesting to encourage the respondents to finish the questionnaire (Robson, 2009, p.249). Robson (2009, p.238) further argues that with self-completion surveys, the length and the complexity of the questionnaire have to be kept to a minimum. Thus, for the present survey, the author will design the questionnaire in a way that limits the response time to under fifteen minutes. Next to this, clear instructions need to be provided. Especially in an online setting, the clarity of wording, the simplicity of the design and the perceived ease of use of the user interface are essential for a high response rate (Robson, 2009, p.249).

Questionnaires are especially vulnerable to a number of response bias factors that can negatively affect the respondent's motivation and the overall results. The most common response bias factors according to Kumar, Aaker and Day (2002, p.213) are:

- Concern about invasion of privacy
- Time pressure and fatigue
- Prestige seeking and social desirability responses
- Courtesy bias (tendency to avoid causing discomfort)
- Uniform response error

- Response style error (e.g. inappropriate bipolar word pair to choose from).

Chart 30 gives an overview of the questionnaire design process that was applied in order to develop the survey for the present research.

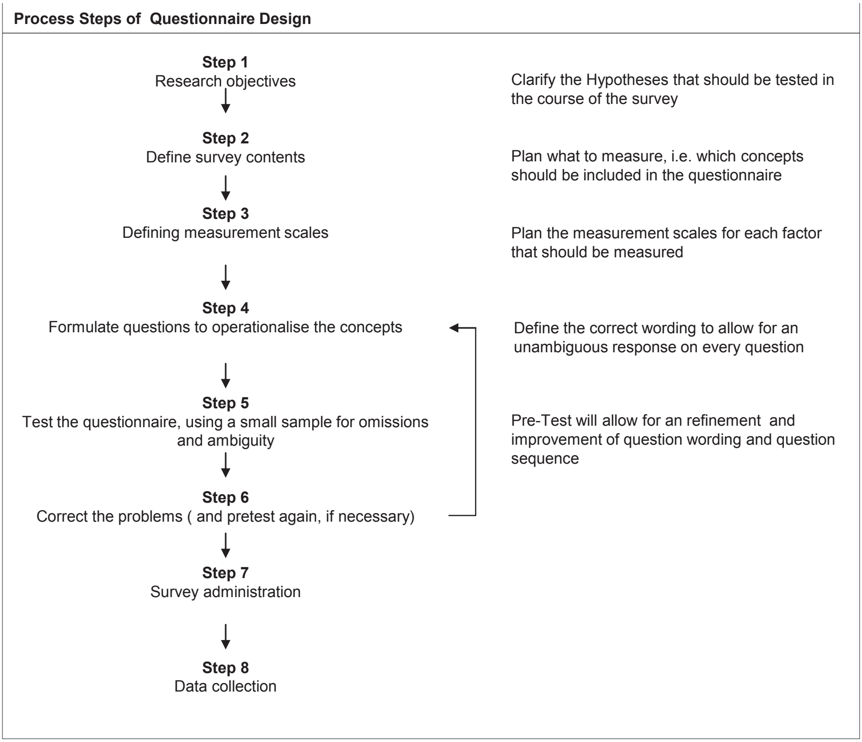


Chart 30: Questionnaire design process, Source: Own drawing, based on Kumar, Aaker and Day (2002, p.276).

6.4 Questionnaire Contents

In the next step, the contents of the questionnaire have to be defined. In order to test Hypotheses H_1-H_7, the seven respective concepts, as well as the dependent variable *Intention*, have to be included in the questionnaire:

- Enjoyment of Driving
- Desire to exert control
- Perceived Risks

- Perceived Usefulness
- Trust
- Perceived Installed Customer Base
- Costs
- Intention.

Next to this, the questionnaire will also contain some demographic items. Demographic items are required in order to develop an understanding of the sample's structure and to judge the level of representativeness of the sample in regard to the target group. Moreover, by studying the effects of background factors, it is possible to identify the origins of salient beliefs, which serve as the cognitive foundation for acceptance behaviour (Fishbein and Ajzen, 2010, p.253). Thus, the author decided to include the following background factors in the questionnaire:

- Age
- Gender
- Car owner (if yes)
  - Car type owned
  - Car brand owned.

Additional to these questions, the questionnaire will determine the so-called Rogers' Innovativeness Criteria for the respondent (Rogers, 2003, pp.22–23). This means categorising the respondent on a scale in terms of his or her general affinity to product innovations and determining the respondent's current state in the ADAS adoption process. This is crucial for understanding the person's belief formation stage. Literature suggests that individuals in later stages of the adoption process hold stronger beliefs towards the innovation (Rogers, 2003, p.175). Thus, the following additional items will be included in the questionnaire:

- General Innovativeness of respondents
- Level of experience with ADAS

In sum, the questionnaire will include eight psychological constructs and seven background factors. While background factors can be collected directly, psychological constructs can only be measured indirectly: thus, appropriate scales have to be developed beforehand.

6.5 Developing Scales

Scaling of factors involves creating "a continuum upon which measured objects are located" (Bradley, 2007, p.209). Since most objects in social research are not numeric in nature, the researcher has to develop a descriptive scale that fits with the research object but does not bias the result in any direction. In general, numbers are assigned according to rules that should correspond to the properties of whatever is being measured (Kumar, Aaker and Day, 2002, p.250). This could be a very simple rule, such as allocating two different numbers for gender (nominal scale), or a rule that allocates numbers according to the rank of various objects (Ordinal or Rank-Order-Scale)(Easterby-Smith, Thorpe and Jackson, 2008, p.230). Table 21 gives an overview of the types of scale and their properties.

Table 21: Types of scales, Source: Based on Easterby-Smith, Thorpe and Jackson (2008, pp.230–231)

Type of Measurement Scale	Rules for Assigning Numbers	Typical Application	Statistical Tests
Nominal	Objects are either identical or different	Classification (by gender etc.)	Percentages, mode/ chi-square
Ordial or Rank-Order	Objects are greater or smaller	Rankings (preference, class standing)	Percentile, median, rank-order correlation
Interval	Intervals between adjacent ranks are equal	Index numbers, temperature scales, attitude measures	Mean, standard deviation, product moment correlations / t-tests, ANOVA, regression, factor analysis
Ratio	There is a meaningful zero, so comparison of absolute magnitudes is possible	Sales, income, units produced, costs, age	Geometric and harmonic mean, coefficient of variation

In order to choose a scale type which satisfies the chapter objectives, i.e. enables a validation of the hypotheses developed so far, the different properties of the various scale types have to be compared. Since ratio scales are not applicable for psychological constructs, only interval and ordinal scales will enable a statistical validation, which is required in order to test the hypotheses developed so far. Consequently, the author will use ordinal scales for each psychological construct within the questionnaire.

There are certain key questions that have to be addressed when designing ordinal scales:

1. The number of categories has to be defined;
2. The types of poles used in the scale have to be defined;
3. It has to be decided whether or not to label every category of the scale;
4. It has to be decided whether or not to balance the categories (Kumar, Aaker and Day, 2002, p.258).

Fortunately, there are some standard rating scales that have proved to be applicable in most cases of survey research. Two of the most widely used scales are the Likert Scale and the Semantic Differential Scale (Bradley, 2007, p.210).

Likert Scales

The Likert Scale is a rating scale used to measure the strength of agreement towards a variety of statements related to the attitude or the object. Usually a Likert Scale consist of two parts: an item part, which is essentially a statement about the object, and an evaluative part, which is a list of response categories ranging from “strongly agree” to “strongly disagree” (Kumar, Aaker and Day, 2002, p.260). The Likert scale demands that the researcher determine items that express strong positive or negative attitudes (but no neutral ones). Then the respondents are asked to rate each statement on a 5- or 7-point scale ranging from “strongly agree” to “strongly disagree”. To be retained in the final Likert attitude scale, an item must meet the criterion of internal consistency, meaning that responses to the item discriminate between people with different attitudes towards the research object (Fishbein and Ajzen, 2010, p.88).

It has to be acknowledged that there is a debate in the literature as to whether or not Likert Scales are producing ordinal-level data or interval-level data. Some authors claim that Likert Scales always produce ordinal-level data, since they only allow for a ranking of categories (Jamieson, 2004, p.1218). Other authors, however, argue that Likert Scales can be interpreted as interval scales, since the continuum between the poles enables one to measure intervals (Allen and Seaman, 2007). Empirical evidence supports the position that treating Likert Scales as if they were interval measures provides more advantages than disadvantages (McNabb, 2008, p.174). The author will reconsider this discussion when selecting appropriate statistical tests in the later part of this research.

Semantic Differential Scale

The Semantic Differential Scale is a rating scale that asks the respondent to state his or her position on a line or space between two descriptions (Robson, 2009, p.299). Usually this involves a bipolar word pair (i.e. good/bad, old/new) that describes the end points of the scale. The respondent is free to choose either position or a given point on the continuum between the poles (Babbie, 2010, p.180). Especially bipolar scales raise the question whether to include a neutral point as a "don't know", or "escape option" for the respondents. While some authors have argued that including a neutral point does influence the results, the majority of meta-studies conducted towards this issue reported an increase in data quality and response rate when a neutral point was included (Bradley, 2007, p.209).

Developing Scales for the Belief Factors

Ajzen and Fishbein (2010) propose that two scales should be employed for each belief factor tested. One scale will be used for evaluating the positive or negative influence of the factor and the other scale will be used for evaluating the relatively strength of this factor (in terms of influencing the acceptance decision). In the case of the present research, the results from the preceding qualitative study enabled the author to develop directed hypotheses. The evaluation of beliefs, i.e. whether the factors are causing a positive or a negative attitude towards ADAS, is thus already predefined at this stage of the research. Consequently, only a measurement of belief strength is necessary for hypothesis testing.

In order to measure the relative strength of the belief factors towards the acceptance of ADAS, a unipolar, seven-point Likert Scale will be developed, ranging from 1 (completely disagree) to 7 (completely agree).

According to Ajzen and Fishbein (2010, p.39) *Intention to Use* is the indication of a person's readiness to perform a given behaviour (in this case, the readiness to use ADAS). The strength of a person's belief in his or her readiness to use ADAS is best represented by a unipolar scale. Consequently, *Intention to Use* will be measured on a seven-point, unipolar Likert Scale, ranging from 1 (completely disagree) to 7 (completely agree).

Developing Scales for the Background Factors

Regarding the demographic items, different scales will be employed depending on the type of item. Gender will be measured on a nominal scale, which will include two categories: male and female. Age could theoretically be measured on a ratio scale, based on the exact age of the respondent. However, the literature indicates that in most cases, questions items asking for age groups are sufficient for the classification of respondents. The advantage of offering age groups to the respondent is that it usually reduces the time taken to complete the question. Moreover, it is found to improve the response rate, since respondents are generally rather reluctant to give their exact age (Oppenheim, 2005, p.132). Consequently, seven mutually exclusive age groups will be offered to the respondent (under 20, 21–30, 31–40, 41- 50, 51–60, 60–70, above 70).

Car ownership will be measured on a nominal scale (yes or no). Similar, the car type owned will be measured on a nominal scale, including a choice of different car categories. Since there are various official and unofficial car category definitions available, the author decided to use the most common categorisation, developed by the European Commission. This categorisation includes the following items:

- A-category: mini cars
- B-category: small cars
- C-category: medium cars
- D-category: large cars
- E-category: executive cars
- F-category: luxury cars
- S-category: sport coupés
- M-category: multi purpose cars
- J-category: sport utility cars (including off-road vehicles)

(Commission of the European Communities, p.2). The letter categories will be omitted to avoid confusing participants, since it is anticipated that not all respondents have heard of the letter categories.

The car brand owned will again be measured on a nominal scale, including a choice of different car brands. In order to offer the participants a set of relevant car brands available in the German market, the author decided to adopt the list of car brands from *mobile.de,* Germany's most popular website for used cars. In sum, the respondents will be offered 100 car brands in alphabetical order, plus the option to tick "other". Since the questionnaire will be administered online, such a number of answer choices can be offered as a single dropdown menu, which respondents are used to from other webpages, and is thus not expected to have any negative effect on the answering time.

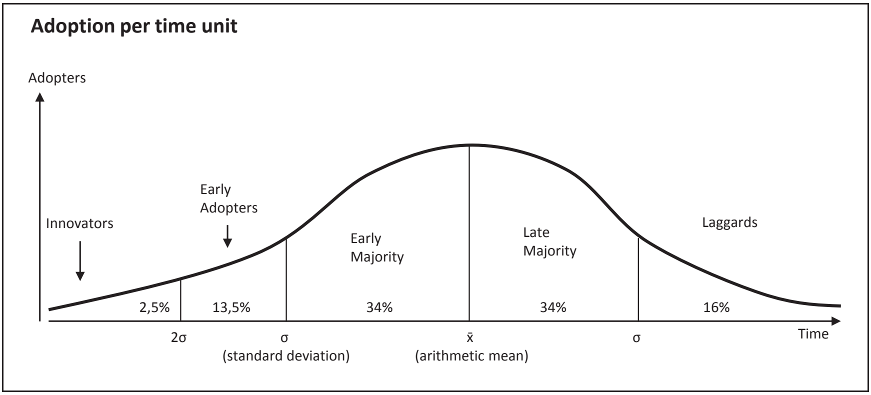
Developing a Scale for Innovativeness

There will be two different scales for determining the Innovativeness of respondents. First, there will be a set of question items, using a unipolar, seven-point Likert Scale ranging from 1 (completely disagree) to 7 (completely agree). Second, the author will use a measurement of Roger's Innovativeness Criteria for the respondents, which will be based on the original 5-point, categorical scale of Rogers (2003, pp.22–23), which includes the following items: (1) innovator, (2) early adopter, (3) early majority, (4) late majority and (5) laggard. This scale is based on the assumption that the points in time at which individuals adopt an innovation follow a normal, bell-shaped distribution (Rogers, 2003, p.80). Rogers simply divides the continuous variable into discrete categories, based on their relative distance from the mean. The following table shows the partitioning of the continuum.

Table 22: Rogers' Innovativeness Scale
Source: Rogers (2003, pp.280–281)

Adopter Category	% adopters	Area covered under normal curve
Innovators	2.5	Beyond $\bar{x}$ - 2σ
Early Adopters	13.5	Between $\bar{x}$ – σ and $\bar{x}$ – 2 σ
Early Majority	34.0	Between $\bar{x}$ and $\bar{x}$ - σ
Late Majority	34.0	Between $\bar{x}$ and $\bar{x}$ + σ
Laggards	16.0	Beyond $\bar{x}$ + σ

$\bar{x}$ (arithmetic mean), σ (standard deviation)



The classification of a respondent's innovativeness thus depends on two variables: the mean year of acceptance of an innovation in a population and the individual's year of acceptance.

Developing a Scale for the Level of Experience with ADAS

The level of experience with ADAS could be measured in terms of the length of ADAS usage (measured in months or years) or the general familiarity with this type of technology. Based on the relatively low market share of ADAS today (see Chapter 2), the author decided to use the latter definition of experience with ADAS. Thus this item will measure the familiarity with ADAS on a six-point categorical scale including the following items:

- Regularly used in own car;
- Available in own car but seldom used;
- Occasionally used in other car (rental, friends etc.);
- Well-known, but never actually used;
- Basic knowledge;
- No knowledge.

Overview of Scales

The following table (Table 23) gives an overview of the scales chosen for the various factors that will be measured with this survey.

Table 23: Overview of measurement scales

Factors	Scales
Belief factors: • Enjoyment of Driving • Desire to exert control • Perceived Risks • Perceived Usefulness • Trust • Perceived Installed Customer Base	Unipolar, seven-point Likert Scale, ranging from 1 (completely disagree) to 7 (completely agree)
Intention to use ADAS	Unipolar, seven-point Likert Scale, ranging from 1 (completely disagree) to 7 (completely agree)
Demographic items: • Gender • Car ownership • Car type • Car brand	Nominal scales: • male/female • yes/no • car categories • car brands
Factors	**Scales**
Respondents general innovativeness	*Question items:* Unipolar, seven-point Likert Scale, ranging from 1 (completely disagree) to 7 (completely agree) *Year of adoption:* Roger's Innovativeness Criteria: 5-point, categorical scale.
Level of experience with ADAS	Six-point, categorical scale.

6.6 Developing a Cover Letter

Next to the questionnaire, the cover letter is of crucial importance, too. Even though a web-based survey does not include a traditional cover letter, the front page of the survey will post a carefully worded introduction text. According to the literature, this text should indicate the aim of the survey and convey its importance for the research purpose. Furthermore, It should be tailored to the audience and should give the name of the sponsor or organisation carrying out the survey (Robson, 2009, p.250).

For the present research, the cover letter will explain the purpose of the research in short words and will convey that this piece of research is aimed at improving Advanced Driver Assistance Systems for the benefit of road safety. This approach is aimed at creating a moral obligation to finish the survey for the common good. The cover letter will also give a few examples of currently available Advanced Driver Assistance Systems, such as Lane-Assistant or Blind-Spot monitoring. These systems, however, will be intentionally presented in as short and as neutral a way as possible, in order not to bias the evaluation of respondents in any direction. The complete cover letter can be found in Appendix A.

6.7 Operationalisation of Concepts

In the next step, the contents of the questionnaire have to be operationalised. This basically means developing formulations, so-called items, for each factor that will be included in the questionnaire. As discussed before, the exact wording of each item determines whether the responses given are the answer to what was asked or to something completely different (Bradburn, Sudman and Wansink, 2004, p.4; Robson, 2009, p.245). Generally, the best way to avoid ambiguous or misleading formulations is to review scientific publications employing similar factors. If a factor was reported to be a valid and significant explanation of behaviour, it is most likely that it was also successfully operationalised in the respective study (Kumar, Aaker and Day, 2002, p.293). Thus, by adopting formulations from related research and by complying with the general rules for questionnaire design, the most appropriate formulation for each question item will be developed.

In the next step, it has to be decided whether it is sufficient to develop singular items for each construct or whether multiple items will be needed for a sufficient measurement of the factors. In his extremely influential article, Churchill (1979, p.66) states that: “In sum, marketers are much better served with multi-item than single-item measures of their constructs”. His basic argument is that almost every psychological construct involves different dimensions, which cannot be measured with a single item scale. Moreover, single items typically have considerable measurement error and produce unreliable responses, since the same scale position is unlikely to be checked in successive administrations of an instrument. Churchill (1979, p.66) concludes that by using multi-item measures, the specificity of items can be averaged out when they are combined. Combining items enables the researcher to make relatively fine distinctions among people and the reliability tends to increase since measurement error decreases as the number of items in a combination increases. Thus, it can be expected that multiple-item measures are generally more reliable because they enable the computation of correlations between items, which, if the correlations are positive and produce a high average, indicate an internal consistency of all the items in representing the presumed underlying attribute (Bergkvist and Rossiter, 2007, p.176).

Churchill's approach has become so popular that multiple-item measures clearly dominate scientific work today (see Table 7). The number of items developed per construct varies from study to study. More items can further reduce measurement error. However, the larger the number of synonymous items the researcher attempts to generate, the greater is the chance of including items that are not proper synonyms of the original attribute descriptor (Bergkvist and Rossiter, 2007, p.177). As a result, most researches use three or four synonymous items to measure a psychological construct.
Correspondingly, between three and four items will be developed in the next step for every construct that will be part of the questionnaire.

Enjoyment of Driving
Enjoyment refers to various personal motives other than transportation (non-functional motives), such as sensory stimulation, excitement or self-expression. Literature suggests that different forms of enjoyment have an influence on behaviour (see Bruner II and Kumar, 2005; Chtourou and Souiden, 2010; Cui, Bao and Chan, 2009; Kim, Chan and Gupta, 2007). During the interviews in the qualitative stage of the present research, enjoyment was mainly attributed to the actual driving activity and expressed with statements such as "I enjoy driving too much to use these assistance systems" (Code #27, interview 16). Thus items measuring the overall enjoyment of driving will be developed, irrespective whether this enjoyment refers to sensory stimulation, the thrill of driving or other personal motives.
There are various ways in which the perceived overall enjoyment of a given activity can be expressed. Kim, Chan and Gupta (2007, p.123) use rather straightforward items, such as "I have fun […]", while van der Heijden (2001, p.183) uses more formal expressions such as: "I find this […] overall entertaining". For the present study, rather formal expressions will be combined with

more straightforward questions. In conclusion, *Enjoyment of Driving* will be expressed with the following items.

Item ID	Item	Original item	Source
1.1	I enjoy driving	I enjoy doing […]	Kim, Chan and Gupta, 2007, p.123
1.2	I drive for pleasure	I […] for pleasure	van der Heijden, 2001, p.183
1.3	Driving is an agreeable way of passing time	[…] is an agreeable way of passing time	van der Heijden, 2001, p.183

Desire to Exert Control

Literature suggests that smart technologies can improve the life of customers, but at the same time, they may be seen as taking away personal freedom and the ability to exert control over one's environment (Heiskanen et al., 2007, p.503). The interviews revealed that in the case of ADAS, customers perceive these technologies as taking away personal freedom. Respondents reported very directly that with the usage of ADAS, they "fear losing control over the vehicle" (Code #6 in interview 17). In order to measure a respondent's desire to exert control, a widely accepted standard scale from the field of psychology will be applied, the so-called Desirability of Control Scale (Burger and Cooper, 1979, p.381). This scale originally includes some twenty items to measure a respondent's desirability of control and is still widely applied in practice (see Fieulaine and Martinez, 2010; Moulding and Kyrios, 2007; Parker, Jimmieson and Amiot, 2009). The most appropriate items of this scale in regard to the desire to exert control over one's vehicle will thus be applied to express *Desire to exert control* in the present study.

Item ID	Item	Original item	Source
2.1	Overall, I am worried about the amount of control technology has in the driving experience	"fear of losing control over the vehicle"	Code #6 in interview 17
2.2	I like to be able to switch any technology off when driving	"I enjoy having control over my own destiny"	Desirability of Control Scaleby Burger and Cooper (1979), recent applications in Fieulaine and Martinez, 2010; Moulding and Kyrios, 2007; Parker, Jimmieson and Amiot, 2009
2.3	I enjoy making my own decisions when driving instead of being guided by technology	"I enjoy making my own decisions"	

Perceived Risks

Reviewing more than thirty years of empirical research on *perceived risk*, Mitchell (1999, p.187) denotes that marketing research still lacks a universally agreed operationalisation of this construct in the consumer behaviour context. Despite this shortcoming, Mitchell developed a general guideline for constructing valid items for *perceived risk*. Taking into account that there are many types of perceived risk (e.g. financial, social, etc.), he proposes to specify the domain of the construct very clearly by delineating what is included in the definition and what is excluded. In order to specify the types of risks involved in a given context, he recommends using statements generated from in-depth interviews (Mitchell and Vincent-Wayne, 1999, p.182). Following this guideline, the most common risks mentioned by the interviewees in the present research were found to be related to safety considerations. The perception that ADAS malfunctions might lead to hazardous situations is intensified by the belief that these systems are technologically immature or not yet safe enough. To operationalise this factor, it is thus useful to have a closer look at acceptance studies, focussing on perceived risks related to safety considerations.

One classic study in this field by Schiffman (1972) focused on *perceived risks* of new products. In order to operationalise *perceived risks,* Schiffman asked the respondents to compare the level of risk associated with a new product with the level of risk associated with the product or category this new product is substituting. This approach allows for a relative evaluation of risk, avoiding a categorical bias, and is thus applicable in a wide range of product categories. Transferred to the context of ADAS, this means allowing respondents to evaluate the level of risk involved in ADAS usage in relation to driving a car without ADAS. Consequently, the following item will be used to evaluate *perceived risks*:

Item ID	Item	Original item	Source
3.1	Overall I would say that it is safer to drive **without** driver-assistance systems	Would you say there is danger in using a new […] in place of […]?	Schiffman (1972)

The interviews further revealed that perceived risks are closely related to doubts about the technological maturity of these systems: "I believe that these systems will malfunction one day or not work the way they should" (Code #11 in interview 21). Thus, linking potential risks to expected malfunctions will reveal a clearer picture about the level of risks that respondents anticipate. An item that follows this approach was developed by Shimp and Bearden (1982) in another classic study, focussing on risk perception of consumer products. The authors asked the respondents to reflect on potential problems with a new product and relate the level of perceived risk to these problems. Thus, the following corresponding item will be used to evaluate *perceived risks*:

Item ID	Item	Original item	Source
3.2	I am worried that advanced driving systems may one day fail when I am driving	"I believe that these systems will malfunction one day or not work the way they should"	Code #11 in interview 21

Another serious concern of interview participants was that the actual use of ADAS might lead to hazardous situations, even if the system works properly: "If the car is doing too much automatically, the driver might fall asleep sometime." (Code #28 in interview 21). In a study by Tsiros and Heilmann (2005), the authors developed an item that corresponds with the perceived health risks of using a certain product (in their case, consuming foods). This item can be adapted to the context of ADAS in the following way:

Item ID	Item	Original item	Source
3.3	Using driver-assistance systems may lead to more accidents	How likely is it that consuming […] may lead to a health risk?	Tsiros and Heilmann, 2005

Perceived Usefulness

The perceived usefulness of an innovation is a core element of the Technology Acceptance Model by Davis, Bagozzi & Warshaw (1989), which is widely applied in practice today. The operationalisation of this element in the literature varies strongly depending on the characteristics of the object under study. Items range from "[…] saves my time" (Hashim, 2008, p.262), or "[…] is useful" (Aboelmaged, 2010, p.402), to "using […] would make it easier for me to […]" (Luarn and Lin, 2005, p.888). During the qualitative phase of the present study, the perceived usefulness of ADAS technology was mentioned by every interview respondent. Perceived Usefulness was found to be mainly associated with an expected benefit towards an individual goal. The interviews revealed that in the context of ADAS, this benefit could be a:

- Comfort Benefit, which was mainly associated with a reduction in driving strain: "Using parking assistance, I don't have to wrench my head anymore" (Code #19 in interview 15)
- Safety Benefit, which mainly refers to the perceived increase in driving safety: "Using blind spot monitoring, I can probably realize dangerous situations much faster" (Code #17 in interview 31).

A combination of safety and comfort items is not feasible in this case, since this would generate an ambiguous scale with an expected low level of internal consistency. Thus, the author decided to use more general items referring to the overall expectation of individuals towards potential benefits of using ADAS technology.

Item ID	Item	Original item	Source
4.1	Driver-assistance systems are helpful in many driving situations	"[…] technology is useful"	Aboelmaged, 2010, p.402
4.2	Overall, driving with driver-assistance systems is advantageous	"Overall, using e-procurement technolo-gy is advantageous"	Aboelmaged, 2010, p.402
4.3	Using driver-assistance systems is practical	Own formulation	

Trust in Own Driving Skills

Trust is the reasonable expectation (confidence) of an individual that a certain behaviour will be beneficial for him or her. The interviews revealed that trust is an important, although ambivalent, influence factor for innovation acceptance. Since ADAS is aimed at substituting manual driving tasks, respondents weighted the level of trust in technology against the level of trust in their own driving skills: "I trust my own eyes more than this computer screen […]" (Code #43 in interview 3). Thus, in order to prove the hypothesis that greater confidence in one's own driving capabilities results in a more negative attitude towards ADAS, a valid measurement for trust in one's own capabilities (also called *Self-confidence*) has to be developed.

Literature suggest various items to express confidence, such as "I feel confident […]" (Hahn and Kim, 2009, p.134), "I would find doing […] secure" (Luarn and Lin, 2005, p.888; Wang, Lin and Luarn, 2006, p.179) or "I impress people with my abilities to "[…](Bearden, Hardesty and Rose, 2001, p.125)". These items will be adapted to the context of confidence in driving capabilities as follows.

Item ID	Item	Original item	Source
5.1	Overall, I am confident in my driving abilities	I am confident in my ability to […]	Bearden, Hardesty and Rose, 2001, p.125; Hahn and Kim, 2009, p.134
5.2	I am confident in my ability to avoid accidents when driving	I am confident in my ability to […]	Bearden, Hardesty and Rose, 2001, p.125; Hahn and Kim, 2009, p.134
5.3	My friends often compliment me on my driving skills	I get compliments from others for my […]	Bearden, Hardesty and Rose, 2001, p.125

Trust in New Technology (Innovativeness)

The questionnaire will include two measures of the respondent's innovativeness. First, question items will be developed to assess the respondent's general affinity towards technological innovations. Second, the so-called Rogers' Innovativeness Criteria for the respondent (Rogers, 2003, pp.22–23) will be assessed based on the year of adoption of already popular past innovations such as mobile phones or the internet.

In order to develop question items for assessing the respondent's general affinity towards technological innovations, the author decided to ask for past experiences with new technology. First, respondents should recall whether or not they feel comfortable when using new technologies and whether or not they are willing to buy new technologies. The last item then evaluates the past experiences with new technologies by asking whether the respondents believe that technology has improved their lives. The complete items are formulated as follows:

Item ID	Item	Original item	Source
11.1	Overall, I feel comfortable using new technology	Own formulation	
11.2	Overall, I would say I like to buy products that have new technology	Own formulation	
11.3	Overall, I believe that technology is improving my life	Own formulation	

Developing Rogers' Innovativeness Criteria for the respondent means categorising the respondent on a scale in terms of his or her general affinity to product innovations (Rogers, 2003, pp.22–23). The measurement scale was already defined based on Rogers (2003, pp.22–23) as a five-point ordinal scale, ranging from *Innovator* to *laggard*. According to this scale, the respondent's innovativeness is dependent on two variables: the mean year of acceptance in a population and the individual's year of acceptance. In order to have a complete distribution of acceptance, an empirical investigation is obviously only feasible for innovations that are already widely diffused. In order to judge the respondent's general affinity to innovations, it is thus necessary to use innovations which are already widely diffused but are still relatively new, so that the respondents are able to recall the time of their adoption. Since it will be almost impossible to find innovations that are perfectly diffused within the population, the author will employ three different, rather popular, innovations. Each item will include a "don't know" item, in case the respondent does not remember the year of his first usage, as well as a "not yet" item in case the respondent has not yet adopted this technology. Results from the three items will be averaged to arrive at the final categorisation of the respondent. The following items will be used for judging the general innovativeness of respondents

Item ID	Item	Original item	Source
11.4	Please report the year when you first used the internet at home	Own formulation	***Based on*** Rogers, 2003, pp.22–23
11.5	Please report the year when you first bought a mobile phone	Own formulation	
11.6	Please report the year when you first bought a smart phone	Own formulation	

Perceived Installed Customer Base

The decision of an individual as to whether or not to adopt an innovation is not only based the innovation itself, but also on the "perceived social pressure" (Fishbein and Ajzen, 2010, p.130) facilitating or impeding the acceptance decision. During the interviews, respondents remarked that they perceive ADAS to be a common technological standard with which they want to comply: "these systems are standard equipment already" (Code #37 in interview S15). The perceived installed customer base thus acts as a descriptive norm in this case, meaning that individuals want to comply with what they perceive that the public is considering reasonable.

Ajzen and Fishbein (Fishbein and Ajzen, 2010) recommend operationalising descriptive norms with items such as "Most people like me use […]" (Fishbein and Ajzen, 2010, p.450), or "Most people whose opinion I value use […]" (Fishbein and Ajzen, 2010, p.144). This approach was followed by most researchers conducting studies on descriptive norms and will also be followed in the course of the present research. Consequently, the following items were developed to express *Perceived Installed Customer Base.*

Item ID	**Item**	**Original item**	**Source**
6.1	I believe many people already use driver- assistance systems	"Most people […] already use […] "	Fishbein and Ajzen, 2010, p.450
6.2	I believe many car manufacturers are now offering driving assistance systems	"these systems are standard equipment already"	Code #37 in interview S15
6.3	I think driving assistance systems will become very popular in the future	Own formulation	Own formulation

Perceived Costs

Costs can be defined as the perceived expectation of material resources necessary to obtain and use Advanced Driver-Assistance Systems. Resources, most importantly price, were brought up by about half of the respondents during the interviews as a factor impeding acceptance: "I would not pay extra money for these systems" (Code 4 in Interview 21). Some respondents remarked that they would rather invest their money on other car equipment, which has a bigger perceived benefit for them and increases the residual value of their car: "I would rather spend my money on leather seats [..]" Code 18 in Interview 7. Also, many respondents worried about the technology becoming outdated soon. Thus, the author decided to use the following items based on the interview results.

Item ID	Item	Original item	Source
7.1	In my opinion, driver- assistance systems are too expensive	"These systems are probably very expensive"	Code #4 in interview 22
7.2	I am worried about how often I am going to have to pay for new updates of driver-assistance systems	Own formulation	
7.3	I am worried about the resale value of the car if the technology is outdated	Own formulation	

Intention

Behavioural intentions are indications of a person's readiness to perform a behaviour. According to Ajzen and Fishbein (2010, p.39), intention is a mixture of behavioural expectations (perceived probability of performing a given behaviour) and willingness to perform a behaviour. Empirical research has revealed that items that combine both characteristics (*behavioural expectation* and *willingness to perform*) significantly increase the predictiveness of the construct *Intention* (Fishbein and Ajzen, 2010, p.39). In order to mix *behavioural expectation* and *willingness to perform*, Ajzen and Fishbein (2010, p.39) recommend the following expressions

- I will engage in the behaviour
- I intend to engage in the behaviour
- I expect to engage in the behaviour
- I plan to engage in the behaviour.

Slight variations of these items are proposed by Putrevu and Lord (1994, p.83). For the context of consumer goods, the authors recommend using:

- It is very likely that I will buy […]
- I will purchase […] the next time I need a […]
- I will definitely try […]

In conclusion, the author will employ the following items for measuring the *Intention* to use ADAS.

Item ID	Item	Original item	Source
9.1	I would like to purchase a car with driver-assistance systems in the future	I plan to purchase[…]	Fishbein and Ajzen, 2010, p.39
9.2	I would like to have more driver-assistance systems in my car	Own formulation	
9.3	Overall I am willing to accept driver- assistance systems in cars, to help me become a safer driver	Own formulation	
9.4	I plan to use driver-assistance systems in future	I plan to engage in […]	Fishbein and Ajzen, 2010, p.39

Level of Experience with ADAS

Determining the respondent's current state in the adoption process of ADAS is crucial for understanding the person's belief formation stage. Literature suggests that individuals who have no knowledge about an innovation might not yet have formed beliefs about it (Rogers, 2003, p.175). According to the previous section, the level of experience with ADAS will be measured on a six-point categorial scale. This variable will be measured directly, meaning that the respondent has to choose a category from the response options given.

Item ID	Item	Original item	Source:
10.4	How much experience do you have with driver-assistance systems? • I regularly use driver-assistance systems • I occasionally use driver-assistance systems • I know what driver-assistance systems are • I have heard about driver-assistance systems before • I have not heard about driver-assistance systems before	Own formulation	

6.8 Constructing the Questionnaire

The survey format was already decided to be web-based. In the next step, the items and scales developed so far must be arranged in such a way that they can be easily administered to a larger audience on the internet.

Questionnaire Technology

Generally, there are two different ways to administer a web-based survey, either using a web-based service or a software package that can be installed on one's own server or webspace. Table 24 shows the main advantages and disadvantages of both options.

Table 24: Types of web-based questionnaire services, Source: Own development, based on Poynter (2010, p.18)

	Web-based service	**Software package**
Main advantages	Relatively easy usage, relatively low costs (often free)	More confidential, since data remains on own server, more flexible
Main disadvantages	Confidentiality issue (since data is stored on the provider's facilities), less flexible in set-up and data storage	Relatively high cost (own server or dedicated web space necessary), more time consuming to set up
Examples	surveymonkey.com, Polldaddy.com etc.	Limesurvey, Surveygizmo, etc.

Due to the advantages in terms of confidentiality and flexibility, the author decided to use a software package on a dedicated server for the present survey. The software of choice was Limesurvey, mainly based on its reputation for stability and reliability (see Kuckartz et al., 2009, p.30; Poynter, 2010, p.18).

Questionnaire Translation

Before the survey could actually be built in the Limesurvey software, it had to be translated into German, since the target audience are German automobile drivers. As already discussed before, language is a critical issue in questionnaire design. Even slight changes in question wording might cause a question to be completely ill directed (Easterby-Smith, Thorpe and Jackson, 2008, p.27). Brace (2008, p.218) recommends that for intercultural studies involving translations, each questionnaire should be translated back to its original language in order to spot any changes in the meaning of question items. Since the present study is not focused on intercultural differences and will only be translated once, the author has refrained from applying this method in its pure form. Instead, the translation of the questionnaire was done independently by the author and a research assistant. Subsequently, the two resulting German questionnaires were compared for differences in meaning. Using the advice of a third research assistant, the most unambiguous formulations were chosen wherever differences existed.

Question Sequence

As outlined in before, the question sequence and layout is crucial for maintaining interest and motivation throughout the questionnaire as well as for increasing the response accurateness (Kumar, Aaker and Day, 2002, p.275). According to Kumar, Aaker and Day (2002, p.286), initial questions should be easy and interesting, followed by the most difficult questions in the middle section. The last questions should again be more interesting, to encourage the respondents to finish the questionnaire (Robson, 2009, p.249). Consequently, the author selected interesting, but easy to answer, items to start the questionnaire. The more complex questions such as those inquiring the year of adoption of certain technologies were placed in the middle section of the questionnaire. Contrary to the strategy proposed by Robson (2009, p.249), the questionnaire ends with demographic items. Since there will be an incentive for finishing the questionnaire, the author expects that individuals will be sufficiently motivated to finish the questionnaire, once started, despite the rather uninteresting demographic questions being asked at the end.
In order to keep the attention of the respondents, it is further necessary to vary the questions, so that items relating to the same concept are interposed at different points of the questionnaire (Robson, 2009, p.249). The author followed this strategy by arranging related question items on different pages of the questionnaire. For instance, the three questions directed at the concept *trust in own driving skills* were placed at different positions on the first, second and third page of the questionnaire, respectively.

Questionnaire Layout

The questionnaire layout needs to be easy to use, yet appealing to the target group (Larossi, 2006, pp.80–82). Especially for web-based surveys, it is crucial that the layout conveys the scientific character of the questionnaire and is clearly distinguishable from advertising related websites (Parasuraman, Grewal and Krishnan, 2007, pp.302–303; Reynolds, Woods and Baker, 2007, pp.255–256). Moreover, the layout must fit different screen resolutions and different browser types (Mooi and Sarstedt, 2011, p.65). The Limewire Software used in the present research is developed in such a way that all popular web browsers are able to display the survey layout without limitations. Limewire furthermore offers several different layout templates, from which the author chose a conservative and familiar-looking version, using subdued colours, in order to emphasize the scientific character of the present study.

Chart 31 shows the layout of the questionnaire in the Limewire software as it finally appeared online. The complete questionnaire can be found in Appendix A.

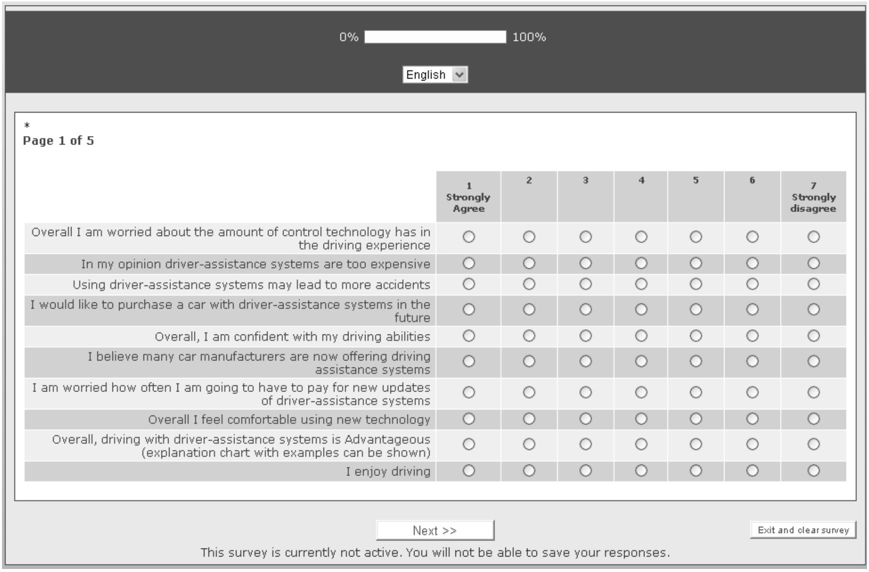


Chart 31: Screenshot of the questionnaire in Limewire software

6.9 Pre-Testing the Survey

Even though all question items were operationalised and translated carefully, it is rarely the case that a questionnaire is flawless in any respect when it is first administered to the public (Neelankavil, 2007, p.184). Thus, a pre-test allows the researcher to try out the questionnaire with a limited external group to isolate problem areas before addressing a larger audience. Ideally, this helps to identify all ambiguity in questions, problems of redundancy, use of incorrect or difficult words, problems in skip patterns and the like (Neelankavil, 2007, p.184). As an alternative to a classical pre-test, Biermer and Lyberg (2003, p.262) recommend using expert reviews, usually by fellow researchers, who are asked to comment on the questionnaire from the perspective of a respondent. However, since there might be significant differences between an expert group and the target group in terms of social status, education, etc., the remarks of experts might lack important aspects. In order to capitalise on the expert knowledge while avoiding this potential threat, the author decided to use a mixture of respondents from the target group and expert respondents for the pre-test of the questionnaire.

In sum, twelve professionals working in various industries were asked via email to fill out the questionnaire and comment on it. Simultaneously, fifty-eight contacts were asked to fill out and comment on the questionnaire via facebook. Within one week, eight experts and ten other individuals tested the questionnaire and gave feedback on it. While the feedback generally showed positive responses on the relative shortness and ease of use of the questionnaire, it also identified some flaws. Next to one spelling mistake and one grammatical error, one respondent indicated that the original question item 5.2 – "I am confident in my ability to avoid accidents when driving" – was ambiguous, since it was not clear whether it meant driving with or without driver-assistance systems. Thus, the author decided to change the item into "Generally, I am confident in my ability to avoid accidents when driving my car", which makes it clearer that this item addresses the general attitude towards one's own driving skills.

Moreover some pre-test respondents reported that they had to guess on one or two of the question items 11.1 to 11.3, which ask for the year when the respondent first adopted the internet, a mobile phone and a smart phone. Since these question items are treated as background variables and do not directly contribute to the conceptual model, this reported vagueness was judged as acceptable.

In sum, the pre-test delivered positive feedback for the questionnaire. After the correction of the identified minor flaws, the questionnaire was thus finalised to be administered to the target population. Since it is not possible to contact the entire target population, a representative sample has to be defined first.

6.10 Sample Definition

The target population of this study has been defined as the population of German car owners, i.e. about 47 million persons in Germany owning a car (Shell, 2009, p.1). Considering this huge population, it will obviously not be feasible to collect data from the entire target group. Thus, a sample has to be selected, which should represent the entire population. In general, there are various ways of deriving a sample from a given population, which can be broadly categorised into probability and non-probability samples. Probability or representative sampling generally means that every individual in the population has a chance (greater than zero) to be selected for the sample. This is usually accomplished via simple random sampling or systematic forms or random sampling (choosing every n^{th} person). Non-probability sampling, on the other hand, could be achieved by simply asking the nearest and most convenient respondents (convenience sampling) or by setting up fixed quotas for certain characteristics in the population (quota sampling). Moreover, there are various other sampling methods, such as extreme case sampling or rare elements sampling, that are used for special purposes (Robson, 2009, pp.265–266). In general, the sampling method has to be chosen according to the population of interest and the type of research intended. For cases with a huge overall population, as in the present research, probability or representative sampling is recommended by the literature (Saunders, Lewis and Thornhill, 2009, p.214).

In order to set up a probability sample, a sampling frame has to be established first. A sampling frame is a complete and most accurate list of characteristics of the overall population of interest (Babbie, 2010, p.208). Considering the size of the given population, deriving a complete list containing the characteristics of every individual will not be feasible in this case. It is consequently necessary to decide on key characteristics of the population which are measurable and sufficiently accurate to base the sampling on. For the present research, the author has decided to dismiss personal (e.g. demographic) characteristics and employ car characteristics (e.g. vehicle category and motorisation) instead. Basing the sampling approach on the ownership of car types has several advantages. First, highly accurate and up-to-date data on licensed car characteristics for the entire population are available from the German Federal Motor Transport Authority. Comparable demographic data is only available on driving license ownership. This statistic, however, is strongly biased since driver licenses have no expiry date in Germany. Second, vehicle categories represent customer categories for the automobile industry, which are of greater interest than demographic categories in the context of the present research. A high-income household, for instance, may decide to spend as little as possible on a car, since they are mostly travelling by train. In this case, from the perspective of this study, this household represents a frugal car customer, despite its high income, which is best represented by the car category owned.

Any generalisation drawn from a probability sample about a population is based on statistical probability. The general rule of thumb is: the greater the sample's size, the lower the likely error in generalising to the population (Saunders, Lewis and Thornhill, 2009, pp.217–218). Obviously time and budget constraints demand judgement on the minimum acceptable sample size needed. This minimum is determined by three main factors: the margin of error that can be tolerated in the sample and the level of confidence needed (e.g. the level of risk the researcher is willing to take that true margin of error may exceed the tolerated margin of error), and finally the estimation of variance in the primary variables of interest in the study. The level of confidence and the level of potential error tolerated depend largely on the analyses and standard tests that will be carried out with the sample. In general, most authors agree that for a given piece of survey-based social research, a confidence level of 95 percent and a margin of error rate of 5 percent is sufficient (see Adler and Clark, 2008, p.114, Gray, 2007, p.113, Blankenship, Breen and Dutka, 1999, p.91).

In order to estimate the variance within a sample without preliminary data (pilot studies or split sampling), one must determine the inclusive range of the scale, and then divide by the number of standard deviations that would include all possible values in the range (Bartlett, Kotrlik and Higgins, 2001, p.45). Since a variance proportion of .5 indicates the maximum variability in a population, most authors use this value when there is limited knowledge available about the sample heterogeneity. Due to this, the estimated minimum sample size may be larger than if the true variability of the population attribute were used (Israel, 2009, p.2).

Based on these figures, the required minimum sample size can be calculated according to Cochran's formula (1977) as follows.

$$N_0 = \frac{(t)^2 \quad x \quad (p)\,(1\text{-}p)}{(d)^2} = \frac{(1.96\,)^2 \quad x \quad (\,0.5)\,(\,1\text{-}\,0.5\,)}{(\,0.05)^{\,2}} = 384.16$$

Where (t) is the t-value for the given alpha level (the t-value for an alpha level of .05, which equals a level of confidence of 95 percent, is 1.96 for sample sizes above 120), (p) is the estimate of standard deviation in the population (in this case .5) and d is the acceptable margin of error for the mean being estimated (in this case .05).

Consequently, for the present survey, a minimum of 384 participants will be needed in order to arrive at a representative sample of the target population. In order to arrive at this minimum acceptable sample size, it is necessary to develop a strategy for attracting respondents, which will be discussed in the next section.

6.11 Sampling Approach

Attracting a sufficient sample size is a key issue in any form of survey research. For mailed surveys, it is necessary to estimate the potential response rate in order to ensure that the minimum acceptable sample size will be reached by sending out a given number of mailings (Bartlett, Kotrlik and Higgins, 2001, p.47). Response rates below .20 are not uncommon for these types of surveys (Kaplowitz, Hadlock and Levine, 2004, p.98). In online based surveys, however, the key issue is rather how to ensure that a sufficient number of participants is attracted to the website and finishes the questionnaire.

6.11.1 Incentives for Participation

In recent years it has become a common practice for surveys to offer financial compensation in order to maximize participation (Marsden, 2010, p.73). There are two main reasons why many researchers employ a form of financial motivation. First, offering extrinsic benefits to participants increases the motivation to finish a questionnaire, whether it is in written form or online (Groves et al., 2011, p.207). Second, there is evidence that incentives can also increase the representativeness of a study. Without an incentive, surveys might be biased due to the fact that people interested in the particular topic are more likely to take part than those who are not. An incentive might motivate those who would otherwise skip the study. As a result, the sample of a study using incentives might better reflect the population of interest (Groves et al., 2011, p.207).

Stevens (2006, p.294) recommends that an efficient incentive should fit the following characteristics to be considered for a mailed survey. It should:

1) Be effective in increasing the response rate;
2) Increase the response rate without biasing the distribution of participants in any way;
3) Reflect a cost that fits in the budget;
4) Be small and light enough to be mailed easily and inexpensively.

In a first step, the researcher has to decide what kind of incentive is appropriate in the given context. Choosing an incentive that is especially attractive to a certain target group might actually bias the results. Stevens (2006, p.294) argues that money is the least-biasing incentive, since is useful to all respondents and is moreover the easiest to send out in a written survey. Furthermore, cash incentives tend to be more efficient than product incentives of similar worth (Groves et al., 2011, p.207). Consequently, the author decided to employ a form of cash incentive in order to increase the participation rate for the present survey.

Another question to be answered is whether an incentive should be mailed out or distributed together with the survey (unaware of who will answer it) or only upon survey completion. There is strong evidence that sending out a small financial compensation for answering a survey (usually a dollar bill or equivalent) significantly increases the response rates (Stevens, 2006, p.167). The promise of cash compensation or any other form of post payment after completion, however, was only found to have a minimal effect on response rates in many cases (Stevens, 2006, p.169).

It is important to acknowledge, however, that there are significant differences between a written survey and an online survey. Sending out cash is not feasible in an online survey and alternative methods such as bank transfers usually involve additional expenditure and effort. Moreover, there is empirical evidence that in an online setting, the promise of a post payment on a lottery basis increases participation more than a small financial reward for participation (Joinson, 2009, p.481).

Consequently, the author decided to use a post-completion incentive in the form of a lottery draw for the present research. As discussed above, a cash prize is the most appropriate, since it appeals to each participant in the same way. With regard to the budget restraints, a 100 Euro Amazon gift voucher was offered as the main lottery prize. The online store Amazon was chosen for the reason that it is the biggest and best known online shop, offering digital gift vouchers that are valid for a wide range of products. A digital gift voucher has the advantage that it can be sent out via email: thus, it is sufficient to ask respondents for their email address, which they might be more likely to share than their home address. Moreover, there will be no additional shipping costs for the incentive. It is expected that this monetary incentive, together with the non-monetary incentive of supporting a study on road safety for the best of everyone, will sufficiently increase the participation rate.

6.11.2 Contacting Participants

Financial incentives alone are not sufficient to attract respondents unless the survey, together with details on the incentive, is successfully communicated to a large audience (Reynolds, Woods and Baker, 2007, pp.255–256). In mailed or email surveys, this is usually accomplished by sending out a cover letter together with the survey to the home or email address of selected participants. In web-based surveys, another strategy must be adopted to attract respondents. Generally there is a wide range of possibilities to attract individuals to a web page, which can be broadly categorized into paid advertising and reputation building. Paid advertising includes banners and text links which can be purchased from popular websites or search engines. Reputation building involves search engine optimisation (to place the website at the top of thesearch results for a given keyword), publications in blogs or bulletin boards or word-of-mouth recommendation (Harris and Dennis, 2007, pp.211–217). For the present research, the author decided to use the latter approach. Since search engine optimisation and word-of-mouth recommendation usually take months, if not years, before becoming effective, the author decided to capitalize on the instant communication possibilities offered by blogs and bulletin boards. These platforms are effective one-to-many communication channels in which information can be rapidly spread among a community.

In this context the term *community* describes an interest group on a certain topic such as cooking, pets or automobiles. Interest groups can further also be based on a certain characteristic, such as home town or region, age group or gender

(Buss and Strauss, 2009, pp.12–15). The author consciously decided not to focus on automobile communities, since this strategy could bias the sample due to the overrepresentation of car enthusiasts. Thus, communities for the elderly, females, cat owners etc. were targeted as well. After a set of popular virtual communities had been selected, the author published the cover letter, adapted to the community, in the respective community board together with a link to the survey. This strategy has two main advantages. First, interested individuals can instantaneously click on the link to start the questionnaire without any time lag or change of media. Second, participants can report on their experience with the questionnaire or post questions on the survey, which are then visible for all other users of the community. These discussions increase the involvement of the community and thus increase the participation rate.

6.11.3 Sampling Bias

It has to be acknowledged that the strategy described above also involves some risks. First of all, the methodology of attracting participants online limits the sample to internet users, as does every web-based questionnaire. However, the rapid diffusion of Internet access in European households increasingly reduces this threat. Currently over 80 percent of households in Germany have internet access, most of which have a broadband connection (Zweiter Deutscher Rundfunk, 2011, p.1). Consequently, the Internet bias is expected to have only a minor effect on the sample representativeness.

Second, attracting potential respondents in blogs and bulletin boards limits the sample to users who regularly read these types of media. A representative 2011 study among German Internet users concluded that around 42 percent of internet users do actively participate in communities and blogs (Busemann and Gscheidle, 2011, p.361). This further limitation of participants could be a substantial constraint to the representativeness of the questionnaire, especially as the study concluded that younger internet users are more likely to participate in such communication channels. While more than 60 percent of German individuals under the age of 19 use newsgroups and bulletin boards, only 14 percent of those above the age of 40 do (Busemann and Gscheidle, 2011, p.361). As a result, younger participants are more likely to be represented in the sample than are older individuals. This directly contradicts the probability sampling approach described in the previous section.

6.11.4 Stratified Probability Sampling

The most common strategy to overcome issues of over- or under-representation is to employ stratified probability sampling (Bhushan, 2007, pp.15–16). Following this strategy, the sample is divided up into non-overlapping subpopulations (strata), based on the characteristics of individuals that are known to be over-/ or underrepresented in the sample, e.g. age-groups or gender (Pride and Ferrell, 2011, p.86). In the present research, individuals over the age of 40 are expected to be underrepresented in the sample, due to the internet bias discussed above. Thus, by dividing up the target population into age subgroups and applying probability sampling within these subgroups, the potential sampling error due to the over-/underrepresentation of age groups can be minimized.

In order to follow the stratified sampling approach in the present research, the author published the questionnaire in blogs and bulletin boards targeted at adults and the elderly, such as communities for retirees or senior bulletin boards. In order to ensure that individuals within the older subgroups had the same probability of being included in the sample, a proportionate allocation strategy was followed. This means using a sampling fraction in each of the strata that is proportional to that of the total population (Daniel, 2012, p.162). Currently 57 percent of German automobile drivers are over the age of 45 (Kraftfahrt-Bundesamt, 2011b, p.1). Thus, at least half of the communities in which the survey was published were directed at people of this age group.

It has to be acknowledged that one prerequisite for stratified sampling is that each subgroup is mutually exclusive, meaning that each individual from the population is only represented in one stratum (Daniel, 2012, p.163). This prerequisite cannot be met by the present study due to specifics of the internet. In general, online communities do not restrict their access to certain age groups. Thus, it is possible that younger individuals will participate in communities for the elderly and vice versa. In sum, however, the stratified probability sampling approach, together with the proportional allocation strategy followed in the present research, is expected to improve the sample representativeness by reducing the potential biases of the sampling approach.

6.12 Administration of the Survey

The questionnaire was administered between the 9th and the 24nd January 2012. During this period, the link to the survey was posted on 58 different blogs and bulletin boards, usually after contacting the board- or blog-owner personally. As discussed in the previous chapter, a variety of different discussion groups were targeted, ranging from bulletin boards for car drivers to communities for the elderly or professional exchange groups.

In total, 471 respondents started the questionnaire, of whom 402 finished it. The datasets were exported directly from Limesurvey into SPSS. In contrast to manual typing of data, the automatic export function of Limesurvey minimizes the threat of human error in the transition process towards data analysis. A first analysis in SPSS was performed to identify abnormalities in the data set. This process revealed fifteen responses that showed answering patterns or extremely inconsistent responses (continuously or alternating extreme cases). These cases were consequently deleted from the data set.

In sum, 387 responses remained for further analysis. In the next step, statistics will be used to evaluate the representativeness of the sample population in regard to the for the overall population using the sample characteristics discussed in the previous section.

6.13 Analysis of Sample Population

The key question to be answered in this section is whether or not the sample derived so far is truly representative of the target population of German automobile drivers. This question cannot be answered directly; however, looking at group characteristics and demographics might help to give an answer. As discussed in the previous section, the representativeness of the sample will be judged using sampling characterstics based on car types of respondents, supplemented with demographic variables, namely age and gender. The sample analysis based on these sampling charcteristics will indicate whether or not the chosen strategy was successful in attracting a sufficiently large and representative sample of the target population.

Comparing the Sample to the Population

The representativeness of the sample will consequently be assessed based on the car ownership. Since the author intentionally used similar car classifications to the ones employed by the German Federal Motor Transport Authority, a direct comparison of the sample with the official statistics of registered cars in Germany is possible. Chart 32 gives an overview of the sample and population distribution in regard to car classifications.

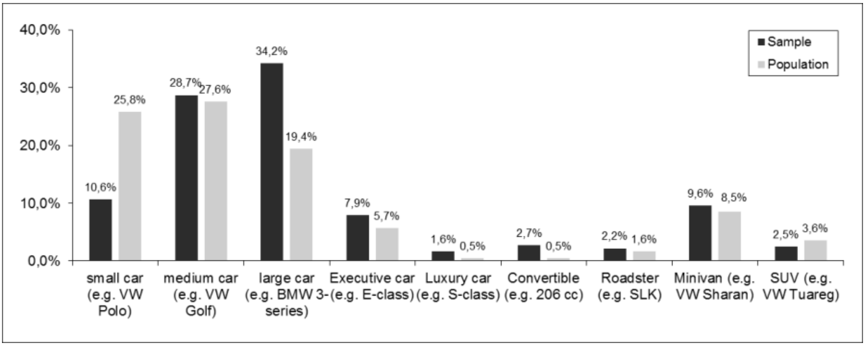


Chart 32: Comparison of sample to overall population based on car types, Source: Own drawing, Population characteristics based on Kraftfahrt-Bundesamt (2012, p.1)

This direct comparison generally shows a good match of the car types within the sample and the overall population. However, the analysis identified an overrepresentation of large cars in the sample, while small cars tend to be underrepresented. In order to evaluate the goodness-of-fit of sample characteristics with the overall population, the literature suggests performing a Chi-square Test (Morien, 2006, pp.202–204; Ross, 2010, pp.605–615). Table 25 shows the chi-squared distribution for the sample regarding car characteristics.

Table 25: Chi-Square Goodness-of-Fit Test for car characteristics

Car Category	Small	Medium	Large	Execu-tive	Luxury	Conv.	Road-ster	Minivan	SUV	Total
Sample per-centage	10.6%	28.7%	34.2%	7.9%	1.6%	2.7%	2.2%	9.6%	2.5%	
Sample distri-bution	41	111	132	31	6	10	8	37	9	
Population percentage	25.8%	27.6%	19.4%	5.7%	0.5%	0.5%	1.6%	8.5%	3.6%	
Expected Value	100	107	75	22	2	2	6	33	14	
Difference	59	-4	-57	-9	-4	-9	-2	-4	4	
χ2 Distribution	**34.7**	**0.2**	**43.4**	**3.3**	**9.4**	**37.5**	**0.8**	**0.5**	**1.4**	**131.1**

The Chi-square Goodness-of-Fit Test results in a summarized Chi-Square Value of χ^2=131.1. The acceptance region for H_0 (No difference between the sample and the overall population) at a significance level of α = .01 with 8 degrees of freedom is below 20.09 (see Anderson, Sweeney and Williams, 2008, p.923). Thus, the results indicate that the sample is not truly representative of the target population when regarding car characteristics. However, when looking at the different car categories independently, it becomes apparent that most of them are actually representative for the target population. When regarding a single Chi-square value, the acceptance region for H_0 (no difference between the sample and the overall population) at a significance level of α = .01 with 1 degree of freedom is below 6.63 (see Anderson, Sweeney and Williams, 2008, p.923). Thus, more than half of the car types of the present sample can be judged as representative of the target population. Table 26 shows the individual car categories and the associated Chi-square values.

Table 26: Representativity of the sample distribution

Car Type	Sample %	Population %	χ2	Outcome
Small	10.6%	25.8%	34.66	Underrepresented
Medium	28.7%	27.6%	0.17	Representative
Large	34.2%	19.4%	43.40	Overrepresented
Executive	7.9%	5.7%	3.29	Representative
Luxury	1.6%	0.5%	9.37	Overrepresented
Conv.	2.7%	0.5%	37.46	Overrepresented
Roadster	2.2%	1.6%	0.81	Representative
Minivan	9.6%	8.5%	0.51	Representative
SUV	2.5%	3.6%	1.42	Representative

There are several possible reasons for the overrepresentation of large cars, convertibles and luxury cars in relation to small cars. One possibility is that the sample does not truly reflect the population and is thus biased by relatively too many large car owners. Another explanation could be that the question asking for the car type itself was biased by incorrect answers. In general, empirical research indicates that individuals do overstate their social status, true income or possessions (Bradburn, Sudman and Wansink, 2004, p.80). Thus, some individuals might have been tempted to report owning a larger automobile than they actual posses. Another potential reason could be that individuals wrongly allocated their car into the predefined car categories. Even though the most common car categories used by the European Commission (Commission of the European Communities, p.2) were employed, it is expected that most individuals have not yet thought about which category their own car belongs to and thus might have unintentionally made a wrong selection. Most probably a combination of the above mentioned reasons has caused the slightly disproportional distribution of the sample compared to the overall population.

Demographic Distribution

Next to the sampling characteristics based on car types, the distribution of the basic demographic variables *age* and *gender* will be analysed. Comparing demographic variables can give an additional insight into the sample distribution and sample representativeness of the target population. It has to be acknowledged, however, that the representativity of the sample is evaluated solely based on the dimension *car types*. Other demographic dimensions such as age, gender, income, education and socio-economic status, even though generally important, are treated as ancillary characteristics in the present study.

Once again, statistics from the German Federal Motor Transport Authority are available on the demographics of German car drivers based on issued driver licenses. According to these statistics, females currently comprise about 40.4 percent of car drivers in Germany (Kraftfahrt-Bundesamt, 2011a, p.7). In contrast, females represent only about 15 percent of respondents within the sample, leading to the conclusion that females are underrepresented in the present study. Chart 33 gives an overview of the gender distribution of the sample compared to the target population.

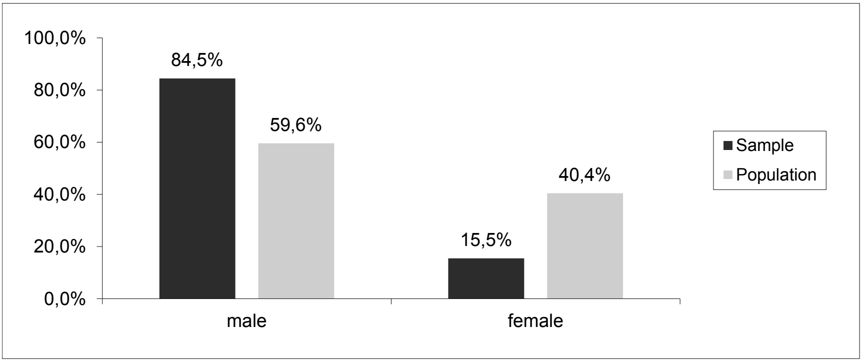


Chart 33: Comparison of gender distribution, Source: Own drawing, population characteristics based on Kraftfahrt-Bundesamt (2011a, p.7)

There are various potential reasons for the underrepresentation of females in the present study. First of all, females are already underrepresented in internet usage. While 80.7 percent of males in Germany use the internet, only 68.9 percent of the female population do so (Initiative D21 e.V, 2011, p.41). Another reason could be that the communities and billboards used for publishing the questionnaire have disproportionately high male visitor rates, thus increasing the probability of men taking part in the study. Another possible explanation is that, in general, men were more interested in the topic (driver-assistance systems) and were thus more likely to participate in the survey. Again, it is likely that a combination of the above mentioned reasons has caused the gender bias of the sample.

Finally, the age distribution of the sample will be compared to the target population based on the statistics on driver licenses of the German Federal Motor Transport Authority (Kraftfahrt-Bundesamt, 2011c, p.1). The analysis shows a strong underrepresentation of the age group of people above 65, while individuals between 25 and 44 tend to be overrepresented in the sample. It is important to acknowledge, however, that driver licenses have no expiry date in Germany. As a consequence, a driver license, once issued to an individual, stays valid forever and the individual will be part of the statistics of the German Federal Motor Transport Authority whether or not he or she actively participates in road traffic. It is thus expected that a considerable number of individuals within the over-65 age group are no longer car drivers and should thus not be represented in the target population. Chart 34 gives an overview of the age distribution of the sample compared to the target population.

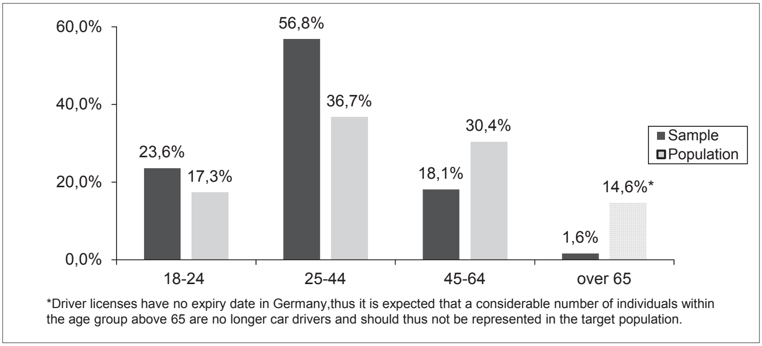


Chart 34: Comparison of age distribution, Source: Own drawing, population characteristics based on Kraftfahrt-Bundesamt (2011c, p.1)

The potential reasons for the underrepresentation of older individuals in the present study are similar to those for female underrepresentation and have already been discussed in the previous paragraph. In conclusion, the stratified sampling strategy followed by the author (contacting older age groups directly by using related communities) has not succeeded in generating a representative sample in regard to these characteristics. It is expected, however, that this strategy has considerably reduced the internet bias, which otherwise would have had a much stronger effect on the sample.

Conclusion

In sum, the comparison of the sample with the target group using the characteristics based on car types has shown a good match, with a slight deviation towards larger cars. Most car categories can be considered as representative of the target population. The additional comparison of the demographic dimensions age and gender has shown that younger, male participants tend to be overrepresented in the study.

6.14 Descriptive Data Analysis

The main idea of analysing quantitative data is to identify patterns and to make sense of those patterns. This involves two steps. First, the researcher has to identify the features of the data set that are relevant for answering the research questions. Second, the researcher has to identify patterns within these features that can be used to draw conclusions about the study's research questions (Easterby-Smith, Thorpe and Jackson, 2008, p.234).

For the first step, Kumar, Aaker & Day (2002, p.361) recommend analysing each question or measure by itself by tabulating the data. Tabulation means counting of cases that fall into various categories in order to determine the empirical distribution (frequency distribution) of the variable in question. This frequency distribution can be either visualised as a bar chart, with each bar representing an answer value, or as a histogram, which combines answer values into categories. Since the answer choices to the relevant belief items are restricted to seven possible values in the present research, histograms arrive at the same distribution as bar charts, as long as all possible values are represented in the data. The main advantage of histograms is that they allow for a graphical test of normality. The comparison of a histogram with a normal distribution bell curve gives an insight into whether or not the data is normally distributed, which is a prerequisite for many statistical procedures. For evaluating the normality of the present data set, the author generated histograms for each question item and compared the resulting charts to the normal distribution curve. The resulting charts can be found in Appendix B. The analysis shows that generally all question items follow a normal distribution with only slight deviations in any direction. For a more detailed analysis of normality, however, it is necessary to extend the graphical analysis with descriptive statistic indexes.

Descriptive statistical indexes help to summarize the information presented in frequency tables, meaning that large amounts of data can be described adequately using just a few numerical indexes (Howitt and Cramer, 2008b, p.21). According to Kumar, Aaker & Day (2002, p.362) descriptive statistical indexes can be categorized into:

- measures of central tendency (mean, median and mode)
- measures of dispersion (range, standard deviation, variation coefficient)
- measures of shape (skewness and kurtosis).

Each of these categories fulfils a different objective. The central tendency scores indicate the most typical and thus most likely values in a data set. The measurement of dispersion is an indicator of the variability within the data set and thus gives a hint on the spread of values around the central tendency. Finally, the measurement of shape refers to the characteristics or the shape of the frequency distribution within a sample. Skewness indicates the extent to which a frequency curve is lopsided rather than symmetrical, while the kurtosis indicates the steepness or shallowness of a frequency curve (Howitt and Cramer, 2008b, pp.19–35). Taken together, these indices allow for a first impression and quick comparison of questions' item results, and are thus the starting point for further analysis. Moreover, the descriptive indexes can give a more detailed answer to the question of whether or not the data gathered shows a normal distribution. If a data set follows a perfectly normal distribution, the arithmetic mean, the median and the mode should have the same value, while the skewness and kurtosis should be about zero (see Hoyle, 2000, p.61; Robson, 2009, p.415; de Vaus, 2002, p.76).

Next to these methods, further advanced procedures for testing normality are available in the literature. The most common ones are the Kolmogorov-Smirnov Test and Lilliefors' Test of Normality (Reinard, 2006, p.155). The Kolmogorov-Smirnov Test quantifies the difference in the spread of a particular distribution with an ideal normal distribution (Singh, 2007, p.101). Lilliefors' Test of Normality is a special case of the Kolmogorov-Smirnov Test that looks at the maximum difference between the sample distribution and population distribution with an unknown mean and standard deviation. The normality of the sample distribution is tested with the composite null hypothesis H_0: *the random sample is from a normal distribution function with unknown mean and variance*, against H_1*: the random sample is not from a normal distribution function* (Panik, 2006, p.630). Generally, Lilliefors' Test of Normality can be seen as a more sensitive version of the Kolmogorov-Smirnov Test (So, 2010, p.90). Consequently, the author decided to use this measure for normality testing and additionally employed Pearson's Skewness Index, which should have a value between -1 and 1 if the data is approximately normal distributed (Brase and Brase, 2010, p.297; Triola, 2004, p.91).

Literature generally suggests that examining isolated normality test values is not sufficient to judge the normality of a data set. Instead, one should integrate different contributing factors into the analysis, such as the visual representation of the data, measures of central tendency, skewness and kurtosis and the sample size (Pett, 1997, p.47). Thus the final evaluation of normality will be based on a combination of these factors.

For the present survey results, the author calculated the most common descriptive statistics for each question item, which can be found in Table 27 together with the results of normality testing.

Table 27: Descriptive Statistics of questionnaire data

Item		Mean	Median	Standard Deviation	Pearson's Index	Lilliefors' Test of Normality Statistic	Sig.
1.1	I enjoy driving	6.19	7.00	1.38	-1.77	.330	.000
1.2	I drive for pleasure	6.02	7.00	1.53	-1.92	.316	.000
1.3	Driving is an agreeable way of passing time	5.56	6.00	1.67	-0.79	.245	.000
2.1	Overall I am worried about the amount of control technology has in the driving experience	4.30	5.00	2.04	-1.02	.142	.000
2.2	I like to be able to switch any technology off when driving	5.80	6.00	1.64	-0.37	.262	.000
2.3	I enjoy making my own decisions when driving instead of being guided by technology	5.05	5.00	1.68	0.08	.192	.000
3.1	Overall, I would say that it is safer to drive without driver-assistance systems	3.02	3.00	1.79	0.03	.173	.000
3.2	I am worried that driver-assistance systems may one day fail when I am driving	4.42	5.00	2.02	-0.87	.179	.000
3.3	Using driver-assistance systems may lead to more accidents	3.78	4.00	1.80	-0.37	.143	.000
4.1	Driver-assistance systems are helpful in many driving situations	4.72	5.00	1.61	-0.52	.169	.000
4.2	Overall, driving with driver-assistance systems is advantageous	4.64	5.00	1.77	-0.61	.164	.000
4.3	Using driver-assistance systems is practical	4.84	5.00	1.59	-0.30	.168	.000
5.1	Overall, I am confident in my driving abilities	5.49	6.00	1.35	-1.14	.256	.000
5.2	Generally, I am confident in my ability to avoid accidents when driving with my car	4.81	5.00	1.54	-0.37	.162	.000
5.3	My friends often compliment me on my driving skills	5.02	5.00	1.38	0.04	.172	.000
6.1	I believe many people already use driver-assistance systems	4.40	5.00	1.69	-1.06	.142	.000
6.2	I believe many car manufacturers are now offering driving assistance systems	5.51	6.00	1.47	-0.99	.242	.000
6.3	I think driving assistance systems will become very popular in the future	5.57	6.00	1.35	-0.95	.263	.000
7.1	In my opinion, driver-assistance systems are too expensive	4.80	5.00	1.60	-0.37	.138	.000
7.2	I am worried about how often I am going to have to pay for new updates of driver-assistance systems	5.26	6.00	1.65	-1.35	.216	.000
7.3	I am worried about the resale value of the car if the technology is outdated	3.00	3.00	1.68	0.00	.189	.000
8.1	Overall, I feel comfortable using new technology	4.78	5.00	1.77	-0.37	.161	.000

8.2	Overall, I would say I like to buy products that have new technology	4.05	4.00	1.94	0.08	.141	.000
8.3	Overall, I believe that technology is improving my life	4.61	5.00	1.76	-0.66	.171	.000
9.1	I would like to purchase a car with driver-assistance systems in the future	3.80	4.00	1.99	-0.30	.138	.000
9.2	I would like to have more driver-assistance systems in my car	3.75	4.00	2.13	-0.35	.159	.000
9.3	Overall, I am willing to accept driver-assistance systems in cars, to help me become a safer driver	4.51	5.00	1.92	-0.76	.166	.000
9.4	I plan to use driver-assistance systems in future	4.20	4.00	1.96	0.31	.148	.000

The analysis of the descriptive indexes shows that, in general, the items approximately follow a normal distribution. All items have a maximum value of 7 and a minimum value of 1 and thus contain all possible values of the scale. The distance of the arithmetic mean and the median is below 1 for all cases, indicating an reasonable fit of the data distribution with normality. Accordingly, Pearson's index of Skewness is between 1 and -1 for most cases and thus also indicates a normal distribution for all but two items. The first two items (1.1 and 1.2) show the strongest deviation from normality following Pearson's index of Skewness and are positively skewed, meaning that the majority of the data sets contain values at the upper end of the scale. The first two items did thus not achieve a sufficient discrimination among respondents.

Looking at the results from Lilliefors' Test of Normality, however, shows that the null hypothesis "*the random sample is from a normal distribution function with unknown mean and variance*" has to be rejected for all items. Thus, using the Lilliefors' Test criteria, none of the items can be attributed a normal distribution.

In sum, the descriptive analysis of the data set has revealed that the data approximately follows a normal distribution when regarding Pearson's index of Skewness or other criteria such as the median mean difference. However, the detailed analysis, using Lilliefors' Test criteria, shows that the hypothesis of a perfect normal distribution cannot be accepted at a reasonable level of confidence. Thus, the data cannot be regarded as perfectly normally distributed. This insight will be important in a later stage of the analysis for choosing appropriate statistical tests.

6.15 Hypothesis Testing

Building up a convincing case for a theory involves developing hypotheses and testing these hypothesis based upon data drawn from the samples. This process allows the researcher to make inferences about the population based on the sample data (Kumar, Aaker and Day, 2002, p.377). The greatest challenge in this process, however, is to define the limits of generalization about study variables beyond the specific sample. Generally, the aim of quantitative data analysis is not to explain variances limited to a specific sample, but to draw conclusions that are valid for the entire target population based on this data. The ability to generalise the conclusions decides whether or not the findings contribute to theory building. Thus, the researcher has to judge how likely it is that the outcome of the present study is representing a true notion in the target population, as opposed to being just a coincidental result.

Theories are statements about relationships of concepts, about the conditions when these relationships occur and about the causes and consequences that are valid in the target population (Easterby-Smith, Thorpe and Jackson, 2008, p.249). As discussed before, developing theories involves testing the underlying hypotheses and judging the generalisability of the findings. The hypotheses for the present research will consequently be tested in the next steps.

Null Hypothesis

In order to test hypotheses, the researcher has to develop a null hypothesis, which basically states that there are "no changes, no effects, no differences"(Gravetter and Wallnau, 2011, p.205) between measured variables. Generally, the null hypothesis thus represents the proposition that there is no difference between the variables of the original hypothesis (also called alternative hypothesis) (Kumar, Aaker and Day, 2002, p.379). Regarding hypothesis H_1 of the present research, the corresponding null hypothesis H_0 is: There is no relationship between the enjoyment of driving and the attitude towards Advanced Driver Assistance Systems. It is important to acknowledge that the null hypothesis can never be proven. A set of data can only help to reject the null hypothesis if there is strong evidence in favour of the alternative research hypothesis H_1 (Easterby-Smith, Thorpe and Jackson, 2008, p.252).

The first step in order to reject the null hypothesis is to define a summary index based on the characteristics of interest. The hypothesis H_1 postulates that there is a strong positive correlation between the factors Enjoyment of Driving and Attitude towards ADAS. The null hypothesis H_0 thus defines a population in which there is no relationship between the two variables, thus the correlation index for the two variables is 0.00 (Howitt and Cramer, 2008b, p.97). The difference between the correlation indexes consequently can be used to calculate the degree of certainty with which the null hypothesis H_0 can be rejected. In order to do so, the central question to be answered is:

If the null hypothesis H_0 were actually true, meaning that the correlation between the variables in the target population is 0.00, how likely is it to arrive at the observed outcome in the study data (Howitt and Cramer, 2008b, p.98)?

Reference Distribution

Since there is no generally valid convention, the quantification of this question's answer requires the use of a reference distribution (Easterby-Smith, Thorpe and Jackson, 2008, p.252). The reference distribution is the distribution of the hypothesis summary index for all possible outcomes, of which the one from this specific study is just one. While there is the possibility to derive a reference distribution from archive data, the most common way of choosing an appropriate reference distribution is to draw it from statistical theory (Howitt and Cramer, 2008b, p.98). These so-called standard reference distributions are based on idealised situations, in which the distribution entirely follows a symmetrical pattern based on what is known about the distribution. Most popular is the normal distribution, for which the standard deviation of the mean is known, and the t-distribution, in which the standard deviation is estimated from the sample data. Easterby-Smith, Thorpe & Jackson (2008, p.253) characterise standard reference distributions as follows:

- They are mathematically well-defined and their shapes reflect a few features called parameters
- Their theoretical properties are well worked out – for example, the normal distribution is symmetrical and bell-shaped
- They are theoretical entities that do not exist in the real world, but researchers can use them as approximations to their own data.

The descriptive data analysis in has shown that a normal distribution can be applied only with certain limitations as a reference distribution for hypothesis testing in the present research. The implications of this will be discussed when choosing appropriate statistical tests the next steps.

Significance Level

In the next step, it is possible to draw a conclusion based on the probability of getting the present results if the null hypothesis were true. This probability is generally referred to as the *significance level (p)* or *alpha (α)*. If this probability is small enough, the researcher can conclude that the observed outcome is too surprising for the null hypothesis to be true. The most commonly chosen minimum values for α in academic research are the 1-percent level, the 5-percent level and the 10-percent level (Kumar, Aaker and Day, 2002, p.381). Generally, the higher the significance level used for testing a hypothesis, the greater the probability of rejecting a null hypothesis when it is true. This is called a Type I Error, as opposed to accepting a null hypothesis falsely, which is called a *Type II Error* (Easterby-Smith, Thorpe and Jackson, 2008, p.255).

One-Tail and Two-Tail Significance

It is also important to distinguish between one- and two-tailed p values. In statistics, the region under the normal distribution that leads to rejection of a hypothesis can be found either on both sides of the curve, with the non-rejection region in between, or on either side of the curve (Beri, 2010, p.340). Chart 35 shows this important difference.

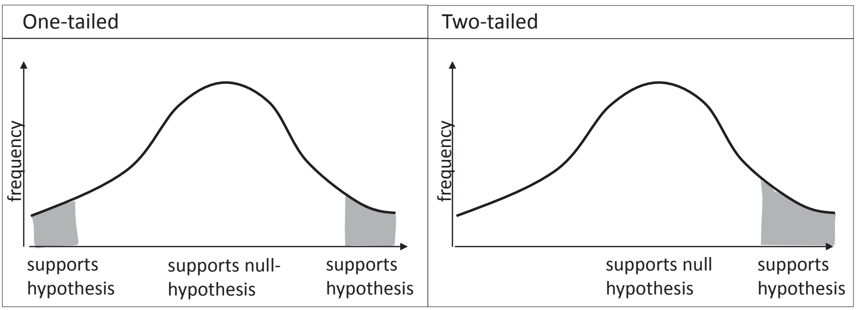


Chart 35: One-tailed and two-tailed hypothesis testing. Own drawing, based on Howitt & Cramer (2008b, p.166).

Depending on this, the p-value is described as two-tailed or one-tailed. One-tailed p values generally result in greater levels of significance (or smaller p-values), but are only applicable if a set of rather stringent rules can be followed. According to Howitt and Cramer (2008b, p.164) one-tailed p values should only be used if:

- the predictions are based on strong and well-researched theory and not on intuition
- the predictions are based on previous similar research demonstrating consistent trends in the predicted direction
- the predictions are well known before any data is collected.

As discussed above, two-tailed p values are larger (more conservative). Thus using two-tailed values usually does not lead to flawed conclusions, while falsely using a one-tailed value might result in result being afforded a higher significance than it actually has. Moreover, since many survey results do not completely comply with all the assumptions on which the statistical calculations are based, especially the perfect normal distribution, the p values are often reported to be smaller than they ought to be. Using the larger two-tailed p value partially corrects for this (Kumar, Aaker and Day, 2002, pp.390–393). Although it is clearly a controversial issue, the literature suggests that there is rarely sufficient justification to use one-tailed p-values (Howitt and Cramer, 2008b, p.167), which is why the author decided to use only two-tailed significance levels in the present research, despite the fact that many of the research hypotheses are directional hypotheses.

Conclusion

To sum up, the five-step process described so far is the formal routine of hypothesis testing, which is also the basis for the present research. Chart 36 shows the complete process model of hypothesis testing.

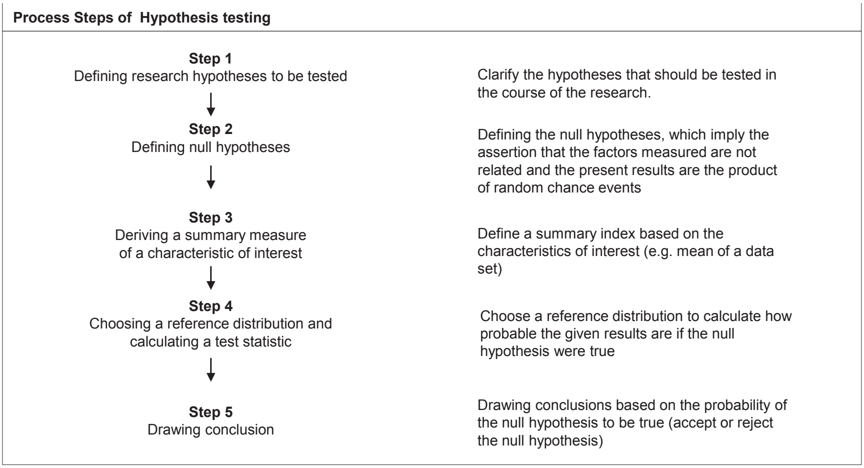


Chart 36: Process steps of hypothesis testing, Source: own drawing, based on Easterby-Smith, Thorpe and Jackson (2008, pp.251–255).

6.16 Overview of Statistical Tests

So far, the general rules for hypothesis testing have been set out. In the next step an appropriate statistical procedure has to be selected to test the present research hypotheses. Broadly, there are two different types of statistical tests, for both of which parametric and non-parametric tests are available:

1. Testing for group differences (are there any differences between two or more groups?);
2. Testing associations of variables (are there any relationships between variables) (Easterby-Smith, Thorpe and Jackson, 2008, p.255).

Since the research objective of the present research deals with the associations of psychological constructs, the second type of statistical tests will be of main importance for this research project. Testing for group differences, however, will also be of relevance for assessing the influence of background variables such as age or gender on the acceptance decision. Chart 37 gives an overview of statistical tests and their appropriate application.

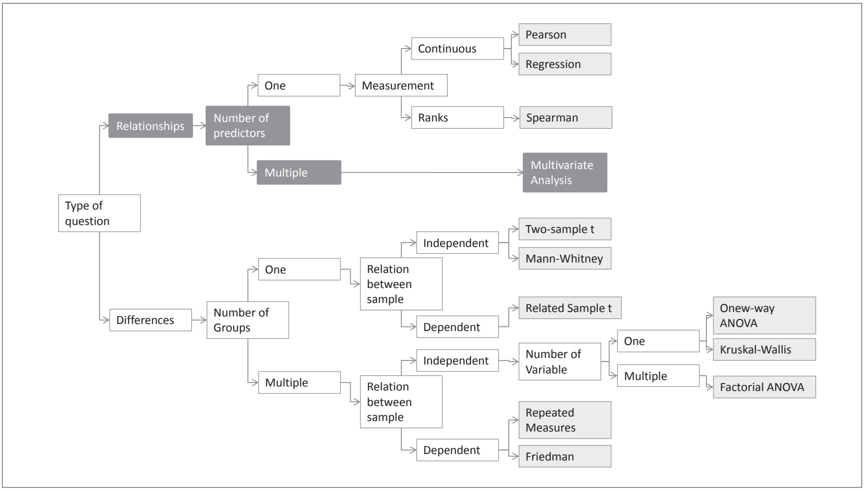


Chart 37: Statistical tests, Source: Own drawing based on Howell (2011, p.566)

Before choosing a statistical test, it is important to acknowledge the major differences between parametric and nonparametric tests, which will be the focus of the next section.

6.17 Parametric and Nonparametric Statistics

Many statistical tests require that details are known about the characteristics of a population: these are known as parametric tests (Howitt and Cramer, 2008b, p.168). As discussed in the previous section, hypothesis testing involves having information or good estimates about the distribution of the population under the null hypothesis (reference distribution). In the previous section, it was estimated that this distribution perfectly follows a normal- or bell shaped-distribution. But if the assumptions for symmetrical distribution are violated in the target population, the situation traditionally calls for nonparametric testing because these types of test make few or no assumptions about the distribution in the population (Easterby-Smith, Thorpe and Jackson, 2008, p.255).

Another basic distinction between parametric and nonparametric statistical methods is that parametric statistics require a numerical value for each individual in the sample. These values are added, squared and otherwise calculated by parametric tests using basic arithmetic. Thus, in terms of measurement scales, parametric tests require interval or ratio-scale data, while nonparametric tests are generally satisfied with ordinal data (Gravetter and Wallnau, 2008, p.472). Many authors argue, however, that when a variable is ordinal but has sufficient levels, such as 7 or more in a Likert scale, then as long as other parametric requirements are fulfilled, it is considered legitimate to conduct parametric tests (Clark-Carter and Howell, 2010, p.188).

Table 28 gives an overview of the main characteristics of parametric and non-parametric tests.

Table 28: Parametric and non-parametric tests, Source: Based on Easterby-Smith, Thorpe and Jackson (2008, p.256)

	Parametric tests	**Non-parametric tests**
Assumed distribution	Normal	Any
Assumed variance	Homogeneous	Any
Required scales	Interval or ratio scale	Ordinal or nominal scale
Advantages	More power to draw conclusions; more versatile tests available	Simplicity; more robust (less affected by extreme values etc.)
Available tests (examples)	Pearson correlation, t-test, Analysis of variance F-ratio test	Spearman correlation, Mann-Whitney U-test, Kruskal-Wallis W-test

In sum, nonparametric tests have fewer requirements or assumptions about the population characteristics and can be used in virtually any setting, while the rather strict regulations of parametric tests restrict their usage to a limited range of cases.

The analysis of the research data has demonstrated that the data sets of all 32 question items only approximately follows a normal distribution and cannot be treated as perfectly normal distributed. Consequently, the author decided to use the more robust non-parametric tests as the main methods of analysis. Parametric tests will be employed as well, where applicable, in order to evaluate which differences occur in the results from the two types of methods. In the first step, the relationships between the variables will be analysed using the Spearman rho statistic from the field of non-parametric statistics and the Pearson correlation from the field of parametric statistics.

6.18 Testing Variable Correlations

Analysing associations between variables is an important method for gaining insights into the interdependencies of constructs. Since the present study has substantially more than two variables, the author will in this first step reduce the complexity by looking at two variables at a time. The selection criteria for testing correlations among variables will be based on the hypotheses developed in the previous chapters. It has to be acknowledged that correlation coefficients cannot prove any causal relationship in a definite way. Two statistically significant correlated variables may in fact be both caused by a third, not regarded, variable. In this regard the purpose of this correlation analysis is to test for associations and the direction of interdependencies between two variables at a time.

The two most common bivariate correlation coefficients are the Pearson product movement correlation coefficient – or Pearson correlation- and the Spearman rho correlation coefficient (Howitt and Cramer, 2008a, pp.78–79). The basic difference between the two coefficients is that Pearson's coefficient should only be used for continuous variables that are fairly close to a normal distribution, while Spearman's rho correlation can also be used for ordinal data (Tufféry, 2011, p.87). As discussed before, the author will employ parametric as well as non-parametric statistics for the present data set: consequently, both correlation coefficients were used. The comparison of the results shows that, even though the results differ only slightly in most cases, the decision on the significance of relationships is different in some of the cases. As a result, the author decided to employ only the more robust Spearman's rho coefficients for interpreting the correlations between the variables. The results of both correlation coefficients can be found in Appendix C.

Following the convention of Cohan (2009, pp.78–81) a correlation coefficient above.10 indicates a small effect, a value above .30 a medium effect and a value over .50 a large effect. The significance values indicate the probability that the Null Hypothesis (no correlation between the variables) is true. As defined be-

fore, all hypotheses will be tested at a two-sided significance level of .01: thus, a value below .01 indicates a significant correlation between the variables.
Out of the items representing the dependent variable *Intention to Use*, the author chose item 9.4 for calculating correlations, since this items shows the highest Item-to-total Correlation (see Table 44). In the next step a correlation coefficient is calculated for each item with the dependent variable 9.4.

Enjoyment of Driving

Table 29: Spearman's rho correlation analysis: Enjoyment of driving

Items			Correlation Coefficient	Sig. (2-tailed)	N
9.4	1.1	I enjoy driving	Not significant		
9.4	1.2	I drive for pleasure	.209	.000	387
9.4	1.3	Driving is an agreeable way of passing time	Not significant		

The correlation analysis of *Enjoyment of Driving* items shows only one significant correlation, between items 1.2 and 9.4. With a correlation coefficient of .209, this effect can be regarded as small and the resulting direction of the effect is surprising, since it contradicts with Hypothesis H_1.

Desire to Exert Control

Table 30: Spearman's rho Correlation Analysis: Desire to exert control

Items			Correlation Coefficient	Sig. (2-tailed)	N
9.4	2.1	Overall, I am worried about the amount of control technology has in the driving experience	-.590	.000	387
9.4	2.2	I like to be able to switch any technology off when driving	-.278	.000	387
9.4	2.3	I enjoy making my own decisions when driving instead of being guided by technology	-.502	.000	387

The correlation analysis of items measuring *Desire to exert control* reveals that every item is significantly correlated with item 9.4. Items 2.1 and 2.3 show a strong negative effect on item 9.4.

Perceived Risks

Table 31: Spearman's rho correlation analysis: Perceived risks

Items			Correlation Coefficient	Sig. (2-tailed)	N
9.4	3.1	Overall, I would say that it is safer to drive without driver-assistance systems	-.579	.000	387
9.4	3.2	I am worried that driver-assistance systems may one day fail when I am driving	-.223	.000	387
9.4	3.3	Using driver-assistance systems may lead to more accidents	-.450	.000	387

The correlation analysis of items measuring the *Perceived Risks of ADAS* shows that every item is significantly correlated with item 9.4. Item 3.1 shows a strong negative effect, while items 3.3 and 3.2 show a medium and a small negative effect respectively.

Perceived Usefulness

Table 32: Spearman's rho correlation analysis: Perceived usefulness

Items			Correlation Coefficient	Sig. (2-tailed)	N
9.4	4.1	Driver-assistance systems are helpful in many driving situations	.691	.000	387
9.4	4.2	Overall, driving with driver-assistance systems is advantageous	.778	.000	387
9.4	4.3	Using driver-assistance systems is practical	.669	.000	387

The correlation analysis of items measuring *Perceived Usefulness* shows not only that each item is significantly correlated with item 9.4, but also that each effect can be considered as very strong.

Confidence in Own Driving Skills

Table 33: Spearman's rho correlation analysis: Confidence in own driving skills

Items			Correlation Coefficient	Sig. (2-tailed)	N
9.4	5.1	Overall, I am confident in my driving abilities	Not significant		
9.4	5.2	Generally, I am confident in my ability to avoid accidents when driving my car	Not significant		
9.4	5.3	My friends often compliment me on my driving skills	Not significant		

No significant effect could be confirmed between the items measuring the *Confidence in own driving skills* and dependent variable 9.4.

Innovativeness

Table 34: Spearman's rho correlation analysis: Innovativeness

Items			Correlation Coefficient	Sig. (2-tailed)	N
9.4	8.1	Overall, I feel comfortable using new technology	.559	.000	387
9.4	8.2	Overall, I would say I like to buy products that have new technology	.599	.001	387
9.4	8.3	Overall, I believe that technology is improving my life	.635	.000	387

The correlation analysis of items measuring *General Innovativeness* shows not only that each item is significantly correlated to item 9.4, but also that each effect can be considered as very strong.

Perceived Installed Customer Base

Table 35: Spearman's rho correlation analysis: Perceived installed customer base

Items			Correlation Coefficient	Sig. (2-tailed)	N
9.4	6.1	I believe many people already use driver-assistance systems	Not significant		
9.4	6.2	I believe many car manufacturers are now offering driving assistance systems	.173	.001	387
9.4	6.3	I think driving assistance systems will become very popular in the future	.298	.000	387

The correlation analysis of *Perceived installed customer base* items shows two significant correlations, between items 6.2 and 9.4 and between items 6.2 and 9.4, respectively. Both correlations have small positive effects.

Perceived Costs

Table 36: Spearman's rho correlation analysis: Perceived costs

Items			Correlation Coefficient	Sig. (2-tailed)	N
9.4	7.1	In my opinion, driver-assistance systems are too expensive	-.185	.000	387
9.4	7.2	I am worried about how often I am going to have to pay for new updates of driver-assistance systems	-.298	.001	387
9.4	7.3	I am worried about the resale value of the car if the technology is outdated	Not significant		

The correlation analysis of *Perceived Costs* items shows two significant correlations, between items 7.1 and 9.4 and between items 7.2 and 9.4, respectively. Both correlations have small negative effects.

Conclusion

In sum, the results indicate that *Perceived Usefulness, Innovativeness*, *Enjoyment of driving* and *Perceived Installed Customer Base* are significantly positive correlated with the *Intention to Use* ADAS technology. *Desire to Exert Control* and *Perceived Risks*, on the contrary, are significantly negative correlated with the *Intention to Use* ADAS technology.

The present results are in correspondence with six out of eight hypotheses. Thus, two hypotheses have to be questioned based on this information. Hypothesis H_5 states that a greater confidence in one's own driving capabilities decreases the intention to use Advanced Driver Assistance Systems. However, no significant correlation between these two variables was found in this analysis. Hypothesis H_1, on the contrary, shows a significant correlation, but in the opposite direction to that expected by the author. Based on the data, the hypothesis has to be reformulated as follows: "The greater the enjoyment of driving, the more positive the attitude towards Advanced Driver Assistance Systems". With only one of three items showing a small effect, however, this new hypothesis certainly needs further verification.

It has to be acknowledged that the testing of hypotheses based on correlation coefficients cannot prove any causal relationship in a definite way. Thus a final decision towards the causal relationships of the psychological constructs cannot be made based on this analysis alone. In order to further investigate the interdependencies of the variables, the measured items will be used to develop factors in the next step. Based on these factors a regression model can be calculated thereafter, which will provide a more elaborate basis for testing the hypotheses.

6.19 Observed and Latent Variables

There are two different kinds of variable used in the present research, those that are measured directly by the researcher (called observed variables) and those that are not measured directly but are inferred from observed variables (called latent variables) (Meyers, Gamst and Guarino, 2006, p.638). So far, only the measured variables have been considered in this analysis. However, in the social sciences, it is quite common that that the characteristics the researcher is interested in cannot be measured directly. Thus the researcher has to select a set of items that are assumed to reflect the construct. The relationship between the set of observed variables and the construct that they are intended to measure is called the *measurement model*. The rationale behind this model is that the answers to multiple observed items combined together better represent the complex notions of a construct than any single measure could do (Easterby-Smith, Thorpe and Jackson, 2008, p.276). A measurement model thus allows for "a greater richness in measurement, capturing nuances of a construct, and it also allows the researcher to assess how reliably the construct has been measured" (Easterby-Smith, Thorpe and Jackson, 2008, p.276).

Since all constructs within the hypotheses of the present research are latent variables, the author has developed at least three observable items for measuring each construct. One of the resulting measurement models, for the construct *Perceived Usefulness,* is shown in Chart 38 below as an example.

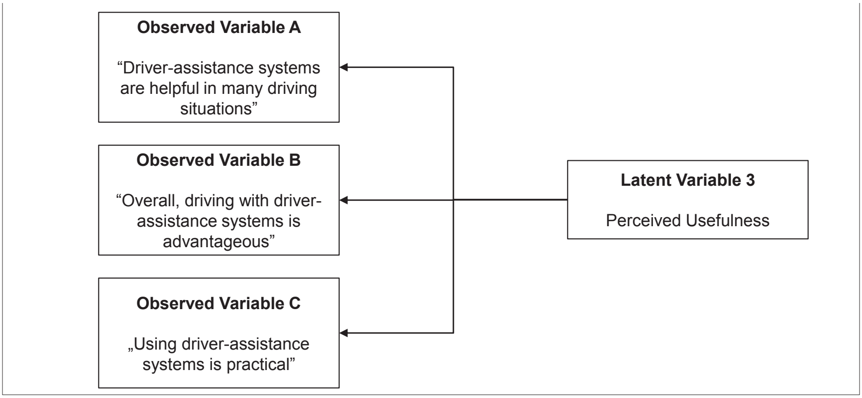


Chart 38: Measurement model for the latent variable *Perceived Usefulness*, Source: Own drawing

The construct *Perceived Usefulness* reflects common features of the observed variables A, B and C. The stronger the influence of the latent variable on the observed variables (also called factor loading), the higher will be the correlation between the observed variables (Byrne, 2009, p.4).

6.20 Factor Analysis Techniques

Generally, the statistical procedure for investigating relations between sets of observed and latent variables is called factor analysis. The basic idea behind factor analysis is that the researcher examines the covariation among a set of observed variables in order to draw conclusions on their underlying latent constructs, also called factors (Byrne, 2009, p.5). There are two different types of factor analyses depending on the level of knowledge of the underlying factors. If the researcher has no clear idea of what constructs might underlie the observed variables, the method of choice for analysing the measurement model is the *exploratory factor analysis* (EFA). This method suggests that there may be as many constructs as there are observed variables. Estimates of the factor loading of each construct for each observed variable are derived in order to reveal how much of the covariation among the observed variables can be accounted for by each construct. It is subsequently possible to create a subset of constructs, usually retaining only the largest (Easterby-Smith, Thorpe and Jackson, 2008, p.278). This procedure helps the researcher to determine the minimum number of concepts which explain the covariation among the observed variables (Byrne, 2009, p.5).

If both the number of factors and their correspondence to the observed variables are explicitly specified prior to the data gathering, the method of choice for analysing the measurement model is the *confirmatory factor analysis* (CFA) (Kline, 2005, p.71). Observed variables are usually assumed to load on only one factor. Thus, the method derives estimates for each of the factor loadings for the latent and the observed variables and gives an evaluation of how well the data fits with the measurement model (Easterby-Smith, Thorpe and Jackson, 2008, p.278). Chart 33, below, gives an overview of the features of EFA and CFA.

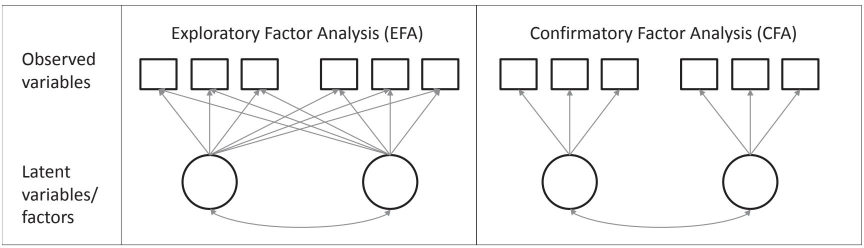


Chart 39: Exploratory factor analysis and confirmatory factor analysis, Source: Own drawing based on Byrne (2008, p.278); Easterby-Smith et al (2005, p.71) and Kline (2009, p.5).

Whether an exploratory or a confirmatory factor analysis is more appropriate for a given research context widely depends on the level of theoretical knowledge available on the factors. For the purpose of the present research, the predictor variables will be analysed using an exploratory factor analysis approach. Even though theoretical knowledge about potential factors was obtained during the literature review and the interview phase, the exploratory factor analysis approach provides the possibility to refine the predictor constructs independent of the *a priori* defined construct framework. Thus, the quantitative data is used not only to confirm the conceptual framework resulting from the qualitative stage, but also to develop the predictor constructs further.

6.21 Factor Analysis of Predictors

Before performing a factor analysis, the literature suggests evaluating the sample size adequacy using the Kaiser-Meyer-Olkin test of sampling adequacy (KMO). Furthermore, it is necessary to assess whether the factor analysis should be continued or not by employing Bartlett's test of sphericity (Schmidt and Hollensen, 2006, pp.302–303). The Kaiser-Meyer-Olkin test of sampling adequacy (KMO) compares the magnitudes of the correlation coefficients to the magnitudes of the partial correlation coefficients. The partial correlation coefficients represent the correlations between each pair of items after removing the linear effects of all other items (Pett, Lackey and Sullivan, 2006, p.77). The standard convention when evaluating the size of the overall Kaiser-Mayer-Olkin values, developed by Kaiser (1974), defines the following levels:

- Above .90 is "marvellous"
- In the .80s is "meritorious"
- In the .70s is just "middling"
- Less than .60 is "mediocre" or "unacceptable".

Bartlett's test of sphericity tests the hypothesis of whether the population matrix is an identity matrix. The existence of an identity matrix puts the correctness of the factor analysis under suspicion (Bajpai, 2011, p.646). As visualised in Table 37, both the KMO statistic and Bertlett's test of sphericity indicate an appropriate factor analysis model: thus, the factor analysis can be performed in the next step.

Table 37: Results of KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.850
Bartlett's Test of Sphericity	Approx. Chi-Square	4377.570
	df	276
	Sig.	.000

The factor analysis was performed using a Varimax rotation method and Kaiser Normalization. Values below .5 were excluded to improve the visibility of the results. All independent variables (question items 1.1 to 8.3) were included in the factor analysis. In sum, the analysis revealed five different components or factors, which can be seen in Table 38.

Table 38: Factor analysis of independent variables

	Factor				
	1	2	3	4	5
V1.1 I enjoy driving	.783				
V1.2 I drive for pleasure	.807				
V1.3 Driving is an agreeable way of passing time	.835				
V2.1 Overall I am worried about the amount of control technology has in the driving experience					
V2.2 I like to be able to switch any technology off when driving				.554	
V2.3 I enjoy making my own decisions when driving instead of being guided by technology					
V3.1 Overall, I would say that it is safer to drive without driver-assistance systems		-.758			
V3.2 I am worried that driver-assistance systems may one day fail when I am driving				.691	
V3.3 Using driver-assistance systems may lead to more accidents		-.588			
V4.1 Driver-assistance systems are helpful in many driving situations		.634			
V4.2 Overall, driving with driver-assistance systems is advantageous		.679			
V4.3 Using driver-assistance systems is practical		.629			
V5.1 Overall, I am confident in my driving abilities	.688				
V5.2 Generally, I am confident in my ability to avoid accidents when driving with my car	.609				
V5.3 My friends often compliment me on my driving skills	.657				
V6.1 I believe many people already use driver-assistance systems					.837
V6.2 I believe many car manufacturers are now offering driving assistance systems					.774
V6.3 I think driving assistance systems will become very popular in the future					.586
V7.1 In my opinion, driver-assistance systems are too expen-sive				.569	
V7.2 I am worried about how often I am going to have to pay for new updates of driver-assistance systems				.671	
V7.3 I am worried about the resale value of the car if the technology is outdated				.505	
V8.1 Overall, I feel comfortable using new technology			.832		
V8.2 Overall, I would say I like to buy products that have new technology			.841		
V8.3 Overall, I believe that technology is improving my life			.756		

In the next step, the composition of the five factors will be examined in order to understand which psychological construct each factor represents.

Factor 1 *Positive Driving Attitude*

The first factor identified in this analysis summarises the items related to the construct *Enjoyment of Driving* (1.1 to 1.3) and those related to the construct *Trust in Own Driving Skills* (5.1 to 5.3). While the first group of items covers aspects related to the general positive attitude towards driving, the second group is directed at the self-perception of one's own driving skills. In order to combine these two different concepts into a general and thus more abstract construct, the author decided use *Positive driving attitude* as a label for Factor 1.

Factor 2 *Perceived Safety and Comfort Benefit*

The identified Component 2 includes items related to Perceived Usefulness (Items 4.1 to 4.3) and items related to the Perceived Risks of ADAS technology (3.1 and 3.3). The interviews during the qualitative research stage revealed that the perceived usefulness of ADAS is strongly related to the technology's perceived ability to reduce traffic related risks. Since reducing the risk of accidents can be seen as one of the main benefits of driver-assistance systems, the combination of *Perceived Usefulness* and *Perceived Risks* in Factor 2 is logically sound. Other benefits of driver-assistance systems were attributed to increased driving comfort. Consequently, the resulting Factor 2 is labelled *Perceived safety and comfort benefit*.

Factor 3 *General Innovativeness*

Factor 3 combines all three items related to the general innovativeness of individuals (8.1-8.3). Consequently this construct will be labelled *General Innovativeness*.

Factor 4 *Perceived Disadvantages*

Factor 4 combines items related to the costs of ADAS technology (7.1 to 7.3) with two items related to the risk of system failure and the desire to stay in control, respectively. Thus, this factor includes consumer fears related to purchasing and maintaining costs, system failure and technological paternalism. The interviews during the qualitative research stage revealed that these three aspects are seen as the main disadvantages of ADAS technology. Consequently factor 4 will be labelled *Perceived Disadvantages* of ADAS technology.

Factor 5 *Perceived Customer Base*

Factor 3 combines all three items related to the *Perceived Customer Base* of driver-assistance systems (6.1-6.3). Consequently this construct will be labelled *Perceived Customer Base*.

Conclusion

The factor analysis of the present survey data has resulted in five mutually exclusive constructs, which are supposed to influence the acceptance behaviour of individuals towards driver-assistance systems. These constructs constitute independent latent (or exogenous) variables, which together with the dependent latent (or endogenous) variable, make up a conceptual model of ADAS acceptance. In the next step, however, the measurement model of the factors has to be analysed in order to determine the reliability of these construct.

6.22 Reliability Analysis of the Factors

The reliability of the measurement model depends on the average correlation among the observed variables and is usually measured using the Cronbach's alpha coefficient (Craig and Douglas, 2005, p.400). This coefficient can have a value of alpha (α) between negative infinity and 1, while generally a value greater than .70 indicates a high level of reliability (Bryman and Bell, 2007, p.164; Dewberry, 2004, p.321). Recent publications increasingly argue in favour of a more relaxed minimum level of .60, acknowledging that striving for high Cronbach's alpha values has increasingly led researchers to increase the number of extremely similar question items (Enders, 2004, p.92; Heinecke, 2011, p.84). For the present research, the following convention based on Shelby (2011, p.142) will be used: α values between .65 and .70 will be judged as "adequate scales", values between .70 and .80 as "good scales" and values above .80 as "very good scales".

While the Cronbach's alpha coefficient evaluates the overall reliability of the model, the Item-to-Total-Correlation (ITTC) measures how well a single indicator fits within the model. The ITTC describes the correlation between a single item and the sum of all items that are supposed to represent one factor. Usually

the Corrected Item-to-Total-Correlation is used, which indicates the correlation between a single indicator and the sum of all other items minus the item evaluated. The value of ITTC can range from 0 to 1, while generally higher values indicate a good fit and a high convergent validity of the item under investigation (Jais, 2007, p.128).
The reliability of the factors is now evaluated using the discussed reliability indices.

Factor 1 Positive Driving Attitude

Table 39: Factor 1 (Positive driving attitude)

Number of Items		**Cronbach's Alpha**		
6		.842		
Item		Arithmetic mean (M)	Standard deviation (S)	Corrected Item-Total Correlation (ITTC)
1.1	I enjoy driving	6.19	1.376	,533
1.2	I drive for pleasure	6.02	1.527	,484
1.3	Driving is an agreeable way of passing time	5.56	1.671	,548
5.1	Overall, I am confident in my driving abilities	5.49	1.349	,694
5.2	Generally, I am confident in my ability to avoid accidents when driving with my car	4.81	1.545	,734
5.3	My friends often compliment me on my driving skills	5.02	1.381	,744

With a Cronbach's alpha value of .842, the factor *Positive driving attitude* can be regarded as a valid and reliable factor, which will be used for the further analysis.

Factor 2 Perceived Safety and Comfort Benefit

Table 40: Factor 2 (Perceived safety and comfort benefit)

Number of Items		Cronbach's Alpha		
5		.779		
Item		Arithmetic mean (M)	Standard deviation (S)	Corrected Item-Total Correlation (ITTC)
3.1	Overall, I would say that it is safer to drive without driver-assistance systems	3,02	1.788	.649
3.3	Using driver-assistance systems may lead to more accidents	3.78	1.801	.730
4.1	Driver-assistance systems are helpful in many driving situations	4.72	1.609	.701
4.2	Overall, driving with driver-assistance systems is advantageous	4.64	1.771	.304
4.3	Using driver-assistance systems is practical	4.84	1.593	.473

Factor 2 *Perceived safety and comfort benefit* has a resulting Cronbach's alpha value of .779 and can thus be regarded as a good scale for the underlying construct.

Factor 3 General Innovativeness

Table 41: Factor 3 (General innovativeness)

Number of Items		Cronbach's Alpha		
3		.870		
Item		Arithmetic mean (M)	Standard deviation (S)	Corrected Item-Total Correlation (ITTC)
8.1	Overall, I feel comfortable using new technology	4.78	1.768	.787
8.2	Overall, I would say I like to buy products that have new technology	4.05	1.945	.772
8.3	Overall, I believe that technology is improving my life	4.61	1.757	.688

With a Cronbach's alpha value of .870, the factor *General Innovativeness* can be regarded as a valid and reliable factor, which will be used for the further analysis.

Factor 4 Desire to Exert Control

The reliability analysis of Factor 4 resulted in a Cronbach's alpha value of .633 and thus it is an inadequate scale for further analysis. In order to develop a more reliable scale, the author decided to dismiss items 7.1 to 7.3, which delivered inconsistent responses (Cronbach's alpha of items 7.1 to 7.3 is .469). Instead, items 2.1 and 2.3 were included, resulting in a new Factor 4, which was consequently relabelled into *Desire to exert control*.

Table 42: Factor 4 (Desire to exert control)

Number of Items		**Cronbach's Alpha**		
4		.707		
Item		Arithmetic mean (M)	Standard deviation (S)	Corrected Item-Total Correlation (ITTC)
2.1	Overall, I am worried about the amount of control technology has in the driving experience	4.30	2.042	.518
2.2	I like to be able to switch any technology off when driving	5.80	1.640	.432
2.3	I enjoy to make my own decisions when driving instead of being guided by technology	5.05	1.684	.584
3.2	I am worried that driver-assistance systems may one day fail when I am driving	4.42	2.023	.286

With a Cronbach's alpha value of .707, the factor *Desire to exert control* can be regarded as a good scale of the underlying construct.

Factor 5 Perceived Customer Base

Table 43: Factor 5 (Perceived installed customer base)

Number of Items		Cronbach's Alpha		
3		.660		
Item		Arithmetic mean (M)	Standard deviation (S)	Corrected Item-Total Correlation (ITTC)
6.1	I believe many people already use driver-assistance systems	4.40	1.686	.515
6.2	I believe many car manufacturers are now offering driving assistance systems	5.51	1.467	.402
6.3	I think driving assistance systems will become very popular in the future	5.57	1.351	.509

Finally, Factor 5, *Perceived installed customer base,* has the lowest Cronbach's alpha value of only .660 and can be seen as just acceptable, following the convention outlined above.

Dependent Variable Intention to Use

Table 44: Dependent variable (Intention to use ADAS)

Number of Items		Cronbach's Alpha		
4		0.910		
Item		Arithmetic mean (M)	Standard deviation (S)	Corrected Item-Total Correlation (ITTC)
9.1	I would like to purchase a car with driver-assistance systems in the future	3.80	1.993	.779
9.2	I would like to have more driver-assistance systems in my car	3.75	2.131	.832
9.3	Overall, I am willing to accept driver-assistance systems in cars to help me become a safer driver	4.51	1.921	.687
9.4	I plan to use driver-assistance systems in future	4.20	1.964	.890

Regarding the Cronbach's alpha values, the reliability analysis has revealed that the dependent variable *Intention to Use* has a very good measurement scales with a Cronbach's alpha value of .91.Thus, the dependent variable represents a reliable measurement of the underlying construct.

Conclusion

In sum, the analysis revealed that the independent as well as the dependent variable can be regarded *as* reliable enough to be used for further analysis. The author will consequently develop a conceptual model which is aimed at explaining the relationships of the independent and the dependent factors. In order to analyse relationships of latent variables or factors, a regression model will be developed next.

6.23 Regression Analysis

In the present section, a regression model will be developed which is aimed at explaining and predicting the acceptance behaviour based on the factors derived so far. At this point it is important to acknowledge the differences between parametric and non-parametric data analysis. Generally, linear regression models (often simply called regression models) can only be applied if the data distribution and measurement scales follow the strict requirements of parametric statistics (Weiers, Gray and Peters, 2011, p.553). For ordered category response data, such as data resulting from Likert Scale items, nonparametric methods based on ranks, such as ordinal regression, are more appropriate (Weiner, Schinka and Velicer, 2003, p.509). In practice, however, it is still quite common to ignore the categorical nature of response variables and use linear regression models for Likert Scale data (Agresti, 2010, p.4; O'Connell, 2006, p.3). Most of the studies conducted in this manner violate the assumptions of homoscedasticity, linearity and normality. However, as discussed before, there is an on-going discussion as to whether or not parametric methods such as linear regression are robust to these sorts of violations. In a direct comparison of linear and ordinal logistic regression on the same data set, Norris et al. (2006) demonstrated that both models provide a comprehensive interpretation of the data even if parametric assumptions are violated.

For the present data set, the author decided to apply both an ordinal regression analysis and a linear regression analysis. A discussion of the results will provide the most comprehensive interpretation of the data as well as a contribution to the on-going discussion of appropriate methodology.

6.24 Developing Factor Scores for Regression Analysis

In order to use factors for any form of regression model, summary scores have to be developed for each respondent and for each factor. These summary scores, also called factor scores, are composite variables that provide information about an individual's response on the factors. A multitude of methods is available for developing these scores, which can be broadly categorized into non-refined and refined methods (DiStefano, Zhu and Mîndrilă, 2009, p.2). Table 45 provides an overview of the methods available for developing factor scores.

Table 45: Factor Score techniques, Source: Based on DiStefano, Zhu and Mîndrilă (2009, pp.2–5)

Non-Refined Methods			
	Methods	**Advantages**	**Considerations**
Sum Scores by Factor	Summarising individual values Arithmetic mean Median Mode	Simple to calculate Preserve the variation of the original data	Items are given equal weight, regardless of the loading value Items must have the same scale
Sum Scores – Above a Cut-off Value	Similar to Sum Scores in which only items with loading values above a cut-off value are included	Sum score represents most relevant item scores	Researcher has to decide on a cut-off value Variation of the original data is not preserved
Sum Scores – Standardised Variables	Before summing, raw scores are standardised to the same mean and standard deviation	Useful if the standard deviations of the raw data vary widely	Variation of the original data is not preserved

Weighted Sum Scores	Factor loading of each item is multiplied by the scaled score for each item before summing	Items with the highest loadings on the factor have the largest effect on the factor score	Factor loadings may not be an accurate representation of the differences among factors due to a researcher's choice of extraction model and/or rotation method
Refined Methods			
	Methods	**Advantages**	**Considerations**
Regression Scores	Regression Scores is a multivariate procedure, which takes into account not only the correlation between the factors and between factors and observed variables (via item loadings), but also the correlation among observed variables, as well as the correlation among oblique factors	Easily calculated using SPSS The computed factor scores are standardised to a mean of zero Standard deviation is 1	Variation and scale of the original data is not preserved
Bartlett Scores	With Bartlett's approach, only the shared (i.e., common) components have an impact on the factor scores	Produces unbiased estimates of the true factor scores Easily calculated using SPSS	Variation and scale of the original data is not preserved

The choice of a factor score method depends widely on the nature and distribution of the data set as well as on the intended application of the sum scores. For linear regression models, Skrondal and Laake (2001) recommend using *Regression Scores* for the explanatory latent variables and *Bartlett Scores* for the dependent latent variables. Based on an extensive meta-study, the authors provided evidence that this method clearly outperforms the explanatory power of using either only regression scores or Bartlett scores for a linear regression model. Consequently, the author decided to apply this methodology for developing the factor scores for the linear regression model.

In order to develop factor scores for the ordinal regression model, it is necessary to utilise the ordinal nature of the categorical scale data. Thus, the author identified the median response for each factor. In contrast to the arithmetic mean and other summary scores used for interval scaled data, the median does not require any knowledge about the scales besides the rank order and thus is suitable for ordinal scaled data (Agresti, 2010, p.10). Table 46 summarizes the factor score methods applied by the author for the regression models in the present research.

Table 46: Factor score methods for linear and ordinal regression

	Linear Regression Model	**Ordinal Regression Model**
Independent variables	Regression Factor Scores	Sum Scores by Factor – Median
Dependent variables	Bartlett Factor Scores	Sum Scores by Factor – Median

6.25 Ordinal Regression Analysis

Ordinal regression provides estimates for predicting the resulting categories of an ordinal dependent variable based on a predictor value or category (Agresti, 2010, p.3). The literature generally provides two different methodologies to deal with ordinal outcome variables in regression models. One solution is to dichotomise the data and then use a logistic regression model. This method requires defining a point for dichotomy, or a cut-off point, before conducting the analysis (Campbell, 2008, p.89). While this point comes naturally for two-response items such as gender, it requires profound theoretical knowledge about the data to define a cut-off point for multi-category response items such as 7-point Likert Scales. The second, more efficient, alternative is known as the *proportional odds* or *cumulative logit model* and was originally developed by McKelvey & Zavoina (1975). This approach results in cumulative response probabilities rather than category probabilities (Campbell, 2008, p.89). In other words, the *proportional odds* method considers the probability of an event and all events that are ordered before it to happen (Muijs, 2011, p.166). Since this approach avoids the potential bias of dichotomy cut-off decisions, the author decided to use the *proportional odds* model for the ordinal regression model in the present research.

Ordinal regression provides information about the relationship between each of the predictor variables separately and the dependent variable. For each predictor, the relationship takes into account the effect of all the other independent variables. The *link function* is the transformation that relates the predicted outcome to the observed dependent variable (Cohen, 2010, p.534). For linear regression, the *link function* is the identity function, since observed and predicted scores are on the same scale. For ordinal regression, the most common link function is the *logit link* or *logistic distribution function*, which uses the natural logarithm of the odds (O'Connell, 2006, p.57). Generally, there are other link-functions available for ordinal regression, such as the *probit link function* and the complementary *log-log function*. For naturally ordered categorical response variables, the literature suggests using the most common *logit link* function, which was consequently applied in the present regression model (Menard, 2010, p.319). The procedure was conducted in SPSS with the PLUM (for polytomous logit universal model) interface.

Testing the Proportional Odds Assumption

Before considering the results of the regression model, it is important to acknowledge one important, but often ignored, assumption underlying ordinal regression, which is called the *proportional odds* or *parallel lines assumption* (Azen and Walker, 2011, p.252). Ordinal regression builds on the underlying assumption that the difference between odds-ratios in each pair of categories is the same. If the assumption of proportional odds is rejected, then the ordinal regression model is called into question and an alternative model should be sought (Ketchen and Bergh, 2004, p.116). For the present regression model, the Null Hypothesis, that the location parameters are the same across the response categories, is not rejected ($p = .103$). Thus the proportional odds assumption is met by the present regression model.

Table 47: Test of parallel lines

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Null Hypothesis	1,022.343			
General	988.117	34.226	25	.103

The null hypothesis states that the location parameters (slope coefficients) are the same across response categories.

Assessing the Goodness-of-Fit for the Model

The first output to be regarded in ordinal regression is the model fitting information, which provides an overall test of the model, based on the differences between the specified model and the (intercept-only) null model (Garson, 2012, p.17). Generally, the *Log Likelihood Ratio Statistic* (-2LL) for the null model should be significantly different from the corresponding value of the research model, while a lower -2LL value indicates a better fit (Menard, 2010, p.207). For the present research model the -2LL value of the model (1,022) is significantly smaller than the corresponding -2LL value of the null-model (1,466). The difference is significant at the .001 level: thus, the model can be considered as well-fitted (see Table 48).

Table 48: Model Fitting Information of the ordinal model

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	1,466.531			
Final	1,022.343	444.189	5	.000

Link function: Logit Link.

Assessing Multicollinearity

Multicollinearity exists when there are strong correlations between two or more predictor variables and it imposes a threat to the validity of any multiple regression analysis. If perfect collinearity exists between two predictors, it becomes impossible to obtain unique estimates of the regression coefficients (Field, 2003, p.131). Although perfect collinearity is rather rare in real life, less than perfect collinearity already imposes a threat on the model validity. In order to assess multicollinearity, SPSS offers two diagnostic tools, *Tolerance* and the *Variance*

Inflation Factor (VIF). To compute the *Tolerance* of each variable, SPSS runs a separate regression analysis, where the predictor becomes the dependent variable to be explained by the remaining predictors. The resulting *Tolerance* value ranges from 0 to 1, while values below .01 indicate multicollinearity for the particular variable (Meyers, Gamst and Guarino, 2006, p.212). As an alternative assessment index, the *Variance Inflation Factor (VIF)* is simply the reciprocal of the tolerance (calculated as 1/Tolerance). Larger VIF values indicate a greater degree of multicollinearity for the particular variable. Generally, a *Variance Inflation Factor* greater than 10 indicates a serious multicollinearity problem (Bajpai, 2010, p.548; Freund, Mohr and Wilson, 2010, p.426; Meyers, Gamst and Guarino, 2006, p.212). Table 49 shows the multicollinearity diagnostics coefficients for the present regression model.

Table 49: Multicollinearity diagnostics coefficients

Model		Collinearity Statistics	
		Tolerance	**VIF**
1	Positive driving attitude	.777	1.287
	Perceived safety and comfort benefit	.501	1.998
	General Innovativeness	.658	1.520
	Desire to exert control	.595	1.680
	Perceived Customer Base	.878	1.140

a. Dependent Variable: Intention to Use

In sum, the predictor variables of the present regression model can be regarded as a valid measurement, since multicollinearity between the factors is very low. This result is not particularly surprising, however, since the predictors were developed based on a principal component (or factor) analysis, which generally results in statistically independent components (or factors).

Summary Statistics

In the next step, the summary statistics of the regression model are examined. For a linear regression model, the most important summary statistic is the R^2 statistics, which refers to the variance in the dependent variable, explained by the predictors (Weinberg and Abramowitz, 2002, p.415). Similarly, for ordinal regression models, SPSS provides three different types of so-called “pseudo R^2 statistics”, namely the Cox and Snell, the Nagelkerke and the McFadden statistic

(Muijs, 2011, p.165). Generally all of these statistics can be taken as additional measures of model effect size, with higher values being better. Of the three types, Nagelkerke's R-square is the most widely reported (Garson, 2012, p.18). The Nagelkerke R-square value of .698 of the present model indicates a high explanatory power of the regression model (see Table 50).

Table 50: Pseudo R-Squared values

Cox and Snell	.683
Nagelkerke	.698
McFadden	.298
Link function: Logit.	

Model Estimates

Finally, the estimated coefficients for the thresholds (intercepts) and the location parameters (or slopes) of the predictor variables will be examined. The thresholds define the cut-off points used and the output indicates the likelihood of being in the actual or lower category of the dependent variable compared to all higher categories. It is generally important that all threshold values differ significantly from each other, because otherwise that level and the one above have the same equations (since by the parallel slope assumption, location slopes are the same and only thresholds differ).

In other words, non-significant thresholds suggest that the cut-off point is not truly different and therefore some levels of the dependent variable should be better combined (Garson, 2012, p.20). As can be seen in Table 51, the thresholds or cut-off points of the dependent variable *Intention to Use* are the seven possible answer categories of the Likert Scale. Each threshold differs significantly from the one before: thus, the data distribution of the dependent variable is suitable for an ordinal regression model.

Table 51: Parameter estimates of the ordinal model

		Estimate	Std. Error	Wald	df	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Thres-hold	[Intention to Use = 1]	2.279	.658	12.000	1	.001	.990	3.56
	[Intention to Use = 2]	3.927	.674	33.959	1	.000	2.60	5.24
	[Intention to Use = 3]	4.931	.690	51.018	1	.000	3.57	6.28
	[Intention to Use = 4]	6.346	.721	77.511	1	.000	4.93	7.75
	[Intention to Use = 5]	7.945	.758	109.81	1	.000	6.45	9.43
	[Intention to Use = 6]	10.045	.806	155.28	1	.000	8.46	11.6
Loca-tion	**Factor 1** (Positive driving attitude)	-.078	.087	.804	1	.370	-.248	.092
	Factor 2 (Perceived safety and comfort benefit)	1.137	.102	123.950	1	.000	.937	1.33
	Factor 3 (General Innovativeness)	.551	.070	62.143	1	.000	.414	.69
	Factor 4 (Desire to exert control)	-.311	.079	15.487	1	.000	-.466	-.15
	Factor 5 (Perceived installed customer base)	.112	.075	2.240	1	.135	-.035	.26

Link function: Logit.

The resulting estimates for the coefficients indicate the amount by which the dependent variable changes if the predictor goes up by 1 and thus allow us to determine which predictor has the strongest relationship with the outcome variable (Muijs, 2011, p.172). The significance level for each estimate value indicates that there is a significant relationship between the dependent and the independent variable (Garson, 2012, p.22). The corresponding significance level according to the Wald test is also given, as well as the confidence interval at 95%. Of the five factors examined in the present research model, two (Factors 1 and 5) have an effect that is not significant at the .05 level. Of the remaining three factors, Factor 2 has the largest effect size of 1.137, followed by Factor 3 with an effect size of .551. Both Factors 2 and 3 have a significant positive effect on the dependent variable *Intention to Use*. Factor 4 has a negative coefficient of -.311, indicating a significant negative relationship with the dependent variable *Intention to Use*.

Odds Ratios

Unlike beta weights in linear regression, the estimated coefficients in ordinal regression cannot be regarded as direct effect size measure for the predictor variables. The parameter estimates have to be converted into cumulative odds ratios in order to derive a meaningful effect size measure (Garson, 2012, p.22). The odds ratio is the natural log base e raised to the power of the negative of the parameter estimate (Tutz, 2012, p.245). Table 52 shows the odds ratios for the five predictor variables in the present model.

Table 52: Odds ratios

		Estimate	**Odds ratio**
Location	Factor 1 (Positive driving attitude)	-.078	1.080
	Factor 2 (Perceived safety and comfort benefit)	1.137	0.320
	Factor 3 (General Innovativeness)	.551	0.576
	Factor 4 (Desire to exert control)	-.311	1.365
	Factor 5 (Perceived installed customer base)	.112	0.893

The odds ratios can be interpreted as follows. Values below 1.0 indicate a decrease in odds, 1.0 indicates no difference and values above 1.0 indicate higher odds. Since the odds are cumulative odds, higher odds mean a higher probability of being in a lower or equal category of the dependent variable (Garson, 2012, p.26). Non-significant predictors (Factor 1 and 5) will not be interpreted at this point. The cumulative odds ratio of .320 for Factor 2 indicates that if the *Perceived safety and comfort benefit* goes up by one, the cumulative odds of being in a lower category of the dependent variable *Intention to Use* are decreased by a factor of .320. In other words, individuals who perceive ADAS technology to have more safety and comfort benefits have a higher probability of using this technology in future. Factor 2, *General Innovativeness*, can be interpreted similarly, with an odds ratio of .576. *Desire to exert control*, on the other hand, has an odds ratio of 1.365, meaning that people scoring one category higher on the *Desire to exert control* scale have increased odds of a factor of 1.365 of being in a lower category of the dependent variable *Intention to Use*. Thus, the higher individuals score on the *Desire to Exert Control* scale, the lower is the probability that they will use ADAS technology in future.

Conclusion
The ordinal regression model of the present research has fulfilled the parallel lines assumption and was found to be well fitted with the data. The model furthermore provides satisfactory explanatory power, as measure by Nagelkerke's R^2 statistics. The analysis of the predictors based on the factor scores has revealed that three of the five variables have a significant influence on the dependent variable *Intention to Use*. *Perceived Safety and Comfort Benefit* was found to have the strongest positive impact on the dependent variable, followed by *General Innovativeness*. *Desire to Exert Control*, on the other hand, was found to have a significantly negative impact on the dependent variable. Chart 40 visualises the final results of the ordinal regression model.

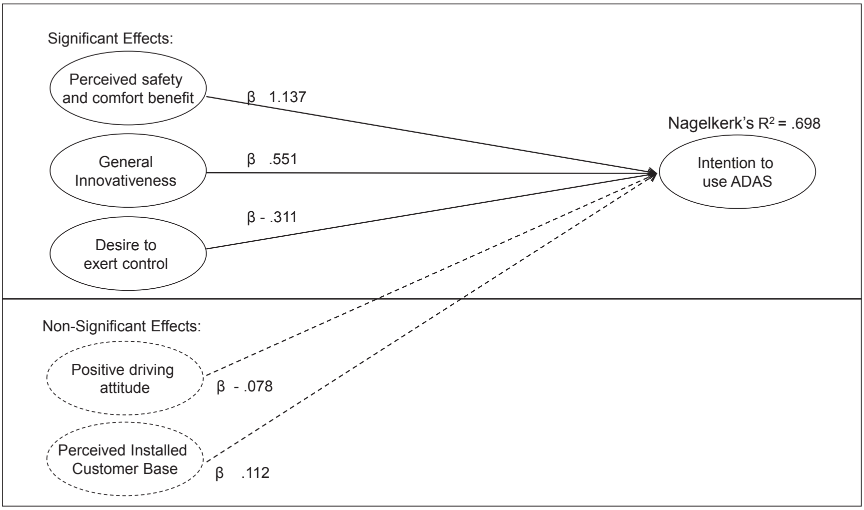


Chart 40: Ordinal regression model, Source: Own drawing

6.26 Linear Regression Analysis

As discussed before, a linear regression model will be fitted to the data in the next step. The linear regression analysis was performed using the dependent variable *Intention to Use* and the five predictor variables, similar to the ordinal regression model. The variables were calculated using regression factor scores and Bartlett factor scores, as described the previous sections.

Assessing Multicollinearity

Before the linear model can be fitted to the data, the predictor variables are tested for multicollinearity. As described in the previous section for the ordinal model, the *Tolerance* and the *Variance Inflation Factor (VIF)* are used as diagnostic tools for assessing the level of multicollinearity between the predictor variables. Table 53 shows the multicollinearity diagnostics coefficients for the linear regression model.

Table 53: Multicollinearity diagnostics coefficients

Model		Collinearity Statistics	
		Tolerance	VIF
1	Positive driving attitude	.743	1.346
	Perceived safety and comfort benefit	.444	2.253
	General Innovativeness	.608	1.646
	Desire to exert control	.531	1.884
	Perceived Customer Base	.853	1.172

Dependent Variable: Intention to Use

In sum, the multicollinearity between the factors is very low. This result, however, is again not particularly surprising. As in the ordinal regression model, the predictors of the linear model were developed based on a principal component analysis (or factor analysis), which generally results in statistically independent components (or factors).

Summary Statistics

In this model, the R squared (R^2) value is used to measure the effect size, i.e. the proportion of variance in the outcome variable that is accounted for by the predictor variables (Stangor, 2011, p.378). The adjusted R^2 value introduces an additional penalty for including nonsensical predictors and thus provides an improved view on how well the dependent variable can be explained by the predictors (Howitt and Cramer, 2008b, p.352; Jank, 2011, p.56). As summarized in Table 54, the adjusted R^2 for the present linear regression model is .729, indicating a high explanatory power of the model.

Table 54: Model summary of the linear model

Model	R	R^2	Adjusted R Square	Std. Error of the Estimate
1	.856[a]	.732	.729	.52064454

a. Predictors: (Constant), Perceived Customer Base, Desire to exert control, Positive driving attitude, General Innovativeness, Perceived safety and comfort benefit

Model Estimates

The standardised Beta-Values represent the weight of individual variables in the final regression equation. In other words, they indicate the effect individual factors have in predicting the dependent variable (Gravetter and Forzano, 2009, p.436). The unstandardised beta values are similar to the standardised beta values in this case, since standardised factor scores were used for the predictors as well as for the dependent variable. The significance values indicate which of the predictors has a significant impact on the dependent variable.

Table 55: Estimated coefficients in the linear model

Model		Unstandardised Coefficients		Standardised Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	.000	.026		.000	1.000
	Factor 1 (Positive driving attitude)	-.044	.031	-.044	-1.43	.152
	Factor 2 (Perceived safety and comfort benefit)	.588	.040	.588	14.77	.000
	Factor 3 (General Innovativeness)	.288	.034	.288	8.479	.000
	Factor 4 (Desire to exert control)	-.100	.036	-.100	-2.75	.006
	Factor 5 (Perceived Customer Base)	.026	.029	.026	.892	.373

a. Dependent Variable: Intention to Use

As can be seen in Table 55, two of the five predictors (Factors 1 and 5) have a non-significant effect on the dependent variable. The remaining three factors have a significant effect at the .005 level. Factor 2, *Perceived safety and comfort* *benefit*, has the strongest positive impact, with a beta coefficient of .588, followed by Factor 3, *General Innovativeness*, with a beta coefficient of .288. Factor 4, *Desire to exert control*, on the other hand, has a negative impact on the dependent variable with a beta coefficient of -.100.

Conclusion
With an adjusted R2 of .729, it can be assumed that almost 73 percent of the variance of the dependent variable is explained by the proposed linear regression model. Factors 1 and 5 are omitted due to the fact that they have a non-significant impact on the dependent variable. Of the remaining variables, Perceived Safety and Comfort Benefit has the strongest positive impact, followed by General Innovativeness. Desire to Exert Control was found to have a negative impact. The complete linear regression model is visualised in Chart 41.

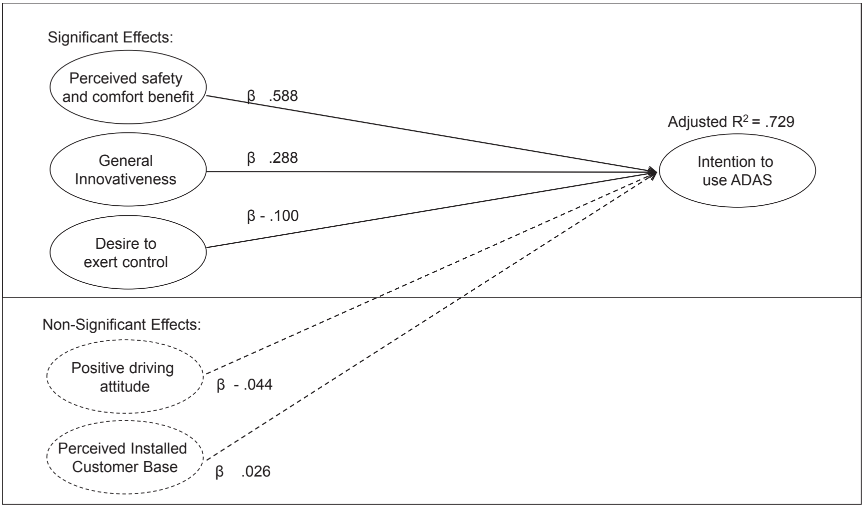


Chart 41: Linear regression model, Source: Own drawing

6.27 Comparison of Ordinal and Linear Regression Model Results

The direct comparison of the resulting ordinal and linear regression models shows only minor deviances. Most importantly, the resulting predictor structure of both models is similar. Both models indicate that only the Factors 2, 3 and 4 significantly impact the dependent variable and thus should be included in the model. Although not directly comparable, the model summary statistics have a comparable value with a Nagelkerke's R^2 value of .698 in the ordinal model and an Adjusted R^2 of .729 in the linear regression model. Similarly, both models report the same effect direction and relative effect strength. Both models report that Factor 2 has the strongest positive impact on the dependent variable, followed by Factor 3. Also each model indicates that Factor 4 has a negative impact on the dependent variable. The absolute effect values of the predictors are not comparable, since the ordinal model results in cumulative odds, while the linear model delivers weighted beta values. Thus, the author had to decide on which model to use for interpretation and further discussion. Since the linear regression model assumes the dependent variable to be interval scaled, the validity of the resulting beta values is at least questionable. Generally, the beta values of the linear model are more precise and easier to interpret than cumulative odds. The violation of the interval scale assumption, however, might lead to a pseudo exactness of these values, which could in turn lead to a misinterpretation of the data (Kitchenham and Mendes, 2009, p.2). Consequently, the odd ratios resulting from the ordinal regression, although slightly harder to interpret, are better estimates for the final regression model of the present data set and will thus be consequently used for data interpretation. In the next step a structural equation model will be fitted to the data in order to further elaborate the proposed conceptual model.

6.28 Structural Equation Modelling

The first step in structural equation modelling is to define the hypothesis model. The hypothesis model specifies which measured and latent variables are included in the analysis and how the relationship between them is directed. Consequently the researcher has the responsibility to carefully considerate the potential latent variables and their interrelations – missing important latent variables could seriously bias the results (Easterby-Smith, Thorpe and Jackson, 2008, p.296). For the present research the hypothesis model was already developed and refined in the previous chapters.

In the second step the model must be specified. This includes estimating the model parameters, either from data, or allocating pre-defined values to them. The model parameters have to be estimated for the hypothesis model as well as for the measurement model. Both models are combined when observable variables are attached to the latent variables in the hypothesis model (Easterby-

Smith, Thorpe and Jackson, 2008, p.296). Chart 42 shows the complete structural equation model.

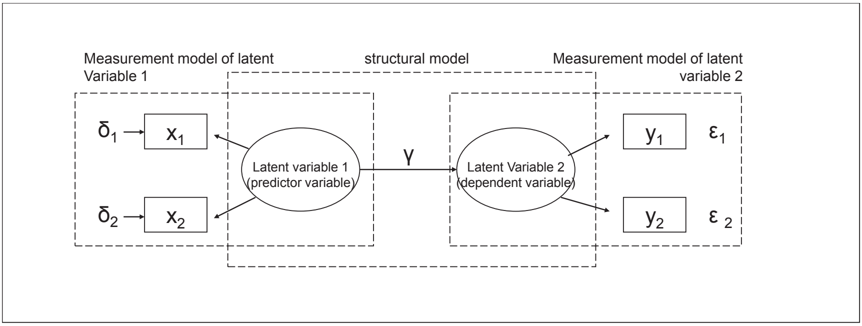


Chart 42: Structural equation model, Source: Own drawing based on: Backhaus (2003, p.394).

The drawing above shows a path diagram with the latent variables shown as circles and the indicators or measured variables shown as rectangles. The vectors ε and σ represent error terms.

Each of the arrows in the figure represents a path between two variables and also a parameter to be estimated from the data. For the measurement model these parameters are also called *factor loadings*, while for the structural model, they are *called path coefficients* (Backhaus, 2003, p.394). In this model the causal linkage between the latent variables is represented by the path coefficient γ. The coefficient can have a value between -1 and 1, with the absolute value representing the strength of the relationship and the sign indicating whether the effect is positive or not. Since latent variables are, by definition, not measurable, there is no observable scale to attach to them. Thus it is commonly assumed that the measurement scale of a latent variable is the same as that of its indicators (Easterby-Smith, Thorpe and Jackson, 2008, p.298).

The third step in structural equation modelling is to estimate model parameters, which is generally done by structural equation modelling software. There are various software packages available for this form of analysis, the most popular ones are AMOS, EQS and LISREL (Byrne, 2001b, p.56). For the present research the author decided to use AMOS statistical package, due to its compatibility with SPSS. However, all these programs work broadly the same way. First starting values are formed and consequently used to calculate the initial estimate of the population covariance matrix. The difference of this matrix to the sample covariance matrix is called the *residual matrix* (Easterby-Smith, Thorpe and

Jackson, 2008, p.298). The initial parameters are modified in order to reduce the difference and thus to increase the goodness of fit of the population covariance matrix and the sample covariance matrix. This procedure is repeated until no further improvements can be made (Hardy and Bryman, 2009, p.442). The ultimate goal of structural equation modelling is to achieve a good fit between hypothesised model and the data.

The fourth step in structural equation modelling is consequently to assess the fit of a model with the data. In order to evaluate the so called *goodness of fit* several tests were established in the field of statistics and most published work in the field reports three or four different indices (Easterby-Smith, Thorpe and Jackson, 2008, p.299). The parameters for assessing the goodness of fit of a model and the associated minimum values will be discussed in detail in the next chapter.

Finally, after evaluating the goodness of fit of the model, the fifth step is to consider alternative models which might fit the measured covariance matrix better than the originally proposed one. It is rather unusual that only a single structural equation model is fitted to a set of data. More likely the a priori defined model does not fit the data to an acceptable degree and so alternatives are explored using modification indices (Easterby-Smith, Thorpe and Jackson, 2008, p.301). Modification indices are parameters indicating how much the model fit could be improved by changing the model to allow additional parameters to be estimated (Bowen and Guo, 2012, p.198). One example of such an index is the *expected parameter change* (EPC) statistics, which estimates the change in the magnitude and direction of each fixed parameter if it were to be become free. Another modification index is the *lagrange multiplier* (LM) which assesses the effect in terms of goodness-of-fit for a subsequent model in which a set of fixed parameters is consequently freed (Schumacker and Lomax, 2008, p.66). Both approaches are called forward search, since they include the stepwise freeing of so far fixed parameters. A different approach is the so called *backward search* which is supported by the *Wald test*. The Wald test assesses which parameters currently included in the model have a value so small that they could be erased from the model (Easterby-Smith, Thorpe and Jackson, 2008, p.300). It is important to acknowledge, however, that changes to the hypothesized models "should not be made based solely on modification indices;

changes must be substantively and theoretically justifiable, not just statistically justifiable.” (Bowen and Guo, 2012, p.198). Consequently, the process of model modification must be guided by conceptual considerations, based on strong empirical justification, instead of conducting a blind search through multiple alternatives (Easterby-Smith, Thorpe and Jackson, 2008, p.300).

Chart 43 shows the phase model for conducting the structural equation modelling.

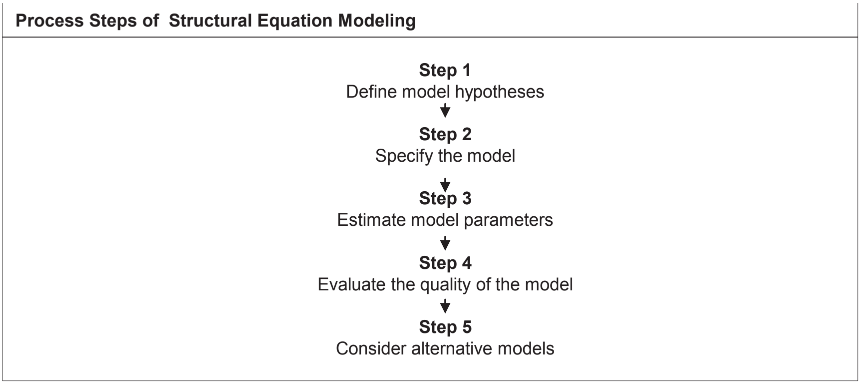


Chart 43: Steps in structural equation modelling, Source: Own drawing, based on Easterby-Smith, Thorpe and Jackson (2008, p.296).

Since the purpose of the structural equation model in the present research process is to verify an already elaborated conceptual model there is a clear emphasis on step 4, which will be the focus of the next chapter.

6.29 Evaluating Model Fit in Structural Equation Modelling

As discussed in the previous chapter, assessing the model fit of the proposed hypotheses model is one of the most crucial steps in structural equation modelling. Since there are various tests available for this purpose, it is necessary to closely reflect upon the advantages and disadvantages of each method. All these assessment methods can be categorized broadly into three main categories:

1. Discrepancy-based indices
2. Relative fit indices
3. Null-model indices.

Discrepancy-Based Indices

Discrepancy-based indices are the standard assessment values and their most common representative is the *Chi square* (χ^2) value. The value of χ^2 Depends on a function of the population covariance matrix, on the sample covariance matrix and on the sample size (Easterby-Smith, Thorpe and Jackson, 2008, p.299). A small value of chi-square indicates a close fit and suggests that the hypothesised model is a good one. A large χ^2 is usually associated with a poor model fit, but could also be simply indicating a large sample size (Hardy and Bryman, 2009, p.444). Thus, the Chi square has to be taken with caution, especially in studies with a larger sample size. Due to this shortcoming, no definite minimum value will be set for the Chi square index in the present study.

Relative Fit Indices

Relative fit indices adjust for the complexity of a model and the sample size. Generally, complex models fit data better than simple models. Thus, relative fit models assign an extra cost to the complexity of the model in order to reward the models which achieve a reasonable fit with few parameters as opposed to models which give a marginally better fit at the cost of increased complexity (Easterby-Smith, Thorpe and Jackson, 2008, p.299). One example of these measures is the *root mean squared error of approximation* (RMSEA), which adjusts the chi-square value by the degrees of freedom of the model as well as by the sample size (Hardy and Bryman, 2009, p.445). The RMSEA is a measure of the average size of the residuals between actual covariance and the proposed model covariance (Meyers, Gamst and Guarino, 2006, p.559). This features make RMSEA to one of the most robust and most popular tests in the in the field of multivariate statistics (Bartholomew, Knott and Moustaki, 2011, p.221). Browne and Cudeck (1993, pp.136–162) suggest that RMSEA values smaller than 0.05 indicate a very close fit, while values greater than 0.1 indicate a poor fit. Meyers, Gamst and Guarino (2006, p.559) argue that values up to 0.08 can be seen as acceptable for most research purposes, while values above 0.1 should be seen as a sign that the model fit needs to be improved. For the present study the author aims at a RMSEA value of < 0.1 as a minimum acceptable level.

Null-Model Indices

Null-model indices assume that all the covariances among the observed variables are zero. It is subsequently evaluated how much better the specified model is than the null model. The most popular example of a null-model index is the *goodness-of-fit index* (GFI), which measures the relative amount of variance and covariance in the sample covariance matric that is jointly explained by the population covariance matrix. A modification of the GFI is the *adjusted goodness-of-fit index* (AGFI), which adjusts for the number of degrees of freedom in the specified model and thus, comparable to the relative fit indices, rewards parsimony (Byrne, 2001a, p.82). Another example for a null-model index is the *non-normed fit index* (NNFI), whose value can vary between 0 and 1 (Easterby-Smith, Thorpe and Jackson, 2008, p.299). A value of 1 indicates a very good model fit, while a value greater than one might indicate overfitting. Generally, values smaller than 0.8 indicate a poor fit (Bartholomew, Knott and Moustaki, 2011, p.222). Similar null-model indices are the *comparative fit index* (CFI), the *relative fit model* (RFI) and the *incremental fit index* (IFI). Values greater than .8 again, indicate a good model fit for all of these indices (Bartholomew, Knott and Moustaki, 2011, p.221; Meyers, Gamst and Guarino, 2006, p.559). A common guideline for interpreting null-model indices was proposed by Knight et al. (1994, pp.767–783) as follows:

- greater than .90 very good fit
- .80 to .89 adequate but marginal fit
- .60 to .79 poor fit
- lower than .60 very poor fit.

Even though, Byrne (2009, p.117) suggests to use only the comparative fit index (CFI) as a method of choice for null-model indices, the author decided to use all indices (AGFI,CFI, RFI and IFI) for the present research.

Table 56 gives an overview on the intended model evaluation indices for the present research and the associated minimum acceptable levels derived from literature.

Table 56: Evaluation Indices and minimum acceptable levels

root mean squared error of approximation (RMSEA)	< 0.1
goodness-of-fit index (GFI),	> 0.8

adjusted goodness-of-fit index (AGFI)	> 0.8
non-normed fit index (NNFI)	> 0.8
comparative fit index (CFI)	> 0.8
the relative fit model (RFI)	> 0.8
the incremental fit index (IFI)	> 0.8

6.30 Evaluating the Quality of the Proposed Model

The hypothesis model was already developed in the previous chapters and the initial structural equation model will be equivalent to the resulting model of the regression analysis (see Chart 40). For estimating the model parameters in step three, the model is transferred to the AMOS software package, which also provides the required quality indices for the model fit of the proposed model covariance matrix with the data covariance matrix. Chart 44 shows the resulting model estimation values, as well as the quality indices discussed in the previous chapter.

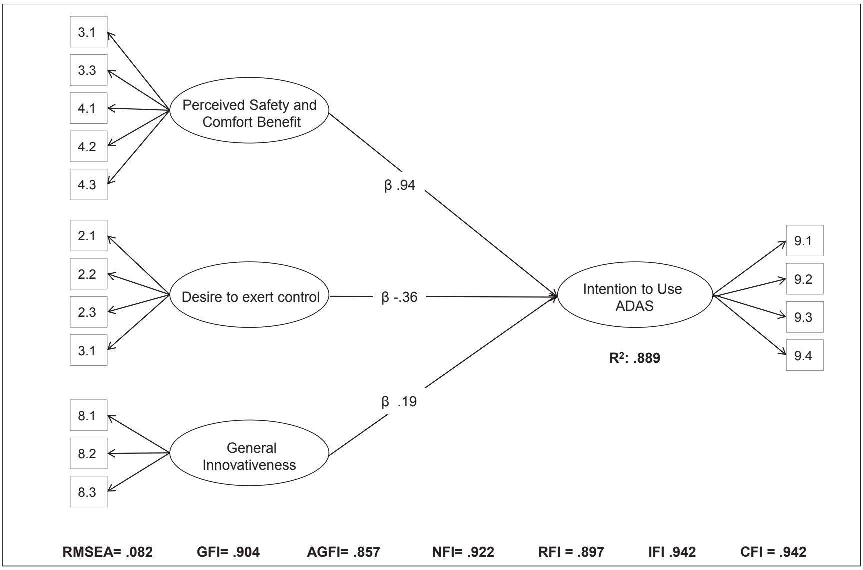


Chart 44: Resulting model from Structural Equation Modelling, Source: Own drawing

With a RMSEA considerably below .01 and null-model indices around .09 the model above shows a very good fit with the data based on the discussed quality criteria. Further improvement by freeing of variables, using the expected parameter change, has not resulted in an increased overall quality. Likewise backward search, meaning the further reduction of variables, has not resulted in any potential for improving the model. The main reason for the good initial fit of the model is that it is based on the results of a previous factor analysis and a regression analysis. With a squared multiple correlation of .889, the proposed model is capable of explaining approximately 89 percent of the variance in the dependent variable *Intention to Use*. In conclusion, the structural equation model approach conducted so far has confirmed the validity of the proposed model structure by indicating a good fit between the data and the model. In the next step, the present data set will be analysed regarding group differences in order to understand the influence of background variables, such as age or gender.

6.31 Testing for Group Differences

When regarding group differences it is important to distinguish whether the analysis will examine one or more groups and whether these groups are independent or somehow related e.g. the same group is tested twice in different time periods (Kumar, Aaker and Day, 2002, p.395). While in the case of gender, obviously only one group will be tested against the other at any time, in the case of age groups or car types there are more potential categories for group building. Since testing for group differences in multiple-group cases increases complexity and thus potential misinterpretations, only one-group settings will be examined in the following analyses. The author decided to test for the following group differences:

- Male / female
- Age above 40 / below 40
- Car owner / non-car owner
- Experience with driver-assistance systems
- Small car owner / large car owner
- Luxury brand car owner / economy car brand owner

Since all of these groups are independent, there are two potential tests for analysing group differences: the Mann-Whitney U-Test and the two-sample T-Test.

The main differentiation between these two tests is that the Two-sample T-Test is a parametric test and thus requires that the variances of both groups are similar and that the data is on an interval or ratio scale. The Mann-Whitney U-Test, on the contrary, is a non-parametric test and only requires ratio scales and less knowledge about the variance of the samples (Howitt and Cramer, 2008b, p.170). The sample analysis has revealed that some demographic variables are over- or underrepresented in the sample. Due to this and the fact that the independent variables (Gender, Age, Car types) are nominal and the dependent variables are ordinal, the most appropriate test for the present analysis is the Mann-Whitney U-Test. Consequently, the defined groups will be compared to each other using the U-Statistic to test for significant differences in the next step. The corresponding Null-Hypothesis for each test is that there is no difference between the two groups under investigation. The Null Hypothesis will be tested two-sided, using a confidence interval of .95. For resulting p-values under .05, the Null-Hypothesis is rejected.

Gender

The analysis of gender differences is based on a sample of N=326 male participants and N=60 female participants. It has to be acknowledged that the female sample is considerably smaller than the male sample. Based on the interview results, the author expected gender-based differences in the perception of ADAS technology. The comparison of the gender groups, however, revealed only minor differences between the two groups. Significant deviations in answer patterns are only observable in three question items, which are listed in Table 57.

Table 57: Group differences for gender (male / female), N:326/60

Item	Description	Significance		Mean male	Mean female
V4.2	Overall, driving with driver-assistance systems is Advantageous	.047	significant	4.57	5.03
V9.1	I would like to purchase a car with driver-assistance systems in the future	.003	significant	3.68	4.48
V9.2	I would like to have more driver-assistance systems in my car	.048	significant	3.85	3.23

Mann-Whitney U Test for independent samples (Significance tested on confidence level 95. alpha > .05)

It can be concluded that female respondents perceived driving with driver-assistance systems as more advantageous than did their male counterparts. As a potential consequence they are also more likely to purchase such a driver-assistance system in the future. Surprisingly, the female group at the same time scored lower on the item asking whether the respondent wants more driver-assistance systems in his or her present car. One potential reason for this apparent contradiction is that on the one hand, females perceive driver-assistance systems as advantageous and thus want to purchase such a system in future, but on the other hand, they have concerns about having more technical systems in their car. Further research is certainly needed to elaborate these findings. In sum, the results of this group analysis revealed the major differences between male and female consumers towards ADAS technology, most importantly that females are significantly more likely than males to buy driver-assistance systems in future.

Age

For the analysis of age differences the participants were divided in two groups – participants under 40 years (N=281) and participants above 40 years (N=105). Due to the fact that there is only limited empirical work regarding the influence of age on technology acceptance, there are no predefined hypotheses concerning the effect of this demographic variable. The analysis shows a considerable number of significant differences between the two age groups under investigation, which are summarised in Table 58.

Table 58: Group differences for age (under 40/ over 40), N:281/105

Item	Description	Significance		Mean under 40	Mean above 40
V1.1	I enjoy driving	.001	significant	6.32	5.83
V1.2	I drive for pleasure	.000	significant	6.20	5.59
V1.3	Driving is an agreeable way of passing time	.005	significant	5.73	5.16
V5.2	Generally, I am confident in my ability to avoid accidents when driving my car	.044	significant	4.92	4.56
V5.3	My friends often compliment me on my driving skills	.042	significant	5.12	4.79
V6.2	I believe many car manufacturers are now offering driving assistance systems	.003	significant	5.68	5.07
V7.1	In my opinion driver-assistance systems are too expensive	.002	significant	4.67	5.17
V7.2	I am worried how often I am going to have to pay for new updates of driver-assistance systems	.007	significant	5.14	5.56
V9.3	Overall, I am willing to accept driver-assistance systems in cars, to help me become a safer driver	.010	significant	4.70	4.04

Mann-Whitney U Test for independent samples (Significance tested on confidence level 95. alpha > .05)

The first major insight of this analysis is that all items related to the enjoyment of driving are rated significantly higher by younger individuals than by their older counterparts. This leads to the conclusion that the perceived enjoyment of driving an automobile is decreasing over time. Moreover, confidence in one's own driving skills (V5.2, V5.3) is rated significantly higher by the younger group, leading to the conclusion that confidence in one's own driving skills, too, is decreasing over time. This insight is particularly remarkable since one would expect that the increased driving experience of the older group would lead to an increased confidence in one's driving abilities. One potential explanation of this apparent contradiction is that with increased driving experience, the over-evaluation of one's own driving skills decreases. The perceived availability of these systems is rated significantly higher by the younger group, which could be due to the fact that the younger group is more actively seeking information about new technologies available. Regarding the price of driver-assistance systems, the older group is significantly more concerned about the purchase price (V7.1), as well as the maintenance price (V7.2). Generally, the younger group is more willing to accept ADAS technology to increase their driving safety (V9.3).

The results of this analysis taken together deliver a particular surprising insight. Since older people have a lower enjoyment of driving and less confidence in their driving skills, one might expect that they are more willing to accept a technology that is aimed at supporting driving tasks. On the contrary, however, the data revealed that the younger group is significantly more willing to accept driver-assistance systems than their older counterparts (V9.3). This apparent contradiction can only be explained by other factors impeding the acceptance of ADAS in the older group. The analysis also showed that the older group perceives the costs of ADAS technology to be higher and the availability of this technology lower, which could be two potential effects leading to the relatively stronger rejection of this innovation by the older group.

Car Owner / Non-Car Owner

The analysis of car owners versus non-car owners is based on a sample of N=366 car owners and N=20 non-car owners. Due to the fact that the sample of non-car owners in the present study is relatively small, this group comparison should be treated with caution and can give only a tendency of potential differences between these groups. Significant deviations in answer patterns between car owners and non-car owners can be observed in seven question items, which are summarised in Table 59.

Table 59: Group differences for car ownership (yes / no), N: 366/20

Item	Description	Significance		Mean Group „car“	Mean Group „non-car“
V1.1	I enjoy driving	.001	significant	6.25	4.95
V1.2	I drive for pleasure	.001	significant	6.12	4.50
V1.3	Driving is an agreeable way of passing time	.003	significant	5.59	5.00

V2.2	I like to be able to switch any technology off when driving	.006	significant	5.83	5.40
V5.1	Overall, I am confident in my driving abilities	.002	significant	5.51	5.05
V5.3	My friends often compliment me on my driving skills	.006	significant	5.05	4.50
Mann-Whitney U Test for independent samples (Significance tested on confidence level 95. alpha > .05)					

The analysis shows a significant difference concerning all aspects related to the concept *Enjoyment of Driving* between car owners and non-car owners. Generally, car owners perceive driving as more enjoyable than non-car owners. The data furthermore shows that car owners are more concerned about the ability to switch off technical devices and are more confident in their driving abilities than are non-car owners.

Experience with ADAS Technology

For the analysis of differences based on the experience ADAS technology, the participants were divided into two groups – participants who have never used driver-assistance systems (N=216) and those who have already used driver-assistance systems (N=175). The analysis of the present data shows that dividing the sample based on experience with driver-assistance systems results in significant deviations in answer patterns in almost every question category. The differences are summarised in Table 60.

Table 60: Group differences for experience with ADAS (non-users /users), N:216/ 170

Item	Description	Significance		Mean non-users	Mean users
V1.2	I drive for pleasure	.048	significant	5.90	6.21
V2.1	Overall, I am worried about the amount of control technology has in the driving experience	.005	significant	4.56	3.98

V2.3	I enjoy making my own decisions when driving instead of being guided by technology	.001	significant	5.27	4.78
V3.1	Overall, I would say that it is safer to drive without driver-assistance systems	.001	significant	3.28	2.71
V4.1	Driver-assistance systems are helpful in many driving situations	.000	significant	4.46	5.08
V4.2	Overall, driving with driver-assistance systems is advantageous	.000	significant	4.28	5.10
V4.3	Using driver-assistance systems is practical	.000	significant	4.46	5.34
V6.1	I believe many people already use driver-assistance systems	.001	significant	4.16	4.73
V6.2	I believe many car manufacturers are now offering driving assistance systems	.010	significant	5.36	5.72
V6.3	I think driving assistance systems will become very popular in the future	.003	significant	5.44	5.77
V7.1	In my opinion driver-assistance systems are too expensive	.002	significant	5.01	4.54
V7.2	I am worried how often I am going to have to pay for new updates of driver-assistance systems	.021	significant	5.41	5.06
V8.1	Overall, I feel comfortable using new technology	.020	significant	4.58	5.03
V8.2	Overall, I would say I like to buy products that have new technology	.000	significant	3.71	4.51
V8.3	Overall, I believe that technology is improving my life	.001	significant	4.38	4.93
V9.1	I would like to purchase a car with driver-assistance systems in the future	.000	significant	3.31	4.42
V9.2	I would like to have more driver-assistance systems in my car	.000	significant	3.39	4.22
V9.3	Overall, I am willing to accept driver-assistance systems in cars, to help me become a safer driver	.000	significant	4.12	5.04
V9.4	I plan to use driver-assistance systems in future	.000	significant	3.67	4.91
Mann-Whitney U Test for independent samples (Significance tested on confidence level 95. alpha > .05)					

The analysis shows a significant difference regarding the desire to exert control. Individuals who have already used driver-assistance systems are much less worried about giving up control over the vehicle than are individuals who have not yet used this technology. As expected, experienced users generally perceive fewer risks associated with driver-assistance systems compared to driving without such systems. At the same time, experienced users evaluate the benefits of driver-assistance systems much more positively than individuals who have never used ADAS so far. Moreover, current and past users of ADAS perceive the costs associated with this technology as significantly lower than do those who have never come into contact with ADAS. It is not particularly surprising that as a consequence, users who have experience with driver-assistance systems are more likely to use these systems in the future. In sum, the analysis of group differences between experienced and non-experienced individuals has shown significant differences in every psychological construct of the proposed conceptual model. Experienced users perceive the risks and the costs of ADAS technology as lower and the usefulness as much higher. As a potential consequence, they have a more positive attitude towards driver-assistance systems and are more likely to use such systems in future.

Car Brand

In order to analyse the influence of car brands, the participants were divided into two groups – owners of non-premium car brands (N=255) and owners of premium car brands (N=111). Non-car owners were excluded from this analysis. The allocation of car brands into premium/ non-premium brands was based on a convention developed by JD Powers & Associates, a leading automotive market research company. Significant deviations in answer patterns between non-premium brand owners and premium brand owners can be observed in three question items, which are summarised in Table 61.

Table 61: Group differences for car brand (Non-Premium/ Premium), N:255/111

Item	Description	Significance		Mean Group Non-Premium	Mean Premium
V1.2	I drive for pleasure	.041	significant	6.04	6.31

V5.2	Generally, I am confident in my ability to avoid accidents when driving with my car	.046	significant	4.76	5.07
V7.1	In my opinion, driver-assistance systems are too expensive	.044	significant	4.94	4.60
Mann-Whitney U Test for independent samples (Significance tested on confidence level 95. alpha > .05)					

The analysis shows a significant difference concerning driving behaviour: Premium-brand owners are more likely to drive for pleasure than are owners of non-premium cars. This relationship is rather logical, since car owners who have invested more money into their cars with more powerful engines, more entertainment and more comfort systems are more likely to drive for enjoyment rather than for purpose. The comparison also shows that premium-brand owners have more confidence in their abilities to prevent accidents than their non-premium counterparts. The analysis furthermore revealed that non-premium car owners are more price-sensitive than premium car owners when it comes to driver-assistance systems. This insight is not particularly surprising, since, generally, non-premium car buyers are expected to be more price conscious about special equipment than premium car brand buyers.

Car Type

For analysing the influence of car types, the participants were divided into two groups – owners of small and compact cars (N=152) and owners of medium and large cars (N=214). Non-car owners were again excluded from this analysis. Significant deviations in answer patterns between small car owners and medium to large car owners can be observed in only two question items, which are summarised in Table 62.

Table 62: Group differences for car type (small/ large), N:152/214

Item	Description	Significance		Mean Group "small"	Mean Group "large"
V5.2	Generally, I am confident in my ability to avoid accidents when driving with my car	.040	significant	4.66	4.99

V6.3	I think driving assistance systems will become very popular in the future	.032	significant	5.46	5.71
Mann-Whitney U Test for independent samples (Significance tested on confidence level 95. alpha > .05)					

The analysis shows significant differences between small and large car owners related to their perceived confidence in the own driving abilities. Large car owners are more confident that they possess the necessary skills to avoid accidents when driving compared to owners of smaller cars. Moreover, the analysis shows that significantly more large car owners believe that driver-assistance systems will become very popular in future. Since currently driver-assistance systems are mainly offered in larger cars, this effect could be rooted in the increased current availability within this group.

Conclusion

The analysis of group differences revealed several important insights, which will be consequently used for developing the conceptual model of ADAS acceptance further. It is particularly worth noticing that very few differences concerning the acceptance of ADAS exist between age and gender groups and between different groups of car owners. Past experiences with this technology, on the contrary, were found to cause significant differences in every psychological construct considered in this study.

6.32 Comparing Innovativeness with Adoption Time

As the last step in the present data analysis, the author compares the derived scale for *Innovativeness* with the measurement of Rogers' Innovativeness Criteria. As discussed before, the classification of a respondent's innovativeness in Rogers' scale depends on two variables: the mean year of acceptance of an innovation in a population and the individual's year of adoption. Rogers (2003, pp.280–281) divides the resulting continuous variable into discrete categories, based on their relative distance to the mean (by multiples of the standard deviation). For the present study the author employed three different, rather popular, innovations, namely the *internet*, *mobile phones* and *smart phones,* for measuring the individual's adoption time.

The key question to be answered in this section is whether the classification of individuals based on Rogers' scale delivers the same results as the Innovativeness scale based on the questionnaire items of the present study. In other words, this comparison is aimed at evaluating whether an individual's time of adoption of past innovations is an appropriate measurement of his or her general innovativeness.

In the first step, a descriptive analysis of the responses and the corresponding classification according to Rogers' criteria will be provided. The following charts show the cumulative years of adoption of respondents as well as the classification intervals, proposed by Rogers (2003, pp.280–281).

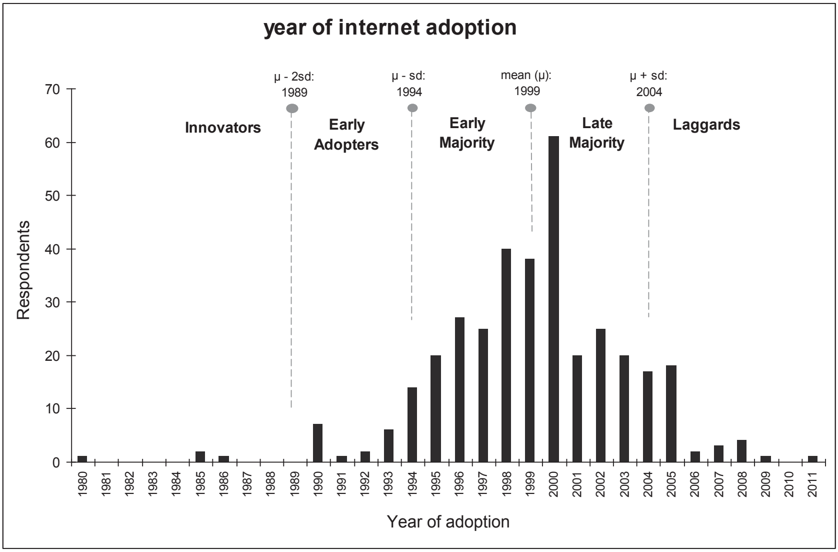


Chart 45: Year of internet adoption

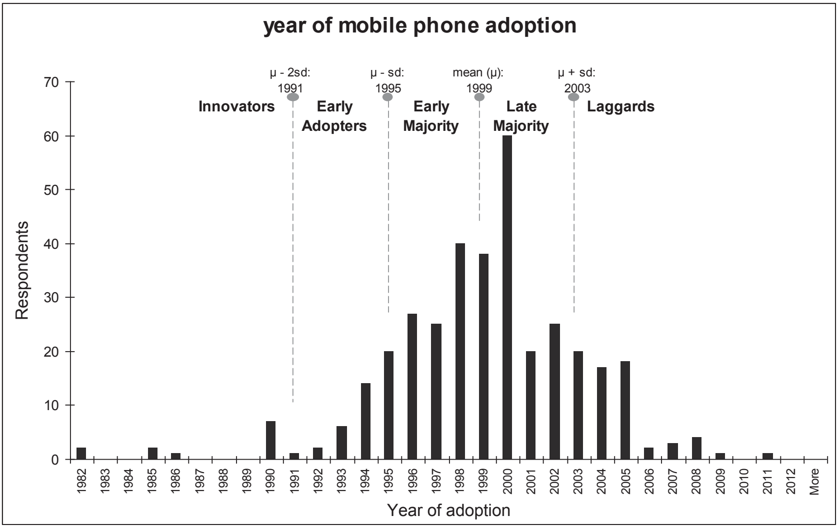


Chart 46: Year of mobile phone adoption

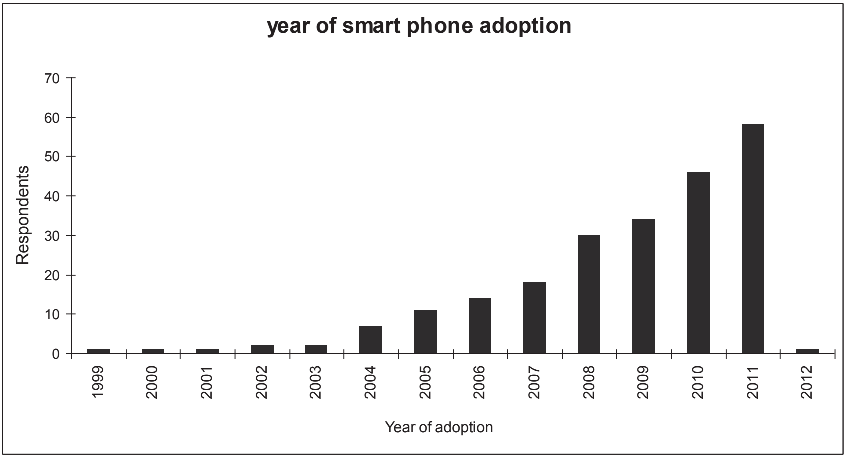


Chart 47: Year of smart phone adoption

The analysis shows that for both the internet and mobile phones, the data distributions approximately follow a bell-shaped curve, as predicted by Rogers. For the adoption year of smart phones, the data distribution follows a steep increase until 2011. The relatively low data frequency of 2012 can be explained by the fact that the questionnaire was sent out in January 2012. Since approximately 40 percent of respondents have not yet adopted smart phones, it is expected that the adoption curve will reach its peak in 2012 and will then decline in the further years. Smart phones are thus not yet diffused enough in the society to use this technology for categorising individuals on Rogers' scale of innovativeness. Consequently, the smart phone scale will be omitted from further analysis.

In the next step, the resulting data distributions of *internet* and *mobile phone* adoption will be compared to the theoretical proportions predicted by Rogers (2003, pp.280–281). Table 63 shows that the distributions approximately follow the expected values developed by Rogers. As a measurement of the goodness-of-fit between the predicted and the actual distributions, the author employed the Chi-square test. Table 63 shows the resulting Chi-Squared values.

Table 63: Adopter categories distribution

	Expected distribution based on Rogers	**Distribution based on internet adoption**		**Distribution based on mobile phone adoption**	
	Percent	Valid Percent	Chi-squared distribution	Valid Percent	Chi-squared distribution
Innovator	2.50%	1.68%	0.97	5.32%	11.37
Early Adopter	13.50%	8.38%	6.95	10.92%	1.75
Early Majority	34%	41.90%	6.57	40.34%	4.22
Late Majority	34%	39.94%	3.72	34.45%	0.02
Laggard	16%	8.10%	13.96	8.96%	11.05
Total	100.00%	100.00%	32.18	100.00%	28.41

In this test, the acceptance region for H_0 (No difference between the sample distribution and expected distribution) at a significance level $\alpha = .01$ with 5 degrees of freedom is below 15.09 (see Anderson, Sweeney and Williams, 2008, p.923). Since the cumulated Chi-Squared values for both internet and mobile phone adoption clearly exceed the acceptance region, H_0 has to be rejected. Thus, the results indicate that the sample distributions of adopter categories significantly differ from the adopter distributions predicted by Rogers. The major differences arise from the underrepresentation of individuals in the category *Laggards* in the sample distribution. There are several possible explanations for this result. First, there could be a measurement bias. It has to be acknowledged that the adoption time was measured using self-reported responses, meaning that individuals had to remember when they first used a certain innovation. The pre-test of the survey indicated that respondents have difficulties in remembering their adoption time for certain innovations: thus, the responses reflect some degree of vagueness. Moreover, individuals might have been tempted to report that they had been using a new technology for longer then they actually had. Second, this result could also indicate that there is a general shift within the society and that full adoption is reached faster by modern innovations than happened in the past. Rogers' (2003) research was mainly based on studies in agriculture and education. It might be the case that the diffusion of high-tech innovation differs significantly concerning the adoption distribution over time from the early studies in this field. Certainly, more research is needed to further investigate the innovation distribution curve of other innovations and thus to test this hypothesis.

In the next step, a correlation analysis will be conducted to assess whether there is a direct proportional relationship between the Rogers categories and the Innovativeness scale developed in the previous chapters. For this purpose, ascending numeric values are allocated to each of the five Rogers categories. The scale for *General Innovativeness* is based on the median of the three questionnaire item results, as it was used in the ordinal regression model. Since both scales are of ordinal nature and the assumption of normality is not met, the author will employ the Spearman rho statistic for the correlation analysis of this data. Table 64 gives an overview of the results of the correlation analysis.

Table 64: Spearman Rho correlation analysis between innovativeness categorisation based on Rogers and the construct *General Innovativeness*

Items		**Correlation Coefficient**	**Sig. (2-tailed)**	**N**
Innovativeness category based on internet adoption time	General Innovativeness	.134	.011	358
Innovativeness category based on mobile phone adoption time	General Innovativeness	.048	.370	357

The analysis shows that there is a significant correlation with a small positive effect between the categorisation of individuals based on their internet adoption date and the individual's general innovativeness (measured by the questionnaire items). In contrast, the analysis also reveals that there is no significant correlation between the categorisation of individuals based on their mobile phone adoption date and their general innovativeness.

In conclusion, this analysis demonstrates that a person's adoption time of an innovation and the related Rogers category is only a very imprecise measurement of an individual's general innovativeness. The efficiency of this scale is largely dependent on the innovation employed and how the adoption time is measured. Generally Rogers' scale works only for completely diffused innovations in a society, such as the internet or mobile phones. A combination of different innovations would further increase the exactness of the measurement. Since self-reported adoption dates generally suffer from a recall bias, a more accurate measurement of this variable is generally recommended in order to increase the efficiency of this scale. For these reasons, measuring general innovativeness with Likert scales based on well-developed questionnaire items, as conducted throughout this thesis, is a more appropriate measurement of this construct.

6.33 Chapter Conclusion

In the present chapter, a survey instrument was developed based on the combined results from the qualitative interviews and the literature review. The interpretation of the resulting data, using an ordinal regression model based on a factor analysis, resulted in a conceptual model for the acceptance of ADAS technology, which was confirmed by structural equation modelling as a good fit with the data. Reviewing the chapter objectives, the proposed requirements for the conceptual model are now revisited.

Sufficiently large and representative sample of the target group

The survey resulted in 387 valid data sets, which is a sufficient sample size for the present research according to Cochran's formula (1977). Regarding representativity, the comparison of the sample with the target group using car characteristics showed a good match with a slight deviation towards larger cars. Most car categories can be considered as representative of the target population.

Valid operationalisation and measurement of the chosen concepts in the form of a questionnaire
Questionnaire items were developed for each psychological construct, which was derived from the interviews and the literature review. All questionnaire items were based on a literature review of comparable empirical research as well as theoretical considerations. Alongside these, nine further items were developed to measure background variables such as age and gender. Special attention was devoted to the questionnaire layout, the cover letter and the question sequence, which certainly contributed to the low withdrawal rate of fewer than twenty percent.

Valid descriptive scales, which fit with the research object but do not bias the result in any direction
Each psychological item was measured on a seven-point Likert scale and the resulting scales were consequently used in an explorative factor analysis. A reliability analysis of the five resulting factors confirmed a sufficient reliability of the measurement models.

Comprehensive analysis of the survey results applying appropriate statistical tests.
Based on the measurement scores resulting from the factor analysis, the author fitted an ordinal regression model as well as linear regression model to the data. The consistent result from both procedures is a conceptual model with three main predictors. This model was confirmed to be a good fit with the data by using structural equation modelling An additional analysis of group differences using the Mann-Whitney U–Test showed significant influences of certain background variables on the dependent variable as well as on the predictors.

In sum, the qualitative research stage has resulted in a comprehensive model for the acceptance of ADAS technology, which fulfils the requirements of the chapter objectives. The implications of the findings will be discussed in more detail in the next chapter.

Chapter 7: Discussion of Findings

7.1 Chapter Objectives

The aim of the previous chapter was to empirically examine the potential predictors of behavioural intention to accept ADAS technology. The present chapter is aimed at consolidating the findings from the previous chapters and to provide justification for the development of a conceptual modal towards the acceptance of ADAS. Specifically, the discussion will focus on the role of the predictors in this model as well as on the influence of background variables. In the next step, the implications of the findings for the different stakeholder groups (academic, economic and governmental) will be discussed in detail. Based on these implications and the individual aims of each stakeholder group, the author will derive recommendations for further action. Finally, the contributions to knowledge of the present research will be summarized and presented, together with the limitations of the present study and the outlook for further research in the field. In conclusion, the objectives of this chapter can be summarized as follows:

- Consolidate the findings from the previous chapters;
- Provide justification for the conceptual model towards ADAS acceptance;
- Provide an overview of the implications of the results and develop recommendations for the different stakeholder groups;
- Discuss potential limitations of this study;
- Describe in detail the contributions to knowledge of this study;
- Provide an outlook on further research.

7.2 Discussion of the Results: Predictors

In this chapter, the role of the predictors derived from the quantitative data analysis will be discussed based on the overall research results. This means that results from the literature review and the qualitative interviews will be employed together with the quantitative results in order to arrive at a comprehensive and detailed picture of the proposed predictor structure.

P. Planing, *Innovation Acceptance,* DOI 10.1007/978-3-658-05005-4_7,

7.2.1 Perceived Safety and Comfort Benefit

Perceived safety and comfort benefit was found to be the strongest predictor of *Intention to Use* ADAS technology, with a beta value of 1.137. As explained in the previous chapter, this beta value translates into cumulative odds of .320, which means that if this factor goes up by one category, the cumulative odds of being in a lower category of the dependent variable *Intention to Use* decreases by more than two-thirds. The strong positive impact of this factor is not particularly surprising and was already postulated in the theoretical work of Brookhuis, de Waard & Janssen (2001, p.251). In a more general context, *Perceived Usefulness* was consistently found to be a major predictor for technology acceptance in literature. In the qualitative stage of the present research the *Perceived Usefulness*, or more precisely the *Safety* and the *Comfort Benefits* of ADAS were consistently found to be the most important reasons for the acceptance of this technology (see Table 19). The results from the qualitative interviews, however, did not reveal whether there is a potential differentiation between *Safety* and *Comfort Benefit*. The factor analysis of the survey data has provided evidence that the two aspects have a common effect. In other words, from the perspective of the customer, the perceived benefits of ADAS in relation to comfort cannot be separated from the perceived benefits in relation to safety. The interviews furthermore revealed some more detailed aspects of perceived benefits of ADAS such as their ability to support special driving operations, e.g. highway driving, city driving or parking. Interviewees furthermore saw especially high benefits for some user groups such as the elderly or handicapped persons. Increased traffic law conformity when using driver-assistance systems, was also brought up by some respondents as a potential benefit. In sum, the research results clearly indicate that increased *Perceived Benefits* (whether related to safety or to comfort effects) will lead towards a stronger intention to use Advanced Driver-Assistance Systems.

7.2.2 General Innovativeness

General Innovativeness was found to be the second most important predictor for the acceptance of ADAS, with a beta value of .551 in the ordinal regression model. This relates to an odds ratio of .576, which means that if *General Innovativeness* goes up by one category, the cumulative odds of being in a lower category of ADAS acceptance decrease by almost half. The concept of *General Innovativeness* is widely applied in empirical literature and was consistently found to be an important predictor or background variable for the acceptance of

ADAS. While there is still an on-going discussion as to whether this factor should be treated as a predictor or as a background variable, the author decided to use it as a predictor in the present case. The justification for this decision is rooted in the results from the qualitative interviews, which revealed that trust in technology is one of the most important aspects of technology acceptance in the case of ADAS (see Table 18). The interview data showed that increased trust in technology is directly linked to increased acceptance of ADAS, while the lack of trust in technology is directly related to a decreased acceptance of ADAS technology. In sum, the *General Trust* or *Positive Attitude Towards New Technologies*, which is represented by the factor *General Innovativeness*, is consistently found to be directly associated with increased intention to use ADAS technology.

7.2.3 Desire to Exert Control

Desire to exert Control was found to be the only negatively correlated significant predictor of the dependent variable *Intention to Use ADAS*, with a beta value of -.311. This translates into cumulative odds of 1.365 being in a lower category of the *Intention to Use ADAS* when the *Desire to exert Control* is one category higher. In other words, individuals with a greater desire to exert control have a significantly lower intention to use driver-assistance systems. Empirical studies in the context of related technologies, aimed at replacing manual tasks, similarly conclude that the perceived loss of control, autonomy and empowerment leads towards technology rejection. These findings are also in line with the interview data from the qualitative stage. More than half of the interviewees actively stated the fear of losing control and feared technological paternalism when driving with driver-assistance systems. The belief that the human driver should be irreplaceable was found to be still deeply rooted in many interview participants. In sum, the desire to exert personal control when driving an automobile has to be regarded as the most important reason for resistance towards driver-assistance technology.

7.2.4 Omitted Factors

In the previous chapter, all factors that did not significantly influence the acceptance of ADAS were omitted from further discussion. Yet, examining these omitted factors can be almost as insightful as looking at the significant predictors. Since each item in the questionnaire was developed from literature and thus was found to be important in certain contexts in other empirical work, it could be fruitful to understand why these particular factors have no significance in the present context. The following five factors were omitted during the analysis of the questionnaire data:

- Enjoyment of Driving
- Trust in own driving skills
- Perceived Risks
- Resources / Perceived Costs
- Subjective Norms / Perceived customer base

The factor analysis revealed that the first two factors, *Enjoyment of Driving* and *Trust in own driving skills,* share so much communality that they can in fact be regarded as one factor. The regression analysis, however, showed that the influence of this combined factor on the dependent variable is non-significant. It can be safely concluded that, contrary to the initial hypothesis of the author, the general enjoyment of driving has no influence on whether individuals will accept driver-assistance technologies or not.

Perceived Risks as an independent factor was omitted because the factor analysis revealed that two of the corresponding items were attributed to the factor *Perceived Safety and Comfort Benefit*. These results indicate that generally driving with driver-assistance systems is perceived as being safer than driving without.

The factor *Perceived Costs* was omitted because the reliability analysis of the factor showed that the three corresponding items were inconsistent. Thus, a final decision on the importance of costs in the context of ADAS cannot be made based on this analysis. The importance of costs in this context is, however, expected to be rather low for three reasons. Firstly, during the interviews, the aspect of lacking resources or perceived costs of ADAS technology played only a minor role. Secondly, most empirical work has concluded that this factor has no significant influence on the intention to use a certain technology (see Table 18). Rather, costs are expected to moderate the relationship between the behavioural intention and the actual acceptance behaviour (or purchase). Finally, since the fitted regression model (without the Factor *Perceived Costs*) has an explained variance of above 70 percent, the remaining explanatory power of *Perceived Costs* can potentially only be rather small.

Subjective Norms in the present context represent the perceived social pressure to adopt ADAS technology expressed by the *Perceived Customer Base*. This construct was identified as an independent factor during the factor analysis but was omitted during the regression analysis, since its effect on the dependent variable was found to be insignificant. This result is in line with the interview data, which indicates only minor effects of social pressure on the acceptance decision. The author decided to use this construct in the questionnaire because there is empirical justification for this factor's relevance to other areas of technology acceptance, such as mobile phones (see Table 18). It is consequently worth noticing that in the case of driver-assistance systems, the perceived diffusion of the technology within the peer group or the society has no significant influence on the intention to use this particular technology. One potential reason for this difference could be that driver-assistance systems, unlike mobile phones or ultra-thin laptops, have a low visibility, meaning that individuals usually do not recognise whether or not one has adopted this technology. Consequently, social pressure has no influence in this context, although it is an important factor for the acceptance of other, more visible, technologies.

7.3 Discussion of the Results: Background Variables

In the next step, the influence of background variables on the conceptual model will be discussed in more detail. Again, the discussion will be based not only on the findings from the quantitative data analysis but also on the results from the qualitative interviews and the literature review. By studying the interrelation of background factors, the origins of salient beliefs that serve as the cognitive foundation for the predictors of acceptance behaviour in this context can be identified (see Fishbein and Ajzen, 2010, p.253).

7.3.1 Gender

The analysis of group differences between male and female respondents revealed that females are more likely to buy driver-assistance systems in the future, which is an important insight, especially from the perspective of the industry. More interesting, from an academic point of view, is that there are no significant differences between males and females in terms of the predictor structure. This means that the two groups do not differ significantly in their perception of the safety and comfort benefits of ADAS technology. Nor do they differ significantly in their desire to exert control or their general innovativeness. There are two potential explanations why *Gender* has an influence on the *Intention to Use ADAS* but not on the predictors. First, Gender could influence the dependent variable through an additional predictor, which is not included in the model so far. Second and more likely, Gender could moderate the relationship between some predictor and the dependent variable. This could mean, for instance, that even though the benefits of driver-assistance systems are evaluated similarly by males and females, these benefits could be of more importance for females, thus explaining the stronger intention to use this technology in this group. Consistent with the findings from the quantitative data, the interviews also revealed that females are more interested in driver-assistance technology. Both findings contradict a study by the European Commission, which concludes that males are more likely to use ADAS than females (European Commision – Eurobarometer, 2006, p.56). From a scientific point of view, the influence of Gender on technology acceptance has been widely ignored so far. Of the empirical works reviewed, only very few have regarded gender differences as a potential explanation for technology acceptance. Some authors, however, expect that gender roles can have a significant impact on individual attitudes and behaviours (see Venkatesh et al., 2003, p.469). Certainly, further research is necessary to investigate the role of gender on the acceptance of technological innovations.

7.3.2 Age

The analysis of the influence of age groups provided some surprising insights. The results indicated that the perceived enjoyment of driving an automobile, as well as confidence in one's own driving capabilities, is lower in the older age group. The older group is also significantly more concerned regarding the purchase price of driver-assistance systems. All of these factors were, however, found to be non-significant predictors of ADAS acceptance. Nonetheless, the questionnaire data indicate that age has an influence on the acceptance decision, since the younger group is significantly more willing to accept driver-assistance systems than their older counterparts. Due to the limited sample size of the interviews and the fact that age groups were only estimated by the interviewers, the results from the qualitative stage do not provide additional insight into this topic. The influence of age has also been widely ignored in the acceptance literature so far. However, there are some exceptions. As Venkatesh et al. (2003, p.469) put it, "age has received very little attention in the technology acceptance research literature, yet our results indicate that it moderates all of the key relationships in the model". Generally, there is a need for more research investigating the effect of age on the acceptance of technology. The present research has revealed that this demographic variable is an important factor influencing the acceptance decision and that age differences have a significant influence on the driving experience and the perception of one's own driving skills. In this particular context, younger individuals are more likely to adopt the technology than are older ones.

7.3.3 Car Ownership

The comparison of car owners and non-car owners has generally shown that car owners perceive driving as more enjoyable and are more confident in their driving abilities than non-car owners. These relationships are not particularly surprising and are logically sound. More interesting in this case is the fact that many question items do not show any deviation in answering patterns between the two groups. According to this analysis, there is no difference between car-owners and non-car owners in regard to their acceptance of driver-assistance technology. This is an interesting insight, which leads to the conclusion that Advanced Driver-Assistance Systems are still an abstract concept for both car owners and non-car owners. The data furthermore shows that car owners are more concerned about the ability to switch off technical devices. Thus car ownership is positively related to the *Desire to Exert Control*. Since only car-owners were interviewed in the qualitative stage, the interviews do not provide any additional insights. Certainly, further research in this direction is needed, since the results of the present research suffer from a relatively low rate of non-car owner participants.

7.3.4 Experience

The analysis of group differences between respondents who have experience with ADAS compared to those who have not clearly shows deviations for each predictor as well as for the dependent variable. In particular, individuals who have already used driver-assistance systems are much less worried about giving up control over the vehicle than individuals who have not yet used this technology. Moreover, experienced users evaluate the benefits of driver-assistance systems much more positively than individuals who have never used ADAS so far. Consequently, it is not particularly surprising that users who have experience with driver-assistance systems are more likely to use these systems in future.

This is consistent with the results from the qualitative interviews, which generally showed that having first experiences with ADAS increases the acceptance of this technology (see Table 18). Related empirical research also consistently reported significant effects of experience with a technology on the acceptance of the respective technology.

In sum, past experience is expected to act as the most important background variable for the acceptance of ADAS. Individuals who have used a technology re-evaluate the perceived risks associated with driver-assistance systems and are more positive towards the benefits of this technology. Moreover, past experience reduces concerns about giving up control over the vehicle.

Apart from the influence of *Past Experience* on other factors, the overall answering pattern of this item also delivers important insights. It is particularly remarkable that only one percent of the respondents answered that they had not heard about driver-assistance systems before (see Appendix B). Thus, the public awareness of driver-assistance systems seems not to be an issue in the diffusion of this technology any more.

7.3.5 Car Type

The analysis of differences between owners of larger cars and owners of compact cars shows only minor differences, mainly related to their perceived confidence in their own driving abilities. What is more striking about these results is the high degree of agreement between the two groups. According to this analysis, there is no significant difference between small and medium to large car owners concerning their intention to use Advanced Driver-Assistance Systems and concerning the perceived usefulness or the perceived risks of this technology. Due to the relatively small sample of different car types during the interviews, no additional information can be inferred from the qualitative data on the influence of car types.

7.3.6 Car Brand

The comparison of premium and non-premium car brand owners revealed only minor differences in question items, none of which were relevant for any of the predictors. Again, more striking is that the comparison revealed that premium and non-premium car brand buyers do agree on many points concerning driver-assistance systems. It is important to recognise that there is no significant difference between premium and non-premium car brand buyers concerning their intention to use Advanced Driver-Assistance Systems. Also, their evaluations of the potential comfort and safety benefits are identical. This leads to the important conclusion that ADAS technology will become equally important for premium and non-premium brand buyers in future.

7.4 Discussion of the Results: Cross-Cultural Perspective

From a geographical point of view the present study is limited to the German market. Yet, the results of this research can be used to draw conclusions on potential effects in different geographical areas and cultures. While multiple authors have reported a significant effect of cultural differences on the acceptance of innovations (see Bagozzi, 2007, p.247; Fishbein and Ajzen, 2010, p.224; Zakour, 2004, p.156), there is still an on-going discussion whether culture should be treated as a predictor for acceptance behaviour or as a background variable, such as age or gender. The author clearly advocates the latter. The model developed throughout this thesis is based on psychological constructs that derive from a belief formation phase in the individual decision making. These beliefs, however, are not predetermined; rather they are accumulated over time by experiences and interaction with the real world and by own inferences based on the given set of information. Differences in individual beliefs must therefore be the result of different learning experiences throughout a lifetime. These real life experiences, in turn, are likely to vary as a function of personal characteristics, social and cultural factors and exposure to media and other sources of information (Venkatesh et al., 2003, p. 469). As a result demographic, cultural or socioeconomic characteristics, such as gender, age, income or education are often found to be associated with differences in behaviour. These variations in personal characteristics, however, do not cause differences in behaviour and by themselves they cannot explain these differences. Rather they provide a segmentation of the given population along certain dimensions and reveal differences in behaviour among different subgroups (Fishbein & Ajzen 2010, p. 234). Consequently, cultural differences should be regarded as background factors and not as predictors. This implies that the predictor structure of the model developed throughout this thesis is independent from the geographical or cultural context it is applied on. Based on this preposition it is possible to incorporate results from cross-cultural research in order to estimate the effect of cultural differences on the predictors in the model.

In the next step the predictor structure of the present model, which consists of the factors *Perceived safety and comfort benefit*, *Desire to exert control* and *General innovativeness*, will be each regarded from a cross-cultural point of view. *Perceived safety and comfort benefits* are specific to the context of driver-assistance systems and due to the lack of research in this area this factor cannot be interpreted from an inter-cultural perspective. The second factor *Desire to exert control*, in contrast, is independent from the present research context and can thus be interpreted by using results from cross-cultural research. The most cited researchers in the area of cross-cultural research are Hofstede (2001) and Trompenaars and Hampden-Turner (2012), who developed cultural dimensions which are measured empirically throughout different countries. One of these cultural dimensions, the so called *Inner- or Outer-direction*, is aimed at measuring the desire to control your own environment (Trompenaars and Hampden-Turner, 2012). Since the present research has revealed that a strong personal motivation to exert control decreases the acceptance of driver-assistance systems it can be concluded that in cultures with a strong desire to exert control over the personal environment there will be an overall lower acceptance of ADAS. In recent empirical research of Trompenaars et al. (2012) it was found that Germany scores average on the control dimension, while the United States, Canada and New Zealand score the highest. Consequently, it can be concluded that individuals from an American or Canadian cultural background are, on average, less likely to accept driver-assistance systems than individuals from a German cultural background. According to this research Nepal, China, Russia and India have the lowest desire to control their environment, thus individuals from these cultural backgrounds are generally more likely to accept driver-assistance systems in future. The complete overview of countries can be found in Chart 48.

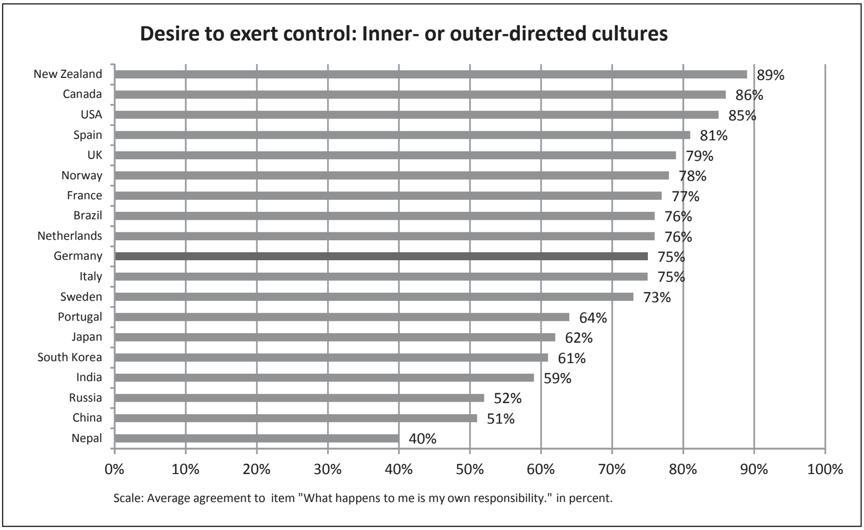


Chart 48: Inner- or outer-directed cultures, Source: Trompenaars et al. (2012)

The present research has furthermore revealed that *General innovativeness* is a predictor for the acceptance of driver-assistance systems. In other words, consumers who generally are positive towards new technologies and innovations are more likely to purchase a car with driver-assistance systems in the future. To measure *General innovativeness* the author decided to use a cross-country comparison of information and computer technology (ICT) usage. This index is part of the Global Innovation Index (GII), developed by INSEAD and the World Intellectual Property Organization (Dutta, 2012). It has to be acknowledged that ICT usage is not a perfect measurement of *General Innovativeness* since this index restricts the consumer innovativeness to the computer and communication product category. Moreover, actual usage might not reflect the attitude towards new technologies due to income or availability restrictions. Being aware of this limitation, inferences can nevertheless be drawn from the most recent cross-country comparisons of this scale. Germany, again, scores average on ICT usage, while countries such as South Korea, Sweden and Japan have the relatively highest rate of ICT users per hundred inhabitants. China, India and Nepal have the lowest rate of ICT users, which as discussed might also be a result of lacking income and availability. Generally, individuals from cultures with a high rate of new technology usage are also more likely to use Advanced Driver-Assistance Systems. Chart 49 gives the overview on ICT usage per country.

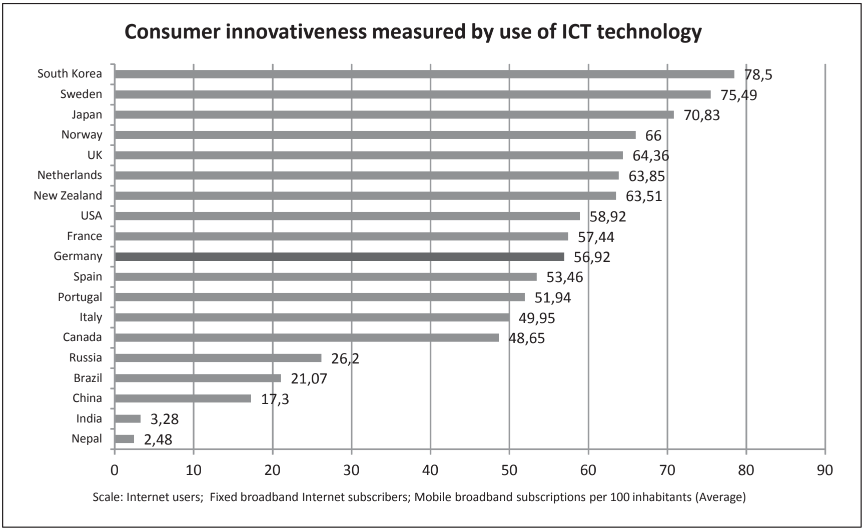


Chart 49: Consumer innovativeness by ICT use, Source: Dutta et al. (2012)

A combined evaluation of the cultural dimensions for control and innovativeness allows for an estimation of the most promising cultures in regard to the acceptance of ADAS. For this purpose the country scores of both dimensions will be multiplied with the beta-values of the respective factors from the regression model (.551 for *General Innovativeness* and -.311 for the *Desire to Exert Control*). Consequently, the resulting combined score will be based on the weighted dimensions according to the predictiveness of the underlying factors. Chart 50 shows the cross-country comparison of the combined score of *Desire to Exert Control* and *General Innovativeness*.

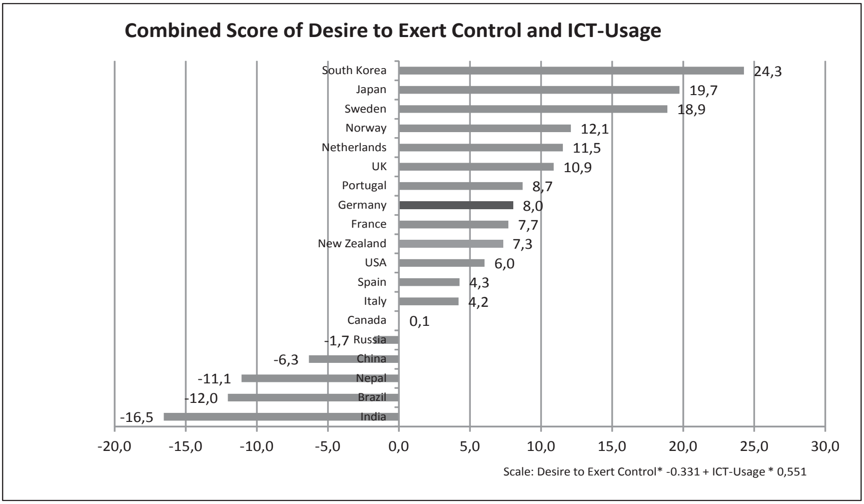


Chart 50: Combined score of desire to exert control and ICT-Usage

This analysis indicates that consumer acceptance of ADAS is expected to be higher in cultures such as South Korea, Japan, Sweden or Norway, who have a low average *Desire to exert control* score combined with a high *Consumer innovativeness* score. At the same time ADAS acceptance is expected to be lower in cultures such as China, Brazil and India, who have a relatively higher *Desire to exert control* score and a lower *Consumer innovativeness* score. In conclusion, the integration of results from cross-cultural research provides a valuable indication which cultures are more or less supportive for the acceptance of Advanced Driver-Assistance Systems. Due to the limitations of the applied methodology in terms of availability of cross-cultural data and appropriate scales, further research is certainly needed to confirm and elaborate these findings.

7.5 Discussion: Summary of Main Findings

So far in this chapter, the findings from all parts of this research have been consolidated. Next, a summary of the main findings will be given. It has to be acknowledged that summaries generally neglect the rich and often important details of findings. On the other hand, however, they allow for an overview of the resulting core ideas and thus provide an important benefit for the reader. The following statements are the key aspects derived from this research project. The study data revealed that:

- Perceived safety and comfort benefits are the most important determinants for the acceptance of driver-assistance systems;
- Individuals who generally trust in new technologies are significantly more likely to adopt ADAS;
- Individuals who have a strong desire to exert control are significantly less likely to adopt ADAS technology;
- The perceived installed customer base (descriptive norm) and the direct social pressure (injunctive norm) were found to have no significant influence on the acceptance decision towards ADAS;
- Females are significantly more likely to buy driver-assistance systems in future than are males;
- Younger respondents are significantly more willing to accept driver-assistance systems than are older ones;
- Past experience was found to act as the most important background variable for the acceptance of ADAS. The more experience individuals have with ADAS technology, the more likely they are to use it in future;
- There is no significant difference between small and large car owners, or between premium and non-premium car buyers, concerning their intention to use Advanced Driver-Assistance Systems.

7.6 Discussion: Final Model for ADAS Acceptance

In order to meet the research objectives set out in the first chapter, the present chapter is aimed at presenting the final model towards the acceptance of Advanced Driver-Assistance Systems, developed throughout this thesis. This model combines the results from the factor analysis, the ordinal regression model and the background factor analysis with the results from the qualitative analysis. The proposed model, based on only three predictors, is able to explain more than two-thirds in the variance of the dependent variable *Intention to Use* and can thus be regarded as a valid instrument for predicting the acceptance of ADAS technology. *Perceived safety and comfort benefit* was found to have the strongest positive impact on the dependent variable, followed by *General Innovativeness*. *Desire to exert control* was found to have a negative effect on the dependent variable. The effects are visualised as arrow paths in the model and the corresponding estimated coefficients are given for each path in the model. Three of the tested background factors, namely *Age*, *Gender* and *Experience*

with ADAS, were found to have a significant effect on the dependent variable. *Experience with ADAS* was additionally found to have a significant influence on each of the predictors.
Chart 51 gives an overview of the final conceptual model of the present thesis.

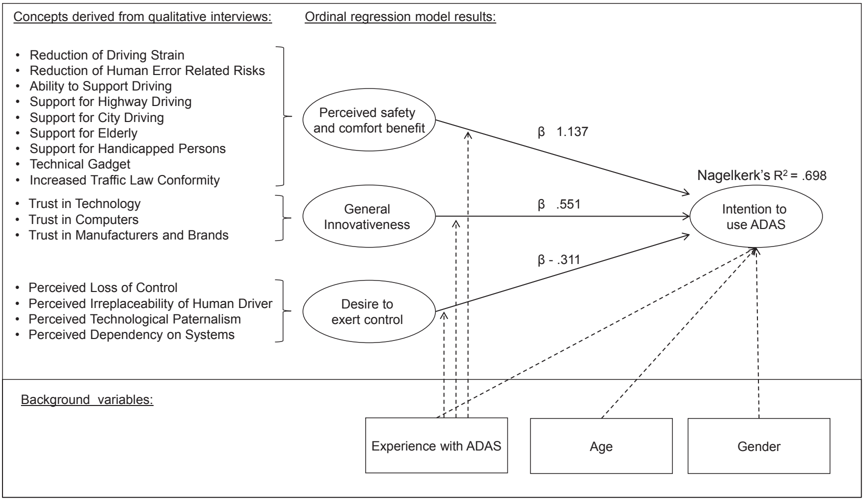


Chart 51: Final conceptual model, Source: Own drawing

Since this model is aimed at advancing the present knowledge in the field it is important to relate the model to the relevant literature. In particular it is important to discuss which parts of the model confirm previous findings and which parts of the model have provided novel insights into the acceptance behaviour of technology.

The qualitative stage of the present research revealed that *Perceived Safety and Comfort Benefits*, which was found the strongest predictor in the model, is linked to various characteristics that are specific to the case of ADAS. On a more general level, however, this psychological construct is strongly related to the concept of *Perceived Usefulness*, which is part of the Technology Acceptance model by Davis, Bagozzi & Warshaw (1989, p.320). As such this factor is frequently applied in acceptance research. Out of the 49 studies reviewed in Chapter 3, 25 have employed *Perceived Usefulness* as a predictor, more than have of these studies even found this factor the strongest predictor of acceptance behaviour. The present study thus confirms perceived usefulness of technology as a significant predictor for the acceptance of this technology. Next to this, rather logical, relationship the present study has, however, also provided an insight into the various facets of this factor, such as reduction of driving strain or the increase in conformity to traffic laws. These facets are strongly related to the individual goals of consumers and specific to the context of driver-assistance systems. In sum, the present study confirms the significance of *Perceived Usefulness* for the acceptance decision and provides novel insights into the belief formation in the context of ADAS.

The second factor of the present model, *General Innovativeness*, is applied more rarely in acceptance literature. The few studies applying this factor, however, emphasize the "role individual innovativeness plays in shaping technology acceptance" (Chiu, Fang and Tseng, 2010, p.454). During the qualitative stage this construct emerged as *Trust in New Technologies* and was mentioned by almost two thirds of the respondents. The regression model confirmed the significance of this determinant, which is, at least partly, contradictory to literature in the field. Thus, the importance of the general attitude towards new technologies in the case of ADAS acceptance is a rather surprising result. As such, these findings contribute to the understanding of high-tech acceptance in a broader context. The present findings indicate that the acceptance of a high-tech product, which is, at least partly, aimed at substituting manual tasks, is determined by the general trust of individuals in new technologies.

The third factor of the model, the *Desire to Exert Control*, can also be related to previous findings in the field. In general, handing over control to a device was repeatedly found to be a negative aspect of technology which leads to resistance (see Brookhuis, de Waard and Janssen, 2001, p.247). Again, this factor was only rarely applied in literature so far. In the context of ADAS, however, this factor consistently appeared as the strongest motive for resistance. The interviews revealed that driver-assistance systems are perceived as restricting the free choice of travel route, travel speed or driving style. Based on this, the survey data furthermore demonstrated that a stronger personal desire to control one's environment is significantly reducing the acceptance of ADAS. These findings are in stark contrast to previous research on innovation acceptance and thus provide a new insight into the decision making of individuals in regard to new technologies. Especially for innovations which are perceived as limiting personal freedom of choice, the application of the factor *Desire to Exert Control* is one of the most promising psychological constructs for explaining resistance towards technology.

From the various models discussed in Chapter 3, the final resulting conceptual model is closest to the United Theory of Acceptance and Use of Technology (UTAUT), developed by Venkatesh et al. (2003), which is one of the most recent models for innovation acceptance. The predictor structure, however, differs significantly from the UTAUT model. This leads to the conclusion that there is no universally applicable model for the acceptance of innovations. Rather, one has to develop context-specific models, based on the characteristics of the relevant object (the technology), the relevant target group and the environmental conditions for the acceptance decision. The model presented above can be seen as a valid predictive model for the specific context of ADAS acceptance.

7.7 Discussion: Revisiting the Hypotheses

In this section the research hypotheses, are reviewed based on the results of the final model. While the correlation analysis, performed before, has provided a first indication which hypotheses should be rejected, the results from the ordinal regression analysis and the structural equation model now allow for a final decision on each hypothesis. Table 65 lists the hypotheses and the corresponding significance values, derived from the ordinal regression model. The significance values represent the two-tailed probability that the Null-Hypothesis (no effect of the Factor) is true. The hypotheses are tested on the .01 level, meaning that for any value above .01 the hypothesis has to be rejected, for any value below it is accepted.

Table 65: Hypothesis revisited

Hypotheses	**Significance (2-tailed) of the Factor in ordinal regression**	**Decision on the Hypothesis**
H_1: The greater the enjoyment of driving, the lesser the intention to use Advanced Driver Assistance Systems.	.370	rejected
H_2: The greater the desire to exert control, the lesser the intention to use Advanced Driver Assistance Systems.	.000	accepted
H_3: The greater the perceived risks associated with Advanced Driver Assistance Systems, the lesser the intention to use Advanced Driver Assistance Systems.	n.a.	n.a.
H_4: The greater the perceived usefulness of Advanced Driver Assistance Systems, the stronger the intention to use Advanced Driver Assistance Systems.	.000	accepted
H_5: The greater the confidence in one's own driving capabilities, the lesser the intention to use Advanced Driver Assistance Systems.	.370	rejected
H_6: The more individuals trust in new technology, the stronger the intention to use Advanced Driver Assistance Systems.	.000	accepted
H_7: The greater the perceived installed customer base of Advanced Driver Assistance Systems, the stronger the intention to use these Systems.	.135	rejected
H_8: The greater the perceived costs of Advanced Driver Assistance Systems, the lesser the intention to use Advanced Driver Assistance Systems.	n.a.	n.a.

Both hypotheses H_1 and H_5 have to be rejected based on these results. The factor analysis conducted before has revealed that the associated variables (*enjoyment of driving* and *confidence in one's own driving capabilities*) are in fact measuring the same construct. This construct was, however, found to be non-significant in the ordinal regression model. The same is true for H_7 since the factor *perceived installed customer base* was found to have no significant influence on the dependent variable. In regard to Hypotheses H_3, the factor analysis revealed that

Perceived Risks are not a distinct construct in the present context and thus this factor was omitted from the regression model. Hypotheses H_8 can neither be proved nor rejected based on the data, since the associated factor *Perceived Costs* was found to be not reliable enough to be included in the regression model. Hypotheses H_2, H_4 and H_6 are accepted based on the results. *Desire to Exert Control*, *General Innovativeness* (*Trust in New Technology*) *and Advantages of ADAS* were each found to be significant factors explaining the acceptance behaviour of ADAS. In conclusion, only three of the initial eight initial hypotheses were finally confirmed by the present research. The three rejected hypotheses, are, however, equally important for the interpretation of the results and for deriving potential recommendation for the different stakeholder groups in the next step

7.8 Recommendations Proposed on the Basis of the Results

As outlined before there are three main stakeholder groups of the present thesis, namely academics, economic institutions and governmental institutions. The results from this thesis have implications for each of these groups. Consequently, recommendations based on these results will be discussed from each perspective separately. The academic view will be divided into the theoretical implications and the methodological implications. This differentiation is necessary because the theoretical implications are mainly restricted to the rather narrow field of innovation acceptance research, while the methodological implications can be transferred to many fields of academic interest.

7.8 1Theoretical Implications

The primary objective of this study was to develop a model that can predict an individual's intention to accept Advanced Driver-Assistance Systems. To achieve this research objective and develop the theoretical background, a literature review was conducted in Chapter 3. Since the scientific discussion is still far from reaching a common agreement for the definition of the term *Innovation*, a comprehensive overview of different definitions was provided. Discussing the major differences and similarities of definitions in the field of innovation research, a contribution towards a unified view was provided by developing a new definition for *Innovation* in the present context. The author critically reviewed four of the most influential theoretical models for innovation acceptance: *Rogers' Diffusion Model*, the *Theory of Planned Behaviour*, *the Tech-*

nology Acceptance Model and the *United Theory of Acceptance and Use of Technology*. For the purpose of ascertaining the strengths and weaknesses of the reviewed models, the author critically evaluated them based on theoretical grounds as well as on their contemporary application in research. While each model claims to be universally applicable, there is no common agreement as to which model is the most appropriate and thus most efficient in predicting acceptance behaviour in a wide range of contexts. The present research contributes to this discussion in two ways.

First, the critical appraisal of the models on theoretical grounds has demonstrated that each behavioural model represents a trade-off between universality and explanatory power. The more universal a model is, the less explanatory power can be attributed to its predictors. Past empirical work has resolved this contradiction by extending the more universal models, like the TPB, with context-specific predictors (see Table 7). The analysis, however, provided justification for the claim that none of the models in its original formulation provides universal applicability and sufficient explanatory power to be generally accepted as a standard model for innovation acceptance in any context. Thus, in order to explain acceptance behaviour in a context-specific case, empirical research that goes beyond standardised models remains imperative for researchers.

Second, by developing the predictors in the present study not only based on previous theoretical and empirical work, but also on extensive qualitative research, the author has provided a new and unique model for innovation acceptance in the case of ADAS. This model not only provides a high degree of reliability and satisfies the fit indices, but is also empirically proven to be successful in explaining more than two-thirds of the variance in acceptance behaviour in the case of ADAS. Even though this model features some similarities to the UTAUT model, the specific predictors of this model differ significantly from every other model developed so far. Further research is certainly needed to clarify whether or not this model can be applied in other contexts than driver-assistance systems. The predictor structure, however, provides a fruitful contribution to further research in the direction of acceptance of high-technology innovations.

7.8.2 Methodological Implications

In terms of methodology, this study offers several major contributions. First of all, applying qualitative and quantitative methods in the same study is a relatively unique methodological approach in the field of innovation acceptance. Of the 49 empirical studies reviewed in Chapter 3, only two followed a pure qualitative research approach and none conducted a methods triangulation of combining interviews and questionnaire techniques. The qualitative research stage was found to be particularly useful for assessing salient beliefs, which otherwise could have not been integrated into the questionnaire. Even the authors of the TPB model recently remarked that "of the multitude of studies conducted in the context of our theory, only a minority have assessed beliefs; most rely on direct measures of the three major components to predict [behavioural] intentions" (Fishbein and Ajzen, 2010, p.206). Applying qualitative interviews has proven to be a successful methodology to assess the context-specific salient beliefs of respondents prior to a quantitative study. Thus, based on the results of the present study, there is a clear justification for continuing to apply methods triangulation in the field of innovation acceptance.

This study also contributes to the examination of the robustness of parametric research by using parallel analysis. As discussed before, there is an on-going discussion as to whether or not parametric tests should be preferred to non-parametric ones even though the underlying assumptions are somewhat violated. The reasoning behind this argument is that as soon as the sample size is large enough and the departure from normality is not substantial, the results of parametric tests remain essentially the same (Miller, 2006, p.52). As a results, many authors argue in favour of the more efficient and more versatile parametric tests whenever possible, unless there is an extreme violation of an assumption of a parametric test or a rather small sample is going to be investigated (see Clark-Carter and Howell, 2010, p.188; Miller, 2006, p.52; Pagano, 2009, p.451). The present research has contributed to this discussion in two ways.

First, the correlation between the variables was analysed using the Spearman rho statistic from the field of non-parametric statistics and the Pearson Product Movement statistic from the field of parametric statistics. The comparison of the results showed that, even though the results differ only slightly in most cases, the decision on the significance of relationships is different in some of the cases.

As a result, the author refrained from using the Pearson coefficients and employed the more robust Spearman rho statistics.

Second, two different regression models were fitted to the data: an ordinal regression model and a linear regression model. Generally, linear regression models can only be applied if the data distribution and measurement scales follow the strict requirements of parametric statistics (Weiers, Gray and Peters, 2011, p.553). For ordered category response data, such as data resulting from Likert Scale items, nonparametric methods, such as ordinal regression, are more appropriate (Weiner, Schinka and Velicer, 2003, p.509). It is still an on-going discussion, however, whether the categorical nature of response variables can be ignored in practice and whether linear regression models can consequently also be fitted to Likert Scale data (Agresti, 2010, p.4; O'Connell, 2006, p.3). As a consequence, the author decided to apply both an ordinal regression model and a linear regression model to the present data set in order to compare the results and thus provide a contribution to the on-going discussion of appropriate methodology. The results from the comparison of the two models generally showed only minor deviances. Most importantly, the resulting predictor structures of the two models were found to be similar. Although not directly comparable, the model summary statistics have a comparable value, with a Nagelkerke's R^2 value of .701 in the ordinal model and an Adjusted R^2 of .729 in the linear regression model. In sum, the comparison of the ordinal and the linear regression model thus supports the claim that linear regression is robust to violations regarding the assumptions of parametric statistics. The good match of the two models, however, is possibly also due to the relatively large sample size. Thus, for the comparison of the two models to be valid, it has to be ascertained whether the data satisfies the assumption of homoscedasticity. In other words, in the linear model it is assumed that there is a constant distribution of residual scores around the regression line (Aguinis, 2004, p.44). A repeated test with randomised fractions of the sample could test this assumption, which is beyond the scope of this research. A second, more important reason not to use linear regression models for ordinal data is that the resulting beta values could lead to misinterpretations. Since linear regression models assume the dependent variable to be interval scaled, the validity of the resulting beta values is at least questionable and could suffer from pseudo-exactness (Kitchenham and Mendes, 2009, p.2). Consequently, although the odds ratios resulting from the ordinal regression are slightly harder to interpret, they are better estimates for the final regression model and were consequently also used for data interpretation in the present research.

In sum, the present research results have twofold implications for the methodological discussion. First, it was confirmed that methods from the field of parametric statistics deliver broadly the same results as methods from the field of non-parametric statistics, even though the underlying assumptions of parametric statistics are clearly violated by the present research. At the same time, however, a detailed analysis of the results did indicate that the results of non-parametric methods are considerably more accurate than the results from the parametric procedures. Thus, the hypothesis that parametric methods are robust towards violations of the underlying assumptions has to be rejected based on these results.

7.8.3 Managerial and Practical Implications

The implications from the present study are of particular importance for the automotive industry, offering a variety of driver-assistance systems as optional equipment for their cars. As discussed in Chapter 2, the current equipment rates of Advanced Driver-Assistance Systems are extremely low. In order to generate return on the development costs of ADAS technology, the industry needs to continue to charge an additional price for ADAS equipment in their cars, while at the same time there is a severe need to increase the equipment rates (Bratzel and Tellermann, 2011, p.54). Consequently, the industry needs to generate demand for ADAS technology within their respective target group.

The results of the present thesis contribute to this problem by offering an understanding of which factors are decisive for the acceptance of ADAS within the target group of German automobile drivers. Based on this understanding, implications can be derived that can help the industry to better market this technology.

Since the study revealed that the *Perceived Safety and Comfort Benefit* is the most decisive factor in ADAS acceptance, the industry should focus its attention on the communication of potential customer benefits of driver-assistance systems. Since learning about technological innovation involves exposure to new and sometimes difficult information, research indicates that using a direct conversation mode rather than a written mode may increase the efficiency of marketing information (Elliott and Fu, 2008, p.47). This could be achieved by increasing the education of car dealers about new ADAS technologies and by motivating dealers (financially or non-financially) to communicate the advantages of ADAS directly to the customer.

More difficult to avoid are concerns related to the *Perceived Loss of Control*, which turned out to be the second strongest determinant of ADAS acceptance. This factor, however, is affected by *Experience with ADAS*. The more individuals have the chance to experience ADAS, the less they will have concerns about losing control or personal freedom when driving with driver-assistance systems. Thus, increasing experience will alter the potential belief sets positively and will thus have a positive effect on the acceptance decision (Fishbein and Ajzen, 2010, p.170). The main problem with *Past Experience* is that driver-assistance systems have a low trialability. Trialability, according to Rogers (2003, p.16), is the degree to which an innovation may be experimented with on a limited basis. To overcome this, car dealers could offer courtesy cars with driver-assistance systems whenever a customer brings in his own car for a service or repair. Alternatively, some car manufacturers have already developed driver-assistance simulators, which offer the benefit that a wide range of potential customers can experience the advantages of driver assistance systems in a short time frame. These efforts will certainly payoff, since based on the results of this study, the amount of experience with driver-assistance systems is directly linked to the willingness to use these systems in the future.

An additional way to overcome resistance resulting from control or safety concerns are marketing schemes that “hook on” driver-assistance systems to more compatible innovations, such as light- or exterior-styling packages. According to the literature, the compatibility of complex incompatible products can be increased when offered as a package that is in sum more compatible to the beliefs of the potential customer group (Rogers, 2003, p.250).

As discussed before, linguistic attributes are another important aspect influencing individual decision-making. Thus it is important to acknowledge that the name given to an innovation often affects its perceived compatibility, and therefore its rate of adoption (Rogers, 2003, p.250). In the field of ADAS, a vast amount of highly technical acronyms and abbreviations are offered to the customer (such as ESP, ABS, ACC etc.), who often draws first conclusions about the possible utility of these systems from the name alone (European Commisson esafety initiative, 2007, p.4). The industry should therefore try to avoid overly technical attributes and focus instead on potential benefits from the customer's point of view.

The analysis of group differences revealed that, generally, female car drivers and younger age groups are more likely to use driver-assistance systems. Based on this information, it could be promising to develop target-group oriented marketing measures specifically targeted to female and younger car drivers.

In general, the research results have indicated that there is a surprisingly high level of awareness of driver-assistance systems in the target group. At the same time, however, in-depth knowledge of the functionalities of available driver assistance systems is rather low and practical experiences with these systems are lacking. Thus, future marketing efforts should focus on creating practical experience and technical knowledge of driver-assistance systems, rather than on mass-media campaigns aimed at increased awareness.

From a cross-cultural perspective it can be concluded that ADAS is more likely to be accepted in cultures with less desire to control the environment and cultures which generally are open to new technologies. An analysis of these cultural dimensions revealed that certain cultures, such as South Korea, Japan or Sweden, are consequently more likely to accept ADAS. It is therefore recommended to allocate international marketing activities in a first step into regions, which are expected to be more supportive for the acceptance of ADAS. This strategy will increase the returns on marketing spending and will enable the manufacturer to increase production of driver-assistance systems, which will enable the company to profit from economies of scale.

In sum, the implications from this research for the industry are substantial and could help to develop more efficient marketing measures in order to increase public acceptance, and thus customer demand for Advanced Driver-Assistance Systems. Governments and legislation should support and complement the efforts of the industry in order to increase road safety. Potential recommendations for this stakeholder group will be the focus of the next section.

7.8.4 Governmental Implications

As discussed in the stakeholder analysis the first chapter, most governments follow the aim to increase road safety and have already developed initiatives to foster the development of safety technologies and to accelerate the market penetration of these technologies. Within the European Union, two basic driver-assistance systems (ABS and ESP) have already become mandatory equipment in every new car (European Commission, 2007). The question of whether or not Advanced Driver-Assistance Systems should one day become mandatory in Europe was addressed by the European Union Implementation Road Maps Working Group (for Driver-Assistance Systems), which concluded that the European Commission should consider regulatory actions, such as making systems mandatory, only as a last option and should favour voluntary solutions instead (European Union eSafety Forum, 2010, p.39). The working group furthermore recommended two fields of action:

"The European Commission should support European campaigns to enhance the customer awareness of the safety benefits of safety systems, and motivate Member States [..] to give fiscal/ financial incentives to customers who buy vehicles equipped with such systems." (European Union eSafety Forum, 2010, p.39).

The first part of this recommendation is strongly supported by the author based on the results of the present research. The analysis of the study data indicates that customer awareness of driver-assistance systems is already quite high (only one percent of respondents indicated that they were not aware of driver-assistance systems). The potential benefits of these systems are, however, not so immanent in the customer's mind. Since *Perceived Safety Benefits* were found to be the strongest determinant of the acceptance decision within the present study, increasing the awareness of potential safety benefits of ADAS is certainly one of the most promising methods to foster customer acceptance of this technology. The study, however, also revealed that from the perspective of the customer, the perceived benefits of ADAS related to safety cannot be separated from the perceived benefits related to comfort. Thus, potential comfort benefits of Advanced Driver-Assistance Systems should be communicated as well.

The second part of the recommendation of the working group aims at providing financial incentives for ADAS adoption. While incentives for adoption have generally proven successful in increasing adoption rates, they also inherit the risk of discontinued adoption. Rogers (2003, pp.238,239) remarks that “if individuals adopt an innovation partly in order to obtain an incentive, there is relatively less motivation to continue using the innovation [once the incentive is gone]”. The risk of discontinued acceptance is, however, expected to be rather low in the present context, since the study data shows that experience with ADAS is increasing the intention to use this technology. Thus an initial (temporary) usage will have a positive effect on the (continued) acceptance decision. Yet, another serious concern about the effectiveness of financial incentives can be inferred from the survey results. Generally, the study data indicates that perceived costs of ADAS technology determine the acceptance decision only weakly, if they do so at all. Thus, it is rather unlikely that a partial compensation of the purchasing price of driver-assistance systems will convince more people to adopt this innovation.

Instead of financial incentives, governmental institutions should thus focus more on supporting local change agencies who inform car customers about the potential benefits of modern driving-assistance systems. The success of local change agents depends widely on their compatibility with client needs and beliefs and their empathy with the clients (Rogers, 2003, p.387). A demonstration, for instance, can be particularly effective if the demonstrator is a respected opinion leader in the system or the society.

In conclusion, governmental authorities should, if possible, avoid implementing regulatory action and inefficient financial or fiscal support systems. Instead they should focus on generating awareness-knowledge of the advantages of ADAS technology by supporting local-level initiatives and local-level change agents.

7.9 Potential Limitations of the Methodology Chosen

Even though the methodology for this particular research was carefully chosen, it has some limitations that have to be acknowledged.

7.9.1 Sample

Regarding the overall sample size, a sufficient number of valid responses was achieved in the present research. Regarding representativity, the comparison of the sample distribution with the target group using car characteristics showed generally a good match, with a slight deviation towards larger cars. Thus, large car owners are slightly overrepresented in the sample, while small car owners are underrepresented. The analysis of other demographic variables revealed that females and the age group of people above 65 are underrepresented in the sample, while males and individuals between 25 and 44 tend to be overrepresented. The possible root causes for this sampling bias were already discussed. Small sub-sample sizes as a result of underrepresentation were clearly acknowledged throughout this thesis.

7.9.2 Context and External Validity

It has to be acknowledged that the subject of the present study was unique (Acceptance of Innovations), the technology examined was homogenous (Advanced Driver Assistance Systems) and the social-economic context was fixed (German car drivers). Therefore, it is quite likely that any other than the current context of study would have delivered different findings. The literature review of empirical work in different technological and social-economic contexts (see Chapter 3) revealed that generally findings in the field of innovation acceptance cannot be transferred from one context to another without some modifications. In particular, since the context of the present study (driver-assistance systems) features some unique characteristics, it is quite unlikely that many of the findings can directly be transferred to other areas of technological adoption. As a general conceptual framework, however, the results of the present research are generalizable on a much broader scale. Concerning the culture and location focus of the present research, it remains to be clarified whether or not the results are directly transferable to other geographical areas, since multiple authors have reported a significant effect of cultural differences on the acceptance of innovations (see Bagozzi, 2007, p.247; Fishbein and Ajzen, 2010, p.224; Zakour, 2004, p.156). The findings of the present research have been discussed from a cross-cultural perspective in Chapter 0. By integrating the results from cross-cultural literature it was possible to develop hypotheses for the determinants of driver-assitance system acceptance in different locations. Yet, further research is needed in the area of cultural influence on acceptance behaviour to answer the question of regional and cultural generalisability of the present findings.

7.9.3 Interviewer Bias

One potential bias in most qualitative studies is that the answers given in the interviews might be biased by the interviewer. Interviewee responses might reveal beliefs generated in the course of the interview rather than beliefs that were pre-existing. Furthermore, it is almost inevitable that an interviewer transfers his or her existing attitudes and beliefs to the interviewee to some degree (Keeling, 1999, p.167). To avoid this bias as far as possible, the author employed three different interviewers, who conducted the interviews independently based on the same detailed interviewer guide (see Chapter 5). By employing multiple interviewers, the author considerably increased the objectivity of the interview data. Yet, the question of whether the results would differ if other interviewers had been employed cannot be answered with definitive certainty. Generally, the results of the interviews were widely supported by the more objective questionnaire data and are thus expected to be a sufficiently objective interpretation of reality.

7.9.4 Normality of Data and Construct Reliability

The descriptive analysis of the questionnaire data revealed some concerns about the normality of data distributions. While Pearson's index of Skewness and other criteria such as the median-to-mean difference generally show that the data approximately follows a normal distribution, Lilliefors' Test of Normality has revealed that a perfect normal distribution cannot be formally accepted at a reasonable level of confidence for any of the items. By employing non-parametric tests throughout this research, a potential bias of non-normal distributions was widely avoided.

Regarding the construct reliability it has to be acknowledged that there are different conventions for minimum acceptable values of Cronbach's alpha. Generally, most authors agree that values above .7 can be regarded as sufficiently reliable. This would question the reliability of Factor 5, *Perceived installed customer base*, with a Cronbach's alpha value of .660. Recent publications, however, increasingly argue in favour of a more relaxed minimum level of .60 or .65 (see Enders, 2004, p.92; Heinecke, 2011, p.84; Shelby, 2011, p.142). Since the impact of Factor 5 on the dependent variable was found to be non-significant, the factor was omitted from the final conceptual model and thus the reliability of this factor should not be decisive for the interpretation of the final results of the present study.

7.9.5 Causal Relationships

Considering the quantitative stage, it must be acknowledged that any form of quantitative model cannot confirm any causal logical reasoning in a definite way (Ogden, 2003, p.426). This critique can usually be avoided by defining a valid and reasonable logical chain. Definite certainty about the underlying causal relationships, however, will never be achieved by empirical research (Popper, 1972). Any statistical test will only prove the model to be valid, not its underlying causal relationships. As Lykken (1968, p.158) concluded, “Statistical significance is perhaps the least important attribute of a good experiment; it is never a sufficient condition for claiming that a theory has been usefully corroborated”. However, by basing the questionnaire contents on a strong conceptual model, developed based on the results from a series of interviews and the literature review, the author has probably avoided this potential bias.

7.9.6 Conclusion on Limitations

The previous sections have outlined the limitations of the present study in detail. Most of these limitations, such as the potential interviewer bias or the inability of quantitative models to prove causal relationships, are characteristics of empirical research in general. Other limitations, especially the subject and location focus of the present research, should invite further research to explore the acceptance of innovations in other fields of study or in different geographical locations. In conclusion, the present research has, despite the outlined limitations, provided a strong and manifold contribution to knowledge, which will be discussed in more detail in the next section.

7.10 Contribution to Knowledge

The original contribution to knowledge of this thesis is an explanative and predictive model of the individual beliefs that lead to either acceptance or rejection of Advanced Driver-Assistance Systems on the German market. This contribution is acknowledged in more detail in the following table.

Table 66: Contribution to Knowledge

Research Question 1: Which factors influence the acceptance of ADAS?	
Gaps in Knowledge	Contribution to Knowledge
Factors influencing acceptance behaviour in the case of ADAS	**1th Major Contribution:** Deriving a comprehensive list of constructs for explaining acceptance behaviour from previous empirical acceptance research. Evaluating the significance of the constructs based on their application in literature and evaluating the applicability of each construct in the context of ADAS. **2th Major Contribution:** Developing constructs relevant for the acceptance of ADAS technology based on qualitative research. A content analysis of the full transcripts of 32 in-depth personal interviews revealed 54 distinct codes and ten main constructs which are expected to influence the acceptance behaviour in the case of ADAS. **3th Major Contribution:** Identifying the key factors for the acceptance of ADAS based on quantitative research. A factor analysis of questionnaire items from 387 respondents of the target population revealed 5 core constructs relevant for the acceptance decision in the case of ADAS.
Research Question 2: How can these factors be arranged in a model, explaining the acceptance behaviour of customers towards ADAS?	
Gaps in Knowledge	Contribution to Knowledge
Predictive model towards the acceptance of ADAS technology	**4th Major Contribution:** Providing a predictive model for the acceptance of ADAS, based on a regression analysis, a structural equation model and a group difference analysis of the constructs. The resulting predictive model provides the following new insights into the acceptance of ADAS: • Perceived safety and comfort benefits are the most important factors for the acceptance of driver-assistance systems; • Individuals who generally trust in new technologies are significantly more likely to adopt ADAS; • Individuals who have a strong desire to exert control are significantly less likely to adopt ADAS technology; • The perceived installed customer base (descriptive norm) and the direct social pressure (injunctive norm) were found to have no significant influence on the acceptance decision towards ADAS;

- Females are significantly more likely to buy driver-assistance systems in future than are males;
- Younger respondents are significantly more willing to accept driver-assistance systems than are older ones;
- Past experience was found to act as the most important background variable for the acceptance of ADAS. The more experience individuals have with ADAS technology, the more likely they are to use it in future;
- There is no significant difference between small and large car owners, or between premium and non-premium car buyers, concerning their intention to use ADAS.

In sum, the present research has provided a contribution to knowledge that is highly relevant from an academic as well as from an economic point of view. The study contributed to the theoretical discussion in the field of innovation acceptance as well as to the methodological discussions in the broader field of social sciences. By developing a framework for the application of research methodologies in the context of technology acceptance, the study furthermore provides guidelines for future research in this field. Most importantly, however, the resulting conceptual model for the acceptance of Advanced Driver-Assistance Systems will support the industry as well as the legislation with an interpretive understanding of the decisive determinants for increasing market penetration rates of ADAS technology.

7.11 Propositions for Further Research

Throughout the course of this research, potential gaps in knowledge were identified and, if possible, filled with new insights based on reading or empirical data. Due to the clearly defined focus of the present thesis, a substantial number of gaps in knowledge in related fields were identified and should be addressed by further research. Since the scope of the present research is the acceptance of ADAS technology, the application of the derived predictor structure in related technological areas could provide an insight into the generalizability of the findings and the universality of the developed conceptual model. Furthermore, the present study was geographically limited to the German market. The integration of results from cross-cultural research has provided first indications how culture potentially influences the acceptance decision in the case of ADAS. Due to the limitations of the applied methodology, further research is needed to confirm and elaborate these findings. Especially the application of the model in different geographical or cultural environments could provide an important contribution to the question of whether and how technology acceptance is affected by cultural factors.

The analysis of group differences revealed that age and gender have a significant influence on the acceptance of innovations. Due to the limited sample size and conceptual limitations, the question of how these factors influence acceptance behaviour could not be answered with absolute certainty. Further research on the influence of age and gender, particularly on a potential moderating or mediating effect of these factors, could deliver a substantial contribution to knowledge. The test of Rogers' innovativeness scale indicated that individuals in the category *Laggards* were underrepresented in both mobile phone and internet adoption. This result could indicate that there is a general shift within the society and that full diffusion is reached faster by modern innovations than was the case in the past. Certainly, more research is needed to further investigate the innovation distribution curve of other innovations and thus to test this effect.

Based on the methodological approach of this thesis, the author clearly advocates increased application of a mixed-methods approach in acceptance research. By relying on a direct measurement of predictors in the framework of one of the existing models for innovation acceptance, researchers risk omitting potentially important factors for their relevant context of study. The application of a more explorative qualitative stage could enable further research to obtain a more comprehensive understanding of the concepts involved in the acceptance decisions in various fields of technologies.

7.12 Chapter Conclusion

The final chapter of this thesis was aimed at consolidating the findings and providing justification for a conceptual model of ADAS acceptance. According to the overall research objective, set out in Chapter 1, this model should be able to explain the individual beliefs that lead to either acceptance or resistance of Advanced Driver-Assistance Systems (ADAS) on the German market. The final conceptual model, visualised in Chart 51, achieved this objective considering the overall explanatory power and reliability of the underlying measurement instruments. The existing relevant limitations of the model were acknowledged in detail.

Based on this model, the author developed recommendations for each stakeholder group, considering their individual aims and objectives. Finally, the incremental and major contributions to knowledge of this study were summarised and recommendations for further research were proposed.

In sum, the present research has met all relevant research objectives and has provided a contribution to knowledge that is highly relevant from an academic as well as from an economic point of view. This research's findings should help academics, automobile companies and governmental institutions to understand the decisive factors for innovation acceptance in the context of driver-assistance systems. This understanding contributes towards increased market penetration of Advanced Driver-Assistance Systems and will thus help to increase traffic safety for the benefit of everyone.

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Appendix A Questionnaire

Cover Letter:

Dear participant,

The purpose of this research is to identify your views on new technology that can be used in cars to improve road safety.

This questionnaire is very brief and will take about five to ten minutes to fill out. Instructions for completing the questionnaire can be found below.

Every participant has a chance of winning a 100 EUR Amazon gift voucher.

Please be assured that all information you provide will be kept strictly confidential. You will not be asked for your name or other identifying information (except for your email address if you want to participate in the lottery).

If you have any questions or concerns, or face any technical problems, please feel free to contact me personally at: P.Planing5295@student.leedsmet.ac.uk

Thank you for your participation!

Patrick Planing

P. Planing, *Innovation Acceptance,* DOI 10.1007/978-3-658-05005-4,

<u>Instructions:</u>

- Please read each statement carefully.
- Don't think too long before answering: please give your first reaction.
- Please note that *Driver-Assistance Systems* for the purpose of this study means systems such as Adaptive Cruise Control, Blind Spot Monitoring, Lane Departure Warning, Lane Change Assistance or Drowsiness Assistance
- **You don't need any knowledge on driver-assistance systems to answer the questionnaire**.
- The following chart gives an overview of some currently available driver-assistance systems

○

Category	Longitudinal Support Systems	Lateral Support Systems	Driver Vigilance Systems
Driving interventions			
Major systems	Adaptive Cruise Control Collision Avoidance System Precrash system Pedestrian Protection System	Lane Departure Warning Lane Change Assistance Blind Spot Detection	Attention- or Drowsiness Assistance Alcohol Lock

Item-ID	*Item*	*Answer Choices*
1. Enjoyment of Driving		
1.1	I enjoy driving	strongly disagree strongly agree o o o o o o o
1.2	I drive for pleasure	strongly disagree strongly agree o o o o o o o
1.3	Driving is an agreeable way of passing time	strongly disagree strongly agree o o o o o o o
2. Desire to exert control		
2.1	Overall, I am worried about the amount of control technology has in the driving experience	strongly disagree strongly agree o o o o o o o
2.2	I like to be able to switch any technology off when driving	strongly disagree strongly agree o o o o o o o
2.3	I enjoy making my own decisions when driving instead of being guided by technology	strongly disagree strongly agree o o o o o o o
3. Perceived Risks		
3.1	Overall, I would say that it is safer to drive **without** driver-assistance systems	strongly disagree strongly agree o o o o o o o
3.2	I am worried that driver-assistance systems may one day fail when I am driving	strongly disagree strongly agree o o o o o o o
3.3	Using driver-assistance systems may lead to more accidents	strongly disagree strongly agree o o o o o o o
4.Perceived Usefulness		
4.1	Driver-assistance systems are helpful in many driving situations (explanation chart with examples can be shown)	strongly disagree strongly agree o o o o o o o

4.2	Overall, driving with driver-assistance systems is advantageous (explanation chart with examples can be shown)	strongly disagree strongly agree o o o o o o o
4.3	Using driver-assistance systems is practical	strongly disagree strongly agree o o o o o o o
5. Trust in own driving abilities		
5.1	Overall, I am confident in my driving abilities	strongly disagree strongly agree o o o o o o o
5.2	Generally, I am confident in my ability to avoid accidents when driving my car	strongly disagree strongly agree o o o o o o o
5.3	My friends often compliment me on my driving skills	strongly disagree strongly agree o o o o o o o
6. Perceived Installed Customer Base		
6.1	I believe many people already use driver-assistance systems	strongly disagree strongly agree o o o o o o o
6.2	I believe many car manufacturers are now offering driving assistance systems	strongly disagree strongly agree o o o o o o o
6.3	I think driving assistance systems will become very popular in the future	strongly disagree strongly agree o o o o o o o
7. Costs		
7.1	In my opinion, driver-assistance systems are too expensive	strongly disagree strongly agree o o o o o o o
7.2	I am worried about how often I am going to have to pay for new updates of driver-assistance systems	strongly disagree strongly agree o o o o o o o
7.3	I am worried about the resale value of the car if the technology is outdated	strongly disagree strongly agree o o o o o o o

8. General Innovativeness		
8.1	Overall, I feel comfortable using new technology	strongly disagree strongly agree o o o o o o o
8.2	Overall, I would say I like to buy products that have new technology	strongly disagree strongly agree o o o o o o o
8.3	Overall, I believe that technology is improving my life	strongly disagree strongly agree o o o o o o o
9. Intention to use ADAS (dependent variable)		
9.1	I would like to purchase a car with driver-assistance systems in the future	strongly disagree strongly agree o o o o o o o
9.2	I would like to have more driver-assistance systems in my car	strongly disagree strongly agree o o o o o o o
9.3	Overall, I am willing to accept driver-assistance systems in cars, to help me become a safer driver	strongly disagree strongly agree o o o o o o o
9.4	I plan to use driver-assistance systems in future	strongly disagree strongly agree o o o o o o o
10. Background Factors		
10.1	Please report the year when you first used the internet at home	Insert Year (YYYY) ____ □ Not yet □ Don't know
10.2	Please report the year when you first bought a mobile phone	Insert Year (YYYY) ____ □ Not yet □ Don't know
10.3	Please report the year when you first bought a smart phone.	Insert Year (YYYY) ____ □ Not yet □ Don't know

10.4	How much experience do you have with driver-assistance systems?	○ I regularly use driver-assistance systems ○ I occasionally use driver-assistance systems ○ I know what driver-assistance systems are ○ I have heard about driver-assistance systems before ○ I have not heard about driver-assistance systems before
10.5	Age	○ Under 20 ○ 21 - 30 ○ 31 - 40 ○ 41- 50 ○ 51 - 60 ○ 61 – 70 ○ Above 70
10.6	Gender	○ male ○ female
10.7	Car owner	○ yes ○ no
10.8	Car type owned	○ Microcar ○ Subcompact car ○ Compact car ○ Mid-size car ○ Full-size car ○ Full-size luxury car ○ Convertible ○ Roadster ○ Minivan ○ SUV
10.9	Car brand owned	○ List of car brands to be provided

Appendix B Variable correlation

Table 67: Pearson Product Movement correlation analysis

		Dependent variables			
		I would like to purchase a car with driver-assistance systems in the future	I would like to have more driver-assistance systems in my car	Overall, I am willing to accept driver-assistance systems in cars to help me become a safer driver	I plan to use driver-assistance systems in future
I enjoy driving	Pearson Correlation			.143**	.144**
	Sig. (2-tailed)			.005	.005
	N			387	387
I drive for pleasure	Pearson Correlation			.226**	.252**
	Sig. (2-tailed)			.000	.000
	N			387	387
Driving is an agreeable way of passing time	Pearson Correlation				.161**
	Sig. (2-tailed)				.002
	N				387
Overall, I am worried about the amount of control technology has in the driving experience	Pearson Correlation	-.531**	-.595**	-.464**	-.587**
	Sig. (2-tailed)	.000	.000	.000	.000
	N	387	387	387	387
I like to be able to switch any technology off when driving	Pearson Correlation	-.252**	-.190**		-.187**
	Sig. (2-tailed)	.000	.000		.000
	N	387	387		387
I enjoy making my own decisions when driving instead of being guided by technology	Pearson Correlation	-.475**	-.536**	-.356**	-.465**
	Sig. (2-tailed)	.000	.000	.000	.000
	N	387	387	387	387

Overall, I would say that it is safer to drive without driver-assistance systems	Pearson Correlation	-.530**	-.555**	-.538**	-.594**
	Sig. (2-tailed)	.000	.000	.000	.000
	N	387	387	387	387
I am worried that driver-assistance systems may one day fail when I am driving	Pearson Correlation	-.209**	-.206**		-.212**
	Sig. (2-tailed)	.000	.000		.000
	N	387	387		387
Using driver-assistance systems may lead to more accidents	Pearson Correlation	-.440**	-.413**	-.386**	-.443**
	Sig. (2-tailed)	.000	.000	.000	.000
	N	387	387	387	387
Driver-assistance systems are helpful in many driving situations	Pearson Correlation	.570**	.621**	.662**	.685**
	Sig. (2-tailed)	.000	.000	.000	.000
	N	387	387	387	387
Overall, driving with driver-assistance systems is advantageous (explanation chart with examples can be shown)	Pearson Correlation	.720**	.766**	.667**	.778**
	Sig. (2-tailed)	.000	.000	.000	.000
	N	387	387	387	387
Using driver-assistance systems is practical	Pearson Correlation	.573**	.615**	.597**	.670**
	Sig. (2-tailed)	.000	.000	.000	.000
	N	387	387	387	387
Overall, I am confident in my driving abilities	Pearson Correlation				
	Sig. (2-tailed)				
	N				
Generally, I am confident in my ability to avoid accidents when driving with my car	Pearson Correlation	-.141**	-.135**		
	Sig. (2-tailed)	.006	.008		
	N	387	387		
My friends often compliment me on my driving skills	Pearson Correlation				
	Sig. (2-tailed)				
	N				
I believe many people already use driver-assistance systems	Pearson Correlation				
	Sig. (2-tailed)				
	N				

I believe many car manufacturers are now offering driving assistance systems	Pearson Correlation			.154**	.158**
	Sig. (2-tailed)			.002	.002
	N			387	387
I think driving assistance systems will become very popular in the future	Pearson Correlation	.227**	.295**	.287**	.327**
	Sig. (2-tailed)	.000	.000	.000	.000
	N	387	387	387	387
In my opinion, driver-assistance systems are too expensive	Pearson Correlation	-.245**		-.173**	-.191**
	Sig. (2-tailed)	.000		.001	.000
	N	387		387	387
I am worried about how often I am going to have to pay for new updates of driver-assistance systems	Pearson Correlation	-.266**	-.229**	-.170**	-.274**
	Sig. (2-tailed)	.000	.000	.001	.000
	N	387	387	387	387
I am worried about the resale value of the car if the technology is outdated	Pearson Correlation	-.179**	-.182**	-.068	-.148**
	Sig. (2-tailed)	.000	.000	.180	.004
	N	387	387	387	387
Overall, I feel comfortable using new technology	Pearson Correlation	.505**	.544**	.450**	.560**
	Sig. (2-tailed)	.000	.000	.000	.000
	N	387	387	387	387
Overall, I would say I like to buy products that have new technology	Pearson Correlation	.492**	.592**	.448**	.594**
	Sig. (2-tailed)	.000	.000	.000	.000
	N	387	387	387	387
Overall, I believe that technology is improving my life	Pearson Correlation	.514**	.558**	.540**	.636**
	Sig. (2-tailed)	.000	.000	.000	.000
	N	387	387	387	387

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Table 68: Spearman Rho correlation analysis					
		Dependent Variables			
Spearman rho		I would like to purchase a car with driver-assistance systems in the future	I would like to have more driver-assistance systems in my car	Overall I am willing to accept driver-assistance systems in cars. to help me become a safer driver	I plan to use driver-assistance systems in future
I enjoy driving	Correlation Coefficient				
	Sig. (2-tailed)				
	N				
I drive for pleasure	Correlation Coefficient			.152**	.209**
	Sig. (2-tailed)			.003	.000
	N			387	387
Driving is an agreeable way of passing time	Correlation Coefficient				.120*
	Sig. (2-tailed)				.018
	N				387
Overall, I am worried about the amount of control technology has in the driving experience	Correlation Coefficient	-.534**	-.597**	-.473**	-.590**
	Sig. (2-tailed)	.000	.000	.000	.000
	N	387	387	387	387
I like to be able to switch any technology off when driving	Correlation Coefficient	-.342**	-.281**	-.179**	-.278**
	Sig. (2-tailed)	.000	.000	.000	.000
	N	387	387	387	387
I enjoy making my own decisions when driving instead of being guided by technology	Correlation Coefficient	-.506**	-.568**	-.394**	-.502**
	Sig. (2-tailed)	.000	.000	.000	.000
	N	387	387	387	387
Overall, I would say that it is safer to drive without driver-assistance systems	Correlation Coefficient	-.508**	-.551**	-.527**	-.579**
	Sig. (2-tailed)	.000	.000	.000	.000
	N	387	387	387	387

I am worried that driver-assistance systems may one day fail when I am driving	Correlation Coefficient	-.222**	-.209**		-.223**
	Sig. (2-tailed)	.000	.000		.000
	N	387	387		387
Using driver-assistance systems may lead to more accidents	Correlation Coefficient	-.437**	-.417**	-.392**	-.450**
	Sig. (2-tailed)	.000	.000	.000	.000
	N	387	387	387	387
Driver-assistance systems are helpful in many driving situations	Correlation Coefficient	.578**	.630**	.640**	.691**
	Sig. (2-tailed)	.000	.000	.000	.000
	N	387	387	387	387
Overall, driving with driver-assistance systems is Advantageous (explanation chart with examples can be shown)	Correlation Coefficient	.725**	.781**	.655**	.779**
	Sig. (2-tailed)	.000	.000	.000	.000
	N	387	387	387	387
Using driver-assistance systems is practical	Correlation Coefficient	.578**	.622**	.581**	.669**
	Sig. (2-tailed)	.000	.000	.000	.000
	N	387	387	387	387
Overall, I am confident in my driving abilities	Correlation Coefficient				
	Sig. (2-tailed)				
	N				
Generally, I am confident in my ability to avoid accidents when driving my car	Correlation Coefficient	-.144**	-.149**	-.133**	
	Sig. (2-tailed)	.005	.003	.009	
	N	387	387	387	
My friends often compliment me on my driving skills	Correlation Coefficient				
	Sig. (2-tailed)				
	N				
I believe many people already use driver-assistance systems	Correlation Coefficient				
	Sig. (2-tailed)				
	N				

I believe many car manufacturers are now offering driving assistance systems	Correlation Coefficient			.142**	.173**
	Sig. (2-tailed)			.005	.001
	N			387	387
I think driving assistance systems will become very popular in the future	Correlation Coefficient	.214**	.270**	.283**	.298**
	Sig. (2-tailed)	.000	.000	.000	.000
	N	387	387	387	387
In my opinion, driver-assistance systems are too expensive	Correlation Coefficient	-.247**	-.103*	-.167**	-.185**
	Sig. (2-tailed)	.000	.044	.001	.000
	N	387	387	387	387
I am worried about how often I am going to have to pay for new updates of driver-assistance systems	Correlation Coefficient	-.275**	-.263**	-.208**	-.298**
	Sig. (2-tailed)	.000	.000	.000	.000
	N	387	387	387	387
I am worried about the resale value of the car if the technology is outdated	Correlation Coefficient	-.159**	-.158**		-.130*
	Sig. (2-tailed)	.002	.002		.011
	N	387	387		387
Overall, I feel comfortable using new technology	Correlation Coefficient	.498**	.544**	.437**	.559**
	Sig. (2-tailed)	.000	.000	.000	.000
	N	387	387	387	387
Overall, I would say I like to buy products that have new technology	Correlation Coefficient	.490**	.592**	.455**	.599**
	Sig. (2-tailed)	.000	.000	.000	.000
	N	387	387	387	387
Overall, I believe that technology is improving my life	Correlation Coefficient	.512**	.556**	.520**	.635**
	Sig. (2-tailed)	.000	.000	.000	.000
	N	387	387	387	387

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

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