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# *Car Infotainment: An early analysis of driver perceptions towards apps in the car*

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*Master Thesis in Information Systems*

# Car Infotainment: an early analysis of driver perceptions towards apps in the car

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## Abstract

Driven by technological advances, the vision of a Connected Car finally becomes reality. As one of the Connected Car innovations, Car Infotainment Systems now get an internet connection. Following the example of the mobile industry, app ecosystems are about to emerge in cars. In-Vehicle technology has already become the new differentiation battleground in the automotive industry. Being technologically possible, however, does not guarantee the success of app-based Car Infotainment Systems. It is not clear whether these systems are appreciated by car drivers, seeing that apps not necessarily provide assistance for driving, but in contrast can be a source of driver distraction and thus threaten traffic safety. It was therefore the purpose of this study to explain the perceptions of car drivers towards Car Infotainment Systems that provide access to an App ecosystem and thereby determine success factors from a user's perspective. For this reason, a research model that extends the Technology Acceptance Model with hypothetical factors has been proposed based on a literature review on driver acceptance. By analyzing data collected through an online survey, perceptions have been measured and nine hypotheses among these factors have been tested. It could be shown that drivers' perceptions of Car Infotainment Systems are slightly positive. Task-technology-fit, usefulness, ease of use, risk and costs could be approved as being influencing factors of the behavioral intention to use Car Infotainment Systems. However, the perceived risk seems to have no direct influence. Implications for both practice and academia could be drawn from these results.

**Keywords** Driver Acceptance, Technology Acceptance Model, TAM, Infotainment, IVI, User Perceptions, In-Vehicle, Success Factors

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Patrick Keuntje

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# 1. Introduction

*This chapter provides an introduction to the problem area of this thesis work. It therefore provides background information, narrows down the field to the particular focus of the research questions, derives the purpose and delimits the research approach. It also serves to provide clarifying definitions of the central concepts used in this thesis and explains the structure of the thesis.*

## 1.1. Background and introduction

The first appearance of car telematics systems can be at least dated back to the introduction of General Motors' OnStar system in 1996 (Yoo, 2010). Introduced as a safety tool for luxury cars, it opened up the telematics field (Yoo, 2010). With the availability of new technologies, more and more functionalities and services can be added in today's in-vehicle systems (Yoo, 2010). Among these new technologies are cheaper and more powerful hardware (Broy, Kruger, Pretschner, & Salzmann, 2007), mobile and wireless communication technologies (Lyytinen & Yoo, 2002), digital mobile technology, global positioning systems, in-car navigation systems and entertainment systems (Yoo, 2010). Hence, IT innovations in the car become a core element in automotive product innovations (Gartner, 2013). An exponential growth in car software can be observed, leading to 80 per cent of today's car innovations coming from computer systems (Broy et al., 2007).

Manifold innovations in this field are currently developed coined under the term "Connected Car": Crash Prevention, Driver Assistance, Energy Management, advanced Man-Machine-Interfaces and interconnected vehicle networks, to name just a few (Broy et al., 2007). A recent Accenture study shows that the complete basis of competition for car makers changes due to these emerging innovations, in-car technology eclipsing car driving performance characteristics in the purchase decisions of car buyers (Accenture, 2014; Schuermans & Vakulenko, 2014). Driven by consumer demand (Zheng, Lin, Zapf, & Knapheide, 2007) and following the success story of mobile app platforms, app platforms are now being integrated into the car, re-inventing car infotainment systems and opening them up for many new functionalities (Schuermans & Vakulenko, 2014). This platform concept relies on a layered modular architecture which has been identified as a contributor for "digital innovation", the carrying out of new combinations of digital and physical components (Yoo, Henfridsson, & Lyytinen, 2010). Digital innovation has shown to be able to digitize key functions of industrial-age products and to transform this industry (Yoo et al., 2010). This phenomenon is considered to happen again now in the car case (Yoo et al., 2010). More than 50 per cent of the cars sold in 2015 are already expected to include connected car features with either embedded, tethered or smartphone linked connectivity (Gartner, 2013; GSMA, 2013). The most functionalities using this connectivity are expected to be added in the infotainment systems (GSMA, 2013; Schuermans & Vakulenko, 2014).

Although the importance of these innovations has been pointed out and huge growth has been predicted in this field, a non-exhaustive internet research revealed that most research studies in the field of connected cars are concerned with technological issues. The impression arises that the user perspective is being overseen in this research field. Predictions about the success of connected car innovations are being made but the user perceptions of these ongoing developments are not being intensively studied. Some studies argue that the emergence of connected car innovations like the re-invention of car infotainment systems are driven by user demand (Schuermans & Vakulenko, 2014; Zheng et al., 2007), others point out that these innovations are becoming possible through the combination of new technologies and hence appear to consider these innovations as being technology-driven (Broy et al., 2007; Lyytinen & Yoo, 2002; Yoo, 2010; Yoo et al., 2010). The technology-driven perspective has obviously attracted more researchers to take a closer look on the barriers and possibilities of the available technologies. This research, however, seeks to take in the user perspective and to find out whether the propagated user demand is actually present and which factors influence this user demand.

Therefore, the focus of this research is going to be placed on car infotainment systems. Among the numerous innovations in the field of connected cars, these systems appear to be the earliest on the market. Since this thesis seeks to look at the innovation from a user's perspective, it is important that users can already build an attitude. Therefore, an innovation that has already more medial presence and is closer to appear on the market seems to be preferable. Moreover, car infotainment systems have a direct user interaction. Most other innovations like driver assistance systems or interconnected car innovations will most likely work without user interaction. As a result, users might be most affected by car infotainment systems which can also be seen again in the importance that users account to in-vehicle technologies (Schuermans & Vakulenko, 2014).

Technology acceptance studies have a long tradition in the Information Systems field (Wu & Wang, 2005). Numerous models and frameworks have been proposed to explain the user's perceptions and adoption behavior of new technologies (Venkatesh, Morris, Davis, & Davis, 2003). In the example of the car infotainment systems, the new functionalities becoming possible are propagated broadly in the media. These include for example specific car apps for news, weather forecasts, social networking and music streaming (GSMA, 2013). However, there are also concerns about these new technologies which motivate this technology acceptance study. It is not clear whether the new systems are really attractive to users and how they can be designed attractively (Zheng et al., 2007) and usable (Broy et al., 2007). This attractiveness concern can be seen as a derivate of classical technology acceptance factors such as perceived usefulness and perceived ease-of-use (Davis, 1989). Moreover, many critiques lead into the direction of perceived risks stemming from the use of car infotainment systems (Zheng et al., 2007). Especially driver distraction and fatigue resulting from an interaction with the system are serious issues being faced in the system design processes (Broy et al., 2007).

Looking at these concerns and the studies that have been conducted in this field, it appears to be an open question whether car infotainment systems are actually positively perceived by car drivers and which factors are influencing this attitude. As it has been argued above, this new generation of Car infotainments systems has not hit the broad market yet. Thus, a study of this technology acceptance is quite early and can still be considered to be in the developmental phase of these systems. The importance of technology acceptance studies in this early pre-adoption phases has been pointed out by some of the most influential adoption researchers (Davis & Venkatesh, 2004; Meschtscherjakov, Wilfinger, Scherndl, & Tscheligi, 2009). In these early stages, costs and effort in the development can still be saved and furthermore high risks such as an image loss of the brand be averted, which are quite pronounced in the automotive sector (Meschtscherjakov et al., 2009). Furthermore, without reaching customers' needs adequately, it will be hard to differentiate for the car manufacturers as it has been argued above. A study of user perceptions in this phase therefore has a high importance for the competitiveness of these industry players.

Car infotainment systems fall into different categories of Information Systems and have some specific characteristics which make it necessary to construct an own research model in this thesis. First of all, the classic technology acceptance models study organizational Information Technology. In contrast, car infotainment systems belong to a category of end-consumer systems (Yoo, 2010). Here, the users are no employees anymore, but in our case for example car drivers (Yoo, 2010). Yoo (2010) argues therefore that IS research has to branch into the new field of experiential computing which takes into account the new characteristics of these systems. Furthermore, cars are nomadic devices. Their context changes already with their geographic position. Computing devices like this are coined under the term nomadic computing (Lyytinen & Yoo, 2002). The organizational and stationary context that has been assumed in classical technology acceptance models is missing here due to the changing environments. Strongly coupled categories to the before mentioned ones are pervasive or ubiquitous computing (Lyytinen & Yoo, 2002; Yoo, 2010). For all of these categories, the question on how to study technology acceptance has been posed again due to these new appearing characteristics.

Furthermore, it has been argued by Henfridsson and Lindgren (2010) that user involvement is very important for the development of mobile and temporarily interconnected systems in which category car infotainment systems can be assigned as well. Thus, gathering opinions and attitudes from car drivers as the potential users of car infotainment systems seems to be quite helpful for supporting the development process of these systems and the insights generated by this research can be of great value for the developing parties such as OEMs and telematics suppliers. It can be argued that these new car infotainment systems with an integrated app platform have a lot in common with the emergence of mobile smartphones and tablets in recent years (Schuermans & Vakulenko, 2014; Yoo, 2010) and that hence the user perceptions and requirements not necessarily need to be studied again. However, car infotainment systems have some very new requirements (Gartner, 2013) such as the risk of driver distraction (Broy et al., 2007) that make a new study of technology acceptance necessary in this case. Furthermore, it has been found that hyped technologies such as the emergence of the iPhone need new acceptance models (Hedman & Gimpel, 2010). For the above mentioned reasons, we approach this user acceptance problem in this thesis by extending the classic technology acceptance model (Davis, 1989) with factors that are typically considered in the related fields of ubiquitous, experiential and nomadic computing and applicable in the context of the car infotainment systems.

## 1.2. Research questions

The focus of this particular research is targeted at the following two particular research questions:

- How are app-based car infotainment systems perceived by car drivers?
- Which factors influence the driver's acceptance of app-based car infotainment systems?

Thus, the research has both a descriptive and an explanatory part.

## 1.3. Purpose

The purpose of this study is therefore to describe the perceptions of car drivers towards car infotainment systems of the new generation. Furthermore, it seeks to determine the factors that influence drivers' intention to use the system. These factors are also going to be measured according to their influencing strength.

For achieving this purpose, this study follows a quantitative strategy by conducting a consumer survey. In the following parts of this thesis, a theoretical model based on the Technology Acceptance Model (TAM) (Davis, 1989) will be proposed, the used constructs and own extensions will be explained and hypotheses based on the causal relationships will be stated. The survey results serve then as a data collection with which the hypotheses are tested with statistical means.

The combination of measured perceptions and determined adoption factors will provide valuable insights for the key industry players. Factors that are important yet negatively perceived need to be focused on and can be considered in the development process. For academics, this study will provide a research model that can be considered as a basis for other future information systems in the car. Especially the test of this research model in a pre-adoption study can encourage future early acceptance studies.

## 1.4. Delimitations

Even though car infotainment systems exist already for a longer time (Yoo, 2010), this research is only concerned with the new evolving car infotainment platforms, which provide Apps in the car. This can be either achieved by replicating Apps from a connected mobile device or by having an independent embedded infotainment device in the car. Since this approach is quite new and only accessible in a few luxury cars, this study focuses solely on the attitude of car drivers in the pre-adoption phase and is thus based on the expectations of car drivers. It should be further pointed out that due to the early stage of the innovation process, the available applications and functionalities can only be guessed in terms of basic categories and cannot be described in detail. As such the focus is limited to the general access to an app ecosystem, specific applications are not considered. As we only take into account car infotainment systems, conclusions and implications are also only valid for these. Proposed and approved hypotheses, however, can be taken into consideration for verification in further technology acceptance studies in the field of ubiquitous, nomadic and experiential computing, especially in further “Connected Car” studies.

In addition, this study takes in a user’s perspective since it is concerned with the technology acceptance of car drivers. It thus doesn’t regard the perspective of the organizations in this industry. However, car manufacturers and their suppliers belong to the addressees of this research as the authors draw conclusions for practical implications of this study.

Previous studies in the scope of car infotainment were mainly concerned with technical issues such as system architecture and means for security enhancements (see e.g.Kleberger, Olovsson, & Jonsson, 2011; Sonnenberg, 2010). These issues are explicitly out of the scope of this study as its focus lies on measuring the attitude of consumers towards a given technology vision.

## 1.5. Abbreviations and concept definitions

In order to facilitate the readability of this thesis, the following tables provide an overview of the abbreviations that are used in this thesis respectively the most important concept definitions.

**Table 1.1: Abbreviations**

| Abbreviation | Full name |
|---|---|
| TAM | Technology Acceptance Model |
| UTAUT | Unified Theory of Acceptance and Use of Technology |
| ECU | Electronic Control Unit |
| PU | Perceived Usefulness |
| PEOU | Perceived Ease of Use |
| BI | Behavioral Intention to Use |
| PTTF | Perceived Task-Technology-Fit |
| PRISK | Perceived Risk |
| PCOSTS | Perceived Costs |

**Table 1.2: Concept definitions**

| Concept | Definition |
|---|---|
| Car Infotainment System | Car Infotainment Systems (or also frequently called In-Vehicle Infotainment, short IVI) are computer systems in automobiles that deliver entertainment and information content. These systems frequently utilize Bluetooth technology and/or smartphones to help drivers control the system with voice commands, touchscreen input, or physical controls. |
| Driver Acceptance | The degree to which an individual intends to use a system and […] to incorporate the system in his/her driving (Adell, 2009, p. 31). |

## 1.6. Structure of the thesis

The remainder of this thesis is structured as followed. In the next section, an overview about user acceptance theories in general and experiences from user acceptance studies in other car-related studies will be provided in order to motivate the research model which is used in this study.

The latter is going to be described in detail in the third section of this thesis. The proposed influencing factors are going to be introduced, described and justified. Hypotheses based on the causal relationships between the influencing factors will be proposed.

After this, a methodology section follows. In this part of the thesis, it will be described in detail the research strategy and approach used to achieve the purpose of the study. Starting with a description of the general research type, the section continues with a motivation of the data collection methods and techniques. Quality and ethical concerns of the methodology will be addressed subsequently.

The empirical results of this data collection will be presented and analyzed in the fifth chapter. The statistical analysis methods will be introduced and motivated. The quantitative results will be interpreted and used to describe the measured user perceptions of car infotainment systems. Furthermore, the validation of the proposed hypotheses and hence of the research model will be done.

These empirical results will then be interpreted and discussed in the “discussion” section. Potential meanings of the analyzed data will be provided and implications for both practice and academics will be suggested.

Lastly, this thesis will end with a conclusion in which the main findings will be shortly presented and the final answer for the research questions will be given based on the discussed empirical results. Furthermore, suggestions for future research will be provided.

# 2. Frame of Reference

*This chapter provides an overview to the field of study. It serves as an introduction to the area under study and builds a frame around the main terms in use in this thesis. The relevant research that has been done in this field is being summarized to place the study into the context of academic research.*

## 2.1. Background – Connected Car

The automotive sector has been transformed heavily in recent years. The basis of competition has moved from classical differentiating features such as design and driving performance to the in-vehicle experience which is mainly characterized by electronics and computer systems (Schuermans & Vakulenko, 2014). About 40 years ago, the first small software module has been placed in a car as a so-called Electronic Control Unit (ECU) which had local and limited functionalities (Broy et al., 2007). From then on, software became increasingly important since local systems became interconnected, exchanged data and made place for always new functionalities (Broy et al., 2007). Already in 2007, it has been found that the software in a car makes up an amount of ten millions lines of code and enables around 270 user interactive functionalities (Broy et al., 2007). As a result of this trend, about 80 per cent of innovations in the car are enabled by computer systems (Broy et al., 2007).

New possibilities such as mobile and wireless communication technologies as well as cheaper and more powerful hardware enable these new innovations (Broy et al., 2007; Lyytinen & Yoo, 2002). Not only in the automotive industry the trend emerged to equip consumer products with computing capabilities or even an internet connection which facilitates new usage possibilities (Yoo, 2010). Industry products such as the mobile phone, the book or the television are just a few of many examples which have experienced a shift in differentiating product features following the paradigm of the "Internet of Things" (Yoo, 2010).

A new focus on car safety and new progresses in electronic and communication technologies in the 1990s shaped the way for automotive companies to embed cellular technology into their vehicles, bringing together the automotive and the mobile phone industry in the new "connected vehicle" industry (Deloitte, 2012; RolandBerger, 2012). Nowadays, consumers are connected to the internet almost anywhere at any time. Different research studies show that the consumers expect this experience to continue in their car (see e.g. Deloitte, 2012). It is thus not surprising that the perspectives for the automotive industry in this field are overall very promising with expected huge market growth (see e.g. Accenture, 2012; Broy et al., 2007; Deloitte, 2012; Gartner, 2013; GSMA, 2013).

### *2.1.1. Driving Forces*

The emergence of the industry field around the connected vehicle is influenced mainly by five driving forces: Technology, regulations, customers, urbanization and the value of data (RolandBerger, 2012).

As already mentioned, a key technology contributing to the emergence of connected cars can be seen in the wireless communication technologies (Lyytinen & Yoo, 2002). Two categories of technologies should be distinguished in this context: DSRC (Dedicated Short Range Communications) – which is specifically developed for the automotive sector to connect cars to the infrastructure or among themselves – and commercial technologies such as Bluetooth, WiFi, 3G and LTE (Long Term Evolution) (RolandBerger, 2012). LTE is thereby expected to be a major contributor (RolandBerger, 2012). All of these technologies enable to connect the car to its surrounding such as the internet, mobile devices, the traffic infrastructure or other vehicles. Further technology advancements can be seen and are to be expected in the field of Human Machine Interfaces (HMI). Computer systems in a car whether embedded or as separate devices such as Smartphones distract the driver from paying attention to the traffic situations and thus threaten the safety. New advanced technologies such as augmented reality, heads-up displays, speech recognition among others promise to reduce this level of distraction and thus facilitate the implementation of increasing numbers of functionalities (RolandBerger, 2012).

Expected environmental benefits and traffic improvements also bring governments on the game board which develop new regulations in order to push the innovations forward and guide them into the right direction (RolandBerger, 2012). For example, it is expected that with advanced traffic management systems which make use of real time data, traffic congestions and hence CO2 emissions can be significantly reduced (RolandBerger, 2012). Concrete existing regulations are concerned with traffic safety and include driver distraction guidelines such as the ban of mobile phones while driving or obligatory emergency support systems such as the eCall system stipulated by the European Union starting in 2015 (RolandBerger, 2012).

Another main driver has already been mentioned: the consumers. As many studies found, consumers are nowadays used to be connected all the time and do not want this experience to stop in the car. It can even be observed that even despite having legal restrictions, car drivers continue to use their smartphones while driving (RolandBerger, 2012). Thus, there is a strong demand for having better adapted connectivity solutions to improve traffic safety and fulfill consumer wishes.

Urbanization is a global trend which will lead to more and more traffic problems (Accenture, 2012). Mobility solutions like car sharing or e-mobility concepts are thus emerging in order to reduce the effects of increasing city populations on the traffic and environment. Concepts around the connected vehicle can facilitate these approaches (RolandBerger, 2012).

Lastly, connecting the car to the internet also allows the collection and sharing of data. As could be seen in other industries recently, business models are likely to emerge around this data (RolandBerger, 2012). For example, a car manufacturer is interested in the usage data of a car in order to extend its services such as automated maintenance suggestions. These business models can in return enable and motivate the OEMs to give away connectivity solutions cheaper to customers and accelerate the distribution of these systems (RolandBerger, 2012).

### *2.1.2. Innovations*

The umbrella terms “Connected Car” or “Connected Vehicle” embrace manifold innovations which can be categorized for example according to their purpose. As Figure 2.1 visualizes, there are five particular categories identifiable: Fees & Charges, vehicle interaction, infotainment, traffic safety and traffic efficiency. Of course, there are many different categorizations existing and the list of innovations is by far not complete.[1] However, this categorization serves as a good overview about the major goals in the field of connected cars.

The category “fees & charges” refers mainly to new emerging business models based on vehicle data such as the geographic position. As an example, this data can be used for new pricing schemes in the insurance industry which facilitates a fair, usage-based alternative to the current pricing mechanisms (Vaia, Carmel, DeLone, Trautsch, & Menichetti, 2012).

[1] For examples of alternative categorizations and additional connected car innovations, see e.g.: http://novero-automotive.com/uploads/pics/connected-car_02.png or http://atos.net/content/dam/global/images/we-do/atos-connected-cars-diagram.jpg

The category “vehicle interaction” embraces innovations which connect the car to the OEM in order to provide new services such as remote diagnostics or automated service appointments. According to Deloitte (2014a), this kind of connected services will be a new area of competition between OEMs in the future.

“Infotainment” is the category of focus in this research study. It embraces mainly but not only in-car entertainment systems, including internet, music and gaming as well as providing information about for example news, stocks, weather and sport (Accenture, 2012). More details about this category will be provided in the next section.

In the category “traffic safety”, innovations are grouped together which either try to prevent traffic accidents or to improve the support in emergency cases. For the first case, examples include the connectivity to hazard warnings or driver assistance systems (Broy et al., 2007). The latter purpose is achieved for example by the eCall system required in the European Union starting in 2015 which automatically sets out an emergency call in case of an accident (RolandBerger, 2012).

Lastly, “traffic efficiency” is concerned with ecological issues. For instance, traffic congestions are to be avoided and thus information about the traffic is collected and shared with the vehicles in order to coordinate the traffic intelligently (Broy et al., 2007).


**Figure 2.1: Categories of Connected Car innovations[2]**

[2] Taken from: http://www.ericsson.com/res/thecompany/images/press/mediakit/connected-vehicle-500.png

## 2.2. Car Infotainment Systems

### 2.2.1. History

It is quite difficult to determine the first occurrences of car infotainment systems since it incorporates multiple key basic functionalities which have been served by different systems in the past. These major components of infotainment today are music, phone and navigation. Looking at it like this, it could be argued that in-vehicle infotainment dates back to the 1930s where the first car radio was introduced (Berkowitz, 2010). However, even though at date, these three pillars may be the most commonly used features or car infotainment systems, the major innovation of the systems in this study is internet connectivity. In these terms, General Motors' OnStar system led the way with its introduction in 1996 as a safety tool for luxury cars (Yoo, 2010). From then on, more and more functionalities were provided in the vehicle making use of the connectivity to mobile services and global positioning systems (Yoo, 2010). The current development shows that customers expect a similar in-vehicle experience as they know it from their smartphone (J. Park, Kim, Nam, & Kim, 2013; Zheng et al., 2007). Thus, the new generations of Car Infotainment Systems follow the great success of the mobile industry that followed on the introduction of App stores and are about to bring applications into the car and thereby opening it up to an app ecosystem.

### 2.2.2. Definition

A car infotainment system in this study is assumed to be "… a set of solutions and applications for vehicles that address various customer priorities, such as entertainment, safety, maintenance, communication, and navigation" (Accenture, 2012, p. 3).

A more detailed explanation of the Car Infotainment Systems that are in the center of this study can be found attached to this thesis (see Appendix 1: Information text). This description has served as a description for the survey participants in order to provide them with a common understanding of the systems of interest. This description can therefore also be seen as the underlying definition of Car Infotainment Systems in this thesis. It extends the above mentioned definition with more details about the design, user interaction and functionalities that are provided. First of all, it shows that Car Infotainment Systems frequently use voice commands, touchscreen interfaces and physical controls for the interaction with the car driver. Functionalities include the classic components of audio, navigation and telephony, but also extended features such as receiving and sending e-mails and text messages, as well as rear-seat entertainment such as movies, games, eLearning and social networking (Accenture, 2014). Moreover, a major pillar is added by internet-connected features such as notifications about traffic conditions, news, stock information, sports scores and weather forecasts (Accenture, 2014). The features available in Car Infotainment Systems further extend the classic components with internet-enabled functionalities. As such information about Points of Interest, free park spaces, concierge services and public transport can be provided as an extension of the classical navigation service (Accenture, 2014). Internet radio and access to streaming services such as Spotify or Pandora are extending the classical audio component (Apple, 2014). Finally, sending and receiving text messages via various services can be seen as an extension to the classic communication via phone (Accenture, 2014).

The description further points out that the Car Infotainment Systems in this study include access to an app ecosystem, making third-party applications available. It also mentions that there are in general two distinguishable ways for achieving the internet-based features: By providing internet access and an app platform in the car system itself or by connecting the smartphone to the car system, replicating its apps on the car system's display and using its internet connection.

### *2.2.3. Current State*

The market around the Connected Car is not clearly shaped yet. Looking particularly at the infotainment industry, the market is very fragmented, having manifold solutions incompatible which makes it hard for third-party developers to enter the market at the current state (Schuermans & Vakulenko, 2014). Interested parties in this market include the car manufacturers (OEMs) who seek to differentiate from their competitors by providing a unique in-vehicle experience (RolandBerger, 2012). Furthermore, their suppliers in the automotive sector are strongly interested in manifesting their market share either by providing embedded solutions for the OEMs or by providing aftermarket devices (RolandBerger, 2012). Since a major component of these systems is their internet connectivity (and fast, reliable connections with 3G or LTE are seen as main contributors to the current developments), mobile network providers build a third group of players in the market (RolandBerger, 2012). Moreover, new players are entering the Connected Car battleground. Mobile and web industry players are interested in subsidizing the infotainment solutions in order to facilitate the use of their products which in turn supports their own business model (RolandBerger, 2012).

As has been indicated earlier, not every infotainment system being already or predicted to come to the market uses the same approach. Two basic approaches have to be distinguished: Separate In-Vehicle Infotainment Systems and Smartphone-enabled Infotainment Systems (Accenture, 2014; RolandBerger, 2012; Schuermans & Vakulenko, 2014).

In the first alternative, all software is running directly on the head unit system in the car. Thereby, the internet connection is established with an in-built SIM card and using the car's antenna or the head unit uses the broadband connection of a connected smartphone (tethering) (RolandBerger, 2012). The infotainment systems in these cases are usually developed by car OEMs, based on an underlying software platform to reduce software development efforts (Schuermans & Vakulenko, 2014). App platforms in the sense of app ecosystems as they have emerged in the mobile industry are not to be seen in this category (Schuermans & Vakulenko, 2014). However, app stores can be provided on top by the OEMs or provided by the underlying software platforms (for example QNX App Portal, currently serving as a showcase).

In the case of smartphone-enabled systems, the apps are running on the smartphone itself. The connectivity of the smartphone, the operating system and the hardware of the smartphone are used to execute applications, the head unit solely serves as a display (Schuermans & Vakulenko, 2014). Apps in this case are accessible through the app platform of the smartphone, probably limited to car-certified apps in most cases (as indicated in Apple, 2014).

The main competitors in the first category are Blackberry's QNX, Microsoft's Windows Embedded Automotive and Linux with the open-source platform Genivi (Schuermans & Vakulenko, 2014). Furthermore, Android (also based on Linux) is on its way to become an important player in this field, pushed by the Open Automotive Alliance (Schuermans & Vakulenko, 2014). The Open Automotive Alliance includes the car manufacturers Audi, General Motors, Hyundai and Honda, as well as Google as the owner of Android and the visual computing company Nvidia (OpenAutomotiveAlliance, 2014). Recently, HTML 5 as a platform also got a push towards the market, seeing Genivi and the web standard association W3C partnering in the W3C Automotive and Web Platform Business Group that has participants from many different market player categories including car OEMs (such as Mitsubishi, Hyundai, Porsche, Jaguar Land Rover and Volkswagen), automotive suppliers (such as Continental), network providers (Vodafone, Telenor), chipset provider Intel, mobile OEMs (BlackBerry, Nokia, LG) and content providers (Pandora) (W3C, 2014).

In the smartphone-enabled category, Fords recently opened Smartphonelink competes with MirrorLink, a standard driven by the Car Connectivity Consortium and with roots in Nokia (Schuermans & Vakulenko, 2014). Furthermore, Apple recently pushed its software CarPlay to the market, partnering with many car OEMs (including Ferrari, Honda, Hyundai, Volvo, Mercedes-Benz and 15 others in the future) (Apple, 2014). Google with its Open Automotive Alliance is further expected to join in this category as well (Schuermans & Vakulenko, 2014; Stevens, 2014). Lastly, also Microsoft entered the competition among the smartphone-enabled systems, announcing Windows in the Car (Schuermans & Vakulenko, 2014). Other smaller players such as OpenCar and CloudCar are also to be mentioned in this category.

#### *2.2.4. Concerns*

The potential advantages of these developments in car infotainment are not seen without critic. The main concern about more and more functionality provided in the car is safety. The main task of a car driver is steering the car safely through the traffic (Meschtscherjakov et al., 2009). With more information and entertainment accessible to him and more interaction with the system, the view of the driver might swift away from the road for too long, risking car accidents (J. Park et al., 2013). Thus, driver distraction needs to be considered in the development of the human machine interfaces. Providing access to car-related data such as location and speed further increases privacy concerns. Allowing third-party developers to write applications for the car can threaten a car driver's privacy (Kleberger et al., 2011).

Moreover, usefulness should be considered as a concern since recent research has shown that there is indeed a significant group of consumers which is not interested in many functionalities of these systems (Accenture, 2014). Also there are significant differences concerning the preferred functionalities, whether the already known smartphone-applications or driving-related applications should be included in the system (Accenture, 2014).

Lastly, Accenture (2012) shows for some countries that the high price of infotainment systems is a major concern. This is further supported by Deloitte (2014b)'s finding that especially for younger people which build the highest market potential for car innovations, price is a major concern in the purchase decision of the car. The question also raised which payment model consumers would prefer, paying initially for purchasing a system or higher prices for single applications or even accepting in-car advertisement in order to have free applications

(Accenture, 2014). The results indicate that a generic answer to this question cannot be given yet. As such, price concerns need to be kept in mind.

## 2.3. Technology Acceptance

This section aims to provide a theoretical background about the phenomenon of interest in this study, which is – abstractly spoken – users' acceptance behavior of technologies. In this particular case we take a look at the acceptance of app-based Car Infotainment Systems and are therefore targeting car drivers as the relevant user group.

According to Adell (2009), acceptance of technologies has been acknowledged as being important and most authors assume that there is a common understanding of this notion. However, she finds many different categories of approaches to define acceptance. It seems therefore necessary to start this section by developing the definition of acceptance which this study is based on. As could be seen in the preceding section, the app-based Car Infotainment Systems which are the focus of this study are not accessible yet for most car drivers. This fact allows only a particular definition of acceptance in this study. Speaking in the acceptance dimensions collected by Adell (2009), this study's acceptance notion can be categorized as attitudinal acceptance (Franken, 2007), since an actual usage behavior cannot be observed yet for app-based Car Infotainment Systems (similarly to the issue identified by J. Park et al. (2013)) and thus the acceptance in this case is mainly based on emotions and prior experiences. As will be seen in the next sections, the main interest of this study is further to determine driver's attitudes towards practical features of the systems. Social influences seem to be an inappropriate focus in a context where almost no friends or relatives of a particular driver have actually got access to the infotainment system. Thus, according to Adell (2009), our study focusses on practical acceptance. Another relevant distinction for this study has to be made between priori acceptability, posteriori acceptability and acceptance (Adell, 2009; Schade & Schlag, 2003). These differ from each other depending on the actual experience which the target group could gain with the system. In this study we have a case of priori acceptability, since the target group could not use the system yet. However, we will continue using the term acceptance due to the naming of the underlying theoretical model in order to avoid confusions. Generally, driver acceptance is concerned with the system acceptance of individuals, since they make the purchasing and usage decision (Adell, 2009). Following this argumentation and considering the non-availability of the system for most people, we define acceptance as "the degree to which an individual intends to use a system and […] to incorporate the system in his/her driving" (Adell, 2009, p. 31).

Knowing why people tend to accept or refuse computers as tools that enhance efficiency and effectiveness has become one of the most criticized issues in the information systems context (Doll, Hendrickson, & Deng, 1998). This section aims to introduce the theory that the research question will be based on. In order to find the right theory for our research, a number of models in the information systems field have been reviewed. There are several models that have been used to evaluate the individual's attitude in various contexts. The diffusion of innovations theory (Moore & Benbasat, 1991; Rogers, 1995), the technology acceptance model (Davis, Bagozzi, & Warshaw, 1989), the theory of planned behavior (Ajzen, 1991) and the unified theory of acceptance and use of technology (Venkatesh et al., 2003) are some examples of the most common models in information systems (IS) context suggested to evaluate the acceptance of IS usage over the past decade (Bhattacherjee, 2001). However, the TAM model is one of the most influential models that has been widely used by researchers for the sake of evaluating the users' acceptance of information systems (Lee, Kozar, & Larson, 2003).

### *2.3.1. Technology Acceptance Model*

The technology acceptance model has been proposed by Davis (1989) based on the theory of reasoned action (TRA) (Fishbein & Ajzen, 1975) which itself is a well-researched intention model suggested to predict and describe behavior concerning various domains (Ajzen & Fishbein, 1980). The TRA includes two constructs that considerably influence the behavioral intention: attitude toward behavior and subjective norm (Davis et al., 1989).

The main purpose of TAM was to introduce a less general model for explaining IT usage behavior, specifically of computers (Davis et al., 1989). Like the TRA model, the behavioral intention is a factor determining the actual systems use in TAM model. However, the main focus here was to evaluate the external factors affecting internal beliefs and intentions (Davis et al., 1989).

In TAM, perceived usefulness and perceived ease of use are assumed to be the influencing factors of an individual's technology acceptance behavior (Lee et al., 2003). TAM indicates that the actual system use – which is computer usage by an individual – depends on behavioral intention which itself, is determined by two variables being perceived usefulness and attitude toward using. Perceived ease of use is another variable that has an effect both on the attitude and the usefulness. Furthermore, all the variables are influenced indirectly by the system attributes in terms of external variables (Figure 2.2). Since subjective norm was the least understood factor in TRA, it has not been considered as a main factor affecting the behavioral intention to use in TAM (Davis et al., 1989).

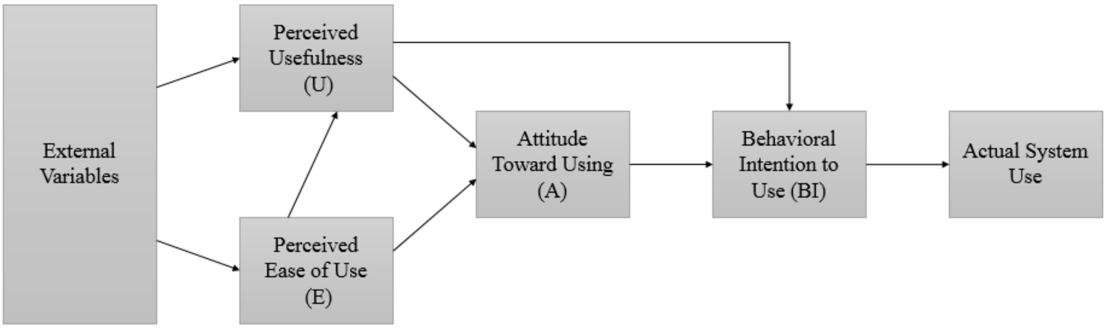



**Figure 2.2: Technology Acceptance Model (Davis et al., 1989, p. 985)**

Perceived usefulness is defined as *the degree to which a person believes that using a particular system enhances his or her job performance* (Davis, 1989, p. 320). Also perceived ease of use refers to *the degree to which a person believes that using a particular system will be free of effort* (Davis, 1989, p. 320).

Venkatesh and Davis (1996), reviewed the TAM model, removed the variable attitude towards system and stated usefulness and ease of use as the two factor directly influencing the behavioral intention to use. Perceived ease of use and perceived usefulness in turn were still affected by external variables (Venkatesh & Davis, 1996).

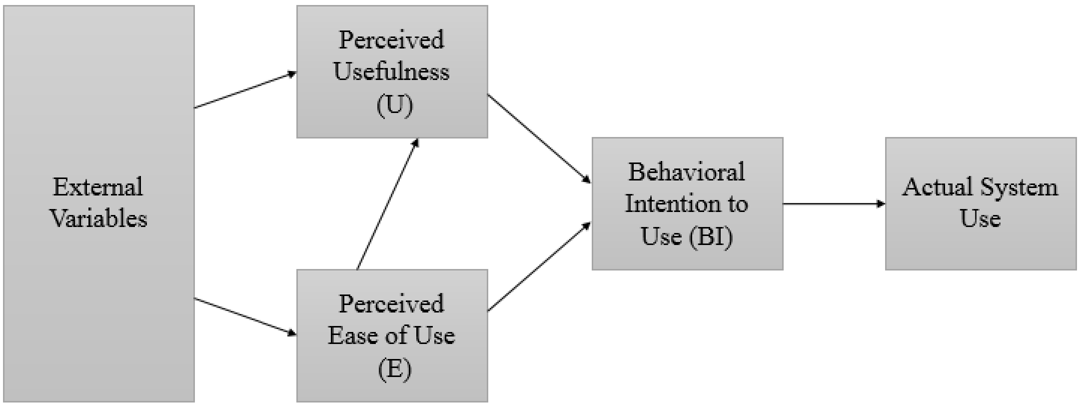



**Figure 2.3: Final TAM model (Venkatesh & Davis, 1996, p. 453)**

Notwithstanding the TAM model usefulness in IS context, it has been extended and developed over the past years by other researchers (Chuttur, 2009). TAM2 and TAM3 are two newer, extended TAM models that have been suggested by Venkatesh and Davis (2000) and Venkatesh and Bala (2008) respectively. TAM2 introduced more variables in order to be able to provide more explanations concerning the perceived usefulness. Furthermore, with TAM2, Venkatesh and Davis (2000) reconsidered the subjective norm as a social influence factor. They also added voluntariness and image as two other social factors. In addition, some the variables experience, job relevance, output quality, and result demonstrability have been added to the previous TAM model. Out of these variable, job relevance, output quality, result demonstrability, and perceived ease of use are considered as the cognitive instrumental process factors (Venkatesh & Davis, 2000).

TAM3 is a combination of TAM2 and the model of the determinants of perceived ease of use (Venkatesh & Bala, 2008). Venkatesh and Bala (2008) argue in TAM3 that the determinants of perceived ease of use will not affect the perceived usefulness. Therefore, a factor called experience has been considered as a moderating variable between ease of use and usefulness, between computer anxiety and usefulness, and also between usefulness and behavioral intentions (Venkatesh & Bala, 2008). Table 2.1 provides an overview of all three TAM models and their variables.

**Table 2.1: TAM models and their variables**

| Model | Variables affecting Behavioral Intention (BI) | Variables affecting Perceived Usefulness (U) | Variables affecting Perceived Ease of Use (E) | Reference |
|---|---|---|---|---|
| **TAM** | Perceived Usefulness (U), Perceived Ease of Use (E) | External Variables | External Variables | (Venkatesh & Davis, 1996) |
| **TAM2** | Perceived Usefulness (U), Perceived Ease of Use (E), Subjective Norm (SN) | Subjective Norm, Image, Job Relevance, Output Quality, Result Demonstrability | – | (Venkatesh & Davis, 2000) |
| **TAM3** | Perceived Usefulness (U), Perceived Ease of Use (E), Subjective Norm (SN) | Subjective Norm, Image, Job Relevance, Output Quality, Result Demonstrability | Computer self-efficiency, Perceptions of External Controls, Computer Anxiety, Computer Playfulness<br>Perceived Enjoyment, Objective Usability | (Venkatesh & Bala, 2008) |

As it is shown in Table 2.1, perceived enjoyment and objective usability are considered in TAM3 as two variables affecting the perceived ease of use in terms of adjustment. In addition, TAM3 introduces four so-called anchor variables with computer self-efficiency, perceptions of external controls, computer anxiety, computer playfulness that also influence the perceived ease of use. According to Venkatesh and Bala (2008), anchor variables are early perceptions of on which the perceived ease of use is based on.

Furthermore, it should not remain unmentioned that the Technology Acceptance Model as well as seven other predictor acceptance theories has been put together in a single model. Venkatesh et al. (2003) suggested their own unified model to evaluate the IT acceptance by users called unified theory of acceptance and use of technology (UTAUT). They thereby analyzed these eight different models on similarities and the evidence found in most studies for the importance of their factors and synthesized a new model with these considerations. They show that with this model a higher amount of the variance in the dependent variable of intention to use can be explained and should hence be considered to have a better predictive power.

### *2.3.2. Technology Acceptance in Related Studies*

To date, the authors are not aware of any other study that examines car drivers' acceptance of app-based Car Infotainment Systems. However, driver acceptance studies have been conducted on various computer systems in the car. It is the intention of this section to provide an overview of these studies, including the theoretical models in use and the findings.

The study with the closest relation to the subject of this thesis has been conducted by J. Park et al. (2013) and deals with the acceptance of smartphone-car connectivity systems which, as discussed in the preceding chapter, can be seen as a subcategory of app-based Car Infotainment Systems. The authors claim to base their research on the Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh et al., 2003). However, they take only the independent variable "facilitating conditions" of this model and omit the other factors, replacing them with own factors, namely technographics, mobile literacy and prior similar experience. With the data they collected they could only find evidence for a relation between facilitating conditions and behavioral intention to use as well as between the technographics and the intention. This study hence did not provide a good insight into the influencing factors. The authors state themselves in the conclusion that they missed to include additional important factors. Recapitulating the theories about technology acceptance it seems further questionable to omit – without providing good arguments – the factors performance and effort expectancy which have been seen as the best explaining factors of user acceptance in many models (King & He, 2006; Venkatesh et al., 2003).

Another quite related study has been performed by E. Park and Kim (2014) about Car navigation systems. Car navigation systems can be seen as similar information systems to Car Infotainment Systems. They also provide additional, context-aware information to the car driver in the vehicle and while driving. Navigation functionality is further a part of the functions of Car Infotainment Systems. In their study, E. Park and Kim (2014) use the basic Technology Acceptance Model (TAM) (Davis, 1989) while omitting the factor perceived ease-of-use and extending the model with the factors perceived locational accuracy, service and display quality, perceived processing speed, and satisfaction. In contrast to J. Park et al. (2013), they find support for all their stated hypotheses and thus provide deeper insight into the relevant factors influencing drivers' acceptance of in-vehicle information systems. However, taking a look at the chosen measurement items in this study, it can be argued that some of the constructs are not clearly distinguishable from other known constructs. As for example, measurement items SDQ1 and ST4 which are supposed to measure Service and Design Quality respectively Satisfaction are also used very similarly to measure the factor of perceived ease-of-use in the basic Technology Acceptance Model (Davis, 1989), the factor which should be explicitly omitted in the study.

Further identified related studies are mainly concerned with different kinds of driver support systems in terms of driving assistance. Together with the studies described above in more detail, Table 2.2: Related Driver Acceptance StudiesTable 2.2 provides an overview of the theories and factors used in these studies. In general, all studies either use UTAUT or TAM as a basic theory. Except for Adell (2009), all studies extended the basic model with additional factors. Due to the underlying theoretical models, almost all studies include factors about the perceived usefulness (respectively performance expectancy) and the perceived ease-of-use (respectively effort expectancy) and especially find strong evidence for the influence of perceived usefulness on drivers' acceptance of the systems. It also becomes apparent that many studies include safety concerns by including factors such as perceived risk (Meschtscherjakov et al., 2009; Planing, 2014), unobtrusiveness (Roberts, Ghazizadeh, & Lee, 2012) and disturbance (Meschtscherjakov et al., 2009). Another often considered factor is concerned with drivers' expectations whether the technology meets its requirements and is thus fitting for their tasks. This can be partly seen in the service quality and satisfaction construct used by E. Park and Kim (2014), in the suitability variable of Meschtscherjakov et al. (2009) and in the perceived efficiency of Höltl and Trommer (2012). However, there is no overall significant influence on the intention to use becoming obvious for these variables. A last common ground of these studies is the consideration of moderating, demographic variables such as age, gender and some kind of experience. Especially for age, some of the studies find evidence for a significant influence on other model variables.

**Table 2.2: Related Driver Acceptance Studies**

| References | Study subject | Theories used | Validated influences |
|---|---|---|---|
| **J. Park et al. (2013)** | Car Connectivity Services | UTAUT (just the facilitating conditions (FC)) + technographics (TG), mobile literacy, and prior similar experience | FC → BI<br>TG → BI |
| **E. Park and Kim (2014)** | Car Navigation Systems | TAM without PEOU, but with perceived locational accuracy (PLU), service and display quality (SDQ), perceived processing speed (PPS), and satisfaction (ST) | PU → ATT<br>PU → BI<br>ATT → BI<br>PLA → PU<br>PLA → ATT<br>SDQ → ATT<br>SDQ → BI<br>PPS →SDQ<br>PPS → ATT<br>ST → BI |
| **Roberts et al. (2012)** | Distraction Mitigation Systems | TAM + Unobtrusiveness (UO) + External Factors (Age, Gender, Feedback Conditions (FC) among others) | PEOU →BI<br>PU → BI<br>UO →PEOU + PU<br>Age → PU<br>FC → UO + PEOU |
| **Adell (2009)** | Driving Assistance Systems | UTAUT | PE → BI<br>SI → BI |

| | | | |
|---|---|---|---|
| **Meschtscherjakov et al. (2009)** | 5 Driver Assistance Systems for eco-efficient driving | TAM + Disturbance (D) + Perceived Risk + Suitability (S) + Demographic Variables (Age, Gender, Frequency of car driving) | S → PU + BI + PEOU<br>D → PU + BI |
| **Planing (2014)** | Advanced Driver Assistance Systems | Many factors including TAM constructs, Perceived Risk, Perceived Costs, Background Variables such as Age and Gender and Experience | An acceptance model similar to UTAUT model,<br>PU → BI<br>Age, Gender and Experience as moderators |
| **Höltl and Trommer (2012)** | Driving Assistance for Traffic Management Systems | TAM without behavioral intention to use but with perceived efficiency and changed driving behavior | PEOU → PU<br>Age → PEOU |
| **Kwon, Choi, and Kim (2007)** | Context-Aware Systems | TAM with second-level factors | PU → BI<br>PEOU → BI<br>PEOU → PU |

# 3. Research Model

*After having pointed out the research purpose and introducing to the research area, it is essential for this study to propose a means to achieve the purpose in this field. Based on various models and theories explaining the user acceptance of technologies and innovations and on prior studies in related fields, this chapter proposes a research model and states hypotheses about potential explanatory factors for the acceptance of Car Infotainment Systems.*

## 3.1. Overview

Again, the research purpose is to measure car driver's perceptions of the upcoming generations of Car Infotainment Systems as well as to identify the factors influencing the acceptance of these systems. For both it is necessary to consider possible important factors and to construct a research model. To measure the driver's attitudes, it is necessary to measure the factors that are of importance for this kind of systems. Furthermore, to identify the influencing factors for the intention to adopt the system, some factors have to be proposed so that the causal relationships can be tested.

As it could be seen in the preceding section, there is little research done closely related to the user acceptance of Car Infotainment Systems. Thus, there is no sufficient experience with user acceptance theories in this particular field which could be used as a starting point for this thesis. A look into other research studies in related academic fields such as ubiquitous/pervasive computing, mobile computing, nomadic computing and in internet-related studies showed that there are manifold theories and research models in use. Thus, a unique favorable theory or research model could not be determined.

However, even though most of the generic user acceptance theories use different notions for their factors, many similarities especially in the most important factors can be seen (Venkatesh et al., 2003). This argument becomes valid seeing that with the Unified Theory of Technology Acceptance eight different acceptance models could be merged together into one model (Venkatesh et al., 2003). The impression arises that hence the choice of the particular model is of less importance.

As could be seen in the preceding chapter, all closely related studies in the automotive field either use the basic TAM (Davis, 1989) or the Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh et al., 2003). The basic TAM is incorporated in the UTAUT, which can thus be considered to be a replacement of TAM. However, this basic TAM version can still easily be identified in UTAUT. Two of the four major determinants of behavioral intention in UTAUT are performance expectancy and effort expectancy which are similarly defined to the perceived usefulness and perceived ease-of-use which are the key determinants of the first TAM version. The additional factors in the UTAUT include social influence and facilitating conditions (Venkatesh et al., 2003). In this study, it seems inappropriate to include a social influence factor since no experience with the system exists and hence persons did not talk much yet about these systems. Thus, it is assumed to be hard for respondents to guess whether they will be socially influenced. For the remaining factor of facilitating conditions, UTAUT only indicates an influence on the actual use directly and not on the behavioral intention to use a system if an effort expectancy construct is part of the research model (Venkatesh et al., 2003). Thus, it is not of relevance for this pre-adoption study where only intentions and not the actual use itself can be measured.

As the basis for this study's research model, the authors therefore chose to use the Technology Acceptance Model (Davis, 1989) in the updated version without the mediating factor of attitude (Venkatesh & Davis, 1996). As has been mentioned in the preceding section, there are newer versions of TAM existing which extend the basic TAM with additional second-level factors. It has been argued that the basic TAM factors have no sufficient explanatory power for the adoption of technology (Legris, Ingham, & Collerette, 2003). The focus of this research is to conduct a first study on the user acceptance of Car Infotainment Systems and belongs to one of the initial acceptance studies on Connected Car innovations. To open up this research field, it seems sufficient and appropriate to start by determining only the directly influencing factors and therefore to use only the first version of the Technology Acceptance Model.

Almost all of the car-related acceptance studies extend their basic theory with additional factors in order to increase their explanatory power and to fit it to the particular context. It has further been argued that the newer emerging computer systems have different characteristics than the ones which were in consideration at the time of TAM's emergence and that hence new adoption models are necessary (Hedman & Gimpel, 2010; Yoo, 2010).Thus, it makes sense to consider additional factors in this study's research model. For these additional factors, potential factors from other TAM extending studies in related areas have been taken into consideration. Matching them with known concerns about Car Infotainment Systems from the literature and considering the characteristic of a pre-adoption study reduced these candidate factors to the research model that is going to be introduced subsequently.

In this research model, first of all, testing the validity of the basic TAM is of interest since it has been increasingly criticized and also because of the call for new acceptance models in today's computing environments. All other tested hypotheses on the factors concern are only concerned with direct implications on the intention to adopt. Interrelations in between the factors are not of interest for this research purpose and can be tested in future research as well as indirect influences of other factors on a second level.

## 3.2. Perceived Usefulness

The perceived usefulness construct has been introduced by Davis (1989) as one of the two major factors influencing the behavioral intention to use information systems. It thereby belongs to the basic Technology Acceptance model which is at the core of this study's research model. Adapted from its initial definition by Davis (1989), perceived usefulness is defined as *the degree to which a driver believes that using an app-based Car Infotainment System would enhance his or her performance while driving*.

The high influence of perceived usefulness on the acceptance of innovations has been shown in many IS studies across different research fields (King & He, 2006). Particularly in the reviewed car-related user acceptance studies, all of the studies that actually tested for the causal relationship between perceived usefulness (respectively the pendant performance expectancy in UTAUT) and the behavioral intention to use the system confirmed this hypotheses (Adell, 2009; Kwon et al., 2007; E. Park & Kim, 2014; Planing, 2014; Roberts et al., 2012).

The importance of perceived usefulness for explaining technology acceptance is further underlined by its presence in various acceptance models (Venkatesh et al., 2003). Represented in the UTAUT as performance expectancy, this construct is similarly defined as "… the degree to which an individual believes that using the system will help him or her to attain gains in job performance" (Venkatesh et al., 2003, p. 447). Incorporating constructs from five other theories about adoption behavior (the Technology Acceptance Model (Davis, 1989), the combined

TAM and Theory of Planned Behavior (Taylor & Todd, 1995), the Motivational Model (Davis, Bagozzi, & Warshaw, 1992), the Model of PC Utilization (Thompson & Higgins, 1991), the Innovation of Diffusion Theory (Moore & Benbasat, 1991) and the Social Cognitive Theory (Compeau & Higgins, 1995)), Venkatesh et al. (2003) confirm the presence of this construct in various theories.

One of the earliest information systems acceptance assessment studies in the automotive field has been performed by Van Der Laan, Heino, and De Waard (1997). The first of the nine indicators used in this study was concerned with assessing the perceived usefulness of respondents and proved to be related to the acceptance (Roberts et al., 2012; Van Der Laan et al., 1997).

Hence, the perceived usefulness also has to be considered as an important factor for determining the acceptance of car infotainment systems in this study. As it is indicated by TAM, persons who perceive an information system as more useful, have considerably also a higher intention to use the system. This is captured in the following hypothesis:

***H1: A driver's perceived usefulness of an app-based car infotainment system has a positive effect on his/her behavioral intention to use the system.***

## 3.3. Perceived Task-Technology-Fit

Another so far unmentioned theory trying to explain the adoption of Information Systems has been suggested by Goodhue (1995), respectively Goodhue and Thompson (1995). The authors argue thereby that there are two streams of theories providing explanations for the utilization and consequent success of information systems. The first category has a focus on the utilization and uses mainly beliefs, attitudes and behavioral constructs for the explanation. The theory of planned behavior and the theory of reasoned action as well as their offspring TAM and the later UTAUT belong to this category. The theory of task-technology-fit which has been suggested by these authors belongs to the other category which assumes utilization and focusses on the impact on the performance of individuals by regarding how the technology provides a fitting solution for the tasks of the user (Goodhue & Thompson, 1995). The theory states that a fit between the task characteristics and the technology characteristics influences both the utilization and the individual performance positively (Goodhue & Thompson, 1995). A combination of utilization and fit models however is possible. Thereby the task-technology-fit is indirectly influencing the utilization by forming beliefs and attitudes (Goodhue & Thompson, 1995).

Following this argumentation, Dishaw and Strong (1999) extended the TAM with task-technology-fit constructs. Hereby, the task-technology-fit is assumed to have a direct influence on the actual usage of the system. However, since in the case of this study no actual usage is observable, we assume to find a direct influence on the behavioral intention to use which is the direct predecessor of actual usage in TAM (Davis, 1989). The primary linkage between the factor models is in this approach is assumed by Dishaw and Strong (1999) to be between the task-technology-fit and perceived usefulness construct. This follows from the argumentation that if the technology provides a good fit with the task, users should perceive the technology as being useful for that specific task (Dishaw & Strong, 1999).

The task-technology-fit theory has to the authors' knowledge so far neither been applied directly or as an extension for explaining the acceptance of car-related information systems. However, in the related area of mobile computing, both of the suggested relationships could be supported (Zhou, Lu, & Wang, 2010). Furthermore, even if not directly stated as a separate construct, considerations of the task-technology-fit can be seen in some of the other constructs proposed in the car-related studies. As such, Meschtscherjakov et al. (2009) uses the construct of suitability to determine whether the system serves its purpose well. Moreover, the construct of Service & Display quality in E. Park and Kim (2014) contains measurement items that ask whether Car Navigation Systems fully meet a driver's needs or whether the functionalities are in line with the purpose of the system. Already in Van Der Laan et al. (1997) effectiveness of the system, whether it provides the right functionalities or is superfluous has been considered as one of the nine most important indicators of user acceptance in the telematics field. This fits with the reflection that the main task of a driver is driving (Zheng et al., 2007), while app-based Car Infotainment Systems go beyond providing driving-related functionalities and are potentially able to provide more and more entertainment and information that is unrelated to this core task. Thus, it seems to be questionable whether these systems actually meet the needs of car drivers.

The authors consider an actual comparison between technology and tasks to be impossible without system experience and thus define this construct as the perceived task-technology-fit: *The perception that the capabilities of the Car Infotainment System match with the driver's requirements* (adapted from Lin & Huang, 2008). Following the reviewed literature about the extended TAM with task-technology-fit constructs, the following hypotheses are proposed:

***H2: The perceived fit between functionalities of an app-based car infotainment system and a driver's task needs has a positive effect on his/her behavioral intention to use the car infotainment system.***

***H3: The perceived fit between functionalities of an app-based car infotainment system and a driver's task needs has a positive effect on his/her perceived usefulness of the car infotainment system.***

## 3.4. Perceived Risk

A major concern for in-vehicle information systems is driver distraction (Roberts et al., 2012). Accounted to the emergence of ubiquitous applications, an increase of crashes due to driver distraction could be observed (Roberts et al., 2012). However, Roberts et al. (2012) find that drivers do not perceive the usage of e.g. smartphones in the vehicle systems as being dangerous even though it has a multiplying effect on the likelihood of car crashes. Car Infotainment Systems seek on the one hand to increase the safety of driving by providing more integrated and easier-to-use systems to communicate for example. On the other hand, the newer generations of Car Infotainment Systems provide more and more information and entertainment at the hand of car drivers which can potentially increase the driver distraction.

The perceived risk of information systems has already been considered as an influencing factor for the technology acceptance in other fields such as mobile and electronic commerce and has been integrated into TAM (Pavlou, 2003; Wu & Wang, 2005). In the directly related study about smartphone-car-connectivity of J. Park et al. (2013), this factor has thought not been included in the research model. However, they indicate that future research about this sort of systems should include safety concerns. Two car-related studies do indeed consider disturbance and/or risk as potential factors but find evidence for an influence on the behavioral intention to use only in one case (Meschtscherjakov et al., 2009; Planing, 2014).

Another concern which is prevalent in most ubiquitous computing areas is privacy and trust (Satyanarayanan, 2001). For providing smart functionalities, app-based car infotainment systems get deep access to car and personal data and connect to the internet. It therefore becomes potentially possible, for example, to track people's car movements. By opening up these infotainment systems as app platforms for third-party app developers, new parties will get access to this data and not only the comparably trustworthy car vendor. Höltl and Trommer (2012) is the only study considering this use of personal information in their survey but they account it to perceived usefulness which seems not to be in accordance with the initial definition of Davis (1989).

According to Mallat, Rossi, Tuunainen, and Öörni (2008), this privacy issue marks one dimension of the perceived risk and takes an influence on the behavioral intention to use mobile ticketing systems. The authors thus propose a definition of perceived risk which includes both of these risk dimensions, driver distraction and privacy. Lu, Hsu, and Hsu (2005) categorize different dimensions of risk. In this particular case, driver distraction represents the dimension of physical risk while the privacy concern falls rather into the category of information risk. The authors thus assume that perceived risk is a formative construct with two dimensions (MacKenzie, Podsakoff, & Podsakoff, 2011) and define perceived risk as *the driver's subjective expectation of suffering from using Car Infotainment Systems* (adapted from Pavlou, 2003; Wu & Wang, 2005).

Following the commonly formulated influence of perceived risk, the authors state the hypothesis:

***H4: The perceived risk of an app-based car infotainment system has a negative effect on his/her behavioral intention to use the car infotainment system***

Moreover, Zheng et al. (2007) implies that a high concern about the safety and security of this system will influence driver's perception of the adequateness of the system for its purpose. An in-vehicle system should rather support the driving task than jeopardizing it. Thus, a negative influence on the perceived task-technology fit can also be assumed.

***H5: The perceived risk of an app-based car infotainment system has a negative effect on his/her perceived task-technology-fit of the car infotainment system.***

## 3.5. Perceived Ease-of-Use

The second key construct in TAM is the perceived ease-of-use. Similarly to perceived usefulness its influence on the acceptance has been proven over years in manifold IS studies (King & He, 2006). It is further not only a key determinant in TAM, but also has equivalents in the Model of PC Utilization (Thompson & Higgins, 1991) and the Diffusion of Innovation Theory (Rogers, 1995) and was hence considered in the construction of the UTAUT (Venkatesh et al., 2003). Adapted from the basic TAM, we define the perceived ease-of-use as *the degree to which a driver believes that using an app-based Car Infotainment System would be free of effort* (Davis, 1989).

TAM studies usually consider two implications of the perceived ease-of-use. Firstly, perceived ease-of-use is considered to take a direct influence on the behavioral intention to use a particular system and secondly, the perceived usefulness is also considered to be influenced by this factor (Davis, 1989). The latter relationship is not considered in the UTAUT anymore (Venkatesh et al., 2003). However, even if the influence has shown to be less strong than on the behavioral intention to use there is still significant support for its influence on the perceived usefulness (King & He, 2006).

Furthermore, perceived ease-of-use (respectively effort expectancy) has been considered in many of the car-related acceptance studies introduced in the last chapter (Adell, 2009; Höltl & Trommer, 2012; Kwon et al., 2007; Meschtscherjakov et al., 2009; Roberts et al., 2012).Even in the study of  E. Park and Kim (2014) which explicitly waived the perceived ease-of-use, this factor was just replaced by other strongly related factors such as Service & Data Quality and satisfaction which in this study even share measurement items with the perceived ease-of-use.

The first relationship has thereby been found to be significant in three studies (Kwon et al., 2007; E. Park & Kim, 2014; Roberts et al., 2012)  whereas the other studies either did not test this relationship (Höltl & Trommer, 2012) or did not find sufficient support for this influence (Adell, 2009). Even though this might imply some doubts on this relationship, Zheng et al. (2007) assumes a relationship between perceived usability (ease-of-use) and the acceptance in the particular case of Car Infotainment. Thus, we consider this relationship in our research model and state the following hypothesis:

***H6: A driver's perceived ease-of-use of an app-based car infotainment system has a positive effect on his/her behavioral intention to use the car infotainment system.***

Moreover, it seems logical that a high complexity in the usage of the system implies a reduced extent of usefulness. The main task in the car is driving and a Car Infotainment System is supposed to support this task rather than distracting from it. If the system usage, however, becomes too complex, it might not be usable during driving anymore and thus loses its perceived usefulness. Support for this assumption could be found in two studies (Höltl &

Trommer, 2012; Kwon et al., 2007). Since an increased complexity of the system might jeopardize both the usefulness of the system and the concentration of the driver on its main task driving and thus becomes also a safety issue (Zheng et al., 2007), we conclude with the following two hypotheses:

***H7: A driver's perceived ease-of-use of an app-based car infotainment system has a positive effect on his/her perceived usefulness of the car infotainment system.***

***H8: A driver's perceived ease-of-use of an app-based car infotainment system has a negative effect on his/her perceived risk of the car infotainment system.***

## 3.6. Perceived Costs

Another category of factors that can influence the intent to adopt an innovation is to be seen in constraints (Venkatesh & Brown, 2001). One of the possible constraints refers to the resources available for a potential adopter, as such the costs of the innovation can limit the adoption intention (Venkatesh & Bala, 2008). The decision to purchase a car is for many people already a strong financial burden. To equip the car with a new generation infotainment system, will increase this financial effort and a high additional price might hinder potential adopters from purchasing this additional system. It is thus not surprisinge that the price of an in-vehicle infotainment system is a key concern for buyers (Accenture, 2012).

Financial considerations have also been done in some of the car-related studies. As such, Planing (2014) explained why costs should be tested as an influencing factor. However, due to measurement issues he had to omit this factor in his analysis. The willingness to pay has also been considered in Höltl and Trommer (2012) as part of the perceived efficiency. Already in the early study of Van Der Laan et al. (1997) this willingness to pay has been suggested as important factor. Furthermore, in the related field of mobile computing this factor is present in some research models (Hong & Tam, 2006; Mallat et al., 2008). Expenses arising in the case of app-based car infotainment systems are first of all the acquisition costs of the system which are considerably high and charged once. Furthermore usage costs arise in the form of a mobile data contract or the acquisition costs of apps. Since some systems might use the mobile data connections of a car driver's smartphones, the mobile data contract costs however do not have to be considered necessarily. This second kind of costs has lower actual fees but arises frequently. Recent research indicates that costs are among the three most important reasons across different generations and the willingness to pay for in-vehicle technologies is a critical issue (Deloitte, 2014b); further infotainment contents are expected to be free of charge by many customers (Deloitte, 2012). By having these two very different kinds of costs, the perceived costs fall into two dimensions and reflect a formative construct (MacKenzie et al., 2011).

The authors therefore define the factor of perceived costs as *the possible expenses of using Car Infotainment Systems, including acquisition costs of the system and usage costs* (adapted from Wu & Wang, 2005) and state the hypothesis:

***H9: The perceived costs of an app-based car infotainment system have a negative effect on his/her behavioral intention to use the car infotainment system.***

## 3.7. Behavioral Intention to Use

The behavioral intention to use is again a key construct of the basic TAM. It is the direct antecedent of the actual usage and thus considered to be its predictor. We assume the connection to the actual usage in this study. However, we cannot test this hypothesis due to the early stage of the diffusion process. It is defined as a *driver's willingness to use the Car Infotainment System* (Davis, 1989). Of course, in this case there is a strong relation between the acceptance of the innovation and a purchasing decision (Van Der Laan et al., 1997; Zheng et al., 2007). As such, the behavioral intention to use is also reflecting a driver's willingness to purchase an app-based Car Infotainment System.

## 3.8. Summary

To sum up, all considered constructs and factors are visualized in Figure 3.1. The arrows between the constructs determine the proposed hypotheses and thus causal relationships. The hypotheses 1, 6 and 7 thereby represent the classic TAM relationships. All other factors and relationships have been developed based on a literature review about Car Infotainment Systems and car-related user acceptance studies. It can be seen that only factors have been included that are considered to have a direct impact on the behavioral intention to use. Indirect, second-level factors as they have been proposed in TAM2 or TAM3 are out of the scope of this thesis and their evaluation remains for future research. Table 3.1 further provides a short summary of the proposed hypotheses and a summarizing table with the construct definitions is attached to this thesis (see Appendix 5: Research model - Factor definitions).

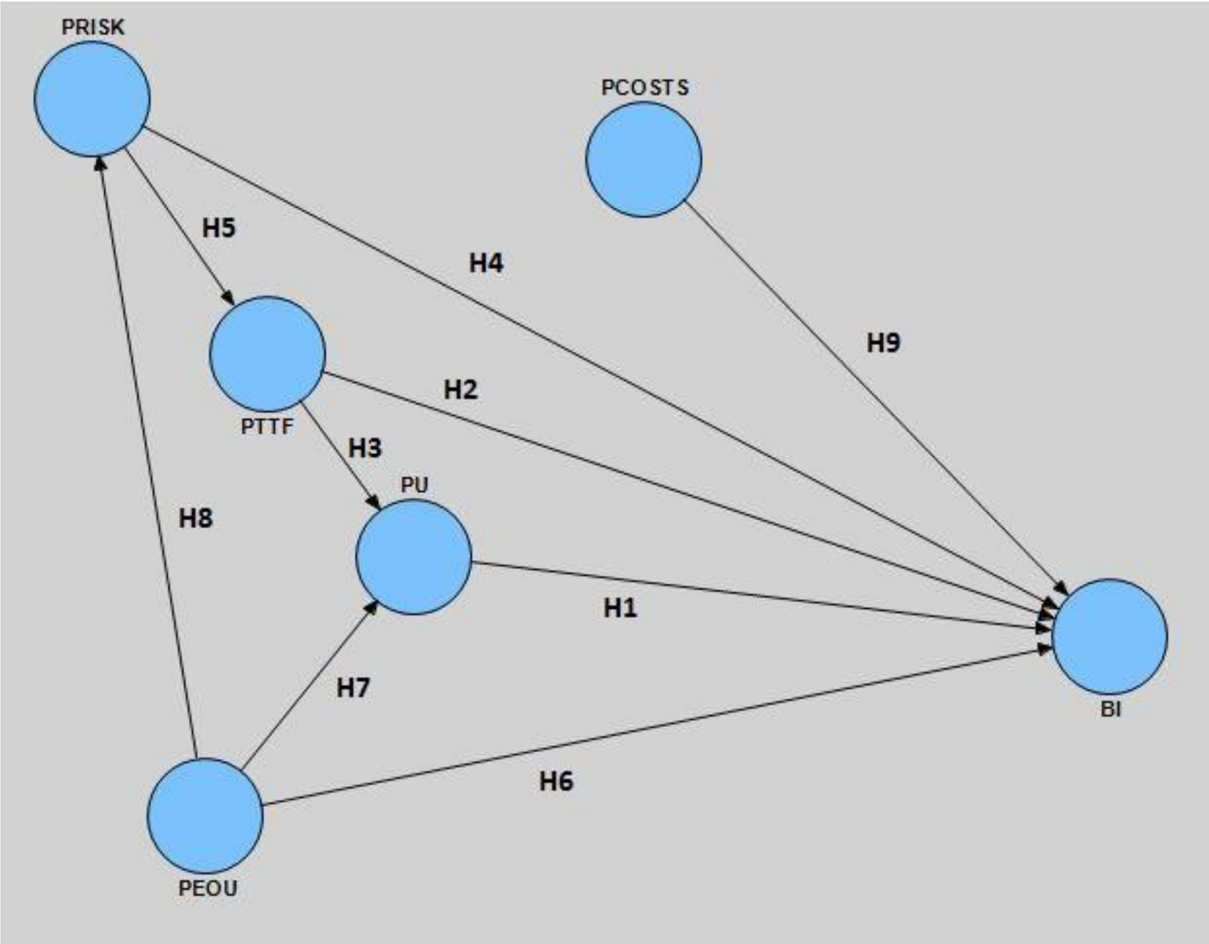



**Figure 3.1: Research Model**

**Table 3.1: Stated Hypotheses**

| Path Code | Hypotheses |
|---|---|
| **PU → BI** | H1: A driver's perceived usefulness of an app-based car infotainment system has a positive effect on his/her behavioral intention to use the system. |
| **PTTF → BI** | H2: The perceived fit between functionalities of an app-based car infotainment system and a driver's task needs has a positive effect on his/her behavioral intention to use the car infotainment system. |
| **PTTF → PU** | H3: The perceived fit between functionalities of an app-based car infotainment system and a driver's task needs has a positive effect on his/her perceived usefulness of the car infotainment system. |

| | |
|---|---|
| **PRISK → BI** | H4: The perceived risk of an app-based car infotainment system has a negative effect on his/her behavioral intention to use the car infotain-ment system |
| **PRISK → PTTF** | H5: The perceived risk of an app-based car infotainment system has a negative effect on his/her perceived task-technology-fit of the car in-fotainment system. |
| **PEOU → BI** | H6: A driver's perceived ease-of-use of an app-based car infotainment system has a positive effect on his/her behavioral intention to use the car infotainment system. |
| **PEOU → PU** | H7: A driver's perceived ease-of-use of an app-based car infotainment system has a positive effect on his/her perceived usefulness of the car infotainment system. |
| **PEOU → PRISK** | H8: A driver's perceived ease-of-use of an app-based car infotainment system has a negative effect on his/her perceived risk of the car info-tainment system. |
| **PCOSTS → BI** | H9: The perceived costs of an app-based car infotainment system have a negative effect on his/her behavioral intention to use the car in-fotainment system. |

# 4. Research Methods

*The main goal of this chapter is to present the means that were used to answer the research questions. By doing this, we intend to discuss the research type, approach, and strategy as well as methods and techniques chosen for data collection. Occurring research quality and ethical issues are being discussed thereafter.*

A research plan is necessary that describes and argues for the means that are used in order to achieve the research purpose and to answer the research questions. As it is argued by many scholars, this selection of the research methodology plays a main role in designing the research process (Recker, 2013). Research methodology is defined as techniques and procedures used to collect and analyze data (Saunders, Lewis, & Thornhill, 2007). This research design describes the process of finding answers to the research questions (Saunders et al., 2007).

## 4.1. Categorization of the study

### *4.1.1. Research type*

Each scientific research is categorized based on its purpose. According to Bhattacherjee (2012), there are three types of research: exploratory, descriptive, and explanatory. In addition, a specific research question can be answered by various types of research (Recker, 2013). For instance, a research type can be approached by both explanatory and descriptive means based on the research question (Bhattacherjee, 2012). The same thing holds true for this study research questions, meaning that the questions include both descriptive and explanatory types of research.

An explanatory research is considered to answer why and how types of questions (Bhattacherjee, 2012). This kind of research aims to provide an answer concerning the casual mechanisms of a phenomenon (Recker, 2013), and to explain relations between variables (Saunders et al., 2007). A descriptive research however, provides answers to what, where, and when types of questions in which a detailed documentation of the target phenomenon is presented (Bhattacherjee, 2012). As Recker (2013) states, descriptive research refers to carefully observing and documenting the phenomenon of interest which can be either unknown or under-studied. Considering these definitions, the first and the second research question of this study aims for a descriptive and explanatory research type respectively.

This study emphasizes on how the upcoming car infotainment systems are perceived by car drivers in order to explain the users' perceptions of car infotainment systems. Therefore, a research model has been proposed and discussed for the sake of measuring the users' perceptions and for evaluating the influential factors concerning car infotainment systems. Hence, based on the nature of the study, not only a descriptive research was pursued to answer the users' perceptions, but also an explanatory one that was used to provide the influential factors.

### *4.1.2. Research approach*

As stated by Bhattacherjee (2012), each scientific research includes two levels being, theoretical level and empirical level. As he further notes, in empirical level, the theoretical concepts and relationships are being tested for the sake of building better theories. In order to do this, there are three main approaches used by researchers: inductive, deductive and abductive.

Inductive reasoning refers to moving from a set of specific facts to a general conclusion while deductive reasoning means that the researcher infers arguments as logical consequences from a set of assumptions (Recker, 2013). Furthermore, inductive and deductive approaches are also called "theory building" and "theory testing" respectively (Bhattacherjee, 2012). A deductive approach involves the development of a theory by providing a number of hypotheses followed by a rigorous test (Saunders et al., 2007). There is also another approach called abductive reasoning which is used when the researcher thinks that some unrelated facts are somehow connected to one another (Recker, 2013).

Based on the definitions provided above and taking into consideration the purpose of this study, this study applies a deductive approach since it tests a previously developed theory with a set of assumptions. As part of this study, an extended technology acceptance model has been developed and nine hypotheses about the casual relationships between the proposed factors have been provided in order to be tested. The deductive approach is often coupled with quantitative measuring. Hence, a quantitative approach was chosen to collect the primary data being the users' perceptions on car infotainment systems. In order to do so, we decided to use an online survey because using the internet could increase the sample size and diversity, and could make an easier access for the respondents who were interested in filling in the questionnaire (Robson, 2011).

### *4.1.3. Research strategy*

In order to test the research hypotheses, a research strategy must be designed. According to Saunders et al. (2007), the role of the research strategy is to enable the researcher to answer the research question and thereby to meet the research objectives. Some of the most popular research strategies are experiment, survey, case study, action research, grounded theory, ethnography and archival research (Saunders et al., 2007).

As it is defined by Bhattacherjee (2012), a survey method refers to using a standardized questionnaire or interview to collect data concerned with people and their preferences. He also states that the survey method can be used for descriptive, exploratory, or explanatory research and is one of the most popular methods when it comes to quantitative research. As Robson (2011) claims, surveys are mostly used for descriptive research. Thus, this strategy seems suitable for this research purpose.

As the research questions in this study concern the perception of the drivers on car infotainment systems, we decided to carry out the survey method. It is the most suited strategy when it comes to measuring a wide variety of unobservable data including people’s preferences and beliefs regarding a phenomenon (Bhattacherjee, 2012). Furthermore, as it has been argued above, for the theory-testing approach used in this study, quantitative methods are most commonly used. A survey strategy allows the collection of quantitative data rather than the alternative strategy options (Saunders et al., 2007). In addition, as the sample size is very large including drivers around the world, a survey method is supposed to be the best way to collect data considering the time, costs and effort which is required for its execution (Bhattacherjee, 2012). This method also facilitates the remote data collection of distant respondents (Bhattacherjee, 2012). Nevertheless, survey research quality includes some threats and requires a sufficient sample size in order to address certain biases which can occur in the data collection (Bhattacherjee, 2012). These threats and issues will be explicitly addressed in later sections. There, the authors provide a description of the means that are used to overcome the problems and to ensure the quality of the research.

## 4.2. Data collection

When it comes to gathering data in a short amount of time and the least cost, survey method is the most suited strategy in quantitative research (Bhattacherjee, 2012). However, the survey data collection itself, has different approaches such as postal questionnaire, internet survey, face-to-face interviews, telephone interviews (Robson, 2011). Thus, based on the characteristics of each approach, based on our limitations in time and cost, and most importantly based on our research purpose, the approach used to carry out the research was internet survey. As Robson (2011) suggests, there are a number of reasons or benefits regarding this data collection. First, the speed of the data collection is high which is ideal when the time period of data collection is short. Second, comparing to alternative approaches, the cost is very low. Third, it allows the distribution of the sample to be wide. However, usually the response rate is poor or medium and the questions must be chosen carefully in order to lessen the response bias (Robson, 2011).

### *4.2.1. Literature review*

In order to build the theory that is to be tested in this study, a literature review has been conducted as recommended by Saunders et al. (2007). The literature review was targeted at finding related studies about technology acceptance theories in general, car infotainment systems and in-vehicle technology as well as the intersection of driver acceptance of computer systems in the car. The results of this literature review have been presented in the second chapter and build the frame of reference of this study. Moreover, in order to complement the rather small number of references found in this intersection area of driver acceptance, wider areas like the technology acceptance in ubiquitous and mobile computing environments have been reviewed. This was done to confirm whether the findings and proposed factors are well-grounded also in other related research areas. Overall, this secondary literature approved the legitimacy of the proposed factors. The authors used the Lund University library search, Google scholar, SpringerLink and ScienceDirect as sources for finding literature references. A huge number of different keywords has been used in this research. Finding relevant literature especially for the last category was quite challenging. Therefore, Table **4.1** provides only the most successful keywords used in order to keep this section useful for readers.

**Table 4.1: Keywords used for finding literature**

| Technology Acceptance Theories | Car Infotainment Systems | Technology Acceptance of in-vehicle information systems |
|---|---|---|
| Technology acceptance | Infotainment | Driver Acceptance |
| Technology adoption | Car Infotainment | Driver Adoption |
| Innovation adoption | In-Vehicle technology | Acceptance In-Vehicle |
| User acceptance | In-Vehicle Infotainment | Driver Perception |

### *4.2.2. Data source*

In this study, the primary data source was concerned with the drivers' perceptions. Therefore, the data source could contain any driver's perception regarding car infotainment systems. The only requirement the authors considered was that respondents should have a driving license in order to ensure that they are able to judge about usability and distraction issues of an in-vehicle system while driving. The data was collected from car drivers from different age groups and continents through an online questionnaire.

### *4.2.3. Target population and sampling*

A population refers to all people or items (unit of analysis) that a researcher is willing to study (Bhattacherjee, 2012). Based on this definition, the target population of this study includes all drivers who have driving license. As it has been argued before, this research is a pre-adoption study. The systems in focus have not hit the broad market yet and it is therefore almost impossible to reach a significant amount of car drivers who could actually use and experience the system. Therefore, having a driver license was the only requirement. As the topic would be interesting for any person around the world, the authors further decided not to limit the research to a specific country or region. Instead, they strived to share the survey in the internet in order to collect data from anyone who is interested in the study.

The sampling techniques used for this study were mainly convenience sampling and snowball sampling. Convenience sampling or accidental sampling refers to a technique in which the data is collected from the population that is reachable, readily available or convenient (Bhattacherjee, 2012). Since the target population with all car drivers is very large and broadly distributed, the authors distributed the survey online in order to reach as many drivers as possible. Therefore, the respondents were addressed via e-Mail and on social networks including Facebook, LinkedIn and Xing. The authors started by addressing their direct contacts for convenience reasons. Additionally, the snowball sampling technique was used in the sense that respondents were asked to recommend others to participate in the study (Bhattacherjee, 2012). Thus, not only direct contacts were addressed. Due to this approach, the responses however stem mainly from Europe, Asia and Northern America since most of the authors' direct contacts are located in these continents. In addition to spreading the questionnaire to contacts, the link has been posted in several automotive user groups in the career networks Xing and LinkedIn. The authors assumed that using these groups will increase the probability of receiving answers from these addressees due to a higher interest in the topic. However, it could be argued that using this approach can introduce a bias due to an assumed higher interest in new car trends. Nevertheless, there is no obvious linkage between the constructs used in the research model and a person's interest in car technologies in general. In contrast, these respondents' familiarity with the trends and technologies might increase the accuracy of the data since their opinion could already manifest earlier. This argument becomes valid seeing that a non-mandatory, open-ended question at the end of the questionnaire received a huge number of responses with manifold different and developed opinions.

## 4.3. Development of the questionnaire

### *4.3.1. Administration of the survey*

Surveys can be categorized into self-administrated and interviewer-administrated surveys (Saunders et al., 2007). In the first category, the participant can choose the circumstances freely in which he wants to respond to the survey. There is no interviewer taking part. Internet surveys and postal surveys which are sent out via mail are two examples of self-administrated questionnaires. In interviewer-administrated surveys, an interviewer is posing the questions directly to the participant, either face-to-face or on the telephone.

For this study, the authors chose an internet survey, since it is easy to distribute, consumes less time and cost for the administration than other alternatives. Furthermore, the results are already available in a digital format, which eases the preparation for the quantitative analysis. It was necessary for this study to reach a broad audience and therefore to spread the questionnaire fast, also to unknown people. Without knowing contact data of many people, it would be hard and time-consuming to reach many respondents with the alternative forms. The authors used Google Form to administrate the survey. This tool is free of charge and provided all necessary functionalities. It already provides basic descriptive statistics and graphics to get a first impression of the received data. Furthermore, it provides the responses in a spreadsheet format with the rating degree questions already coded as numbers. The results could as such quickly be used for data analysis. Sharing an online questionnaire is convenient, since it only requires to copy the URL and to send it via e-mail or to provide it on social networks.

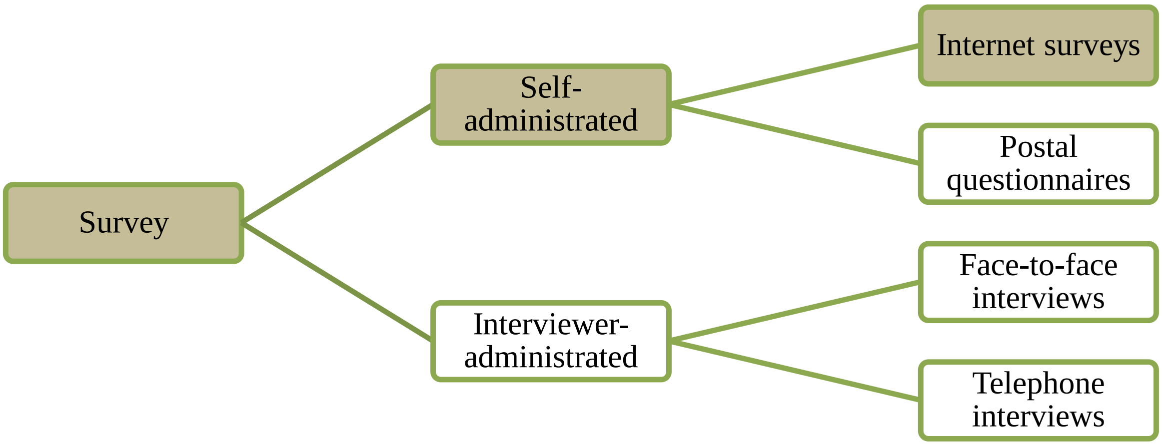



**Figure 4.1: Types of surveys (based on Robson, 2011)**

### *4.3.2. Designing the questionnaire*

In this study, the questionnaire was divided into three parts. The first part informed the respondents about the characteristics and functionalities of an app-based car infotainment system and offered a demonstration video of Volvo's integrated infotainment system using Apple CarPlay (see Appendix 1: Information text).

The second part asked for the demographic (e.g. gender, age, origin) and general information (e.g. driving experience/frequency, willingness to buy a car) of the participant (see Appendix 2: Demographic Questions). This information was not necessary for testing the hypotheses or analyzing the driver's perceptions. Instead, this data was collected in order to provide a transparent and detailed description of the sample used in this study. Only those respondents who had driving license were included in our sample. Thus, the first question was also used to evaluate this criterion and people outside the target group were directly forwarded to the end of the questionnaire. In total, six questions were provided in the first part.

In the third part of the questionnaire, questions were designed for the sake of reflecting the participants' perceptions on each factor of the research model by asking for their level of agreement to factor-related statements. In order to increase the validity and reliability in this part, establishing a comprehensive relation between the questions and the hypothetical factors within the proposed model was pursued. The initial measurement items can be found attached to this thesis (see Appendix 3: Measurement Items before Pre-Test). Before formulating the questions, the literature concerning each factor was reviewed as recommended by MacKenzie et al. (2011). Therefore, the questions were validated and carefully formulated based on prior studies in order to lessen the ambiguity and to enhance the research validity (MacKenzie et al., 2011). However, the measurement items for many factors have been designed in a different contexts, such as in a working environment (Davis, 1989; Venkatesh & Brown, 2001). Thus, adjustments to the context of this study in the measurement items had to be done in order to increase the comprehensibility. For each factor, several questions were formulated to measure the perceptions. For each of these measurement items, the respondents were provided with a 5-point Likert-scale which is most commonly used when the purpose is to test causal relationships (Saunders et al., 2007). Thus, the respondents were provided with five choices being from strongly disagree=1 to strongly agree=5 in order to show their level of agreement. As such, initially four questions were designed to reflect the factor perceived usefulness. All of them are statements which describe the usefulness of app-based Car Infotainment Systems and respondents could rate to which degree they agree on this statement.

The questionnaire ended with an open-ended question allowing the respondents to add their own opinions, suggestions and comments. Although surveys are highly dependent on the closed questions to collect quantitative data, introducing some open-ended questions may bring unexpected insights that could not be generated from the pre-formulated statements (Bhattacherjee, 2012).

### *4.3.3. Questionnaire pilot test*

To increase the validity of the results, questionnaires should be pre-tested (Recker, 2013; Robson, 2011). Especially, since the measurement items were modified to fit the context of this study, the clarity and comprehensibility of the questions needed to be evaluated in order to ensure that no confusion arises for the participants. All measurement items have been designed as required questions meaning that a participant has to answer all questions to be able to submit the questionnaire. This has been done in order to avoid a non-response bias. However, if a respondent does not understand a question but is required to answer it, this may result in a random answer. And this would introduce another bias into the results.

In order to address these issues in this study, a pilot test was carried out which addressed content validity and the wording of questions (Bhattacherjee, 2012). Questions should be clear, understandable and specific, not too general, too detailed or even ambiguous. Also the length of the questionnaire should be evaluated. A questionnaire that is too long and consumes too much time to be filled out, the response rate could be affected negatively due to the necessary effort. For the pilot test, 13 persons were specifically selected to fill out the questionnaire and make comments about the comprehensibility and clarity of the questions as well as the overall impression and length of the questionnaire. To get a broad feedback, this sample of 13 persons included academic experts in the field of mobile computing and in the field of driver acceptance studies, Information Systems teachers and master students as well as an industry expert in the field of Car Infotainment. The pilot test received 8 answers, covering all of the above mentioned groups. These groups are also recommended by MacKenzie et al. (2011) to be consulted for the formulation of measurement items.

The responses in the pilot test first of all confirmed the estimated time period necessary for taking part in the survey. Overall, the time period was reported with around five minutes. It was furthermore expected that people report to feel uncomfortable to answer questions about a system that they never used. However, this was not a particular issue of the statement formulation but is due to the character of a pre-adoption study. In a real-life purchasing decision, potential buyers are mostly also faced with a limited trial time in unusual situations or even just get a system demonstration by a salesman. Considering this, the information and demonstration video seem to provide a sufficient introduction for answering to this survey in a pre-adoption study. This specific issue had already been considered in the formulation of the measurement items which applied some of the phrasings for pre-adoption studies recommended by Karahanna, Straub, and Chervany (1999). Furthermore, it has been argued that questions appeared to be too generic and in some cases it was unclear whether the statements refer to future, potential or currently available car infotainment systems. It has also been mentioned that the questions should be a bit more detailed in order to increase the importance of the results for practitioners.

Taking this critic into consideration, the authors revised the measurement items and the information text (as can be seen in “Appendix 1: Information text” and “Appendix 4: Revised Measurement Items”). A major focus was put on clarifying that the system of interest in this study is a future system that includes an app ecosystem with third-party developers. Therefore, the information text was extended slightly and in almost all measurement items, the word “app-based” has been added. Furthermore, in the beginning of the criticized categories, a short introduction sentence was added in accordance with Adell (2009) to make clear that a potential system is addressed. In order to draw better implications for practice, the measurement items for perceived usefulness have been split to address car-specific applications and the replication of smartphone apps separately. For the same reason, an additional measurement item was included for the perceived ease-of-use. Main concerns regarding the comprehensibility have been mentioned for the perceived task-technology-fit category. Confusions arose on how the system is related to the task of driving. To make clear that not the action of driving directly but the purpose of using the car should be supported by the system, these measurement items have been reformulated and a help text has been included.

Table 4.2 shows an overview of the final constellation of measurement items per hypothetical factor.

**Table 4.2: Design of the questionnaire after pilot-test**

| Hypothetical Factor | Number of Questions | Type of Measurement Items |
|---|---|---|
| Perceived Usefulness | 5 | Reflective |
| Perceived Ease of Use | 4 | Reflective |
| Perceived Task-Technology-Fit | 3 | Reflective |
| Perceived Risk | 2 | Formative |
| Perceived Costs | 2 | Formative |
| Behavioral Intention to Use | 2 | Reflective |

## 4.4. Quantitative data analysis

In order to find answers to the research questions, the data collected with the survey was analyzed quantitatively. Both research questions needed different analysis methods. For the data analysis, software tools have been used. For the descriptive analysis and data cleaning, Microsoft Excel and GNU R have been used. The calculation of validity and reliability indicators as well as the Structural Equation Modeling (SEM) has been performed with smartPLS.

The first research question requires the aggregated measurement and description of the participants' perceptions about each factor. Therefore, descriptive statistical methods, such as the arithmetic mean and the standard deviation are used to describe the perceptions. Furthermore, histograms serve to display the data and to show distribution of answers for a particular hypothetical factor or for a particular question. While in most reflective constructs, the answers to each question are expected to be highly correlated and thus an aggregation for the whole factor seems sufficient, the formative constructs such as perceived risk and perceived costs might have significant different perceptions in their measurement items. Also for the perceived usefulness, slight differences between the usefulness of smartphone and car-specific applications are expected. As a result, for these constructs, precise descriptive statistics for each measurement item are important and can provide deeper insights. Descriptive statistics and visualization of the distribution of answers was also applied for providing the demographic and general information of the participants.

The second research question requires a different approach. Here it is necessary to determine the influencing factors of the behavioral intention to use. Thus, causal relationships between the hypothetical factors have to be tested. The hypotheses which have been aggregated in the research model need to be tested. For this purpose, inferential statistics are necessary. Since the research model contains more than one dependent variable, it is not appropriate to perform a common linear regression analysis. Instead, a path analysis with Structural Equation Modeling has been used which can deal with multiple dependent variables and therefore combines both factor analysis and regression analysis (Lowry & Gaskin, 2014). Two different approaches exist for Structural Equation Modeling: covariance-based modeling and partial least squares approaches. The main disadvantage of covariance-based modeling techniques is that they cannot deal with formative constructs (Lowry & Gaskin, 2014). Since the research model on hand contains two formative constructs (namely perceived risk and perceived costs), a partial least squares approach was applied by using smartPLS.

## 4.5. Ensuring research quality

A research must measure the right construct in a consistent manner to support both reliability and validity (Bhattacherjee, 2012). In addition, the constructs and hypotheses must be compared with the prior literature to enhance the internal validity as well as generalizability (Bhattacherjee, 2012). According to Saunders et al. (2007), the internal validity and reliability of the research depend on the questionnaire design and structure, and the rigor of the pilot testing. In this part of the study, all the faced quality issues and ethical concerns are presented. Furthermore, this section provides the means that the authors used in order to ensure a sufficient research quality.

### *4.5.1. Reliability*

As it is defined by Recker (2013), reliability indicates to what extent a variable is consistent in measuring the things it is intended to. In fact, if a research is to be repeated with the same scales, the same results must be represented (Recker, 2013). Reliability itself refers to consistency but not accuracy (Bhattacherjee, 2012). Aside from consistency, reliability also checks the robustness of the measurement model, and whether it is free of random or unstable error (Quinton & Smallbone, 2005). Hence, all the data gathered was checked after the data collection and some wrong or repetitive data was removed.

As it was mentioned earlier, the authors intended to use an online survey and spreading that out through Linkedin and Facebook which not surprisingly, brings sampling issues that can threaten the reliability of the research. According to Wright (2005), even the demographic information gathered from the respondents may be questionable since the characteristics of people in online communities may not be known well. Taking advantage of convenience and snowball sampling techniques, the data collection was not limited to a specific way. The authors gathered data through other ways such as direct e-mail and Yahoo groups which relatively enhanced the differentiation of the data. In the end, all the data collected was checked and compared in order to remove invalid responses.

Furthermore, reliability can be threatened when the respondents of a study are provided with imprecise, ambiguous questions regarding an unfamiliar topic (Bhattacherjee, 2012). In order to decrease the influence of these two issues, all the questions needed were made as simple as possible and then validated and tested through the pilot test. In addition, since the topic was not a very familiar topic for all respondents, the necessary information including a video was provided on the first page of the questionnaire. According to Saunders et al. (2007), it is necessary to provide a clear picture of the target phenomenon before collecting the data.

According to Bhattacherjee (2012), in order for a measure to be reliable, it must be both valid (measuring the right construct) and reliable (measuring the construct in a consistent manner). Statistical means have been applied to ensure both the reliability of each measurement item as well as of a set of measurements. The evidence of our study regarding these issues is provided in the analysis section.

### *4.5.2. Validity*

Validity or so called construct validity is defined as the extent to which a measure appropriately represents the underlying construct which it is supposed to measure (Bhattacherjee, 2012). Internal validity concerns whether the findings provide sufficient substantiated evidence for the interpretations offered in qualitative data analysis (Recker, 2013), which usually occurs when the independent variable affects the dependent variable (Neuman, 2011). In order to meet this goal, the whole questionnaire was divided into several parts including several sets of questions. In the third part of the questionnaire (see Appendix 4: Revised Measurement Items), each set of questions is strictly related to a construct of the proposed research model. The questions and their wording are based on the prior studies on TAM and their validated items regarding each specific construct. However, two of the whole questions were added by the authors have then be validated through the pilot test. Thus, not only the questions were validated based on the literature review, but also the whole questionnaire was tested to increase the clarity and to lessen the ambiguity of the questionnaire.

There were three kinds of validity that were ensured by the pilot test process: face validity, content validity and predictive validity. According to Bhattacherjee (2012), predictive validity is defined as the degree to which a measure successfully predicts a future outcome that is theoretically expected to predict. Despite choosing the constructs based on the literature review, the statistical tests shows that all the relations except one were supported which will enhance the predictive validity of our research. Furthermore, convergent and discriminant validity have been ensured with statistical tests after the data collection. The results are presented in section 5.3.

### *4.5.3. Generalizability*

Generalizability or so called external validity is defined as whether the observed relations can be generalized from the sample to the population or to other people, organizations, contexts, or time (Bhattacherjee, 2012). In other words, it refers to the effectiveness of generalizing experimental findings (Neuman, 2011). Based on the nature of our study which refers to evaluating the drivers' perception on car infotainment systems, the survey was open to any driver who wanted to participate in our study. Needless to mention, it is only concerned with car infotainment systems as a whole, but not a specific application or company product. On the other hand, the authors strived to spread out the survey online wherever possible in order to gather data from as many drivers as possible. Using the online survey gave the authors the chance to enhance the generalizability of the study since the data gathering was not limited to a specific country or region. Additionally, having a driving license was the only restriction considered in this study. Regardless of all the steps taken above, the results of the study cannot be generalized to all car infotainment innovations since each innovation has its own specific pros and cons. Also, since the convenience sampling technique was used for the data collection process which itself means that the respondents were not selected randomly; the results cannot be generalized to all car drivers around the world.

Furthermore, in order for our research to be transferable to other settings or studies, the authors strived to provide a comprehensive description of the context including constructs, assumptions, process of data collection as well as the main findings.

### *4.5.4. Ethics*

As it is defined by Bhattacherjee (2012), ethics is the moral distinction between right or wrong or so called good or bad. However, Robson (2011) claims that there is a distinction between moral and ethics themselves. Although both are related to good or bad, ethics are usually concerned with general principles of what one ought to do, while moral usually refers to whether or not a specific act is consistent (Robson, 2011). According to Neuman (2011), one of the major ethical issues in survey research is the invasion of privacy. As he further states, respondents must have the right to decide when and to whom they reveal personal information. The researcher must respect the respondents in order to get accurate data from them. As Neuman (2011) suggests, when the researchers trust their respondents and provide mutual respects, they can expect to collect accurate and honest information from participants. In addition, respondents must be allowed to participate voluntarily without being harmed so that they have the right to withdraw from the study at any time and they will not be harmed as a result of their answers (Bhattacherjee, 2012; Neuman, 2011; Robson, 2011). On the other hand, even if the respondents participate in the study voluntarily, their identity must be protected. Anonymity and confidentiality can both play a main ethical role in this part of the research (Bhattacherjee, 2012; Neuman, 2011; Robson, 2011). Anonymity means that a given response from a specific respondent cannot be identified by the readers of the study, while confidentiality means that the respondents identity must not be provided in any report, paper, or public forum (Bhattacherjee, 2012).

In order to consider all the issues above, some steps have been taken in our study. First, the necessary information about the whole questionnaire and the target phenomenon was provided in the first page of the survey. Second, since it was an online survey, the respondents had the right to withdraw from the questionnaire at any time they want. Third, the questions were asked in a friendly way whereby the respondents could feel at ease while answering them. Forth, with respect to the participants' time, the questions were made as easy as possible so that a response took only around five minutes. Fifth, there was not any field regarding name or phone or contact detail, thus, there were no issues concerning anonymity. However, there was a field at the end of the about the e-mail address that could be filled in voluntarily by those who were interested in the findings of our study. Sixth, no confidential data was needed from the participants. Therefore, there was no reason for them to be worried about their identity.

Another ethical issue that must be taken into account is the honesty of the researcher regarding the findings and results. According to (Bhattacherjee, 2012), unexpected or negative findings concerning the research must be fully demonstrated regardless of their influence such as casting some doubt on the research design and results. Hence, all the result and finding in this study are the exact responses that the authors received through the online survey. Responses that were excluded from the data analysis are transparently described in the analysis section.

# 5. Data Analysis

*This section presents the results of the conducted survey. Therefore, it first presents the demographics of the sample. After assessing the measurements' validity and reliability, a descriptive analysis of driver's perceptions is following. Lastly, this section provides the results of the hypothesis tests of the proposed research model.*

## 5.1. Demographic profile and general information

First of all, after data collection and before analyzing data, the authors went through the data in order to check and to clean the data from invalid responses. Out of 187 responses, only 169 responses were accepted as valid. Hence, 18 responses including four groups as follows were deleted from the primary data. First, five respondents indicated that they did not understand all questions in a mandatory question provided by the authors at the end of the questionnaire. In order to provide biases from randomly given answers, the authors decided to delete these respondents. Furthermore, since the purpose of the study was to evaluate the drivers' perception on car infotainment systems, those responses which indicated that no driving license is held by the respondent were deleted as well. In addition, the authors visually inspected the remaining data set for irregularities. By doing so, two responses were identified that have been sent twice identically in between few seconds. It was assumed that these double answers occurred due to internet connection issues on the respondent side. For both of these cases, one data row has been deleted from the data set. Lastly, the authors also looked for fake answers or patterns in the responses which could indicate that a participant randomly answered the questions without stating his real perceptions. This way, three responses were found with having the same rating for each of the degree questions and were eliminated. Further patterns could not be found.

### *5.1.1. Demographic profile of the respondents*

All background information collected of the respondent is intended to be presented in this section. This information mainly consists of participants' gender, age, origin, driving experience and frequency as well as willingness to purchase a car.

As it can be seen in the statistics appended to this thesis (Appendix 6: Demographic Profile), the majority of the respondents were male drivers with 73.37 percent, representing 124 individuals. On the contrary, only 26.63 percent of the respondents were female, being 45 individuals. This might be due to a higher interest of male persons in automotive topics. The age factor in this study was divided into five groups: younger than 25, 25 to 34, 35 to 44, 45 to 54, 55 or older. A large proportion of the respondents were young drivers with less than 25 years of age (70 individuals), followed by 58 respondents being between 25 to 34 years old. The other groups with 35 to 44 years, 45 to 54 years and 55 years or more were represented with 12, 16, and 13 respondents respectively. This distribution is not representative for the car drivers in the world population. However, younger people of the so-called Generation Y are considered to be the most important addressees of connected car innovations and thus represent a major market potential (Deloitte, 2014b). Thus, this non-representative sample might even be beneficial when it comes to insights for future innovations.

Furthermore, the authors also asked respondents for their home continent to increase transparency about the reached sample. As it has been mentioned earlier in the methodology section, the used sampling techniques were convenient sampling and snowball sampling. Therefore, it could be expected that most of the respondents would stem from Europe due to a major amount of the direct contacts of the authors being European. Although the authors strived to share the survey online so that more people could get access to that, around 57 percent of the drivers were from Europe followed by North America and Asia being about 20 and 16 percent respectively. The remaining groups consisted of Australia and Africa having the same portion being 3 percent, and South America at about 1 percent.

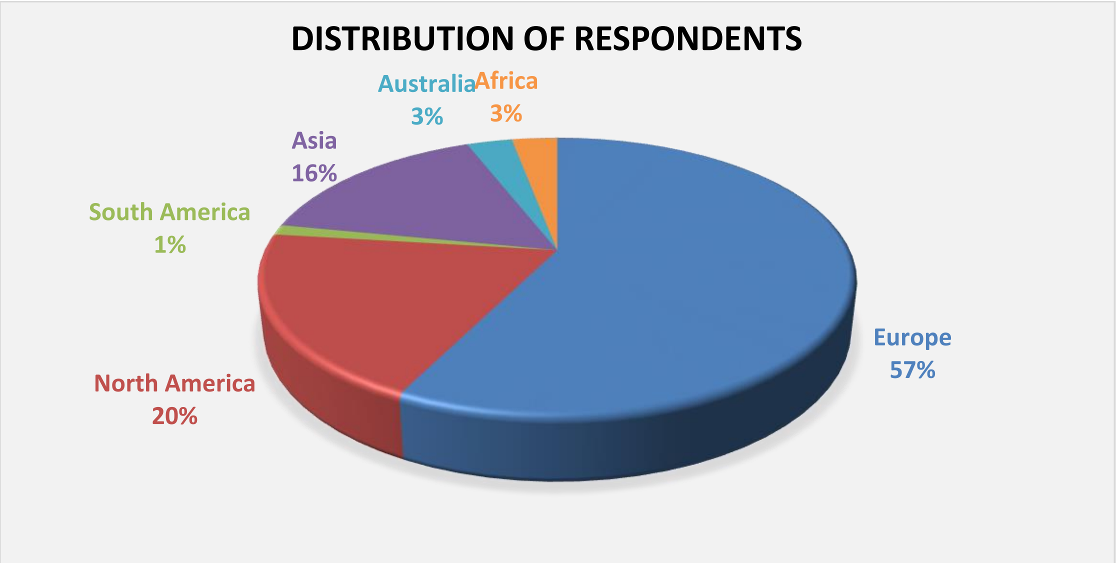



**Figure 5.1: Distribution of respondents**

### *5.1.2. General information of the respondents*

The time of having a driving license was more equally distributed, so that only 44 respondents had a less than five year old driving license. 63 respondents had a 5 to 10 year old driving license and 62 respondents had their driving license for more than 10 years. As it becomes obvious, the majority of the respondents are experienced drivers, which indicates that the sample seems to be adequate in order to answer questions regarding perceived risks while driving as it was the case in this study.

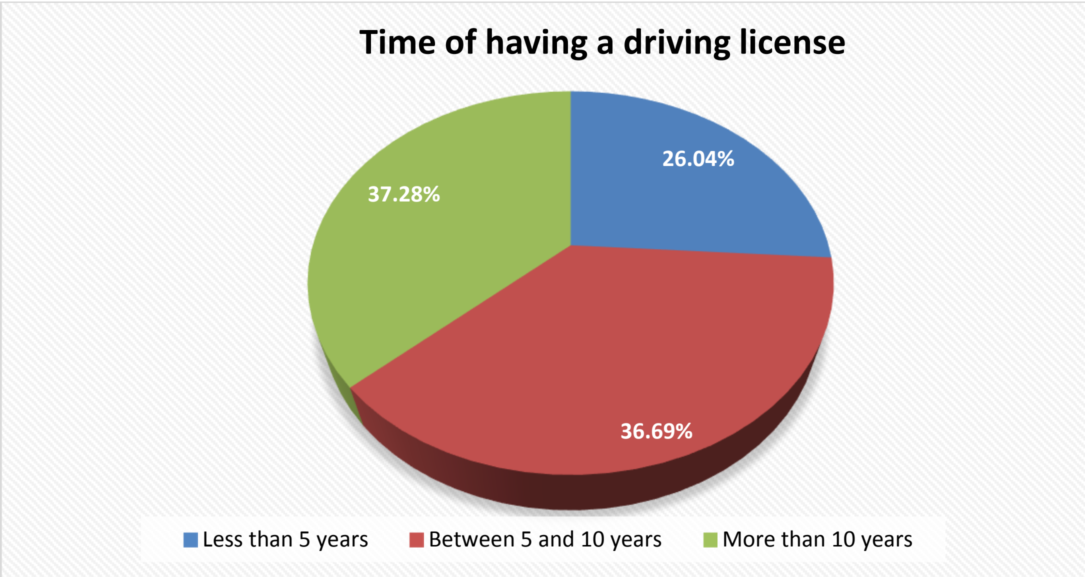



**Figure 5.2: Time of having a driving license**

Figure **5.3** demonstrates how often the respondents use their cars. As it is shown, the majority of the respondents being 48.52 percent are using their cars almost every day of their lives for different reasons. On the other hand, the second largest portion belongs to those who drive less than once in a month (21.89 percent). The rests are concerned with two groups including those who drive more than once a week and those who drive at least once a month, by having 19.53 and 10.06 percent respectively. Again, this indicates that the majority of the respondents have a good driving experience which assumable enables them to judge adequately about risks while driving.

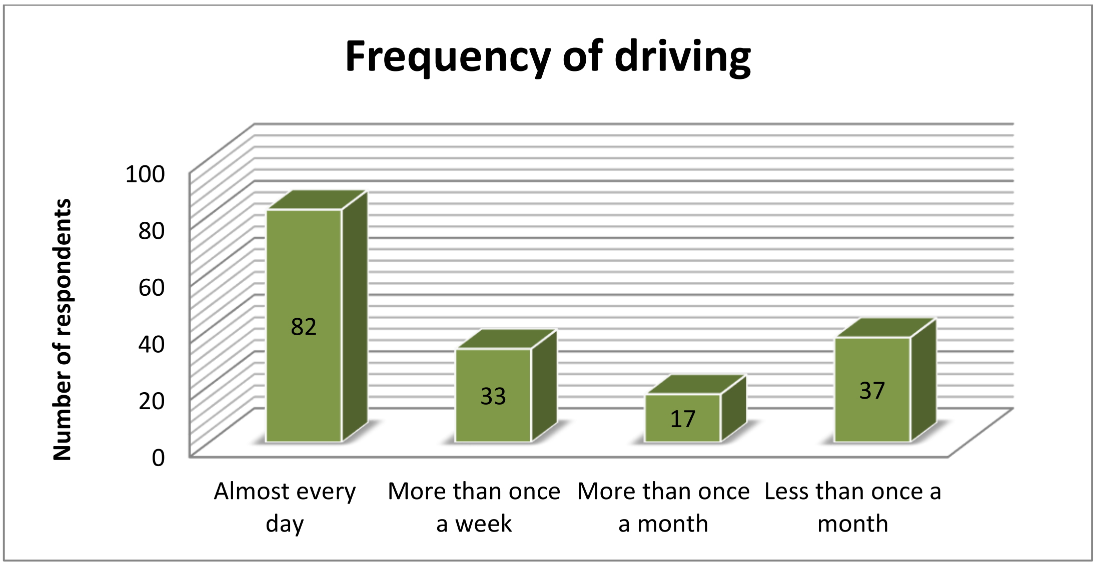



**Figure 5.3: Frequency of driving**

The other question asked, was concerned with the willingness to buy a car or a new car (see Figure 5.4). Out of all 169 respondents, only a few of them (17.16 percent) were not willing to buy a car in the next five years. On the other hand, 36.69 percent of the drivers were willing to buy a car in the next three years followed by those who would like to buy a car in the next five years (25.44 percent). The remaining portion presenting 20.71 percent consists of those who will buy a car in the coming year. This distribution is quite similar to the results achieved in the study of Generation Y presented in Deloitte (2014b) and shows once again that the sample of this study represents a target group of big importance for automotive innovations.

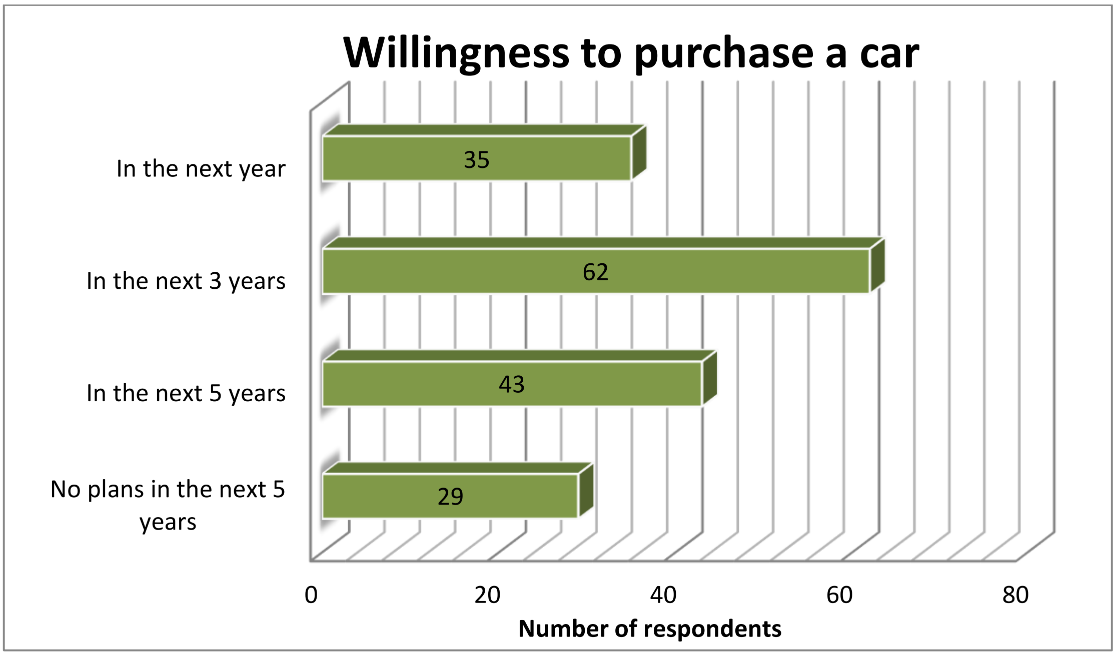
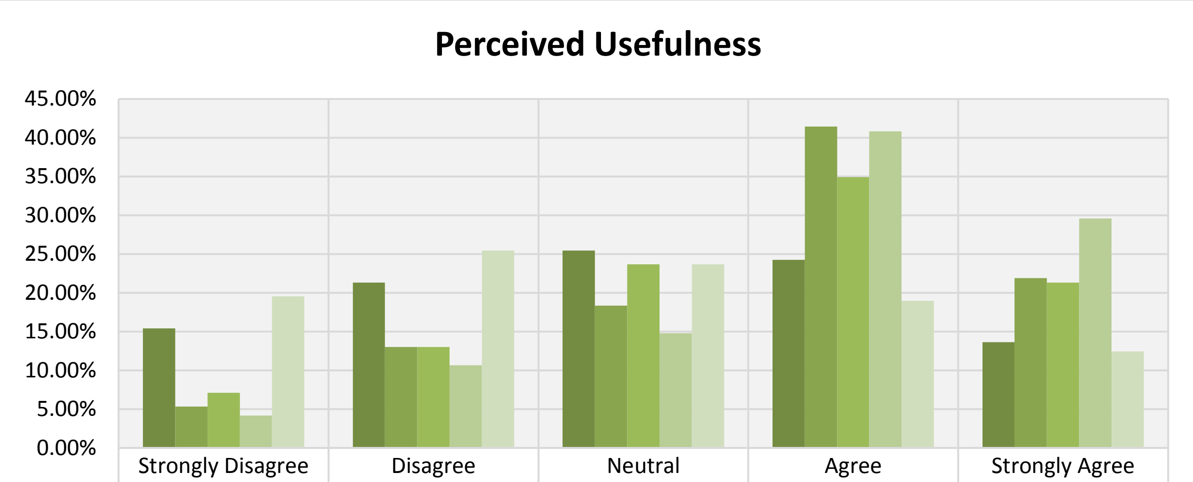



**Figure 5.4: Willingness to purchase a car**

## 5.2. Descriptive analysis

This section is concerned with the nature of the data collected from the survey. All the important information regarding each construct and their indicators is presented and discussed. A summary of the mean value and standard deviation concerning each specific construct items, and the overall value of the constructs is shown in Appendix 8: Summary of Results per Measurement Item. The mean values vary from 2.79 to 4.23. Based on the mean values, the highest mean value belongs to perceived ease of use (PEOU2) by having 4.23 followed by perceived risk (PR1) being 4.17. On the contrary, the lowest mean value refers to two perceived usefulness items being PU5 and PU1 representing 2.79 and 2.99 respectively. Additionally, in the figures provided below, the percentage of responses regarding each construct item is shown. The answers are spread on a five-point Likert-scale.
In addition, a summary of the descriptive statistics concerning each specific item is demonstrated in Appendix 9: Detailed descriptive statistics per measurement item.

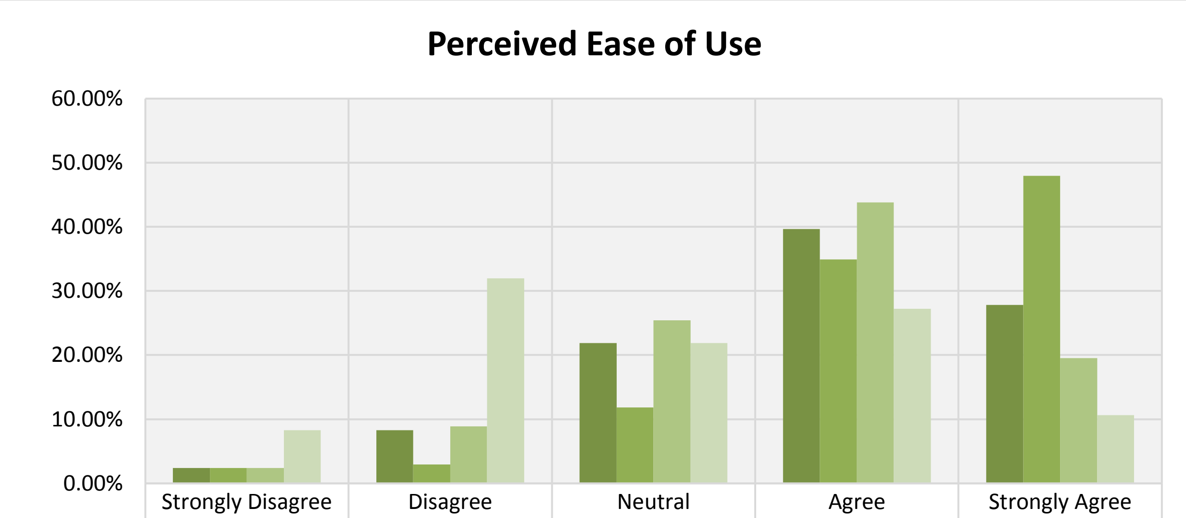



| | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|---|---|---|---|---|---|
| PU1 | 15.38% | 21.30% | 25.44% | 24.26% | 13.61% |
| PU2 | 5.33% | 13.02% | 18.34% | 41.42% | 21.89% |
| PU3 | 7.10% | 13.02% | 23.67% | 34.91% | 21.30% |
| PU4 | 4.14% | 10.65% | 14.79% | 40.83% | 29.59% |
| PU5 | 19.53% | 25.44% | 23.67% | 18.93% | 12.43% |

**Figure 5.5: Responses on perceived usefulness**

The overall mean value of the perceived usefulness is 3.34, meaning that the respondents perceived car infotainment systems as a useful technology (see Appendix 8: Summary of Results per Measurement Item). However, even though the value is positive, it is not strong enough since the answers are mostly spread between all items with a slight difference in the choice "Agree".

Based on all mean values concerning each items of the perceived usefulness construct, the lowest and highest values are 2.79 and 3.81 belonging to PU5 and PU4 respectively. As it is shown in Figure **5.5**, more than 70 percent of the respondents chose ‘agree’ and ‘strongly agree’ when they were asked about ‘*whether they find having access to apps with car-specific functionalities useful while driving their ca*r’. On the other hand, a large portion of participants (Around 45 percent) either disagreed or strongly disagreed when they were asked about ‘*if they had access to more apps and functionalities, the quality of their driving would improve*’. Furthermore, when it comes to having access to smartphone applications while driving, respondents had a comparably neutral attitude with about 26 percent and 24 percent of the respondents choosing “Neutral” in PU1 and PU3. However, also around 24 percent and 35 percent respectively of the participants agreed with using smartphone apps while driving. The ranges of all scales concerning perceived usefulness show that the most agreed-upon statements are PU2 and PU4 having more than  60 percent each for either “Agree” or “Strongly Agree”. These items were concerned with the usefulness of car-specific applications. The strongest disagreement can be found in the measurement items PU1 and PU5.



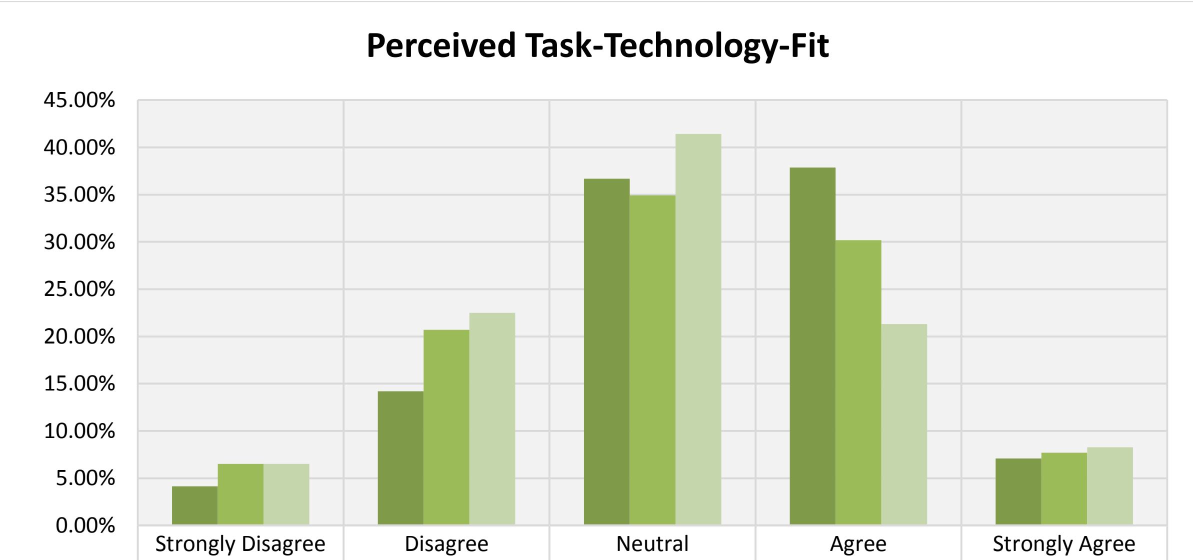

| | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|---|---|---|---|---|---|
| PEOU1 | 2.37% | 8.28% | 21.89% | 39.64% | 27.81% |
| PEOU2 | 2.37% | 2.96% | 11.83% | 34.91% | 47.93% |
| PEOU3 | 2.37% | 8.88% | 25.44% | 43.79% | 19.53% |
| PEOU4 | 8.28% | 31.95% | 21.89% | 27.22% | 10.65% |

**Figure 5.6: Responses on perceived ease of use**

The overall mean value of the perceived ease of use concerning car infotainment systems is 3.69 (see Appendix 8: Summary of Results per Measurement Item), which is slightly higher than perceived usefulness. However, it should be taken into account that PEOU4 is a negatively formulated statement so that the calculated average is not representative for the overall perceived ease of use. Since PEOU4 had to be eliminated due to validity and reliability issues anyway, a new average excluding PEOU4 has been calculated as 3.91.

Thus, the respondents perceived car infotainment systems as an easy technology to use. Furthermore, considering the all mean values regarding each items of perceived ease of use (excluding PEOU4), the lowest and highest values belong to PEOU3 and PEOU2 by having 3.69 and 4.23 respectively. Comparing to perceived usefulness, all the items presented here are higher than 3, which reflects the positive perception of the ease of use.

As it is demonstrated in Figure 5.6, the largest portion of the answers belongs to either ‘Agree’ or ‘Strongly Agree’ when it comes to PEOU2. In fact, around 83 percent of the respondents either agreed or strongly agreed when there where asked about ‘*whether learning to operate app-based Car Infotainment Systems would be easy for them’*. Furthermore, over 40 percent of the respondents either disagreed or strongly disagreed when they were asked about ‘*whether having more apps/functions would make the Car Infotainment System more difficult to use*’, indicating also a positive attitude in the omitted item PEOU4. The ranges of all scales concerning perceived ease of use show that the largest portions belong to the choices “Strongly Agree” and “Agree” by sharing more than 60 percent in every remaining measurement item. An overall lower level of standard deviation compared to perceived usefulness indicates that the respondents have a more common perception of this hypothetical factor.

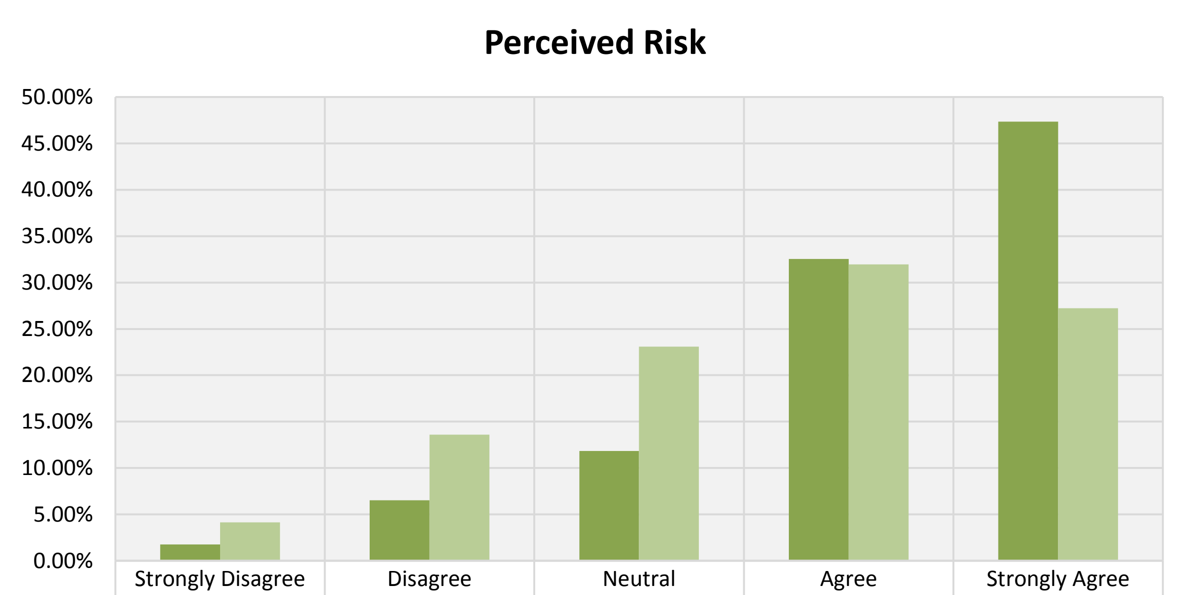



| | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|---|---|---|---|---|---|
| PTTF1 | 4.14% | 14.20% | 36.69% | 37.87% | 7.10% |
| PTTF2 | 6.51% | 20.71% | 34.91% | 30.18% | 7.69% |
| PTTF3 | 6.51% | 22.49% | 41.42% | 21.30% | 8.28% |

**Figure 5.7: Responses on perceived task-technology-fit**

The overall mean value of the perceived task-technology-fit regarding car infotainment systems is 3.15, which is lower than both perceived usefulness and perceived ease of use (see Appendix 8: Summary of Results per Measurement Item). The mean value here does not show a strong positive attitude, nevertheless, all the mean values regarding the items are higher than 3. In general, responses seem to be equally distributed, indicating a neutral perception of the task-technology-fit. However, a slight positive tendency becomes apparent. As the Figure **5.7** indicates, the answers are mostly spread between two choices being ‘Neutral’ and ‘Agree’. It can be seen that the majority of respondents chose “Neutral” choice as their answer regarding all three questions. However, a large portion of respondents (37.87 percent) agreed when they were asked about ‘*in helping them to achieve the purposes of their car drives, the functionalities of app-based Car Infotainment Systems would be appropriate.*’ On the other hand, the largest portion (41.42 percent) belongs to ‘Neutral’ choice when it comes to PTTF3, which shows that the respondents did not fully agree or disagree when they were asked about ‘*whether the functions of app-based Car Infotainment Systems would fully meet their needs while driving*’.

The ranges of all scales concerning perceived task-technology-fit indicate that the largest and the smallest portions belong to the choices “Neutral” and “Strongly Disagree” by having 41.42 and 4.14 percent for PTTF3 and PTTF1 respectively.



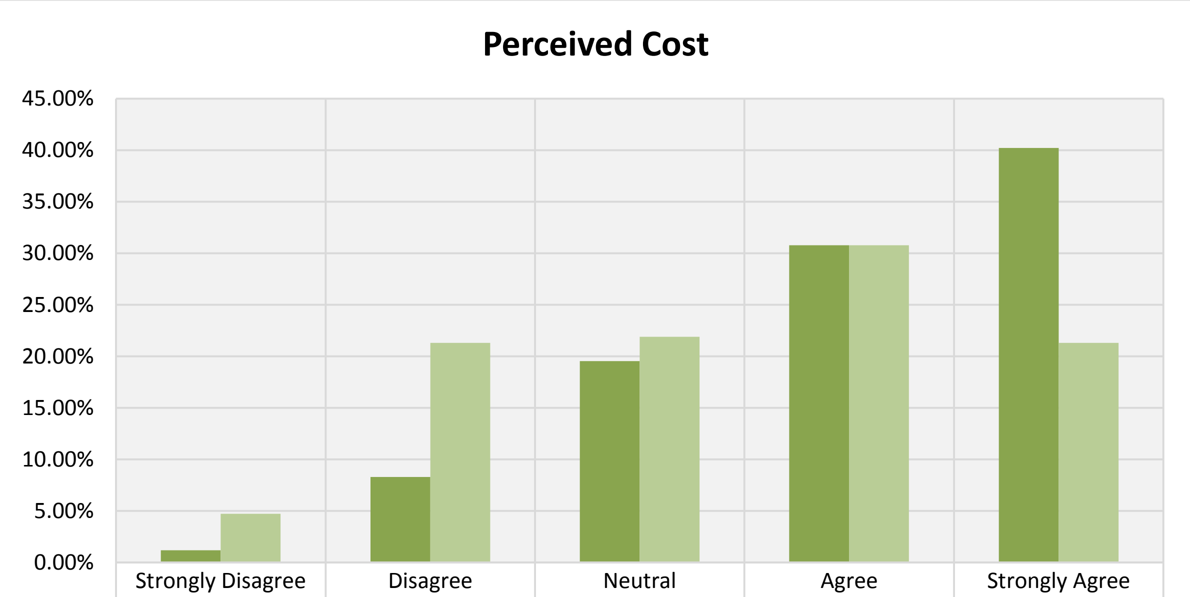

| | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|---|---|---|---|---|---|
| PR1 | 1.78% | 6.51% | 11.83% | 32.54% | 47.34% |
| PR2 | 4.14% | 13.61% | 23.08% | 31.95% | 27.22% |

**Figure 5.8: Responses on perceived risk**

As it is demonstrated by Figure 5.8, there are only two items regarding the perceived risk. The overall mean value of this construct is 3.91, which is comparable to the perception of perceived ease of use, and thus very high. This can be concluded from Figure 5.8 as well, because most of the answers have been spread between 'Agree' and 'Strongly Agree'.

The highest mean value belongs to PR1 in which around 80 percent of the respondents either agreed or strongly agreed when they were asked about '*whether they think using Car Infotainment Systems while driving has potential risks*'. The same thing holds true for PR2, in which over 59 percent of the respondents either agreed or disagreed when they were asked about '*whether they think using Car Infotainment Systems with third-party applications puts my privacy at risk*'. The ranges of all scales concerning perceived risk show that the largest and the lowest portions belong to PR1, particularly the choices "Strongly Agree" and "Strongly Disagree" by having 47.34 and 1.78 percent respectively.

Consequently, based on the numbers shown above, the majority of the respondents perceive car infotainment systems as risky, also in terms of privacy.




| | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|---|---|---|---|---|---|
| PC1 | 1.18% | 8.28% | 19.53% | 30.77% | 40.24% |
| PC2 | 4.73% | 21.30% | 21.89% | 30.77% | 21.30% |

**Figure 5.9: Responses on perceived cost**

The overall mean value of the perceived cost is 3.72, meaning that the respondents perceive the costs as being high and that they have a low willingness-to-pay for applications.

As it is shown in Figure **5.9**, most of the answers refer to two choices being "Agree" and "Strongly Agree". Furthermore, over 70 percent of the respondents either showed their agreement or strong agreement when they were asked about '*whether they think the acquisition costs of a Car Infotainment System are expensive*'. In contrast, less than 10 percent disagree with this statement. When it comes to PC2, the answers are almost equally spread between four choices being "Disagree", "Neutral", "Agree", and "Strongly Agree". However, the choice "Agree" contains about 9 percent more respondents. Therefore, it seems that the respondents agree less on 'whether they would only use free Car Infotainment applications'. Price-sensitivity seems to be significantly higher for the acquisition costs.

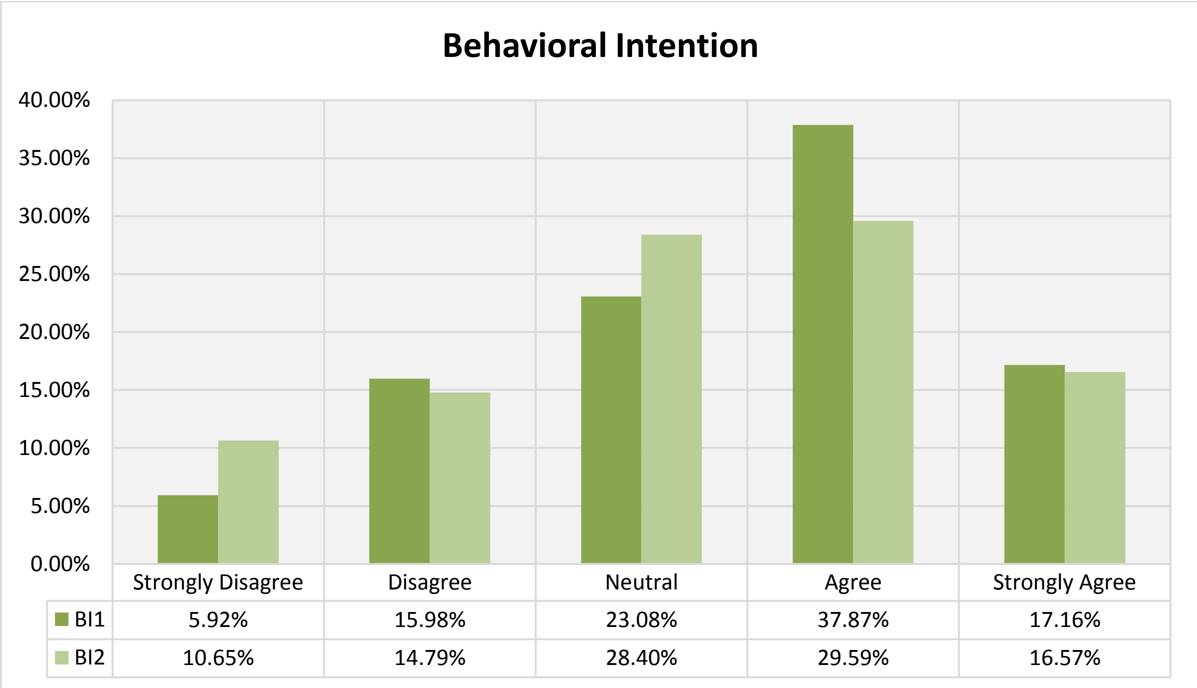



**Figure 5.10: Responses on behavioral intention**

The overall mean value of the behavioral intention to use car infotainment systems is 3.36. This means that the respondents had a slightly positive attitude towards car infotainment systems, but it is not really strong since the answers are mostly spread between two choices namely 'Neutral' and 'Agree'.

The mean value for BI1 is 3.44 while it does not exceed 3.27 when it comes to BI2. As it is demonstrated by Figure **5.10**, the majority of the respondents (37.87 percent) showed their agreement when they were asked about '*if they have a chance, they plan to experiment with or regularly use an app-based Car Infotainment System while driving*'. By adding those who strongly agreed on BI1, the portion will exceed 55 percent of the whole respondents. On the other hand, around 25 percent of the respondents either disagreed or strongly disagreed when they were asked about '*If they were planning to buy a car, they would equip it with an app-based Car Infotainment System*'. Furthermore, the number of respondents who had agreement or were neutral are quiet the same with a slight difference when it comes to BI2. This concludes that the respondents had a better attitude towards BI1 than BI2.

## 5.3. Measurement Validity and Reliability

In order to draw valid conclusions, it is important to asses both the reliability and the validity of the used measurement items, so that it can be assured that the constructs are correctly measured and explained. Unfortunately, for most kinds of validity and reliability commonly accepted and agreed-on quality criteria exist only for constructs with reflective indicators (MacKenzie et al., 2011), so that a test of the validity and reliability of the formative constructs perceived risk and perceived costs had to be skipped.

Validity or more precisely, construct validity, refers to whether the measurement items measure indeed the construct which they intend to measure (Bhattacherjee, 2012). To do so, the authors tested first of all the validity of each individual reflective indicator. MacKenzie et al. (2011) suggest therefore to test whether the relationship between an indicator and its hypothesized construct is strong and significant. This can be measured by calculating the squared completely standardized loadings if each indicator only loads on one hypothetical factor in the specified measurement model (MacKenzie et al., 2011). This value should then be higher than 0.5 in order to indicate a good individual indicator validity (MacKenzie et al., 2011). As Table **5.1** shows, all reflective indicators except for PEOU4 have a significant relationship to their hypothesized construct. As a result, PEOU4 was deleted from the measurement model again after it had been added to it due to a recommendation of an expert in the pilot-test. Possible reasons for the low relationship to the perceived ease of use could be that the amount of available applications is not significantly related to the perceived ease of use. Another possibility could be that respondents were confused by the only negatively stated question stated in this set of measurement items. For formative factors, there is unfortunately no commonly accepted standard on how to assess the individual indicator validity (MacKenzie et al., 2011).

**Table 5.1: Individual Indicator Validity**

| | Loadings | | | | Squared Loadings | | | |
|---|---|---|---|---|---|---|---|---|
| | BI | PEOU | PTTF | PU | BI | PEOU | PTTF | PU |
| BI1 | 0,902 | | | | 0,814 | | | |
| BI2 | 0,899 | | | | 0,808 | | | |
| PEOU1 | | 0,845 | | | | 0,714 | | |
| PEOU2 | | 0,831 | | | | 0,690 | | |
| PEOU3 | | 0,834 | | | | 0,696 | | |
| PEOU4 | | 0,460 | | | | 0,211 | | |
| PTTF1 | | | 0,847 | | | | 0,717 | |
| PTTF2 | | | 0,899 | | | | 0,809 | |
| PTTF3 | | | 0,852 | | | | 0,726 | |
| PU1 | | | | 0,853 | | | | 0,728 |
| PU2 | | | | 0,787 | | | | 0,619 |
| PU3 | | | | 0,796 | | | | 0,634 |
| PU4 | | | | 0,783 | | | | 0,613 |
| PU5 | | | | 0,747 | | | | 0,558 |

After testing the individual validity of measurement items, the validity of a set of indicators at the construct level has been assessed. Two different kinds of validity have been considered in this analysis: convergent validity and discriminant validity. Convergent validity thereby refers to whether a construct is well explained by its indicators whereas discriminant validity means than the measurement items of a construct do not explain another construct that they are not intended to measure (Bhattacherjee, 2012). According to MacKenzie et al. (2011), the average variance extracted (AVE) is a good measure to assess convergent validity for reflective constructs. It takes into account the averaged square completely standardized factor loadings for each construct (Fornell & Larcker, 1981). A value above the threshold of 0.5 is considered to indicate good convergent validity (MacKenzie et al., 2011). As it can be seen in Table **5.2**, all reflective constructs satisfy this criterion clearly and can be considered to be appropriately measured by their measurement items. MacKenzie et al. (2011) further suggest the so-called adequacy coefficient for analyzing this convergent validity for formative constructs even though no consensus has yet been reached for this case and thus the usage is not dependable. However, to the author's knowledge smartPLS does not provide the necessary values to calculate this coefficient and therefore did not perform an analysis of the convergent validity for the formative constructs.

The discriminant validity can be checked by comparing this average variance extracted for each construct with the squared correlation of this construct with the other constructs. This shows that each construct's variance is shared more with its own indicators than the construct shares with other constructs (MacKenzie et al., 2011). If the AVE is bigger than the squared correlation, sufficient discriminant validity can be assumed (Fornell & Larcker, 1981). As Table **5.2** shows, this criterion is fulfilled for all reflective constructs.

**Table 5.2: Convergent and Discriminant Validity**

| | AVE | BI | PCOSTS | PEOU | PRISK | PTTF | PU |
|---|---|---|---|---|---|---|---|
| **BI** | 0,811 | 1 | | | | | |
| **PCOSTS** | | 0,035 | 1 | | | | |
| **PEOU** | 0,721 | 0,197 | 0,003 | 1 | | | |
| **PRISK** | | 0,084 | 0,001 | 0,061 | 1 | | |
| **PTTF** | 0,751 | 0,406 | 0,001 | 0,158 | 0,058 | 1 | |
| **PU** | 0,630 | 0,473 | 0,017 | 0,152 | 0,096 | 0,502 | 1 |

For testing formative constructs on discriminant validity, correlation values have to be significantly different from a perfect correlation (correlation equal to 1 or -1) (MacKenzie et al., 2011). As can be seen in Table **5.3**, both formative constructs have a low correlation value (below 0.5) and are certainly not perfectly correlated and discriminant validity is therefore assumed.

**Table 5.3: Correlation between Constructs**

| | BI | PCOSTS | PEOU | PRISK | PTTF | PU |
|---|---|---|---|---|---|---|
| **BI** | 1 | | | | | |
| **PCOSTS** | -0,186 | 1 | | | | |
| **PEOU** | 0,444 | -0,058 | 1 | | | |
| **PRISK** | -0,290 | 0,027 | -0,248 | 1 | | |
| **PTTF** | 0,637 | -0,028 | 0,397 | -0,240 | 1 | |
| **PU** | 0,687 | -0,129 | 0,389 | -0,311 | 0,709 | 1 |

Reliability is concerned with the consistency and precision of the measurement, meaning that the same result will be achieved in multiple measurements under the same conditions (Bhattacherjee, 2012).

The individual reliability of indicators is recommended to be assessed by calculating the squared multiple correlation of the indicators (MacKenzie et al., 2011). In cases where each indicator only loads on one construct, those values are equal to the squared loading (MacKenzie et al., 2011). The threshold value is again 0.5 and therefore in this case where indeed indicators are only related to one construct each, the test is equal to the one for individual validity. The set of measurement items remains therefore identically. For formative factors, it is recommended to assess this reliability by analyzing test-retest reliability or inter-rater reliability. However, due to the short time period available for this study, the effort for these tests could not be carried.

To see whether the measurement items are reliably explaining the hypothetical factor they are assigned to, the internal consistency has to be tested (MacKenzie et al., 2011). For this purpose, the inter-item correlations as well as the correlations between the indicators and the construct have to be calculated. High correlations indicate a reliable measurement. A combined index of these correlations can be calculated with Cronbach's Alpha. A high value of this index (close to 1) suggests a good reliability. For accepting the measurement items, an alpha-value of 0.7 should be reached at least (MacKenzie et al., 2011). Cronbach's alpha has been calculated for all reflective constructs in the research model. As can be seen in Table 5.4, all of these constructs showed values clearly above 0.7. Formative constructs cannot be statistically tested for internal consistency reliability since they contain measurement items for different dimensions. These items are not assumed to be necessarily correlated and thus the indicating index would likely show a low value even though the dimensions were measured adequately (MacKenzie et al., 2011). In this study, both the perceived risk and the perceived costs are formative constructs that are hence not tested for internal consistency reliability. Another alternative to assess the reliability at the construct level for a set of indicators is the Construct or Composite Reliability (MacKenzie et al., 2011). Table 5.4 shows these values as well and as it can be seen, all values also exceed the threshold of 0.7. Overall, a very good reliability of the measurement model can be assumed.

**Table 5.4: Reliability Indicators for Reflective Constructs**

| | Composite Reliability | Cronbach‘s Alpha |
|---|---|---|
| **BI** | 0,8958 | 0,7673 |
| **PEOU** | 0,8855 | 0,8071 |
| **PTTF** | 0,9002 | 0,8335 |
| **PU** | 0,8949 | 0,8529 |

## 5.4. Path Analysis

In order to answer the second research question, the causal relationships between the hypothesized factors have been examined with the use of smartPLS. Therefore, both the measurement model with all reflective respectively formative measurement items (except for PEOU4) and the causal model with all stated hypotheses have been modeled. Then, the partial least squares algorithm has been executed. To get a first impression of the causal relationships that have been identified, Table 5.5 highlights the hypotheses inside the correlation matrix between the constructs. The Pearson correlation coefficient is a standardized value between -1 and 1. Values close to zero indicate a weak or no causal relationship, while higher absolute values indicate either a strong positive or a strong negative relation between the hypothesized constructs. As it can be seen, all hypotheses have correlations significantly different from zero (*→ p<0.1, ** → p<0.05, *** → p<0.01). As it can be seen, the weakest relationship is indicated for H9 (PCOSTS→ BI). However, the significance still shows that in more than 90 percent of the samples that could be made, this correlation or a stronger one would be achieved. Other not hypothesized significant relationships can be seen between the perceived ease of use and the perceived task-technology-fit. A direct explanation for this causal relationship cannot be seen, so the result might be due to cross-correlations along the path PEOU→PRISK→PTTF and due to the paths PEOU→PU and PTTF→PU. The latter one can also influence the correlation between these two constructs since the correlation value does not take into account the directions of causal relationships. The same applies for the correlation between perceived risk and perceived usefulness. This could be due to the relationships PRISK→PTTF→PU as well as the paths PEOU→PRISK and PEOU→PU. To sum up, in overall the hypotheses seem to hold true according to the correlations.

**Table 5.5: Hypotheses and Correlations**

| | BI | PCOSTS | PEOU | PRISK | PTTF | PU |
|---|---|---|---|---|---|---|
| **BI** | 1 | | | | | |
| **PCOSTS** | -0,186* | 1 | | | | |
| **PEOU** | 0,444*** | -0,058 | 1 | | | |
| **PRISK** | -0,290*** | 0,027 | -0,248** | 1 | | |
| **PTTF** | 0,637*** | -0,028 | 0,397*** | -0,240** | 1 | |
| **PU** | 0,687*** | -0,129 | 0,389*** | -0,311*** | 0,709*** | 1 |

Nevertheless, these correlations can only serve as an indicator for the causal model. In order to test the causal model correctly, all relationships have to be taken into account simultaneously. This is the strength of Structural Equation Modeling. The partial least squared algorithm offered by smartPLS is thereby one of the two main algorithm groups for Structural

Equation Modeling. As has been argued before, the choice for this algorithm has been made due to the formative constructs inside the research model. The partial least squares algorithm has been performed and the results are shown in Figure **5.11**. The blue circles represent the hypothesized constructs and the arrows indicate the hypothesized causal relationships between the constructs. The number in the circles represents the amount of explained variance by the regression model; the numbers next to the arrows are the so-called path values that indicate the strength of the relationship. The significance level of the causal relationship is indicated with *, if $p<0.05$ and with **, if $p<0.01$. It can be seen, that considering the complete model synchronously, the relationship between perceived costs and behavioral intention to use becomes significant on a higher level ($p<0.05$ instead of $p<0.1$). Instead, the relationship between perceived risk and behavioral intention to use became insignificant ($p>0.05$). It seems as if most of the correlation indicated to behavioral intention to use in the prior performed step stems from its tight linkage to the perceived task-technology-fit. All other causal relationship have been approved with either $p<0.05$ (PEOU→PU and PCOSTS→BI) or $p<0.01$ (the remaining paths).

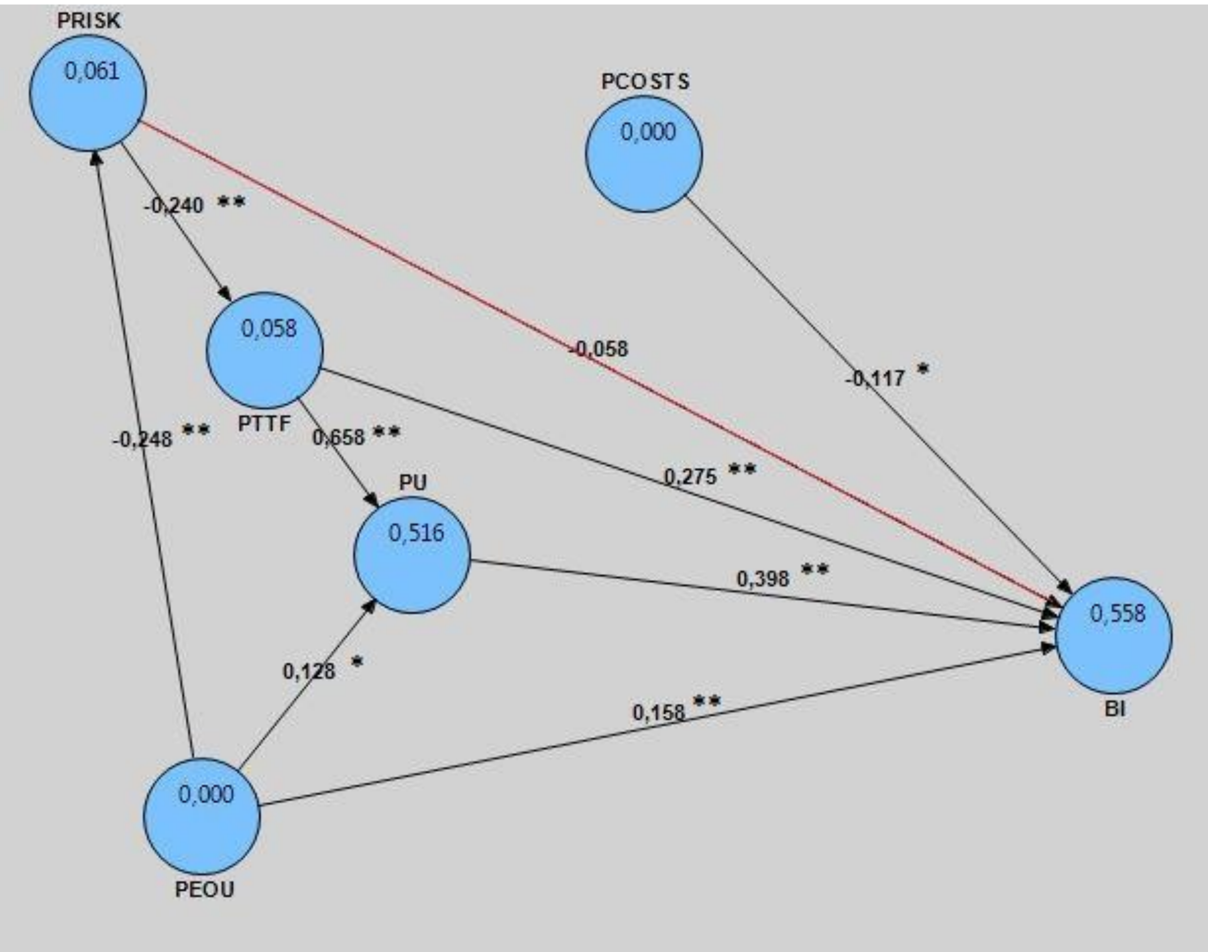



**Figure 5.11: Path Analysis**

The significance of these relationships has been calculated using the t-values that are provided with the bootstrapping-method of smartPLS. These t-values are shown in Figure **5.12**. According to statistical tables, for samples with more than 100 responses, the lower limits for the t-value are 1.98 for $p<0.05$ and 2.36 for $p<0.01$.

As a result, it can be seen that all hypotheses except for H4 are supported by the data collection that has been done in this study, H4 has to be rejected. Perceived risk has no significant direct effect on the behavioral intention to use. The weakest identified relationship has been found between the perceived costs and the behavioral intention to use. Moreover, the basic TAM relationship between perceived ease of use and perceived usefulness is not very strong with a path-value of 0.128. However, both relationships are still statistically significant and thus have to be supported. Also important is to see, that also the sign of the path values matches with the hypothesized influence. As such, perceived ease of use is negatively influencing the perceived risk, perceived risk is negatively influencing the perceived task-technology-fit and perceived costs take a negative influence on the behavioral intention to use. Furthermore, all other supported paths have positive path values as it has been stated in the respective hypotheses. As a result, all hypotheses except for H4 have to be supported for their expected influence as well as their predicted direction of the influence (positive or negative).

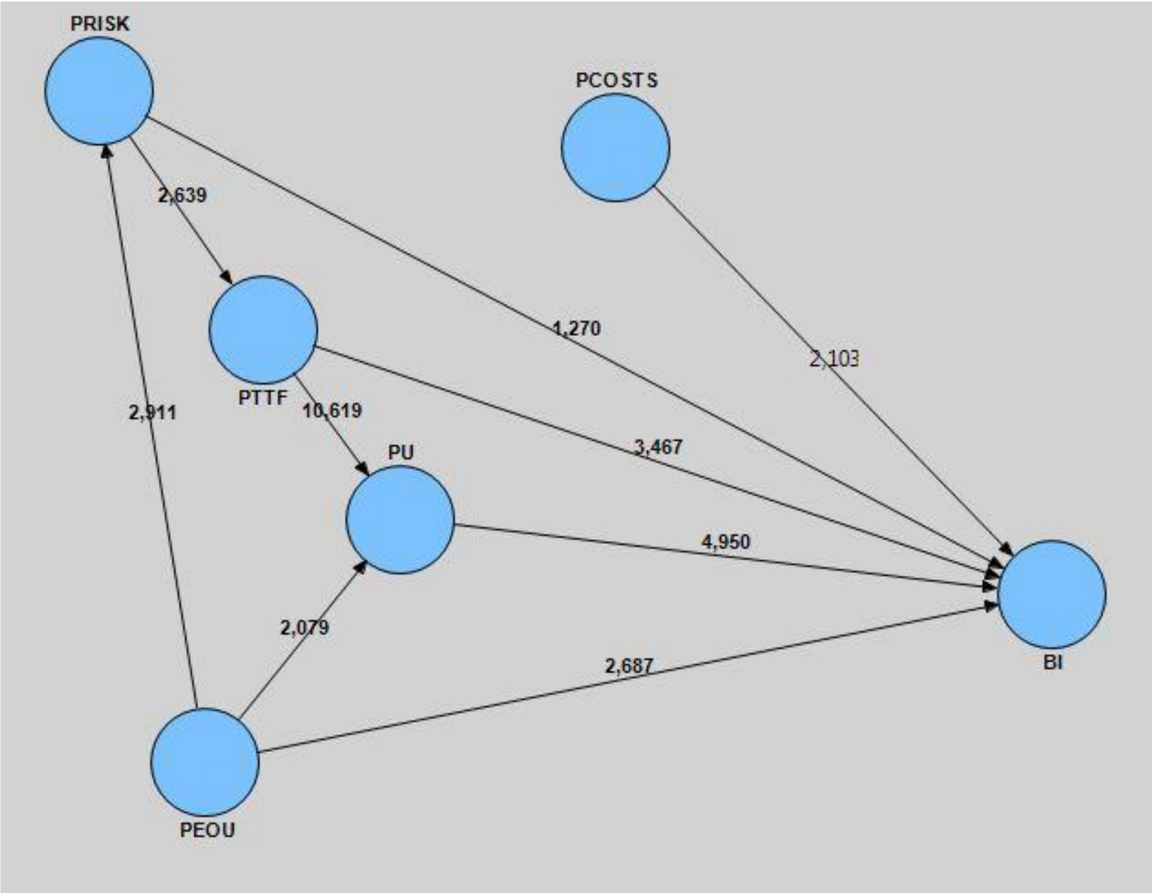



**Figure 5.12: T-values from the path analysis**

The test results for each hypothesis are summarized in Table **5.6**. Hypothesis 4 which predicted a negative influence between perceived risk and behavioral intention to use had to be rejected. As such, perceived risk is the only factor in this research model that does not have a significant direct effect on the behavioral intention to use. However, with its influence on the perceived task-technology-fit, it is still a part of the resulting explanatory factor model. As it can be seen in Table **5.7**, the calculated total effect of the perceived risk on the behavioral intention to use is still significant. These total effect values also take into account indirect effects that are calculated along the paths. The indirect effect of perceived risk on the behavioral intention to use is significant, seeing that its value is higher than the total effect between perceived costs and behavioral intention to use or the direct effect of perceived ease of use on the behavioral intention to use.

**Table 5.6: Test results**

| Hypothesis | Test result |
|---|---|
| **PU → BI** | Supported (**, p<0.01) |
| **PTTF → BI** | Supported (**, p<0.01) |

| | |
|---|---|
| **PTTF → PU** | Supported (**, p<0.01) |
| **PRISK → BI** | Rejected |
| **PRISK → PTTF** | Supported (**, p<0.01) |
| **PEOU → BI** | Supported (**, p<0.01) |
| **PEOU → PU** | Supported (*, p<0.05) |
| **PEOU → PRISK** | Supported (**, p<0.01) |
| **PCOSTS → BI** | Supported (*, p<0.05) |

**Table 5.7: Total Effects in the Research Model**

| | BI | PCOSTS | PEOU | PRISK | PTTF | PU |
|---|---|---|---|---|---|---|
| **BI** | | | | | | |
| **PCOSTS** | -0,117 | | | | | |
| **PEOU** | 0,256 | | | -0,248 | 0,060 | 0,167 |
| **PRISK** | -0,187 | | | | -0,240 | -0,158 |
| **PTTF** | 0,537 | | | | | 0,658 |
| **PU** | 0,398 | | | | | 0,000 |

Since this research model contained multiple dependent variables, its analysis contains multiple regressions. Table **5.8** summarizes these regressions each with their dependent variable and the independent variables that are used to explain the variance in the dependent variable. The value of r-squared can be interpreted as exactly this amount of variance in the dependent variable that is explained by the independent variables.

The first regression shows the relation between perceived risk and perceived ease of use. This regression therefore contains only hypothesis 8. As it could be seen in Figure **5.11**, perceived ease of use negatively influences the perceived risk of car infotainment systems, the path value is -0.248. This regression on perceived ease of use explains only 6.1% of the variance in perceived risk. However, this is not an important value for this study since the main goal was to find the directly influencing factors of the behavioral intention to use app-based car infotainment systems.

The second regression contains the perceived task-technology-fit as the dependent variable. The regression model covers only hypothesis 5 and therefore considers only the perceived risk as the explaining factor for the perceived task-technology-fit. Once again, it was not the goal to exhaustively explain the construct of perceived task-technology-fit, thus only this one factor was used as an explaining construct. Only directly influencing factors for the behavioral intention to use where searched and in order to provide a full picture, the apparent interrelations were stated. Thus, it is not surprising that only 5.8% of the variance in the perceived task-technology-fit are explained by the perceived risk. As it was predicted, the influence of the perceived risk is negative, seeing the path value with -0.240.

In contrast, the third regression explains more than half of the variance in the perceived usefulness ($R^2$ = 51.6%). Being the dependent variable of this regression, perceived usefulness was tried to be explained by perceived task-technology-fit and perceived ease of use, taking into account the hypotheses H3 and H7. With a positive path coefficient of 0.128, perceived ease of use, however has a rather weak positive influence on the perceived usefulness, compared to the path coefficient of 0.658 for hypothesis 7. H3 which stems from the basic TAM model is therefore not as significant as the impact of perceived task-technology-fit on perceived usefulness.

Regression 4, however, is the most important for the purpose of this study. Here, the dependent variable is the behavioral intention to use app-based car infotainment systems. The regression considers all other constructs as directly influencing, independent variables. Namely perceived costs, perceived risk, perceived task-technology-fit, perceived usefulness and perceived ease of use can thereby explain 55.8% of the variance in the dependent variable. It therefore seems like a good explanation of this construct has been found. In this regression, however, the perceived risk has no significant direct impact. The strongest impact could be measured for hypothesis 1, stating a positive relationship between perceived usefulness and the behavioral intention to use. With a path value of 0.398, this basic TAM relationship seems to be the most important causal component. It is followed by H2 and H6, with coefficients of 0.275 and 0.158 respectively. Perceived task-technology-fit and perceived ease of use are covered as explaining factors in these hypotheses. Lastly, on a lower significance level, a rather low negative impact of the perceived costs on the behavioral intention to use could be found.

**Table 5.8: Summary of Regressions**

| | Independent Variables | Dependent Variable | $R^2$ |
|---|---|---|---|
| **Regression 1** | • Perceived Ease-of-Use | Perceived Risk | 6.1% |
| **Regression 2** | • Perceived Risk | Perceived Task-Technology-Fit | 5.8% |

| | | | |
|---|---|---|---|
| **Regression 3** | • Perceived Task-Technology-Fit<br>• Perceived Ease-of-Use | Perceived Usefulness | 51.6% |
| **Regression 4** | • Perceived Costs<br>• Perceived Risk<br>• Perceived Task-Technology-Fit<br>• Perceived Usefulness<br>• Perceived Ease-of-Use | Behavioral Intention To Use | 55.8% |

## 5.5. Open Question Analysis

In the end of the questionnaire, the authors offered an open-ended question where respondents could mention things they could not express in the standardized questionnaire. An overwhelming amount of 45 answers could be gathered this way, including critics, opinions and ideas. It is the intention of this section to analyze the topic-related opinions and ideas mentioned in this open question field since it could deepen the insight into the attitude of respondents.

As expected, the most frequent comment included safety considerations. The two dimensions of perceived risk became apparent thereby. Six answers mentioned explicitly that they are concerned about driver distraction and resulting accidents. Three further answers included privacy concerns into their considerations about apps in the car. Risk was therefore the most important factor in this open-ended questionnaire part. However, one further respondent also mentioned that the risk actually depends strongly on the applications. Another participant made another relationship by expecting a decreased risk through car infotainment systems. He stated that the system makes it easier to, for example, receive phone calls and thereby increases safety. In this statement, it can further be seen that a linkage between ease of use and perceived risk exists.

Following perceived risk, the authors could identify cost considerations as the second major concern. Four comments called car infotainment system as expensive and one additional answer took the other dimension of perceived costs into account, the price of applications. Hereby, the link between usefulness and costs has been made in terms of a cost-benefit analysis, so there is a tradeoff that car drivers do when deciding about purchasing such a system.

The authors think however, that this is not a direct relation between the constructs but reflected through the positive and negative coefficient in the causal model.

Frequent comments have further been made about the perceived usefulness of the system. Three participants explicitly stated the systems as attractive or useful. However, others some other comments included statements such as “toy”, “luxury feature” or “want” in the sense that it is not a necessary tool for driving but a nice additional feature. Some suggestions have further been made in this section, stating that car infotainment systems are more important for passengers than for the driver and could provide for example educational contents for the other persons in the car. However, the internet access would be also valuable for the car driver.

Not directly related to one of the factors, three respondents mentioned that they perceive the openness of the system as a critical success factor. The value provided by third-party developers is accordingly expected to be higher than the applications provided by the car OEMs themselves. As such, the app-based car infotainment systems with third-party applications that this study focusses on seem to provide a more useful system than previous generations for these respondents.

Lastly, two respondents stated explicitly that they perceive the system as being too difficult to use. The linkage to perceived risk has been mentioned in these responses as well as a connection to the perceived usefulness by stating that more than phone calls or playing music is not possible without being significantly distracted.

# 6. Discussion of the main findings

*This chapter includes the main findings of the study based on the empirical results collected regarding drivers' perception on car infotainment systems. According to the tests results, aside from the forth hypothesis, all the other hypotheses were supported.*

In the following, the empirical results of this study are discussed and interpreted in the context of the proposed research model. The findings are therefore explained in this section. It is also attempted to compare the findings to previous research. However, as it has been argued before, technology acceptance of car infotainment systems in general with or without access to app-ecosystems has not been studied before as such. Hence, to draw conclusions from a comparison of these findings with other car-related systems might be cumbersome.

## 6.1. Behavioral intention to use

As it was discussed in the previous chapter, drivers had a rather positive perception on using car infotainment systems, even though the result was not strong. Since the behavioral intention to use can influence the purchasing decision (Van Der Laan et al., 1997; Zheng et al., 2007), and as it is the direct antecedent of the actual usage in TAM (Davis, 1989), it can be concluded that drivers have a slightly positive attitude toward purchasing a car equipped with infotainment systems. However, the answers in this construct are quite distributed, having among the highest standard deviations in the questionnaire. Opinions and attitudes therefore seem to spread across the sample. As a result, it is of even greater importance to determine the factors that are influencing this purchasing and usage intention. This study presented a research model with five influencing factors that explain a major part of this distribution of the behavioral intention to use, with accounting for around 56 of its variance.

## 6.2. Perceived usefulness and perceived ease of use

Based on the descriptive analysis provided before, car infotainment systems were considered as being both useful and easy to use by having the overall mean value of 3.34 and 3.91 respectively.

The perceived usefulness has been found as the strongest directly influencing factor with a path value of 0.398. Therefore, it is one of the most important factors in the research model. Taking that into consideration, it seems as if Car Infotainment System's perceived usefulness should be improved. This can either be achieved by increasing the effort to point out the advantages of the systems or by reflecting on the functionalities that should be provided. An increase in the behavioral intention to use should be achievable according to the findings of this data collection. The results further indicated that the replication of smartphone apps is perceived as being less useful as applications that have a particular use case in the car. The recommendation derives to focus more on these car-specific applications in the development of car infotainment systems. This finding is in line with most car-related technology acceptance studies. Perceived usefulness is the factor that has been found to have an impact on the technology acceptance in the most cases. The relationship between perceived usefulness respectively performance expectancy in the UTAUT and the behavioral intention to use has been supported in five driver acceptance studies (Adell, 2009; Kwon et al., 2007; E. Park & Kim, 2014; Planing, 2014; Roberts et al., 2012).

Furthermore, the perceived ease of use seems to be not a big concern for car drivers. A significant number of the respondents considered the app-based car infotainment systems to be easy to learn. These findings show the enthusiasm of drivers about car infotainment systems. It could be found that all basic TAM relationships are significant in this sample. Thus, the perceived ease of use is indirectly influencing the behavioral intention to use through positively influencing the perceived usefulness. It is further also directly influencing the behavioral intention to use. However, the path coefficients are significantly lower than the one between perceived usefulness and the behavioral intention to use. Furthermore, this study could approve a strong negative relationship between the perceived ease of use and the perceived risk, meaning that a positive perception of the ease of use reduces the risk that is being feared while driving. Thus, it seems as if, in overall, perceived ease of use is not a major concern for car infotainment system since it is positively perceived by the respondents and in addition does only have a low direct impact on the behavioral intention to use. It is hence surprising that most current efforts in the research about car infotainment seems are done in the Human Machine Interface (HMI) design. It seems as if more efforts should be placed in usefulness concerns. Testing the perceived ease of use in a driver acceptance study is of course not new. Its impact on the behavioral intention to use has already been shown for Distraction Mitigation systems (Roberts et al., 2012) and for context-aware systems (Kwon et al., 2007).As argued before, E. Park and Kim (2014) replaced the perceived ease of use with multiple other factors. For these they also found support for an influence on the behavioral intention to use and also on the perceived usefulness. This latter relation has also been found by Höltl and Trommer (2012) and Kwon et al. (2007). However, not all studies could support both hypotheses (Adell, 2009; Höltl & Trommer, 2012; Roberts et al., 2012). Seeing that the relationships found in this study are among the weakest in the causal model, it might be concluded that perceived ease of use plays a less important role for driver acceptance than it had in technology acceptance of computer systems in working environments.

## 6.3. Perceived Task-Technology-Fit

As it has been mentioned before, the task-technology-fit construct has not been used in car-related studies so far. Therefore, one of the major findings of this study was to prove its importance in the research model. Considering the overall mean value regarding this construct, it can be said that the respondents perceived car infotainment systems as a technology that meet their needs while driving. However, this value is not strong enough to fully show the drivers' agreement on the task-technology-fit of app-based Car Infotainment Systems. The perceived task-technology-fit turned out to be the second strongest direct antecedent of the behavioral intention to use car infotainment systems, following the perceived usefulness. The strongest relationship in the research model could further be found between the task-technology-fit and the perceived usefulness. With a path value of 0.658, this is by far the strongest implication.

Therefore, it can be concluded that an increase of the task-technology-fit will positively influence both the perceived usefulness and the behavioral intention to use. By considering both this direct and indirect effect on the acceptance of car infotainment, the perceived task-technology-fit turned out to be the most important factor in the research model with a total effect of 0.537 on the behavioral intention to use (see Table **5.7** on page 71). It could be argued that the perceived task-technology-fit and the perceived usefulness are too strongly related to each other in terms of their definition. This could explain the high path value between these constructs and also the implication to the behavioral intention. However, the tests for discriminant validity in the preceding section revealed that these constructs are sufficiently different from each other.

## 6.4. Perceived Risk

As it is noted by Roberts et al. (2012), one of the major concerns regarding in-vehicle information systems is driver distraction which can potentially increase the number of crashes. On the other hand, privacy can be a potential risk about using car infotainment systems. It was also considered as a construct influencing behavioral intention in prior mobile-related studies (Mallat et al., 2008). Therefore, the authors considered these two dimensions as a construct called perceived risk which has already been considered as an influencing factor in technology acceptance model in other fields (Pavlou, 2003; Wu & Wang, 2005).

This claim was proven by having the highest mean value measured based on the respondents' answers. Thus, respondents agreed upon the risk of car infotainment systems. The concerns about driver distraction and resulting crashes are thereby more significant than privacy concerns linked with the introduction of third-party applications. Interestingly, however, the risk construct did not have a significant direct influence on behavioral intention to use car infotainment systems in the sample of this study. The fourth hypothesis was rejected. Nevertheless, it is an important factor in this research model since is considered to have a significant negative effect on the perceived task-technology-fit construct. The fifth hypothesis was proven. A higher perceived risk therefore decreases the perception of the task-technology-fit, which as it has been argued above is the most influential factor for the behavioral intention to use car infotainment. In terms of the total effect, the perceived risk thus still has a significant negative effect on the behavioral intention to use, even if its direct influence could not be proven significantly. The perceived risk has been suggested as an influencing factor for driver-related applications in many cases (see e.g. Meschtscherjakov et al., 2009; J. Park et al., 2013; Planing, 2014). However, its influence has not been tested among users or could not be supported. Therefore, this study contributed by testing its influence and finding that there is only a significant indirect influence on the behavioral intention to use.

## 6.5. Perceived Cost

Different types of costs concerning car infotainment systems were another issue that motivated the authors to consider this construct as an influencing factor in their proposed model. Acquisition of the technology, usage costs for applications were the two dimensions of expenses regarding car infotainment systems. In addition, as it was described by recent research, costs were in the first three most important issues shaping the attitude of the users toward in-vehicle technologies (Deloitte, 2014b). Indeed, it has been found that car infotainment systems to date are being perceived as expensive and respondents tended to state that they would only use free applications. Thereby, the acquisition costs showed to be a bigger concern than the usage costs which is not surprising since the price level of these two components is quite different today.

Furthermore, it could also been shown that the perceived costs actually negatively influence the driver's attitudes towards the system, even if the coefficient was the lowest one among the supported hypotheses. This means that as the costs of the technology increase the behavioral intention to purchase such a car will decrease. To the authors' knowledge, the perceived costs have only been considered once before in a driver-related acceptance study (Planing, 2014). However, it has not been subsequently tested quantitatively which shows that this study provided the first evidence that perceived costs can have indeed a negative impact on the behavioral intention to use in-vehicle systems, even if not a very strong one.

# 7.Conclusions and Future Research

*This chapter serves as a summary of the findings related to the research questions. Based on these, implications for practice are pointed out. The contribution of this study, limitations and suggestions for future research are presented consequently.*

In order to explain car driver's acceptance of app-based car infotainment systems, a two-step approach has been taken. Two research questions where posed for the purpose of this study. First of all, the perceptions of car drivers about the system should be measured. Therefore, quantitative data was collected from car drivers about their attitude towards several characteristics of the systems. Descriptive statistical analysis of the responses was used in order to measure these overall perceptions. The results were then used to analyze which of these characteristics, or in that case the so-called factors, influence the behavioral intention to use app-based car infotainment systems. This behavioral intention is considered to be the most important factor for the actual usage (Davis, 1989) which in that case also includes a purchasing decision. Structural Equation Modeling was used to determine the influential factors.

## 7.1. Research Questions

**Research Question 1: How are app-based car infotainment systems perceived by car drivers?**

Overall, the empirical results revealed, that app-based car infotainment systems are perceived positively by car drivers. An aggregated positive intention to use the system could be found. The respondents indicate especially that they perceive the system as being easy to use. There is also an overall positive perception of the usefulness of the system. However, the results show that this applies more to car-specific applications than to the applications known from smartphones. The provided functionalities are expected to meet car drivers' needs in most cases. Nevertheless, the systems are also perceived as being risky, especially in terms of driver distraction. Privacy issues are also a concern, but not as negatively perceived as distraction. To date, the systems are perceived as being expensive by many respondents. A tendency to use only free applications could further be identified.

In general, even though the aggregate values draw a rather positive image of the perceptions, it should also be seen that a significant amount of the car drivers shows no intention to use the system or perceives certain characteristics as negative. It was therefore important to determine which factors are actually influencing this intention in order to be able to draw implications for practice.

**Research Question 2: Which factors influence the driver's acceptance of app-based car infotainment systems?**

The research model of this study considered five hypothetically influencing factors based on a literature review on the system and driver acceptance studies: Perceived Usefulness, Perceived Ease-of-Use, Perceived Risk, Perceived Task-Technology-Fit and Perceived Costs. The results revealed that all factors except for the Perceived Risk have a direct influence on the behavioral intention to use and therefore the user's acceptance. Perceived Usefulness is thereby the strongest directly influencing factor. Considering also indirect influences, the Perceived Task-Technology-Fit becomes the most influential factor. Furthermore, Perceived Risk could be found to be a significant indirect factor by influencing the perception of the task-technology-fit. As expected, Perceived Costs and Perceived Risk have a negative impact on the acceptance, whereas Perceived Usefulness, Perceived Ease-of-Use and Perceived Task-Technology-Fit influence the acceptance positively. About 56 percent of the variance in the behavioral intention could be explained using the proposed research model.

Further indirect effects could be found between the Perceived Ease-of-Use and Perceived Risk as well as Perceived Usefulness. The Perceived Task-Technology-Fit has also been found to be a factor influencing the usefulness construct. Together, Perceived Ease-of-Use and Perceived Task-Technology-Fit could explain main parts of the Perceived Usefulness.

## 7.2. Implications

The results show that in overall the attitude towards app-based Car Infotainment Systems is positive. This tendency, however, is not particularly strong and also many respondents showed no intention to use the system. Therefore, the results allow implications for practice on where they can improve their products. This is especially valuable since this study has been conducted in an early development stage.

Major improvement potential can be found in the Perceived Usefulness. It is the strongest directly influencing factor and its positive perception is not particularly strong, comparing it for example to the Perceived Ease-of-Use. The questions regarding this factor allow furthermore comparing the perception of the apps known from smartphones with new car-specific applications. Drivers' expectations regarding the latter category are higher, seeing more potential usefulness in these applications. It seems logic that focusing on these applications which are designed to support the driver in his driving could further enhance the Perceived Task-Technology-Fit which has the strongest total effect on the driver acceptance in this study.

Considering how much research is being done on the design of Human Machine Interfaces, it is surprising that the system's Ease-of-Use is already perceived very positively. As expected, however, improving the Ease-of-Use will lead to a lower risk perception, which is currently very high. Regarding the Perceived Risk, it can be said however, that it is surprisingly no directly influencing factor but only has a negative effect on the Perceived Task-Technology-Fit. Privacy concerns exist among car drivers, but the focus should be still put on driver distraction concerns since these are significantly stronger.

Furthermore, it has been found that the costs are perceived as being too high. And this has a significant negative influence on the behavioral intention to use. It should thus be attempted to lower the prices, especially for the acquisition costs. The price sensitivity of car drivers for application costs is lower. Therefore, business models that concentrate more on the purchasing of applications might enhance the acceptance.

## 7.3. Contribution

This study contributes knowledge in certain ways. First of all, it is the first user acceptance study on app-based car infotainment systems. To the author's knowledge, there is no other research on this topic. Therefore, this study provides the first evidence for previously considered factors that influence the acceptance of these systems. Furthermore, the literature review revealed that there are few studies on user acceptance for in-vehicle computer systems in general. The positive results of this study show again the applicability of Information Systems (IS) theories in this field. The Technology Acceptance Model (Davis, 1989) remained valid in this context of a pre-adoption setting and in a field that is not the traditional focus of IS research. This IS research entered the automotive domain and proved the correctness of the theory in an experiential computing context, that has some characteristics different from the traditional working environment being focused on in the traditional IS research (Venkatesh & Brown, 2001).

Lastly, this study showed the influence of five factors on the behavioral intention to use app-based car infotainment systems and succeeded thereby to explain major parts of the variance in the dependent construct. Therefore, the research model used can serve as a basis in other related settings and additional factors can be used around this core model in future studies of the same systems.

## 7.4. Limitations

Limitations have to be mentioned for the results of this study. Being restricted in resources, especially in time, the study could not be completely conducted in the desirable way. The main limitations stem from the methodology used in the data collection phase. The sample achieved in this study is not representative for the world population of car drivers. It consists of too many male respondents and covers mainly younger drivers. While the latter could be argued to be fitting to the target group of the industry (Deloitte, 2014b), more female answers would have been favorable. Further, the responses distribution over the continents is not representative. Therefore, conclusions drawn from this study can only be considered to be valid for the European, Asian and North American market. The sampling method further was a non-probability sampling strategy. Starting the survey in the direct contacts of the authors therefore jeopardizes the generalizability of this study (Bhattacherjee, 2012). However, no specific criteria for the selection of participants were considered in this study which makes the authors believe that the findings are still generalizable to a certain extent, if the sample characteristics are being considered.

A further limitation to the results stems from the nature of this study. It is a pre-adoption study about the driver acceptance of app-based Car Infotainment Systems. The study can therefore not draw conclusions about the actual usage of the systems. In addition, respondents to this survey did not need to have prior experience with the system focused on in this study. Therefore, their perceptions are based solely on the description provided by the authors in the beginning of the questionnaire in most cases. Perceptions could be different after a person actually got access to an app-based Car Infotainment System and could try it.

## 7.5. Future Research

Based on the limitations of the study and the contributions made, several opportunities for future research arise:

First of all, in a future study with less restriction in time and resources, the same approach could be used with a different sampling strategy. This could end up in better generalizable results and could therefore test whether the found results hold true in a representative sample. A larger sample size would further be favorable in this context of a consumer study. A bigger sample size might also enable researchers to draw conclusions about group differences according to the age, gender, origin or driving experience. These factors are often mentioned as moderating or background variables in technology acceptance studies in general (Venkatesh et al., 2003), and also in driver acceptance scenarios (Yannis, Antoniou, Vardaki, & Kanellaidis, 2009; Young, Bayly, & Lenné, 2012).

Secondly, a post-adoption study would be a favorable complement to this study after the systems actually hit the broad market and first app ecosystems related to car driving emerge. It would be interesting to see in which way the perceptions change, whether the causal model holds true and how strong the relationship between the pre-adoption behavioral intention to use and the post-adoption actual usage is. Having these results, one can finally judge whether a pre-adoption study like in this case has sufficient predictive power.

The positive results achieved with the research model in this study should further encourage researchers to use the research model as a whole or only some hypothetical factors in future inquiries about driver acceptance. It can be interesting to see whether the findings prove to be generalizable for other in-vehicle computer systems. Over time specific characteristics about in-vehicle in terms of user acceptance might emerge. Since all hypotheses except for one held true in this study, there is also the opportunity to extend the research model by other directly or indirectly influencing factors to increase the amount of variance explained in the behavioral intention to use. For a first driver acceptance study on these systems, the authors limited themselves to consider only directly influencing factors and their inter-relationships.

# Appendix 1: Information text

**Before Pre-Test:**

In order to have a common understanding of Car Infotainment Systems, we provide a short description here including a short demonstration video. Please read through this and take it as a basis for answering the following questions.

Car Infotainment Systems (or also frequently called In-Vehicle Infotainment, short IVI) are computer systems in automobiles that deliver entertainment and information content. These systems frequently utilize Bluetooth technology and/or smartphones to help drivers control the system with voice commands, touchscreen input, or physical controls.

While each system is different, typical tasks that can be performed with an in-vehicle infotainment system include managing and playing audio content, utilizing navigation for driving, delivering rear-seat entertainment such as movies, games, social networking, etc., listening to incoming and sending outgoing emails and messages, making phone calls, and accessing Internet-enabled or smartphone-enabled content such as traffic conditions, sports scores and weather forecasts.

With the integrated Internet connection, the trend emerges that the Car Infotainment Systems open themselves as app platforms in order to attract third-party app developers who provide new car-related applications using the car's data such as location and speed.

(Definition adapted from: (Webopedia, 2014) )

Additional video can be found on: https://www.youtube.com/watch?v=kqgrGho4aYM

**After Pre-Test:**

In order to have a common understanding of *the new, upcoming generations of Car Infotainment Systems with integrated app-platforms*, we provide a short description here including a short demonstration video. Please read through this and **take this description as a basis for answering** the following questions.

Car Infotainment Systems (or also frequently called In-Vehicle Infotainment, short IVI) are computer systems in automobiles that deliver entertainment and information content. These systems frequently utilize Bluetooth technology and/or smartphones to help drivers control the system with voice commands, touchscreen input, or physical controls.

While each system is different, typical tasks that can be performed with an in-vehicle infotainment system include managing and playing audio content, utilizing navigation for driving, delivering rear-seat entertainment such as movies, games, social networking, etc., listening to incoming and sending outgoing emails and messages, making phone calls, and accessing Internet-enabled or smartphone-enabled content such as traffic conditions, sports scores and weather forecasts.

With the integrated Internet connection, the trend emerges that the Car Infotainment Systems open themselves as app platforms in order to attract third-party app developers who provide new car-related applications using the car's data such as location and speed. *Furthermore, applications can be made available which are already installed on a driver's smartphone.*

(Definition adapted from: (Webopedia, 2014) )

Additional video can be found on: https://www.youtube.com/watch?v=kqgrGho4aYM

# Appendix 2: Demographic Questions

## Personal Details

**How long do you have your driving license? ***

- I don't have a driving license
- Less than 5 years
- 5-10 years
- More than 10 years

**How frequently do you drive usually? ***

- Almost every day
- More than once a week
- More than once a month
- Less than once a month

**What is your gender? ***

- Male
- Female

**Which continent do you come from? ***

- Europe
- Asia
- North America
- South America
- Africa
- Australia

**How old are you? ***

**I can imagine to buy a car in ... ***

- .... the next year
- ... the next 3 years
- ... the next 5 years
- I have no plans to buy a car in the next 5 years.

# Appendix 3: Measurement Items before Pre-Test

| Measurement Item | Reference |
|---|---|
| **Perceived Usefulness** | |
| Using Car Infotainment Systems while driving would increase my productivity. | (Davis, 1989) |
| I would find using a Car Infotainment System useful while driving my car. | (Davis, 1989) |
| If I were to adopt a Car Infotainment System, it would make driving easier. | (Karahanna et al., 1999) |
| If I were to adopt a Car Infotainment System, the quality of driving would improve. | (Karahanna et al., 1999) |
| **Perceived Ease of Use** | |
| I would find Car Infotainment Systems easy to use. | (Davis, 1989) |
| Learning to operate Car Infotainment Systems would be easy for me. | (Davis, 1989) |
| I would find it easy to get a Car Infotainment System to do what I want it to do. | (Davis, 1989) |
| **Perceived Task-Technology-Fit** | |
| In helping me to drive a car, the functionalities of Car Infotainment Systems would be appropriate. | (Lin & Huang, 2008) |
| The functionalities of Car Infotainment Systems would be very compatible with driving. | (Lin & Huang, 2008) |
| In general, the functions of Car Infotainment Systems fully meet my needs while driving. | (Zhou et al., 2010) |
| **Perceived Risk** | |
| I think using Car Infotainment Systems while driving has potential risks. | (Wu & Wang, 2005) |
| I think using Car Infotainment Systems with third-party applications puts my privacy at risk. | (Wu & Wang, 2005) |
| **Perceived Costs** | |

| | |
|---|---|
| I think the acquisition costs of a Car Infotainment System are expensive. (Help Text: Today, a Car Infotainment System costs around 500-2000 Euros for a mid-class car.) | (Wu & Wang, 2005) |
| I would only use free Car Infotainment applications. | (own measurement item) |
| **Behavioral Intention to Use** | |
| Given the chance, I plan to experiment with or regularly use a Car Infotainment System while driving. | (Karahanna et al., 1999) |
| If I were planning to buy a car, I would equip it with a Car Infotainment System. | (own measurement item) |

# Appendix 4: Revised Measurement Items

| Measurement Item | Reference | Commentary |
|---|---|---|
| **Perceived Usefulness** | | |
| *Imagine, an app-based infotainment system was on the market and you could get it into your own car.* | (Adell, 2009) | Increase clarity that we talk about future, app-based systems. (C) |
| *Having access to my smartphone apps in the car* would increase my productivity. | (Davis, 1989) | (C) |
| *Having access to car-specific apps* while driving would increase my productivity.<br><br>*(Help Text: Such apps could help for example help to find a parking lot.)* | (Davis, 1989) | More details, provides interesting insights for practitioners. (P) |
| I would find *having access to my smartphone apps* useful *in my car*. | (Davis, 1989) | (C) |
| I would find *having access to apps with car-specific functionalities* useful while driving my car.<br><br>*(Help Text: Such apps could help for example help to find a parking lot.)* | (Davis, 1989) | (P) |
| ~~If I were to adopt a Car Infotainment System, it would make driving easier.~~ | ~~(Karahanna et al., 1999)~~ | Item was found to be confusing. |
| If I *had access to more apps and functionalities*, the quality of driving would improve. | (Karahanna et al., 1999) | (C) |
| **Perceived Ease of Use** | | |
| I would find *app-based* Car Infotainment Systems easy to use. | (Davis, 1989) | (C) |
| Learning to operate *app-based* Car Infotainment Systems would be easy for me. | (Davis, 1989) | (C) |
| I would find it easy to get an *app-based* Car Infotainment System to do what I want it to do. | (Davis, 1989) | (C) |
| *Having more apps/functions would make the Car Infotainment System more difficult to use.* | *(Karahanna et al., 1999)* | (P) |
| **Perceived Task-Technology-Fit** | | |

| | | |
|---|---|---|
| In helping me to *achieve the purposes of my car drives*, the functionalities of *app-based* Car Infotainment Systems would be appropriate.<br><br>*(Help text: Purpose of driving - what you use your car for (e.g. shopping, commuting to work, leisure activities, travel))* | (Lin & Huang, 2008) | (C), Clarity about what is the supported task. (T) |
| The functionalities of *app-based* Car Infotainment Systems would be very compatible with *my driving purposes*. | (Lin & Huang, 2008) | (C), (T) |
| In general, the functions of *app-based* Car Infotainment Systems *would* fully meet my needs while driving. | (Zhou et al., 2010) | (C) |
| **Perceived Risk** | | |
| I think using Car Infotainment Systems while driving has potential risks. | (Wu & Wang, 2005) | |
| I think using Car Infotainment Systems with third-party applications puts my privacy at risk. | (Wu & Wang, 2005) | |
| **Perceived Costs** | | |
| I think the acquisition costs of a Car Infotainment System are expensive. (Help Text: Today, a Car Infotainment System costs around 500-2000 Euros for a mid-class car.) | (Wu & Wang, 2005) | |
| I would only use free Car Infotainment applications. | (own measurement item) | |
| **Behavioral Intention to Use** | | |
| *Imagine, an app-based infotainment system was on the market and you could get it into your own car.* | (Adell, 2009) | (C) |
| Given the chance, I plan to experiment with or regularly use an *app-based* Car Infotainment System while driving. | (Karahanna et al., 1999) | (C) |
| If I were planning to buy a car, I would equip it with an *app-based* Car Infotainment System. | (own measurement item) | (C) |

# Appendix 5: Research model - Factor definitions

| Factor | Definition |
|---|---|
| **Perceived Usefulness** | The degree to which a driver believes that using an app-based Car Infotainment System would enhance his or her performance while driving (Davis, 1989). |
| **Perceived Ease of Use** | The degree to which a driver believes that using an app-based Car Infotainment System would be free of effort (Davis, 1989). |
| **Perceived Task-Technology-Fit** | The perception that the capabilities of the Car Infotainment System match with the driver's requirements (Lin & Huang, 2008). |
| **Perceived Risk** | The driver's subjective expectation of suffering from using Car Infotainment Systems (Pavlou, 2003; Wu & Wang, 2005). |
| **Perceived Costs** | The possible expenses of using Car Infotainment Systems, including acquisition costs of the software and following costs (Wu & Wang, 2005). |
| **Behavioral Intention to Use** | Driver's willingness to use the Car Infotainment System (Davis, 1989). |

# Appendix 6: Demographic Profile

| Gender | Total (percentage) |
|---|---|
| Male | **124** (73.37%) |
| Female | **45** (26.63%) |

| Age group | Total (percentage) |
|---|---|
| Younger than 25 | **70** (41.42%) |
| Between 25 and 34 | **58** (34.32%) |
| Between 35 and 44 | **12** (7.10%) |
| Between 45 and 54 | **16** (9.47%) |
| Older than 55 | **13** (7.69%) |

| Region | Total (percentage) |
|---|---|
| Africa | **5** (2.98%) |
| Asia | **27** (15.98%) |
| Australia | **5** (2.98%) |
| Europe | **97** (57.40%) |
| North America | **33** (19.53%) |
| South America | **2** (1.18%) |

# Appendix 7: General Information on the Respondents

| **Driving License** | **Total (percentage)** |
|---|---|
| Less than 5 years | **44** (26.04%) |
| 5-10 years | **63** (37.28%) |
| More than 10 years | **62** (36.69%) |

| **Driving Frequency** | **Total (percentage)** |
|---|---|
| Almost every day | **82** (48.52%) |
| More than once a week | **33** (19.53%) |
| More than once a month | **17** (10.06%) |
| Less than once a month | **37** (21.89%) |

| **Car purchasing intention in …** | **Total (percentage)** |
|---|---|
| … the next year | **35** (20.71%) |
| … the next 3 years | **62** (36.69%) |
| … the next 5 years | **43** (25.44%) |
| No plans in the next 5 years. | **29** (17.16%) |

# Appendix 8: Summary of Results per Measurement Item

| Construct | Items code | Mean | Std. Deviation |
|---|---|---|---|
| **Perceived Usefulness (PU)** | PU1 | 2.99 | 1.271 |
| | PU2 | 3.62 | 1.120 |
| | PU3 | 3.50 | 1.167 |
| | PU4 | 3.81 | 1.099 |
| | PU5 | 2.79 | 1.296 |
| | Total | 3.34 | _ |
| **Perceived Ease of Use (PEOU)** | PEOU1 | 3.82 | 1.005 |
| | PEOU2 | 4.23 | 0.936 |
| | PEOU3 | 3.69 | 0.961 |
| | PEOU4 | 3.00 | 1.162 |
| | Total | 3.69 | _ |
| **Perceived Task-Technology-Fit (PTTF)** | PTTF1 | 3.30 | 0.940 |
| | PTTF2 | 3.12 | 1.031 |
| | PTTF3 | 3.02 | 1.014 |
| | PTTF total | 3.15 | _ |
| **Perceived Risk (PR)** | PR1 | 4.17 | 0.991 |
| | PR2 | 3.64 | 1.138 |
| | PR total | 3.91 | _ |
| **Perceived Cost (PC)** | PC1 | 4.01 | 1.018 |
| | PC2 | 3.43 | 1.175 |
| | PC total | 3.72 | _ |
| **Behavioral Intention (BI)** | BI1 | 3.44 | 1.125 |
| | BI2 | 3.27 | 1.209 |
| | BI total | 3.36 | _ |

# Appendix 9: Detailed descriptive statistics per measurement item

| Constructs | Items (Indi-cators) | Measures | Strongly Disagree | Disa-gree | Neu-tral | Agree | Strongly Agree |
|---|---|---|---|---|---|---|---|
| Perceived Useful-ness (PU) | PU1 | Freq. | 26 | 36 | 43 | 41 | 23 |
| | | (%) | 15.38% | 21.30% | 25.44% | 24.26% | 13.61% |
| | PU2 | Freq. | 9 | 22 | 31 | 70 | 37 |
| | | (%) | 5.33% | 13.02% | 18.34% | 41.42% | 21.89% |
| | PU3 | Freq. | 12 | 22 | 40 | 59 | 36 |
| | | (%) | 7.10% | 13.02% | 23.67% | 34.91% | 21.30% |
| | PU4 | Freq. | 7 | 18 | 25 | 69 | 50 |
| | | (%) | 4.14% | 10.65% | 14.79% | 40.83% | 29.59% |
| | PU5 | Freq. | 33 | 43 | 40 | 32 | 21 |
| | | (%) | 19.53% | 25.44% | 23.67% | 18.93% | 12.43% |
| Perceived Ease of Use (PEOU) | PEOU1 | Freq. | 4 | 14 | 37 | 67 | 47 |
| | | (%) | 2.37% | 8.28% | 21.89% | 39.64% | 27.81% |
| | PEOU2 | Freq. | 4 | 5 | 20 | 59 | 81 |
| | | (%) | 2.37% | 2.96% | 11.83% | 34.91% | 47.93% |
| | PEOU3 | Freq. | 4 | 15 | 43 | 74 | 33 |
| | | (%) | 2.37% | 8.88% | 25.44% | 43.79% | 19.53% |
| | PEOU4 | Freq. | 14 | 54 | 37 | 46 | 18 |
| | | (%) | 8.28% | 31.95% | 21.89% | 27.22% | 10.65% |
| Perceived Task-Technology-Fit (PTTF) | PTTF1 | Freq. | 7 | 24 | 62 | 64 | 12 |
| | | (%) | 4.14% | 14.20% | 36.69% | 37.87% | 7.10% |
| | PTTF2 | Freq. | 11 | 35 | 59 | 51 | 13 |
| | | (%) | 6.51% | 20.71% | 34.91% | 30.18% | 7.69% |
| | PTTF3 | Freq. | 11 | 38 | 70 | 36 | 14 |
| | | (%) | 6.51% | 22.49% | 41.42% | 21.30% | 8.28% |
| Perceived Risk (PR) | PR1 | Freq. | 3 | 11 | 20 | 55 | 80 |
| | | (%) | 1.78% | 6.51% | 11.83% | 32.54% | 47.34% |
| | PR2 | Freq. | 7 | 23 | 39 | 54 | 46 |
| | | (%) | 4.14% | 13.61% | 23.08% | 31.95% | 27.22% |
| Perceived Cost (PC) | PC1 | Freq. | 2 | 14 | 33 | 52 | 68 |
| | | (%) | 1.18% | 8.28% | 19.53% | 30.77% | 40.24% |
| | PC2 | Freq. | 8 | 36 | 37 | 52 | 36 |
| | | (%) | 4.73% | 21.30% | 21.89% | 30.77% | 21.30% |
| Behavioral Intention (BI) | BI1 | Freq. | 10 | 27 | 39 | 64 | 29 |
| | | (%) | 5.92% | 15.98% | 23.08% | 37.87% | 17.16% |
| | BI2 | Freq. | 18 | 25 | 48 | 50 | 28 |
| | | (%) | 10.65% | 14.79% | 28.40% | 29.59% | 16.57% |

# Appendix 10: Detailed Responses

| TIME | PU1 | PU2 | PU3 | PU4 | PU5 | PEOU1 | PEOU2 | PEOU3 | PEOU4 | PTTF1 | PTTF2 | PTTF3 | RISK1 | RISK2 | PRICE1 | PRICE2 | BI1 | BI2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 05.02.2014 04:40 | 3 | 5 | 4 | 5 | 2 | 5 | 5 | 4 | 3 | 4 | 4 | 3 | 4 | 2 | 3 | 2 | 4 | 3 |
| 05.02.2014 13:50 | 1 | 1 | 3 | 2 | 2 | 5 | 5 | 4 | 2 | 1 | 2 | 3 | 4 | 5 | 5 | 5 | 2 | 1 |
| 05.02.2014 13:50 | 4 | 3 | 4 | 2 | 3 | 5 | 5 | 4 | 5 | 3 | 4 | 3 | 5 | 4 | 5 | 5 | 4 | 2 |
| 05.02.2014 13:50 | 1 | 4 | 4 | 5 | 1 | 5 | 5 | 5 | 2 | 4 | 4 | 4 | 5 | 4 | 5 | 3 | 5 | 5 |
| 05.02.2014 13:52 | 2 | 3 | 4 | 4 | 2 | 3 | 5 | 4 | 4 | 4 | 3 | 2 | 5 | 4 | 3 | 2 | 3 | 2 |
| 05.02.2014 13:55 | 3 | 5 | 3 | 5 | 3 | 3 | 3 | 2 | 3 | 4 | 3 | 2 | 4 | 5 | 4 | 3 | 4 | 3 |
| 05.02.2014 13:57 | 3 | 3 | 5 | 3 | 4 | 4 | 4 | 4 | 3 | 4 | 2 | 4 | 4 | 3 | 3 | 2 | 4 | 5 |
| 05.02.2014 13:59 | 4 | 4 | 5 | 4 | 3 | 5 | 5 | 4 | 2 | 5 | 4 | 4 | 3 | 4 | 3 | 2 | 4 | 5 |
| 05.02.2014 14:02 | 3 | 4 | 3 | 4 | 4 | 4 | 4 | 4 | 3 | 3 | 3 | 3 | 4 | 3 | 4 | 3 | 4 | 4 |
| 05.02.2014 14:08 | 2 | 2 | 4 | 2 | 1 | 5 | 5 | 5 | 1 | 2 | 2 | 3 | 5 | 2 | 5 | 5 | 2 | 5 |
| 05.02.2014 14:12 | 1 | 2 | 4 | 5 | 1 | 3 | 5 | 4 | 2 | 3 | 3 | 4 | 3 | 3 | 4 | 4 | 2 | 3 |
| 05.02.2014 14:22 | 4 | 4 | 3 | 5 | 3 | 4 | 5 | 5 | 2 | 4 | 3 | 3 | 5 | 5 | 3 | 3 | 5 | 4 |
| 05.02.2014 14:38 | 4 | 5 | 4 | 4 | 2 | 4 | 5 | 5 | 2 | 4 | 4 | 3 | 5 | 3 | 4 | 3 | 4 | 3 |
| 05.02.2014 14:40 | 3 | 4 | 3 | 3 | 3 | 2 | 4 | 4 | 2 | 2 | 1 | 2 | 4 | 4 | 5 | 4 | 2 | 1 |
| 05.02.2014 14:43 | 2 | 4 | 3 | 4 | 3 | 4 | 4 | 3 | 2 | 3 | 3 | 2 | 3 | 5 | 5 | 5 | 2 | 2 |
| 05.02.2014 14:54 | 2 | 4 | 3 | 4 | 2 | 3 | 4 | 3 | 4 | 3 | 3 | 2 | 4 | 4 | 4 | 2 | 3 | 3 |
| 05.02.2014 14:57 | 3 | 5 | 4 | 5 | 3 | 4 | 5 | 4 | 3 | 4 | 4 | 4 | 5 | 4 | 4 | 2 | 3 | 5 |
| 05.02.2014 15:01 | 4 | 4 | 5 | 4 | 2 | 3 | 5 | 4 | 4 | 3 | 4 | 5 | 4 | 5 | 4 | 4 | 5 | 2 |
| 05.02.2014 15:08 | 1 | 2 | 1 | 2 | 2 | 4 | 5 | 3 | 3 | 3 | 3 | 2 | 4 | 5 | 5 | 4 | 4 | 1 |
| 05.02.2014 15:12 | 5 | 4 | 4 | 4 | 1 | 4 | 5 | 4 | 3 | 3 | 2 | 3 | 5 | 4 | 4 | 2 | 5 | 4 |
| 05.02.2014 15:13 | 5 | 3 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 5 | 5 | 5 | 5 | 5 | 4 |
| 05.02.2014 15:31 | 2 | 2 | 3 | 2 | 2 | 3 | 4 | 4 | 4 | 3 | 2 | 3 | 5 | 2 | 1 | 2 | 2 | 3 |
| 05.02.2014 15:55 | 2 | 2 | 1 | 3 | 2 | 5 | 4 | 4 | 2 | 2 | 2 | 1 | 5 | 4 | 4 | 4 | 2 | 1 |
| 05.02.2014 16:03 | 4 | 4 | 5 | 4 | 1 | 3 | 5 | 4 | 2 | 3 | 4 | 5 | 5 | 3 | 5 | 4 | 4 | 2 |
| 05.02.2014 16:05 | 4 | 3 | 4 | 4 | 4 | 4 | 4 | 4 | 2 | 4 | 3 | 4 | 3 | 4 | 4 | 4 | 4 | 3 |

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 05.02.2014 16:05 | 1 | 4 | 1 | 2 | 1 | 2 | 3 | 2 | 4 | 2 | 2 | 1 | 5 | 4 | 3 | 4 | 1 | 1 |
| 05.02.2014 16:07 | 3 | 4 | 4 | 4 | 3 | 4 | 5 | 3 | 3 | 4 | 4 | 3 | 5 | 3 | 4 | 3 | 4 | 4 |
| 05.02.2014 16:39 | 4 | 3 | 3 | 3 | 3 | 5 | 5 | 4 | 2 | 3 | 3 | 3 | 4 | 3 | 3 | 2 | 4 | 3 |
| 05.02.2014 16:54 | 2 | 2 | 2 | 2 | 1 | 1 | 5 | 3 | 3 | 3 | 1 | 2 | 4 | 4 | 2 | 2 | 1 | 1 |
| 05.02.2014 17:20 | 5 | 4 | 5 | 4 | 5 | 5 | 5 | 4 | 1 | 4 | 4 | 3 | 2 | 3 | 5 | 4 | 4 | 4 |
| 05.02.2014 17:49 | 2 | 4 | 4 | 5 | 4 | 4 | 4 | 3 | 3 | 4 | 4 | 3 | 4 | 2 | 3 | 4 | 4 | 3 |
| 05.02.2014 18:01 | 2 | 2 | 3 | 3 | 1 | 2 | 3 | 2 | 4 | 3 | 3 | 2 | 5 | 3 | 5 | 4 | 1 | 1 |
| 05.02.2014 18:12 | 3 | 4 | 4 | 3 | 2 | 5 | 5 | 5 | 3 | 3 | 4 | 2 | 4 | 2 | 3 | 4 | 3 | 3 |
| 05.02.2014 18:22 | 4 | 4 | 4 | 4 | 3 | 4 | 5 | 5 | 3 | 3 | 3 | 3 | 5 | 5 | 5 | 4 | 3 | 3 |
| 05.02.2014 18:24 | 3 | 5 | 3 | 5 | 4 | 4 | 5 | 4 | 3 | 4 | 2 | 3 | 5 | 5 | 4 | 2 | 3 | 3 |
| 05.02.2014 18:28 | 4 | 4 | 4 | 4 | 3 | 3 | 4 | 4 | 2 | 3 | 3 | 3 | 3 | 3 | 4 | 3 | 3 | 3 |
| 05.02.2014 18:32 | 1 | 3 | 1 | 4 | 2 | 4 | 4 | 4 | 5 | 3 | 3 | 3 | 3 | 3 | 5 | 5 | 3 | 2 |
| 05.02.2014 18:39 | 4 | 4 | 4 | 4 | 3 | 4 | 5 | 3 | 2 | 3 | 4 | 3 | 3 | 3 | 3 | 2 | 4 | 3 |
| 05.02.2014 19:03 | 2 | 4 | 3 | 2 | 2 | 4 | 2 | 3 | 2 | 4 | 2 | 2 | 4 | 5 | 4 | 5 | 2 | 1 |
| 05.02.2014 19:31 | 4 | 4 | 4 | 4 | 3 | 4 | 3 | 3 | 4 | 4 | 3 | 3 | 4 | 3 | 4 | 4 | 4 | 3 |
| 05.02.2014 19:33 | 3 | 3 | 3 | 5 | 5 | 4 | 4 | 4 | 2 | 3 | 3 | 3 | 4 | 1 | 2 | 5 | 4 | 4 |
| 05.02.2014 19:47 | 3 | 4 | 5 | 5 | 2 | 3 | 5 | 4 | 2 | 2 | 2 | 2 | 4 | 4 | 5 | 2 | 4 | 2 |
| 05.02.2014 19:54 | 3 | 3 | 4 | 4 | 3 | 5 | 5 | 5 | 2 | 4 | 4 | 4 | 4 | 5 | 3 | 4 | 4 | 3 |
| 05.02.2014 20:11 | 1 | 1 | 3 | 1 | 2 | 4 | 4 | 4 | 3 | 3 | 4 | 5 | 5 | 5 | 4 | 5 | 2 | 2 |
| 05.02.2014 20:40 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 3 | 5 | 5 | 5 | 2 | 4 | 4 | 3 | 5 | 3 |
| 05.02.2014 20:55 | 1 | 1 | 2 | 1 | 1 | 4 | 3 | 3 | 1 | 1 | 1 | 1 | 5 | 5 | 5 | 1 | 1 | 1 |
| 05.02.2014 21:20 | 4 | 4 | 5 | 4 | 4 | 3 | 5 | 5 | 4 | 4 | 4 | 4 | 5 | 2 | 5 | 4 | 5 | 4 |
| 05.02.2014 21:36 | 4 | 4 | 5 | 4 | 4 | 4 | 4 | 3 | 3 | 4 | 4 | 4 | 5 | 1 | 5 | 5 | 4 | 5 |
| 05.02.2014 23:07 | 2 | 3 | 3 | 4 | 2 | 4 | 5 | 3 | 3 | 4 | 3 | 4 | 5 | 3 | 4 | 4 | 4 | 3 |
| 05.03.2014 00:49 | 3 | 4 | 5 | 5 | 3 | 5 | 5 | 5 | 2 | 3 | 4 | 3 | 4 | 3 | 4 | 2 | 5 | 4 |
| 05.03.2014 08:14 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 3 | 3 | 5 | 5 | 5 | 5 |
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| 05.03.2014 14:47 | 2 | 2 | 2 | 3 | 2 | 4 | 3 | 4 | 2 | 3 | 3 | 4 | 5 | 4 | 5 | 4 | 3 | 2 |
| 05.03.2014 15:40 | 4 | 5 | 4 | 4 | 5 | 5 | 5 | 3 | 3 | 4 | 3 | 3 | 4 | 3 | 5 | 3 | 4 | 4 |

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| 05.03.2014 16:33 | 2 | 2 | 2 | 2 | 1 | 5 | 5 | 5 | 1 | 1 | 2 | 2 | 1 | 1 | 5 | 5 | 3 | 3 |
| 05.03.2014 17:34 | 5 | 5 | 5 | 4 | 4 | 3 | 4 | 3 | 4 | 4 | 4 | 4 | 4 | 3 | 3 | 4 | 4 | 3 |
| 05.03.2014 18:36 | 3 | 4 | 4 | 5 | 2 | 4 | 4 | 3 | 3 | 3 | 2 | 3 | 4 | 3 | 4 | 3 | 4 | 3 |
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| 05.03.2014 20:25 | 5 | 5 | 5 | 5 | 3 | 4 | 5 | 4 | 4 | 3 | 3 | 3 | 4 | 3 | 2 | 1 | 5 | 5 |
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| 05.03.2014 22:18 | 4 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 2 | 5 | 5 | 5 | 3 | 2 | 5 | 4 | 5 | 5 |
| 05.03.2014 22:36 | 3 | 3 | 3 | 5 | 4 | 3 | 3 | 3 | 3 | 4 | 3 | 3 | 4 | 3 | 3 | 3 | 3 | 3 |
| 05.03.2014 22:54 | 3 | 4 | 5 | 5 | 1 | 5 | 5 | 3 | 3 | 4 | 4 | 3 | 5 | 5 | 2 | 3 | 4 | 4 |
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| 05.04.2014 03:40 | 1 | 4 | 3 | 5 | 1 | 4 | 4 | 4 | 2 | 4 | 4 | 2 | 5 | 2 | 5 | 1 | 4 | 2 |
| 05.04.2014 05:24 | 3 | 4 | 2 | 4 | 3 | 2 | 4 | 4 | 5 | 2 | 2 | 2 | 5 | 4 | 5 | 3 | 1 | 2 |
| 05.04.2014 06:57 | 2 | 2 | 3 | 3 | 1 | 3 | 5 | 2 | 5 | 2 | 3 | 2 | 5 | 5 | 5 | 5 | 2 | 2 |
| 05.04.2014 07:45 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 5 | 5 | 5 | 5 | 1 | 1 |
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| 05.04.2014 13:06 | 3 | 4 | 4 | 4 | 2 | 2 | 3 | 4 | 2 | 3 | 2 | 2 | 5 | 4 | 3 | 4 | 2 | 1 |
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| 05.04.2014 15:19 | 1 | 1 | 2 | 2 | 1 | 5 | 4 | 4 | 3 | 1 | 2 | 2 | 5 | 4 | 3 | 4 | 2 | 2 |
| 05.04.2014 15:26 | 1 | 4 | 1 | 5 | 1 | 3 | 4 | 3 | 5 | 2 | 2 | 2 | 5 | 5 | 5 | 5 | 2 | 2 |
| 05.04.2014 15:29 | 3 | 3 | 2 | 4 | 3 | 4 | 4 | 2 | 4 | 3 | 3 | 3 | 5 | 5 | 4 | 3 | 3 | 4 |

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| 05.04.2014 16:12 | 5 | 5 | 5 | 5 | 4 | 3 | 3 | 3 | 3 | 4 | 4 | 3 | 4 | 5 | 4 | 3 | 4 | 4 |
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| 05.04.2014 17:51 | 5 | 5 | 4 | 5 | 5 | 4 | 3 | 4 | 4 | 3 | 3 | 3 | 3 | 3 | 4 | 3 | 4 | 4 |
| 05.04.2014 17:57 | 3 | 4 | 3 | 4 | 3 | 3 | 3 | 4 | 4 | 2 | 2 | 2 | 5 | 5 | 3 | 3 | 2 | 2 |
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| 05.04.2014 21:58 | 2 | 4 | 3 | 3 | 4 | 5 | 5 | 4 | 4 | 3 | 3 | 3 | 4 | 3 | 5 | 5 | 3 | 3 |
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| 05.05.2014 01:18 | 2 | 2 | 3 | 2 | 2 | 2 | 3 | 2 | 3 | 2 | 2 | 2 | 5 | 4 | 4 | 4 | 2 | 3 |
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| 05.05.2014 02:27 | 5 | 3 | 5 | 3 | 2 | 3 | 5 | 2 | 2 | 3 | 3 | 2 | 4 | 5 | 5 | 1 | 4 | 4 |
| 05.05.2014 07:58 | 5 | 5 | 5 | 5 | 4 | 5 | 5 | 5 | 3 | 4 | 4 | 4 | 3 | 4 | 5 | 4 | 4 | 5 |
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| 05.05.2014 10:28 | 3 | 4 | 3 | 4 | 3 | 4 | 4 | 4 | 4 | 4 | 4 | 3 | 3 | 4 | 5 | 3 | 4 | 4 |
| 05.05.2014 10:28 | 3 | 3 | 4 | 4 | 2 | 4 | 4 | 4 | 1 | 4 | 4 | 4 | 4 | 3 | 3 | 2 | 3 | 3 |
| 05.05.2014 10:46 | 3 | 4 | 4 | 4 | 4 | 5 | 5 | 2 | 2 | 4 | 4 | 4 | 4 | 4 | 2 | 1 | 3 | 4 |
| 05.05.2014 10:55 | 2 | 4 | 4 | 4 | 3 | 4 | 4 | 2 | 2 | 3 | 4 | 3 | 5 | 4 | 3 | 4 | 5 | 4 |
| 05.05.2014 11:46 | 4 | 5 | 4 | 5 | 5 | 4 | 5 | 4 | 5 | 4 | 4 | 3 | 4 | 4 | 3 | 2 | 5 | 5 |
| 05.05.2014 13:52 | 1 | 5 | 2 | 5 | 3 | 2 | 4 | 3 | 4 | 5 | 4 | 2 | 5 | 5 | 5 | 5 | 2 | 2 |
| 05.05.2014 14:04 | 5 | 5 | 5 | 5 | 3 | 5 | 5 | 5 | 2 | 5 | 5 | 5 | 2 | 4 | 3 | 2 | 5 | 5 |
| 05.05.2014 14:37 | 3 | 4 | 4 | 5 | 4 | 3 | 5 | 2 | 2 | 5 | 4 | 4 | 5 | 5 | 5 | 4 | 5 | 4 |
| 05.05.2014 14:49 | 4 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 2 | 4 | 5 | 4 | 3 | 2 | 5 | 4 | 4 | 4 |
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| 05.05.2014 15:30 | 1 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 4 | 3 | 3 | 3 | 5 | 5 | 4 | 4 | 4 | 2 |
| 05.05.2014 16:09 | 3 | 3 | 4 | 4 | 3 | 3 | 5 | 5 | 4 | 2 | 3 | 3 | 5 | 4 | 5 | 5 | 3 | 3 |
| 05.05.2014 16:58 | 2 | 4 | 4 | 4 | 2 | 3 | 2 | 3 | 2 | 4 | 2 | 3 | 1 | 5 | 1 | 2 | 3 | 5 |
| 05.05.2014 17:11 | 1 | 3 | 1 | 2 | 1 | 3 | 4 | 4 | 4 | 4 | 1 | 1 | 4 | 4 | 5 | 4 | 2 | 2 |
| 05.05.2014 17:30 | 2 | 4 | 2 | 4 | 1 | 3 | 4 | 4 | 5 | 3 | 3 | 3 | 5 | 4 | 4 | 4 | 4 | 4 |
| 05.05.2014 19:28 | 1 | 4 | 4 | 3 | 2 | 4 | 4 | 4 | 2 | 2 | 3 | 4 | 3 | 3 | 5 | 4 | 2 | 3 |
| 05.05.2014 19:42 | 2 | 4 | 3 | 5 | 3 | 5 | 5 | 5 | 2 | 4 | 3 | 3 | 5 | 5 | 4 | 3 | 3 | 4 |
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| 05.05.2014 19:57 | 2 | 5 | 2 | 5 | 2 | 4 | 5 | 4 | 4 | 3 | 2 | 4 | 5 | 2 | 5 | 4 | 2 | 1 |
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| 05.05.2014 21:56 | 3 | 4 | 3 | 4 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 5 | 3 | 3 | 3 | 3 | 3 |
| 05.05.2014 22:58 | 4 | 4 | 3 | 3 | 2 | 5 | 4 | 4 | 4 | 4 | 4 | 2 | 2 | 1 | 5 | 3 | 5 | 5 |
| 05.05.2014 23:56 | 1 | 1 | 1 | 1 | 1 | 3 | 1 | 1 | 5 | 2 | 1 | 1 | 5 | 5 | 5 | 1 | 1 | 1 |
| 05.06.2014 02:13 | 4 | 3 | 4 | 5 | 3 | 4 | 4 | 4 | 3 | 3 | 3 | 3 | 3 | 4 | 4 | 4 | 3 | 4 |
| 05.06.2014 06:48 | 3 | 4 | 4 | 4 | 3 | 3 | 4 | 4 | 4 | 3 | 3 | 3 | 4 | 4 | 2 | 2 | 4 | 4 |
| 05.06.2014 08:51 | 2 | 4 | 2 | 4 | 3 | 3 | 4 | 3 | 4 | 3 | 4 | 3 | 4 | 1 | 4 | 5 | 3 | 4 |
| 05.06.2014 09:55 | 2 | 2 | 4 | 4 | 5 | 4 | 4 | 4 | 2 | 3 | 3 | 3 | 5 | 5 | 3 | 1 | 3 | 4 |
| 05.06.2014 09:59 | 2 | 3 | 4 | 2 | 2 | 2 | 3 | 3 | 4 | 4 | 2 | 2 | 5 | 4 | 5 | 4 | 4 | 3 |
| 05.06.2014 10:15 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 4 | 3 | 4 | 5 | 5 | 3 | 3 | 3 | 3 |
| 05.06.2014 11:40 | 4 | 4 | 5 | 5 | 4 | 4 | 4 | 3 | 3 | 4 | 4 | 3 | 5 | 2 | 5 | 2 | 4 | 4 |
| 05.06.2014 16:16 | 3 | 2 | 5 | 4 | 2 | 4 | 4 | 4 | 2 | 3 | 2 | 3 | 4 | 2 | 5 | 3 | 4 | 2 |
| 05.06.2014 17:02 | 4 | 4 | 5 | 4 | 4 | 4 | 4 | 4 | 2 | 4 | 3 | 2 | 4 | 4 | 5 | 4 | 5 | 3 |
| 05.07.2014 00:01 | 2 | 5 | 3 | 5 | 2 | 5 | 5 | 5 | 1 | 4 | 4 | 4 | 5 | 5 | 3 | 3 | 5 | 5 |
| 05.07.2014 02:19 | 4 | 5 | 4 | 5 | 5 | 2 | 2 | 2 | 2 | 4 | 3 | 3 | 2 | 1 | 4 | 3 | 4 | 4 |
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| 05.07.2014 21:36 | 5 | 4 | 5 | 5 | 5 | 3 | 4 | 2 | 5 | 5 | 5 | 5 | 5 | 5 | 4 | 5 | 4 | 5 |
| 05.08.2014 09:56 | 1 | 2 | 3 | 3 | 1 | 3 | 3 | 3 | 4 | 3 | 2 | 3 | 5 | 4 | 4 | 3 | 3 | 3 |
| 05.08.2014 10:24 | 4 | 5 | 4 | 5 | 2 | 3 | 5 | 3 | 3 | 4 | 3 | 5 | 4 | 4 | 5 | 4 | 4 | 3 |
| 05.08.2014 10:38 | 3 | 2 | 4 | 1 | 4 | 5 | 5 | 3 | 2 | 2 | 1 | 2 | 4 | 4 | 3 | 2 | 2 | 3 |
| 05.08.2014 10:39 | 1 | 1 | 1 | 1 | 1 | 3 | 3 | 3 | 4 | 4 | 4 | 3 | 5 | 3 | 5 | 5 | 4 | 2 |
| 05.08.2014 11:01 | 2 | 3 | 4 | 2 | 2 | 3 | 4 | 4 | 4 | 3 | 3 | 4 | 5 | 4 | 3 | 4 | 1 | 3 |
| 05.08.2014 11:37 | 3 | 4 | 4 | 5 | 2 | 5 | 5 | 5 | 1 | 3 | 4 | 4 | 4 | 4 | 5 | 4 | 4 | 4 |
| 05.08.2014 12:02 | 1 | 1 | 3 | 4 | 2 | 3 | 5 | 4 | 3 | 2 | 1 | 2 | 5 | 2 | 2 | 2 | 2 | 3 |
| 05.08.2014 12:41 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 1 | 5 | 5 | 5 | 3 | 4 | 5 | 2 | 4 | 4 |
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| 05.08.2014 19:58 | 3 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 5 | 4 | 4 | 3 | 3 | 3 | 2 | 2 | 4 | 4 |
| 05.08.2014 20:42 | 4 | 3 | 4 | 4 | 4 | 4 | 4 | 4 | 3 | 4 | 5 | 4 | 5 | 3 | 3 | 3 | 5 | 4 |
| 05.08.2014 21:48 | 3 | 4 | 4 | 4 | 2 | 3 | 4 | 2 | 4 | 3 | 3 | 4 | 5 | 4 | 4 | 3 | 3 | 3 |
| 05.09.2014 10:39 | 5 | 5 | 5 | 5 | 4 | 4 | 5 | 5 | 4 | 5 | 5 | 5 | 4 | 2 | 3 | 4 | 3 | 4 |
| 05.09.2014 13:40 | 4 | 5 | 4 | 5 | 2 | 4 | 4 | 5 | 5 | 4 | 5 | 5 | 3 | 5 | 5 | 5 | 2 | 5 |
| 05.09.2014 14:21 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 1 | 5 | 5 | 4 | 2 | 4 | 5 | 3 | 5 | 5 |
| 05.09.2014 19:45 | 4 | 5 | 3 | 3 | 5 | 5 | 5 | 4 | 2 | 4 | 2 | 3 | 5 | 3 | 5 | 5 | 4 | 2 |
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| 05.10.2014 12:04 | 4 | 4 | 5 | 5 | 2 | 5 | 5 | 5 | 4 | 4 | 4 | 3 | 5 | 3 | 4 | 4 | 5 | 4 |
| 05.10.2014 12:07 | 4 | 5 | 4 | 5 | 4 | 4 | 4 | 4 | 2 | 3 | 3 | 4 | 4 | 3 | 3 | 2 | 5 | 4 |

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