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Electric Carsharing Usage and Shifting Effects between Public Transport, Car Ownership, Carsharing, and Electric Carsharing: A Data Mining Analysis and a Survey of Electric Carsharing Users

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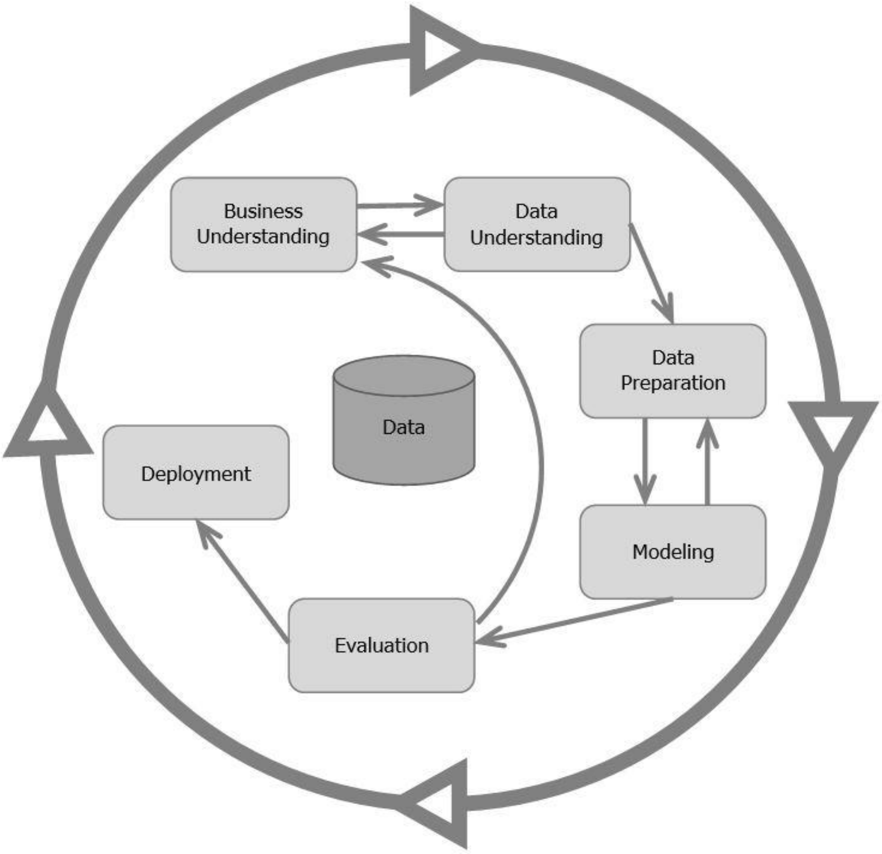

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List of Abbreviations

Art.	-	article
approx.	-	approximately
cf.	-	confer
CRISP-DM	-	Cross-Industry Standard Process for Data Mining
ed.	-	edition
eds.	-	editors
e. g.	-	exempli gratia
et al.	-	et alii
etc.	-	etcetera
f.	-	following
HTML	-	Hyper Text Markup Language
i. a.	-	inter alia
ibid.	-	ibidem
i. e.	-	id est
KDD	-	Knowledge Discovery from Data
MiD	-	Mobilität in Deutschland
n. d.	-	no date
No.	-	number
p.	-	page
POS	-	part of speech
pp.	-	pages
s.	-	see
StentiWS	-	SentimentWortschatz
STTS	-	Stuttgart-Tübingen-Tagset
TF-IDF	-	term frequency - inverse document frequency
Vol.	-	Volume
XML	-	Extensible Markup Language

1. Introduction

Mobility always plays a crucial role in all areas of life. Individual mobility is a basic need of the modern society and in the past, the automotive industry was mostly in focus (cf. Wallentowitz et al., 2010, p. 1). In recent decades a comprehensive infrastructure was developed specific to the automobile, which increases its attractiveness compared to other transportation means and consolidates the dominance of the car (cf. Canzler, 2008, p. 110). It has changed the environment on earth more than any other invention and its diffusion causes problems for the natural and built environment (cf. Firnkorn and Müller, 2015, p. 30). The signs of a trend reversal in mobility behavior intensify. Mobility is changing, because today's mobility behavior is not feasible and sustainable in the future.

The world's population has tripled from 1950 till today and the growth continues: Instead of the 7.3 billion people living on earth today, it is anticipated that by 2050, 9.7 billion people will be populating the earth (cf. United Nations, 2015a, pp. 1-2). In parallel with the growing population, the size of the global vehicle fleet has increased enormously. In 2010 the amount of vehicles in operation worldwide exceeded the one billion mark[5] (cf. Sousanis, 2011, p. 1). The global vehicle fleet predicted to increase from one billion to as much as 2.5 to 3 billion vehicles by 2050 (cf. United Nations Environment Programme, 2012, p. 16). Although sales are declining in the mature markets of the industrial countries, the automotive sector is strongly growing in emerging markets like China and India (cf. Wallentowitz et al., 2010, p. 1). More resources are necessitated to accommodate the growing demand, which will occur along with increasing environmental impact. Key challenges of the 21st century are the sustainable use of resources and the global climate protection (cf. Bertram and Bongard, 2014, p. 1). The automotive sector is seen as one of the main contributors of environmental impact. In Germany a passenger car is the most important and used means of transportation, but it is also responsible for about fourteen percent of carbon dioxide emissions (cf. Kiermasch, 2013, p. 18). Apart from this, the automotive industry is faced with the problem that conventional combustion engines are dependent on a finite resource. Fossil combustible materials are becoming scarce and consequently precious goods while their production processes become more extensive and ecologically controversial (cf. Bozem et al., 2013, p. 15). Road traffic is based on the primary energy sources oil (cf. Heymann et al., 2011, p. 3). The search for substitutes to fossil fuels, as well as ways to reduce carbon dioxide emissions have led to a new dynamic on the research field of alternative drive concepts such as the electric vehicle. In recent years the policy and automotive industry promote the development and market launch of electric vehicles as an alternative to traditional gasoline-engined and diesel-engined vehicles (cf. Doll et al., 2011, p. 1). According to the survey "*Elektromobilität 2025*", electric mobility is considered extremely important and decides on the long-term viability of the automotive industry (cf. Ol-

[5] The figure describes the approximate number of registered cars, trucks and buses on a world scale (cf. Sousanis, 2011, p. 1).

iver Wyman, 2009, p. 1). If electric vehicles are driven by renewable energy, they provide for enormous emission reduction, but even if a German electricity mix[6] is used, the greenhouse gas emissions are below those of comparable vehicles with combustion engines (cf. Barthel, 2012, p. 2). Apart from the basic efficiency of the drives, electric mobility is promised as a key technology for a sustainable, environmentally and climate friendly future mobility. With this in mind the German Federal Government has set itself ambitious goals by 2020: One million electric vehicles should drive on German roads and Germany should become the international leading market and lead supplier of electric mobility (cf. Nationale Plattform Elektromobilität, 2014, p. 3). However, with a share of only 0.1 percent, electric vehicles could not enforce on the overall market (cf. Oliver Wyman, 2009, p. 1). In Germany electric vehicles have a share of merely around 0.05 percent of all registered passenger cars in 2014 despite the significant upward trend of additional 55.9 percent more compared to the previous year and 18,948 electric vehicles on Germany's roads (cf. Kraftfahrtbundesamt, 2015, p. 1). The goal of the German Federal Government does not seem attainable. A widespread usage is prevented by the vigorous limitation of the range, long charging time which takes several hours, a limited charging infrastructure and enormous extra costs at the acquisition (s. chapter 2.1.1). Electric vehicles do not yet accomplish the appropriate cost-value ratio for a private usage and currently cannot substitute conventional personal vehicle ownership. But only the replacing of a conventional vehicle with an electric vehicle is not enough to rise to the challenges (cf. Kiermasch, 2013, p. 11). In addition to the growing population, an increasing urbanization is taking place. While in 1950, thirty percent of the world’s population residing in urban areas, today more people live in urban areas than in rural areas and this number continues to increase from fifty-four percent in 2014 to sixty-six percent by 2050 (cf. United Nations, 2015b, p. 21). This is accompanied by the expectation that the number of kilometers traveled in urban areas will triple by 2050 from today’s sixty-four percent (cf. Van Audenhove et al., 2014, p. 9). The motorized individual transport causes daily increasing traffic congestion, limited parking spaces as well as rising emissions and is a major burden for urban areas and their residents (cf. Fraunhofer IAO, 2014, p. 1). Under these circumstances, new mobility concepts are needed that can contribute to the reduction of motorized individual transport and that are more sustainability oriented. The need for resource conserving mobility solutions is also the focus of today's society. As a result of the growing eco-consciousness in both, public as well as business sectors and the associated trend towards sustainable consumption, change the mobility behavior of road users (cf. Fazel, 2014, p. 1). Many of these factors and challenges require a rethinking of personal vehicle ownership (cf. Shaheen and Cohen, 2013, p. 5). The attitude for the usage and ownership of cars has changed especially among young people and particularly

[6] In 2014 the German electricity mix consisted of 26.2 percent renewable energies, 25.4 percent brown coal, 17.8 percent stone coal, 15.8 percent nuclear energy, 9.5 percent natural gas and 5.4 percent other and therefore the share of renewable energies has grown again as well as overtook brown coal as an energy source for the first time (cf. Bundesverband der Energie- und Wasserwirtschaft e. V., 2015a, pp. 14-16).

in large cities (cf. Institute for Mobility Research, 2011, p. 26; Barthel, 2012, p. 1). Mobility is consumed more flexible, spontaneous and situational than before, due to the improved supply of coordinated mobility alternatives and mobility apps, which clarify the best travel connections (cf. Institute for Mobility Research, 2015, p. 13). The car is increasingly losing its relevance as a status symbol and the emotional attachments to the car dissolve (cf. Doll et al., 2011, p. 1). It will not completely disappear from the streets, because furthermore there will be rides that are covered with an individual vehicle due to its use purpose, but cars have become common goods to a significant degree (cf. Canzler and Knie, 2015, p. 8). The crucial change goes towards the willingness to use, rather than to own, which means away from property towards temporary availability (cf. Institute for Mobility Research, 2015, p. 14). In 2013 the main theme of the leading global exhibition for digital business CeBIT was *Shareconom*y[7] which accentuates the increasing meaning of the new usage concept of sharing-instead-of-owning (cf. Schade et al., 2014, p. 3). This changes affects positive on carsharing, which is a mobility concept based on sharing-instead-of-owning. There is an obvious movement towards shared mobility concepts (cf. Van Audenhove et al., 2014, p. 7). Carsharing denotes the shared use of passenger cars, which is organized by a special supplier (cf. ADAC, 2014, p. 1). It reduces the number of vehicle ownership, indicates positive environmental impacts like improved air quality as well as decreases traffic-related issues such as congestion and limited parking spaces (cf. Lee et al., 2012, p. 89; Firnkorn and Müller, 2011, p. 1527). While it decreases the negative effects of private vehicle ownership and without associated obligations and ownership costs, car sharing users gain the flexibility and other benefits of a private car (cf. Shaheen and Cohen, 2013, p. 5 f.). Carsharing has become a more and more popular and visible transportation mode, which slowly moves out of the niche (cf. Canzler and Knie, 2015, p. 23). In the beginning of the year 2015, 1,040,000 subscribers were registered in about 150 German carsharing providers, which is an increase of 37.4 percent over the previous year (cf. Bundesverband CarSharing e. V., 2015a, p. 2). According to a study from Frost and Sullivan (2012, p. 1), 15 million participants will use carsharing services in Europe by 2020. One of the key trends in the field of carsharing is the increasing usage of electric vehicles in carsharing fleets (cf. Shaheen and Cohen, 2013, p. 16; Degirmenci and Breitner, 2014, p. 970; Peters and Dütschke, 2010, p. 20). The electric mobility finds its way into the motorized individual transport due to greater integration into carsharing offers (cf. Institute for Mobility Research, 2015, p. 30). The market development is further promoted and potential customers get the opportunity to try out electric vehicles without the high acquisition costs (cf. Doll et al., 2011, p. 1).The adoption of electric vehicles into carsharing can decrease or even compensate crucial problems and at the same time a mobility services is created in

[7] Shareconomy (also called sharing economy or collaborative consumption) is a phenomenon driven by economic and sustainable motives in which participants borrow, swap and share, rather than buying and hoarding possessions whereby resources can be better used and new business models as well as a new consumer culture are created (cf. Pelzer and Burgard, 2014, p. 24).

both senses efficient and environmentally friendly (cf. Peters and Hofmann, 2011, p. 56; Barthel, 2012, p. 11). The already practiced or planned projects by Drive CarSharing, car2go and others (s. chapter 2.3) demonstrate the basic feasibility and the willingness of carsharing providers to offer electric carsharing. But research about the most recent developments like electric carsharing is still scarce (cf. Ruhrort et al., 2014, p. 288). Carsharing with electric vehicles can contribute essentially to address the challenges mentioned above, but for all that the willingness to use electric carsharing must exist in the population. This implies that electric carsharing has to meet market demands in order to increase market penetration and receive high profit margins. Thus it becomes increasingly considerable to take a demand-driven perspective and gather knowledge about attitudes of users toward electric carsharing. To learn more about the users' perspective and to recognize risks and chances, it is important to investigate attitudes from opinions of users about the usage of electric carsharing and additionally to draw conclusion to the willingness to use electric carsharing.

In the following, this research tries to analyze attitudes of users towards electric carsharing usage which are contained in users' opinion about electric carsharing and influence the intention to use electric carsharing. Chances and risks as well as advantages and disadvantages are identified with regard to the attitudes towards electric carsharing. Further, shifting effects of the mobility behavior of the electric carsharing users are examined. The research questions are:

What opportunities and risks can be identified with regard to the attitudes of users towards electric carsharing?

What shifting effects occur between public transport, own passenger cars, carsharing with conventional vehicles and electric carsharing when using electric carsharing?

The internet contains an increasing number of ways for consumers to express their opinions about products and services such as posting reviews and comments in blogs, forums or social networks (cf. Liu et al., 2005, p. 342). In the German speaking internet one of the most discussed sectors is the automotive industry (cf. Kaiser, 2009, p. 95). New and measurable sources of information have been developed. Data mining is a research method with techniques and tools that helps extracting information from large amounts of data. User opinions on the internet mostly consist of written text, which is assigned to unstructured data and can be analyzed with methods of text mining, a special field of data mining. Attitudes about electric carsharing can be determined from expressed opinions in the internet with a specific method of text mining that is called opinion mining. Furthermore, users of electric carsharing will be interviewed to gain further knowledge and thereby in particular the shifting effects will be analyzed.

The course of research is structured as follows. After the research subject was introduced in this chapter, in the next chapter an overview about electric carsharing is given. The theoretical background about electric mobility, carsharing and their connection electric carsharing are compiled as well as the typical usage and characteristic of electric carsharing users are described. In addition, the current status of electric carsharing in Germany was determined. Besides academic literature, studies and journal articles also several internet sources are referred in the second chapter, to satisfy the topicality as well as the progressing process of electric carsharing. In the third chapter the research method data mining is explained. The data mining process will be characterized and text mining as well as the method opinion mining will be presented. Chapter four is divided in two parts, the data mining analysis and the survey. The direction of the data mining analysis will be defined by the development of the process model in the first section of the fourth chapter. The analysis of the user opinions about electric carsharing usage is following in the next sections based on the developed model. The first part of the fourth chapter ends with the evaluation and deployment of the results from the data mining analysis. In the second part of chapter four the survey of electric carsharing users is constructed, implemented and analyzed according to qualitative content analysis. In the fifth chapter the results of both analyses are discussed and implications are presented. The chapter is followed by the discussion of the research methods in which also the limitations of the research and further research are described. In the end, a summary of key findings is shown in chapter seven.

2. Electric Carsharing – Development and Status quo

2.1 Development of Electric Carsharing

2.1.1 Electric Mobility

The term mobility describes the need for a change of place (cf. Bertram and Bongard, 2014, p. 5). Instruments and means are necessary to satisfy such needs for mobility. Transport is defined as the entirety of all instruments like means of transportation or transportation routes, which enables or rather realizes mobility (cf. Borchardt, 2012, p. 21). Thereby the goal of transport is obviously the gratification of mobility needs (cf. Bertram and Bongard, 2014, p. 6). Basically transport can be divided into two areas freight and passenger transport (cf. Borchardt, 2012, p. 22). This paper considers only *passenger transport*, which is split up in individual and public transport. *Individual transport* can further be subdivided into individual motorized (passenger car, motorcycle) and non-motorized (cycling and walking) transport (cf. Frauendienst, 2011, p. 170). *Public transport* frames the super ordinate group for all local public transport and long-distance passenger transport (cf. Barthel, 2012, p. 15). The *long-distance passenger transport* includes air transport, maritime transport, coaches as well as long-distance trains (cf. Borchardt, 2012, p. 22 f.). The *local public transport* comprises means of transport such as regional trains, commuter trains, subways, trams and buses (cf. Bundesministerium für Verkehr, Bau und Stadtentwicklung, 2010, p. 17). A characteristic of the individual transport in contrast to public transport is that the transport users freely decide about the times and routes of their trips (cf. Bertram and Bongard, 2014, p. 7). Public transport, cycling and walking can be summarized under the term eco-modes of transportation

("*Umweltverbund*") to distinguish them from individual motorized transport (cf. Barthel, 2012, p. 16). *Multimodal* behavior refers to the flexible combination of different means of transport within a period of time (cf. Schade et al., 2014, p. 2). *Intermodal* behavior indicates the usage of various means of transportation within a route and according to this intermodality is a subset of multimodality (cf. Maertins, 2006, p. 53). Modal split is the distribution of transport volumes on different modes of transportation (cf. Bertram and Bongard, 2014, p. 7). In Germany, the modal split is still dominated by passenger cars with a share of 58 percent of all trips[8] (cf. Bundesministerium für Verkehr, Bau und Stadtentwicklung, 2010, p. 25). Internal combustion engines will not make a significant contribution to sustainable mobility in the future, because of the lacking energy efficiency and the related pollutant emissions (cf. Canzler and Knie, 2009, p. 17). Against the background of climate change and dwindling fossil fuels a turnaround in the automotive drive technology is promised under the heading of electric mobility (cf. Kampker et al., 2013, p. 1).

The term *electric mobility* is not clearly defined and it usually referrers just to the locomotion with electric powered vehicles (cf. Barthel, 2012, p. 53). With respect to the vehicle type it can be differentiated between vehicles of individual (electric vehicles, electric bikes) and public transport (buses, rail bound vehicles) (cf. Acatech, 2010, p. 18). Rail bound vehicles are powered directly by a power line, while electric vehicles are powered from accumulators (batteries) (cf. Kiermasch, 2013, p. 15). Within the meaning of the German Federal Government electric mobility includes those vehicles that are driven by an electric motor and their energy is mainly sourced from the electricity grid, so they are externally rechargeable (cf. Bundesministeriums für Umwelt, Naturschutz, Bau und Reaktorsicherheit, 2015). These include battery electric vehicles, plug-in hybrid electric vehicle and range extended electric vehicles. A plug-in hybrid electric vehicle possesses a combination of an internal combustion engine with an electric motor and a battery which can be charged at the electricity grid (cf. Wallentowitz et al., 2010, p. 58). It is therefore only partly an electric vehicle such as the Toyota Prius (cf. Kiermasch, 2013, p. 15). Vehicles with the range extender technology such as the Opel Ampera have an internal combustion engine, which serves as a generator and charges the battery when needed (cf. Bertram and Bongard, 2014, pp. 33-34). The battery electric vehicle has only an electric drive train and its battery is recharged via the electricity grid (cf. Heymann et al., 2011, p. 3). In this paper, the terms electric mobility and electric vehicle exclusively refer on the *battery electric vehicle* without internal combustion engine. Due to this restriction, a clear distinction can be made in comparison to conventional vehicles.

About hundred years ago electric vehicles and petrol cars were on a same level and even road vehicles were largely driven electrically (cf. Canzler and Knie, 2015, p. 21). However the internal combustion engine based on fossil fuels could prevail and the electric drive became a niche product (cf. Wallentowitz et al., 2010, p. 1). The electric drive could only persist in rail

[8] Around a quarter of all daily journeys are covered by foot (24 %), 10 % by bicycle and 9% by public transport (cf. Bundesministerium für Verkehr, Bau und Stadtentwicklung, 2010, p. 25).

bound transportation since the power supply is possible without storage technology (cf. Schindler et al., 2009, p. 153). The discussion of fine dust, climate change and volatile oil prices have led to a new dynamic on the field of electric mobility. After a first hype in the early nineties, the issue has been rediscovered with the central statement that the electric vehicle will contribute to sustainable transportation development (cf. Schwedes et al., 2013, p. 72). In 2009 the German Federal Government started the National Development Plan for Electric Mobility with the objective of promoting the research and development, market preparation and market introduction of electric vehicles within the framework of the second stimulus package (cf. Die Bundesregierung, 2009, p. 2). The funding priority "electric mobility in model regions" funds projects in eight model regions, which should provide information about the practical benefits of electric mobility in everyday life (cf. Dütschke et al., 2012, p. 4). Only since 2010, the first electric vehicles have been available in any significant quantity (cf. Barthel, 2012, p. 54). In the end of 2010, the Japanese automobile manufacturer Mitsubishi launched the i-MiEV on the German market, which is the first electric vehicle manufactured in high volume (cf. Bertram and Bongard, 2014, p. 35). In the end of 2014 there are already seventeen electric vehicle models (including plug-in hybrids and range extender) of German manufacturers on the market (cf. Nationale Plattform Elektromobilität, 2014, p. 3). In June 2015, the top five of the best-selling electric vehicle models in Europe were reportedly the Nissan LEAF (8,633), the Renault Zoe (8,479), the Tesla Model S (7,382), the Volkswagen e-Golf (5,632) and the BMW i3 (4,738) (cf. EV Obsession, 2015). The electric mobility is currently largely in the phase of market preparation (cf. Barthel, 2012, p. 64). The range of forecasts for the share of electric vehicles in the automotive market for the year 2020 varies from 2 to 25 percent (cf. Arthur D. Little, 2010, p. 1; Bertram and Bongard, 2014, p. 24 f.). Canzler and Knie (2015, p. 36) assume that by 2030 especially the segments of passenger cars will be electrified, because the supply of attractive vehicles is growing on the market, at the same time costs are decreasing particularly for expensive storage units and a secondary market arises.

Electric vehicles offer various advantages over conventional vehicles.

An electric engine transforms about three times more electrical energy in mechanical energy than a petrol or diesel engine with a maximum efficiency of 92 percent. Therefore an electric vehicle has a higher *energy efficiency* (cf. Kiermasch, 2012, p. 17). The efficiency advantage benefits particularly in urban transport, since the energy consumption is reduced due to the braking force recovery and almost no consumption at idle (cf. Acatech, 2010, p. 18).

Harmful substances are not released in the conversion of electric current into kinetic energy in the motor as it is the case with internal combustion engines (cf. Kiermasch, 2012, p. 17). In inner cities and urban conglomerations the quality of life improves by the *zero local emissions* with regard to pollution from fine particulate and nitrogen oxide which are associated with significant health problems (cf. Die Bundesregierung, 2009, p. 8).

Conventional vehicles also cause an impairment of quality of life due to *noise pollution*. Electric vehicles prevent noise pollution, because they generate almost no engine noise and only the tyre noise is perceivable (cf. Kiermasch, 2012, p. 17). The engine noise is stronger than the rolling noise till forty kilometers per hour consequently a significant reduction in noise is noticeable particularly in urban road transport with frequent starting, accelerating and idle mode (cf. Barthel, 2012, p. 62 f.). Additionally the low noise emission is often positively judged by drivers (cf. Baum et al., 2012, p. 104; Bühler et al., 2014, p. 35, 40).

In Germany the passenger car is responsible for about 14 percent of carbon dioxide emissions (cf. Bertram and Bongard, 2014, p. 25 f.). Electric vehicles can afford a significant contribution to the reduction of global *carbon dioxide emissions* relative to passenger cars powered by fossil fuels but the savings depend eventually on the type of electricity generation (cf. Firnkorn and Müller, 2015, p. 31). The more electricity originates from carbon dioxide-free generation (e. g. wind), the less greenhouse gases are caused. Renewable energies are on the increase in the German electricity mix (cf. Bundesverband der Energie- und Wasserwirtschaft e. V., 2015a, p. 14). This has a positive effect on the emissions balance of electric vehicles.

The storage of electricity is becoming increasingly important with the expansion of renewable energies, since the present energy supply system does not cover high proportions of renewable energies yet (cf. Bertram and Bongard, 2014, p. 51 f.). The intelligent usage of the batteries of electric vehicles as energy storage offers the possibility to increase the overall efficiency of the power supply (cf. Fournier et al., 2014, p. 64). The concept of storing and distributing electricity from public electricity grid in electric vehicles is called *vehicle to grid* (cf. Acatech, 2010, p. 13). Electric vehicles contribute to the stabilization of the electricity grid and could help to balance the fluctuation in the production of renewable energy sources like wind and solar energy (cf. Institute for Mobility Research, 2015, p. 30). Though, vehicle to grid could adversely affect the lifetime of the battery (cf. Bozem et al., 2013, p. 74). Among other technical challenges, a certain number of vehicles are necessary to fulfill the compensation function (cf. Bertram and Bongard, 2014, p. 52). Today, vehicle to grid is not a relevant option due to the low spread of electric vehicles and missing technical conditions (cf. Canzler and Knie, 2015, p. 32).

The oil reserves dwindle and therefore oil prices continue to rise (cf. Bozem et al., 2013, p. 15). In Germany, 98.4 percent of the 44.4 million passenger cars drive exclusively with a fuel that is refined from crude oil and according to this the road transport is based on the primary energy source oil (cf. Kraftfahrtbundesamt, 2015, p. 1; Heymann et al., 2011, p. 3). Electric mobility allows a wider diversification of the primary energy sources used for mobility, because in Europe oil is hardly required for electricity generation and it opens up the access to the entire spectrum of the renewable energies (cf. Die Bundesregierung, 2009, p. 8). Electric vehicles can *reduce* the dependence of fossil fuels, rising oil prices and its imports from producer countries (cf. Wallentowitz et al., 2010, p. 2).

Lower operating costs are another advantage of electric vehicles compared to conventional vehicles. Kiermasch (2012, p. 18) states that an electric vehicle like the i-MiEV by Mitsubishi expends around 2.90 euro electricity costs per hundred kilometers on the other hand a vehicle with an economical diesel engine causes about 7 euro in fuel costs per hundred kilometers. In addition to the reduced costs of consumption the maintenance costs are also lower because oil change and exhaust emission tests do not apply and the wear of electric motors should be less than of internal combustion engines (cf. Barthel, 2012, p. 57 f.).

Exploiting the potential of electric mobility is associated with numerous challenges which prevent that the technology is perceived as a valid alternative to the internal combustion engine.

The above mentioned, low variable costs can not compensate the *high manufacturing costs*. Due to high battery costs, electric vehicles have a significantly higher purchase price in comparison to conventional vehicles (cf. Kampker et al., 2013, p. 19). The value added share of a battery is up to forty percent with respect to the entire vehicle (cf. Nationale Plattform Elektromobilität, 2014, p. 20). Heymann et al. (2011, p. 6) indicate that the sixteen kilowatt hour battery of a Mitsubishi i-MiEV is almost twice as expensive as a complete similarly sized small car with internal combustion engine. Production costs of batteries range from 600 to 1,200 euro per kilowatt hour (cf. Bertram and Bongard, 2014, p. 100). The National Platform for Electric Mobility assumes the cost of production of a lithium-ion battery were in the range of 380 euro per kilowatt hour in 2013 (cf. Nationale Plattform Elektromobilität, 2014, p. 20). Various forecasts predict falling battery prices of at least 60 percent till 2020 (cf. Canzler and Knie, 2015, p. 30; Bertram and Bongard, 2014, p. 130 f.).

The battery is also related to the significant restriction of the *limited range*, which is a big barrier to their complete diffusion besides the high acquisition cost (cf. Clemente et al., 2013, p. 251). The range of electric vehicles is determined by the energy density of the battery and amounts between 100 to 300 kilometers which is considerably shorter compared to a conventional vehicles with a range of approximately 800 kilometers (each depending on the vehicle type) (cf. Barthel, 2012, p. 55; Wappelhorst et al., 2014, p.3). In practice the range can be significantly reduced through the use of a radio, air conditioning or heating as well as outside temperature, individual driving style, road and traffic conditions (cf. Fazel, 2014, p. 25). This factor limits the possible application of electric vehicles largely to the short haul, because a battery system that can absorb sufficient energy for longer distances would be too big and too heavy for a passenger car (cf. Heymann et al., 2011, p. 7). At present, several new battery technologies are at the research stage with the objective to achieve a higher energy density and thus counteract the problems of weight and range (cf. Canzler and Knie, 2015, p. 30).

Everyday use of electric vehicles is also limited by the *long charging times*. The refueling of a conventional passenger car takes a few minutes compared to an electric vehicle that need several hours to recharge (cf. Dütschke et al., 2013, p. 2). In Germany nowadays a complete recharge of the sixteen kilowatt hour battery of a Mitsubishi i-MiEV lasts a little less than five hours at a normal household connection power of 3.7 kilowatts (cf. Fazel, 2014, p. 25). Charging stations with DC voltage reduce the charging time to less than thirty minutes (Kiermasch, 2013, p. 20)

A powerful and comprehensive *charging infrastructure* is indispensable for the use of electric mobility. Electric vehicles can be charged at a common household socket or at public respectively semipublic charging stations (cf. Bertram and Bongard, 2014, p. 109). A large part of vehicle owners in urban areas do not possess a garage or a fixed parking space and therefore have no charging opportunity for an electric vehicle (cf. Kiermasch, 2013, p. 20). In the end of 2014 there were 2,521 public charging stations with altogether 5,553 charging points in Germany and at least one charging station is operated in 839 towns and municipalities (cf. Bundesverband der Energie- und Wasserwirtschaft e. V., 2015b). Until now the expansion of the charging infrastructure was not nationwide, but was carried out mainly in agglomerations and in particular in the funded model regions and the expansion was slowed down due to lack of business and financing models since 2012 (cf. Nationale Plattform Elektromobilität, 2014, p. 22 f.). A comprehensive and visible public charging infrastructure could increase the user acceptance and could decrease the range anxiety (cf. Peters and Hoffmann, 2011, p. 11).

Electric vehicles cannot replace conventional vehicles under the current surrounding conditions (cf. Barthel, 2012, p. 58). However the substitution of a conventional passenger car through an electric vehicle would not go far enough because of the existing transportation problems such as the caused land consumption (cf. Canzler and Knie, 2015, p. 2). With regards to the limited range and insufficient charging infrastructure application areas of electric vehicles are mainly cities and urban agglomerations, where also their environmental benefits have the best effects. Considering these points it has to be reassessed if it is reasonable to offer electric vehicles in the same way as conventional passenger vehicles. A forward-looking model is the integration of electric vehicles into well-connected, intermodal and shared used transportation solutions (cf. Barthel, 2012, p. 72). Electric carsharing as an urban mobility offer provides an opportunity for new forms of mobility (cf. Kiermasch, 2013, p. 50).

2.1.2 Carsharing

Electric carsharing is based on the carsharing concepts of vehicles with internal combustion engine (cf. Wallentowitz et al., 2010, p. 164). Carsharing is less an independent mode of transportation rather than a form of mobility that ensures the highest possible level of mobility without limitations (cf. Barthel, 2012, p. 29). In the foreground is the use of vehicles and not the ownership of vehicle (cf. Kampker et al., 2013, p. 129). It is based on a shared fleet organized by a carsharing operator with members who gain access to vehicles when needed and are allowed to rent them temporarily (cf. Stillwater et al., 2009, p. 27). The carsharing provider carries cleaning, care, maintenance and repair (cf. Lawinczak and Heinrichs, 2008, p. 9). The flexibility and convenience of the motorized individual transport can be engaged without bearing the associated costs and obligations of private vehicle ownership (cf. Heymann et al., 2011, p. 18). Main characteristics for carsharing include the option of short-term rental (hourly or minutely) and the self-employed, unguarded as well as permanent (24/7) access to the vehicles (cf. Barthel, 2012, p. 29). There are two different sharing concepts, station-based and free-floating carsharing.

Station-based carsharing is the traditional concept, which is based on fixed stations like rented parking-lots (cf. Seign and Bogenberger, 2013, p. 1). The vehicles are booked in advance and after ending the ride the vehicles have to be returned to the initial station where they were rented (cf. Steiner et al. 2014, p. 3). In larger cities several stations are commonly spread over the city (cf. Kiermasch, 2013, p.28). The decentralized network of stations is mostly located near places of residence or public transportation interconnections like railway stations to ensure access to destinations beyond public local transport (cf. Lawinczak and Heinrichs, 2008, p. 9; Wappelhorst et al., 2013, p. 1). The time-consuming search for parking space is not applicable because each vehicle is dedicated to a fixed parking space (cf. Kiermasch, 2013, p. 29). The station-based carsharing providers offer a wide range of various vehicle types in order to cover as many journey purposes as possible (cf. ADAC, 2014, p. 1). These traditional carsharing operators are well established and provide comparatively low usage fees (cf. Van Audenhove et al., 2014, p. 24). Station-based carsharing concepts stand out by predictability and reliability, since the vehicles are available at the assigned station at the booked time and they can be reserved for predictable journeys in advance partly up to six months (cf. Bundesverband CarSharing e. V., 2015a, p. 6). The disadvantages of the traditional carsharing concept are that the vehicles can be picked up and returned at the specified stations only, whereby the network of stations is sometimes insufficiently dense and customer processes as well as pricing structures can be comparatively complex (cf. Van Audenhove et al., 2014, p. 24). The customer must specify the pickup and return time in advance and relatively high penalties will be due if the vehicle comes back later than planned (cf. Kiermasch, 2013, p. 41).

The newer carsharing concept called *free-floating* differs in some points from the classical station-based carsharing concept by omitting fixed stations (cf. Schade et al., 2014, p. 3). The vehicles are freely distributed throughout a designated business area of a city on public parking lots and on special parking spaces of the carsharing provider (cf. Wallentowitz et al., 2010, p. 165). Free-floating carsharing concepts enable location independent car usage based on the global positioning system localization of available vehicles via smartphone applications, which features a level of flexibility similar to private passenger cars (cf. Firnkorn and Müller, 2015, p. 31). Users are allowed to take and leave vehicles at any location within the defined area (cf. Firnkorn and Müller, 2011, p. 1519). In particular one way journeys are possible which means the vehicles can be used for individual routes and need not to be returned to the initial place where they were rented (cf. Baum et al., 2012, p. 74). Free-floating concepts allow a short-term use of the vehicles based on minutes (cf. Kiermasch, 2013, p. 32).

The special feature of this business model is the high flexibility, because a booking requirement in advance is not compulsory, therefore the vehicles can be used spontaneously and instant access without a timed return (open end) (cf. Wallentowitz et al., 2010, p. 165). The settlement of use is minute-based according to the principle "pay as you go" (cf. Steiner et al., 2014, p. 3). In 2009 car2go was the first free-floating carsharing system and was launched by the automobile manufacturer Daimler in the city of Ulm in Germany (cf. Firnkorn and Müller, 2011, p. 1519). Car2go was expanded to other cities in Germany, Europe and the US and similar free-floating systems have been started by other automobile manufacturer (cf. Schade et al., 2014, p. 4). The number of users of free-floating offers has increased significantly since their introduction (cf. Bundesverband CarSharing e. V., 2015a, p. 2). This high number of users in a relatively short time span confirms a high acceptance of such offers (cf. Kiermasch, 2013, p. 41). Thus opposed to traditional carsharing, the vehicle fleet normally consists of a very limited number of vehicle models[9] (cf. Baum et al., 2012, p. 74). Free-floating carsharing cannot convey to such predictability and reliability as station-based concepts, because it is not guaranteed that a free vehicle is available at the right time (cf. Bundesverband CarSharing e. V., 2015a, p. 6). Another disadvantage of free-floating concepts is that they are very cost intensive and thus they lead to higher usage fees (cf. Van Audenhove et al., 2014, p. 25). Partially traditional carsharing provider do not perceive free-floating as a competitor, because through the increased interest in free-floating concepts, the interest in carsharing in general rises (cf. Kiermasch, 2013, p. 41). A station-based carsharing provider reports that his new customers also use free-floating carsharing, but they prefer further vehicle models especially larger ones and the usage of the traditional offer seems to be beneficial during longer periods and distances (cf. ibid). Meanwhile some station-based carsharing providers offer additionally free-floating solutions such as stadtmobil in Hannover, Stadtteilauto Osnabrück or book-n-drive in Frankfurt (cf. stadtmobil Hannover GmbH, 2015; Stadtteilauto OS GmbH, 2015a; book-n-drive mobilitätssysteme GmbH, 2015a, p. 1).

The traditional carsharing concept is frequently considered in the context of sustainable mobility with a strong focus on *environmental impacts* (cf. Köhler et al., 2009, p. 2989; Degirmenci and Breitner, 2014, p. 970). Environmental impacts are decisive factors for the still carefully nurtured image of an environmentally friendly service as well as for the entitlement of government funding and privileging (cf. Barthel, 2012, p. 48). There is not yet much research of long-term environmental impacts of free-floating carsharing concepts due to the novelty of the concept (cf. Kiermasch, 2013, p. 42). Therefore, the following studies refer to the station-based concept, unless it is explicitly dealt with free-floating carsharing. A variety of studies conclude that carsharing is associated with significant positive environmental effects (cf. Wilke, 2007, p. 27; Shaheen and Cohen, 2013, p. 8). A Swiss study suggests that

[9] For example, the free-floating fleets of car2go consist of Smarts (cf. Schade et al., 2014, p. 4). DriveNow is the only free-floating carsharing provider operating with different vehicle models like BMW X1, BMW i3 or MINI (cf. Kiermasch, 2013, p.35 f.).

each active user of carsharing is saving annually around 290 kilogram of carbon dioxide emissions (cf. Haefeli et al., 2006, p. 45). Firnkorn and Müller (2011, pp. 1525-1526) applied the same methodological approach on a free-floating system and indicated an average reduction of 146 (worst case) to 312 (best case) kilogram of carbon dioxide per year. The designed as a city car and fuel-efficient smart fortwo electric drive (or short smart ed) presuppose this positive environmental contribution (cf. Kiermasch, 2013, p. 43). One effect on the environmental impact of carsharing is linked to the composition of the fleet. In Germany the average age of registered passenger cars is nine years (cf. Kraftfahrtbundesamt, 2015, p. 1). Vehicles in carsharing fleets are significant younger with an age of on average two years (cf. Barthel, 2012, p. 50). Additionally the fleets contain an above average number of small cars with accordingly low fuel consumption (cf. Baum et al., 2012, p. 69 f.). For this reason carsharing fleets gain significant efficiency and emission benefits which are even upgradable through new technologies such as electric vehicles (cf. Maertins, 2006, p. 34). Fuel-efficient and low-emission vehicles are in demand earlier and as a result environmental innovations with proportionate quantities can achieve faster market penetration (cf. Borchardt, 2012, p. 95). Compared to vehicles in private ownership, carsharing vehicles save almost twenty grams carbon dioxide per kilometer due to the effect of age and another 8 grams per kilometer due to the size effect (cf. Wilke, 2007, p. 129). Wilke (2007, p. 134) indicates that the emissions saved by carsharing can be attributed to approximately one third of the younger and smaller vehicles and the remaining reduction effects result from behavioral changes of users. Carsharing relieves the traffic and pollutant emissions, because it effects a change in transport behavior of users with regard to increased usage of the eco-modes of transportation in addition to a simultaneous reduction in vehicle kilometers traveled (cf. Kiermasch, 2013, p. 42). It is assumed that a so-called "*learning effect*" contributes to a declining usage of passenger cars among carsharing customers over time (s. below) (cf. Baum et al., 2012, p. 66 f.). The decrease in vehicle kilometers traveled is ranging from 28 percent to 45 percent (cf. Shaheen and Cohen, 2013, p. 9). This reduction declines carbon dioxide emissions as well as emissions from fine particulate and nitrogen oxide (cf. Borchardt, 2012, p. 97). Station-based carsharing vehicles are shared by on average 42 customers accordingly free-floating carsharing vehicles by 103 customers and therefore they feature a much more intensive usage compared to private vehicles (cf. Bundesverband CarSharing e. V., 2015a, p. 3). Carsharing leads to a reduction in vehicle volume and traffic, because it decreases the vehicle fleet per shared passenger vehicle (cf. Borchardt, 2012, p. 93). In the literature, the number of privately *owned vehicles replaced* by one carsharing vehicle varies from 4 up to 10 (cf. Shaheen and Cohen, 2013, p. 9; Borchardt, 2012, p. 93 f.; Kiermasch, 2013, p. 42). According to the survey of Firnkorn and Müller (2011, p. 1525) more than one quarter of the participants could forgo a car purchase if the free-floating fleet of car2go was permanently offered. Maertins (2006, pp. 39-42) identifies that carsharing provides only a moderate immediate motivation to abandon private vehicle ownership, but it has quite a potential to avoid the (re-)acquisition of passenger vehicles.

Through a decrease of the total number of vehicles, the static land consumption will be declined whereby the parking space and traffic jam situation will relax and additionally the parking search traffic will be reduced (cf. Glotz-Richter et al., 2007, p. 333).

Carsharing is in a functional and economic gap between the individual and public transport (cf. Fournier et al., 2014 p. 65). The spatial self-determination is mostly given, but the temporal use depends on the availability of the vehicles and must be coordinated with other users (cf. Borchardt, 2012, p. 76). Carsharing also takes an intermediate position in terms of cost (cf. Fazel, 2014, p. 34). It stabilizes the use of public transport and complements the offer as a cooperation partner particularly on occasions which are difficult to cover by public transport (cf. Barthel, 2012, p. 50). Carsharing takes also an intermediate position between car rental and private vehicle ownership (cf. Lawinczak and Heinrichs, 2008, p. 9). It differs from classic car rental by the decentralized location of the vehicles, short minimum rental, permanent accessibility, no personal vehicle handover and withdrawal, no new contract before every ride and no filled up tank after every ride (cf. Borchardt, 2012, p. 77; Lawinczak and Heinrichs, 2008, p. 11). Therefore, carsharing offers more an alternative to private vehicle ownership than car rental (cf. Barthel, 2012, p. 29). However car rental cannot be seen in direct competition to carsharing as it is used mainly in other contexts (cf. Wilke, 2007, p. 10). In contrast to carsharing, several users share a vehicle at the same time for a common path during carpooling respectively ridesharing (cf. Borchardt, 2012, p. 76). *Peer-to-peer carsharing* is a mostly informally organized concept whereby private vehicle owner rent their vehicles to others (cf. Fazel, 2014, p. 35). It received more support with the establishment of internet platforms like Tamyca or Drivy (cf. Van Audenhove et al., 2014, p. 24). An essential advantage of carsharing over peer-to-peer carsharing exists in professional and therefore low-conflict apportionment of transaction costs such as maintenance, repairs and care (cf. Petersen, 1995, p. 62). Thus, this concept is not part of this research.

Besides the peer-to-peer carsharing concept, there are three additional carsharing business models depending on the type of operator as well as the location of the vehicles: classical carsharing providers, integrated mobility providers and innovative automobile manufacturer. (cf. Van Audenhove et al., 2014, pp. 24-25; Schade et al., 2014, p. 4).

The *classical carsharing providers* were the first organizations which have offered carsharing services. In 1988, StattAuto Berlin (now Greenwheels) realized the first carsharing project in Germany (cf. Petersen, 1995, p. 72). These original carsharing operators were often set up on a not-for-profit or co-operative basis and were highly environmentally motivated (cf. Baum et al., 2012, p. 71). In the mid nineties a change took place from ecological project to mobility services whereby local carsharing providers formed networks and have become economically motivated organizations (cf. Wilke, 2007, p. 35). The aim of this professionalization was to free carsharing out of its ecological niche existence and thus to gain a broader clientele (cf. Borchardt, 2012, p. 79). The usage of carsharing was also facilitated by the use of modern information and communication technology like smartphone applications for booking and accessing vehicles (cf. Heymann et al., 2011, p. 18). The classical carsharing provides mainly uses the station-based carsharing concept (cf. Van Audenhove et al., 2014, p. 24). Examples of these providers include cambio, stadtmobil and Greenwheels which are represented nationwide or book-n-drive and Stadtteilauto Osnabrück which do not belong to any network (cf. Borchardt, 2012, p. 80; book-n-drive mobilitätssysteme GmbH, 2015a; Stadtteilauto OS GmbH, 2015a).

Entrepreneurial public transport operators have started offering carsharing in addition to their core business and aim to develop into wide exhibited, *integrated mobility providers* (cf. Van Audenhove et al., 2014, p. 24). For this purpose the German railway company Deutsche Bahn AG founded their carsharing operation Flinkster (originally called DB Carsharing) in 2001 (cf. Maertins, 2006, p. 11). Integrated mobility providers offer focused station-based carsharing at specified locations (cf. Schade et al., 2014, p. 4). Alternatively they set on a few key stations mostly at railway stations and airports to provide customers with connectivity and therefore are well connected with other forms of mobility such as long-distance transport, public local transport or Call a Bike (cf. Arnold et al., 2010, p. 53). These providers already have a huge customer base, which they can leverage to reach the critical mass for profitability more quickly and their customers can also use the same mobility cards and smartphone apps for the carsharing services (cf. Van Audenhove et al., 2014, p. 24). Additionally, the incumbency and seriousness of the strong brand of the public transport operator also help to gain new customer groups (cf. Maertins, 2006, p. 25; Borchardt, 2012, p. 85).

During the last few years automobile manufacturers started to offer carsharing-fleets and increasing the competition with established classical concepts (cf. Schade et al., 2014, p. 4). *Innovative automobile manufacturers* were the first to offer the cost intensive free-floating carsharing concept, because carsharing is not their core business and automobile manufacturers have more options for communication and pricing due to their business size and the resulting higher liquidity (cf. Bundesverband CarSharing e. V., 2015a, p. 5). Examples for free-floating operators include DriveNow (BMW), car2go (Daimler) and Multicity Carsharing (Citroën), while Quicar (VW), Mu (Peugeot) or Ford Carsharing are station-based concepts (cf. Schade et al., 2014, p. 4). Innovative automobile manufacturers became mobility providers, whereby carsharing serves them for market and consumer research, to increase customer retention as well as for creating new sales markets (cf. Barthel, 2012, p. 33). Carsharing conduces as a showcase for innovative products of automobile manufacturers such as electric vehicles (cf. ADAC, 2014, p. 1). The market entry of innovative automobile manufacturers supports the carsharing sector to reach new user-milieus and thus to transform into a mainstream transportation mode (cf. Firnkorn and Müller, 2015, p. 35; Schäfers, 2013, p. 69).

Since 1997 the number of carsharing users and available vehicles has increased from about 20,000 users respectively less than 1,000 vehicles to more than one million registered drivers and nearly 15,400 vehicles in early 2015 in Germany (cf. Bundesverband CarSharing e. V., 2015a, pp. 2-3). This growth confirms already the success and acceptance of this alternative mobility concept (cf. Arnold et al., 2010, p. 53). Basically to consider is that the number of users does not necessarily have the expressiveness of how many of the registered drivers actively use the service. For example there are carsharing providers with up to forty percent passive customers (cf. Maertins, 2006, p. 8). According to the Bundesverband CarSharing e. V. (2015a, p. 5) the number of carsharing users will double by the end of this decade. Carsharing reflects the current transformation of the urban understanding of mobility to an unpropertied vehicle usage and could also serve as an incubator for the introduction of electric mobility, thus enabling and shaping the gradual change into a new form of mobility (cf. Fazel, 2014, p. 33).

2.1.3 Electric Carsharing

The introduction of electric vehicles and the carsharing trend are two current market dynamics that are connected by electric carsharing. Carsharing can facilitate the diffusion of electric vehicles and vice versa (cf. Seign and Bogenberger, 2013, p. 1). Two or more innovations are often packed together in order to support their diffusion because of their functional or perceived interrelatedness and this is termed as a technology cluster or *innovation package* (cf. Rogers, 2003, p. 143). Alternative mobility concepts such as carsharing are considered as a suitable application area for electric mobility in many studies (cf. Hoffmann et al., 2012, p. 29; Lee et al., 2012, p. 94; Dütschke et al., 2013, pp. 6-8; Firnkorn and Müller, 2015, p. 38). The electric carsharing systems currently in use demonstrate the fundamental feasibility as well as the willingness of carsharing providers to experiment (cf. Doll et al., 2011, p. 29). Electric vehicles are integrated in station-based as well as in free-floating carsharing concepts (cf. Dütschke et al., 2013, p. 4). The integration of electric vehicles into carsharing can decrease or even compensate the essential obstacles of electric mobility mentioned in section 2.1.1 (cf. Peters and Hofmann, 2011, p. 56; Baum et al., 2012, p. 104). At the same time, an in both directions efficient and environmentally friendly mobility offer is created (cf. Barthel, 2012, p. 11). There are some reasons which indicate that electric carsharing counters favorable conditions compared to classical private ownership of electric vehicles.

Carsharing as an urban mobility offer is suitable for the application of electric vehicles despite the limited battery range because of the mostly short term rentals and the frequently short-distance used in city traffic (cf. Arnold et al., 2010, p. 53; Steiner et al., 2014, p. 9). If electric carsharing is used as a part of an integrated transport system and acts as a feeder to public transport, the challenge of the limited range will not arise any longer (cf. Barthel, 2012, p. 72). Furthermore, high vehicle availability and the opportunity to combine various vehicles can also compensate the range limitations (cf. Baum et al., 2012, pp. 79, 104). A comprehensive charging infrastructure will not be a mandatory requirement for station-based carsharing concepts, if the fixed stations are equipped with a charging station, where the vehicles can be recharged after their rental (cf. Barthel, 2012, p. 67). Especially integrated mobility providers located at transport hubs have good conditions both to implement the required charging infrastructure as well as to offer integrated mobility services directly to many traveling customers (cf. Arthur D. Little, 2010, p. 3). Through electric carsharing, potential drivers from urban areas, who do not possess a fixed parking space with a charging opportunity, get the possibility to use electric vehicles and this enhances the potential circle of users of electric mobility (cf. Baum et al., 2012, p. 79). A major drawback of electric vehicles is their high acquisition cost (s. section 2.1.1), but carsharing customers do not have bear the expense (cf. Heymann et al., 2011, p. 18). The investment costs can be better distributed through the collective usage (cf. Barthel, 2012, p. 67). The cost effectiveness of electric vehicles is improved by minimizing downtime (cf. Doll et al., 2011, p. 1). In addition, the costs are confronted by a high efficiency of the utilization in carsharing (cf. Baum et al., 2012, p. 78 f.). Another benefit of electric carsharing is that it offers interested customers the opportunity to test electric vehicles without having to carry the high acquisition costs and associated obligations (cf. Doll et al., 2011, p. 1). There is a correspondingly lower threshold for usage as the permanent commitment to the electric vehicle is omitted (cf. Barthel, 2012, p. 67). Electric carsharing offers a possibility to try out electric vehicles, which helps to overcome the fears as well as the uncertainties of users and create transparency (cf. Seign and Bogenberger, 2013, p. 6). Due to the favorable test drives, individuals gain experience with the new technology whereby electric carsharing is also an important ambassador for the functionality and utilizability as well as for the acceptance of electric mobility (cf. Baum et al., 2012, p. 79). The visibility and perception of electric vehicles in road transport could also contribute to their acceptance (cf. Barthel, 2012, p. 64). Electric carsharing increases the public awareness of electric mobility and helps to accelerate their further market penetration (cf. Fournier et al., 2014, p. 66). As an innovation is barely available yet, trialability and observability are relevant factors to push the widespread adoption of innovations forward (cf. Rogers, 2003, p. 15). According to Rogers (2003, p. 208) there are five attributes of innovations explaining the rate of adoption of a new technology. Observability and trialability were already mentioned and the others are relative advantages, compatibility as well as complexity.

In addition to the opportunities for the electric mobility, electric carsharing also provides advantages for carsharing. As already mentioned in section 2.1.1, electric vehicles come up with several environmental benefits, which help to preserve the ecological balance sheet of carsharing or even to extend them (cf. Barthel, 2012, p. 71). Electric carsharing contributes actively to the reduction of carbon dioxide emissions in transport as well as enables the supersession of vehicles with internal combustion engine from congested cities and thus decreases pollution plus lack of sufficient parking space (cf. Baum et al., 2012, p. 65). The sustainability advantages of electric carsharing feature a good image, which supports marketing activities (cf. Seign and Bogenberger, 2013, p. 6). Different recipients can be addressed by an environmentally friendly image. On the one hand, an ecologically favorable balance sheet of a fleet is an important argument for state actors in supporting of carsharing such as the preferential treatment in the granting of public parking spaces (cf. Barthel, 2012, p. 71). On the other hand, the already environmentally friendly mobility concept gets more attractive for environmentally conscious customer groups and can further be strengthened (cf. Baum et al., 2012, p. 79). The environmentally aware users form still the largest group of carsharing customers (s. section 2.2.2) and the ecological motivations are the second most important factor for the use of carsharing apart from the financial aspects (cf. Haefeli et al., 2006, p. 27). The adoption of electric vehicles into carsharing enhances the attention value for example by increased media coverage, which in turn offers the opportunity to popularize carsharing in general as well as the carsharing provider per se and to generate also new customers (cf. Barthel, 2012, p. 92). The integration of innovative electric vehicles could gain a new, technically minded and tech-savvy customer base that was reserved towards carsharing previously (cf. Peters and Dütschke, 2010, p. 22; Wappelhorst et al., 2014, p. 16). The sustainable and innovative image and the additional attention can also serve as a catalyst in the search for potential cooperation partners such as energy suppliers or other mobility service providers (cf. Barthel, 2012, p. 71). Vehicle to grid as a new, lucrative business model is considered as an opportunity for carsharing providers in order to foster profitability by generating additional revenues with unutilized electric vehicles (cf. Fournier et al., 2014, p. 76). Innovative automobile manufacturers require driving experience and test results of their new, innovative vehicles for as many users as possible, which are favorable and quite convenient to obtain in carsharing services (cf. Barthel, 2012, p. 82). Additionally, considering the beginning of a new mobility paradigm, electric carsharing could be a way for automobile manufacturers to survive in the long run (cf. Fournier et al., 2014, p. 66). Nevertheless, the above-mentioned opportunities are very holistic and must be specified for different carsharing providers, customer groups and markets (cf. Seign and Bogenberger, 2013, p. 7). Despite the advantages and opportunities, many barriers and challenges exist for the adoption of electric carsharing, which largely result from the overall challenges of electric mobility.

Due to the limited range, electric vehicles are currently not yet suitable for all kinds of rides such as vacation journeys (cf. Barthel 2012, p. 73). However, the long charging time is more challenging for the carsharing providers than the limited range, because the vehicles have to be available for a high utilization (cf. Kiermasch, 2013, p. 46). Electric vehicles have to be charged more often than conventional vehicles needing a refill (cf. Seign and Bogenberger, 2013, p. 6). Charging time should be scheduled, but it downsizes the availability of the electric vehicles (cf. Doll et al., 2011, p. 9). Charging decreases the flexibility and can lead to inconveniences for the user (cf. Fournier et al., 2014, p. 67). Waiting periods are often scheduled yet to ensure sufficiently charged batteries with the disadvantage of limited utilization (cf. Barthel 2012, p. 75). Expensive fleet management procedures are necessary for free-floating carsharing concepts like manually picking up the electric vehicle and delivering it to the charging station, while users are expensively incentivized to motivate them to connect a vehicle to a charging station (cf. Seign and Bogenberger, 2013, p. 6). Availability and reliability of electric carsharing are necessary for the compatibility of the innovation with the needs of the clients (cf. Rogers, 2010, p. 228). This means electric vehicles should be relatively fully charged at least 60 to 70 percent to encounter range anxiety and customers need dependable information about the remaining range (cf. Seign and Bogenberger, 2013, p. 4). Suitable booking systems and onboard computers are necessary to assist the customers usage and to avoid outages by empty batteries (cf. Baum et al., 2012, p. 76). Station-based electric carsharing providers have to consider high investment costs for the construction of charging facilities at the stations, while free-floating systems require an already developed charging infrastructure in their designated business area (cf. Kiermasch, 2013, p. 46). Furthermore, there are often compatibility issues, since vehicles support other charging methods than the respective charging station (cf. Baum et al., 2012, p.75).

Another barrier is the high acquisition cost of electric vehicles due to the expensive batteries, as mentioned in section 2.1.1. Despite the lower variable cost, the initial costs are too high for carsharing provider to bear at present (cf. Fournier et al., 2014, p. 67). The additional financial burden cannot be adjusted by greater surcharges currently (cf. Barthel 2012, p. 92). Customers are mostly not willing to pay more for electric mobility (cf. Hoffmann et al., 2012, p. 19).

In addition to financial and technical challenges, potential users still exhibit knowledge gaps and uncertainties about electric mobility and the own mobility needs (cf. Kiermasch, 2013, p. 20). Electric vehicles have different and novel characteristics comparing to conventional vehicles and for the moment they are at an early stage of market penetration (cf. Arnold et al., 2010, p. 29 f.). As a disruptive technology, it only occurs in niche segments in early stages (cf. Adner, 2002, p. 668). The same as with the innovative technology electric vehicle, the service innovation carsharing is little known and still a niche offer (cf. Seign and Bogenberger, 2013, p. 1). In Germany, carsharing recorded double-digit growth rates, but only 1.5 percent of the possible holders of driving licenses are registered for carsharing by now (cf. Bundesverband CarSharing e. V., 2015a, p. 2). From the user perspective, innovations represent a risk firstly, because potential users are afraid of the new technology (e. g. range anxiety) and the first usage is afflicted with uncertainties regarding actual attributes and consequences as well as with unfamiliarity compared to the conventional usage (cf. Seign and Bogenberger, 2013, p. 5; Peters and Dütschke, 2010, p. 15). Electric carsharing is still unknown and some users are still not convinced, which translates into a fear of novelty generating reluctance against the mobility service offer (cf. Fournier et al., 2014, p. 67).

2.2 Usage and Typical Users of Electric Carsharing

2.2.1 Usage of Electric Carsharing

A prerequisite for the usage of electric carsharing is the signing of a usage contract or a one-time registration (cf. Barthel, 2012, pp. 30, 37). Online registration is often possible and has to be completed in one of the local service points, where customers usually get more information about how to use electric carsharing and the user manual (cf. Citroën Deutschland GmbH, 2015a, p. 1; Kiermasch, 2013, pp. 26, 33). A valid driving license and identity card are required for the completion of the contract (cf. car2go Deutschland GmbH, 2015a, p. 1; DB Rent GmbH, 2014, p. 2). At the local service points customers receive their own customer cards or a glued radio frequency identification chip for the driving license, which both act as a personal key to the entire carsharing fleet (cf. DB Rent GmbH, 2014a, p. 2; DriveNow GmbH & Co. KG, 2015a, p.1). Currently car2go withdrawals its member cards, since all vehicles can be opened with the car2go app (cf. car2go Deutschland GmbH, 2015a, p. 1). The carsharing providers collect a one-time registration fee, which varies depending on the provider and is calculated to cover administrative costs (cf. Baum et al., 2012, p. 73). For example, customers pay € 9.90 for Multicity Carsharing, € 29 for DriveNow or € 50 for Flinkster (cf. Citroën Deutschland GmbH, 2015a, p. 1; DriveNow GmbH & Co. KG, 2015a, p.1; DB Rent GmbH, 2014a, p. 2). The usage of electric carsharing is generally described in five steps (s. figure 1).

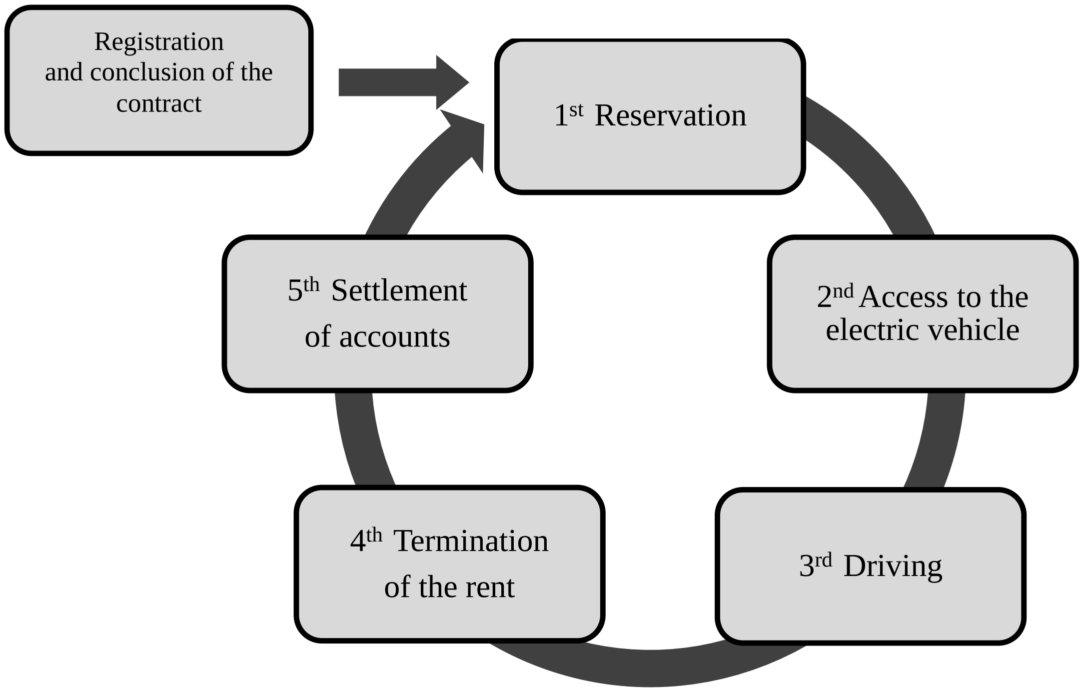

Figure 1: Usage of electric carsharing
Source: Own depiction with reference to Kiermasch (2013, pp. 27, 34).

The first step is the *reservation*. Electric carsharing customers can reserve an electric vehicle at any time by telephone, via the website or mobile app (cf. Audenhove et al., 2014, p. 24). A telephone booking is often liable to charges (cf. DriveNow GmbH & Co. KG, 2015a, p.1; DB Rent GmbH, 2014b, p. 2). Users receive real-time information about the position of available electric vehicles and about the level of their charged vehicle battery (cf. Firnkorn and Müller, 2011, p. 1520). The customer data and an available vehicle are only required to make a reservation (cf. Kiermasch, 2013, p. 28). The carsharing providers work together with booking centers, which have an overview if an electric vehicle is available at the requested time (cf. Borchardt, 2012, p. 84). There are some differences between the two carsharing concepts. Station-based vehicles can be reserved from five minutes up to six months in advance (cf. cambio Mobilitätsservice GmbH & Co KG, 2015, p. 6). The minimum booking time is generally one hour and after that the user can be charged every half an hour depending on the provider (cf. DB Rent GmbH, 2014a, p. 2). When booking, the user has to specify the vehicle type, the desired carsharing station as well as the time of departure and return (cf. ADAC, 2014, p. 1). Some electric carsharing providers demand a reservation of the planned range beforehand (cf. cambio Mobilitätsservice GmbH & Co KG, 2015, p. 29). An open end booking is still the exception in station-based concepts and usually only an adoption with additional charging (cf. Borchardt, 2012, p. 84; cambio Mobilitätsservice GmbH & Co KG, 2015, p. 22). Generally, an extension of the planned reservation will be charged extra and unused remaining hours will only count as half as much (cf. DB Rent GmbH, 2014b, p. 11). As opposed to station-based concepts, booking an electric vehicle in advance is not compulsory in free-floating concepts, thus the vehicles may be rented spontaneously in the street (cf. Firnkorn and Müller, 2011, p. 1520). There is no minimum booking time and the users do not need to determine the rental period in advance (cf. ADAC, 2014, p. 2). Free-floating electric carsharing concepts enable instant access and open end journeys (cf. Steiner et al., 2014, p. 3). The customer can use the website of the provider or a mobile app to locate an available electric vehicle and has the opportunity to book it directly (cf. DriveNow GmbH & Co. KG, 2015a, p.1; Citroën Deutschland GmbH, 2015a, p. 1). The free-floating vehicles can be reserved free of charge for only 15 or 30 minutes beforehand (cf. Van Audenhove et al., 2014, p. 24). Alternatively, users can spontaneously pick up any free vehicle without a reservation (cf. car2go Deutschland GmbH, 2015a, p. 1).

The second step describes the *access to the electric vehicles*. In case of reservation, the user receives a booking confirmation with information about the current location of the electric vehicle (cf. Kiermasch, 2013, p. 34; DB Rent GmbH, 2014b, p. 5 f.). The vehicles of station-based concepts are at their carsharing stations, while vehicles of free-floating concepts may be taken spontaneously in the street. The independent access to carsharing vehicles around the clock is carried out via key locker at the stations or electronic access systems such as smart cards, radio frequency identification chips glued on the driving licenses and mobile apps (cf. Barthel, 2012, p. 30; DB Rent GmbH, 2014b, pp. 5-7). Some station-based carsharing providers place the keys to open the vehicles in a key locker at the stations, which can usually unlock with the customer card and a pin code (cf. Van Audenhove et al., 2014, p. 24). But this access system has been predominantly replaced by smart cards and mobile apps (cf. Kiermasch, 2013, p. 25). Frequently, electric vehicles can be open by holding the customer card over the card reader behind the windscreen, but more and more vehicles can also be open by a mobile app (cf. cambio Mobilitätsservice GmbH & Co KG, 2015, p. 10; DriveNow GmbH & Co. KG, 2015a, p. 2). As a consequence, the key is located usually in a special holder in the glove compartment of the vehicle (cf. Citroën Deutschland GmbH, 2015a, p. 1; DB Rent GmbH, 2014b, p. 6). In most cases, a personal pin code must be entered on the on-board computer (cf. Kiermasch, 2013, p. 34). Users of free-floating concepts are charged as soon as the car is unlocked by the electronic access medium (cf. Firnkorn and Müller, 2011, p. 1520). Before driving, the user must evaluate the condition of the vehicle and check it for possible damages (cf. car2go Deutschland GmbH, 2015a, p. 2; Citroën Deutschland GmbH, 2015a, p. 1). At station-based concepts the damage control includes mostly the charging station and the charging cable (cf. cambio Mobilitätsservice GmbH & Co KG, 2015, p. 31). Station-based carsharing electric vehicles are always connected to charging stations, while free-floating vehicles are rarely connected. First the charging cable has to be removed from the vehicle, then the cable has to be unplugged from the charging station and when driving the charging cable should be stored in the car boot (cf. Citroën Deutschland GmbH, 2015b, p. 6; cambio Mobilitätsservice GmbH & Co KG, 2012, p. 2).

Now, the carsharing user can *drive* the electric vehicle. An electric vehicle drives like a conventional vehicle with an automatic gearbox (cf. DB Rent GmbH, 2014b, p. 14). The most providers of station-based carsharing ensure that at least the booked range is available and often calculate an additional safety cushion (cf. cambio Mobilitätsservice GmbH & Co KG, 2015, p. 29). The traditional fuel gauge has been replaced by a battery charge indicator, which helps users to manage the charge level (cf. Citroën Deutschland GmbH, 2015b, p. 4 f.; cambio Mobilitätsservice GmbH & Co KG, 2012, p. 1). During the rent, electric vehicles of station-based carsharing concepts should be charged in exceptional cases only and thereby resulting electricity costs will be charged to the user (cf. cambio Mobilitätsservice GmbH & Co KG, 2012, p. 1). There is no obligation to charge up a free-floating electric vehicle (cf. car2go Deutschland GmbH, 2015a, p. 2). But if a user connects an electric vehicle to a charging station and the battery charge level is below a certain degree, the user will be rewarded with free minutes to his account[10]. The charging process is free of charge and the electricity costs are included in the rental prices (cf. DriveNow GmbH & Co. KG, 2015a, p. 2). The user finds the nearest suitable charging station on the website of the provider, via the mobile app or via the navigation system in the vehicle (cf. Citroën Deutschland GmbH, 2015a, p. 1 f.). The free-floating electric carsharing vehicles have parking permits, so that the vehicles can be parked free of charge in every public parking space in the designated business area and additionally the users have not to bother with parking tickets (cf. DriveNow GmbH & Co. KG, 2015a, p. 2; Citroën Deutschland GmbH, 2015a, p. 2).

[10] For charging an electric vehicle, Multicity Carsharing users get ten free minutes if the charge level is below fifty percent, DriveNow users get twenty free minutes if the residual range is below thirty kilometers and car2go users get ten free minutes if the battery performance is below thirty percent (cf. Citroën Deutschland GmbH, 2015a, p. 2; DriveNow GmbH & Co. KG, 2015a, p. 2; car2go Deutschland GmbH, 2015a, p. 2).

The fourth step is the *termination of the rent*. At the end of a trip, the user returns the electric vehicle to the same station where it was picked up in case of the station-based carsharing concept or respectively to any parking space in the designated business area of the free-floating provider (cf. Schade et al., 2014, p. 3). The user has to put the key back to its holder and locks the vehicle with the customer card, the driving license with the chip or the mobile app (cf. DB Rent GmbH, 2014b, p. 8; car2go Deutschland GmbH, 2015a, p. 2). The tenancy ends by locking the electric vehicle or replacing the key into the key locker at the stations (cf. Citroën Deutschland GmbH, 2015b, p. 3; Kiermasch, 2013, p. 29). Station-based electric carsharing vehicles have to be reconnected to the charging stations every time at the end of the rental and the charging process needs to be run (cf. cambio Mobilitätsservice GmbH & Co KG, 2015, p. 32). At the termination of the rent, free-floating vehicles must have a residual range of at least ten to fifteen kilometers (cf. Citroën Deutschland GmbH, 2015b, p. 5; DriveNow GmbH & Co. KG, 2015b, p. 4).

The last step of using electric carsharing is the *settlement of accounts*, which is different between the station-based and the free-floating concepts. Invoicing of station-based provider is carried out usually monthly or fourteen days after rental by direct debiting (cf. cambio Mobilitätsservice GmbH & Co KG, 2015, p. 27). Depending on provider and tariff, there are also fixed costs such as monthly or annually membership fees to cover operating costs (cf. Barthel, 2012, p. 29). The choice of the tariff complies with the expected frequency of use and in addition many carsharing providers offer also special, discounted rates for subscribers of public local transport and railway (cf. Bundesverband CarSharing e. V., 2015b, p. 3). There are always usage-based costs, which incur only at the actual rental (cf. ADAC, 2014, p. 1). These variable costs depend mostly on the tariff and on the selected vehicle category, whereby electric vehicles are usually in categories of the small vehicles (cf. Lawinczak and Heinrichs 2008, p. 9; DB Rent GmbH, 2014a, p. 2). The expenses generally consist of a time charge as well as a distance charge and vary depending on the provider and the tariff (cf. Clemente et al., 2013, p. 264). A fixed amount is charged per booked unit of time, which prevents that vehicles will be parked for a long time (cf. Kiermasch, 2013, p. 29). During daytime the time-based price is between two to five euro per hour and at night the time-based rental is strongly reduced or in some cases even for free (cf. DB Rent GmbH, 2014a, p. 2; stadtmobil carsharing AG, 2014, p. 1). The cost per kilometer is between fifteen to thirty cent including electricity costs and driving over one hundred kilometers will reduce the amount by fifteen to thirty percent (cf. cambio Mobilitätsservice GmbH & Co KG, 2015, p. 23; stadtmobil carsharing AG, 2014, p. 1). Besides the electricity costs, insurance, taxes, cleaning, maintenance and care are also included in the rental price (cf. Barthel, 2012, p. 29).

Basically, fixed costs, such as a monthly based fee, do not exist in free-floating electric carsharing concepts (cf. Firnkorn and Müller, 2011, p. 1520). The electronic invoicing is carried out a few days after the rental (cf. Kiermasch, 2013, p. 35). Compared to the station-based concept, only the rental period will be billed (cf. Baum et al., 2012, p. 74). The settlement is minute based according to the pay as you go principle and thus represents a simple pricing structure for the user (cf. Van Audenhove et al., 2014, p. 25; Steiner et al., 2014, p. 3). There are also special packages with reduced costs per minute for user, who drives regularly and often (cf. Citroën Deutschland GmbH, 2015b, p. 3). Generally, Multicity Carsharing costs 28 cents per minute, car2go calculates 29 cents per minute and DriveNow's BMW i3 is charged with 34 cents per minute[11] (cf. Citroën Deutschland GmbH, 2015b, p. 3; car2go Deutschland GmbH, 2015a, p. 2; DriveNow GmbH & Co. KG, 2015c, p. 1). The rental price includes electricity costs, insurance, taxes, cleaning, maintenance, valeting and parking fees (cf. DriveNow GmbH & Co. KG, 2015a, p. 2). Car2go only calculates nineteen cents per minute for parking and DriveNow bills fifteen cents per minute as well as free of charges at night (cf. car2go Deutschland GmbH, 2015a, p. 2; DriveNow GmbH & Co. KG, 2015c, p. 1).

2.2.2 Typical User of Electric Carsharing

The study MiD 2008 (Mobility in Germany 2008)[12] has identified seven segments of transport users by combining variables of the use of transportation means with different characteristics such as the availability of a passenger vehicle (cf. Bundesministerium für Verkehr, Bau und Stadtentwicklung, 2010, pp. 110-115). Persons, who do not have a passenger car available, are split in three different segments including the two smallest groups *cyclist* (five percent) and *less mobile persons* (six percent) as well as the *captives of public transport* (eight percent) (cf. Barthel, 2012, p. 18). *Cyclist* are relatively rare on the road with other transportation means and come from all age groups with a focus on individuals under the age of thirty (cf. Bundesministerium für Verkehr, Bau und Stadtentwicklung, 2010, p. 113). Le*ss mobile persons* are dominantly older people, who are rarely on the road compared to the average population and usually walk only short distances (cf. ibid). A lot of the *captives of public transport* are young individuals, who cannot afford an own car and therefore are dependent on public transport, but a significant proportion of the captives are voluntarily forgo on a passenger car (cf. ibid, pp. 111-113). The public transport user segments mainly live in core cities and urban areas (cf. ibid, p. 111). The *public transport regular customers* (seven percent) and the *public transport occasional customers* (nineteen percent) also compile from all sections of the population and nearly all have a driving license (cf. ibid, pp. 111-113). The regular customers drive with the public local transport almost every day, while the occasional customers decide often situational, which transportation means they choose and they are formally higher educated than the other segments (cf. ibid). Nineteen percent are classified as *potential customers of public transport*, since the subjective reachability of destinations by public local transport

[11] Each rental transactions of car2go and DriveNow include 50 respectively 200 kilometers, and each additional kilometer costs 29 cents (cf. car2go Deutschland GmbH, 2015, p. 2; DriveNow GmbH & Co. KG, 2015c, p. 3).
[12] In the study MiD 2008 60,713 people from 25,922 households in Germany were interviewed to their mobility behavior and mobility requirements (cf. Bundesministerium für Verkehr, Bau und Stadtentwicklung, 2010, p. 1).

is good, but this group is skeptical about public transport for various reasons (cf. ibid, pp. 110-112). This segment is distributed also across all age groups with a slight focus on the middle-aged cohorts between thirty and fifty years (cf. ibid, p. 113). The largest segment *regular users of motorized individual transport* (thirty-six percent) is recruited also across the whole population and it is hardly represented in urban areas, but focuses mainly on the peripheral areas where the car is often the only alternative for the daily routes (cf. ibid, pp. 110-113).

For Maertins (2006, pp. 17 f., 20-23) it is not enough to consider only the transport behavior and so he identified four different types of intermodal users in carsharing, arising from the combination of mobility orientations, socio-demographic characteristics and attitudes[13]. *Pragmatic public transport users*, *environmentally aware cyclist and public transport users*, *fun-oriented car-lovers* as well as *highly mobile pragmatic multimodal users* (cf. Barthel, 2012, p. 40). Public transport largely covers the mobility needs of *pragmatic public transport users* and they realize their transport behavior by purely practical considerations (cf. Maertins, 2006, p. 21). The term "pragmatic" indicates a low value orientation or affinity towards transportation means compared to high affinity respectively higher value orientation such as *car-lovers* or *environmentally aware cyclist and public transport users* (cf. Hoffmann et al., 2012, p. 27). Education as well as income is slightly below the average and *pragmatic public transport users* is one of the youngest clusters together with the *car-lovers* with an average age of thirty-six years (cf. Maertins, 2006, p. 21). The car is the focus of f*un-oriented car-lovers* due to the need for flexibility, freedom and the fun factor (cf. ibid). *Environmentally aware cyclist and public transport users* prefer the eco-modes of transportation due to idealistic reasons and they are well educated and form the oldest clientele (cf. ibid, p. 22). *Highly mobile pragmatic multimodal users* use mainly the railway for their frequent journeys and have high demands on flexibility and comfort (cf. ibid, p. 22). They are rather male and have high incomes (cf. ibid, p. 22). Identical to the *pragmatic public transport users,* they possess the most public transport subscriptions as well as BahnCards and have the best availability of passenger vehicles together with the *car-lovers* (cf. ibid, pp. 22-23). According to Maertins (2006, p. 64) the *environmentally aware cyclist and public transport users* (forty-one percent) form the largest user group in carsharing services followed by the *pragmatic public transport users* (thirty-one percent), the *fun-oriented car-lovers* (nineteen percent) and the *highly mobile pragmatic multimodal users* (nine percent). The largest cluster among new customers is *car-lovers* and at the same time this cluster represents the largest potential group (cf. ibid, p. 25, 65).

The motives for the usage of carsharing have changed over time. In the initial phase environmental motives played a central role and meanwhile pragmatic as well as economic motives come mostly to the fore (cf. Wilke, 2007, p. 15). This is related to the professionalization of

[13] In this survey, 770 customers of 14 different carsharing providers from 35 cities were interviewed (cf. Maertins, 2006, p. 8).

traditional carsharing providers and the introduction of new, innovative provider with more flexible offerings (s. section 2.1.2). Electric carsharing is also part of this development. The traditional, environmentally aware users can be reached especially by the environmentally friendly image of electric carsharing, but also new, technically interested customers can be gained with the adoption of innovative electric vehicles (cf. Wappelhorst et al., 2014, p. 16; Dütschke et al., 2013, p. 9; Canzler and Knie, 2015, p. 24). A study of a field trial[14] showed that the *pragmatically oriented public transport users* have also a high willingness to use electric carsharing, in addition to the ecologically convinced users (cf. Hoffmann et al., 2012, pp. 26-28). The *pragmatically oriented public transport users* was one of the youngest clusters with an average age of thirty-six years, the daily use of public transport was very high, the education and income were below average (cf. Hoffmann et al., 2012, p. 26). The project BeMobility was continued by interviewing respondents from T_1 or T_2, who used station-based electric carsharing further on (T_3: n = 79) (cf. Scherf et al., 2013, p. 42). The sample showed similar characteristics to the previous surveys, in Berlin station-based electric carsharing users were almost all male (95 percent), highly educated, employed (97 percent), the average age was thirty-nine years, 42 percent used public transport almost every day and 34 percent drove with a bicycle almost daily (cf. ibid). Three online surveys[15] about free-floating electric carsharing in Berlin showed that the majority of all participants are male, full-time employed and well educated, which is comparable to surveys about station-based electric carsharing (cf. Steiner et al., 2014, p. 5). Half of the respondents have a subscription for public transport (cf. ibid, p. 8). According to an online survey answered by users of the carsharing provider car2go in Ulm (n = 743), 49.3 percent of the participants had driven an electric carsharing vehicle of car2go at the time of the survey (cf. Firnkorn and Müller, 2015, p. 31). The car2go users were highly educated, mostly full-time employed (66.2 percent), 68.3 percent male, nearly half between twenty to thirty-four years, over the half have a net household income over 2500 euro per month and only 17.2 percent do not have a vehicle available in their own household (cf. ibid, p. 33 f.). A qualitative study of the BeMobility project with nine regular users[16] of electric carsharing showed also a typical *innovator sample*, because the users were predominately male, well educated and with above-average income (cf. Ruhrort et al., 2014, pp. 295, 304). On the one hand there were users, who were strongly environmentally concerned and interested in electric carsharing as a socio-cultural project, while on the other hand there were users,

[14] The project BeMobility aimed the combination of station-based carsharing with electric vehicles in multimodal transport concepts in Berlin and the willingness to use electric carsharing was asked before the field trail (T_0: n = 292) (cf. Hoffmann et al., 2012, pp. 7, 28). The mobility types of Maertins (2006, p. 21 f.) were transferred to the context of electric carsharing (cf. Hoffmann et al., 2012, p. 27).

[15] The participants were asked before using free-floating electric carsharing in August 2012 (T_0: n = 1479), shortly after they had begun to use it (T_1: n = 150) and one year after the introduction from July to September 2013 (T_2: n = 492) (cf. Steiner et al., 2014, p. 4 f.).

[16] If users make use of electric carsharing more than four times in the year 2011, they would be frequent users (cf. Ruhrort et al., 2014, p. 291).

who were interested in electric carsharing as a technological innovation, because aspects of fun and flexibility were more in focus (cf. ibid, p. 299).

If an individual has a need that cannot be satisfied locally, a demand for mobility will be created and that leads to a need of mobility (cf. Borchardt 2012, p. 21). In turn, mobility behavior originates from the individual handling with the decision-making situation for the implementation of the need of mobility under given conditions and the mobility behavior is influenced by lifestyles, emotional aspects, habits and the available mobility offer (cf. Bertram and Bongard, 2014, p. 6). The choice of transportation means and therefore the acceptance for a particular mobility concept is a strongly routinised behavior, which is influenced by habits and long-term decisions (cf. Deutsches Zentrum für Luft- und Raumfahrt, 2007, p. 35). The choice of transportation means is less determined by the lifestyle than rather by the phase of life (cf. Canzler, 2008, p. 116). Attitudes, norms and values also affect this choice (cf. Ruhrort, et al., 2014, p. 291). On the one hand the choice of transportation means is determined by objective influential factors and on the other hand by subjective influential factors, which are far more complex (cf. Deutsches Zentrum für Luft- und Raumfahrt, 2007, pp. 35-38). Significant influential factors are highlighted in figure two and some factors are explained detailed which are particularly relevant for the consideration of electric carsharing. Ruhrort et al. (2014, p. 298) assumed that in most cases, electric carsharing would not create entirely new carsharing patterns and that the use of electric carsharing needed to be seen in the context of usual carsharing routines and attitudes.

The objective influential factors include socio-demographic factors, which already mentioned above. But in that presented studies are limitations, which should be taken in account. The surveys were conducted in an early stage of adoption. Many users had not much experience with electric carsharing, due to the limited number of electric vehicles available in carsharing services at that time (cf. Hoffmann et al., 2012, pp. 22-23). Additionally, the samples contained predominantly residents of urban areas and early adopters as well as innovators were over-represented, which require further research for the time after these first try-outs (cf. Wappelhorst et al., 2014, p. 10; Ruhrort, et al., 2014 p. 304).

The choice of transportation means vary significantly depending on the spatial structure and the existing transportation system. The everyday mobility of individuals is influenced to a large extent by the existing spatial opportunities to exercise activities and the spatial distribution of population, workplaces and infrastructure are a key element for the explanation of mobility (cf. Bundesministerium für Verkehr, Bau und Stadtentwicklung, 2010, p. 33).

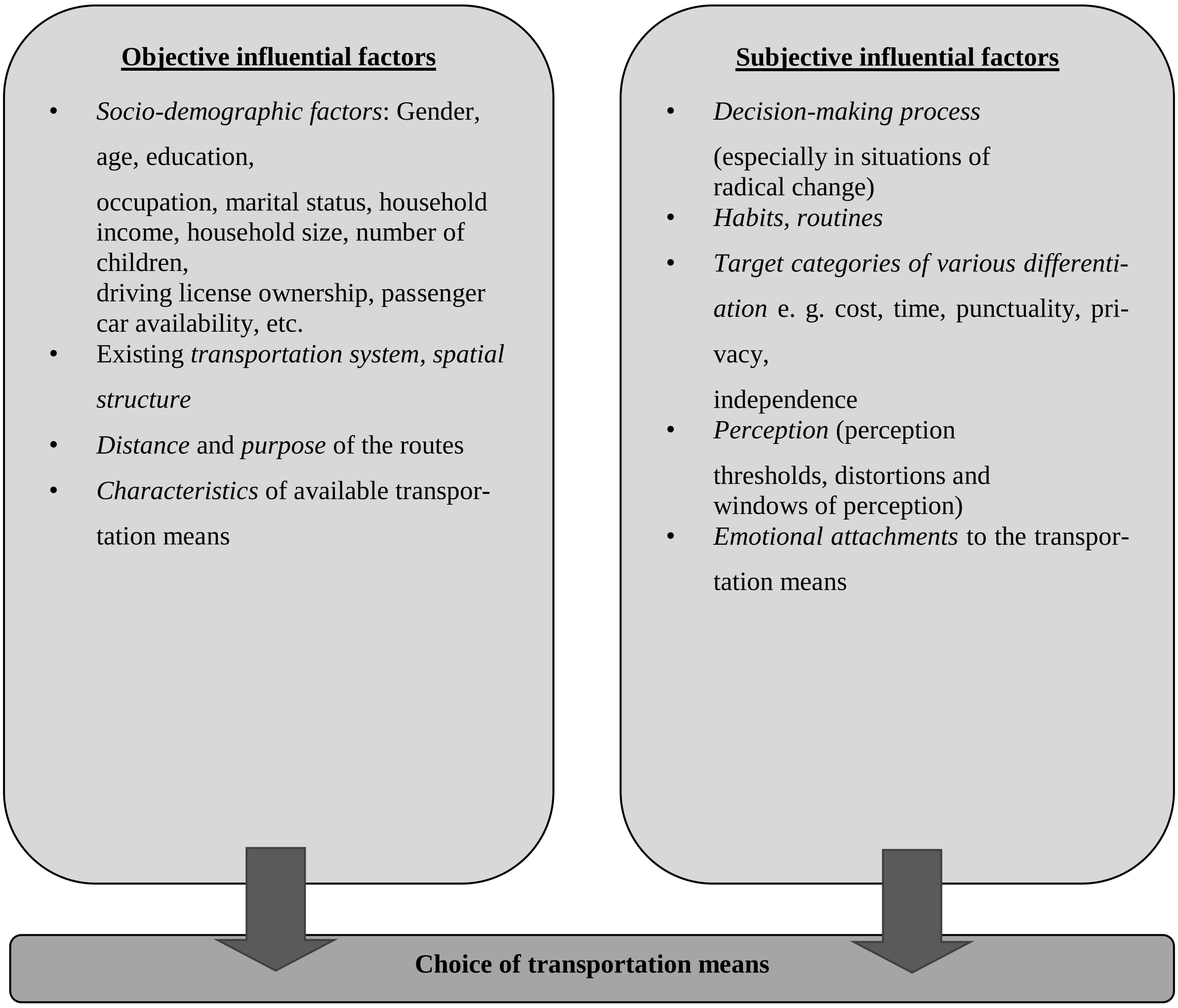

Figure 2: Factors that influence the choice of transportation means
Source: Own depiction with reference to Kiermasch (2013, p. 57) and Deutsches Zentrum für Luft- und Raumfahrt (2007, p. 35 f.).

While densely built-up areas offer favorable conditions for the use of public transport, rural areas can often only be made accessible with the motorized individual transport (cf. Wappelhorst et al., 2014, p. 18). Conversely, the transportation system has high influence on the specification of the spatial structure, since settlement structure and transportation are in a mutual dependent relationship (cf. Bundesministerium für Verkehr, Bau und Stadtentwicklung, 2010, p. 33). The place of residence has great impact on the mobility behavior and shows that urban residents frequently use public transport as already illustrated above, due to the higher offer of public transport as well as the mostly shorter paths in big cities (cf. Barthel. 2012, p. 19). In rural areas the availability of passenger cars is much higher than in urban agglomeration (c. Wappelhorst et al., 2014, p. 11). The most successful carsharing services encounter largely in big cities with over 200,000 inhabitants (cf. Bundesverband CarSharing e. V., 2015a, p. 9). Likewise electric carsharing services are located mostly in urban areas (s. section 2.3) and practical experiences as well as research are generally concentrated on urban contexts (c. Wappelhorst et al., 2014, p. 4). A key criterion for the attractiveness of electric carsharing and an important prerequisite for its market penetration is a dense station network or respectively a wide business area with sufficient vehicles (cf. Barthel. 2012, p. 45). From the point of view of users as well as providers, an optimal electric carsharing station should be located near places of residence, directly accessible, barrier-free to use, easy and quick to find, reliable available (not occupied by unauthorized parker) and visible from the street (cf. Lawinczak and Heinrichs, 2008, 11 f.). The previous studies about station-based electric carsharing discovered that the station network was not dense enough and distance as well as location of those carsharing stations was not optimal (cf. Hoffmann et al., 2012, p. 23; Scherf et al., 2013, p. 43). Similarly, the users of free-floating electric carsharing indicated that the size of the business area within the city was not large enough for their purpose and the area should be extended to the peripheral areas of the city (cf. Steiner et al., 2014, p. 9). The number of available electric vehicles in carsharing fleets is still limited (s. section 2.3). Another local barrier of the diffusion of electric carsharing is a less developed charging infrastructure in some spatial structures (cf. Firnkorn and Müller, 2015, p. 37).

The distance and purpose of the routes are also referred to objective influential factor. According to MiD 2008, each German covers daily an average 3.5 ways with a respective length of almost twelve kilometers (cf. Bundesministerium für Verkehr, Bau und Stadtentwicklung, 2010, p. 21). These are forty-one kilometers per day and the required travel time is about eighty minutes (cf. Bertram and Bongard, 2014, p. 10). The travel distance shrinks to thirty-six kilometers in large cities (cf. Bundesministerium für Verkehr, Bau und Stadtentwicklung, 2010, p. 42). Only less than two percent of the daily ways cover distances exceed one hundred kilometers (cf. ibid, p. 25). These values are well below the current range of electric vehicles (cf. section 2.1.1). Only twenty percent of the trips with conventional station-based carsharing vehicles last longer than twenty-four hours or exceed one hundred kilometers, because most rents are ended within six hours and after less than thirty kilometers (cf. Maertins, 2006, p. 13). The electric vehicles of the station-based carsharing by e-Flinkster are mostly used for short distances and covered on average twenty-seven kilometers per booking (cf. Hoffmann et al., 2012, p. 15). The average distance covered in one trip by free-floating electric carsharing is remarkably shorter, namely twenty-one minutes and six kilometers (cf. Ruhrort et al., 2014, p. 294). Therefore, today's electric vehicles in carsharing services should fulfill the requirements regarding the range and as a rule, several bookings in a row would be possible without recharging (cf. Barthel, 2012, p. 79).

In Germany, shopping and leisure form over fifty percent of the purposes of trips (cf. Bundesministerium für Verkehr, Bau und Stadtentwicklung, 2010, p. 23). Equally, conventional vehicles of station-based carsharing concepts are mainly rented for shopping trips as well as transport and leisure purposes (cf. Wilke, 2007, p. 15). Station-based electric carsharing is usually utilized for planned trips in a private context (cf. Hoffmann et al., 2012, p. 15). In most cases, users of free-floating carsharing spontaneously borrowed the vehicles without a reservation and usually took advantage of one way rides (cf. Kiermasch, 2013, p. 61). Public transport was regularly used for everyday purposes, whereas free-floating electric carsharing was applied for special occasions that are often difficult to cover by public transport such as trips at night times, outside the public transport network or when transporting heavy objects (cf. Steiner et al., 2014, p. 7 f.). Bad weather and carrying bulky things were common reasons for choosing carsharing over bicycles (cf. ibid, p. 7). The demand for carsharing is much stronger at the weekend than on weekdays and additionally a seasonal increased use is recorded in the summer months (cf. Barthel, 2012, p. 42). The previous studies showed that the use frequency of electric carsharing was relatively low and many respondents reported that they used it for the purpose of testing the new vehicle, because they were fascinated by the novelty and the mobility concept but electric carsharing did not become part of their mobility routines (cf. Ruhrort et al., 2014, p. 292).

Whether modal split by volume of transport or transport performance, the passenger car is the main transportation means for road users in Germany (cf. Bertram and Bongard, 2014, p. 10). However, the share of motorized individual transport in the modal split has decreased from fifty-eight percent in 2008 to fifty-two percent in 2013 (cf. Bundesministerium für Verkehr, Bau und Stadtentwicklung, 2010, p. 25; Karlsruher Institut für Technologie, 2015, p. 34 f.). Simultaneously, the shares of public transport and bicycle traffic have increased especially in the young population and in urban areas and the driving license quota as well as the car availability have dropped particularly in this group (cf. Bundesministerium für Verkehr, Bau und Stadtentwicklung, 2010, pp. 25, 100). These developments also come along with an increased flexibility in the choice of transportation, most notably in urban areas and in the growing group of the multimodal transport users (cf. Scherf et al., 2013, p. 42). Carsharing users frequently choose public transport and bicycle compared to the German average (cf. Deutsches Zentrum für Luft- und Raumfahrt, 2007, pp. 32-35). This was also reflected in the studies about electric carsharing: the mainly used transportation means were bicycle and public local transport with a high share of commutation tickets, job and semester tickets, whereas using the own passenger car played a minor role (cf. Hoffmann et al., 2012, p. 13; Wappelhorst et al., 2014, p. 11 f.; Steiner et al., 2014, p. 8 f.; Ruhrort et al., 2014, p. 296). Several respondents are registered at more than just one carsharing provider and made use of both station-based and free-floating concepts (cf. Scherf et al., 2013, p. 44). Carsharing in general as well as electric carsharing are almost exclusively a supplementary mobility option and do so far not become main transportation means (cf. Wilke, 2007, p. 17; Steiner et al., 2014, p. 9). Carsharing is relatively rarely used and only a few users had rented vehicles regularly, while the majority of the users only rarely took advantage of carsharing (cf. Wilke, 2007, p. 15; Hoffmann et al., 2012, p. 23; Ruhrort et al., 2014, p. 292). Due to carsharing, users implement a kind of learning curve, with increasing the duration of affiliation, they less and less recourse to the vehicles and they learn to manage everyday life without motorized individual transport (cf. Kiermasch, 2013, p. 56). Assumingly, similar usage patterns are established in electric carsharing (cf. Hoffmann et al., 2012, p. 23; Scherf et al., 2013, p. 43).

The limited range is one characteristic of electric carsharing, which is often discussed (cf. Dütschke et al., 2012, p. 14 f.). About forty percent of the participants who used station-based electric carsharing evaluated the range as insufficient (cf. Hoffmann et al., 2012, p. 15). Steiner et al. (2014, p. 3) suggested that the main reason for the range anxiety was that station-based carsharing vehicles were usually borrowed for leisure purposes with longer distances. Eighty percent of users of free-floating electric carsharing positively assessed the range after a long term use (T_2), which can be explained by the relatively short average distances of six kilometers per rental and the availability of several alternative transportation means as a safety cushion (cf. Steiner et al., 2014, p. 6). The integration of electric carsharing fleets in public transport has the potential to compensate range limitations (cf. Hoffmann et al., 2012, p. 16). The range demand of an individual usually does not match the actual need of range, but this range anxiety may disappear through self-reflection of the mobility profile and growing experience with electric carsharing (cf. Kiermasch, 2013, p. 20).

The subjective and objective influential factors affect the decision process of an individual in choosing a transportation means with a different weight and composition factor (cf. Deutsches Zentrum für Luft- und Raumfahrt, 2007, p. 36). With regard to the subjective factors, studies showed that users have a suitable mobility behavior for electric carsharing in advance of membership such as the more intensive use of public transport and bicycles (cf. Kiermasch, 2013, p. 57). The choice in favor of electric carsharing also depends on the personal attitude to the passenger car, the fundamental openness to carsharing and of the affinity towards public transport (cf. Barthel, 2012, p. 41). If the mobility context (new offers in public transport, broken car, etc.) or the life situation (moving, job change, etc.) changes, the existing cognitive elements will be activated and there is a new conscious decision-making process regarding the mobility behavior (cf. Deutsches Zentrum für Luft- und Raumfahrt, 2007, p. 36). Changed circumstances or respectively so-called situations of radical change (personal or occupational change of the life situation, transition into a new phase of life) are often catalyst for the actual use of carsharing and appear as important components of the decision-making process (cf. Wilke, 2007, p. 171; Kiermasch, 2013, p. 57).

In addition to the situations of radical change, other conditions exist that may lead to rethink mobility habits or routines. These are for example changes in the provided infrastructure or capacity constraints such as limited parking spaces or increasing traffic congestion, which induce dissatisfaction with the previous routines (cf. Ruhrort et al., 2014, p. 298; Barthel, 2012, p. 41). In these situations, also referred to as window of perception, acceptance thresholds are exceeded with the current condition and the willingness to perceive alternative offers such as electric carsharing increases (cf. Kiermasch, 2013, p. 58).

Habits and routines strongly impact everyday mobility behavior and they have to be crossed, so that users successfully integrated electric carsharing in their everyday behavior patterns (cf. Peters and Dütschke, 2010, p. 16). The reason is that over ninety percent of the decisions in the choice of transportation means are made routinely (cf. Maertins, 2006, p. 35). In order to develop routines, sufficient opportunity to use a certain transportation means must be available, but as mentioned above most users only rarely access electric carsharing which is not enough to integrate its usage into everyday routines (cf. Deutsches Zentrum für Luft- und Raumfahrt, 2007, p. 37). Ruhrort et al. (2014, p. 297) identified that mobility routines can be steady patterns of flexible choice and proposed the term *routines of flexibility* which defines a practice for multi-optional users, who routinely choose different transportation means flexible. Low access thresholds, simplicity as well as reliability of new mobility concepts are part of the main prerequisite of acceptance, especially if specific mobility behavior is strongly embedded in practice (cf. Kiermasch, 2013, p. 58). The elimination of fixed costs such as monthly fees and deposits resulted in a decrease of the access threshold. For this reason new users had been approached, who have higher affinity for cars, pragmatic orientations and interest in cost-efficient car availability compared to previous users (cf. Maertins, 2006, p. 61). A decisive role for the acceptance of electric carsharing plays simplicity in terms of usability and pricing system. Simple, consistent and quick reachable booking options, good accessibility to vehicles, intuitively handling, easy return as well as the type of the offer make the usability a significant factor (cf. Barthel, 2012, p. 44 f.). Features such as instant access, open end booking and one-way rides could help make electric carsharing more flexible, increase the user convenience and approach new customer groups (cf. Wilke, 2007, p. 1). Free-floating carsharing concepts as well as free-floating electric carsharing concepts provide those features and could achieve a very high number of registrations in a relatively short time span, which confirms a high acceptance (cf. Kiermasch, 2013, p. 61). Furthermore, electric carsharing profits from the capabilities of new information and communication technology to enable locating vehicles easily, ad-hoc booking and opening without additional cards (cf. Schade et al., 2013, p. 3). The prices of carsharing providers strongly decide about the conviction of the offer as well as the future use intentions and if from a subjective point of view, the prices are ease to control and to calculate, the prices will be evaluated as low or reasonable (cf. Maertins, 2006, p. 15). The comprehensibility of the price system of electric carsharing is on a very high level with more than ninety percent (cf. Scherf et al., 2013, p. 42; Steiner et al., 2014, p. 8). Reliability is the (at least subjectively) permanent availability and functional efficiency of vehicles (cf. Barthel, 2012, p. 45). Today, the digital presence and immediate availability are more important than the equipment or the propulsion of the vehicle (cf. Canzler and Knie, 2015, p. 24). Waiting periods are often calculated in order to ensure sufficiently charged batteries, but long charging times limit the availability of electric vehicles and have to be overcome with intelligent charging technology (cf. Seign and Bogenberger, 2013, p. 6). Most electric vehicles have battery charge level indicators, so that users can ensure if the batteries have enough residual range available for the trip (cf. Kiermasch, 2013, p. 46). Thus mechanization and professionalization of carsharing are essential improvements to reduce barriers to entry as well as usage restrictions (cf. Deutsches Zentrum für Luft- und Raumfahrt, 2007, p. 37). As shown in figure 2, emotional attachment to the transportation means is also an important factor in the choice of transportation means. The current development favors this acceptance for alternative mobility concepts like electric carsharing because the mobility behavior changes especially among the younger generation (s. section 1). Although the group of 18 - 29 year olds was in total more out and about, but much less with passenger cars (cf. Arnold et al., 2010, p. 51). The possession of driving license and car ownership also decreased in this age group (cf. Bundesministerium für Verkehr, Bau und Stadtentwicklung, 2010, p. 69; Institute for Mobility Research, 2011, p. 9). Additionally, the share of new car buyers under the 18 - 29 year olds declined by fifty percent from 1999 to 2009 (cf. Rees, 2010, p. 1). The reason for this decline is that in this age group and also in the urban middle classes the car significantly loses its impact as a status symbol and prestige object (cf. Doll et al., 2011, p. 1; Baum et al., 2012, p. 78). Especially in urban areas, the car ownership is more perceived as a burden instead of a relief and the flexibility of the user is paramount (cf. Pelzer and Burgard, 2014, p. 25). This change reinforces the idea of carsharing. The car is increasingly losing its emotional special position and priorities are shifting, since today young people rather waive a car than internet or smartphone (cf. Kiermasch, 2013, p. 59 f.). In addition also financial reasons play a role, because mobility costs are rising and driving is getting more expensive (cf. Barthel, 2012, p. 24). Particularly the 18 - 29 year olds pragmatically select between different transportation means, whichever offer has the lowest price and is the most flexible and therefore especially free-floating electric carsharing creates the right offer in urban areas (Arnold et al., 2010, p. 51 f.).

The costs are a major influential factor in the choice of transportation means. Twenty to twenty-five percent of the users stated, that the financial advantage compared to the private car is a main reason for the use of carsharing (Haefeli et al., 2006, p. 27.). The costs for the use of carsharing especially for short distances and rare needs are significantly below the cost of an own car (cf. Baum et al., 2012, p. 68). The market trend suggested that there is a willingness to pay extra for a one-way use in carsharing concepts (cf. Scherf et al., 2013, p. 44).

2.3 Electric Carsharing – Status quo

Since the German federal government funds electric mobility in 2009, the first electric vehicles have been integrated into the carsharing fleets. As the first carsharing provider in Germany in the end of 2009 *Drive-CarSharing* integrated two electric vehicles (E-City of Mega) in its fleet in Dusseldorf within the framework of a support project of the model region Rhine-Ruhr (cf. Doll et al., 2011, p. 5). Meanwhile Drive-CarSharing offers electric carsharing together with local energy suppliers and other cooperation partners in eighteen cities, for example Bamberg (Renault Zoe), Bochum (i. a. Renault Twizy), Dusseldorf (Citroën C-Zero), Essen (i. a. BMW i3), Koblenz (Nissan LEAF) or Wuppertal (i. a. smart ed)[17]. This station-based electric carsharing service provides a total of about 140 electric vehicles (including

[17] Own research on drive-carsharing.com

range extender and plug-in hybrids) in projects and with providers like RUHRAUTOe (s. below) (cf. e-carsharing.net, 2015, p. 1). The vehicles are also available for users of Flinkster and the other way round users of Drive-CarSharing can book vehicles with Flinkster, too (cf. Drive-CarSharing GmbH, 2015).

In 2012 started *RUHRAUTOe* the nationwide first carsharing project with a pure electric vehicle fleet with twenty range extender of the brand Opel Ampera in Essen (cf. Universität Duisburg-Essen, 2012, p. 1). The project is funded by the Federal Ministry of Transport and Digital Infrastructure within the model region electric mobility and some of the additional project partners are the University of Duisburg-Essen, Drive-CarSharing and the Verkehrsverbund Rhein-Ruhr (cf. Drive-CarSharing GmbH, 2014, p. 1 f.). In spring 2013 ten smart eds were added and further electric vehicles as well as locations are replenished (cf. Universität Duisburg-Essen, 2012, p. 1). RUHRAUTOe is the first carsharing provider with an electric luxury vehicle in its fleet, the Tesla S is in the fleet since 2014 (cf. Weinand, 2014, p. 1). Meanwhile, more than fifty electric vehicles (including range extender and plug-in hybrids) are in use at RUHRAUTOe (cf. Regionalverband Ruhr, 2015, p. 2). In the project are eight of the most popular and innovative models of electric vehicles available at almost thirty stations in eleven cities including Bochum, Oberhausen, Dortmund and Wuppertal (cf. Drive-CarSharing GmbH, 2015). RUHRAUTOe has the most diversified range of electric vehicles in carsharing in Germany starting with the Renault Twizy over the BMW i3 to the electric van Nissan e-NV200 (cf. Regionalverband Ruhr, 2015, p. 2).

Flinkster, the carsharing operation of the Deutsche Bahn AG, was the second German provider introducing electric vehicles into its station-based carsharing fleet under the brand *e-Flinkster* in the end of 2009 in Berlin (cf. Barthel, 2012, p. 68). It was part of the project Berlin elektroMobil (short BeMobility) in the model region Berlin/Potsdam and funded by the German Federal Ministry of Transport, Building and Urban Development (cf. Scherf et al., 2013, p. 42). Nowadays, e-Flinkster contains about one hundred electric vehicles (e. g. smart ed, Mini E, Peugeot iOn, but also including range extender and plug-in hybrids) at over fifty stations in circa twenty-seven cities, i. a. Hamburg, Frankfurt, Stuttgart, Dusseldorf, Cologne, Garmisch-Partenkirchen (cf. Wappelhorst et al., 2014, p. 6). The Flinkster customers have access to over 600 electric vehicles (including range extender and plug-in hybrids), because of the cooperation with other carsharing providers like Drive-CarSharing, Multicity Carsharing or car2go (cf. Deutsche Bahn AG, 2015, p. 1).

In March 2011, the station-based carsharing provider *cambio* followed by two Mitsubishi i-MiEV in Hamburg (cf. Doll et al., 2011, p. 5). Meanwhile, users can drive the Mitsubishi i-MiEV in Hamburg (at three stations) and in Cologne, the Renault Zoe in Aachen (at three stations), Hamburg and Cologne (at two stations) as well as the smart ed in Aachen (at eight sta-

tions), Hamburg, Eschweiler and Herzogenrath[18]. The electric vehicles are charged with green electricity only (cf. cambio Mobilitätsservice GmbH & Co KG, 2012, p. 2).
One year later in March 2012, *stadtmobil*, another classical carsharing provider (s. section 2.1.2) took the first electric vehicle, an E-Fiat 500, in operation in Karlsruhe (cf. Stadtmobil CarSharing GmbH & Co. KG, 2015a, p. 1). Today, stadtmobil has about fifteen electric vehicles in the region of Karlsruhe such as the Renault Zoe, the smart ed or the BMW i3 (cf. Stadtmobil CarSharing GmbH & Co. KG, 2015b, p. 1 f.). Stadtmobil has also electric vehicle in its fleets in the regions Rhine – Main, Rhine – Neckar, Rhine – Ruhr and Stuttgart, for example Offenbach (smart ed, Mitsubishi i-MiEV) and the Renault Zoe in Heidelberg, Mannheim, Krefeld or Waiblingen[19].
In August 2011, *car2go* was the first free-floating carsharing provider, who added five smart eds to its fleet in Ulm (cf. car2go Deutschland GmbH, 2011, p. 2). After the successful implementation, the number was increased to twenty-five electric vehicles (cf. car2go Deutschland GmbH, 2013, p. 3). But in the end of 2014, the technical pilot area of car2go in Ulm was closed for economic reasons (cf. Bundesverband CarSharing e. V., 2015a, p. 4 f.). Meanwhile in Stuttgart, car2go launched a carsharing fleet with electric vehicles only in November 2012 (cf. car2go Deutschland GmbH, 2013, p. 1). The free-floating electric carsharing service has started with 300 smart eds and today the number has increased to 500 vehicles (cf. ibid. pp. 1-2). In December 2012, sixteen smart eds could be booked in Berlin, but firstly only in a station-based carsharing concept with a special parking space at the Potsdamer Platz (cf. car2go Deutschland GmbH, 2014, p. 2). This changed in April 2014, since then the electric vehicles could be rented as well as returned in the whole business area of car2go like the 1,200 gasoline-powered smarts in Berlin (cf. ibid.). Besides Stuttgart, car2go has completely electric carsharing fleets in Amsterdam and San Diego and is the largest provider of electric carsharing with almost 1,300 smart eds and more than a hundred thousand customers in the three locations with electric vehicles only (cf. car2go Deutschland GmbH, 2015b, p. 1).
Likewise the automobile manufacturer BMW has started to offer electric carsharing. In June 2013 *DriveNow* added forty electric vehicles of the type BMW ActiveE to the free-floating carsharing fleet in Berlin and also twenty of them to the fleet in Munich (cf. DriveNow GmbH & Co. KG, 2013, p. 1). In July 2015, the sixty BMW ActiveEs were replaced by hundred BMW i3, which are divided as followed: forty in Berlin, thirty in Munich and also thirty in Hamburg (cf. DriveNow GmbH & Co. KG, 2015d, p. 1). Further expansion is planned for autumn followed by Cologne and Dusseldorf, so that up to 400 BMW i3 will be integrated to the fleet of DriveNow in the coming months (cf. ibid.).
In Germany, the first free-floating concept with a completely electric carsharing fleet was *Multicity Carsharing* launched by the automobile manufacturer Citroën in cooperation with the Deutsche Bahn AG in August 2012 in Berlin (cf. Scherf et al., 2013, p. 44). It started with

[18] Own research on cambio-carsharing.de
[19] Own research on stadtmobil.de

100 Citroën C-Zeros and further 250 vehicles were added in April 2013, which means that the whole electric carsharing fleet consists of 350 Citroën C-Zero at present (cf. Steiner et al. 2014, p. 3). The electric vehicles are powered by green electricity from hundred percent renewable energy sources at the charging stations (cf. Ruhrort et al., 2014, p. 289). As already mentioned, the users of Multicity Carsharing have access to the vehicles of Flinkster due to the cooperation with the Deutsche Bahn AG (cf. Citroën Deutschland GmbH, 2015b, p. 4).

Additionally to this completely electric free-floating carsharing concept, there are also station-based carsharing providers with electric vehicles only. One was already mentioned above, RUHRAUTOe.

Another exclusive electric carsharing provider is *E-WALD*, who began in November 2013 (cf. E-WALD GmbH, 2015a, p. 2). Today, E-WALD offers more than 200 electric vehicles in its station-based fleet such as the Renault Zoe, the Nissan LEAF or the Mitsubishi i-MiEV and the focus is on the regions aside the urban centers at about 100 locations in Bavaria, Baden-Wuerttemberg, Hessen, North Rhine-Westphalia, Rhineland Palatinate and Schleswig Holstein (cf. e-carsharing.net, 2015, p. 2; E-WALD GmbH, 2015b, p. 1). Cooperation with Flinkster completes the offer (cf. e-carsharing.net, 2015, p. 2).

In July 2011 the German branch of *Move About*, one of the leading global carsharing providers with exclusive electric vehicles fleets, opened the first electric carsharing station in Bremen and offers both electric carsharing for private customers as well as enhanced vehicle pools for commercial users (cf. Move About GmbH, 2014, p. 1). There are ten electric vehicles at seven public carsharing stations available, for example a Nissan Leaf in cooperation with the Bremer Straßenbahn AG (cf. Move About GmbH, 2015, p. 1 f.).

In December 2014 Stadtmobil Südbaden and Energiedienst (an energy supply company of green electricity) founded the joint venture company my-e-car GmbH, which offers carsharing with electric vehicles only (cf. Stadtmobil Südbaden AG, 2015, p. 2). There are about thirty Renault Zoe available at twenty-three stations in thirteen cities in South Baden (cf. my-e-car GmbH, 2015, p. 1 f.).

Besides the big station-based carsharing providers, the automobile manufacturers and exclusive electric carsharing providers, smaller station-based carsharing providers have also begun to add electric vehicles into their carsharing fleets. In October 2012, *teilAuto*, a carsharing provider in Saxony-Anhalt, Saxony and Thuringia, received the first two Citroën C-Zero in Dresden and since January 2015 there are additionally five VW e-Golfs available in Dresden and Leipzig (cf. Mobility Center GmbH. 2015, p. 1). In Tübingen, Rottenburg and Reutlingen a Renault Zoe can be booked at *teilAuto - CarSharing Tübingen* since last year (cf. teilAuto - CarSharing Tübingen, 2015, p. 1). *Book-n-drive* is a classical carsharing provider in the Rhine – Main area and offers electric vehicles additionally to its conventional carsharing vehicles since 2014 (cf. book-n-drive mobilitätssysteme GmbH, 2015a, p. 1). There are one smart ed in Frankfurt and two Citroën C-Zero in Wiesbaden (cf. book-n-drive mobilitätssysteme GmbH, 2015b, pp. 37, 61). In September 2015 book-n-drive starts to provide three VW e-

Golfs in Bad Homburg (cf. Hillebrecht, 201, p. 1). In May 2014, *Stadtmobil Südbaden* integrated the first two Renault Zoes in its carsharing fleet (cf. Stadtmobil Südbaden AG, 2014, p. 1). Besides the joint venture company my-e-car GmbH, the carsharing provider has also Renault Zoe in its own fleet, for example in Offenburg or Bad Dürrheim (cf. Stadtmobil Südbaden AG, 2015, p. 1 f.). Currently, *stadtteilauto Osnabrück* has five Mitsubishi i-MiEVs in its station-based carsharing fleet (cf. Stadtteilauto OS GmbH, 2015b, pp. 1-3). Since March 2015 a Renault Zoe is part of the fleet of *Stadtteilauto* in Münster and further electric vehicles shall follow during this year (cf. Stadtwerke Münster GmbH, 2015, p. 1). As well since this year, *StattAuto* has three electric vehicles available in Lübeck (Renault Zoe, Nissan LEAF) and Kiel (Renault Fluence) (cf. StattAuto eG, 2015, p. 1 f.).

There are more providers and projects with electric carsharing that not all could be included here. But these examples illustrate the dynamics of electric carsharing, because mainly in the recent months many new electric vehicles were integrated into carsharing. According to the Bundesverband CarSharing e. V. (2015c) there are almost 1,600 electric vehicles used in carsharing in Germany, representing a share of ten percent of all electric vehicles in Germany[20]. As depicted in table one, the most electric vehicles are in the fleets of the automobile manufacturers.

Carsharing provider	**Number of electric vehicles in the fleets**	**Share of electric vehicles in the fleets**
Automobile manufacturers	950	14 %
Exclusive electric carsharing providers	366	100 %
Other carsharing provider	245	3 %
Total	**1,561**	**10 %**

Table 1: Electric carsharing in Germany
Source: Own depiction with reference to Bundesverband CarSharing e. V. (2015c).

[20] The number includes range extender and plug-in hybrids.

3. Research Method Data Mining

3.1 Definition and Process of Data Mining

The internet overwhelms us with data that are generated and collected daily. The size of data grows rapidly in domains like marketing, finance, insurance, health care, retail and manufacturing (cf. Sharafi, 2013, p. 51). Lying buried in this flood of data is potentially useful information which is rarely extractable, because manual analysis is too slow as well as very expensive (cf. Fayyad et al., 1996a, p. 37 f.). Because technology has enabled humans to create this volume of data, it is only natural that technology can help with potential solutions against the data overload (cf. Leong et al., 2004, p. 187). Data mining is about solving problems by assisting humans in evaluating data with its specific tools and computational methods (cf. Witten et al., 2011, p. 4). Its roots lie in the most diverse areas of research such as statistics, machine learning, information retrieval, database systems, artificial and business intelligence[21] (cf. Hotho et al., 2005, p. 3). Since data mining aroused in the early nineties as a subfield of computer science, it has addressed a various range of applications and has been the key concern of several interdisciplinary researchers (cf. Nadali et al., 2011, p. 161). However, data mining cannot be regarded as a mature field and the failure rate of data mining projects is as high as sixty percent (cf. Marbán et al., 2009, p. 88).

Remarking its origins and widespread adoption in business, data mining can be defined in a lot of different ways. In addition, there are many other names that have a congeneric meaning, including knowledge extraction, information discovery, information harvesting, data archeology data dredging or database exploration (cf. Petersohn, 2005, p.10). Han et al. (2012, p. 5 f.) point out that the term "*knowledge mining from data*" should be more appropriate because data mining is not about generating data per se. Data mining and another popular used phrase, *knowledge discovery from data* (KDD) , are controversial in research. KDD "*is the non-trivial process of identifying valid, novel, potential useful, and ultimately understandable pattern in data*" (Fayyad et al., 1996b, p. 6). On the one side, data mining is treated as a synonym for KDD, meaning it is an overall process of discovering knowledge from data, while on the other side data mining is considered as one of the steps of the KDD process (cf. Kurgan and Musilek, 2006, p. 2). It describes the modeling phase of the process referring to the specific methods and algorithms for extracting knowledge from large data sets (cf. Fayyad et al., 1996a, p. 42). Besides Fayyad et al. (1996a; 1996b) this view is shared among others, such as Azevedo and Santos (2008, p. 182), Hotho et al. (2005, p. 3) or Kurgan and Musilek (2006, p. 2). In practice, data mining is widely defined as the entire knowledge discovery process (cf. Sharafi, 2013, p. 68). Most researchers also use the terms data mining and KDD synonymously (cf. Adriaans and Zantinge, 1998, p. 5). For example, Sharma and Osei-Bryson (2009, p. 4114), Witten et al. (2011, p. 5), Han et al. (2012, p. 8), Hippner et al. (2011, p. 789), Peter-

[21] The various adjacent and overlapping areas of research are in depth explained and distinguished in Sharafi (2013, pp. 52-56) and Han et al. (2012, pp. 23-28).

sohn (2005, p.10) or Nadali et al. (2011, p. 161) imply that data mining is a process of discovering useful patterns or knowledge from data. Therefore, in this paper the broad view of data mining is assumed. The overall ambition of data mining is to extract meaningful patterns which lead to some, usually economic, advantage (cf. Witten et al., 2011, p. 5). A direct application of data mining algorithms can be a result in meaningless and invalid patterns (cf. Fayyad et al., 1996b, p. 2). The purpose of a process model is to avoid this problem and to provide a road map for data mining projects. General process models describe the individual phases and structure the specific activities (cf. Sharafi, 2013, p. 56). According to Marbán et al. (2009, p. 89) a good process model should have the characteristics of effectivity, maintainability, predictability, repeatability, quality, improvability and traceability. In the literature, a number of models are published[22]. All of them are composed of multiple phases that take place in a similar sequence. The focus, scope and number of their specific phases are the main differences between them (cf. Sharafi, 2013, p. 57). The three most popular data mining process models will be introduced and briefly explained in the following.

The KDD by Fayyad et al. (1996b) was already mentioned above. It is the first reported and the most cited[23] process model of data mining (cf. Kurgan and Musilek, 2006, pp. 3-4, 14). The KDD became a foundation for future models and consists of nine basic steps as shown in table two. The model is a waterfall life cycle with feedback loops (cf. Marbán et al., 2009, p. 89). At the beginning, an understanding of the application domain is developed and the goal of the data mining project from the point of view of the end-user is derived (cf. Fayyad et al., 1996a, p. 42). After that a subset of samplings of the data is selected and in the next step data cleaning and pre processing takes place (cf. Azevedo and Santos, 2008, p. 183). The Fourth phase is the transformation of the data by dimension reduction or other transformation methods (cf. Sharafi, 2013, p. 61). Thereupon the goals from the first phase are matched with a particular data mining method (for example classification, s. below) and the sixth phase consists of choosing the data mining algorithm(s) (cf. Fayyad et al., 1996c, p. 84). Subsequently, those methods and algorithms are applied for searching patterns from the prepared data (cf. Hotho et al., 2005, p.21). As mentioned before, Fayyad et al. (1996a, p. 42) called this seventh step data mining. In the second to last step the mined patterns are interpreted respectively evaluated and thereafter the KDD process concludes by knowledge consolidation and transferring the findings back into the domain (cf. Sharafi, 2013, p. 61).

The SAS Institute – one of the largest producer of statistical software applications – developed a widely used model with five steps which are represented by the acronym SEMMA (cf. SAS Institute Inc., 1998, p. 3). The steps named *Sample, Explore, Modify, Model*, and *Assess* (s. table 2). SEMMA is also a life cycle and begins with sampling the data by analyzing a

[22] Kurgan and Musilek (2006, pp. 1-24) describe and compare several major process models of data mining, and review their usage to both academic and industrial problems.

[23] It should be noted that the papers by Fayyad et al. (1996a; 1996b; 1996c) are also frequently used because of the well-established definitions of data mining and KDD.

small portion of a large data set (cf. Azevedo and Santos, 2008, p. 184). The second phase consists on the exploration of the data by searching for anomalies and unexpected trends with the purpose to gain understanding and ideas about the data (cf. Rohanizadeh and Moghadam, 2009, p. 42). Before modeling the data by using software tools to seek automatically for patterns that reliably prognosticate a desired result, the data is modified by creating, selecting and transforming the variables for the analysis (cf. SAS Institute Inc., 1998, p. 3). In the last step of the model the usefulness and reliability of the results from the data mining process are evaluated (cf. ibid.). SEMMA was incorporated into the software package SAS Enterprise Miner (cf. Kurgan and Musilek, 2006, p. 7). Although the process model is independent from the chosen analytical tool, it is difficult to apply SEMMA outside the limitations of the SAS software package (cf. Marbán et al., 2009, p. 89). The model includes some of the essential steps of any data mining project, but it is based on the technical part of the data mining process only, it does not consider the management side (cf. Rohanizadeh and Moghadam, 2009, p. 42). The KDD process seems more complete than SEMMA, because of the first and the last phases. Azevedo and Santos (2008, p. 186) suppose that the development of an understanding of the application domain and the identification of the goal from the customer's point of view are taking place in the first step *Sample*, because the data cannot be analyzed unless these provisions.

The Cross-Industry Standard Process for Data Mining (CRISP-DM) arose from the needs of the industrial practice and has similarities with the KDD (cf. Sharafi, 2013, p. 64). It was developed by a consortium of SPSS Inc. (a producer of statistical software applications), NCR (a database provider), DaimlerChrysler AG (an automotive corporation) and OHRA (a health insurance company) through an effort founded by the European Commission (cf. Kurgan and Musilek, 2006, p. 5). It was released in the year 2000 as the first standard and tool-independent data mining process model (cf. Marbán et al., 2009, p. 88). The CRISP-DM is a very popular and detailed data mining process model which specified the life cycle of a data mining project in six major steps (s. table 2), scilicet, *business understanding, data understanding, data preparation, modeling, evaluation* and *deployment* (cf. Sharma and Osei-Bryson, 2008, p. 77). The first step is centered on understanding the project objectives from a business point of view then transferring this knowledge into a data mining problem definition and a tentative road map to achieve the set targets (cf. Sharma and Osei-Bryson, 2009, p. 4114). During the *data understanding* phase, the initial data are collected, their quality is identified and first insights into the sample are enabled to get familiar with the data (cf. McCue, 2007, p. 50). The next step of CRISP-DM contains all activities such as data selection, data cleaning, data transformation and data integration to construct the final dataset from the raw data (cf. Chapman et al., 2000, p. 11). Fourth, the appropriate techniques, algorithms and related parameters are determined and applied and when necessary going back to the previous step, if special requirements for the algorithms exist (cf. Nadali et al., 2011, p. 162). The *evaluation* phase consists on a critical evaluation and review of the whole process model particularly with regard to precisely achieve the business objectives of the first phase (cf. Sharafi, 2013, p. 67). In the last step of the process the results and the discovered knowledge are organized and presented in a way that the customers can use it, which depending on the requirements, can be as simple as providing a report or as complex as accomplishing a repeatable data mining process across the enterprise (cf. Azevedo and Santos, 2008, p. 183). The sequence of the six steps is not strict and moving back and forth between them is always required (cf. Chapman et al., 2000, p. 10). A detailed explanation of each phase of the CRISP-DM is presented in chapter 4.1.1.

Table two provides a direct, side-by-side comparison of the steps across all data mining process models. There are several characteristics common for all models like using similar stages, often following the same sequence, involving important iterations and loops between most, if not all, of their phases (cf. Kurgan and Musilek, 2006, p. 7). The major difference is in SEMMA, which does not include the development of an understanding of the application domain and the closing deployment phase. Therefore this model does not consider the roles of the organization and the stakeholders during a data mining project (cf. Rohanizadeh and Moghadam, 2009, p. 42). The nine-step model mostly differs from the other two models in determining the data mining methods and algorithm comparatively late in the process. In CRISP-DM and SEMMA these activities take place before preprocessing the data (s. table 2), so that the data are correctly prepared for the modeling phase without the need to step back to some previous phases (cf. Kurgan and Musilek, 2006, p. 8). The KDD is developed from an academic perspective, while CRISP-DM and SEMMA are very industry-oriented (cf. Azevedo and Santos, 2008, p. 183). Both models were designed based on experiences coming from the KDD and they are not tied to industrial needs (cf. Kurgan and Musilek, 2006, p. 5). Azevedo and Santos (2008, p.186) conclude that CRISP-DM and SEMMA can be viewed as an implementation of the KDD.

KDD	SEMMA	CRISP-DM
1. Application Domain Understanding	---	1. Business Understanding
2. Selection	1. Sample	2. Data Understanding
3. Preprocessing	2. Explore	3. Data Preparation
4. Transformation	3. Modify	
5. Choosing the data mining methods	(2.)	(2.)
6. Choosing the data mining algorithm	(2.)	(2.)
7. Data Mining	4. Model	4. Modeling
8. Interpretation/Evaluation	5. Assess	5. Evaluation
9. Consolidating discovered knowledge	---	6. Deployment

Table 2: Steps of the major data mining process models
Source: Own depiction with reference to Kurgan and Musilek (2006, pp. 6, 9-12) and Azevedo and Santos (2008, p. 186).

Although the focus of the data mining process is in the modeling phase, it only takes up a small amount of time from the whole process and in contrast, a higher effort is actually dedicated on the data preparation step (cf. Sharafi, 2013, p. 60). Based on experience from several data mining projects, approximately about fifty percent of the time and effort is spent on the data preparation, fifteen percent on selecting and understanding the data, ten percent on the first phase, the modeling step and the evaluation and five percent on the final phase (cf. Kurgan and Musilek, 2006, p. 17; Hippner et al., 2011, p. 791). On the one hand data preparation mostly requires that much effort, because of the time consuming manual work involving data cleaning and transformation, which is hard to automate and on the other hand, the modeling phase uses automated or semi-automated methods with special tools on already prepared data, which consumes relatively less time (cf. Kurgan and Musilek, 2006, p. 17).

Apart from designing process models, to simplify the application of data mining algorithms and methods, tools were developed such as IBM SPSS Modeler (formerly SPSS Clementine), Weka, SAS Enterprise Miner or RapidMiner (cf. Marbán et al., 2009, p. 88). An explicit requirement for an automatism is not included in the definition of data mining process, but a quality criterion should be an automatic or (more usually) semiautomatic process (cf. Petersohn, 2005, p. 8).

The modeling phase involves two kinds of goals: the *verification* of previously established hypotheses and the *discovery* of novel patterns, which is subdivided into the *prediction* of future behavior of some variables and the *description* of patterns in a human-understandable form (cf. Sharafi, 2013, p. 64). This distinction is useful for understanding the overall discovery goal, even if the borders between description and prediction are not strict (cf. Fayyad et al., 1996a, p. 44). These goals can be accomplished by the following common data mining methods[24]:

Classification is the most common discovery method and it assigns data instances into predefined classes or categories (cf. Miner, 2012, p. 85). This method is also called supervised learning, due to the fact that a training data set is labeled with predetermined classes and is then applied to classify future data instances into those classes (cf. Liu, 2011, p. 8).

Clustering is an unsupervised learning process whereby data instances are grouped into clusters according to their mutual similarity or distance (cf. Rajman and Vesely, 2004, p. 13). It is a widely-used descriptive method (cf. Fayyad et al., 1996a, p. 44 f.).

Association rule mining or *dependency modeling* is the method of discovering relationships and dependencies between different data instances (cf. Ester and Sander, 2000, p. 159). The popular application of association rule mining in the retail industry is the market basket analysis (cf. Hippner et al., 2011, p. 798).

[24] For more details and background information on the data mining methods and their algorithms see Nisbet et al. (2009, pp. 235-258) for classification, Han et al. (2012, pp. 443-541) for clustering and Ester and Sander (2000, pp. 159-187) for association rules.

While data mining previously operates on structured data mainly stored in databases, through the rising developments of the internet increases the volume of unstructured data in form of text (cf. Sharafi, 2013, p. 51 f.).

3.2 Text Mining – Analyzing Unstructured Data

Text mining is as a specialized field of data mining which analyses unstructured text files instead of structured, numerical data (cf. Bohnacker et al., 2002, p.438). Therefore the essential difference between data mining and text mining is the consistency of the underlying data. Unstructured data is indicated as written text which has not been processed into a structured format such as a relational database or spreadsheets (cf. Miner, 2012, p. 44). On the other hand text is called semi structured when it appears as a field in a spreadsheet or database frequently surrounded by structured data (cf. ibid.). Although texts are assigned to unstructured data, they can be considered as a structured object from different perspectives such as grammar, typography or linguistics (cf. Feldman and Sanger, 2007, p. 3; Hippner and Rentzmann, 2006, p. 287). Text mining covers all kinds of texts for example research papers, business reports, emails or articles (cf. Hearst, 1999; pp. 3-4). A basic part of text mining is the document, which is defined as a unit of discrete text-based data within a corpus, that mostly, but nonessential, correlates with some real-world documents like the examples mentioned before (cf. Feldman and Sanger, 2007, p. 3). The increasing use of information technology has led to the creation of an enormous number of data. The majority of these web data is in unstructured text format spread out in blogs, social networks, feedbacks, reviews, news, etc. (cf. Li and Wu, 2010, p. 354). Estimates show that about eighty-five percent of the enterprise information is stored in the form of text (cf. Hotho et al., 2005, p. 19; Shi and Kong, 2009, p. 4167). Text mining is a process of analyzing unstructured data and as a result, it has become an essential field in the research of data mining (cf. Shi and Kong, 2009, p. 4167). To date, most researchers and analysts have centered on analyzing numerical data, because unstructured data are difficult to decipher automatically (cf. Fan et al., 2006, p. 78; Hearst, 1999; p. 3). But text mining has a higher commercial value than data mining, because if analyzed correctly, unstructured data can frequently lead to useful knowledge about products or services of a company as well as its competitors (cf. Miner, 2012, p. 557). Text mining has been successfully applied in various areas, including marketing, medicine, security, law, corporate finance and scholarly disciplines (cf. Nisbet et al., 2009, p. 174). It is essentially a part of descriptive data mining techniques, but it can also be predictive in combination with prognostic methods like trajectory identification and trend analysis (cf. Rajman and Vesely, 2004, p. 13). Text mining is a truly interdisciplinary method involving techniques from natural language processing, information retrieval, information extraction and especially data mining[25] (cf. Hotho

[25] Qi et al., (2009, p. 399) discuss the differences between text mining, data mining, natural language processing, information retrieval and extraction.

et al., 2005, p. 22). Compared with data mining, text mining leads to more qualitative results (cf. Sharafi, 2013, p. 80). Text mining is also known as *text data mining*, *textual data mining*, *text knowledge engineering*, *knowledge discovery in texts* or *knowledge discovery in textual databases* (cf. Mehler and Wolff, 2005, p. 2). The diversity in the naming of text mining illustrates the different understandings of the meaning of text mining and what it encompasses, but they have also a close relation to data mining respectively KDD. Text mining (in this case the synonym *knowledge discovery from text*) was first mentioned by Feldman and Dagan (1995, p. 122) who developed it on the basis and as an extension of the KDD. Hotho et al. (2005, p. 22) consider text mining as the application of methods and algorithms that extract useful patterns from text. Accordingly as one step of the knowledge discovery process model. In the literature, text mining frequently is described as a process (cf. Sharafi, 2013, pp. 80-84; Witten et al., 2011, p. 386; Shi and Kong, 2009, p. 4167). For Shi and Kong (2009, p. 4167) "*text mining is the natural extension of data mining to the direction of unstructured and semi-structured text data, it especially emphasizes on the process of exploring and innovating knowledge from text data*". Leong et al. (2004, 188) describe it as a sub-specialty of data mining and as a computer-assisted process. According to them, content analysis is the theoretical origin of text mining (cf. Leong et al., 2004, p. 188). This conventional analysis is costly in terms of time and just feasible to a certain degree, thereby an automated assistance is crucial due to the large amounts of unstructured data (cf. Kaiser and Bodendorf, 2009, p. 128). Text is expressed by natural language, which is amorphous and thus difficult to interpret for computers (cf. Witten et al., 2011, p. 386). The key to success of text mining is the combination of linguistic skills of humans with the speed and accuracy of a computer (cf. Fan et al., 2006, p. 78). Due to the request for automated analysis of unstructured data, in the past few years a range of text mining tools have been developed. There are pure text mining tools such as Megaputer TextAnalyst, ClearForest Text Analytics Suite or Inxight and data mining tools, which have a text mining extension like RapidMiner with its Text Processing Extension, SAS Text Miner, IBM SPSS Modeler or the KNIME Text Processing extension (cf. Hippner and Rentzmann, 2006, p. 289; KDnuggets™, 2015). Text mining and data mining systems have a number of similarities in terms of their architecture (cf. Feldman and Sanger, 2007, p. 1). But the automatic text mining tools have a long way to go before they compete against the ability of humans because the activity is very sensitive to the particular text under consideration (cf. Witten et al., 2011, p. 389). A computer can only identify the syntax of a text, which pertains to the structure of sentences and paragraphs in a given language, but it cannot completely understand the meaning (cf. Miner, 2012, p. 44). Semantics typically deals with the relationships between the individual words within the surrounding context and their meanings (cf. ibid.). In contrast to data mining the challenge of text mining is in the processing of the unstructured data for the automatic analysis (cf. Kaiser, 2009, p. 91). This is reflected in the process of text mining, which indeed has a similar structure to a classic data mining process but differs in the data preparation and often applies specific text mining techniques in the modeling phase (cf.

Hippner and Rentzmann, 2006, p. 288). Text mining has a more laborious data collection and preparation phase than data mining (cf. Miner, 2012, p. 77). Some preprocessing of the textual data is necessary to reconstruct the missing data structure (cf. Rajman and Vesely, 2004, p. 7). Although the processes for data and text mining are different, a particular, widely recognized process model for text mining has not been prevailed so far (cf. Schieber and Hilbert, 2014, p. 7). Miner (2012, pp. 74-87) and Hotho et al. (2005, p. 2 f.) adapted the CRISP-DM as a basis of their proposed text mining process. Almost all text mining process models are similar in their structure to the established data mining process models[26] (cf. Schieber and Hilbert, 2014, p. 17 f.). Some exemplary text mining process models are presented by Shi and Kong (2009, p. 4168), Fan et al. (2006, p.78), Li and Liu (2012, pp. 131-138), Nisbet et al. (2009, p. 184) and Hippner and Rentzmann (2006, p. 288). The last mentioned six-step model is shown in figure 3 and it also refers strongly to the CRISP-DM.

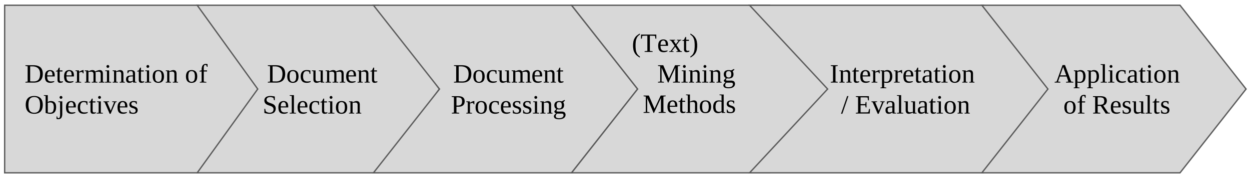

Figure 3: Six step text mining process model
Source: Own depiction with reference to Hippner and Rentzmann (2006, p. 288).

The first two phases hardly differ in terms of their activities from the phases of the CRISP-DM (cf. Schieber and Hilbert, 2014, p. 21). The text mining process starts with the determination of the purpose of the text mining analysis (cf. Hippner and Rentzmann, 2006, p. 288). The goal of the phase *Document Selection* is to identify potentially relevant documents from available data sources (cf. Schmunk et al., 2013, p. 256). This second step is strongly related to the information retrieval (cf. Hearst, 1999, p. 3 f.). In the two final phases five and six, the procedure corresponds to the process of data mining projects again (cf. Miner, 2012, pp. 75-77). In the fifth phase the achieved results are interpreted and evaluated for validity (cf. Hippner and Rentzmann, 2006, p. 289). Feedback loops should be established especially between *Interpretation/Evaluation* and the foregoing mining phase, because if the desired quality of results is not achieved, a return to step four is made and the text mining methods are adapted accordingly (cf. Choudhary et al., 2009, p. 730). Finally, the results of the analysis are applied according to the predetermined objectives (cf. Hippner and Rentzmann, 2006, p. 289). Particularly, the first two steps as well as the last two steps of the text mining process are carried out mostly manually or checked by a human supervisory authority, because the automation usually is not possible without any domain knowledge (cf. Möhring et al., 2014, p. 236). Step three and four in the process model contain the most significant difference between

[26] Schieber and Hilbert (2014, pp. 1-23) explored various text mining process models and compared their approaches.

text mining and data mining. In the *Document Processing* step a series of specialized techniques are necessary to structure the textual data, to reduce their dimensionality and to prepare them for the text mining methods (cf. Choudhary et al., 2009, p. 734). The goal is to convert the unstructured data in a structured form (cf. Leong et al., 2004, p. 188). For this purpose, the texts are divided into terms and analyzed by various methods, which mostly are assigned to the natural language processing (cf. Hippner and Rentzmann, 2006, p. 288 f.). In addition to the linguistic preprocessing, there are techniques used for term filtering, for calculation of statistical indicators, for indexing the texts, the weighting of terms or to convert the terms in a vector-based storage form (cf. Schieber and Hilbert, 2014, pp. 33-38). The processing of textual data is described in depth in chapter 4.1.4[27]. Only this diverse methods and techniques for data preparation show how different text mining presents itself at the third stage of its process model compared to data mining. The amount of preprocessing depends on which texts are analyzed, because the effect of the later final result is great (cf. Sharafi, 2013, p. 85). If the textual data possess a certain structure, some methods of data mining can be used for the analysis at step four of the text mining process (cf. Choudhary et al., 2009, p. 734). Depending on the application focus, the literature describes various methods[28]. *Classification* and *clustering* are classic methods of data mining and also the most commonly used methods in text mining (cf. Schieber and Hilbert, 2014, p. 22). A popular practical application of text classification is email spam filtering (cf. Miner, 2012, p. 882). With respect to the traditional classification approaches like nearest neighbor or naïve bayes, the support vector machine only considers a selection of the closet vectors and has been applied successfully to text classification tasks (cf. Hotho et al., 2005, p. 31; Pang et al., 2002, p. 84). Text clustering is used for document selection tasks, as well as for the visualization of results (cf. Rajman and Vesely, 2004, p. 13). If the content of the documents within one cluster is more similar and contents between the clusters are more unsimilar, the search effectiveness is improved and in general the quality of clustering is considered better (cf. Feldman and Sanger, 2007, p. 82). In text mining, *association rules* identify direct relationships between concepts or sets of concepts and investigate dependencies between terms (cf. Fan et al., 2006, p.79). Trend analysis is a type of association analysis, which finds the time-dependent changes for an object or event in documents collected over a period of time (cf. Miner, 2012, p. 86). There are some methods that have specialized in the analysis of texts itself. *Information extraction* analyzes large amounts of natural language in order to identify and extract specific information (e. g. company names, dates or prices) from single words, phrases or passages (cf. Hotho et al., 2005, p. 39). *Text summarization* reduces the content based on selection and generalization of what is important in the document by statistically weighting all the sentences (cf. Rajman and Vesely, 2004, p.

[27] For more detailed information on the methods of the document processing phase see Rajman and Vesely (2004, pp. 8-12); Hotho et al. (2005, pp. 24-28) or Miner (2012, pp. 46-51).
[28] An overview of common methods of text mining is shown in Hotho et al. (2005, pp. 28-45) and Feldman and Sanger (2007, pp. 64-129).

18 f.). *Information visualization* or *visual text mining* presents large document collections respectively their keywords in visual hierarchies, graphs or maps and enables navigating through the documents, in addition to simplify searching (cf. Choudhary et al., 2009, p. 731). The analysis of expressed opinions in texts is called *opinion mining* and offers a very high potential in the context of text mining (cf. Schieber and Hilbert, 2014, p. 22). In this paper, this method of text mining is applied in the data mining analysis about electric carsharing usage and is described in the next section.

3.3 Analysis Method Opinion Mining

Two basic types of information can be contained in texts, facts and opinions (cf. Kaiser, 2009, p. 91). Facts are objective statements about entities or abstract concepts whereas opinions are subjective statements that reflect people's sentiments, attitudes or perceptions about the entities or abstract concepts and their attributes (cf. Liu, 2008, p. 1). While the methods of the classical text mining focus on the analysis of general facts, opinion mining deals with the identification and the analysis of expressed opinions in text documents (cf. Tsytsarau and Palpanas, 2011, p. 482). Opinion mining is a specialized form of text mining and is integrated in the fourth step of the text mining process. The classic mining process persists, but the objective of the analysis changes (cf. Kaiser, 2009, p. 91). The terms *opinion mining* and *sentiment analysis* can be used interchangeably, because both denote the same research field (cf. Pang and Lee, 2008, pp. 8-10). Liu (2008, p. 1) defines opinion mining in the following way: "*Given a set of evaluative text documents D that contain opinions (or sentiments) about an object, opinion mining aims to extract attributes and components of the object that have been commented on in each document d* $\in$ *D and to determine whether the comments are positive, negative or neutral.*" The *object* is an entity which can be anything, like a product (e. g. the Mitsubishi i-MiEV), a service (e. g. electric carsharing), a topic, an event, a person, or an organization (e. g. car2go) (cf. Liu and Zhang, 2012, p. 417). Opinion mining is a part of the text mining field and received an extensive research interest in recent time (cf. Schmunk et al., 2013, p. 255). Finding out "what other people think" has always been an interesting and important piece of information for organizations during the decision-making process (cf. Pang and Lee, 2008, p. 1). Conducting extensive and costly surveys, polls or focus groups in order to identify opinions of the general public about products and services may no longer be necessary for organizations (cf. Liu, 2011, p. 459). The ever-growing Web 2.0[29] provides a rich source of information for organizations and enables a new kind of market research (cf. Kaiser, 2009, p. 90). The special feature of the Web 2.0 is that it is based on content created by the internet user itself (e. g. reviews of products at merchant sites) which is called the *user generated content* and includes information about the attitudes and opinions of the user (cf.

[29] The buzzword Web 2.0 refers to the transformation of the Internet from a static to an interactive medium where customers increasingly operate in social networks, blogs or web forums (cf. Kaiser, 2009, p. 90).

Strohmaier and Zens, 2014, p. 73). These opinions have huge impact on other people and thus influence their buying behaviors (cf. Liu, 2011, p. 459). According to a recent global survey, forty-four percent of the respondents gather information about new products through active internet searching and over a quarter (twenty-six percent) read social media postings, achieving the largest increase of any source for new product information (cf. The Nielsen Company, 2015, p. 29). A lot of consumers consult reviews before they make a major purchase (cf. Miner, 2012, p. 22). Therefore, it is important for organizations to know the different opinions of the customers to their products and services, because due to this it is possible to recognize chances and risks and to implement appropriate actions (cf. Kaiser and Bodendorf, 2009, p. 128). The feedback of customers is a very valuable information source on customer satisfaction (cf. Miner, 2012, p.55). To discover various pertinent sources, extract relevant sentences with opinions, read and organize them into usable forms is a challenging task for potential customers as well as for organizations (cf. Hu and Liu, 2004a, p. 168). Opinion mining is becoming an increasingly popular subject of research in the area of data mining because of the importance of automatically extracting useful knowledge from customer opinions in unstructured data (cf. Lee et al., 2008, p. 230).

Opinion mining can be divided in three areas with different approaches:

- *Sentiment classification: Document-level sentiment classification* classifies a whole document as expressing a positive or negative opinion or sentiment about an object (cf. Li and Liu, 2012, p. 128). This task determines the overall opinion of an opinion holder about an object. In case of reviews, blogs or social media postings, an *opinion holder* is usually the author of the text that holds the opinion who can be a person or an organization (cf. Liu, 2008, p. 2). For example, Pang et al. (2002) determined whether a movie review is positive or negative and Dave et al. (2003) used reviews of consumer electronics products. Each sentence is examined in the *sentence-level sentiment classification* as in Wiebe and Riloff (2005).
- *Aspect-based opinion mining:* In many cases a classification on document-level or sentence-level is not detailed enough, because documents as well as sentences can contain both positive and negative opinions about objects and/or their aspects (cf. Liu, 2011, p. 481). An object has a set of *aspects* which can be product features, components or attributes (cf. Liu and Zhang, 2012, p. 417). The more complete point of view is the *aspect-based opinion mining* which was first established under the term *feature-based opinion mining*[30] (cf. Reinel and Scheidt, 2015, p. 131). The goal is to discover opinions on objects and on each of their aspects (cf. Lee et al., 2008, p. 230). Popescu and Etzioni (2005) and Hu and Liu (2004a; 2004b) determine the reviews of aspects of cameras and scanners.

[30] Liu changed the term from feature to aspect, because indeed feature is a proper term for the product domain, however the term is inappropriate and confusing for objects such as events and topics (cf. Liu, 2011, p. 462).

- *Mining comparative opinions:* It aims to find sentences in which similar objects are compared with each other and to determine the preferred object (cf. Kaiser, 2009, p. 91). Most *comparative sentences* contain comparative or superlative adjectives or adverbs which can be used for the identification (cf. Liu, 2008, p. 5). Mining opinions from comparative sentences is presented in Ganapathibhotla and Liu (2008) and Jindal and Liu (2006).

In this paper, the aspect-based opinion mining approach is used to identify the orientation of the opinion of electric carsharing users about the object electric carsharing as well as about its aspects.

In this approach an opinion is defined as a quintuple (s. table 3).

$(o_i, a_{ij}, oo_{ijkl}, h_k, t_l)$	
o_i	name of an object
a_{ij}	aspect of an object o_i
oo_{ijkl}	orientation of the opinion about aspect a_{ij} of object o_i
h_k	opinion holder
t_l	the time when the opinion is expressed by the opinion holder h_k

Table 3: Definition of an opinion as a quintuple
Source: Own depiction with reference to Liu (2010, p. 632; 2011, p. 463)

If an opinion is on the object (or entity) itself as a whole, the special aspect GENERAL is used (cf. Liu, 2011, p.463). Opinion orientations can be characterized regarding the polarity (positive versus negative) or the intensity which is much more difficult (cf. Dave et al., 2003, p. 520). This paper only determines the polarity of the opinions about electric carsharing and its aspects.

The opinion mining approaches are part of the fourth step of a mining process and this *modeling* step can be further divided into subtasks (cf. Schmunk et al., 2013, p. 256). To discover all opinion quintuples in a document, the basic procedure of aspect-based opinion mining is represented in the following five steps:

In the first step all objects and related expressions in a document are discovered and grouped (cf. Liu, 2011, p. 465). Analogous to the previous step, this proceeding continues with the aspects and their synonyms. Usually various opinion holders use different words or phrases to express the same object and accordingly to the aspects (cf. Liu, 2008, p. 3). Thirdly, the opinion holder and the time points when the opinion is expressed are identified (cf. Liu, 2011, p. 465). After that, the orientation of the opinion on an object and aspect can be determined (cf. Liu and Zhang, 2012, p. 419). In the last step all the previously determined parts are brought together to generate every possible opinion quintuples (s. table 3) in the document (cf. Liu, 2011, p. 465).

Here, the two most extensive tasks are the identification of the aspects and the classification of the expressed opinions on the aspects. Opinion mining is a quite context-sensitive and a very domain dependent method, because each domain may have its own set of individual words and special phrases to express opinions or aspects (cf. Dey and Haque, 2009, p. 209). Opinion mining is taking place in natural situations of communication and opinion holder use their own forms of expression, so that contents can be captured realistically (cf. Kaiser, 2009, p. 90). But the analysis of user generated content from websites and social media postings is challenging because there is no fixed structure or standardized terms and forms of expression like irony and cynicism makes it even more difficult (cf. Möhring et al., 2014, p. 233). Compared to literary texts or editorially created news, user generated content is often noisy and contains spelling mistakes, grammatical errors, homonyms, abbreviations, symbols, incorrect punctuation and malformed sentences (cf. Reinel and Scheidt, 2015, p. 135; Dey and Haque, 2009, pp. 205-210). Due to the lack of any regulation or quality control of information, a huge amount of data on the web is of low quality, faulty, or even deceptive (cf. Liu, 2011, p. 5). Because of this major bottleneck, opinion mining systems cannot provide completely faultless results and is rather intended to achieve a recall factor which presents useful results for certain applications (cf. Dey and Haque, 2009, pp. 205-208). In addition, large proportions of the research in the area of opinion mining have been done for texts in English language and due to linguistic peculiarities the achieved results cannot simply be transferred to texts in other languages (cf. Reinel and Scheidt, 2015, p. 135).

Web documents are also different from standard text because they comprise explicit structural markup with links between websites and therefore offer various opportunities but also a few challenges (cf. Miner, 2012, p. 37). The web is a massive repository of documents that contains unstructured information (textual page content), semi-structured information (HTML, XML[31]), hyperlink information and usage information (cf. Mitra and Acharya, 2003, p. 15). *Web mining* takes advantage of this additional information and is similar to text mining (cf. Witten et al., 2011, p. 389). It is influenced by results and techniques of data and text mining to automatically extract and evaluate information for knowledge discovery from web documents (cf. Mitra and Acharya, 2003, p. 16). The difference between the web mining process and the otherwise similar data mining process is usually in the data collection in which first of all the data mostly have to be collected with the help of web crawler[32] (cf. Liu, 2011, p. 7).

There are three different types of web mining:

[31] Hyper Text Markup Language (HTML) and Extensible Markup Language (XML) enables a website to be a combination of textual information (page payload), formatting information (like tables or headers), multimedia components (e. g. videos) and hyperlinks to other websites (cf. Miner, 2012, p. 986).

[32] Web crawlers are programs that search for information in the internet by looking for hyperlinks in websites and use these referenced pages as a new starting point to expand the result set (cf. Menczer, 2011, p. 311).

- *Web structure mining* explores connection structures within websites and different websites to each other in particular on the basis of their linking (cf. Miner, 2012, p. 954).
- *Web usage mining* gathers information of the behavior of visitors on websites to evaluate log files and to identify as well as classify behavior pattern of user with support of data mining methods (cf. Petersohn, 2005, p. 14).
- *Web content mining* analyzed the content of websites for example to classify and cluster web documents according to their topics or to retrieve and extract useful information (cf. Liu, 2011, p. 7). This type of web mining is also called web text mining due to its frequent use of methods of text mining (cf. Miner, 2012, p. 954). It also includes techniques of opinion mining to discover opinions from customer reviews on websites or social media postings (cf. Liu, 2011, p. 7).

The analysis of user opinions of electric carsharing can be assigned to web content mining as user generated content on websites is examined.

Based on the presented theoretical knowledge, the practical application of aspect-based opinion mining in context of the analysis of electric carsharing usage takes place in the next chapter.

4. Analysis of Electric Carsharing Usage

The empirical analysis is divided into two parts, the data mining analysis and the survey. The data mining analysis starts with the development of the data mining process model. Accordingly, the practical implementation based on this model is taking place. For this, opinion mining will be applied to the examined object electric carsharing. Subsequently, the evaluation of the obtained results from RapidMiner finishes the first part of the empirical analysis. This is followed by the second part of the analysis which contains the design of the survey, its implementation and finally the analysis of the survey according to qualitative content analysis.

4.1 Data Mining Analysis

4.1.1 Development of the Data Mining Process Model

As explained in the third chapter, opinion mining is a special method of text mining and it is just one part in the whole text mining process. Text mining is a specific field of data mining that concerns unstructured text data. A direct implementation of mining methods can induce meaningless and incorrect results (cf. Fayyad et al., 1996a, p. 39). The purpose of a process model is to avoid this. The text mining process has a similar composition as the data mining process. Due to the different data structure, there are differences in the data collection, special modeling methods like opinion mining and in particular the data preparation is more extensive. As already mentioned opinion mining and text mining are relatively new research fields. There is no standardized analytical technique or commonly accepted process model in text mining, while several well-known and relatively mature process models exist in data mining such as the KDD, SEMMA and the CRISP-DM (s. section 3.1). Thus, the already introduced CRISP-DM (s. figure 4) will be applied in this paper, because the primary distinction between data mining, text mining and opinion mining is merely the type of data. Some advantages of the model especially over the KDD and SEMMA have already been described in chapter 3.1. Sharma and Osei-Bryson (2009, p. 4115) indicate that the CRISP-DM is more detailed than any other data mining process model and it offers an advanced guidance for the various tasks of a data mining project. Additionally, the CRISP-DM is one of the most popular data mining process models (cf. Nadali et al., 2011, p. 161).

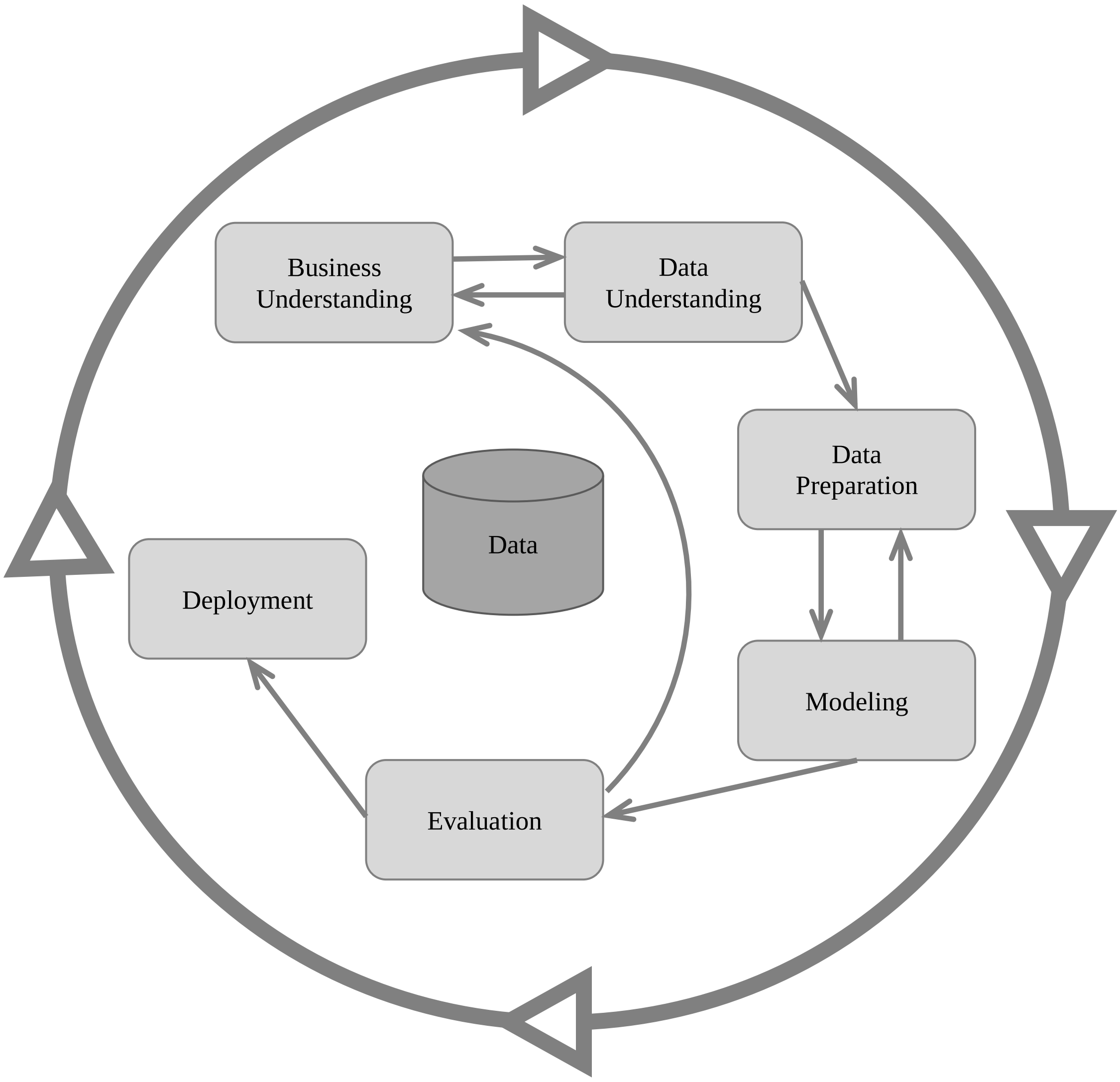

Figure 4: Six phases of the CRISP-DM model
Source: Own depiction with reference to Chapman et al. (2000, p. 10).

According to repeated polls conducted by KDnuggets, which is the leading internet resource on data mining, it is the most frequently used methodology in organizations for data mining projects (cf. Kurgan and Musilek, 2006, p. 15). The current poll from 2014, which include two hundred respondents, reports that the majority of the respondents used the CRISP-DM in their data mining projects[33] (cf. KDnuggets™, 2014a, p. 1). Also for those reasons the CRISP-DM will be adopted as a foundation, but it will be slightly modified especially in the second, third and fourth phase of the process model, because of the special cases of opinion and text mining. The six phases are depicted in figure four. The outer circle represents the life cycle of data mining projects and the arrows point out the most frequent and significant dependencies between the phases (cf. Chapman et al., 2000, p. 10). The sequence of the phases does not need to be followed rigidly, because going forth and back between the individual steps is usually required, depending on the quality of results of the already executed phase (cf. Sharafi, 2013, p. 65). In the following the six phases of the process model are described conceptually in the context of opinion mining.

1. Business Understanding

This starting phase of the CRISP-DM marks the beginning of a data mining project and focuses on building an understanding of the area of concern from a business perspective (cf. McCue, 2007, p. 50). This knowledge is converted into the objectives of the data mining project (cf. Azevedo and Santos, 2008, p. 183). In the context of opinion mining the object to be examined is determined and background information of this object is described (cf. Hu and Liu, 2004a, p. 170). This first phase also encompasses a preliminary project plan to achieve the defined objectives (cf. Sharma and Osei-Bryson, 2008, p. 79). At the end of the phase Business Understanding, the assessment and selection of tools and techniques that are appropriate for the purposes of analysis takes place, which is important in this early phase since the decision may influence the entire project (cf. Chapman et al., 2000, p. 17).

2. Data Understanding

In the second phase the raw data are in the focus. In the context of classic data mining, the necessary data are usually already collected and stored in a data warehouse, while for opinion mining, the data collection is a substantial task that comprises crawling a large number of appropriate websites (cf. Liu, 2011, p. 7). Data Understanding begins with the opinion collection about the object to be analyzed on the internet. To find the required user opinions, first relevant sources of information are identified on the internet such as blogs, online forums, review sites or social networks and the selected websites are examined for expressed opinions about

[33] The poll conducted by KDnuggets in October 2014 asked the question "*What main methodology are you using for your analytics, data mining, or data science projects?"* and specified only eight choices which are distributed as follows: 43 percent *CRISP-DM*, 27.5 percent *my own*, 8.5 percent *SEMMA*, 8 percent *others, not domain-specific*, 7.5 percent *KDD Process*, 3.5 percent *my organizations'*, 2 percent *a domain-specific methodology* and 0 percent *none* (cf. KDnuggets™, 2014a, p. 1).

the object and its aspects (cf. Schmunk et al., 2013, p. 256). Thereafter applicable opinions are extracted and collected. Furthermore, data description and exploration are part of the Data Understanding as well as the assessment of the data quality in order to identify possible problems (cf. Schieber and Hilbert, 2014, p. 31). Consistencies and redundancies between different sources should be verified and it can also be necessary to exclude some data since they contain information that is not needed for the analysis (cf. Chapman et al., 2000, p. 42). If some noisy data are detected in this phase, they will be removed or cleaned (cf. Li and Wu, 2010, p. 357). After completion of the second phase, the data are saved in a review database (cf. Hu and Liu, 2004a, p. 170).

3. Data Preparation

The third step is dedicated to the preparation of the identified data and is one of the most time consuming phase in the whole data mining project. The review database contains textual data, so the original tasks of the CRISP-DM are replaced by special preprocessing methods from the text mining area to convert the unstructured data into a suitable format for mining algorithms. If the textual data are not clean and contain misspelled words, which occur especially in text gathered from the internet, *spelling normalization* is required (cf. Miner, 2012, p. 48). *Fuzzy matching* algorithms can be used to cope with word variants or spelling errors (cf. Hu and Liu, 2004a, p. 171). This technique of text preprocessing clusters together words with similar spellings such as for example “Car2Go”, “Car 2 Go” and “car-2-go” that actually refer to the same carsharing provider car2go. *Letter case normalization* transforms the text to either all lower case or all upper case, whereby words that are identical except for the upper and lower case, are summarized (cf. Rajman and Vesely, 2004, p. 9). In order to enable the analysis of a text, it must be disassembled into its individual parts. *Sentence boundary detection* is the process of dividing entire text documents into single grammatical sentences, based on punctuation marks at the end of sentences as delimiters (i.e. point, exclamation and question mark) (cf. Schmunk et al., 2013, p. 258). In most cases, it is necessary to disassemble text into words. In order to separate text into individual words then called tokens, a *tokenization* process is required which uses all punctuation marks, space characters and other non-text characters as token delimiters (cf. Hotho et al., 2005, p. 24). Texts contain a large number of words that have little significance to the analysis. Extremely common words such as articles, conjunctions, prepositions, etc. are called stopwords. The method *stop word filtering* is applied to remove words that occur very often and is possible without loss of information, because stopwords have little impact on the large majority of text mining tasks (cf. Miner, 2012, p. 47). Due to this reduction of the number of tokens, the content-related quality of analysis is increased and depending on the used mining method, the computing time is decreased considerably (cf. Sharafi, 2013, p. 87). Most lists of stopwords are available for English, but there are also some lists for the German language that can be found on the internet[34]. *Stemming* is another method that reduces the size of the data and normalizes related words into a single form. After the removal of prefixes, suffixes and parts of the pluralizations (e. g. the plural "s" from nouns) every word is represented by its basic word stem (cf. Miner, 2012, p. 47 f.). For example, stemming will ensure that connect, connection, connective and connected will be recognized all as the term connect. A more advanced method of stemming is called *lemmatization* which attempts to arrange words based on their grammatical basic form such as nouns to the singular form or verb forms to the infinite tense (cf. Schieber and Hilbert, 2014, p. 34). But to determine the basic form, additional grammatical information such as the part of speech of every word in the document has to be known. Due to this process, lemmatization is mostly pretty costly in terms of time as well as still fault-prone and therefore stemming is used more often in practice (cf. Hotho et al., 2005, p. 25). Stemming and lemmatization will reduce the number of tokens and increase the frequency of some words, but on the other hand it may also cause a reduction of the interpretability of terms in the context of sentences (cf. Schieber and Hilbert, 2014, p. 34 f.). For example, lemmatization would produce the term connect for the verb connected, but connection and connective maintains in the noun and adjective case. To enhance the available information about tokens, additional linguistic preprocessing may be applied such as *part-of-speech (POS) tagging*. The POS of a token is a linguistic category (e. g. noun, verb, adjective) which is determined by its syntactic or morphological behavior (cf. Liu, 2011, p. 472 f.). The POS tagging is the starting point of syntactical analysis and produces the POS tag for each token (cf. Hippner and Rentzmann, 2006, p. 288). Most POS tags have been developed for the English language like the standard Penn Treebank POS tags (cf. Liu, 2011, p. 472 f.). The Stuttgart-Tübingen-Tagset (STTS) has gradually become a de facto standard for the POS tagging of German texts and has fifty-four tags including eleven major classes (cf. Zinsmeister et al., 2014, pp. 4097-4100). POS tagging is an important preprocessing task of opinion mining which helps to identify the aspect of an object as well as opinion words. Aspects are usually nouns and adjectives are normally used to express opinions (cf. Hu and Liu, 2004a, pp. 169-171). Depending on the application, additional resources in form of dictionaries, word lists or the like are occasionally necessary for further linguistic preprocessing tasks (cf. Hotho et al., 2005, p. 29).

After text preprocessing has been completed, diverse methods of document transformation are applied, because for many text mining algorithms, the texts must be converted into a different data structure. The most common document transformation model represents documents as vectors in an *n*-dimensional vector space, i. e. each document is described by a numerical feature vector (cf. Rajman and Vesely, 2004, p. 10). For this purpose, the literature mostly refers to the *vector space model* according to Salton et al. (1975, pp. 613-620). Generally, the individual tokens (terms) are in the columns of the matrix and the documents are in the rows (cf.

[34] Some examples of German stopwordlists are under: www.ranks.nl/stopwords/german or http://www.phpbar.de/w/Stoppwortliste_deutsch (cf. ranks.nl, n. d.; phpbar.de, 2005).

Hippner and Rentzmann, 2006, p. 289). In order to determine the entries in the cells of the matrix, mostly three different approaches are used and terms are indexed and weighted with regard to the importance and relevance of each term.

- Binary term vectors: The simplest way of document encoding expresses only if a term appears in a document or not, i. e. the cell is set to one if the corresponding token is used in the document and the cell is set to zero if the token is not used (cf. Hotho et al., 2005, p. 26).
- Calculation of frequency: Term frequency is the number of times a given term is presented in a relevant document and document frequency indicates in how many documents a term occurs (cf. Miner, 2012, p. 50).
- Term weighting scheme: Considered individually the two simple frequency measures cannot describe a document best possible, because frequent as well as very rarely occurring words have almost no or little significance for a document (s. stopwords above). To improve this, the two measures are brought into relationship and form a weighted frequency, where the weights reflect the importance of a term in a specific document of the considered document collection (cf. Schieber and Hilbert, 2014, p. 37). The *TF-IDF* weighting approach is often used in the area of text mining and stands for *term frequency inverse document frequency* (cf. Li and Liu, 2012, p. 133). Thus a weight for a given term in a relevant document is computed by term frequency times inverse document frequency (cf. Hotho et al., 2005, p. 26). High TF-IDF values are assigned to terms which occur frequently in a specific document but rarely in the entire document collection and the more important a word, the higher its TF-IDF value (cf. Sharafi, 2013, p. 92).

Based on the weighting, the number of tokens can be reduced by removing insignificant or irrelevant tokens with statistical calculations what is referred as *attribute selection* or respectively *feature selection* (cf. Schieber and Hilbert, 2014, p. 37).

By using these measures and transforming documents into vectors, unstructured textual data can be converted into structured data. Depending on the mining methods and algorithms of the subsequent Modeling phase, individual preprocessing and transformation tasks are used. Moreover, feedback loop between the third and fourth phase of the CRISP-DM are often necessary, for example when documents must be processed again, because certain requirements of the method were not yet known in the preparation process (cf. Schieber and Hilbert, 2014, p. 46).

Additionally, preparatory analyses may be carried out in the final step of Data Preparation. First subtasks of aspect-based opinion mining are often accomplished in this phase such as identifying and extracting the aspects of an object as well as the opinion words including their orientation (positive or negative).

4. Modeling

After preparing the data, at this phase the mining methods can be used to extract opinions from the documents. As described in chapter 3.3, opinion mining has three different approaches and the aspect-based opinion mining approach is used in this data mining analysis, because sentiment classification on document-level or sentence level is not detailed enough and mining comparative opinions is very complex especially if multiple entities are compared. As mentioned above, the aspect-based opinion mining task includes five subtasks. The main focus is on the three core task: Aspect extraction, opinion orientation identification and finally summarizing aspects and opinion orientations. The first core task aims to identify the aspects of the particular object and related expressions that have been expressed by users (cf. Hu and Liu, 2004a, p. 169). An aspect has an *aspect name* given by the user and it has many *aspect expressions* that indicate the aspect, e. g. “electric car”, “e-car”, “electric automobile” and also “electric vehicle” itself. Generally, there are explicit and implicit aspects, whereby most aspects appear explicitly in documents, e. g., range in “the range is absolutely sufficient” (cf. Popescu and Etzioni, 2007, p. 9 f.). If aspects do not appear in sentences, they are called implicit aspects, e. g., range in “we drive only sixty kilometers, which is sufficient” (cf. Hu and Liu, 2004a, p. 175). Nevertheless, implicit aspects occur much less frequent than explicit ones and semantic understanding as well as more sophisticated techniques are necessary to find such implicit aspect (cf. Hu and Liu, 2004b, p. 757). This data mining analysis focuses on extracting explicit aspects expressions that appear as nouns or proper nouns in the documents.

The core task opinion orientation identification can be divided into three steps. First, the words are discovered that are usually used to convey opinion. These words are called opinion words and they are mostly adjectives and adverbs, but also verbs (e. g. love, dislike) as well as nouns (e. g., problem, pleasure) can imply opinions (cf. Liu and Zhang, 2012, p. 423). Thereafter, the orientation of the opinion words is determined by identifying the polarity as positive or negative (cf. Liu, 2008, p. 5). Thirdly, the opinion orientation of each sentence is declared depending on the orientation of the opinion words within the sentence. Obviously sentence-level sentiment classification is applied to each sentence that includes at least one aspect (cf. Liu, 2011, p. 481).

In the last subtask of aspect-based opinion mining, the results of the above tasks are summarized, which is necessary since both the aspects and opinion orientations are ascertained independently (cf. Hu and Liu, 2004, p. 168). It is assumed that the opinion orientation of a sentence refers to the contained aspect (cf. Liu, 2011, p. 481). Through this, individual cases are assigned incorrectly, in which the opinion orientation of a sentence does not refer to the included aspect, but the number of such cases is so low that the sum of all aspect opinion orientations is distorted only marginally (cf. Kaiser, 2009, p. 94).

The identification of aspects and opinion orientations can be comprehended as a classification task (cf. Kaiser and Bodendorf, 2009, p. 129). The tasks of aspect-based opinion mining can

be implemented generally on the basis of machine learning methods and dictionary-based approaches (cf. Schmunk et al., 2013, p. 255).
In the machine learning method, the algorithm receives an amount of training data to learn a model how aspects, opinion words as well as the opinion orientation of a sentence can be deduced from the words occurring in the sentence (cf. Reinel and Scheidt, 2015, p. 132). For example, Pang et al. (2002) applied this supervised learning method on their sentiment classification of movie reviews and Kaiser (2009) used the machine learning algorithm support vector machine to the problem of aspect-based opinion mining on midsize cars. The performance of machine learning methods depends on the quantity of training data and the variation of the language and thus, the more training data and the less the language variation, the better the performance (cf. Kaiser, 2009, p. 96). Especially machine learning methods are achieved mainly good results only if the texts of the training data and the texts to be examined come from exactly the same data source (cf. Reinel and Scheidt, 2015, p. 136).
For the dictionary-based approach, lexical resources such as wordlists for each class (e. g. positive, negative) are needed and in contrast to machine learning methods, no model is learnt but the class of a word or sentence is directly derived from the wordlist (cf. Schmunk et al., 2013, p. 258). A prerequisite for dictionary-based approaches are lexical resources in the respective language of the text. Lexical resources exist in large numbers for the English language such as SentiWordNet by Baccianella et al. (2012) or the popular WordNet by Miller et al. (1990). But there are also resources for German, for example, GermanPolarityClues by Waltinger (2010) or SentimentWortschatz (shortly StentiWS) by Remus et al. (2010). Instead of those lexical resources, wordlist can be generated manually such as collecting the most frequently occurring words of a class, but this manual approach is very time consuming (cf. Liu, 2011, p. 478). Examples for the application of dictionary-based approaches are Popescu and Etzioni (2007), who used WordNet as well as Reinel and Scheidt (2015) using their own generated wordlist specified on the insurance industry. The major shortcoming of dictionary-based approaches is the inability of finding opinion words with domain and context-specific orientations, e. g., if a smartphone is quiet, it is typically negative, but if a car is quiet, it is positive (cf. Liu, 2011, p. 478).
In this data mining analysis the dictionary-based approaches is applied, because the text to be analyzed will come from several sources, what is disadvantageous for machine learning methods. Schmunk et al. (2013) compared both techniques and discovered that the dictionary-based approach performed best recognizing the opinion words as well as they recommended this approach for the identification of aspects due to its implementation simplicity. Dictionary-based approaches are easier to implement than machine learning methods and in-depth data mining knowledge is not necessary, while at the same time dictionary-based approaches achieve good classification results (cf. Schmunk et al., 2013, pp. 261-264). For extracting the aspects an unsupervised method is used, which partially is due to Hu and Liu (2004a; 2004b). Firstly, the wordlist for each aspect will be generated manually, by collecting the most fre-

quently occurring aspects (and corresponding words) in all sentences. The POS tagging is applied to filter nouns that many people have expressed (cf. Hu and Liu, 2004a, p. 171). In order to recognize opinion words and their orientation, the wordlist StentiWS from Remus et al. (2010) will be used. Additionally, some opinion words with domain and context-specific orientations will be added manually to the wordlist to avoid the mentioned above disadvantages of dictionary-based approaches. For this case, the POS tagging also is applied filtering adjectives. After that, the infrequent aspects are extracted using the extracted opinion words (cf. Hu and Liu. 2004a, p. 171). Only extracting frequent aspects can miss many genuine aspect expressions that are infrequent and in this step it is assumed that opinion words, which describe frequent aspects, can also characterize infrequent aspects and accordingly can be used to identify infrequent aspects (cf. Liu, 2011, p. 487 f.). In the last step of aspect-based opinion mining a final summary is produced.

5. Evaluation

The Evaluation phase includes a critical assessment of the procedure. In this fifth phase and in the following phase, the way of proceeding corresponds again to the process of a classic data mining analysis (cf. Miner, 2012, p. 76 f.). Before proceeding to final Deployment, the results of the data mining analysis need to be assessed. The results obtained in the Modeling phase are to be interpreted and evaluated with regard to the defined requirements and objectives of the Business Understanding phase (cf. Schieber and Hilbert, 2014, p. 41). In addition, the validity of the applied mining methods will be reviewed. In this data mining analysis the three performance measures precision, recall and accuracy are selected. They were often used as measures of classification success (cf. Hotho et al., 2005, p. 29 f.; Hu and Liu, 2004a, p. 175 f.). Precision measures the precision of the obtained results (i. e., if a word really belongs to the target class) and recall is a measure of the completeness of the extracted expressions (i. e., if all words of a target class are extracted) (cf. Reinel and Scheidt, 2015, p. 141). The accuracy is identified by the percentage of correctly classified sentences within the total number of evaluated sentences (cf. Schmunk et al., 2013, p. 259). According to Chapman et al. (2000, p. 27) the previous procedure should be assessed and further steps should be determined in this phase. Furthermore the data mining tool will be evaluated for quality and achievement of the objectives to figure out if it had fulfilled the incurred requirements of the process model.

6. Deployment

If the results and the procedure successfully pass the evaluation process, they can be deployed (cf. Miner, 2012, p. 77). The Deployment phase comprises the final appraisal of the results for problems of business practice. For example, recommendations for action and implications for research and practice can be given in this final phase (cf. Schieber and Hilbert, 2014, p. 43 f.). Finally, the target group oriented preparation and presentation of the obtained knowledge by the opinion mining takes place (cf. Chapman et al., 2000, p. 29).

4.1.2 Business Understanding

Within the scope of this data mining analysis, the method opinion mining is applied to the object electric carsharing. Electric carsharing and the background of this research were already described in the first and the second chapter. In order to gain knowledge about attitudes of users about electric carsharing usage, their opinions from reviews, blogs or comments on the internet can be analyzed by opinion mining. Furthermore, the analysis provides the possibility to receive information about opportunities and risks of electric carsharing, like improvement potentials, customizations or fixes and their implementation supports increasing the market penetration of electric carsharing. To extracted information from user opinions, the approach aspect-based opinion mining is used for the analysis and was explained before in section 3.3. A preliminary project plan was developed in the previous section and is based on the CRISP-DM process model. In contrast to classic data mining, where in this phase is already known, what information is required for the analysis, in opinion mining it is initially necessary to collect all opinions and only afterwards to begin with the interpretation. There is no selection of already known product features and aspects, instead of that, still unknown aspects that describe electric carsharing have to be identified.

To achieve the above mentioned objectives, the selection of an appropriate data mining tool for the analysis is an essential part of this phase. First of all, opinion mining deals with unstructured text data, consequently the selection refer to text mining tools only. There is a variety of software tools[35] for analysis of unstructured data in the market and a distinction can be made between commercial and free products or respectively open source software (cf. Möhring et al., 2014, p. 236). On the one hand open source software often used latest technology and has a large number of algorithms, so that the users of these applications can benefit from the opportunities, but on the other hand open source software can have disadvantages such as lack of stability, scalability and usability as well as insufficient documentation and support (cf. Sharafi, 2013, p. 94). Common commercial text mining tools are the SAS Text Miner and the IBM SPSS Modeler Text Analytics[36]. The SAS Institute (has been mentioned relating to SEMMA in section 3.1) offers the SAS Text Miner as an additional program of the SAS Enterprise Miner (cf. Miner, 2012, p. 98). The software encompasses a wide range of algorithms and tools for text mining to extract knowledge from large amounts of text-based information (cf. SAS Institute Inc., 2013, p. 1 f.). IBM SPSS Modeler Text Analytics provides analysis tools that apply advanced linguistic methods and natural language processing to quickly process a plurality of unstructured text data and extract key concepts (cf. IBM Corporation, 2012, p. 1). IBM SPSS was one of the first, who integrated an text analytics tool in its

[35] An overview of commercial, free and open source text mining software can found at KDnuggets™ (2015).
[36] Examples of the application of SAS Text Miner can be found in Miner (2012, pp. 418-455, 585-603), as well as for IBM SPSS Modeler Text Analytics in Miner (2012, pp. 509-532).

predictive data mining workbench IBM SPSS Modeler (originally named SPSS Clementine) (cf. Miner, 2012, p. 92).

Popular open source software tools are KNIME, Weka and RapidMiner. KNIME (Konstanz Information Miner) is an analytics platform that possesses additional extensions for text mining including also functionality from natural language processing (cf. KDnuggets™, 2015, p. 5). The KNIME Text Processing enables to integrate, process and analyze textual data (cf. Sharafi, 2013, p. 95). Weka (Waikato Environment for Knowledge Analysis) is an open source platform for machine learning, data mining and text mining that includes techniques for the main data mining problems such as classification, clustering or association rule mining (cf. Witten et al., 2011, p. 403 f.). The software is widely available and is used for text mining in research as well as in the practical application (cf. Sharafi, 2013, p. 96). Miner (2012, p. 533-542) exhibits an example for the application of Weka as well as two tutorials for RapidMiner (ibid., p. 375-394; 543-556). RapidMiner, formerly known as YALE (Yet Another Learning Environment), is an open source software tool for data analysis (cf. Sharafi, 2013, p. 95). Besides data mining, the application fields are in the areas of text mining, predictive analytics, machine learning, web mining, time series analysis as well as opinion mining (cf. RapidMiner, 2014, p. 19). RapidMiner offers the possibility of expanding existing functionalities through extensions such as the Text Processing Extension for text mining, the R Extension packages or the Weka Extension that integrates the whole functionality of Weka (cf. Ertek et al., 2014, p. 243). In addition to the open source software version, there are commercial software editions (cf. Möhring et al., 2014, p. 237).

In this paper, the decision was made to use RapidMiner for the following reasons:

- Compared to the expensive licenses of the both commercial software tools mentioned above, RapidMiner is a free of charge, open source product and free available on the internet for download.
- Besides Macintosh, Linux, or Unix systems, all usual Windows versions are supported, because the software is written in the Java programming language (cf. RapidMiner, 2014, p. 20).
- Users do not require any programming experience to perform opinion mining. A graphical user interface (GUI) simplifies familiarization and therefore the software is operable across many departments (cf. Möhring et al., 2014, p. 236).
- According to Sharafi (2013, p. 98) RapidMiner can support the data mining process as a whole very well.
- The software is widely adopted. In 2013 and 2014, RapidMiner was ranked as the most popular data analytics software in the annual software poll of KDnuggets™ (2014b, p. 5)[37]. Gartner Inc. (2015, pp. 1-2), an information technology research and consulting

[37] The poll conducted by KDnuggets in 2014 asked the question "*What Analytics, Big Data, Data mining, Data Science software you used in the past 12 months for a real project?"* and 3,285 data miners took part. RapidMiner got the most votes (1,453), what is a share of 44.2 percent. In comparison We-

company, placed RapidMiner in the leader quadrant of its Magic Quadrant for Advanced Analytics Platforms in 2015 and described it as a platform that "*supports an extensive breadth and depth of functionality*" (Gartner Inc., 2015, p. 6).

RapidMiner contains more than 1,500 operations for various tasks of data analysis and the software tool, along with its extensions, documentations and the community, can be found and download from www.rapidminer.com (cf. RapidMiner, 2014, p. 19 f.). RapidMiner version 6.5 is used in this analysis. To perform opinion mining using this tool, the Text Processing Extension has to be installed, which can be accomplished in RapidMiner by selecting *Help → Marketplace (Updates and Extensions)*.

4.1.3 Data Understanding

Data Understanding begins with the collection of opinions from users about electric carsharing on the internet. Opinions can be found in customer reviews on review sites, blogs, social networks or other forms of communication of the Web 2.0. This data mining analysis relates only to the German-speaking opinions, because in an international comparison only Switzerland has more carsharing users in the ratio of to the total population than Germany and also in absolute terms Germany is on the second place behind the United States (cf. Viehmann, 2013, p. 1). Such statistics are not available for electric carsharing, but in Germany are two cities (Stuttgart and Berlin) with large carsharing fleets including electric vehicles only and electric carsharing has existed since about five years (s. section 2.3).

Before relevant opinions were extracted and put in the review database, a manual search for relevant websites was conducted. At first, various review sites were taken into consideration. Review sites are websites on which users have the opportunity to share their experiences with products, services or organizations (cf. Hass et al., 2008, p. 12).

Since electric carsharing is a service that has been offered by various providers, the search for terms like "electric carsharing" or "carsharing elektro" did generally not lead to an appropriate result. Therefore the search term "carsharing" was entered and reviews were found about several carsharing providers and their offers of both conventional carsharing as well as electric carsharing. Eventually, the reviews had to be examined one by one to extract only those about electric carsharing. In this investigation assisted the current overview of electric carsharing in chapter 2.3. Some entries were generally excluded, such as entries before 2009 or reviews on carsharing providers without electric vehicle in their fleets, for example Quicar, Greenwheels or Citeecar. If a carsharing provider offers electric carsharing, those entries were excluded which were posted before the introduction of the first electric vehicles or dealt with locations without electric vehicles. For example car2go possesses electric carsharing only in Ulm since 2011 (until 2014) as well as in Stuttgart and Berlin since 2012 and consequently,

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ka is on position six with 17 percent of the votes and KNIME is on position seven with 15 percent (cf. KDnuggets™, 2014b).

reviews about car2go in Hamburg, Munich, Cologne and Dusseldorf as well as entries before 2011 did not need to be considered. Due to these complex requirements, an automatic web crawler could not be used and the reviews had to be crawled manually.

Five general review sites and three review sites that specialize in comparison of carsharing providers were investigated. Firstly twenty-one reviews with customer opinions on electric carsharing were found:

- ciao.de (9), dooyoo.de (3), yelp.com (1), yopi.de (1), testberichte.de (0).
- carsharingchecker.com (3), carsharing-experten.de (2), flexauto.de (2).

But the reviews on dooyoo.de and yopi.de had already been detected on ciao.de (s. appendix B). In order to avoid redundancies, only those four reviews on ciao.de were included in the data mining analysis (s. appendix A: opinion holders 3, 4, 8). An example of the search of applicable reviews on review sites shows the screenshot in appendix C (example 1). Altogether seventeen reviews of five review sites were put in the review database (s. appendix A).

Furthermore, experience reports as well as reviews with opinions of electric carsharing users were discovered on blogs. Blogs are user-generated websites in diary style on which the bloggers (writers) post their entries and visitors are allowed to leave comments (cf. Hass et al., 2008, p. 12). The blog entries had been found in many different ways. For example, to search for blogs with opinions about electric carsharing, the word combination "multicity carsharing blog" was entered in the Google search field. As already mentioned in section 2.3, Multicity is an exclusive electric carsharing provider with 350 electric vehicles in its fleet. The search was restricted to German, in order to got only websites in German language. This search revealed about 17,300 hits (s. appendix C, example 2). Nine blogs could be discovered on this way (s. opinion holders 11, 31, 32, 40, 41, 42, 50, 53, 91). There were also two blogs, which reviews had already been found on ciao.de (s. opinion holders 2, 3; appendix B). The last usable blog entry for the data mining analysis was spotted at result 113 and the search was terminated at the 200th result. Five blogs with appropriate entries about electric carsharing usage were descried on Google with the word combination "car2go Stuttgart blog" (s. opinion holders 43, 44, 46 - 48). In Stuttgart car2go has a carsharing fleet that only consist of electric vehicles of the brand smart ed (s. section 2.3). This combination produced about 33,500 hits (s. appendix C, example 2), the last usable blog were at result 67 and the search was stopped at result 160. Not selected results of both search queries mainly included blogs, in which only news and facts about the respective carsharing provider had been posted, but no opinion about electric carsharing usage. Additionally, some results were repeatedly listed as hits. Altogether twenty-five blog entries were put in the review database (s. appendix A).

By searching for blogs, more user opinions could be gained from other sources such as comments on blogs or on websites. Especially, the corporate blog by DriveNow had some comments with opinions about electric carsharing usage among the blog entries that concerned the introduction of the BMW ActiveE to the fleets in Munich and Berlin in 2013 (s. opinion holders 18 - 26). One example of a usable comment is shown in appendix C (example 3).

As part of a product testing by probierpioniere.de, a platform for people, who want to try new products, the participants were asked to share their experiences with electric carsharing of the provider Multicity in 2013 (cf. probierpioniere.de, 2013, pp. 1-2). Some participants reported about their experiences with Multicity on their blogs or on review sites (i. a. opinion holders 2, 3, 10, 32, 33). Partly these opinions were already discovered and mentioned above. However, some user opinions could be found in comments on the website about the product testing (s. opinion holders 34 – 39). Altogether twenty comments from blogs or websites were put in the review database (s. appendix A).

Through the blog search, the online forum mietwagen-talk.de could be identified, in which opinions about electric carsharing usage are exchanged (s. opinion holders 64 - 70, 74 - 88). An online forum is an online discussion site, where people can hold discussions or conversations about specific topics as well as exchange opinions about all kinds of objects (cf. Kaiser and Bodendorf, 2009, p. 128). No other forum had been found, where users posted messages about usage experiences of carsharing with electric vehicles. Altogether twenty-two postings about electric carsharing usage from online forums were put in the review database (s. appendix A).

Furthermore, user opinions could be discovered in postings on the social networks Facebook and Google+. Also the micro blogging platform Twitter was observed, but no usable tweets were identified. Complete sentences are rarely written on Twitter and the extensive use of irony and sarcasm would complicate an analysis (cf. Reinel and Scheidt, 2015, p. 136).

Four posts were found on Google+ (s. opinion holders 57 - 60). More post were identified, but they overlapped with previously collected data. Users have expressed their opinions about the usage of electric carsharing on Facebook in own posts or in comments at the respective Facebook page of electric carsharing providers. For example, twelve comments could be gathered among the Facebook posts about the introduction of the BMW i3 by DriveNow (s. opinion holders 97 - 100, 102 - 109). Altogether thirty-three postings or comments from social networks were put in the review database (s. appendix A).

Table four shows an overview of the collected data. In total 117 different documents with opinions about electric carsharing usage were put in the review database.

Source	**Review Site**	**Blog**	**Comment**	**Online Forum**	**Social Network**	**Total**
Documents with Opinion	17	25	20	22	33	**117**

Table 4: Overview of the sources of the collected documents with user opinions
Source: Own depiction

After the manual search in a source was successful, the manually crawling of selected posts was carried out. Screenshots were made of the discovered texts with expressed opinions. The individual texts from the sources were first inserted into a Microsoft Word document and saved in a folder. Some spelling mistakes, grammatical errors and other obviously noisy parts could be corrected with the spelling and grammar check. Apparently formal errors such as typing errors were improved to increase the accuracy of the analysis. Neglected upper and lower case was another frequent mistake like in this example:

*„… **e**in wirklich interessantes **a**uto – eines mit dem man gerne fährt. **t**oll ist die **o**ne-**p**edal **b**edienung. **d**as **b**remspedal braucht man kaum noch im täglichen **v**erkehr. **b**eeindruckend ist der ansatzlose **a**nzug…*“ (raw text by opinion holder 114).

In this short paragraph, both substantives and words at the beginning of a sentence were falsely lowercase.

The blog entries and reviews on review sites are most detailed, while the posts on Facebook and the comments are rather short. According to Reinel and Scheidt (2015, p. 145) the entries in online forums and blogs are characterized by a high quality with regard to grammar and orthography, while on the other hand, comments as well as postings in social networks often possess an inferior quality. In addition, many reviews as well as blog entries are long and only a few sentences contain opinions on the objects or respectively its aspects (cf. Hu and Liu, 2004a, p. 168). Generally, the text was not copied completely, because there were many sentences and paragraphs that did not contain expressed opinion, but had editorial elements and pure facts such as information about the carsharing provider. For example, the following sentences were excluded of the analysis:

„Gefahren wird nur mit Elektroautos und zwar mit dem Citroen C-Zero. Einem Vier-Sitzer, meist in weiß, manchmal in silbern.“ (*It is driven with electric cars only, namely with the Citroen C-Zero. A four-seater, mostly in white, sometimes in silver*) (Excluded of opinion holder 3).

„Wer sich bei Multicity anmelden möchte, der kann dieses im Internet erledigen. Auf der Website findet ihr eine Schaltfläche für die Registrierung.“ (*If you want to register for Multicity, you can do this on the internet. You will find a button for registration on the website.*) (Excluded of opinion holder 53).

No applicable opinion can be found in these texts and so they are not necessary in this data mining analysis.

In addition to the 117 text documents with the expressed opinions about electric carsharing usage, other information was collected. The source of each document as well as the exact URL of the source can be found in appendix A. If opinions from a large number of people are analyzed, knowing each opinion holder is not necessary (cf. Liu, 2011, p. 464). In this analysis the opinion holder are just distinguished by numbers (s. appendix A). One part of an opinions’ quintuple is the time when the opinion is expressed by the opinion holder (s. section 3.3). In almost all posts a timestamp was specified, except the two reviews of the review site carsharing-experten.de did not have any time specification (s. opinion holders 15, 16, appendix A). Additionally, the name of the electric carsharing provider, the brand of the electric vehicle and the city were collected (s. appendix A). The electric carsharing provider is always known. Two opinion holders did not specify the brand of the used electric vehicle and they wrote both about electric carsharing by the provider E-WALD (s. opinion holders 112, 113). There are five documents without a specific city (s. opinion holders 29, 69, 112, 113, 114).

4.1.4 Data Preparation

Before the actual analysis, some preprocessing steps are required. Spelling normalization was accomplished already in the previous phase (s. section 4.1.3). As already mentioned in chapter 4.1.1, a dictionary-based approach will be applied in the Modeling phase, because on the one hand the text documents to be analyzed come from several sources with much language variation and on the other hand machine learning methods need a large quantity of training data, but there are only 117 documents. For the dictionary-based approach of aspect-based opinion mining, the data have to be preprocessed for three tasks: aspect extraction, opinion orientation identification and finally the combination of both previous tasks.
Since wordlists for aspects of electric carsharing do not exist, this wordlists needed to be generated manually. Therefore, first of all frequent nouns and proper nouns were identified by POS tagging. In order to work with the RapidMiner, firstly the 117 documents were loaded into the software tool using the "*Process Documents from Files*" operator. Before that, the Microsoft Word documents were converted to plain text files (".txt" extension) to get no trouble with the encoding (especially with the vowel mutations). This selected operator reads data from a collection of text files and prepares the textual data using text preprocessing algorithms for the application of classic data mining methods (cf. Ertek et al., 2014, p. 244). A very important parameter of the operator is "*vector creation*", where TF-IDF, Term Frequency, Term Occurrence and Binary Term Occurrence can be selected (cf. Miner, 2012, p. 388 f.). Here, the most commonly used numerical representation, the TF-IDF, was picked (s. section 4.1.1). The "*Process Documents from Files*" operator is a nested operator, which means it has a sub-process consisting of other operators. RapidMiner has large amount of text preprocessing operators available. Five of them were used in this sub-process for extracting frequent aspects through POS tagging (s. figure 5).

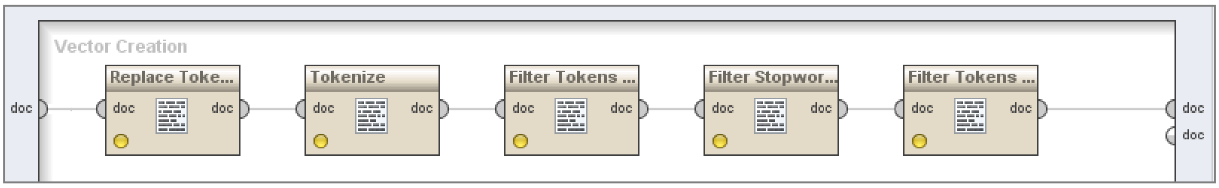

Figure 5: Sub-process of "*Process Documents from Files*" operator
Source: Screenshot of RapidMiner Version 6.5, sub-process of "*Process Documents from Files*" operator including the operators "*Replace Tokens*", "*Tokenize*", "*Filter Tokens (by Length)*", "*Filter Stopwords (German)*" and "*Filter Tokens (by POS Tags)*".

First the "*Replace Tokens*" operator was used to replace all occurrences of particular regular aspect expression within each token by its specified substitute. The replace dictionary is shown in figure six. These specific expressions were chosen in view of subsequent operators, which among others, remove numerals and short words. The second operator called "*Tokenize*" was applied with its mode "*non letters*" that generates tokens consisting of one single word. It is the default setting and according to the RapidMiner Help View the most appropriate option before creating word vectors.

Next, the "*Filter Tokens (by Length)*" operator filtered out tokens that are less than three characters long. The "*Filter Stopwords (German)*" operator removed common stopwords of the German language from the document collection (s. section 4.1.1). This operator has a built-in stopwordlist and it only works properly when every token represent a single German word (cf. Miner, 2012, p. 389). This was complied already with the "*Tokenize*" operator beforehand. Finally, the operator "*Filter Tokens (by POS Tags)*" was applied to filter tokens based on their POS tags. According to the RapidMiner Help View, the POS tags for German language are in the STTS system. To extract frequent aspects, nouns (NN) and proper nouns (NE) were filtered out with the expression "NN.*|NE.*"[38]. The text preprocessing tasks letter case normalization and stemming (s. section 4.1.1) were not applied in this case, because they would had distort the POS tagging.

replace what	replace by
i3	BMWi3
car2go	cartwogo
Car2Go	cartwogo
Car2go	cartwogo
iOn	PeugotiOn

Figure 6: Replace dictionary of the "*Replace Tokens*" operator
Source: Screenshot of RapidMiner Version 6.5, operator "*Replace Tokens*".

In order to get a wordlist, the output port *wordlist* ("*wor*") of the "*Process Documents from Files*" operator needed to be connected to the result port of the entire process and the blue play button was clicked to run the process. After about 4:30 minutes, the process run was completed and the wordlist was represented in the result perspective. The wordlist contained 2419 entries which are the filtered nouns and proper nouns from the 117 documents. Each row corresponded to a filtered token, the third column comprised the total occurrences of a token and the fourth column included the document occurrences of a token. The tokens were sorted by total occurrences in descending order and the table was copied into a Microsoft Ex-

[38] All POS tags of the STTS tag table are shown at Universität Stuttgart (2014).

cel file. The POS tagging was not one hundred percent accurate, because the list included about fifty wrongly tagged nouns and proper nouns, e. g., "*dünn*" (*thin*) (ADJ), "*parkte*" (*parked*) (VVFIN) or "*öffnete*" (*opened*) (VVFIN). The most frequently mentioned aspects had been filtered out manually from the wordlist. The most occurred noun was "*Auto*" (*car*) with 268 total occurrences, followed by "*Carsharing*" (*carsharing*) with 89 total occurrences. The object electric carsharing appeared once only in this list with the expression "*Elektrocarsharing*" (*electric carsharing*)[39]. It was already noticed in the Data Understanding Phase that most of the texts contained opinions about the used brand of an electric vehicle or the electric carsharing provider itself and not about electric carsharing in general. Therefore, it was difficult to identify universal aspects of electric carsharing, which referred not only to a specific electric vehicle or one of the electric carsharing providers. For this reason, the aspects *electric vehicle components* and *carsharing components* were established which comprised aspects that were strongly dependent on a specific electric vehicle or respectively an electric carsharing provider.[40] Since the opinion holders expressed the aspects by many different words, the expressions were grouped under an appropriate general term. Table five contains a summary of the eight general terms. Besides the frequent aspects, the total occurrences and number of expressions already contain the numbers of infrequent aspects. The infrequent aspects are identified after the opinion words are extracted (s. below). The top three frequent aspect expressions of the general term *electric vehicle* were "*Auto*" (*car*), "*Autos*" (*cars*) and "*Fahrzeug*" (*vehicles*). This was followed by some mentions of brands of electric vehicles. Eighty tokens were summarized to *carsharing components* such as "*App*" (*mobile application*), "*Karte*" (*card*) or "*Geschäftsgebiet*" (*business area*). Under *electric vehicle components*, for example, the frequent tokens "*Navi*" (*navigation system*), "*Motor*" (*engine*) or "*Schlüssel*" (*key*) were grouped. The most mentioned terms of *electric carsharing provider* in the wordlist were "*Multicity*", "*Flinkster*" and "*DriveNow*". Later, the expressions "*cambio*", "*multicity*" as well as "*cartwogo*" were added. The POS tagger did not regard these tokens as proper nouns, because they were written in lower case. The general term *Driving* contained frequent nouns like "*Fahrt*" (*drive*), "*Fahren*" (*driving*) or "*Beschleunigung*" (*acceleration*). For example, the expressions "*Ladestation*" (*charging station*), "*Ladesäule*" (*charging pole*) or "*Ladekabel*" (*charging cable*) were arranged under *charging*. The aspect *costs* comprised thirty-seven expressions such as "*Kosten*" (*costs*), "*Euro*" (*euro*) or "*Preis*" (*price*). Lastly, *range* covered frequent aspect expressions like "*Reichweite*" (*range*), "*Akku*" (*accumulator*) or "*Batterie*" (*battery*).

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[39] A manual search run produced two further expressions that could not be find automatically due to the tokenization process, "*elektronisches Carsharing*" (electronic carsharing) and "*e-CarSharing*" (*e-carsharing*).

[40] One example is the aspect expression "*Rückspiegel*" (rear-view mirror) of the aspect electric vehicle components, which was mostly mentioned due to a problem with the rear-view mirrors of the Citroën C-Zeros from Multicity Carsharing (s. opinion holders 1 – 3, 40, 50).

Aspects of electric carsharing	Total Occurrences	Number of Expressions
Electric Vehicle	947	70
Carsharing Components	454	80
Electric Vehicle Components	381	71
Electric Carsharing Provider	316	21
Driving	304	55
Charging	272	45
Costs	129	37
Range	123	26

Table 5: Overview of the aspects of electric carsharing
Source: Own depiction, s. footnote 40

After generating the wordlists of frequent aspects of electric carsharing, the opinion words as well as their orientation were identified using the current version of SentiWS (v1.8c). Besides adjectives and adverbs, the wordlist also contains nouns and verbs (cf. Remus et al., 2010, p. 1168). The current version comprises 1,650 positive and 1,818 negative words and including their inflections, there are 15,649 positive and 15,632 negative word forms (cf. Universität Leipzig, 2011, p. 1). Unfortunately, there are sixty-eight duplicates in both wordlists[41]. In order to dissolve these overlaps, the double words had been deleted from the positive wordlist, because they are rather expressions of negative sentiment in the case of analyzed object electric carsharing, e. g., "*Reparatur*" (*repair*). Thus, the positive wordlist contained 15,581 positive words. To add domain as well as context-specific opinion words, which did not appear in both SentiWS lists, POS tagging is applied again, but this time with the expression "ADJA.*|ADJD.*" for adjectives (ADJA for attributive and ADJD for predicative or adverbial adjectives). After about 5:50 minutes, the process run was completed and the wordlist contained 653 entries. The result table was copied into a Microsoft Excel file, the tokens were sorted by total occurrences in descending order and tokens that were already mentioned in the SentiWS lists were marked. Again, the POS tagging was no perfect, because words like "*Unannehmlichkeiten*" (*inconveniences*) (NN) and "*Jülich*" (*name of a German town*) (NE) appeared in the wordlist. 175 adjectives were already in the positive wordlist and 85 in the negative one. With this method, a total of 62 positive and 25 negative adjectives could be added to the wordlists, e. g., "*lautlos*" (*soundless*), "*umweltfreundlich*" (*environmentally friendly*), "*kundenfreundlich*" (*customer-friendly*) or "*sportlich*" (*sporty*) as well as "*gewöhnungsbedürftig*" (*getting used to*), "*stressig*" (*stressful*), "*wacklig*" (*shaky*) or "*verwirrend*" (*confusing*). Additionally, a few uppercase adjectives were found, which were also included to the respective wordlist, e. g. "*Großartig*" (*great*) or "*Lästig*" (*annoying*). Since opinion words also could be nouns, the previously created wordlist by POS tagging of the nouns was examined for appropriate opinion words. Due to compound nouns that are used very frequently in the

[41] The duplicates were marked with an "x" in the Microsoft Excel file (s. previous footnote).

German language, it is possible to express in a word both an aspect and an opinion on this aspect (cf. Reinel and Scheidt, 2015, p. 135). For example, the nouns “*Spaßfaktor*” (*fun factor*), “*Fahrspaß*” (*driving pleasure*), “*Vergnügen*” (*pleasure*) or respectively “*Kontra*” (*cons*), “*Schwachpunkt*” (*weak point*), “*Macken*” (*defect*) were attached. 37 positive words and 19 negative words from the wordlist of the nouns were integrated to the opinion wordlists. In this task, the first infrequent aspect expressions could already been collected for the wordlist of aspects. In the further course of the data mining analysis, another 15 positive and 10 negative opinion words were noticed and added to the respective wordlist. The final wordlist of positive opinion words contains 15,695 word forms and the negative one comprises 15,586 word forms. Lastly, both lists of opinion words were copied to plain text files and thus they were ready for the next phase.
According to the assumption, that the opinion orientation of a sentence refers to the contained aspect (s. section 4.1.1), the entire text documents needed to be divided into sentences. Again, the 117 text files were loaded into RapidMiner using the “*Process Documents from Files*” operator. For this task, only two operators were used in the sub-process. The “*Tokenize*” operator was applied with its mode “*linguistic sentences*” and German language was selected. With this mode, the operator splits complete sentences based on punctuation marks at the end of sentences as delimiters. Other punctuation marks such as commas were not used as a delimiter, because it would cause the risk to separate expressed aspects and the information about their opinion orientation (cf. Schmunk et al., 2013, p. 258). The second operator was “*Filter Tokens (by Length)*” to remove tokens that are less than five characters long. The resulted wordlist contained 2081 entries. The sentence “*Das ist wohl doch zu riskant.*“ (*This is probably too risky.*) occurred in two text documents (s. opinion holders 6 and 7). All entries were copied into a Microsoft Excel file. Subordinate clauses that are nested within one another are often used in German language and this complicates the automatic analysis of German texts compared to English (cf. Reinel and Scheidt, 2015, p. 135). Therefore, some long sentences with many subordinate clauses were divided manually. In a common review format the reviewer describes some brief pros and cons before writing a detailed review (cf. Liu, 2011, p. 486). Here, long sentences with enumerations resulted (s. opinion holders 1 - 9). These sentences were also split carefully. Furthermore, some short sentences without opinion word or aspect were removed, e. g. “*Weiter so.*” (*Keep it up.*) or “*Wo das ist?*” (*Where is that?*). In the end, 2077 sentences were ready for the Modeling phase.
The final wordlist of the aspects of electric carsharing could only be created after the infrequent aspects were added. As already mentioned in chapter 4.1.1, infrequent aspects can be find by using the relationship between opinion words and aspects. In this task, the analysis process of the Modeling phase could already been prepared, since the sentences to be analyzed, the opinion words and the hitherto existing aspects were combined. The main process for the task identifying infrequent aspects is presented in figure seven.

Initially, the Microsoft Excel file, which contained the 2077 sentences, was loaded into RapidMiner using the "*Read Excel*" operator. This operator reads Microsoft Excel files and the "*import configuration wizard"* from the parameters view was used to import the file (cf. RapidMiner, 2015, p. 204). A wizard is a dialog that guides users through the loading process in four simple steps (cf. RapidMiner, 2014, p. 100). In the first step, the Excel file that should be imported was selected. This is followed by specifying the Excel sheet within the selected file. All opinion sentences stored in one sheet and in this task, the next step could be skipped. If the data contain attribute names, they can be annotated in this third step. In the last step of the wizard, the data types (e. g., nominal, numeric, text, etc.) and roles (e. g., attribute, label, etc.) of the variables can be specified (cf. Miner, 2012, p. 550). For the further course, it is important that the data types are set properly and in this case the text variable particularly needed to have the type specified as text. The role was defined as label.

Once the data were loaded, the "*Data to Documents*" operator transformed the data set to a collection of documents by creating a document for each sentence within the Excel file. The documents needed to be preprocessed by the "*Process Documents*" operator. In this task, a word vector should not been generated, thus the checkbox for "*create word vector*" was disabled. In addition, the checkbox "*keep text*" was enabled to keep the original text in a column in the output table. Three operators were used in the sub-process of this nested operator. Again, the "*Replace Tokens*" operator was used with the same replace dictionary as shown in figure six. Second, "*Tokenize*" was applied with its mode "*non letters*" and lastly, tokens that were less than three characters long were filtered out by the "*Filter Tokens (by Length)*" operator. Back on the process view, the operator "*Set Role*" was selected to change the role of the attribute "*text*" to "*regular*" for later algorithms.

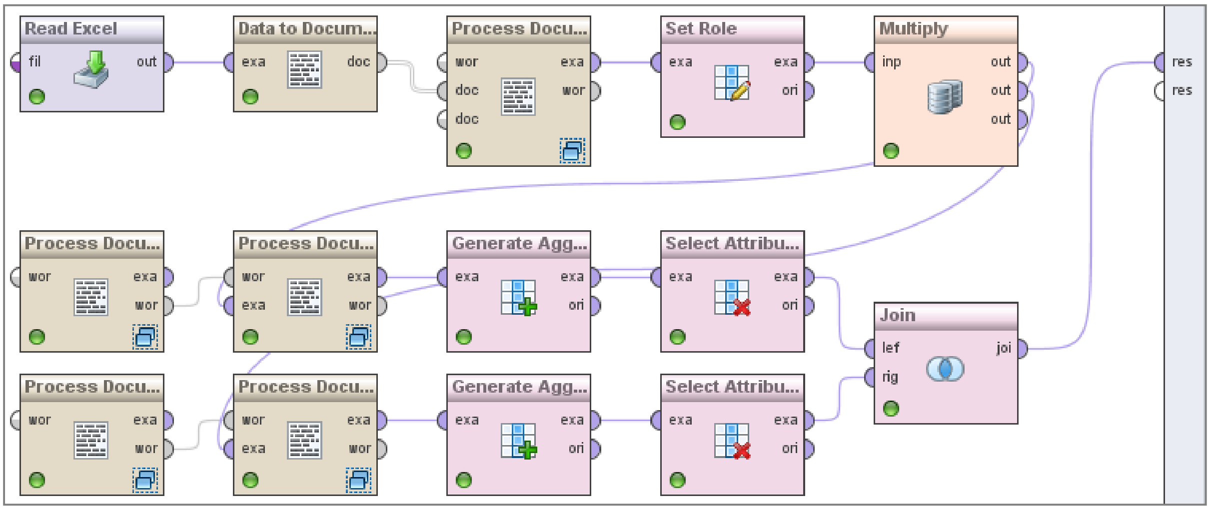

Figure 7: Operators in the main process for the task identifying infrequent aspects
Source: Screenshot of RapidMiner Version 6.5, process view including the operators "*Read Excel*", "*Data to Documents*", "*Process Documents*", "*Set Role*", "*Multiply*", two "*Process Documents from Files*", two "*Process Documents from Data*", two "*Generate Aggregation*", two "*Select Attributes*" and "*Join*".

A wordlist containing all positive and negative opinion words was stored in a plain text file and loaded into the same main process view by the "*Process Documents from Files*" operator. The parameter "*vector creation"* was set to Binary Term Occurrences to create word vectors based on binary term occurrences. In the sub-process only the "*Tokenize*" operator was needed with its mode "*non letters*". The output port *wordlist* of the "*Process Documents from Files*" operator was connected to the input port *wordlist* of the next operator called "*Process Documents from Data*". In this operator the parameter "*vector creation"* was set to Term Occurrences to count how often an opinion word occurs in each of the prepared sentences and in the sub-process the "*Tokenize*" operator was used with its mode "*non letters*". In order to see how many opinion words were mentioned in each of the sentences, the term occurrences were aggregated with the "*Generate Aggregation*" operator. This operator performs a particular aggregation function on every example of the selected attributes to generate a new attribute (cf. RapidMiner, 2015, p. 36). To specify the name of the new attribute, "Opinion words" was entered in the "*attribute name"* parameter. By the "*attribute filter type"* parameter "*all*" was selected and the aggregation function "*sum*" was chosen through the "*aggregation function"* parameter. After that, the "*Select Attributes*" operator was applied to shorten the result table, because there were 31,250 regular attributes in the example set. Multiple attributes can be selected through a list with the option *subset* of the "*attribute filter type*" parameter (cf. ibid., p. 425). The attribute "text" and the new generated attribute "Opinion words" were chosen and thus, all other attributes will be removed. The output port *example set* of the "*Set Role*" operator was connected to the input port *example set* of the "*Process Documents from Data*" operator. This created process can represent how many opinion words appear in each sentence.
In order to represent simultaneously how many aspects appear in each sentence, the four recently added operators had been copied and adjusted. Similarly, a wordlist containing all hitherto extracting aspects was loaded into the process view by the "*Process Documents from Files*" operator and the same settings were used as mentioned above. The "*Process Documents from Data*" operator could be copied without adjustments. Since the connection from the output port *example set* of the "*Set Role*" operator to the input port *example set* of this second "*Process Documents from Data*" operator was necessary, the "*Multiply*" operator was applied to copy the input data of the "*Set Role*" operator into two connected output ports (s. figure 7). In the second "*Generate Aggregation*" operator the new attribute was named "Frequent Aspects" and this new attribute as well as the attribute "text" were selected in the "*Select Attributes*" operator. Finally, the "*Join*" operator joins the two example sets using "text" as the specified key attribute. Once the process run completed the example set was presented in the result view. The result table was copied into a Microsoft Excel file. Manually, infrequent aspects were discovered after filtering out sentences without opinion words as well as sentences that already contained at least one hitherto existing aspects. For example, the words "*Einzugsgebiet*" (*catchment area*), "*Kundensupport*" (*customer support*) or "*Broschüre*" (*brochure*) were added to the general term *carsharing components*. During this investigation

some opinion words could have been identified by filtering out sentences with opinion words and without aspects. Lastly, lists of each general term including frequent and infrequent aspects were copied to plain text files.
In the end of the Data Preparation phase, the Excel file containing the 2077 sentences to be analyzed, one wordlist with positive and one with negative opinion words as well as eight wordlists including the aspect expressions of the respective general term were prepared completely for the Modeling phase.

4.1.5 Modeling

After all the previous steps, the final subtask of aspect-based opinion mining was carried out in the Modeling phase. The main process that summarized the results of the above tasks is depicted in appendix D. This process is a more complex extension of the above described main process of the task identifying infrequent aspects (s. section 4.1.4). The four firstly added operators (i. e., "*Read Excel*", "*Data to Documents*", "*Process Documents*" and "*Set Role*") could be adopted without any adjustments. Thus, the sentences to be analyzed were ready for the process run. Similarly, the "*Multiply*" operator was necessary to copy the input data of the "*Set Role*" operator. Concededly, this operator got ten output ports this time, because ten wordlists had to be considered, two wordlists including the opinion words (i. e., positive and negative) and eight wordlists containing the aspects (i. e., electric vehicle, electric vehicle components, electric carsharing provider, carsharing components, driving, costs, charging and range). Therefore, the following four operators were required ten times: "*Process Documents from Files*", "*Process Documents from Data*", "*Generate Aggregation*" and "*Select Attributes*". Each wordlist were loaded into RapidMiner using its own "*Process Documents from Files*" operator. The settings of this operator could be taken from the last application. Likewise, the "*Process Documents from Data*" operator could be adopted with the same settings. In the "*Generate Aggregation*" operators a total of ten new attributes were generated named "positive", "negative", "electric vehicle", "electric vehicle components", "electric carsharing provider", "carsharing components", "driving", "costs", "charging" and "range". One of the new attributes as well as the attribute "text" were selected in the respective "*Select Attributes*" operator. Additionally, five "*Join*" operators were applied with the specified key attribute "text". The following attributes were joined together: "positive" and "negative", "electric vehicle" and "electric vehicle components", "electric carsharing provider" and "carsharing components", "driving" and "costs", "charging" and "range". After about 25 seconds, the process run was completed and five example sets were represented in the result perspective. The tables were copied into one Excel sheet for further analysis. Based on this Microsoft Excel file the calculations for the analysis of the results were carried out. Each row contained one of the 2077 sentences. In total the sentences contained 1795 positive opinion words and 755 negative opinion words. Initially, 576 sentences were deleted, which did not contain at least one opinion word and 299 sentences were removed, because they did not include at least one aspect expression. Thus, only 1202 sentences remained.

The Analysis became more difficult with sentences, which on the one hand comprised different connoted opinion words or on the other hand included multiple aspects. In the following, some sentences containing opinion words with different orientations are picked randomly to demonstrate that they would lead to distorted results.

"*frei als Entschuldigung der Unannehmlichkeiten, dazu super freundlicher Mitarbeiter am Telefon!"* (*Free as an excuse of the inconvenience, to that super friendly staff member on the phone*) (Sentence No. 2044).

Aspect: *Carsharing components* (*staff member*); Positive opinion word: *free, super, friendly*; Negative opinion word: *inconvenience*.

"*28Cent/Minute klingen erst mal gut, aber leider summieren sich die Cents*." (*28 cents / minute sound good firstly, but unfortunately the cents add up.*) (Sentence No. 29).

Aspect: *Costs* (*cent*); Positive opinion word: *good*; Negative opinion word: *unfortunately*.

In sentence No. 2044 erroneous sentence separation can be recognized by which the first two opinion words cannot assign to the identified aspect. These two sentences are difficult to assess with aspect-based opinion mining, since several opinion orientations are present in one sentence and they have to be assigned to the correct aspect. An incorrect assignment leads to falsified results. A solution approach could be that the orientation of a sentence is deduced by the majority of the contained opinion orientations and if there is no clear majority of either positive or negative opinion words, the orientation neutral could be assigned as it would be the case for sentence No. 29 (cf. Schmunk et al., 2013, p. 258 f.). However, this approach also leads to distortions of results, when several opinion orientations in a sentence encounter multiple aspect expressions as in the following examples.

"*Bis nach Sindelfingen geht es mit knapper Restreichweite, ohne Klimaanlage und mit sehr vernünftigem Beschleunigungsverhalten über die Landstraße weiter*." (*Till Sindelfingen, it continues on the country road with narrow remaining range, without air conditioning and with very reasonable acceleration behavior*.) (Sentence No. 326).

Aspects: *Range* (*remaining range*), *electric vehicle components* (*air conditioning*), *driving* (*acceleration behavior*); Positive opinion word: *reasonable*; Negative opinion word: *narrow*.

"*Preislich überzeugt Multicity mit 28ct/min und der stetigen Erweiterung des Geschäftsgebiet, welches zur zeit noch am kleinsten ist und stetiger Neueinflottung*." (*Multicity convinced in terms of price with 28 ct / min and the steady expansion of the business area, which is currently the smallest and continuous extension of the fleet*.) (Sentence no. 1648).

Aspects: *Electric carsharing provider* (*Multicity*), *carsharing components* (*business area*); Positive opinion word: *convinced, expansion*; Negative opinion word: *smallest*.

These sentences show that in a sentence both positive as well as negative statements regarding multiple aspects can be made and the problem of the flawless allocation of aspects and opinion words arises again. Assignment problems also emerge in enumerations and nested sentences, because an automatic tool cannot correctly capture the content. Therefore, 213 sentences containing different opinion orientation were eliminated. Till now, a total of 1088 sentences were deleted from the original result table which corresponds to approximately fifty-two percent.

Next, the behavior of the sentences with various aspects was examined to see if they also needed to be excluded from the analysis. For this, a comparison is made between the three following approaches (s. appendix E):

- In the first approach all 989 sentences were considered. There were two sentences including five different aspects, thirteen sentences with four different aspects, sixty-nine sentences with three different aspects, 280 sentences with two varying aspects and only one aspect occurred in 625 sentences.
- The second approach included 905 sentences with not more than two different aspects.
- The last approach contained the 625 sentences with only one aspect.

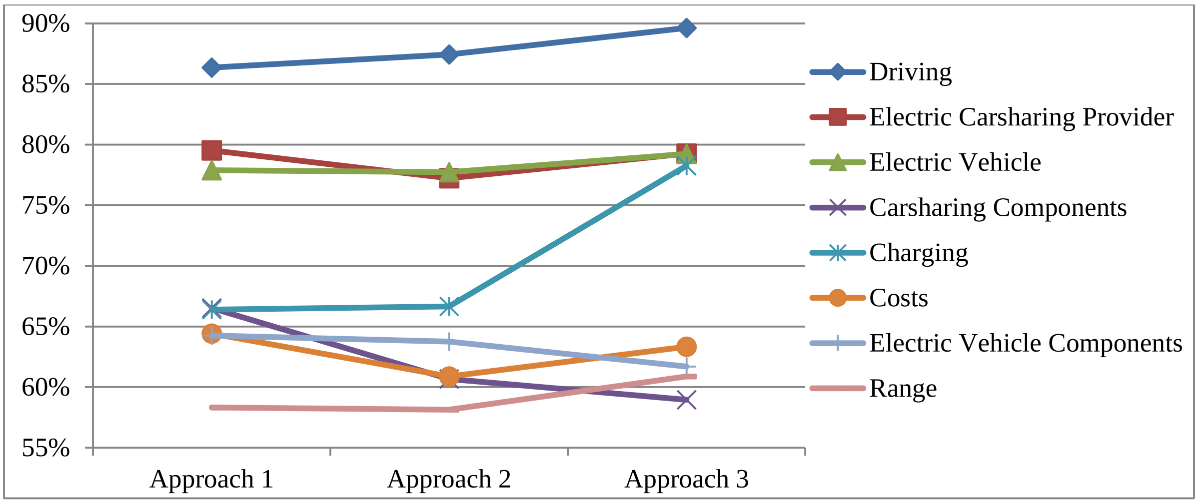

Figure 8: Distribution of aspects with positive opinion orientation in comparison
Source: Own depiction, s. footnote 48

The distribution of aspects changes between the previously introduced three approaches. In the eighth figure the distribution of the aspects with positive opinion orientation is depicted. *Driving*, *electric carsharing provider* and *electric vehicle* were the most positive mentioned aspects within all three approaches. On average 88 percent of the aspect expressions of *driving* had a positive opinion orientation, 79 percent of *electric carsharing provider* and 78 percent of *electric vehicle*. Overall, *range* had been rated the most negative by an average of 59 percent. On average 63 percent of the aspect expressions of *costs* and *electric vehicle components* were mentioned positive. The values of these mentioned aspects only shifted marginal among one to four percent in the individual approaches. But considering the remaining aspects *carsharing components* (an average 62 percent) and *charging* (an average 70 percent), the values shifted stronger about eight and twelve percent between the approaches. If all sentences were considered (approach 1), the two aspects would had been in the midfield of the distribution, but if sentences containing only one aspect were considered (approach 3), carsharing components would had been rated the most negative and charging would had been part of the most positively rated aspects (s. figure 8). In this data mining analysis the second approach is selected, because the third approach would remove about 37 percent of the sentences to be analyzed and gross outliers from the first approach were eliminated. 84 additional sentences were excluded from the analysis. Thus, a total of 1172 sentences were deleted from the original result table which corresponds to approximately fifty-six percent. In the end, 905 sentences including 1017 positive and 318 negative opinion words remained for the analysis. Proportional more negative opinion words (approx. 58 percent) were eliminated than positive opinion words (approx. 43 percent).

Figure 9 shows an overview of the results of the aspect-based opinion mining analysis of user opinions about electric carsharing. The aspects are listed in ascending order of positive opinion orientations. The opinion holders rated the aspect *driving* the most positive. 87 percent of the opinion words assigned to this aspect had a positive orientation. *Electric vehicle* (78 percent) and *electric carsharing provider* (77 percent) were also reviewed as rather positive. With 42 percent *range* had received the most negative reviews. *Carsharing components* and *costs* performed rather worse compared to the other aspects. In comparison *charging* and *electric vehicle components* were in between the more positively or respectively more negatively rated aspects of electric carsharing.

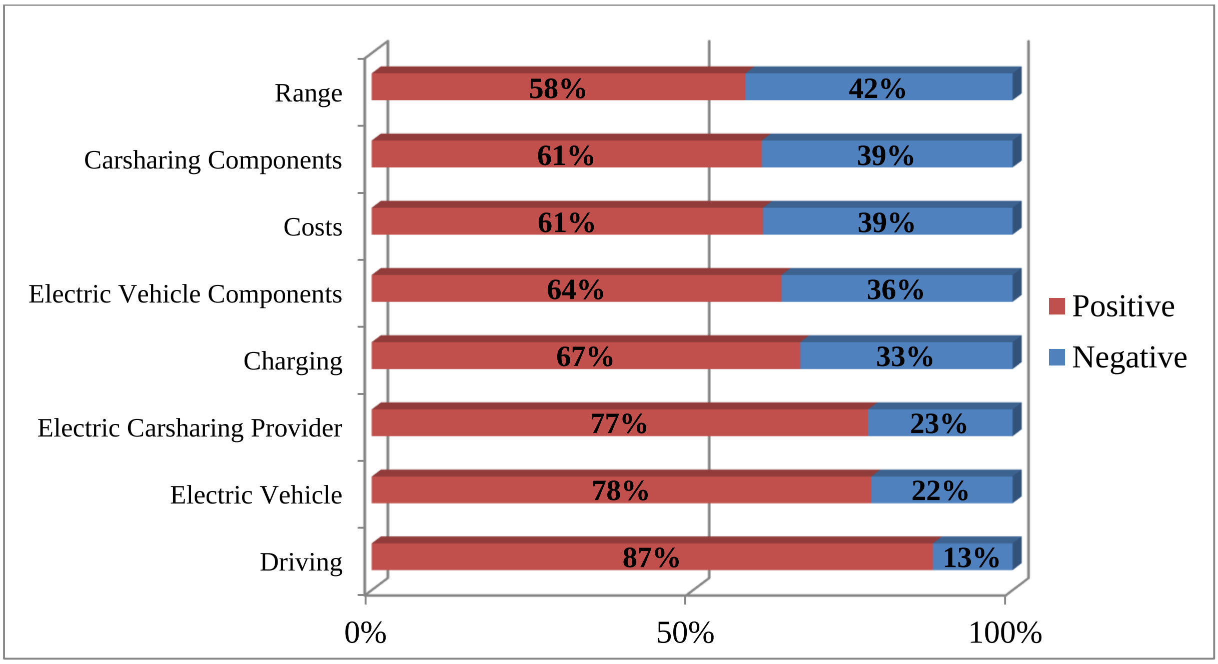

Figure 9: Visualization of aspect-based opinion mining of electric carsharing
Source: Own depiction, s. footnote 48

4.1.6 Interpretation and Evaluation

The further information that was collected in the Data Understanding phase also needs to be considered for the interpretation to understand the background of the data (s. appendix L). 80 percent of the opinion holder wrote about their experience with free-floating electric carsharing. The most reviewed electric carsharing providers were Multicity Carsharing (35 percent), DriveNow (34 percent), car2go (11 percent) and Flinkster (10 percent). These providers have over one hundred electric vehicles available in their carsharing fleets (s. section 2.3). The opinion holder mainly used the Citroën C-Zero (39 percent). The BMW i3 (18 percent), the BMW ActiveE (17 percent) and the smart ed (17 percent) were also frequent used electric carsharing vehicle. These numbers do not correspond to the numbers of the best-selling electric vehicle models in Europe mentioned in chapter 2.1.1, but these brands are in use at the three most frequently mentioned electric carsharing providers. Most electric vehicles were rented in Berlin by 60 percent of all opinion holders. 9 percent of the opinion holders used electric carsharing in Stuttgart as well as 9 percent in Munich and 7 percent in Hamburg. This distribution also fits, because the most electric carsharing providers operate in Berlin. Car2go has an exclusive electric carsharing fleet in Stuttgart and in Munich as well as in Hamburg are business areas with electric vehicles by DriveNow (s. section 2.3). Only 10 percent of the text documents were released in the years 2011 and 2012 and 8 of these 11 opinion holders were users of station-based electric carsharing. These were the years when the carsharing providers slowly began to launch electric vehicles to their fleets as mentioned in chapter 2.3. Most of the collected text documents with opinions about electric carsharing usage were written in 2013 by 46 percent of the opinion holders. In this year the product testing of Multicity Carsharing by probierpioniere.de took place and the BMW ActiveE was introduced by DriveNow (s. section 4.1.3). 18 percent of the opinion holders expressed their opinion about electric carsharing in 2014. 25 percent of the 117 text documents were posted in 2015. In 2015 the BMW i3 was launched by DriveNow and thus 20 of the 29 text documents of this year dealt with electric carsharing with the BMW i3. The postings of seven opinion holders were performed by the same person, who was a member of the online forum mietwagen-talk.de (s. opinion holders 65, 70, 77, 80, 81, 84, 86). But these seven text documents dealt with experiences of different electric vehicles or electric carsharing provider. Likewise opinion holder 49 and 50 are the same person, who wrote about electric carsharing in his blog. Opinion holder 59 and 60 are one person, who posted on Google+ as well as opinion holder 78 and 82 are one member of the online forum. Again all text dealt with different experiences. Other overlaps could not be discovered, but they certainly could be possible, in view of the detected redundancies (s. section 4.1.3). Most of the reviews and postings were created after the opinion holder gained first experiences with electric carsharing. They were written shortly after the introduction of a specific electric vehicle into a carsharing fleet or within the scope of product testing, e. g., "*Ich teste gerade das Multicity Carsharing*" (*I am testing Multicity Carsharing right* *now*) (opinion holder 1) or "*Habe soeben den BMW i3 in Berlin ausprobiert*" (*I just have tried out the BMW i3 in Berlin*) (opinion holder 108). It can be assumed that many opinion holders did not have much experience with electric carsharing, when they wrote their opinions. The opinion holders stated in many texts that they already had experience with conventional carsharing or they were already registered at the carsharing provider, e. g., "…*schon etwas Erfahrung mit Carsharing gehabt*" (*already had some experience with carsharing*) (opinion holder 3).

The results of aspect-based opinion mining show that electric carsharing is mostly approved by the opinion holders. The most positively perceived aspect of electric carsharing is *driving*. The opinion holders were enthusiastic about the driving experience and the driving pleasure, e. g., "*Das ist mal Fahrfreude pur*" (*That is pure driving pleasure*) (opinion holder 109) or "*Fährt sich echt klasse!*" (*Genuinely, great to drive!*) (opinion holder 111). They also expressed approval about the acceleration and the low noise driving, e. g., "*Der tolle Nebeneffekt ist außerdem die ruhige Geräuschkulisse*" (*The quiet soundscape is also the great side effect*) (opinion holder 91) or "*Die Beschleunigung ist dabei ein echtes Highlight und macht richtig Spaß*" (*The acceleration is a real highlight and a real pleasure*) (opinion holder 47). The low noise emission was already explained as one of the advantages of electric vehicles in chapter 2.1.1. Similarly, driving was positively rated due to driving pleasure, low driving noise, driving comfort and acceleration in other studies about electric carsharing (cf. Baum et al., 2012, pp. 78, 104; Dütschke et al., 2012, p. 17). Two other studies showed that their participants had already high expectations about the driving characteristics of electric vehicles before experiencing the vehicle, but the initial expectations were exceeded after more usage experience with the electric vehicle and the participants evaluated the driving characteristics even more preferable (cf. Hoffmann et al., 2012, p. 14; Bühler et al., 2014, p. 40). This indicates that the aspect driving of electric carsharing is rated more positive after experience, which is a huge opportunity for electric carsharing provider.

But there were also some negative statements about *driving*. Some opinion holders stated that driving was unusual and they had to get used to it first, e. g., "*Die ersten Minuten der Fahrt waren sehr ungewohnt*" (*The first minutes of the drive were very unusual*) (opinion holder 5) or "*Was ich noch ein bisschen gewöhnungsbedürftig finde: Starten! Insbesondere weil man nichts hört*" (*What I need to getting used to is: Starting! Especially because you do not hear anything*) (opinion holder 17). These impressions also supports to the assumption that many opinion holders were inexperienced with electric carsharing or respectively electric vehicles. Peters and Dütschke (2010, p. 15 f.) referred that the usage of new innovations is afflicted with uncertainties and it is perceived as unfamiliar compared to the previous option. Some driving characteristics of electric vehicles are different from conventional vehicles and initially users need some time to get used to them.

The second most appreciated aspect of electric carsharing is the *electric vehicle*, e. g., "*Das Auto hat mich bei meinen bisherigen Probefahrten überzeugt!*" (*The car has convinced me* *during my previous test drives!*) (opinion holder 90) or "*Ich finde das Fahrzeug schön*" (*I think the vehicle is beautiful*) (opinion holder 42). There were many opinion holders, who were enthused by the BMW i3, e. g., "*Bin grade zum ersten Mal mit dem i 3 gefahren und begeistert*" (*I drove the i3 for the first time and I am enthusiastic*) (opinion holder 29), "*...finde ich die i3 ziemlich gut*" (*I find the i3 pretty good*) (opinion holder 99) or "*Der i3 ist eine geile Nummer*" (*The i3 is an awesome number*) (opinion holder 102). The DriveNow customers looked forward to the launch of the BMW i3. The vehicle is very popular and when it was introduced, it was discussed extensively on the internet (s. section 4.1.3). Due to its technical fascination and charisma, the BMW i3 increases its attractiveness for the users. In the past DriveNow could already acquire and retain successfully customers with this strategy, those were mostly technically interested men (cf. Canzler and Knie, 2015, p. 24). Thus especially free-floating electric carsharing becomes attractive for the car-affine customer group. Due to low access thresholds like no monthly fees, it offers them the opportunity to try out electric vehicles without bearing associated obligations. As already mentioned in chapter 2.1.3, electric carsharing provides advantages for carsharing providers such as gaining new, technically interested customers with the integration of innovative electric vehicles. The study of Ruhrort et al. (2014, p. 299) found out that the electric vehicles were valued as technological innovations, which was a central motive for using electric carsharing.

Besides the positive opinions about the *electric vehicle*, some opinion holders also made negative statements about this aspect of electric carsharing. Opinion holders complain about the limited availably of the vehicles, e. g., "*Leider sind nicht so viele Autos vorhanden*" (*Unfortunately, there are not so many cars available*) (opinion holder 63). As described in chapter 2.1, electric vehicles are at an early stage of market penetration and likewise electric carsharing is still a niche offer. The diffusion has just started. Due to the rising adaption of electric vehicles into carsharing fleets (s. section 2.3), it can be assumed that the availability of electric vehicles will be higher in the future. Some opinion holders were concerned about the conditions of the vehicles or had general technical difficulties, e. g., "*die Hälfte der Fahrzeuge war schmutzig*" (*half of the vehicles were dirty*) (opinion holder 4) or "*Das Auto wollte nicht aufgehen*" (*The car won't open*) (opinion holder 5). These problems could also occur with conventional carsharing vehicles and are more directed to carsharing service in general. Other opinion holders mentioned the limited space negatively, e. g., "*Weil der iOn recht schmal ist, ist das seitliche Raumgefühl vorn eingeschränkt*" (*Because the iOn is quite narrow, the lateral sense of space is limited in the front*) (opinion holder 80). This barrier was also reported in the study of Bühler et al. (2014, p. 41 f.). As mentioned in chapter 2.2.2, some users used electric carsharing instead of public transport or the bicycle for the purpose of transporting heavy or bulky things. If the electric vehicle is very small like the smart eds, this purpose cannot be served. This obstacle is depending on the selection of vehicles. There are electric carsharing providers like car2go, who only offer small vehicles, but there are also providers like RUHRAUTOe, who offer a whole range of different sized electric vehicles.

Many opinion holders were pleased with the *electric carsharing provider*, e. g., "*Ich finde Multicity Carsharing total klasse*" (*I find Multicity Carsharing really great*) (opinion holder 41) or "*Ich habe car2go in Stuttgart genutzt und bin echt zufrieden*" (*I have used car2go in Stuttgart and I am really satisfied*) (opinion holder 12). It can be assumed that they have experienced electric carsharing positively. When they are satisfied with the provider, likewise they might be satisfied with the whole concept of electric carsharing. This suggests that their acceptance of electric carsharing is high. Some of the opinion holder stated that they still used the services of the provider and others indicated that they had at least the intention to use the provider furthermore, e. g., "*und nutze Multicity inzwischen ausschließlich*" (*and meanwhile I use Multicity only*) (opinion holder 31) or "*Insgesamt habe ich mich gefreut dass ich das Multicity Carsharing System testen kann und werde sicherlich auch weiterhin nutzen*" (*Overall, I am pleased that I can test the Multicity Carsharing system and certainly I will use it furthermore*) (opinion holder 1). It can be supposed that the opinion holders were attracted by the offering and had the intention to use electric carsharing furthermore. They perceived electric carsharing as a relevant option in their mobility behavior and it had become part of their choice of transportation means. Other opinion holders recommend the electric carsharing provider, e. g., "*Ich kann Multicity empfehlen*" (*I can recommend Multicity*) (opinion holder 92) or "*Ich bin weiterhin überzeugt von dem car2go-Konzept und empfehle es jedem weiter*" (*I am still convinced of the car2go concept and recommend it to everyone*) (opinion holder 16). Based on the recommendation increased customer retention can be assumed for this opinion holders (cf. Hoffmann et al., 2012, 22 f.).

Clearly, there were also opinion holder, who mentioned the *electric carsharing provider* negatively, e. g., "*andererseits finde ich, multicity hat noch viele Mängel*" (*on the other hand, I think multicity still has many deficiencies)* (opinion holder 38) or "*Flinkster muss auf meine monatlichen Beiträge verzichten*" (*Flinkster must renounce my monthly frees*) (opinion holder 13). Opinion holders frequently complain about the missing authorization pin of Multicity Carsharing (s. opinion holders 4, 6, 7, 10, 34, 37, 41, 52). They consider the missing pin as uncertain, because only the member card is required to rent one of the vehicles and there is a greater risk of improper use. Like this example, most negative comments rather depend on the provider and did not much refer to electric carsharing.

The aspect *charging* was rated more negative than the three aspects mentioned before, but nevertheless it had 67 percent sentences with positive opinions. Charging was partly perceived as simple, e. g., "*Laden ist sehr einfach*" (*Charging is very simple*) (opinion holder 69). An opinion holder of free-floating electric carsharing was relieved that charging is not obligated (s. opinion holder 3) and another free-floating user was pleased by the incentive system (s. opinion holder 46). The charging infrastructure in Berlin and Stuttgart was appreciated, e. g., "*Gute e-Ladeinfrastruktur in Stuttgart*" (*Good e-charging infrastructure in Stuttgart*) (opinion holder 48) and "*mit Abstand die meisten Ladesäulen und die beste Infrastruktur"* (*by far the most charge spots and the best infrastructure*) (opinion holder 68). As mentioned in chapter 2.3, in Stuttgart and Berlin are exclusive free-floating electric carsharing providers with hundreds of electric vehicles in their fleets. This concept would not work well, if there were a low density of charging station, because unlike to the station-based concept, a free-floating electric vehicle does not have its own charging pole. While the above-mentioned cities have an acceptable charging infrastructure, there are regions and cities with a limited charging infrastructure. This was also reported negatively by some opinion holders, e. g., „*Hier braucht es langfristig gesehen ein bessere Ladeinfrastruktur*“ (*Here it needs a better charging infrastructure in the long run*) (opinion holder 100). As mentioned in chapter 2.1.3, especially free-floating electric carsharing concepts need a sufficient existing charging infrastructure in their business areas. Another opinion holder encumbers oneself about an inoperative charging station (s. opinion holder 68) and some of them had difficulties with the charging cable, e. g., "*mit dem Ladekabel hatte ich etwas Probleme*" (*I had some problems with the charging cable*) (opinion holder 111). Several opinion holders described the problem that the charging stations were occupied by conventional vehicles, e. g., "*Ladestation (...) wird durch ein nicht E-Auto blockiert*" (*Charging station is blocked by a non electric vehicle*) (opinion holder 100). When a charging station was blocked, the users had additional effort to find the next free station. This is an exhausting problem particularly in areas, where only a limited number of charging station is available. Accordingly, one opinion holder stated "*Hier schlug sich die Suche nach einer Ladestation negativ auf die Kostenbilanz nieder*“ (*Here, the search for a charging station impacts negatively on the cost balance*) (opinion holder 46). As already explained above, electric carsharing as well as electric mobility are in the stage of market penetration. Initial problems occur in the area of charging, because on the one hand the technology is not yet mature enough and on the other hand, there is a lack of experience for the users. When the charging infrastructure is more spread and the users got accustomed to the charging process, these challenges suppose to appear much less.

The aspect *electric vehicle components* also positioned in the midfield of the aspects of electric carsharing. Some opinion holders were pleased by the condition and cleanliness, e. g., "*Zustand und die Sauberkeit waren Top*" (*Condition and cleanliness were top*) (opinion holder 115). Some vehicles impressed by their space such as the BMW i3 or the Renault Zoe, e. g., "*für Carsharing geräumiger Innenraum*" (*spacious car interior for carsharing*) (opinion holder 86) or "*Der Innenraum (...) bietet für einen Kleinwagen ein gutes Platzangebot*" (*The car interior provides good space for a small car*) (opinion holder 77). Especially the car interior of the BMW i3 convinced several opinion holders, e. g., "*Der Innenraum gefällt mir äußerst gut*" (*The car interior very pleased me*) (opinion holder 86). Some opinion holders also reported positively about automobile accessories, e. g., "*die Ausstattung ist gut mit Klimaanlage und Navi*“ (*the automobile accessories are well with air conditioning and navigation system*) (opinion holder 2) or "*und die Rückfahrkamera echt spitze*" (*and the rear view camera really great*) (opinion holder 98). All these mentioned components could also be components of a conventional vehicle, which means that they are not a unique selling proposition of vehicles in electric carsharing fleets. Partly, components that were electric vehicle specific were noted positively such as the electric engine or the recuperation, e. g., "*Das Glanzstück des Zoe ist meinen Augen der Motor*" (*The engine is the highlight of the Zoe in my view*) (opinion holder 77) or "*Bei hohen Geschwindigkeiten reicht die Rekuperation jedoch gut zum Verzögern aus*" (*the recuperation is good enough for delaying at high speeds*) (opinion holder 81). Besides the conventional components, the mentioned components relate to different electric vehicles, hence no general statement about the electric vehicle components can be made in relation to electric carsharing. Only, components of the electric vehicle BMW i3 are particularly popular.

But about one third of the sentences with the aspects *electric vehicle components* included negative opinion words. Again some general components were mentioned negatively like the design or the seats (s. opinion holders 69, 81). Similarly, the engine and the small car trunk were disliked by some opinion holders (s. opinion holders 60, 77, 80). These findings also show that tastes are different. The subjective opinion of the opinion holders varied in particular in the perception of the design or the facilities. Components such as automobile accessories and engine performance might play an important role for users, who belong to customer clusters like the fun-oriented car-lovers or technically interested customers (s. section 2.2.2). But there are also pragmatically oriented electric carsharing users, who are more interested in reliability and availability of the vehicles and electric carsharing. However, one electric carsharing component were rated frequently negative, the navigation system, e. g., "*und auf dem ziemlich langsam agierenden Navi*" (*and on the rather slow acting navigation system*) (opinion holder 46). Besides this opinion holder, there were also two other opinion holders, who complain about the navigation system of the vehicles by car2go (s. opinion holders 43, 44). The navigation system of the Citroën C-Zeros by Multicity Carsharing got many negative comments (s. opinion holders 1, 3, 4, 5, 35, 84). It is integrated into the rear-view mirror, which was perceived as unfamiliar, e. g., "*Ich finde diesen Ort für ein Navi verwirrend*" (*I think, this place for a navigation system is confusing*) (opinion holder 3). But the biggest issue was, that the users had to adjusted the position of the rear-view mirror very often, because it often turned down by the weight of the navigation system, e. g., "*Das Navi am Rückspiegel ist so schwer, dass der Rückspiegel immer wieder umklappt*" (*The navigation system in the rear view mirror is so heavy, that the rear view mirror turns down over and over again*) (opinion holder 1). These complaints seem to be depending on the vehicle or the carsharing provider, but the navigation system is an important instrument for electric carsharing users. Firstly, in many cases the electric carsharing users do not often use a car and their main transportation means are public transport or the bicycle (s. section 2.2.2). They know the railway tracks or bike paths, but they are not so familiar with the road networks. Thus, these users are more dependent on the navigation system, which supports them to find their way comfortably. Additionally, the navigation system is an important tool for finding the nearest charging station.

Therefore, electric carsharing users attach particular importance to a quick and easy to use navigation system.

Only 61 percent of the sentences containing the aspect *costs* included positive opinion words. Some stated that the costs of electric carsharing are fair, e. g., "*die Kosten für die Fahrzeug-miete sind fair*" (*the cost for vehicle rental are fair*) (opinion holder 48). Opinion holder 41 wrote "*Das Preis-/Leistungsverhältnis stimmt einfach*" (*the price-performance ratio is just right*). In particular, the charges of Multicity Carsharing were perceived as inexpensive (s. opinion holder 2, 4, 10, 52, 63). This could be expected, because Multicity Carsharing has the lowest price per minute compared to the other two free-floating electric carsharing providers in Berlin (s. section 2.3). Opinion holders expressed their positive opinion about free parking (s. opinion holder 10) and that electric carsharing can be more inexpensive than an own car or a rental car depending on the usage (s. opinion holders 31, 1). Some opinion holders posted that the price system was clearly, e. g., "*Die Tarifstruktur ist erstaunlich übersichtlich*" (*The tariff structure is remarkably clear*) (opinion holder 3). According to Maertins (2006, p. 15) the prices will be rated as low or reasonable, when they are perceived as ease to control and to calculate from a subjective point of view.

Some of the opinion holders noted that electric carsharing was relatively expensive and they noticed this only when they got the invoice, e. g., "*Aber dann habe ich die erste Abrechnung erhalten und war doch etwas erschrocken*" (*But then I received the first bill and was a bit shocked*) (opinion holder 1). A few cents per minute sounds attractive and inexpensive firstly, but the minutes add up quickly. Opinion holder 3 had to determine negatively, that Multicity Carsharing did not calculate lower prices per minute for parking like the competing provider (s. section 2.3). Some opinion holder did not like about Multicity Carsharing that cost calculation begins with unlocking the vehicle and thus before they had checked for damages, e. g., "*Daher sind der Fahrzeug Check und die Inbetriebnahme schon gebührenpflichtig*" (*Therefore, the vehicle checks and commissioning are already subject to charge*) (opinion holder 115). The prices, the price structure and other fees depend strongly on the electric carsharing provider and there are also different between the station-based and free-floating concept.

The aspect *carsharing components* has the same rather negative distribution of positive and negative opinion words as the aspect costs compared to the other aspects of electric carsharing. Many opinion holders mentioned positively the simplicity of the concept and the rental process, e. g., "*finde ich dieses Konzept großartig und herrlich unkompliziert*" (*I think this concept is great and wonderfully uncomplicated*) (opinion holder 3) or "*Der Gesamte Mietprozess ist technisch clever und simpel umgesetzt worden*" (*The whole rental process has been implemented technically clever and simple*) (opinion holder 48). According to Rogers (2003, p. 15) an innovation that is perceived as less complex will be adopted faster. The registration process was also noted positively, e. g., "*Die Anmeldung ist super einfach*" (*The registration is super easy*) (opinion holder 11) or "*Die Registrierung verlief problemlos*" (*The registration went smoothly*) (opinion holder 91). This is a relevant component, because the registration is the first access threshold for using electric carsharing and a complex registration process could discourage potential user. Similarly, the mobile app and the service employees were expressed as satisfying (s. opinion holders 15, 33, 49, 90). These opinions were not specifically directed at electric carsharing but at carsharing services in general. In addition, a few opinion holder appreciate the flexibility and availability, e. g., "*Dementgegen stehen die absolute Flexibilität und die unglaublich hohe Verfügbarkeit*" (*That is countered by the absolute flexibility and the incredibly high availability*) (opinion holder 45) or "*Auch in meiner Nähe fand sich eine Station*" (*Also there was a station close to me*) (opinion holder 16). These arguments depend on the location of the electric carsharing user. Considering these two cases, Stuttgart has a large free-floating electric carsharing fleet by car2go and the station-based carsharing provider stadtmobil has 15 electric vehicles available in Karlsruhe (s. section 2.3).

The opinion holders often mentioned negatively the following *carsharing components*, the missing authorization pin, the mobile app and the limited business area. The missing authorization pin was a problem appearing only by Multicity Carsharing and was already described above. Some of the opinion holders complained about the mobile app, e. g., "*die App ist echt langsam*" (*the app is really slow*) (opinion holder 2) or "*Die App ist schlichtweg eine Katastrophe*" (*The app is just a disaster*) (opinion holder 4). The mobile app by the electric carsharing provider is an important instrument for electric carsharing users to book or locate the vehicles. Especially, free-floating users rely on the app, because the vehicle could be everywhere in the business area. Additionally, the app can be used to unlock the vehicle and to locate nearest charging stations (s. section 2.2.1). Likewise to the navigation system, the electric carsharing users attach particular importance to a quick and reliable mobile app.

The other big obstacle was the limited business areas of the free-floating electric carsharing providers, e. g., "*Das Geschäftsgebiet von Multicity Carsharing ist derzeit noch relativ klein*" (*Currently, the business area of Multicity Carsharing is still relatively small*) (opinion holder 41) or "*Ein Nachteil von Car2Go ist das begrenzte Geschäftsgebiet*" (*One disadvantage of car2go is the limited business area*) (opinion holder 46). Opinion holder 100 proposed also an extension of the business area of DriveNow in Munich. Multicity carsharing got the most negative comments about the business area (s. opinion holders 1, 3, 4, 10, 38, 83, 91). Carsharing users often complain about the small business areas in the social networks. Permanent availability is very essential for electric carsharing users, especially for pragmatically oriented ones (s. section 2.2.2). Longer ways and more complex access routes to use electric carsharing could decrease the acceptance of the users and lowers the intention to use the service. Due to the limited business areas, the opportunity to use electric carsharing is restricted. According to the study of Steiner et al. (2014, p. 9) the size of the business area was a factor against the daily use of free-floating electric carsharing.

The aspect *range* got the lowest number of positive rated sentences, nevertheless there were 58 percent sentence containing positive opinion words about the range. Several opinion holders perceived the range as sufficient (s. opinion holders 3, 10, 22, 46, 48, 80, 88, 92, 100), e.

g., “*Auch die Reichweite empfand ich als ausreichend*” (*I perceived the range as sufficient*) (opinion holder 3) or “*Für alles, was man so in der Stadt vorhat, ist die Reichweite von 150 km bei voller Batterieladung völlig ausreichend*“ (*For everything you plan in the city, the range of 150 kilometers with a full battery charge is sufficient*) (opinion holder 92). These findings indicate that the combination of carsharing and electric vehicles reduces the range anxiety especially in urban areas (cf. Baum et al, 2012, p. 140). Most of these opinion holders were free-floating electric carsharing users, which supports the results by Steiner et al. (2014, p. 6) that users of free-floating electric carsharing rated the range generally more positive than station-based users.

As mentioned in chapter 2.1.1, the limited range is one of the main barriers of electric vehicles and it is determined through the energy density of the battery. Consequently, opinion holders also posted negative statements about the battery of electric vehicles as well as about the range. “*Das größte Problem am C-Zero jedoch: die Batterie*“ (*The biggest problem of the C-Zero, however: the battery*) (opinion holder 69) and „*Lediglich die Akkuleistung hat mich enttäuscht*“ (*Only the battery performance has disappointed me*) (opinion holder 79) were statements by opinion holders, who used station-based electric carsharing. This also affirms the assumption from above that station-based electric carsharing users assess the range rather insufficient. The range can be significantly reduced by the use of air conditioning or heating, which leads to comfort losses (cf. Barthel, 2012, p. 57). This was also perceived by some opinion holders, e. g., “*Am Schlimmsten ist es bei eingeschalteter Klimaanlage: die Reichweite sinkt dabei um 20 Kilometer pro Minute (jedenfalls gefühlt)*“ (*It is at worse when the air conditioning switched on: then the range decreases by 20 kilometers per minute (at least felt)*) (opinion holder 5) or “*Als ich die Klimaanlage ausgeschaltet habe, sprang die Reichweite förmlich nach oben*” (*When I switched off the air conditioning, the range jumped up*) (opinion holder 3).

The aspects driving, electric vehicle and the electric carsharing provider were seen as the most favorable aspects of electric carsharing. The highly positive rated aspect driving is an advantage for electric carsharing providers, because it can be assumed that this aspect was already expected as affirmative by the users before the first ride and this approval rose after experienced it. There is an opportunity that new customers, who were attracted by the pleasant driving characteristics, could be gained for electric carsharing and on the other hand existing customers became more satisfied by the experienced low noise or driving experience. As already mentioned also the vehicle is an opportunity for electric carsharing providers to address more technically interest and car-affine customers. There are more and more sophisticated models on the market that are joyfully expected by the users such as the BMW i3. Carsharing itself became more popular after the professionalization and the introduction of concepts of the innovative automobile manufacturer. Most conventional carsharing providers already have a large customer base. Therefore electric carsharing as an innovation package benefits from carsharing and carsharing provider got more encouragement when they adopt electric vehicles. It seems that a carsharing provider will get better reputation, if it is also an electric carsharing provider. But the findings also show that pleasant driving characteristics, pleasing vehicles and popular providers alone are not enough for being a successful mobility concept. The reliability of components such as the navigation system or the mobile app plays a significant role for electric carsharing users. Constant actuality must be given particularly to locate the nearest charging station. New stations should be added promptly and inoperative stations should be hidden during downtime. Likewise, the users attach great importance to the availability. On the one hand there need to be enough electric vehicles in use, so that users can select them in various locations and they can easily switch them, if the battery level is not high enough for the use purpose. A high availability of free-floating electric vehicles might reduce range anxieties, because the user is able to change an empty vehicle with a better charged one. On the other hand a high availability of electric carsharing stations or locations, where free-floating vehicles can be used, is advantageous, because users prefer shorter and uncomplex access routes to the electric vehicles. This increases their flexibility and convenience. The availability of charging infrastructure is crucial especially for free-floating electric carsharing users as mentioned above. A higher availability of charging stations influences positively on the availability of electric vehicles and carsharing stations or respectively business areas. It can be assumed that a business area of a free-floating electric carsharing provider would not expand to an area, where users do not have the possibility to charge the vehicles. Otherwise, another assumption is that users of free-floating electric vehicles perceived the range as sufficient in the small business areas of the providers and if the business areas would be widen too much, range anxieties would stronger occur. The expressions about the costs varied, because on the one hand the prices and the price structure depend strongly on the respective provider. There are also differences between station-based electric carsharing concepts and free-floating electric carsharing concepts (s. section 2.2.1). On the other hand the perception of the costs depends on mobility behavior of the user. Users might compare the costs of electric carsharing with their main transportation mode. On this basis, users, who frequently use public transport or the bicycle, perceived the costs of electric carsharing as more expensive than users with an own car. Overall it can be said that the user opinions about the aspects of electric carsharing strongly depend on the location of the user as well as on which provider is available and was used. Electric car sharing providers differ in their carsharing concepts, vehicle selection, availability of the electric vehicles, station network or business area and price structuring. DriveNow is more attractive for car-affine and technically interested customers. These users are impressed by the acceleration and performance of the electric vehicles and for them the driving characteristics and selection of vehicles play an important role. They would use electric carsharing to try out new vehicle models and because of the driving fun. Multicity Carsharing and car2go addresses more pragmatically-oriented users. Reliability and availability are relevant requirements for their usage. Also financial reasons play a role.

In the Evaluation phase, hundred sentences were tested manually to find out the values of precision, recall and accuracy. These are eleven percent of the remaining 905 sentences which had been chosen for the analysis. Every tenth sentence was picked for the evaluation to get texts of all different data sources (sentence no. = 9, 46, 75,..., 2037, 2064). For each sentence were identified if it contained positive and negative opinion words. Likewise the eight aspects were tagged manually. Only the explicitly mentioned aspects were tagged, because in the analysis the implicit aspect expressions had not been considered (s. section 4.1.1). Finally, the results of the 100 sentences generated by RapidMiner were compared with the manually produced results. Table 6 gives the precision and recall results of extracting opinion word orientations. 88 percent of the opinion words were identified with a precision of 78 percent. For extracting opinion words and identifying their orientation, satisfactory values could be achieved by the processes of RapidMiner as well as by adjusting the SentiWS wordlist with more (mostly domain- and context-specific) words. In terms of precision the negative opinion words scored better than the positive ones, but twelve percent more positive opinion words could be extracted. The sources of error for precision and recall were analyzed to recognize what needs to be improved for future analysis. As mentioned in chapter 4.1.3, not all sentences in reviews containing opinions. Opinion holders liked to describe situations when they used electric carsharing or aspects. If there is no indication of whether an opinion holder likes an aspect or not, the human tagger does not consider such sentences as opinion sentences. But the software tool tags such sentences as opinion sentences, if they contain a word of the opinion word list. This decreases the precision. Some words that have different meanings (called homonyms) were incorrectly identified as an opinion word, e. g., in the following sentence the word "*einfach*" meant "*just*" and not "*easy*": "*…werde ich einfach dann Samstag schnell aufladen…*" (*I will just quickly recharge then Saturday*) (sentence no. 352). The recall decreased, because some words were missing in the opinion word list such as "*beste*" (*the best*) (sentence no. 581) or "*verlierte*" (*lost*) (sentence no. 238). The term "*1+*" (*A+ grade*) (sentence no. 506) could also be added to the positive opinion word list, but the term would have been excluded from the sentence, because of incorrect text preprocessing (the "*Tokenization*" operator removes all numbers). Opinion shifters were another source of errors. Words that can shift or change opinion orientation are called opinion shifters such as the negation words "not" or "never" (cf. Liu, 2011, p. 482). For example, the following sentence turned, due to the word "nicht" (not), "*…ist auch nicht so toll*." (*is not so great*) (sentence no. 1295). It is easy to recognize such shifters manually, but it is not simple for an automated software tool.
Table 7 shows the precision and recall results of extracting aspects. Extracting aspects gained very good values by a manually generated wordlist containing frequent as well as infrequent aspects and by the processes of RapidMiner. To increase the recall more aspect expressions need to be added to the wordlist of aspects. For example, "*Scheiben*" (*pane*) (sentence no. 439) and "*City-Modus*" (*city-mode*) (sentence no. 597) should be included to the wordlist of *electric vehicle components*. In one sentence (no. 332) the term "*Car-sharing*" was split by

the “*Tokenization*” operator into two single tokens and RapidMiner tagged “*Car*” as an aspect, because the token was in the wordlist of *electric carsharing provider* due to identify the provider car2go that was often expressed by “*Car 2 go*”. This shows that adding a lot of words to a wordlist will lead to a high recall, but precision could suffer especially when these words have different meanings.

	Positive Opinion Words	**Negative Opinion Words**	**All Opinion Words**
Precision	77%	79%	78%
Recall	94%	82%	88%

Table 6: Precision and recall of positive and negative opinion words
Source: Own depiction, s. footnote 50

	Electric Vehicle	**Electric Vehicle Components**	**Electric Carsharing Provider**	**Carsharing Components, Driving, Costs, Charging, Range**	**All Aspects**
Precision	100%	100%	91%	100%	99%
Recall	95%	92%	100%	100%	98%

Table 7: Precision and recall of the aspects of electric carsharing
Source: Own depiction, s. footnote 50

Table 8 provides the values of the accuracy of the aspect-based opinion mining about electric carsharing. RapidMiner as well as the wordlists caused errors in 31 percent of all sentences. Comparing sentences containing two different aspects to sentences including only one aspect shows that sentences with one aspect have a significant higher accuracy. Besides the sources of errors mentioned above, the assignment of opinion words and aspects were often incorrect. On the one hand opinion words refer to additional aspects in the sentence that were often implicitly expressed (e. g., sentence no. 167) and on the other hand opinion words related to aspects of competitors, which were mentioned for comparison (e. g., sentence no. 1658). For example, 62 percent of the negative sentences about the aspect driving additionally include another aspect. Often only those other aspects were mentioned negatively and as shown in figure 8, driving was rated more positively when the sentences only contain this aspect. In the selected second approach the aspect charging got more negative opinions than in the third approach, because many sentences containing negative statements about the aspect range. Carsharing components are rated more negatively in the third approach, because the sentences did not include positive mentions about aspects like driving, electric vehicle and especially electric carsharing provider. The aspects electric vehicle and electric vehicle components as well as electric carsharing provider and carsharing components are often reported in combination, for example the components space or authorization pin (s. above). Therefore many sentences containing expressions about both aspects.

Accuracy all sentences	**69%**
Accuracy with containing only one aspect	78%
Accuracy with containing two different aspects	52%

Table 8: Accuracy of aspect-based opinion mining
Source: Own depiction, s. footnote 50

In summary, the results are good and satisfactory, especially for extracting aspects. In order to increase the values of the performance measures, further improvements are desirable. The evaluation of whole process and the software tool are taking place in chapter five.

4.1.7 Deployment

In total electric carsharing was perceived positively by these users. On average 69 percent of the sentences had positive statements about the aspects of electric carsharing and only 31 percent of the sentences had negative ones. Particularly driving and the electric vehicles convinced the opinion holders. Likewise the electric carsharing providers were mentioned positively. Electric carsharing is appreciated by technically minded users, because of the driving experience, the acceleration and the innovative features of the electric vehicles. Especially car-affine users were impressed by the electric vehicles by DriveNow. The other electric carsharing provider could also convince through low access thresholds, availability and the simplicity of their offerings. Sometimes there were technical problems with the vehicles and the charging process, which could trace back to the fact that electric carsharing has started only five years ago and the reviews were written after first experiences in the initial phase of electric carsharing. Today new models are improved like the BMW i3 or the Renault Zoe. Additionally, users gain more experience with electric carsharing and get accustomed by its specific features such as the low noise or the limited range. But electric carsharing providers should not rest on their acclaimed electric vehicles, because also features that are rather related to carsharing service itself are significant. Especially the mobile app and the navigation system in the vehicle play an important role for electric carsharing users. Some providers have to improve these two instruments to configure the usage more convenient and comfortable. In particular free-floating electric carsharing providers should enhance the search for free charging station. Inoperative charging stations should not display on the cards of the mobile app or respectively navigation systems. A big obstacle is an occupied charging station, because this delays the search for free stations and therefore is more expensive for the electric carsharing user. The providers should work out solutions with the owner of the charging stations to reduce the possibility for parking for drivers of conventional vehicle. In order to higher the availability of carsharing vehicles and to lower the range anxiety of the users, electric carsharing providers need to offer alternatives together with cooperation partners. For example, customers of Multicity Carsharing can also use services like Flinkster and Call-a-bike. Flinkster offers vehicles with more space, if users need a vehicle for transport and this provider also have conventional vehicles that can be used for journeys with longer distances. Today the availability of electric carsharing is limited, but due to the rising adoption of electric vehicles into carsharing fleets (s. section 2.3), it can be assumed that there will be more possibilities to use electric carsharing in the future.

4.2 A Survey of Electric Carsharing Users

In the second part of the fourth chapter the process of preparation, implementation, analysis and interpretation of the survey will be presented and explained. Users of electric carsharing are questioned in order to gain more knowledge about their attitudes towards electric carsharing and to examine shifting effects of their mobility behavior.

4.2.1 Selection of the Sample and Creation of the Questionnaire

Due to the research questions (s. chapter 1), individuals who use electric carsharing or have used it are in the target group of the survey. This group includes mainly adults aged over eighteen years, who hold a driving license for category B. Some people consider that they have an opinion on any topic, although they actually know nothing about the topic and thereby so-called non-opinions emerge, which can distort the response results of a survey (cf. Brosius et al., 2012, p. 88 f.). To avoid such distortions the sample selection shall include possibly only those respondents, who know something about the subject. Therefore for this survey, electric carsharing users are searched in the internet and contacted directly. During the data collection of the data mining analysis (s. section 4.1.3) some contact information of electric carsharing users have already been collected. Accordingly, some of the opinion holders from the previous analysis are part of the sample in this analysis. Further potential candidates for the survey were identified, because they had reviewed electric carsharing provider on their Facebook pages or had indicated that they had used carsharing with electric vehicles in comments on websites, blogs, online forums or social networks, primarily also on Facebook.

With regard to the implementation of surveys it can be distinguished between written and oral interviews. In this research the choice fell on a written survey method, because it is less expensive and the respondents can decide freely when and in what situation they would like to fill out the questionnaire. A disadvantage of this survey method is the lack of interaction, because there is no interviewer for further inquiry or explanations available. Therefore, the comprehensibility of the questionnaire is very important (cf. Fazel, 2014, p. 229). Since the potential participants will be contacted personally, the possibility for asking questions in case of uncertainties is given. Additionally, a pretest will be conducted to avoid an incomprehensible questionnaire. Due to the low costs and rapid feasibility, the online survey was identified as a suitable survey approach for the study (cf. Brosius et al., 2012, p. 107). Online survey have the disadvantage that only the part of the population can be reached which is online accessible (cf. ibid.). This is not an incisive problem in this research, because the usage of electric carsharing involves the usage of the internet in terms of the registration, booking or locating available vehicles (s. section 2.2.1). In addition, due to the requirements of the selection of the sample mentioned above, the sample only contains internet user. A partly standardized questionnaire is used as the survey instrument that contains closed-ended as well as open-ended questions. Open-ended questions have no predetermined answer choices and allow the interviewee to express themselves freely about a subject. In this survey most questions are open-ended questions, because a qualitative analysis is applied in this research. Open-ended questions are preferred for qualitative analysis, because it can be deduced in which dimensions electric carsharing is perceived and assessed. Attitudes, opinions and behaviors will be queried, which depend on details and rather subjective assessments. Open-ended questions do not frame user responses and can help to recognize new trends (cf. Miner, 2012, p. 509). A disadvantage is that the respondent must deal with the problem himself (without assistance) to give an answer and at worst case the respondent does not come to an answer (cf. Schumann, 2012, p. 59 f.). A questionnaire with open-ended questions is similar to the data collection of opinion mining, because both data have highly subjective information content. The next section is dedicated to the creation of the questionnaire.

Before the creation of a questionnaire has to be determined which questions shall be answered by the analysis of the questionnaire that means the direction of the analysis must be defined. In this survey the attitudes of users towards electric carsharing are analyzed and shifting effects of the mobility behavior during electric carsharing usage are examined. The research questions of the first chapter are:

- *What opportunities and risks can be identified with regard to the attitudes of users towards electric carsharing?*
- *What shifting effects occur between public transport, own passenger cars, carsharing with conventional vehicles and electric carsharing when using electric carsharing?*

The present questionnaire comprises three thematic blocks with a different number of questions. The complete questionnaire can be found in the appendix F.

Block A of the questionnaire contains four questions about electric carsharing usage.

The use frequency of electric carsharing is investigated with the first question (A1). For this the established scales of the representative study MiD (s. section 2.2.2) are used (*"(almost) daily"; "1-3 days per week"; "1-3 days per month"; "less than monthly"; "(almost) never"*) (cf. Bundesministeriums für Verkehr, Bau und Stadtentwicklung, 2010, p. 93). The question is extended by the answer "*I never used carsharing with electric vehicles*" to filter out individuals, who never used electric carsharing before. Such non-users of electric carsharing are excluded through the selection of the sample and therefore it will be expected:

H_1: *All participants had already used or use electric carsharing.*

The second question (A2) relates to the motives for the usage of electric carsharing. As already mentioned in section 2.2.2, there are environmental, pragmatic as well as economic motives for the usage of carsharing as well as electric carsharing. Besides users who had attitudes that emphasize environmental concerns more strongly, there are users, who are interested in electric carsharing as a technological innovation and who had attitudes that emphasize fun and flexibility oriented factors (cf. Ruhrort, 2014, p. 299). Attitudes impact the choice of transportation means and therefore it is important to detect which factors influence the motives for the usage of electric carsharing.

The personal attitudes towards the use of electric carsharing are determined in the next two questions. Here it will be asked what the user likes about electric carsharing (A3) and what the user does not like about it (A4).

H_2: *Advantages and disadvantages, opportunities and risks are identified with regard to the attitudes of users towards electric carsharing.*

Block B of the questionnaire comprises three questions about the use of transportation means and the mobility behavior.

In the first question of block B the participants shall specify the use frequency of five different transportation means in comparison (B1). The five most common used transportation means of electric carsharing users are chosen (s. section 2.2.2). Besides electric carsharing and carsharing with conventional vehicles, these are public transport, bicycle and the own car (cf. Hoffmann et al., 2012, p. 13). According to Ruhrort et al. (2014, p. 296) electric carsharing is not the main transportation means and is used as a complement for particular use cases.

H_3: *Electric carsharing is a supplementary mobility option and not the main transportation means for electric carsharing users.*

A frequent discussed topic is that carsharing as well as electric carsharing substitutes journeys preformed with public transport (cf. Schlesiger, 2015, p. 1; Schwarz, 2015, p. 1). When the choice of transportation means changes and a new transportation means is used other transportation means will be used less. To find out which transportation means is directly replaced by electric carsharing, the participants are asked what transportation means they would use, if electric carsharing would not exist (B2). This question based broadly on a question from the survey of BeMobility 2.0 (cf. Steiner, 2014, p. 7). According to this following hypothesis is:

H_4: *The participants would use public transport, if electric carsharing would not exist.*

In order to examine in depth the shifting effects between electric carsharing and the other transportation means, the last question of block B relates to the changed mobility behavior since using electric carsharing in relation to the other forms of mobility (B3).

H_5: *Journeys with other transportation means are shifted to electric carsharing.*

The last block C includes four questions with personal information such as gender (C1), age (C2), current occupation (C3) and highest educational achievement (C4). After the socio-demographic data are requested, participants have the possibility to formulate criticisms and suggestions in a text entry field (C5). Except the last question, every question was a mandatory question to avoid that participants skip questions and cause non-responses.

4.2.2 Implementation of the Survey and Analysis of the Closed Questions

Google Forms is chosen as the online survey tool, because it is free of charge, has a very good usability, supports the question types and is responsive which means the survey has a pleasant presentation on every end device. The questions of each block are presented on one site. Practically, the responses are collected automatically in a spreadsheet of Google Sheets.

Before implementing the survey, several pretests were taken place to check the questionnaire and to determine the duration of the survey. The link of the survey was sent to five people, who had reviewed the questionnaire on linguistic comprehensibility and content-related completeness. Only marginal changes had been made on the basis of the returns of the pretests. In addition the duration of the survey was examined. Overall, the average duration of the survey is about five to ten minutes.

After the questionnaire was finally designed and the list with contact information of electric carsharing users was created, the questionnaire had been sent as a link via various channels. Overall hundred electric carsharing users were contacted and they were addressed via Facebook messages (81), email (9) and private messages on mietwagen-talk.de (10). On this way a total of twenty-six participants (n = 26) could be recruited and survey was responded between 09/24/2015 and 10/09/2015. Thus the response rate was 26 percent. This is an acceptable value. In comparison, the qualitative study of electric carsharing users by Ruhrort et al. (2014, p. 291) had a response rate of 25 percent. Most Facebook messages arrived in the file "Other" and the user got no notification. Therefore it is assumed that many Facebook messages are unread. Furthermore a distortion of the response rate could occur, when recipients have forwarded the link of the survey. Partial non-response occur at the questions A2, A3, A4 and B3 (s. participant 4) as well as at the questions B2 (s. participant 5). The question B1 about the use frequency of five different transportation means in comparison was answered incorrect by two participants (s. participant 5 and 18), because they mentioned one of the transportation means more than just ones. Because of the small sample, these participants are not excluded from the whole analysis, but just from the analysis of the relevant questions.

	n = 26	**Percent**
Gender	Female	**12%**
	Male	**88%**
Age	18-30	**39%**
	31-40	**42%**
	41-50	**19%**
Current occupation	Student, apprentice, pupil	**23%**
	Full-time employees	**31%**
	Part-time employees	**4%**
	Self-employed	**42%**
Highest educational achievement	Secondary school certificate	**4%**
	University entrance qualification	**38%**
	Polytechnic / university degree	**58%**

Table 9: Socio-demographics of the participants of the survey
Source: Own depiction, s. footnote 51

An overview of the socio-demographic data of the participants is shown in table nine and in diagram form in appendix G. With 88 percent the participants of this survey are predominantly male. Approximately one fifth of the sample is between 40 and 50 years old and the rest is distributed almost equally strong on the age groups 18 to 30 and 30 to 40. The majority of the twenty-six participants are gainfully employed, whereby self-employment is the most stated form of employment. Six participants belong to the group “student, apprentice, pupil”. Participants of the survey are mostly well educated. Over the half of the sample has a polytechnic or university degree.

In figure ten the use frequency of electric carsharing (A1) of the sample is represented. All participants had already used electric carsharing. Thus, the first hypothesis (**H1**) is confirmed by the data. Almost two thirds of the participants use electric carsharing 1 to 3 days per month, fifteen percent use an electric carsharing vehicle 1 to 3 days per week, even three participants use electric carsharing (almost) on a daily basis and only two participants use it less than monthly.

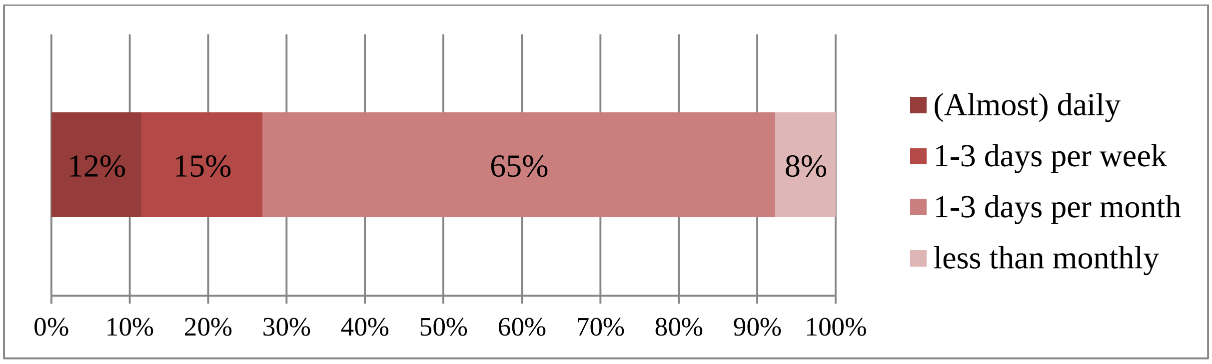

Figure 10: Question A1: Use frequency of electric carsharing
Source: Own depiction, s. footnote 51

Figure eleven shows the distribution of the five most common used transportation means of electric carsharing users. In the sample of this question (B1) are only twenty-four participants (s. above). With 42 percent both public transport and bicycle are the most frequent used transportation means of the participants. Therefore public transport and bicycle are the main transportation means for twenty of the twenty-four participants. Only participant 6 states that electric carsharing is his most frequent used transportation means, which makes it to his main transportation means. The own car is the least used transportation means of 67 percent of the participants. Both kinds of carsharing are in the midfield. Carsharing in general closed the gap between public and individual transport (s. 2.1.2). Most participants (42 percent) specified that use electric carsharing as fourth most frequent transportation means. These results support the third hypothesis (**H3**), which imply that electric carsharing is not the main transportation means for electric carsharing users, but a supplementary mobility option.

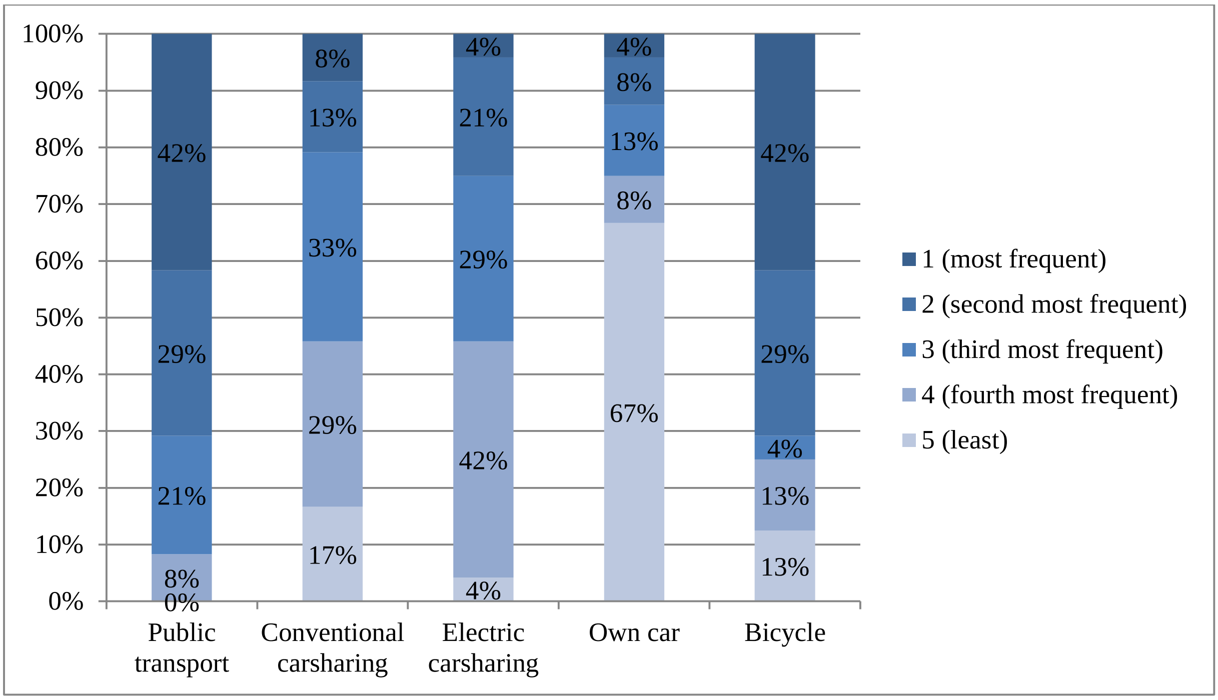

Figure 11: Question B1: Five most common used transportation means
Source: Own depiction, s. footnote 51

4.2.3 Qualitative Content Analysis according to Mayring

Mayring's approach of qualitative content analysis will be applied in the analysis of the survey, because in comparison to other approaches like Grounded Theory, qualitative content analysis is much more descriptive and less theory-oriented (cf. Kuckartz, 2010, p. 96). Due to its strongly inductive procedure, the approach is particularly suitable for problems without the availability of much prior knowledge and the exploration is paramount (cf. ibid.). According to Mayring (2000, p. 2) qualitative content analysis is "*an approach of empirical, methodological controlled analysis of texts within their context of communication, following content analytical rules and step by step models, without rash quantification*". The category system is the central point in Mayring's qualitative content analysis, which also enables the intersubjectivity of the analysis and there are two approaches for developing a category system: inductive category development and deductive category application (cf. Mayring, 2015, p. 51). To analyze the interview material, this study uses inductive category development, since the category system cannot clearly formulated in advance and the categories shall be developed as near as possible to the material. Inductive category development derives categories directly from the material without referring to pre-formulated concepts of theories (cf. Mayring and Brunner, 2013, p. 327). For this approach a general definition of a category must be determined derived from research question and theoretical background, which means firstly a criterion of selection must be established that decides which part of the material is taken into account (cf. Mayring, 2000, p. 4). Through this, expressions are excluded, which are insignificant or deviating from the research focus. After that, determining the level of abstraction of the developed categories must take place (cf. Mayring and Brunner, 2013, p. 327). Following the criterion of selection, the material is worked through and categories are deduced under the consideration of the level of abstraction (cf. Mayring, 2000, p. 4). A new category does not need to be developed every time a criterion of selection is fulfilled, because some text passages can be assigned to an already formed category (subsumption) (cf. Mayring, 2015, p. 87). The developed categories are revised within a feedback loop and if necessary some categories are reduced to main categories (cf. Mayring, 2000, p. 4). At the same time the reliability is checked as well as if the created category system achieved the objectives of the analysis (cf. Gläser-Zikuda, 2008, p. 71).

One benefit of qualitative content analysis according to Mayring is the step by step model (s. figure 12), which conduces as a guideline in this analysis. The first three steps of the general content analytical process model were already presented in the previous sections of this chapter. The fourth and fifth steps took place in chapter 4.2.1. According to the next step, mainly a combination of both analytical techniques *summarizing* and *structuring* has been chosen. Summarizing decreased the material to receive the significant content and structuring filter out specific facets from the material (cf. Mayring, 2015, p. 67). In order to declare unclear test passages, in some cases the content analytical technique *explication* is applied, which method *narrow context analysis* considers additional material from the direct environment of the unclear statement (cf. Mayring, 2002, p. 118). The specific process model depends on the approach of developing the category system. As already mentioned above, inductive category development will be performed and therefore the content analytical process model is adjusted to the procedure described above. There are three different units of analysis and they shall be defined in the seventh step of the general content analytical process model (cf. Mayring, 2015, p. 61). The analytical units are the three open-ended questions of block A (i. e., A2, A3, A4) as well as both open-ended questions of block B (i. e., B2, B3) and they will be analyzed successively in chronological order. Due to non-responses (s. participant 4 for A2, A3, A4, B3 and participant 5 for B2), there are twenty-five contextual units for each analytical unit, which means twenty-five answers to one of the five open-ended questions. The coding units are single words and short phrases, because the answers were written in note form. In the eighth step the actual analysis will take place using the inductive category development approach as described above. The tasks of this step are applied in the following. Finally, the results will be interpreted with regard to the research question and the content analytical quality criteria will be applied (s. section 4.2.4).

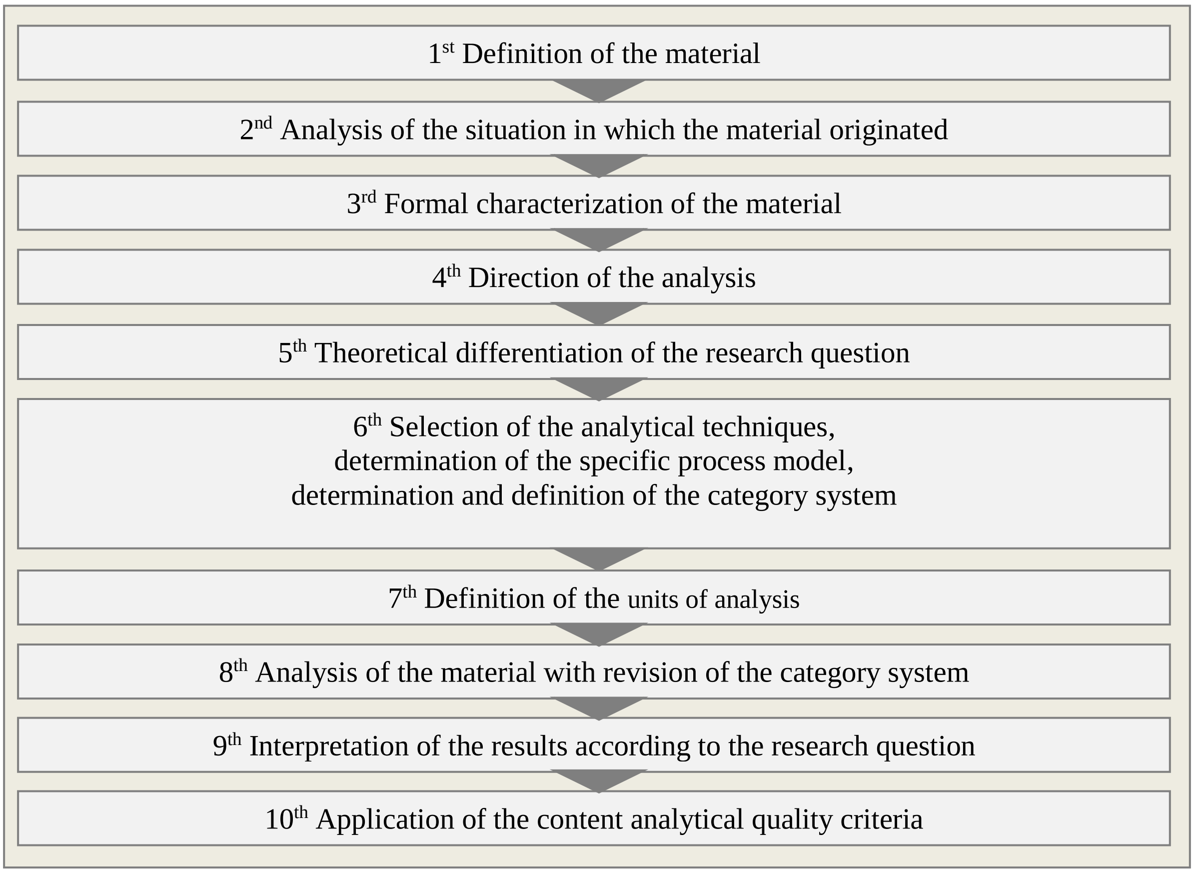

Figure 12: General content analytical process model
Source: Own depiction with reference to Mayring (2015, p. 62).

The analysis started with the first open-ended question about the motives of electric carsharing usage. The material was worked through and first inductive categories are developed. Some synonymous and similar phrases were grouped, for example, "*weniger Kosten*" (*reduced costs*) or "*günstig*" (*inexpensive*) were subsumed under the inductive category "*finanzielle Gründe*" (*financial reasons*). In order to ensure the traceability and to avoid misinterpretations due to translation, the inductive categories were still named in German language. In total forty-three categories could be found inductively. After the revision some categories were renamed. Several categories were aggregated to main categories according to specific content areas, which is a method of the analytical technique structuring called *content structuring* (cf. Mayring, 2015, p. 99). A total of nine main categories were determined and their definitions, coding rules and anchor examples are listed in the coding agenda in appendix H. Three main categories got subcategories, which should describe particular characteristics of the main categories. *Better air quality* is the subcategory of *environmental aspects*. The main category *pleasing electric vehicle* has the three subcategories *low noise*, *acceleration* and *driving fun*. *Pragmatic reasons* includes the seven subcategories *no own car*, *at night and poor availability of public transport*, *good availability*, *transport*, *bad weather*, *time savings* as well as *further practical/functional reasons*. The main categories had at least four mentions and the subcategories had at least two mentions.

After that, the two questions about likes and dislikes of electric carsharing were evaluated. Additionally, the method narrow context analysis was applied, because participant eight only noted "*S.o.*" for "see above", which means that his answers of the previous question A2 also apply for question A3. The category development of question A3 resulted in forty-nine inductive categories. These categories were grouped to twelve main categories without subcategories and they are shown in appendix I. The smallest main category got two mentions. The category *electric vehicle or features* refers to all five categories which include expressions about the electric vehicle or its features (main categories 6 - 11). A total of forty-one categories were generated for question A4. Nine main categories emerged and are listed in appendix J. Likewise, no subcategory was formed and the smallest main category obtained two mentions.

Subsequently, the analysis for the two open-ended questions of block B took place. Question B2 asked what transportation means the participant would use, if carsharing with electric cars would not exist. The category development of question B2 was straightforward, because the statements could be aggregated to one the five common transportation means of question B1 or a combination of them. Figure thirteen (n = 25) shows the distribution of the transportaon means or combinations of transportation means that the participants would use, if electric carsharing would not exist. Over the half of the sample would use conventional carsharing. Only one fifth would take public transport. Thus the fourth hypothesis (**H_4**) that participants would use public transport, if electric carsharing would not exist can only be supported by thirty-two percent of the participant, who would use public transport or a combination of public transport and bicycle. In the first place electric carsharing replaces conventional carsharing according to the results. Thus the fourth hypothesis (**H_4**) is not significantly supported by the data.

Finally, question B3 about the changed mobility behavior since using electric carsharing in relation to the other transportation means was analyzed. Forty categories were developed inductively. These categories were aggregated to seven main categories and six subcategories as listed in appendix K. The main category *no change* has the three subcategories *no change without justification*, *no change due to limited availability of electric carsharing* as well as *no change due to rare usage. Using less public transport*, *using less bicycle* and *using less conventional carsharing* are the three subcategories of *using less other transportation means.* The main categories had at least three mentions and the two smallest subcategories had only one mention.

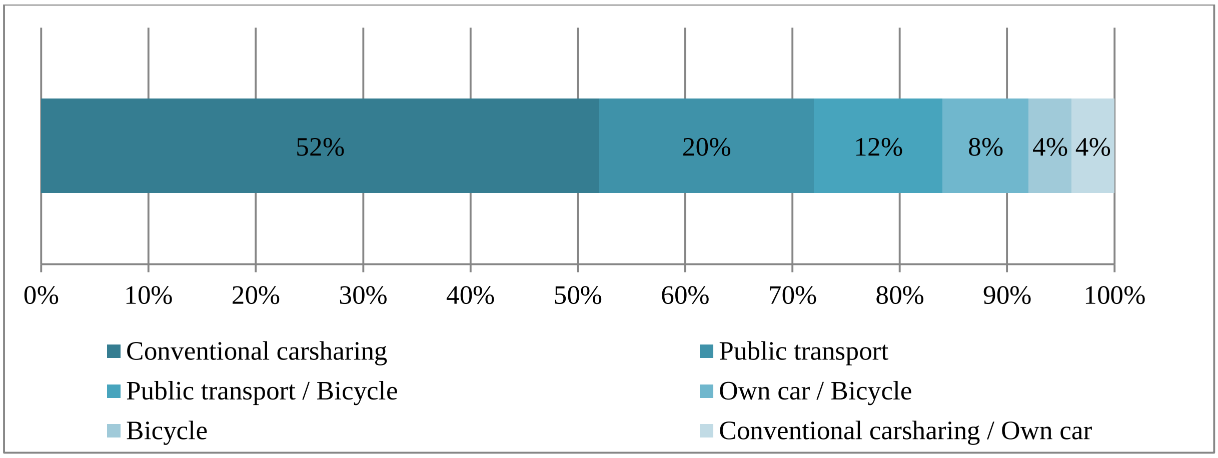

Figure 13: Question B2: Chosen transportation means, if electric carsharing would not exist
Source: Own depiction, s. footnote 55

4.2.4 Interpretation of the Results

In order to discover what opportunities and risks can be identified regarding attitudes of users towards electric carsharing and what shifting effects occur between the common transportation means when using electric carsharing, the category systems and results of the closed question will be interpreted as well as evaluated. Furthermore, frequencies of the developed categories were analyzed, to answer the two research questions and to examine the five hypotheses.

To investigate the attitudes of electric carsharing users, a requirement of the survey was a sample that only includes individuals who used electric carsharing. As already mentioned in chapter 4.2.2, the first hypothesis (**H_1**) is supported by the results of the first question A1, because all participants still use electric carsharing. These results can be evaluated in depth in question B1, where the participants should arrange the five termed transportation means according to their use frequency. Participants using electric carsharing (almost) daily placed electric carsharing as most or second most frequent used transportation means (s. participants 4, 6, 26). Both participants who stated that they use electric carsharing less than monthly positioned it on the fourth place (fourth most frequent) (s. participants 19, 22). Electric carsharing was placed in position two and three by weekly users (s. participants 3, 14, 17). Most of the sample used it on a monthly base and they positioned electric carsharing as third (6 mentions) or fourth (8 mentions) most frequent used transportation means. Only two of them put it on the second (participant 8) and last (participant 10) position. Due to this, the results of question A1 as well as the positioning of electric carsharing in B1 seem to be valid. As mentioned in chapter 2.2.2, the studies of the project BeMobility also showed that electric carsharing is not used frequently (cf. Scherf et al., 2013, p. 43; Ruhrort et al., 2014, p. 292).

The second questions asked about the motives for using electric carsharing. The most frequent mentioned motives belong to the main category *pragmatic reasons* with twenty-two mentions. Twelve participants (48 percent) fall under this category, which is divided in seven subcategories. Three participants indicated that they used electric carsharing, because they do not have an own car, e. g., "*kein eigenes Auto*" (*no own car*) (participant 12). Another pragmatic reason was the *good availability* of electric carsharing, e. g., "*Verfügbarkeit nahebei*" (*availability close by*) (participant 22). Others used it when public transport is not good available, at night, for transport, in bad weather conditions, for saving time or further practical or functional reasons (s. appendix H). One half of the participants stated that public transport is their main transportation mode and the other half noted the bicycle (s. question B1). This finding supports the thesis by Wilke (2007, p. 15) that motives for the usage of carsharing have changed to more pragmatic reasons. It can be assumed that electric carsharing is no longer perceived as extraordinary and that it is considered as a usual transportation means. Half of the participants using electric carsharing frequent (on a daily or weekly base, s. A1) mentioned pragmatic reasons. The aim of the professionalization to change from an ecological project to a mobility service and thus to gain a broader clientele (s. 2.1.2) seems to be achieved. Accompanying these pragmatic attitudes could be that electric carsharing users already had experience with conventional carsharing and thus are familiar with the service.

The second most frequent expressed motive was *environmental aspects* with twelve mentions by eleven participants, e. g., "*Umweltfreundlichkeit*" (*environmental friendliness*) (participant 14). The including subcategory *better air quality* was considered by two participants, e. g., "*bessere Luft*" (*better air*) (participant 5). This is a frequent mentioned motive in the carsharing as well as electric carsharing literature (cf. Baum et al., 2012, p 79; Canzler and Knie, 2015, p. 24). On the one hand the origin of carsharing itself was highly environmentally motivated (s. section 2.1.2) and on the other hand an environmentally friendly mobility offer was created in double senses with electric carsharing (s. 2.1.3). The environmentally friendly image is important for the diffusion of electric carsharing to gain more of the traditional, environmentally aware users of conventional carsharing (cf. Dütschke et al., 2013, p. 9). Four of the six[42] participants, who are daily and weekly electric carsharing users reported environmental aspects as a motive for the usage.

28 percent of the sample indicated that they drove electric carsharing for the purpose of *testing and curiosity*, e. g., "*Testfahren*" (*test drives*) (participant 24) or "*Neugier*" (*curiosity*) (participant 11). Hoffmann et al. (2012, p. 23) found similar motives and concluded thereof on one-off effects, because these users were attracted by the novelty, but electric carsharing did not become part of their every-day mobility routines. Considering answers of the questions A1 and B1 shows that these seven participants only used electric carsharing on a monthly base (6) or less (1) and they had placed it as the third (1) and fourth (6) most frequent used transportation means. Expect participant 22, no one stated also pragmatic reasons for taken advantage of electric carsharing. This motive stands in contrast to the assumption of the pragmatic reasons and therefore some individuals still need to try out electric carsharing to in-

[42] As already mentioned in the previous chapter, participant 4 stated that he uses electric carsharing (almost) daily, but cannot be consider for question A2, A3, A4 and B3, because of non-responses.

crease the diffusion of the new technology as well as of the alternative mobility concept. As mentioned above in chapter 2.1.3, trialability can support the widespread of innovations like electric carsharing.

Also 28 percent took advantage of electric carsharing due to the *pleasing electric vehicle*, e. g., "*Fahrgefühl*" (*driving experience*) (participant 23). The subcategory *driving fun* was mentioned mostly, e. g., "*Fahrspaß*" (*driving fun*) (participant 13). The other two subcategories were *low noise* and *acceleration*, e. g., "*weniger Lärm*" (*little noise*) (participant 5) or "*Beschleunigung*" (*acceleration*) (participant 23). According to Maertins (2006, p. 25, 65) the fun-oriented car-lovers are a growing cluster of carsharing users. In this cluster the car is in the focus and the fun factor plays an important role (cf. Hoffmann et al., 2012, p. 26). Innovative products of automobile manufacturers such as electric vehicles support carsharing provider to gain more car-affine customers.

24 percent of the participants had *financial reasons* as a motive to use an offering of electric carsharing providers, e. g., "*günstig*" (*inexpensive*) (participant 6). Five of these six participants were self-employed and also five of them indicated that the own car was the least used transportation mode. Cost-efficient car availability plays an important role for these electric carsharing users. As mentioned in chapter 2.2.2, costs are a major influence factor in the choice of transportation means, especially due to rising mobility costs. In the Swiss study of Haefeli et al. (2006, p. 27) financial advantage compared to the own car was the main reason for the use of conventional carsharing. According to the present findings, financial reasons are not the most decisive motive for the use of electric carsharing. This could be related to the issue that the own car plays a subordinate role in this sample (s. B1), but public transport as well as the bicycle are the main transportation means and these two forms of mobility are more inexpensive than carsharing or respectively electric carsharing.

One fifth of the sample was motivated to use electric carsharing due to the *interest in technological innovation*s, e. g., "*Neue Technik*" (*new technology*) (participant 10). This discovery supports the assumption that technically interested customers can be gained with electric carsharing (cf. Peters and Dütschke, 2010, p. 22; Wappelhorst et al., 2014, p. 16). Ruhrort et al. (2014, p. 299) also found out that some users are more interested in electric carsharing as a technological innovation than as an environmentally friendly service. These five participants use electric carsharing 1-3 days per month and two of them also reported the motive *testing and curiosity*. Four of these participants belong to the youngest age group and the occupation group of the students.

Four participants noted *convenience and comfort* as motives, e.g., "*Komfort*" (*comfort*) (participant 18). Likewise, *flexibility* was a motive reported by four participants, e. g., "*Flexibilität*" (*flexibility*) (participant 14). Three participants mentioned both motives (s. participant 14, 18, 26). Also three participants, who expressed convenience and comfort, are frequent users of electric carsharing (s. A1). All five participants would use the bicycle or the bicycle in combination with other transportation means, if electric carsharing would not exist (s. B2). As mentioned in chapter 2.1.1, users of individual transport can freely decide about the times and routes of their trips and Heymann et al. (2011, p. 18) implied that carsharing engaged the flexibility and convenience of the motorized individual transport without costs or obligations of an own car. Therefore carsharing as well as electric carsharing is in a functional gap between the public and individual transport. Particularly, due to the professionalization of traditional carsharing providers as well as to the introduction of new, innovative provider (especially with free-floating concepts), the service got more flexible and thus new customer, who set great store by flexibility, could be attracted.

Lastly, three participants had taken advantage of electric carsharing for *further symbolic and emotional motives*, e. g., "*Vorbild sein*" (*being a role model*) (participant 11). Besides the environmental aspects, the pleasing electric vehicle and the interest in technological innovations, there were further symbolic and emotional motives. These three participants all noted that the bicycle is their most frequent used transportation mode.

With regard to the attitudes of users towards electric carsharing the answers of the question A2 show already a tendency of advantages and disadvantages, opportunities and risks.

An advantage is that almost half of the sample has pragmatic motives to use electric carsharing, which means that these users consider it as a suitable transport option. They used it for occasions, in which their main transportation mode is insufficient such as at a late hour, to save time, for transport or in bad weather. In these cases also flexibility and convenience play a role. According to Rogers (2003, p. 15) a compatible innovation will be adopted more rapidly than incompatible ones. The compatibility attribute of the diffusion of innovation model shows the consistence of an innovation with existing values and standards, past experience as well as needs of potential adopters (cf. Rogers, 2003, p. 240). The results demonstrate that electric carsharing seems to meet a felt need and it seems to be perceived in relationship to existing practices that are already familiar to the user.

The double environmental friendliness is also an advantage of carsharing with electric vehicles. During the professionalization of carsharing and the market entry of new providers like the integrated mobility providers or the innovative automobile manufacturer (s. section 2.1.2), carsharing became mainstream. The original environmental aspects moved more into the background and pragmatic as well as financial aspects were promoted. On the one hand new customers were gained, but one the other hand the largest user group, the environmentally aware individuals, were less addressed. This user group is readdressed by adopting an environmentally friendly product like the electric vehicle into carsharing fleets. The compatibility with the existing values of environmentally aware users is boosted. The customer retention can be increased in this group. Additionally, more environmentally aware individuals could be attracted to carsharing services. Especially individuals could be acquired now, who avoid internal combustion engines due to their noise or environmental reasons.

The pleasing electric vehicle has already attracted new customers, but there is a risk, that these new customers only use electric carsharing a few times to satisfy their curiosity and for some try outs. The aim of electric carsharing provider is to increase the occupancy rate of its fleet with users taken advantage of the service frequently and not to provide electric vehicles, which had high acquiring costs, for customers who only use it a few times for the purpose of a test drive. In the worst case, these users were only attracted to the vehicle and not to the service and then they buy an own electric vehicle without using electric carsharing again.

These findings support the second hypothesis (**H2**). Some advantages and disadvantages, opportunities and risks could be identified regard the attitudes of users toward electric carsharing. For an in-depth examination the following questions about the likes (A3) and dislikes (A4) are observed.

76 percent of the participants liked the *electric vehicle or features* of it when they used electric carsharing. The six main categories about the electric vehicle or its features are summarized under this most frequent mentioned category. 28 percent of the sample was satisfied by the *driving experience*, e. g., "*gutes Fahrgefühl*" (*good driving experience*) (participant 21). Almost one quarter was enthusiastic about the *low noise*, e. g., "*leise Fahrweise*" (*low noise driving*) (participant 13). One fifth mentioned the *acceleration* as likable, e. g., "*Beeindruckende Beschleunigung*" (*impressive acceleration*) (participant 25). Four participants liked the *offered electric vehicles* themselves, e. g., "*schöne Modelle*" (*beautiful models*) (participant 13). These participants were all in the youngest age group, three belong to the occupation group of the students and were motivated to use electric carsharing due to interest in technological innovation. Also *driving fun* was advocated by three participants, e. g., "*Fahrspaß*" (*driving fun*) (participant 2). Five participants were pleased by *further aspects of the electric vehicles* such as the automatic transmission, e. g., "*keine Gangschaltung* " (*no gearshift*) (participant 7) or the dynamic driving style, e. g., "*dynamisches Fahren*" (*dynamic driving*) (participant 12). These findings show that the electric vehicle is in the focus of electric carsharing. The vehicle got 32 mentions and therefore was mentioned more often as likeable as the service itself (adding up the number of mentions of the residual categories corresponded to 20 mentions). With one exception, all participants from the youngest age group were in this category. All participants from the occupation group of the students noted that they liked the vehicle or features. All participants using public transport as most frequent transportation mode liked the electric vehicle or features. Six of the seven participants, who were motivated to use electric carsharing because of the pleasing electric vehicle, also stated that the electric vehicle or features of it were what they like about electric carsharing. Electric vehicles also were perceived as pleasant due to low noise, acceleration and the driving experience in other studies (cf. Bühler et al., 2014, p. 35, 40; Dütschke et al., 2012, p. 17). Some of these features cannot be offered by conventional carsharing vehicles, especially the low noise. The relative advantage attribute of the diffusion of innovation model describes the improvement over the previously available idea (cf. Rogers, 2003, p. 15). Besides the measurable objective advantage (e. g., economic terms), the subjective advantage (e. g., convenience, satisfaction) play an important role (cf. Fazel, 2014, p. 94). The satisfying electric vehicle and its

features are a perceived added value over conventional carsharing and the higher this added value, the higher is the relative advantage of electric carsharing.

20 percent of the sample expresses positively the *simplicity* of electric carsharing or features of it, e. g., "*leicht zu mieten*" (*easy to rent*) (participant 25). Three of these participants also mentioned pragmatic motives for using electric carsharing. As already mentioned in chapter 2.1.3, complexity is one of the five attributes of the diffusion of innovation model according to Roger. The complexity expresses how difficult it is to use the innovation and generally ideas and products are adopted faster, if they are comprehensible (cf. Rogers, 2003, p. 15). Therefore simplicity is a great advantage that supports the widespread distribution of electric carsharing.

Again environmental aspects were considered positive by five participants, e. g., "*umweltfreundlicher als Verbrenner*" (*more environmentally friendly than combustion engine*) (participant 15). Four of them indicated that the own car was the least used transportation mode. Not all of these five participants reported environmental aspects as a motive for the usage, but only three of them stated that they also use electric carsharing due to environmental aspects. One explanation for the relatively rare mentions of this category could be that these aspects could not be experienced directly. Similarly, in the study of Bühler et al. (2014, p. 42) environmental friendliness of an electric vehicle was mentioned less frequent as an advantage by their participants after they gained more experience. Thus, they assumed that the environmental benefits of electric vehicles turned out to be less important over time (cf. Bühler et al., 2014, p. 46).

Three participants liked the *new experience* about electric carsharing, e. g., "*Neue Erfahrung*" (*new experience*) (participant 19). Only one of those participants also mentioned testing and curiosity as a purpose for using the service. All participants were self-employed. As mentioned before, an attribute of the diffusion of innovation model is the trialability, which describes the possibility of gaining first experience before the actual decision for or against an innovation is made (cf. Rogers, 2003, p. 15). Users can decrease uncertainty and are more willing to use the innovation (cf. Fazel, 2014, p. 95). Due to the elimination of monthly fees or deposits, the access threshold was reduced and thus the trialability was improved.

Three participants expressed *parking* as favorable, e. g., "*bevorzugte Parkplätze*" (*privileged parking*) (participant 26). In station-based carsharing concepts each vehicle has its own fixed parking space and vehicles of free-floating carsharing concepts can be parked free of charge in public parking spaces in the business area (s. section 2.2.1). Thus the time-consuming search for parking space can be avoided. Hoffmann et al. (2012, p. 20) found out that there is a (small) willingness to pay more for electric carsharing, if there is an option for free parking. In the study of Steiner et al. (2014, p. 6) about half of the respondents indicated anxiety of finding a parking space in time. Recently parking is privileged for electric vehicles, but it is not privileged yet for conventional carsharing vehicles (cf. Gastel, 2015, p. 1). This is also a relative advantage of electric carsharing over conventional carsharing.

Finally, two participants mentioned that they liked the *prices* of electric carsharing, e. g., "*Günstiger als klassisches Carsharing*" (*Cheaper than classic carsharing*) (participant 26). The price for using electric carsharing is different between the providers and carsharing concepts (s. section 2.2.1). For example, in Berlin the most inexpensive free-floating electric carsharing provider is Multicity with 28 cent per minute (cf. Citroën Deutschland GmbH, 2015b, p. 3). Whether electric carsharing is perceived as inexpensive, thus depends on the location and the respective provider. Therefore a general statement about the fact that the prices of electric carsharing are beneficial is not possible.

Besides the question about the positive factors of electric carsharing, the next question also asked about negative factors. The most frequent mentioned categories of the question about the dislikes of electric carsharing (A4) are *limited range* and *limited availability of electric carsharing or electric vehicles*. 32 percent of the sample complains about the *limited range* of the electric vehicle, e. g., "*geringe Reichweite*" (*low range*) (participant 3). This is one of the biggest barriers of the diffusion of electric vehicles and range anxiety is often addressed in the media (s. section 2.1.1). In the study by Hoffmann et al. (2012, p. 23 f.), forty-eight percent of the respondents stated that limited range was the reason for not using the station-based electric carsharing vehicles, but in comparison between experienced and inexperienced users, range got a better rating by the experienced ones. In the study about free-floating electric carsharing by Steiner et al. (2014, p. 6) eighty percent of the experienced users evaluated the range generally positive. It was argued that free-floating carsharing vehicles were used for shorter distances than station-based vehicles (cf. ibid). In this survey is no differentiation between both concepts. A differentiation between experienced and inexperienced users can only be made to a certain degree with the assumption that pragmatic motivated users are more experienced than users with the motive testing and curiosity. Only one of the pragmatic motivated participants noted the range, but it was mentioned by four of the seven participants who stated that they use electric carsharing for the purpose of testing and curiosity. Additionally, only one of the frequent electric carsharing users (s. A1) criticizes the range. This could indicate that the range anxiety slides into the background after gaining more experience with electric carsharing and users get accustomed to the limited range.

The *limited availability of electric carsharing or the electric vehicles* was also mentioned negatively by 32 percent of the participants, e. g., "*zu wenig Autos verfügbar*" (*not enough cars available*) (participant 10). Half of the frequent users of electric carsharing object to this category. Today, there are only two electric carsharing provider with large fleets in Berlin and Stuttgart and electric carsharing is clearly underrepresented in other cities, but the number of providers and electric vehicles in carsharing fleets is rising (s. section 2.3). Due to the limited number of electric vehicles, the opportunity to use electric carsharing is restricted. In the studies about station-based electric carsharing one of the major reasons for the low intensity of use was the low availability of electric vehicles and the low station density (cf. Scherf et al., 2013, p. 43 f.). Also major reasons for lower satisfaction with free-floating electric carsharing were a relatively low availability and a relatively small business area (cf. Ruhrort et al., 2014, p. 295). Therefore users had to go longer ways and accept more complex access routes to use electric carsharing. The user acceptance decreases, especially for users, who use electric carsharing due to pragmatic reasons or motives like flexibility and convenience. Only two participants with such motives did not like the availability. The availability of electric carsharing and the vehicles depends strongly on the location. While there are a total of 406 electric vehicle in free-floating concepts in Berlin (350 Multicity Carsharing, 40 DriveNow, 16 car2go), there are only 30 electric vehicles in free-floating concepts in Munich (by DriveNow) (s. section 2.3).

Seven participants did not like the *pricing* of electric carsharing, e. g., "*Preis ist recht hoch*" (*Price is quite high*) (participant 21). Public transport was one of the most frequent used transportation means of these participants and except participant 21, all of them positioned the own car on the last or second last place. Electric carsharing as well as conventional carsharing is more expensive than public transport and this might be a reason why these participants prefer their main transportation mode and perceived the pricing of electric carsharing negatively. As already mentioned above, the prices differ between the providers, for example, car2go offers the smart eds as well as the conventional smart for the same price (29 cent per minute), DriveNow's BMW i3 and BMW X1 are charged with 34 cent per minute, while their MINI or BMW 1 Series are only charged with 31 cent per minute, the Citroën C-Zero is offered by Flinkster in the category of the small vehicles to which also conventional vehicles belong like the Ford Fiesta and is charged between 8 am to 10 pm with 5 euro per hour and 18 cent per kilometer (cf. car2go Deutschland GmbH, 2015a, p. 2; DriveNow GmbH & Co. KG, 2015c, p. 1; DB Rent GmbH, 2014a, p. 2).

24 percent of the sample is not pleased by the *limited number of charging stations*, e. g., "*Zu wenige Lademöglichkeiten* " (*Not enough charging options*) (participant 8). The charging infrastructure was already discussed as one of the disadvantages of electric mobility in chapter 2.1.1. Once again this is partly a local problem. While the availability of the charging stations is quite well in locations like Berlin or other funded model regions, there are other regions or cities with an insufficient availability of charging stations, for example, "*Die katastrophale Ladestationsversorgung in München*" (*The catastrophic providing of charging stations in Munich*) (participant 24). Half of these participants were also dissatisfied with the limited range. It can be possible that these participants might need the charging station to use them as a range extension. Users of free-floating electric carsharing have to connect an electric vehicle to a charging station when the residual range is below a certain mileage and there is also an incentive system by which the users will get free minutes if they charged the vehicle when the battery charge level is below at a certain point (s. section 2.2.1). Thus a sufficient charging infrastructure is more important and beneficial for users of free-floating electric carsharing.

One fifth of the participants expressed issues with the *electric vehicle or features* of it, e. g., "*'billige' Machart*" (*'cheap' design*) (participant 22) or "*fallen (...) unverhältnismäßig oft aus*" (*drop out disproportionately often*) (participant 12). Both participants, who used electric carsharing less than monthly, are in this category. If the convenience of electric carsharing usage was not satisfying due to usability problems or an unpleasant vehicle, this transportation mode would not become part of their normal mobility routines. The bicycle was the most frequent used transportation mode for four of these participants and the other participant placed bicycle as the second most frequent used transportation mode. The bicycle is a reliable transportation means and as an individual transport, it is independent of timetables and driving route (s. section 2.1.1). Besides the availability, the reliability of electric vehicles is important and a poor reliability of the vehicle can lead to the perception that electric carsharing itself is unreliable. Functional efficiency and permanent availability of electric vehicles are important prerequisites for the acceptance of electric carsharing, particularly for users whose mobility behavior is strongly embedded in practice (cf. Kiermasch, 2013, p. 58). Availability and reliability also influences the compatibility of an innovation (s. section 2.1.3). Canzler and Knie (2015, p. 24) stated that immediate availability is more significant than the pleasing features of an electric vehicle.

Sixteen percent of the participants are dissatisfied with *inaccessible charging station*, e.g., "*Ladesäule versperrt oder besetzt*" (*Charging pole blocked or occupied*) (participant 25). In station-based concepts every vehicle has its own parking space and consequently its own charging station (s. 2.2.2). Thus an inaccessible charging station is more a problem for users of free-floating electric carsharing. Free-floating users have to consider the residual range of their vehicle to avoid financial penalty, if the rent is terminate with an empty battery. They are also rewarded for starting the charging process of an almost empty vehicle (s. section 2.2.2). Baum et al. (2012, p. 75) assumed that charging stations are often used, because the parking space is free for electric vehicles that are being recharged. In big cities parking space is rare and therefore the charging stations are often blocked by other vehicles.

Four participants dislike the *insufficient charge level* of electric carsharing vehicles, e. g. "*Waren nicht immer aufgeladen*" (*Were not always charged*) (participant 1). If the charge level of a vehicle is perceived as insufficient, it debases the reliability and availability, which reduces the compatibility of electric carsharing with the needs of the user. In some circumstances the residual range is not enough for the purpose of the ride and the user must reschedule. An electric vehicle cannot become charged in minutes like a conventional vehicle. Due to the current limited availability of electric vehicles, the unsatisfied user cannot replace the vehicle and uses other transportation means. In order to avoid such defaults, a reliable booking system is necessary and users need dependable information about the remaining range of an electric vehicle before booking.

Three participants complained about the *laborious charging*, e. g., "*Aufwand um an Ladestation zu fahren und auto dort anzuschließen ist deutlich höher als die 10 Bonusminuten, die man bekommt*" (*Effort to drive to the charging station and connecting the car is significantly higher than the received 10 bonus minutes*) (participant 11). Users of station-based electric carsharing need to unplug the vehicle from the charging station before the ride and they have to connect the vehicle to the station after every rent (s. section 2.2.1). This procedure takes time, especially for users with not much experience. It increases the complexity of electric carsharing and can lead to reduced convenience and flexibility. Charging is also reported as a barrier in the study of Bühler et al. (2014, p. 41 f.). Free-floating electric carsharing users are not obligated to charge the vehicle, but as already mentioned they have to observe the residual range and the willingness for charging is increased by the incentive system. The rent is calculated by minute and finding a free charging station as well as the connection of the vehicle with the station takes time and consequently money.

Two participants did not like inoperative charging station, e. g., “*Tanksäulen die nicht funktioneren*” (*charging poles that are inoperative*) (participant 5). Both participants are weekly electric carsharing user. If users of station-based carsharing concepts do not start the charging process, they have to reckon with penalties. Baum et al. (2012, p. 75) annotated, that there are compatibility problems with the charging infrastructure, because of missing standards. Participant 14 describes that he has problems with a charging station, which do not function reliably with vehicles of Multicity Carsharing and through this he often loses time and money.

Only participant 26 stated “*Ich bin rundum zufrieden*“ (*I am completely satisfied*) and thus did not reported any dislikes.

The participants had different attitudes with regard to the usage of electric carsharing. The majority of them mentioned a generally high level of satisfaction with the electric vehicles. There were only few participants, who had usability problems with the electric vehicle. Issues with the vehicle could be explained by the fact that electric mobility is in the phase of market preparation and automobile manufacturer have just begun to bring their first electric vehicles on the market (s. section 2.1.1). Participant 12 even expressed “*"Kinderkrankheiten" in der Nutzung*” (*childhood diseases in the usage*). But the development goes on and continually new, more sophisticated models launched on the market. Offering these new models in carsharing fleets could be an opportunity for carsharing provider to increase the relative advantage over conventional carsharing. The results of the survey show, that from the point of view of the user, electric mobility generally fits for the usage in carsharing concepts. Besides the vehicle, parking was reported as another relative advantage of electric carsharing and could also be explained by the window of perception as mentioned in chapter 2.2.2. Electric carsharing was not perceived as too complicated. In contrast one fifth noted the simplicity of electric carsharing and features of the service positively. If an innovation is less complex, it will be adopted faster, so this simplicity is an opportunity for electric carsharing provider to gain more potential users, especially pragmatic users. The findings also indicate that electric carsharing has favorable characteristics beyond the environmental benefits. Electric carsharing providers should increase the promotion of their reliability and the availability of their vehicles, because these factors are decisive in the choice of transportation means (s. section 2.2.2). These factors are more important than the environmental friendliness or pleasant, innovative electric vehicles to become a part of the evoked set of users and to cross the existing habits and routines, which strongly influence the everyday mobility behavior. In order to develop routines, sufficient opportunity must be available so that users can take advantage of electric carsharing. The limited availability of electric vehicles in carsharing services is disadvantageous for the widespread of electric carsharing, because it debases the compatibility and increases the complexity for usage. A greater availability of electric vehicles also benefits the observability of electric carsharing. Likewise more charging station would be advantageous for the observability. Due to the limited number of vehicles available in electric carsharing, there is the disadvantage that users are not able to gain much experience with the service and its peculiarities such as the limited range or the charging process. If users were more experienced, they would become inured to the range anxiety through self-reflection of the mobility profile, because the demand of range does mostly not correspond to the actual need of range as described in chapter 2.2.2. Thus an extended availability of electric carsharing is an opportunity to improve the use frequency and in this way users gain more experience that could lead to reduce the range anxiety. The findings show, that charging of electric vehicles often is recognized as a disadvantage. In total 36 percent are dissatisfied with charging, because of inaccessible and inoperative charging stations or because the whole charging process was perceived as laborious. Users of station-based electric carsharing always have to deal with the charging process, while refueling of conventional vehicles of station-based carsharing mostly is not necessary. Therefore the charging process lowers the relative advantage of electric carsharing. Generally, the time of the procedure does not matter for station-based users, because rent is billed by hour and consequently it does not cost extra money. This is different for free-floating electric carsharing users, where the settlement is minute based according to the pay as you go principle (s. section 2.2.1). Their vehicles do not have their own charging stations, so free charging station must be searched, which is an additional effort. It is particularly difficult in an area with a low density of charging infrastructure. The mobile app, the website of the provider or the navigation system in the vehicle supports finding the nearest suitable charging station (s. section 2.2.1), but it is not displayed, if a charging station is already connected to another vehicle or much less if the parking space is occupied. In addition, an inoperative charging station is still displayed. Solutions have to be developed for this disadvantage, especially in the light of the risk that the number of electric vehicles increases much faster than the expansion of charging infrastructure. Furthermore the charging process needs to be less laborious. As mentioned above, because of missing standards for the charging infrastructure, the usability of charging station is restricted. This is a disadvantage of electric carsharing, particularly compared the carsharing with conventional vehicles. There are charging stations, where the charging process started automatically due to a customer ID built into the charging cable (cf. CITROËN Deutschland GmbH, 2015b, p. 6). But there are also charging stations, which have to be activated by a smart card. A standardized solution would simplify the charging process and thereby increasing the convenience of users. This solution should contain as few steps as possible like the first presented variant without additional card. The additional time for charging could cause that users rarer bring the vehicles to a charging stations. This leads to the risk that more vehicles with low battery levels would be available, which would increase dissatisfaction of the users. These findings support the second hypothesis (**H_2**), because advantages and disadvantages, opportunities and risks were identified regarding attitudes of users towards electric carsharing.

Besides the personal attitudes also the affinity towards public transport influences the choice of transportation means in favor to electric carsharing (s. section 2.2.2). As already analyzed with question B1, electric carsharing is a supplementary mobility option and together with conventional carsharing, it closes the gap between public and individual transport. If a new transportation mode gets part of the choice of transportation means, the intention to use and the actual use of other transportation means will shift. According to the media, public transport would suffer mostly from electric carsharing. But the results of both first questions of block B do not indicate a so-called cannibalization effects to the disadvantage of the use frequency of public transport. 42 percent of the electric carsharing users stated that public transport is their most used transportation mode and 29 percent declared it as their second most used transportation mode after the bicycle or in one case conventional carsharing. Only 17 percent of the participants used electric carsharing more often than public transport and three of them are frequent electric carsharing users (s. participants 6, 8, 17, 26). The majority of the sample (67 percent) reported that the own car was the least used transportation mode. Only 21 percent of the participants used their own car more frequent than electric carsharing.

54 percent of the sample used electric carsharing more frequent that conventional carsharing. Eight of these thirteen participants were motivated for the usage by pragmatic reasons and seven by environmental reasons. Eight of them liked the electric vehicle or its features and four appreciated environmental aspects. All participants using electric carsharing frequently were part of this 54 percent (expect the non-response). 46 percent of the participants used conventional carsharing more often than electric carsharing. Six of these eleven participants were motivated for the usage of electric carsharing by testing and curiosity, ten of them liked the electric vehicle or its features, seven of them were dissatisfied by the limited range and four did not like the limited availability of the electric carsharing or the vehicles. Ten used electric carsharing on a monthly base and one participant used it less than monthly. These examination shows that some users of conventional carsharing were attracted by the electric vehicle or the novelty of electric carsharing, but the convenience of use was not satisfying enough to become a significant role in their choice of transportation means, due to barrier of use such as the limited range and the limited availability. According to question B2 conventional carsharing would be used by 52 percent of the participants, if electric carsharing would not exist. Considering these answers, it can be assumed that there are shifting effects. The usage of public transport seemed to be stable, but most electric carsharing users shifted their usage of an own car and conventional carsharing to electric carsharing. The shifting effect be-

tween electric carsharing and the other transportation means was examined in depth with the last question about the changes mobility behavior.

24 percent of the sample stated that their mobility behavior has *not changed* since they have been used electric carsharing. This category also is divided in three subcategories. 12 percent of the participants did not give any justification why there were no changes, e. g., “*gar nicht*” (*not at all*) (participant 16). Two participants mentioned no change because of the limited availability of electric carsharing, e. g., “*Gar nicht, die Auswahl ist viel zu gering*” (*Not at all, the assortment is far too low*) (participant 9). Participant 19 noted “*Da ich es extrem selten benutze, hat sich insofern nichts geändert*“ (*Because I use it extremly rare, nothing has changed so far*) and she also answered in question A1 that she uses electric carsharing less than monthly. The other participant (22) who also uses it less than monthly was part of the previous subcategory. The residual four participants of the main category *no change* were monthly electric carsharing users. Accordingly five participants placed electric carsharing on the fourth position of the most frequent used transportation means and the other one participant placed it on position three. The participants used electric carsharing not so often and therefore their mobility behavior did not change. Electric carsharing does not play an important role in their everyday mobility behavior. Two participants justified this by the limited availability of electric carsharing, which was already described above. No significant dislike appeared in the results. Two participants did not like the limited range and other two had issues with the electric vehicle or features. Five of the participants liked the electric vehicle or features of it. The most mentioned motive in this group was pragmatic reason by four participants. Five of them reported that the bicycle was their most or second most frequent used transportation mode and all of the used public transport more often than electric carsharing. It seems that public transport and the bicycle for most of these participants is a more appealing mobility offer, which is better suited to the needs of these users. No one of this group was motivated for using electric carsharing by reasons like flexibility or convenience and comfort. This indicates that the other transportation means are more flexible and convenient.

16 percent reported that their mobility behavior *barley* has changed, e. g., “*So gut wie gar nicht*” (*almost not*) (participant 24). These participants used electric carsharing on a monthly base and belong to the youngest age group. Among others, two participants disliked the limited range and the residual two did not like the pricing of electric carsharing. Public transport was used more frequent than electric carsharing. They only liked the electric vehicle or features of it, which also indicated that they were attracted by the electric vehicle, but the usage of electric carsharing was not satisfying enough to make it part of their common mobility routines.

24 percent of the participants does not see any need for an *own car* since they use electric carsharing, e. g., “*kein Auto gekauft*” (*did not buy a car*) (participant 6). Four of these six participants were frequent electric carsharing user according to question A1. All of them used electric carsharing more frequent than conventional carsharing (expect the non-response). Four

were motivated by financial reasons and four mentioned environmental motives. None of them stated dissatisfaction with the limited range and none of them is part of the oldest age group. These results show that journeys with an own car are shifted to electric carsharing. These answers describe the trend reversal of mobility behavior which was mentioned in chapter one. The car significantly loses its impact as a status symbol, especially among the younger generation (cf. Doll et al., 2011, p. 1). Because of the new usage concept of sharing-instead-of-owning, using an own car shifts towards using a common good. This development is an opportunity for carsharing in general. As already mentioned in chapter 2.1.2, with carsharing the convenience and flexibility of the passenger car can be captured without carrying the obligations or costs of an own vehicle. The study of Firnkorn and Müller (2015, p. 34 f.) showed that the willingness to abdicate an own car acquisition is greater for electric carsharing users than for conventional carsharing users. That electric carsharing vehicles can replace an own car or at least avoid the (re-)acquisition of an own car and therefore decreases the number of privately owned vehicles, is an important argument for state actors in supporting of electric carsharing.

The most frequent main category was *using less other transportation means* by 28 percent of the participants. This category is subdivided in three subcategories. 16 percent of the participants stated that they reduced use of *public transport*, e. g., "*ÖVM deutlich weniger genutzt*" (*public transport significantly less used*) (participant 17). All of them used least the own car, whereby two of them did not have an own car. Two of these four participants were frequent electric carsharing users. In the next subcategory, two participants used the *bicycle* less since they took advantage of electric carsharing, e. g., "*Nutze weniger das Fahrrad*" (*Using less the bicycle*) (participant 1). Participant 8 mentioned that he reduced the use of *conventional carsharing* "*Viel seltener konventionelles Carsharing*" (*Much less conventional carsharing*). He also reported that he used electric carsharing more frequent than conventional carsharing. Only two of the four participants, who stated that they used less public transport, also answered that they used electric carsharing more frequent than public transport and likewise the participants, who used less the bicycle, noted that the bicycle is their most frequent used transportation mode. Only one of these participants specified that electric carsharing is his most frequent used transportation mode. These findings show that there are shifting effects mostly from public transport to electric carsharing, but also from the bicycle as well as from conventional carsharing to carsharing with electric vehicles. But these shifting effects are not so huge, which means electric carsharing could not replace the main transportation mode of the users except in one case (s. participant 6). However, electric carsharing became the second most frequent used transportation mode for three of these participants.

Sixteen percent of the sample would *prefer electric carsharing* over conventional carsharing, e. g., "*Versuche die Elektrovariante vor der konventionellen zu Bevorzugen*" (*Try to prefer the electric variant over the conventional*) (participant 25). They used electric carsharing on a monthly base. Public transport or the bicycle were the most or second most frequent used transportation means, while the own car was the least used transportation mode for all of them. But only one of these four participants specified that he used electric carsharing more frequent than conventional carsharing. The other three participants placed conventional carsharing on the third position and the electric variant on the fourth position. These three participants used electric carsharing for the purpose of testing and curiosity liked the electric vehicle or its features and did not like the limited range. Two of them were also unsatisfied with the availability of charging stations and electric carsharing or the vehicles. This indicates that both participants would use electric carsharing more frequent, if its availability would be better. The three participants would like to shift their journeys with conventional carsharing to electric carsharing, but the current circumstances prevent this.

Sixteen percent of the participants *weighted* between carsharing and other transportation means before they use it, e. g., “*aufgrund Kosten/Nutzen*” (*due to cost-benefits*) (participant 14). All of them did not like the pricing of electric carsharing, but they like the electric vehicles or their features. Three of the four participants mentioned flexibility and pragmatic reasons as their motives for the use of electric carsharing. These participants optimize their mobility practice according to their needs. Three of them are in the youngest age group. According to Arnold et al. (2010, p. 51 f.), this age group pragmatically selects between different mobility options and chooses the transportation mode, which is the most flexible and inexpensive one.

Fittingly, *flexibility* was mentioned by three participants according to question B3, e. g., “*Höhere Flexibilität*” (*higher flexibility*) (participant 10). Two of them used electric carsharing 1 -3 days per week. These answers indicate that the mobility behavior of these participants has changed to more flexibility. Their mobility routines include carsharing and according to Ruhrort et al. (2014, p. 297) these routines can be routines of flexibility which means they are stable patterns of flexible choice (s. section 2.2.2).

Also the results of question B3 support the third hypothesis that electric carsharing is not the main transportation mode, but more a supplementary mobility option. Electric carsharing did not change the mobility behavior of 24 percent of the participants and it did only barely change the behavior of 16 percent. These ten participants did not use electric carsharing frequently and therefore their journeys with other transportation means were mainly not shifted to electric carsharing. Consequently, hypothesis five (**H_5**) cannot be supported by forty percent of the sample. On the other hand 24 percent of the participants mentioned that they did not need an own car since they used electric carsharing. In this case the mobility behavior has shifted from the use of an own car towards the use of electric carsharing. But only one participant specified that electric carsharing is his most frequent used transportation mode. The other participants preferred public transport or the bicycle. Thus some journeys with an own car were shifted to electric carsharing, but not all. Additionally, 28 percent of the participants stated that they use less public transport, the bicycle or conventional carsharing. But again electric carsharing could not replace all journeys with these transportation means, except participant 6, who stated using less public transport. The fifth hypothesis (**H_5**) can only be supported by participant 6. Only some journeys with public transport, the bicycle or conventional carsharing were shifted to electric carsharing by the residual six participants. Thus the fifth hypothesis (**H_5**) is not significantly supported by the data.

5. Discussion of the Results and Implications

The results of the data mining analysis and the survey show, that from the point of view of the user, electric mobility generally fits for the usage in carsharing concepts. Advantages and disadvantages as well as opportunities and risks were identified with regard to the attitudes of users towards electric carsharing. Additionally, the survey investigated the shifting effect between electric carsharing, conventional carsharing, public transport, the bicycle and the own car when using electric carsharing.

The participants of the survey were predominantly male electric carsharing users. The gender of the opinion holder of the data mining analysis was not identified, because they mostly used usernames and in some cases these names were unisex. Nevertheless, most names and texts could be associated to men. Especially the users of DriveNow were male. But there were also several female opinion holders and most of them wrote about Multicity Carsharing (s. opinion holders 1 - 3, 11, 32 – 34, 41, 52, 92, 93). The opinion holders were predominantly urban residents and assumedly most of the survey participants were urban residents, too, because electric carsharing is offered mainly in urban agglomeration. These characteristics are consistent with other studies about electric carsharing (cf. Steiner et al., 2014, p. 5; Hoffmann et al., 2012, p. 12). Similarly, the majority of the survey sample was well-educated, mainly between 18 - 40 years and employed, which correspond to previous analyzed electric carsharing users (cf. Scherf et al., 2013, p. 42; Firnkorn and Müller, 2015, p. 33). The main transportation means of the participants were preponderantly public transport and the bicycle, whereby mainly the own car was the least used transportation mode. According to other studies about electric carsharing (s. section 2.2.2) it can be assumed that the opinion holders of the data mining analysis had similar mobility behaviors. In the rarest of cases, electric carsharing became the main transportation means. Therefore public transport and the bicycle are probable no firm opponent for electric carsharing, but rather electric carsharing compensates their weaknesses and complements both transportation means. It seems that the own car also is not a direct competitor, at least in those both samples of urban residents. Together with conventional carsharing, electric carsharing is in a functional gap between public and individual transport. Both carsharing variants are used supplementary. Many opinion holders were already conventional carsharing users before they had used electric carsharing. In the survey approximately one half of the sample used electric carsharing more frequent than the conventional offers and the other half used conventional carsharing more often than the electric variant. The majority would use conventional carsharing, if electric carsharing would not exist.

Therefore, assumedly the biggest rival of electric carsharing is conventional carsharing. The participants of the survey mostly used electric carsharing on a monthly basis. In contrast, most texts about electric carsharing were posted after the first use experience of the opinion holders. Presumably, the answers of the survey were given by more experienced electric carsharing users and the opinions were written by electric carsharing users, who had less experience at the time. The majority of both samples mentioned a generally high level of satisfaction with the electric vehicles and the driving characteristics. Better acceleration, high driving pleasure and low noise emission are significant unique selling proposition of an electric vehicle compared to a conventional vehicle. Such driving characteristics are a relative advantage of electric carsharing over conventional carsharing. The technical fascination around electric vehicles and the charisma of electric vehicles could also increase the attractiveness of electric carsharing as against the conventional variant. New car models were more attractive than the predecessor models for the opinion holders. The BMW i3 or the Renault Zoe are more sophisticated and thus fewer problems with them were reported. The reputation of electric carsharing is improved by newer, refined car models with more convenient, ingenious automotive accessories. Through this, technically interested, fun-oriented and car affine customers can be gained for electric carsharing. Due to the electric vehicles and their features, electric carsharing also has the opportunity to address individuals, who have no experience with carsharing or were reserved towards carsharing previously. For these users the trialability of the innovation is relevant. In particular, free-floating electric carsharing has a good trialability, because of low access thresholds. In the free-floating concepts are no monthly fees, they have a simple pricing system with only a time component and they enable location independent usage within a business area. Besides the trialability, the observability also speeds up the adoption of an innovation and is necessary so that potential users notice the pleasant electric vehicles. But the observability depends on the availability of the innovation and the limited availability of electric vehicles was a frequently mentioned disadvantage of electric carsharing in both analyses. User acceptance decreases, if users have to go longer and more complex access routes to use electric carsharing. The limited availability of electric carsharing was one of the main reasons, why the use frequency of electric carsharing was low and the participants were not able to integrate the service to their mobility routines. But the availability of electric carsharing is a local barrier. There are cities like Berlin, where the availability of electric carsharing was expressed positively. It can also be assumed, that the limited availability is only a current problem, because the numbers of electric vehicles in carsharing fleets are rising. If the mobility context changes, in this case more offers of electric carsharing, there will be a new conscious decision-making process regarding the mobility behavior of potential users. When the availability rises, the disadvantage could be turned into an advantage. Some participants were even motivated to use electric carsharing due to the good availability. Likewise other pragmatic reasons were noted as motives for the use of electric carsharing such as no own car, supplementary to public transport or bicycle or for time savings. Pragmatic reasons was the most frequent mentioned motive in the survey, but these pragmatic motivation for the use of electric carsharing can also be operated by conventional carsharing. Therefore this motive shows that electric carsharing is compatible with the needs of its users, but it is not a relative advantage against conventional carsharing. Only the good availability can be an advantage, if the availability is higher than conventional carsharing. For example in Stuttgart no conventional carsharing provider offers the free-floating concept, but there is a free-floating electric carsharing provider, which means the availability and flexibility of electric carsharing is higher. Besides the pragmatic motives, users of electric carsharing need additional motives to use the electric variant instead of the conventional. As already mentioned above, technical interest and car affinity can be addressed additionally by electric carsharing. Also motives from the environmental awareness of the users can be operated better by electric carsharing, because it is more environmentally favorable. Environmentally aware users are the original user from the classic carsharing concepts and the biggest customer group of carsharing. The compatibility with the existing values of environmentally aware users is boosted and the customer retention can be increased in this group. Additionally, more environmentally aware individuals could be attracted to carsharing services. Especially those individuals could be acquired now, who avoid internal combustion engines due to their noise or environmental reasons. But environmentally friendliness was not mentioned more positive than the pleasing electric vehicle or its features in both analyses. One reason might be that the environmental friendliness of electric carsharing cannot be experienced directly. In the literature about electric carsharing or electric mobility the environmentally friendliness is one of the most important advantages and it is also promoted strongly in the media. Environmental friendliness is a far-reaching concept. Assumedly it is not very tangible and it is difficult to grasp for users, who not deal with this subject in depth. Electric carsharing providers should take more attention to the reasons that turn it into an environmental friendly concept. Two participants of the survey mentioned the improved air quality, which is easier to imagine. Many people are disturbed by the car exhaust gases and smog, which are also associated with significant health problems. This issue has recently been greatly discussed again in the course of the VW emissions scandal. Such environmental scandals are an opportunity for electric carsharing providers to promote their environmental benefits. Another relative advantage of electric carsharing over conventional carsharing is a new car number plate, which provides certain privileges in road traffic such as free parking on chargeable public parking spaces and driving on bus lanes. Hamburg is one of the first cities which will offer this opportunity since the law of electric mobility was changed (cf. Meyer-Wellmann, 2015, p. 1). This advantage should be used and promoted by electric carsharing providers. Electric vehicles can also be parked freely at charging stations, when the vehicle is connected with the station. But the limited availability of charging stations is another major disadvantage of electric carsharing and mentioned negatively in both analyses. This is particularly a problem of free-floating electric carsharing users and it also depends on the location. While Berlin and Stuttgart had an acceptable infrastructure, there are fewer stations in Munich. The risk is that the number of electric vehicles will increase even more, while the expansion of the charging infrastructure still stagnates. The carsharing providers have to co-operate more with the owners of the charging stations. Other problems also occur while trying to use the charging stations. Participants as well as opinion holders complain about inaccessible and inoperative charging stations. When they search for the nearest charging station, the navigation systems or mobile apps do not display, if a station is defect or occupied by another vehicle. At least users need the possibility to recognize in advance, if a charging station is already connected to another vehicle or if the station is out of commission. To implement this technically, the electric carsharing provider need arrangements with the owners of the charging stations, which would have the benefit that their stations would be better utilized. Larger fines should be levied against occupying charging station by conventional vehicles. To expose these parking offenders more often, an incentive system could be helpful while the user achieves free minutes by reporting illegal parking. This incentive would also be fair, because it takes more time and therefore more money, if a station is blocked and another station needs to be found. A disadvantage of electric carsharing over conventional carsharing can be the charging process. In free-floating electric carsharing concepts, connecting the vehicle to a charging station and starting the charging process should not be part of the rental period, which means the termination of the rent should be possible before connecting to the charging station. All three free-floating electric carsharing providers have different incentive systems with various amounts of free minutes and disparate limits of residual range (s. section 2.2.1). It seems that a suitable system has not been found yet and there is still a need for further research in this area. Electric carsharing users need to be convinced by the carsharing service and the vehicles. The convenience of use must be high enough to make electric carsharing part of their usual mobility routines. The navigation system and the mobile app are important for electric carsharing users as for users of conventional carsharing, because both support the search for charging station. Electric carsharing providers should place a higher priority on these instruments and should prefer the latest technology. In order to overcome such disadvantages like the space of the vehicle or the limited range for long distance journeys, cooperation with other carsharing providers or car rental companies might be beneficial. These cooperation partners could be used as complements, increasing the multiplicity of provision and covering other motives for usage. Electric carsharing as an offer in mobility packages together with frequently used transportation means could further reduce the first access threshold. These mobility packages and cooperation might also be advantageous for users, who have uncertainties about the limited range. The range anxiety could be reduced, if the users could use a safe option as an alternative just in case. Both analyses contained negative statements about the limited range and the battery performance of electric vehicles. These concerns can be partly explained by the limited experience of the users. The actual need of range is often below the demand of range of electric carsharing users. Through growing experience and more routine, users get accustomed by the restriction and know how to deal with a low battery level. It

can be assumed that the range of electric vehicles will improve in the long term, because several new battery technologies are in research and development to counteract the range problems. There are also various forecasts that predict strongly reducing battery prices in the next five years and therefore the acquisition costs of electric vehicles decrease. On the other hand the oil prices continue to rise, which could cause raising prices of conventional carsharing. Under these circumstances it might be possible that electric carsharing will be more inexpensive than conventional carsharing, which is a huge opportunity to gain more customers due to financial considerations.
User opinions are important to improve offerings and the service of electric carsharing and to learn more about the motives, likes and dislikes of the users. Electric carsharing provider should offer more opportunities to review the usage. Comparing the three free-floating electric carsharing providers, only Multicity Carsharing allows reviews on their Facebook Page. But this leads to the risk that the users write unilateral about their most disadvantages or advantages. A review system with some fixed categories and the opportunity to write a detailed report should be introduced by the electric carsharing providers. One example for a suitable and helpful review format is on the review site ciao.de. Here the reviewer is asked to write some brief pros and contras separately and also rate some important fixed categories (e. g., service, condition of the vehicles, availability) and then they can give a detailed review.

6. Discussion of the Research Methods, Limitations and Further Research

This study showed the opportunities and risks of electric carsharing regarding attitudes of electric carsharing users as well as the shifting effects between the five common transportation means when using electric carsharing. Initially, the opinions of electric carsharing users on the internet were analyzed by data mining and then a survey was conducted to examine motives and attitudes of electric carsharing users as well as their changed mobility behavior.
The texts containing opinions about electric carsharing usage for the data mining analysis were released during an early adoption stage of electric carsharing. The opinion holders mostly wrote about their first experiences with the service and the electric vehicle. These opinions may change after more experience with electric carsharing and with further development and expansion of electric carsharing. It would be interesting to investigate their opinions towards electric carsharing and their frequency of use after the first try outs. Additionally, a data mining analysis of the booking details of electric carsharing users could improve the interpretation of the results. The sample mostly contains early adopters as well as innovators and residents of urban areas, especially Berlin, were over-represented. Therefore the sample is not representative of the average population, which requires further research. In particular, the opinions on the availability of charging stations and electric carsharing strongly depend on the location of the opinion holder. Likewise the time varies, when the texts were released. Opin-

ion holder of 2012 might had other experiences than opinion holders from this year. The availability of electric carsharing has risen and the vehicle models have been improved. Another limitation that should be taken into account is that the results presented here are based on opinions mainly from users of free-floating electric carsharing. In a sample that contains only station-based electric carsharing users, negative expressions about the limited range may occur more often and issues with public charging stations would not mentioned frequently.
It also has to be noted that 905 sentences or respectively 117 text documents are fairly limited. The more data are available, the more reliable are the results. Electric carsharing is at an early stage of market penetration and texts about user opinions are very limited. It seems that it is not common to rate carsharing in general on review sites. There are review sites that are specialized on carsharing, but these are currently not well accepted. The text documents were written about the experience with a specific electric vehicle or a particular electric carsharing provider. Electric carsharing in general was not mentioned frequently. Therefore, the opinions strongly related to these electric vehicles or electric carsharing providers. It seems that opinion mining about electric carsharing needs much more data, in order to achieve a high degree of representativeness and generalisability. The electric carsharing providers differ from each other even within one of the two carsharing concepts in terms of pricing, choice of vehicle, number of vehicles or density of the stations or the size of the business area. In view of this, the individual electric carsharing providers should be analyzed separately according to aspect-based opinion mining and then the result could be compared to each other. Opinions of users are an interesting and important piece of information for electric carsharing providers to improve their service or introduce new product offerings. The internet, especially the web 2.0, provides a source of user opinions. Data mining with its method aspect-based opinion mining offers a cost-effective analysis of these user opinions. Besides being cost-effective, opinion mining has some advantages over conventional primary research methods such as no influence on the interviewers, free expression of opinion, natural communication situation without guidelines, strong subjective information content, relatively short implementation periods and no effort in creating a questionnaire or finding a sample. Disadvantages are the generalization and representative, because only opinions of internet users are analyzed. Individuals, who do not use the internet, are excluded from the analysis, which is a certain self-selection. In this analysis, it can be assumed that electric carsharing users are predominantly internet users, because the internet is used for booking and locating the vehicle as well as in some cases for opening the vehicle. Another issue of opinion mining is opinion spam, which means some opinion holders give dishonest reviews that shall promote or demote some products, services or organizations (cf. Liu, 2011, p. 460). Aspect-based opinion mining as well as data mining itself cannot be considered as mature research fields und failure rates are high. Since the research is still in the early stages, there is also a development requirement in the field of data mining tools. Software tools cannot understand or interpret texts as humans do. In this data mining analysis the tool RapidMiner was chosen (s. section 4.1.2). The quick further devel-

opment of the tool suggests that the developers identify improvement potential continuously and implement them into new application within the tool. RapidMiner is clearly structured and a lot of partial steps are intuitive and easy to learn. The manual (s. RapidMiner, 2014) and the operator reference manual (s. RapidMiner, 2015) were helpful up to a certain degree. But there is no documentation for the operators of the Text Processing Extension. The three chapters about text mining in Hofmann and Klinkenberg (2014) as well as the forum of RapidMiner could provide remedy. Notably, answers of questions by the developers of RapidMiner prove to be particularly helpful and a professional response can be expected within two business days generally. Mostly remedy could be provided by independently trying out different alternatives until the correct setting is found for the desired outcome. A range of manual reviews of the data had to be done to clean the data prior to load them into RapidMiner. The POS tagging leaded to some mistakes. There were also problems with ambiguous terms. Dealing with opinion shifters is not provided by RapidMiner, which caused distortion especially in terms of the precision. The review of RapidMiner shows that the software tool is still strongly developable. However, it is doubtful that there are much better alternatives, since the research in the area of opinion mining, especially aspect-based opinion mining, is still in its early stages. In particular, the linguistic peculiarities of a language complicate the development of an error-free technical implementation. The quick further development of RapidMiner assumes that this software tool simplifies the practical use of opinion mining for users in the future. Nonetheless, there has been rapid progress in the research field of data mining and the process of aspect-based opinion mining is being continually enhanced. Higher benefits will ensue, when the technologies improve.

In order to increase the values of the performance measures in this data mining analysis, further improvements are desirable. In the first place the amount of data has to increase. Better results should be achievable by further enlargement of the used dictionaries. There are some limitation of the selected approaches and tasks. The implicit expressed aspects and opinion words were not considered. This leads to a decreasing accuracy. Furthermore, the intensity of opinions can be very useful to identify the stronger opinion orientation of an aspect if there are positive as well as negative opinion words. Another issue is that evaluating opinions can sometimes be subjective, especially when a sentence does not clearly express an opinion (cf. Hu and Liu, 2004a, p. 175). The high values of precision and recall of extracting aspects should be considered critically, because the wordlists of the aspects were generated manually from the author, who also evaluated the sentences manually. In the aspect electric vehicle components were several components that were not specific for electric vehicles but could rather appear for conventional carsharing vehicles. A separate aspect should be created for general vehicle components. If there would had been a larger amount of data or the data would had contained only opinions about one electric carsharing provider, the two aspects electric vehicle components and carsharing components should had been divided in more separate aspects. In order to get familiar with the data and to create optimal wordlists, a part of the material should be analyzed manually by qualitative content analysis.

An online survey with open-ended questions can be compared to data collection of opinion mining. It is also cost-effective and it has strong subjective information content, because participants freely express their answer without predetermined response options. But there is an effort through questionnaire creation and finding a sample. The implementation period is much longer and manually analyzing amounts of text is time-consuming. There are risks that the rate of returns is low, questions could be misunderstood and answers could be denied. Qualitative content analysis according to Mayring is suitable for the analysis of the open-ended questions, because of its rule-based approach and the traceability of the analysis is given by the category system with its coding agenda and anchor examples. A disadvantage of the category-based analysis might be that the focus on the individual case can get lost. Same as previously mentioned the sample of the survey included predominantly male, well-educated and employed participants, which also indicates that the sample contains mainly innovators and early adopters. This requires further research with a sample that is more representative of the average population. In this sample the use of an own car was very low and the participants were first and foremost users of public transport and the bicycle. It would be interesting how the results change, when the sample contains more participants, who frequently use the own car. All participants were electric carsharing users, but the frequency of use was relatively low. One reason for this was the limited availability of electric vehicles and therefore electric carsharing. Further research is necessary when the availability of electric carsharing rises to investigate if the frequency of use would rise due to more availability. Comparing frequent and infrequent electric carsharing could be interesting, but only seven of the twenty-six participants used electric carsharing more or at least on a weekly basis. According to the literature research of Fazel (2014, p. 227) forming suitable subgroups need at least thirty participants in each group. Further research could also examine the motives behind the non-usage of electric carsharing. Answers of the participants also depend on their location and which electric carsharing provider they had used. But the answers were more directed to electric carsharing in general than to a specific electric carsharing provider. It can be assumed that the generalization of the survey is better as of the data mining analysis. It also seems that the participants had more experience with electric carsharing as well as carsharing in general. Besides the use frequency of electric carsharing, the use frequency of conventional carsharing would be interesting, because conventional carsharing is the main competitor to electric carsharing. Some participants mentioned that they would prefer electric carsharing over the conventional variant. This statement needs to be investigated especially against the background of the rising availability of electric carsharing. The stability of user dissatisfaction with the range and the charging process require further analysis, in particular after gathering more usage experience, especially after raising the availability of electric vehicles as well as of the charging stations. This survey only contains electric carsharing users, but it might be beneficial for electric car-

sharing providers to analyze non-users and their reasons why they do not use electric carsharing as well as what aspects are necessary to change their behavior. The question B1 should be improved, because two participants could not give correct answers and there were participants, who for example never used an own car, because they do not own a car. A question about bicycle and car ownership should be added as well as questions about the use frequency of the other transportations means according to question A1. A before and after usage of electric carsharing comparison could be recommended to investigate the shifting effect more precisely.
Both analyses are based on subjective statements and in order to increase the credibility of these analyses, quantitative studies should been conducted. Further research should investigate how electric carsharing can be optimized to become a bigger part in user daily mobility routines with considering that carsharing is a complement of users main transportation means for specific use cases.

7. Conclusion

With regard to the growing population, increasing urbanization, raising environmental impacts and dwindling oil resources, new mobility concepts are needed that can contribute to the reduction of motorized individual transport and to address the mentioned challenges. Today's mobility behavior is not sustainable and feasible in the long run. Electric carsharing is an in both senses efficient and environmentally friendly mobility concept, which rises to the challenge of changing current mobility behaviors. The aim of this study was to identify opportunities and risks with regard to the attitudes of users about electric carsharing and to investigate the shifting effects between electric carsharing, public transport, own car and conventional carsharing when using electric carsharing. For this purpose the most important theoretical basics about electric mobility, carsharing and their connection to electric carsharing were presented in the first part of the second chapter. The typical usage of electric carsharing and characteristic of electric carsharing users as well as influential factors on the choice of transportation means were explained in chapter 2.2. The current status of electric carsharing in Germany was established in preparation for the data collection. Furthermore in chapter three the research method data mining and its specific field text mining with the special method aspect-based opinion mining was described. The fourth chapter started with the development of the process model of the data mining analysis. According to the CRISP-DM process model its six phases were conducted in the sections of chapter 4.1. First the software tool RapidMiner was selected. Then the texts that contain opinion about electric carsharing were collected and prepared for aspect-based opinion mining. In this phase, a wordlist of aspects of electric carsharing were created by POS tagging and an existing wordlist, which comprises opinion words and their orientation, was adjusted. The data were loaded into RapidMiner and in the Modeling phase the analysis took place. After that the interpretation of the results and the evaluation of them were carried out. The first part of the fourth chapter ended with the last phase of the CRISP-DM. The second part of the fourth chapter comprised the survey of electric carsharing users. First the sample was selected and the questionnaire was created. Then the survey was implemented and the closed questions were examined before conducting qualitative content analysis according to Mayring to analyze the results of the open-ended questions in the next section. Chapter 4.2 ended with the interpretation of the results of the survey. In the fifth chapter the results of both analyses were discussed and implications were presented. After that the discussion of the research methods including limitations and further research took place.

The results presented here give reason to argue that electric carsharing is an attractive mobility concept, which can satisfy the needs of its users, regardless of whether pragmatic reasons, environmental awareness or interest in cars and technology play a role. It can be shown that electric carsharing is especially well adapted to the typical mobility patterns of conventional carsharing users. The satisfaction of the service depends on the electric vehicle and its characteristics, but it also depends on factors such as simplicity, high availability of vehicles or the condition of vehicles, which are not specific for electric carsharing and rather apply to any carsharing service. The findings suggest that the navigation system and the mobile app are important instruments, especially for free-floating electric carsharing users and should be placed to a higher priority by electric carsharing providers. Both are auxiliary means for the search for the nearest charging stations and here is room for improvements, since inoperative and inaccessible charging stations are displayed. The improved law of electric mobility is an opportunity for electric carsharing, because it allows free parking and driving on bus lanes, which are relative advantages over conventional carsharing as well as own conventional cars. Both analyses contained negative statements about the limited availability of electric carsharing and the charging infrastructure. There is a risk that the increase of the number of electric vehicles continues, but the expansion of the charging infrastructure is still too slow. In order to change current mobility behaviors, the availability of electric carsharing has to rise. When the availability of electric carsharing increases, the use frequency could be higher and therefore users gain more experience with the vehicles and the service. With more experience the users get accustomed to the limited range and the charging process. Electric carsharing is part of the mobility routines of most of its users, but the use frequency is still low. That is why shifting effects between the common transportation means and electric carsharing only appear marginal. Most users shift from conventional carsharing to electric carsharing and the own car was no longer necessary. Electric carsharing as well as conventional carsharing are supplements to the main transportations means of the users, which were public transport and the bicycle. The own car played a minor role, but there were use purposes that need to be covered with motorized individual transport.

In the future, an innovative, attractive urban mobility system will be one that provides favorable conditions for bicycle users as well as a high quality public transport system combined with a selection of options for using motorized individual transport such as the flexible free-floating electric carsharing and station-based carsharing with vehicle for transport and long distances.

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Appendix

Appendix A: Overview User Opinions about Electric Carsharing

Part 1:

Opinion holder	Source	Kind of source	Time	Provider	City	Electric vehicle
1	ciao.de	Review site	15.08.13	Multicity	Berlin	Citroën C-Zero
2	ciao.de	Review site	03.08.13	Multicity	Berlin	Citroën C-Zero
3	ciao.de	Review site	16.08.13	Multicity	Berlin	Citroën C-Zero
4	ciao.de	Review site	16.09.13	Multicity	Berlin	Citroën C-Zero
5	ciao.de	Review site	05.08.13	Multicity	Berlin	Citroën C-Zero
6	ciao.de	Review site	17.08.13	Multicity	Berlin	Citroën C-Zero
7	ciao.de	Review site	19.08.13	Multicity	Berlin	Citroën C-Zero
8	ciao.de	Review site	05.09.13	Multicity	Berlin	Citroën C-Zero
9	ciao.de	Review site	14.04.14	car2go	Stuttgart	smart ed
10	Blog	Blog	25.08.13	Multicity	Berlin	Citroën C-Zero
11	Blog	Blog	08.06.14	Multicity	Berlin	Citroën C-Zero
12	carsharingchecker.com	Review site	18.06.13	car2go	Stuttgart	smart ed
13	carsharingchecker.com	Review site	25.01.15	Flinkster	Köln	E Ford Focus
14	carsharingchecker.com	Review site	08.03.13	Multicity	Berlin	Citroën C-Zero
15	carsharing-experten.de	Review site		car2go	Stuttgart	smart ed
16	carsharing-experten.de	Review site		stadtmobil	Karlsruhe	Fiat 500 Elektro
17	blog.car2go.com	Comment	08.11.11	car2go	Ulm	smart ed
18	blog.drive-now.de	Comment	05.06.13	DriveNow	Berlin	BMW ActiveE
19	blog.drive-now.de	Comment	06.06.13	DriveNow	Berlin	BMW ActiveE
20	blog.drive-now.de	Comment	06.06.13	DriveNow	Berlin	BMW ActiveE
21	blog.drive-now.de	Comment	06.06.13	DriveNow	Berlin	BMW ActiveE
22	blog.drive-now.de	Comment	07.08.13	DriveNow	Berlin	BMW ActiveE
23	blog.drive-now.de	Comment	12.06.13	DriveNow	München	BMW ActiveE
24	blog.drive-now.de	Comment	16.06.13	DriveNow	München	BMW ActiveE

25	blog.drive-now.de	Comment	19.06.13	DriveNow	München	BMW ActiveE
26	blog.drive-now.de	Comment	27.02.14	DriveNow	München	BMW ActiveE
27	blog.drive-now.de	Comment	17.08.15	DriveNow	Hamburg	BMW i3
28	blog.drive-now.de	Comment	15.07.15	DriveNow	Berlin	BMW i3
29	blog.drive-now.de	Comment	18.07.15	DriveNow		BMW i3
30	Blog	Blog	15.06.13	DriveNow	Berlin	BMW ActiveE
31	Blog	Blog	15.09.13	Multicity	Berlin	Citroën C-Zero
32	Blog	Blog	08.08.13	Multicity	Berlin	Citroën C-Zero
33	Blog	Blog	12.08.13	Multicity	Berlin	Citroën C-Zero
34	probierpioniere.de	Comment	26.07.13	Multicity	Berlin	Citroën C-Zero
35	probierpioniere.de	Comment	28.07.13	Multicity	Berlin	Citroën C-Zero
36	probierpioniere.de	Comment	29.07.13	Multicity	Berlin	Citroën C-Zero
37	probierpioniere.de	Comment	30.07.13	Multicity	Berlin	Citroën C-Zero
38	probierpioniere.de	Comment	15.08.13	Multicity	Berlin	Citroën C-Zero
39	probierpioniere.de	Comment	19.08.13	Multicity	Berlin	Citroën C-Zero
40	Blog	Blog	29.08.13	Multicity	Berlin	Citroën C-Zero
41	Blog	Blog	03.09.13	Multicity	Berlin	Citroën C-Zero
42	Blog	Blog	05.06.13	DriveNow	Berlin	BMW ActiveE
43	Blog	Blog	15.05.13	car2go	Stuttgart	smart ed
44	Blog	Blog	04.03.13	car2go	Stuttgart	smart ed
45	Blog	Comment	01.05.13	car2go	Stuttgart	smart ed
46	Blog	Blog	17.02.13	car2go	Stuttgart	smart ed
47	Blog	Blog	03.12.12	car2go	Stuttgart	smart ed
48	Blog	Blog	16.09.14	car2go	Stuttgart	smart ed
49	Blog	Blog	01.02.14	DriveNow	Berlin	BMW ActiveE
50	Blog	Blog	01.03.14	Multicity	Berlin	Citroën C-Zero
51	Blog	Blog	21.02.13	Flinkster	Berlin	smart ed
52	Blog	Blog	06.10.14	Multicity	Berlin	Citroën C-Zero
53	Blog	Blog	25.09.14	Multicity	Berlin	Citroën C-Zero

54	Facebook	Social network	13.03.14	Multicity	Berlin	Citroën C-Zero
55	Facebook	Social network	12.12.13	Multicity	Berlin	Citroën C-Zero
56	Facebook	Social network	21.02.15	e-Golf	Dresden	teilAuto
57	Google+	Social network	17.08.13	Multicity	Berlin	Citroën C-Zero
58	Google+	Social network	11.11.12	Multicity	Berlin	Citroën C-Zero
59	Google+	Social network	07.05.12	Flinkster	Berlin	smart ed
60	Google+	Social network	08.08.13	DriveNow	Berlin	BMW ActiveE
61	Facebook	Social network	08.01.15	Multicity	Berlin	Citroën C-Zero
62	Facebook	Social network	07.12.14	Multicity	Berlin	Citroën C-Zero
63	Facebook	Social network	02.07.14	Multicity	Berlin	Citroën C-Zero
64	mietwagen-talk.de	Forum	01.01.14	DriveNow	München	BMW ActiveE
65	mietwagen-talk.de	Forum	22.11.13	DriveNow	Berlin	BMW ActiveE
66	mietwagen-talk.de	Forum	22.11.13	DriveNow	München	BMW ActiveE
67	mietwagen-talk.de	Forum	20.10.14	DriveNow	München	BMW ActiveE
68	mietwagen-talk.de	Forum	05.06.13	DriveNow	Berlin	BMW ActiveE
69	mietwagen-talk.de	Forum	13.01.13	Cambio		Citroën C-Zero
70	mietwagen-talk.de	Forum	27.08.11	Flinkster	Berlin	Mini-E
71	Facebook	Social network	19.10.14	stadtmobil	Karlsruhe	Renault Zoe
72	Facebook	Social network	02.04.12	stadtmobil	Karlsruhe	Fiat 500 Elektro
73	Blog	Blog	20.08.15	DriveNow	Hamburg	BWM i3
74	mietwagen-talk.de	Forum	08.06.13	DriveNow	Berlin	BMW ActiveE
75	mietwagen-talk.de	Forum	16.06.13	DriveNow	Berlin	BMW ActiveE
76	mietwagen-talk.de	Forum	31.01.13	car2go	Berlin	smart ed
77	mietwagen-talk.de	Forum	04.09.13	Flinkster	Marburg	Renault Zoe
78	mietwagen-talk.de	Forum	12.06.13	Flinkster	Hamburg	Fiat 500 Elektro
79	mietwagen-talk.de	Forum	17.06.13	Flinkster	Hamburg	Fiat 500 Elektro
80	mietwagen-talk.de	Forum	30.03.13	Flinkster	Berlin	Peugeot iOn
81	mietwagen-talk.de	Forum	08.06.12	Flinkster	Frankfurt	Citroën C-Zero
82	mietwagen-talk.de	Forum	21.02.12	Flinkster	Hamburg	smart ed

83	mietwagen-talk.de	Forum	22.05.13	Multicity	Berlin	Citroën C-Zero
84	mietwagen-talk.de	Forum	25.03.15	Multicity	Berlin	Citroën C-Zero
85	mietwagen-talk.de	Forum	19.07.15	DriveNow	München	BMW i3
86	mietwagen-talk.de	Forum	15.07.15	DriveNow	Berlin	BMW i3
87	mietwagen-talk.de	Forum	28.07.15	DriveNow	Berlin	BMW i3
88	mietwagen-talk.de	Forum	04.07.15	Flinkster	Frankfurt	Peugeot iOn
89	Blog	Blog	06.03.12	Flinkster	Berlin	Citroën C-Zero
90	Blog	Blog	30.09.14	Multicity	Berlin	Citroën C-Zero
91	Blog	Blog	30.05.14	Multicity	Berlin	Citroën C-Zero
92	Blog	Blog	23.04.14	Multicity	Berlin	Citroën C-Zero
93	Facebook	Social network	21.08.15	Multicity	Berlin	Citroën C-Zero
94	Facebook	Social network	31.07.15	Multicity	Berlin	Citroën C-Zero
95	Facebook	Social network	08.07.15	Multicity	Berlin	Citroën C-Zero
96	Facebook	Social network	26.08.15	Cambio	Aachen	smart ed
97	Facebook	Social network	11.08.15	DriveNow	München	BMW i3
98	Facebook	Social network	27.08.15	DriveNow	München	BMW i3
99	Facebook	Social network	18.07.15	DriveNow	Berlin	BMW i3
100	Facebook	Social network	18.07.15	DriveNow	München	BMW i3
101	Blog	Blog	15.07.15	DriveNow	Berlin	BMW i3
102	Facebook	Social network	09.08.15	DriveNow	Berlin	BMW i3
103	Facebook	Social network	04.08.15	DriveNow	Berlin	BMW i3
104	Facebook	Social network	28.07.15	DriveNow	Hamburg	BMW i3
105	Facebook	Social network	15.07.15	DriveNow	Berlin	BMW i3
106	Facebook	Social network	15.07.15	DriveNow	Hamburg	BMW i3
107	Facebook	Social network	16.07.15	DriveNow	Berlin	BMW i3
108	Facebook	Social network	15.07.15	DriveNow	Berlin	BMW i3
109	Facebook	Social network	15.07.15	DriveNow	Hamburg	BMW i3
110	Facebook	Social network	16.07.12	StadtTeilAuto OS	Osnabrück	Citroën C-Zero
111	Facebook	Social network	11.06.12	StadtTeilAuto OS	Osnabrück	Citroën C-Zero

112	Facebook	Social network	31.07.14	E-WALD		
113	Facebook	Social network	08.07.14	E-WALD		
114	Facebook	Social network	24.11.14	E-WALD		BMW i3
115	yelp.com	Review site	10.05.14	Multicity	Berlin	Citroën C-Zero
116	flexauto.de	Review site	08.09.13	car2go	Stuttgart	smart ed
117	flexauto.de	Review site	18.10.13	car2go	Stuttgart	smart ed

Part 2:

h_k	Source URL	Last accessed
1	http://reisen.ciao.de/Multicity_Carsharing__Test_8945076	15.09.2015
2	http://reisen.ciao.de/Multicity_Carsharing__Test_8942521	15.09.2015
3	http://reisen.ciao.de/Multicity_Carsharing__Test_8945203	15.09.2015
4	http://reisen.ciao.de/Multicity_Carsharing__Test_8950912	15.09.2015
5	http://reisen.ciao.de/Multicity_Carsharing__Test_8942931	15.09.2015
6	http://reisen.ciao.de/Multicity_Carsharing__Test_8945418	15.09.2015
7	http://reisen.ciao.de/Multicity_Carsharing__Test_8945734	15.09.2015

8	http://reisen.ciao.de/Multicity_Carsharing__Test_8948814	15.09.2015
9	http://reisen.ciao.de/Car_2_Go__Test_8992068	15.09.2015
10	http://www.testopus.de/berlin/citroen-multicity-berlin/	15.09.2015
11	http://www.whaelse.com/citroen-multicity-carsharing-im-elektroauto-durch-berlin/	15.09.2015
12	http://www.carsharingchecker.com/car2go/	15.09.2015
13	http://www.carsharingchecker.com/flinkster/	15.09.2015
14	http://www.carsharingchecker.com/flinkster/	15.09.2015
15	http://www.carsharing-experten.de/car2go-carsharing/meine-car2go-erfahrug-dem-serviceteam.html	15.09.2015
16	http://www.carsharing-experten.de/stadtmobil-erfahrung/stadtmobil-karlsruhe.html	15.09.2015
17	http://blog.car2go.com/2011/08/10/car2go-elektromobil/	15.09.2015
18	http://blog.drive-now.de/2013/06/05/elektrisierende-fahrfreude-mit-dem-bmw-activee-in-berlin/	15.09.2015
19	http://blog.drive-now.de/2013/06/05/elektrisierende-fahrfreude-mit-dem-bmw-activee-in-berlin/	15.09.2015

20	http://blog.drive-now.de/2013/06/05/elektrisierende-fahrfreude-mit-dem-bmw-activee-in-berlin/	15.09.2015
21	http://blog.drive-now.de/2013/06/05/elektrisierende-fahrfreude-mit-dem-bmw-activee-in-berlin/	15.09.2015
22	http://blog.drive-now.de/2013/06/05/elektrisierende-fahrfreude-mit-dem-bmw-activee-in-berlin/	15.09.2015
23	http://blog.drive-now.de/2013/06/12/60-x-elektrisierende-fahrfreude-mit-dem-bmw-activee/	15.09.2015
24	http://blog.drive-now.de/2013/06/12/60-x-elektrisierende-fahrfreude-mit-dem-bmw-activee/	15.09.2015
25	http://blog.drive-now.de/2013/06/12/60-x-elektrisierende-fahrfreude-mit-dem-bmw-activee/	15.09.2015
26	http://blog.drive-now.de/2013/06/28/bmw-activee-tipps-tricks-teil-2/	15.09.2015
27	http://blog.drive-now.de/2015/07/15/bmw-i3-aufladetipps/	15.09.2015
28	http://blog.drive-now.de/2015/07/15/jetzt-bei-drivenow-mit-dem-bmw-i3-lautlos-durchstarten-100-elektrisch-0-emissionen/	15.09.2015
29	http://blog.drive-now.de/2015/07/15/jetzt-bei-drivenow-mit-dem-bmw-i3-lautlos-durchstarten-100-elektrisch-0-emissionen/	15.09.2015
30	http://konstantinklein.com/emachine-zum-ersten-mal-mit-einem-elektroauto-unterwegs/	15.09.2015
31	https://bioberlin.wordpress.com/2013/09/15/getestet-multicity-erstes-rein-elektrisches-und-stationsunabhangiges-carsharing-in-deutschland/	15.09.2015

32	http://knuffs-welt.blogspot.de/2013/08/multicity-carsharing-von-citroen.html	15.09.2015
33	https://zauberbluetchen.wordpress.com/2013/08/12/citroen-multicity-carsharing/	15.09.2015
34	http://www.probierpioniere.de/pp/roller-ui/Produkte/entry/citro%C3%ABn_multicity_carsharing_130_tester1	15.09.2015
35	http://www.probierpioniere.de/pp/roller-ui/Produkte/entry/citro%C3%ABn_multicity_carsharing_130_tester1	15.09.2015
36	http://www.probierpioniere.de/pp/roller-ui/Produkte/entry/citro%C3%ABn_multicity_carsharing_130_tester1	15.09.2015
37	http://www.probierpioniere.de/pp/roller-ui/Produkte/entry/citro%C3%ABn_multicity_carsharing_130_tester1	15.09.2015
38	http://www.probierpioniere.de/pp/roller-ui/Produkte/entry/citro%C3%ABn_multicity_carsharing_130_tester1	15.09.2015
39	http://www.probierpioniere.de/pp/roller-ui/Produkte/entry/citro%C3%ABn_multicity_carsharing_130_tester1	15.09.2015
40	http://herrpfleger.de/2013/08/test-carsharing-anbieters-multicity-in-berlin/	15.09.2015
41	http://jules-produkt-bewertungen.blogspot.de/2013/09/heute-mochte-ich-die-zeit-nutzen.html	15.09.2015
42	http://www.drivegutschein.de/2013/06/05/elektrofahrzeuge-bei-drivenow-1er-bmw-activee-im-kurztest-berlin/	15.09.2015
43	http://techhive.de/bericht-car2go-stuttgart-ausprobiert-1544842/	15.09.2015

44	http://zoepionierin.de/fast-100-tage-car2go-in-stuttgart/	15.09.2015
45	http://zoepionierin.de/fast-100-tage-car2go-in-stuttgart/	15.09.2015
46	http://www.oekoalltag.de/praxistest-von-car2go-in-stuttgart-versuch-macht-kluch/	15.09.2015
47	http://dietenberger.de/blog/2012/12/03/car2go-oder-catch-me-if-you-can/	15.09.2015
48	http://e-auto-pirat.de/ein-elektrisches-auto-zum-mitnehmen-car2go/	15.09.2015
49	http://reisebloegle.de/drivenow-die-exklusive-art-des-carsharing/	15.09.2015
50	http://reisebloegle.de/multicity-brauchst-du-einen-gibt-es-keinen/	15.09.2015
51	http://www.kfz-betrieb.vogel.de/elektromobilitaet/articles/395513/	15.09.2015
52	http://greenvana.eu/de/de-e-carsharing-von-multicity/	15.09.2015
53	http://hauptstadt-diva.de/multicity-carsharing/	15.09.2015
54	https://www.facebook.com/multicitycarsharing/photos/a.231348946987608.49997.218524801603356/488211024634731/?type=1&comment_id=1289402& offset=0&total_comments=17&comment_tracking=%7B%22tn%22%3A%22R1%22%7D	15.09.2015
55	https://www.facebook.com/multicitycarsharing/posts/442906389165195?comment_id=2181917&offset=0&total_comments=1&comment_tracking=%7B%2	15.09.2015

	2tn%22%3A%22R%22%7D	
56	https://www.facebook.com/photo.php?fbid=1051020468248105&set=o.172880419355&type=1	15.09.2015
57	https://plus.google.com/+SebastianJabbusch/posts/KWn4HTdpg5N	15.09.2015
58	https://plus.google.com/116853477671271658679/posts/DFMZW1xpV4N	15.09.2015
59	https://plus.google.com/+MarkusBirth/posts/eRcKF3k1nZW	15.09.2015
60	https://plus.google.com/+MarkusBirth/posts/KCuPZ5sXwkM	15.09.2015
61	https://www.facebook.com/030berlin/activity/10205698375283717	15.09.2015
62	https://www.facebook.com/MrTickTack/activity/745349922190832	15.09.2015
63	https://www.facebook.com/stevie.wald/activity/649739588450487	15.09.2015
64	http://www.mietwagen-talk.de/drivenow/8416-drivenow-carsharing-in-m-nchen/index40.html#post619658	15.09.2015
65	http://www.mietwagen-talk.de/drivenow/14334-bmw-1er-activee-drivenow-berlin	15.09.2015
66	http://www.mietwagen-talk.de/drivenow/14334-bmw-1er-activee-drivenow-berlin/#post611842	15.09.2015

67	http://www.mietwagen-talk.de/drivenow/14334-bmw-1er-activee-drivenow-berlin/#post693622	15.09.2015
68	http://www.mietwagen-talk.de/drivenow/13352-der-bmw-activee-bei-drivenow-im-praxistest/	15.09.2015
69	http://www.mietwagen-talk.de/carsharing-anbieter-deutschland/12405-erfahrungsbericht-citroen-c-zero-cambio/	15.09.2015
70	http://www.mietwagen-talk.de/flinkster/9049-mini-e-von-flinkster-berlin/	15.09.2015
71	https://www.facebook.com/notes/stadtmobil-karlsruhe-carsharing/ettlingen-macht-elektromobil/10152824400153377	15.09.2015
72	https://www.facebook.com/media/set/?set=a.10151352407305174.821097.212357315173&type=1	15.09.2015
73	http://www.e-carsharing.net/unsere-bmw-i3-testfahrt-in-hamburg/	15.09.2015
74	http://www.mietwagen-talk.de/drivenow/p571126-bmw-activee-bei-drivenow-in-berlin-und-m-nchen/#post571126	15.09.2015
75	http://www.mietwagen-talk.de/drivenow/p572952-elektro-1er-bmw-activee-bald-auch-bei-drivenow-verf-gbar/#post572952	15.09.2015
76	http://www.mietwagen-talk.de/car2go/p537248-erste-elektro-smarts-f-r-car2go-berlin/#post537248	15.09.2015
77	http://www.mietwagen-talk.de/flinkster/13938-renault-zoe-von-einfach-mobil-und-flinkster/	15.09.2015
78	http://www.mietwagen-talk.de/flinkster/13403-fiat-500e-karabag-flinkster-hamburg-hauptbahnhof/	15.09.2015

79	http://www.mietwagen-talk.de/flinkster/p573363-fiat-500e-karabag-flinkster-hamburg-hauptbahnhof/#post573363	15.09.2015
80	http://www.mietwagen-talk.de/flinkster/12908-peugeot-ion-von-flinkster-berlin/	15.09.2015
81	http://www.mietwagen-talk.de/flinkster/11090-citroen-c-zero-flinkster-frankfurt-hauptbahnhof/#post476402	15.09.2015
82	http://www.mietwagen-talk.de/flinkster/10228-smart-electric-drive-flinkster-hamburg-hauptbahnhof/	15.09.2015
83	http://www.mietwagen-talk.de/carsharing-anbieter-deutschland/13242-bersicht-der-carsharing-anbieter-in-berlin/	15.09.2015
84	http://www.mietwagen-talk.de/carsharing/16523-c-zero-multicity-berlin/	15.09.2015
85	http://www.mietwagen-talk.de/drivenow/p753310-i3s-vor-einflottung-in-deutschland/#post753310	15.09.2015
86	http://www.mietwagen-talk.de/drivenow/16994-bmw-i3-drivenow-berlin/	15.09.2015
87	http://www.mietwagen-talk.de/drivenow/p755082-bmw-i3-drivenow-berlin/#post755082	15.09.2015
88	http://www.mietwagen-talk.de/flinkster/p750562-zwei-stunden-mit-dem-peugeot-ion-durch-frankfurt/#post750562	15.09.2015
89	http://omnipolis.com/selbstversuch-mit-echter-elektromobilitat-flinkster/	15.09.2015
90	http://my-trend.org/2014-09-30-testbericht-multicity-carsharing?utm_source=feedburner&utm_medium=twitter&utm_campaign=Feed%3A+My-trendorg+%28My-Trend.org+Aktuelle+Trends%21%29	15.09.2015

91	https://weddingweiser.wordpress.com/2014/05/13/multicity-elektrisiert-carsharing-den-wedding/	15.09.2015
92	http://dasnuf.de/citroen-multicity-testbericht/	15.09.2015
93	https://www.facebook.com/LudwigNicole/activity/1162846710396533	15.09.2015
94	https://www.facebook.com/stickathing/activity/1172450149448630	15.09.2015
95	https://www.facebook.com/frankeggen72/activity/10207198364583316	15.09.2015
96	https://www.facebook.com/armin.langweg.aachen/posts/1620297861553167	15.09.2015
97	https://www.facebook.com/DriveNow.DE/photos/a.121881157895370.31599.112694915480661/874593945957417/?type=1&comment_id=875056242577854&offset=0&total_comments=11&comment_tracking=%7B%22tn%22%3A%22R8%22%7D	15.09.2015
98	https://www.facebook.com/DriveNow.DE/posts/883454385071373	15.09.2015
99	https://www.facebook.com/photo.php?fbid=969530123067173&set=o.112694915480661&type=1	15.09.2015
100	https://www.facebook.com/DriveNow.DE/posts/863389580411187	15.09.2015
101	http://www.mietwagen-news.de/allgemein/das-leise-beste-von-drivenow-der-bmw-i3-2015-07-15.html	15.09.2015
102	https://www.facebook.com/DriveNow.DE/photos/a.259197344163750.61845.112694915480661/871018889648256/?type=1&comment_id=8710557263112	15.09.2015

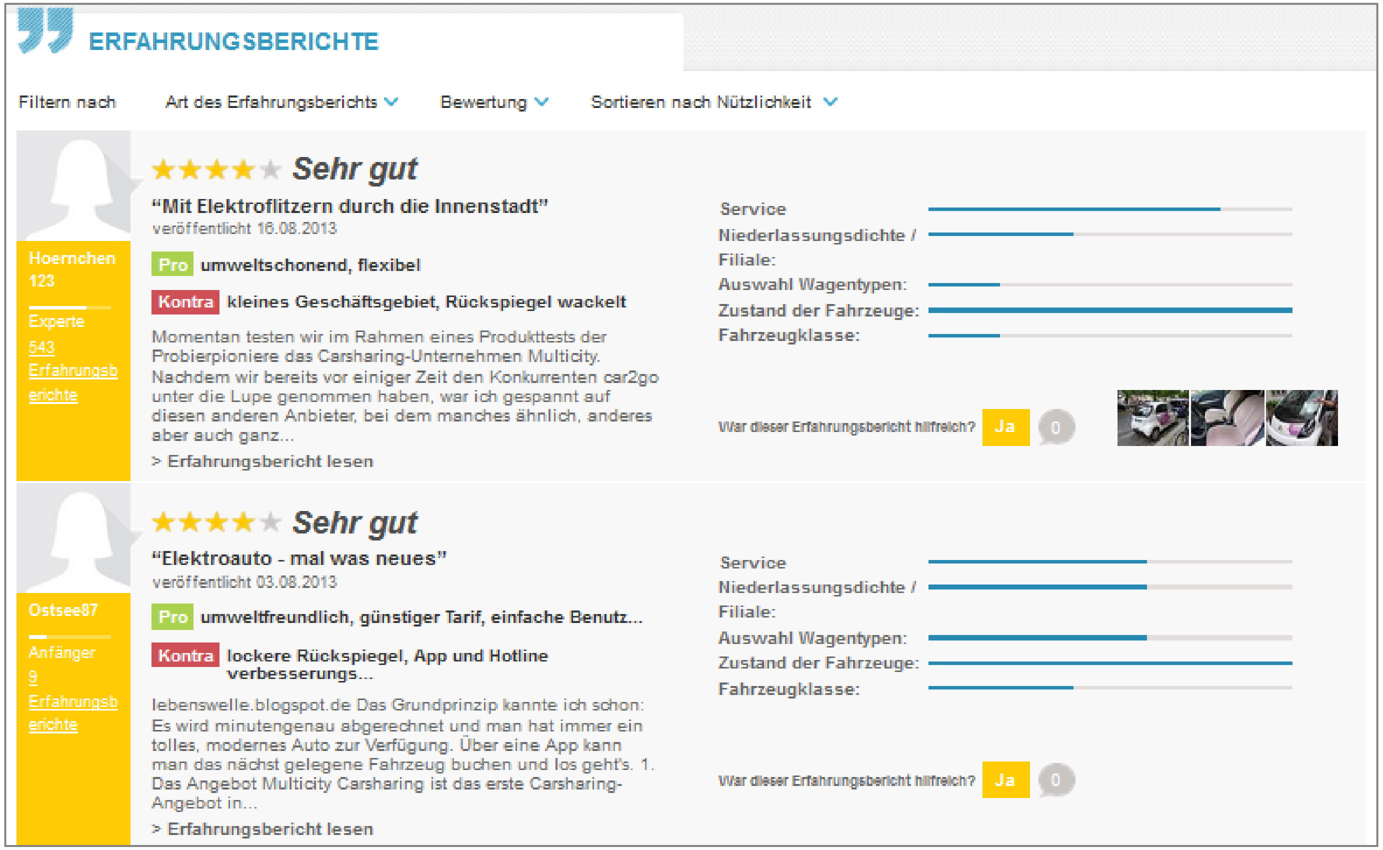
	39&reply_comment_id=873850069365138&total_comments=1&comment_tracking=%7B%22tn%22%3A%22R8%22%7D	
103	https://www.facebook.com/DriveNow.DE/photos/a.259197344163750.61845.112694915480661/871018889648256/?type=1&comment_id=871503686266443&offset=0&total_comments=10&comment_tracking=%7B%22tn%22%3A%22R4%22%7D	15.09.2015
104	https://www.facebook.com/DriveNow.DE/photos/a.121881157895370.31599.112694915480661/862950513788427/?type=1&comment_id=868005163282962&offset=0&total_comments=20&comment_tracking=%7B%22tn%22%3A%22R9%22%7D	15.09.2015
105	https://www.facebook.com/DriveNow.DE/photos/a.121881157895370.31599.112694915480661/861756723907806/?type=1&comment_id=861949673888511&offset=0&total_comments=98&comment_tracking=%7B%22tn%22%3A%22R9%22%7D	15.09.2015
106	https://www.facebook.com/DriveNow.DE/photos/a.121881157895370.31599.112694915480661/861756723907806/?type=1&comment_id=861874903895988&offset=0&total_comments=98&comment_tracking=%7B%22tn%22%3A%22R9%22%7D	15.09.2015
107	https://www.facebook.com/DriveNow.DE/photos/a.121881157895370.31599.112694915480661/861756723907806/?type=1&comment_id=862478170502328&offset=0&total_comments=98&comment_tracking=%7B%22tn%22%3A%22R9%22%7D	15.09.2015
108	https://www.facebook.com/DriveNow.DE/photos/a.121881157895370.31599.112694915480661/861756723907806/?type=1&comment_id=861902137226598&offset=0&total_comments=98&comment_tracking=%7B%22tn%22%3A%22R9%22%7D	15.09.2015
109	https://www.facebook.com/DriveNow.DE/photos/a.121881157895370.31599.112694915480661/861756723907806/?type=1&comment_id=861876950562450&offset=0&total_comments=98&comment_tracking=%7B%22tn%22%3A%22R2%22%7D	15.09.2015
110	https://www.facebook.com/StadtTeilAutoOsnabrueck/posts/328401900577868	15.09.2015
111	https://www.facebook.com/StadtTeilAutoOsnabrueck/posts/316057808478944	15.09.2015

112	https://www.facebook.com/100008179095087/activity/1436687366613886	15.09.2015
113	https://www.facebook.com/hippiecrushingmka/activity/736244433083633	15.09.2015
114	https://www.facebook.com/photo.php?fbid=10202765551251615&set=o.289966671178045&type=1	15.09.2015
115	http://www.yelp.com/biz/multicity-flinkster-b%C3%BCro-berlin?osq=carsharing	15.09.2015
116	http://www.flexauto.de/pages/carsharing-vergleich/car2go.php	15.09.2015
117	http://www.flexauto.de/pages/carsharing-vergleich/car2go.php	15.09.2015

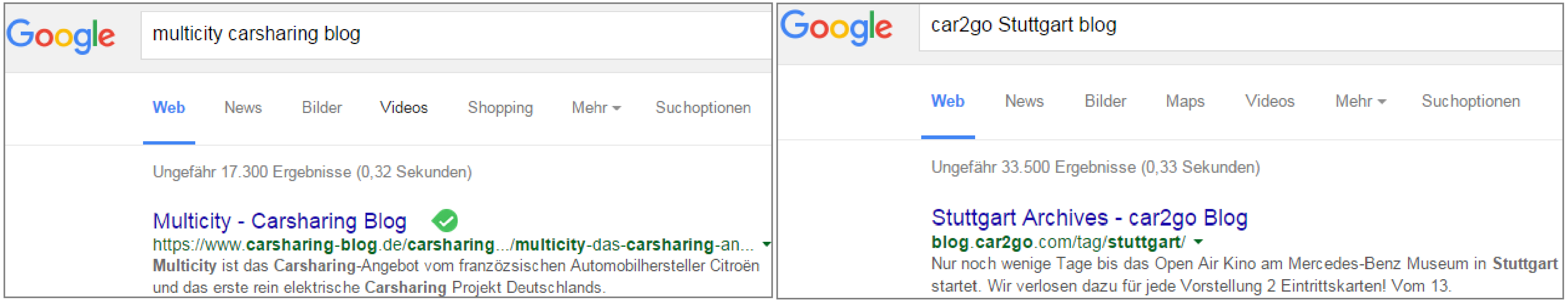
Appendix B: Redundancies between Sources

Opinion holder 2	**Screenshots**	**Last accessed**
http://reisen.ciao.de/Multicity_Carsharing__Test_8942521	Opinion holder 2	15.09.2015
http://lebenswelle.blogspot.de/2013/08/test-multicity-carsharing-berlin.html	Opinion holder 2_2	15.09.2015
Opinion holder 3		15.09.2015
http://reisen.ciao.de/Multicity_Carsharing__Test_8945203	Opinion holder 3	15.09.2015
http://www.dooyoo.de/transport-automobildienstleister/multicity-carsharing/1640832/	Opinion holder 3_2	15.09.2015
http://www.yopi.de/testbericht/multicity-carsharing/451096	Opinion holder 3_3	15.09.2015
http://amelietestetalles.blogspot.de/2013/08/im-test-muliticity-in-berlin.html	Opinion holder 3_4	15.09.2015
Opinion holder 4		15.09.2015
http://reisen.ciao.de/Multicity_Carsharing__Test_8950912	Opinion holder 4	15.09.2015
http://www.dooyoo.de/transport-automobildienstleister/multicity-carsharing/1644589/	Opinion holder 4_2	15.09.2015
Opinion holder 8		15.09.2015
http://reisen.ciao.de/Multicity_Carsharing__Test_8948814	Opinion holder 8	15.09.2015
http://www.dooyoo.de/transport-automobildienstleister/multicity-carsharing/#revs	Opinion holder 8_2	15.09.2015

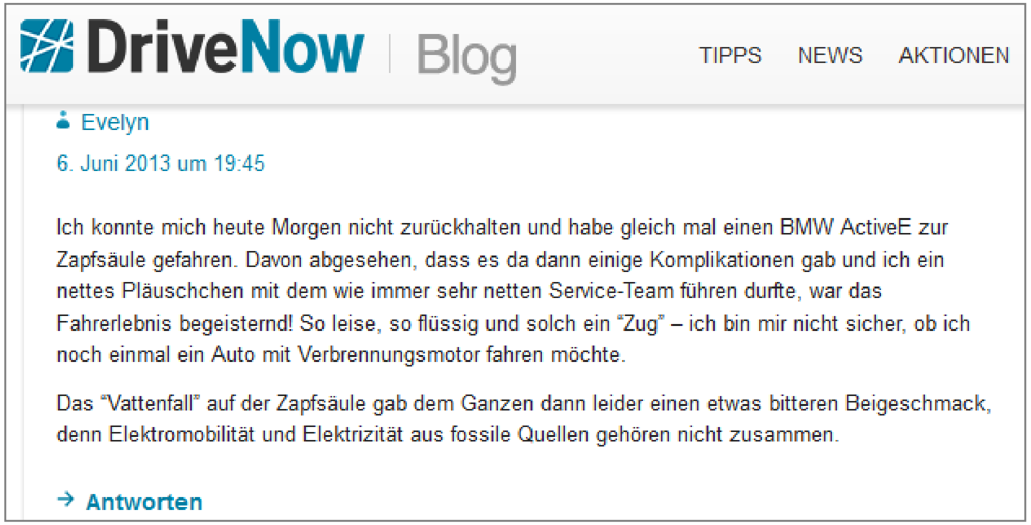
Appendix C: Examples of the Data Collection



Example 1: Searching user opinions on the review site ciao.de
Source: http://reisen.ciao.de/Multicity_Carsharing__11102433 (Accessed 30.04.2015)

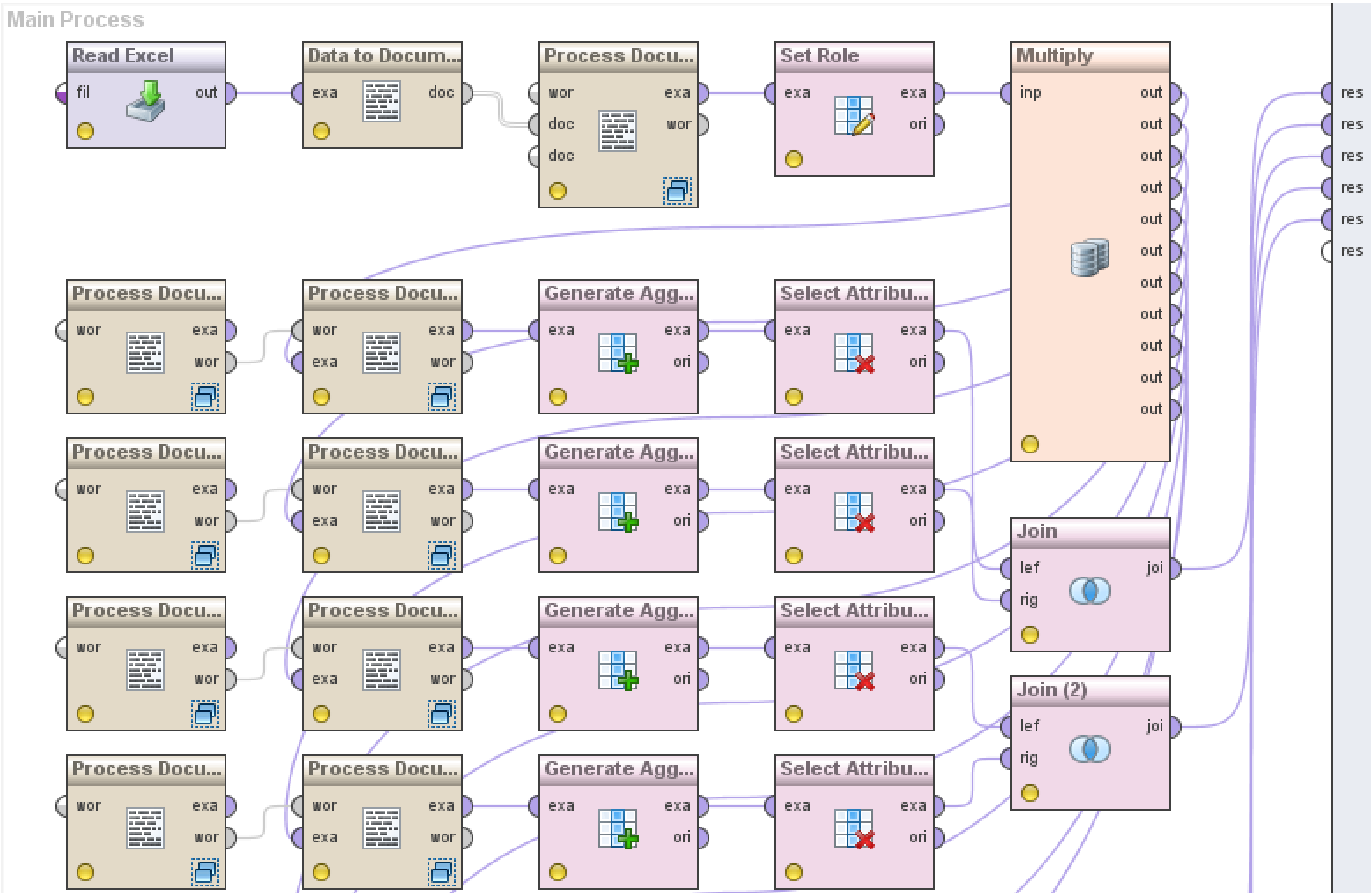


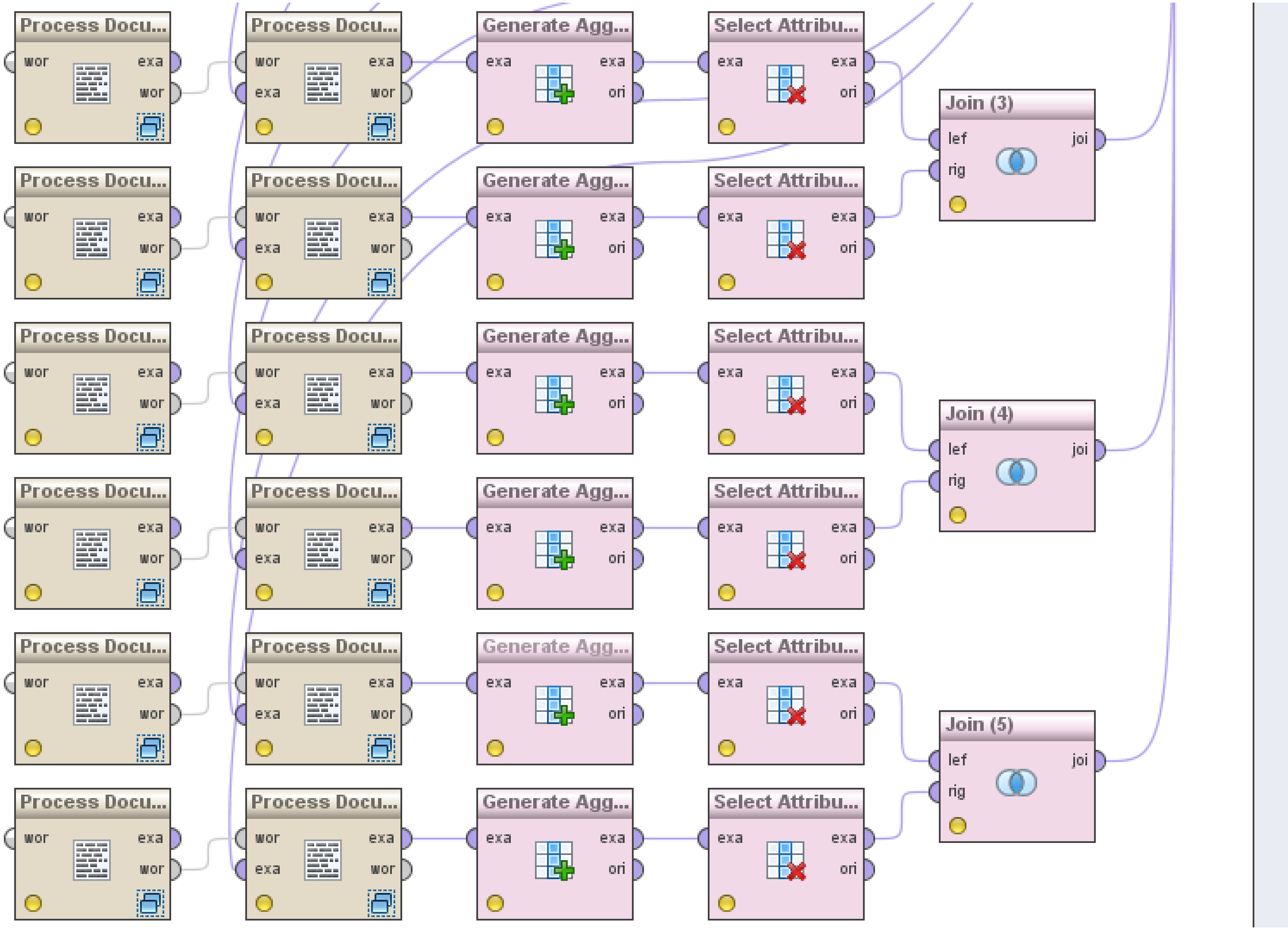
Example 2: Searching blogs on Google with the word combination “multicity carsharing blog” and “car2go Stuttgart blog”.
Source: www.google.de (Accessed 30.04.2015)



Example 3: Searching comments about electric carsharing usage on the corporate blog by DriveNow (s. opinion holder 21)
Source: http://blog.drive-now.de/2013/06/05/elektrisierende-fahrfreude-mit-dem-bmw-activee-in-berlin/ (Accessed 05.05.2015)

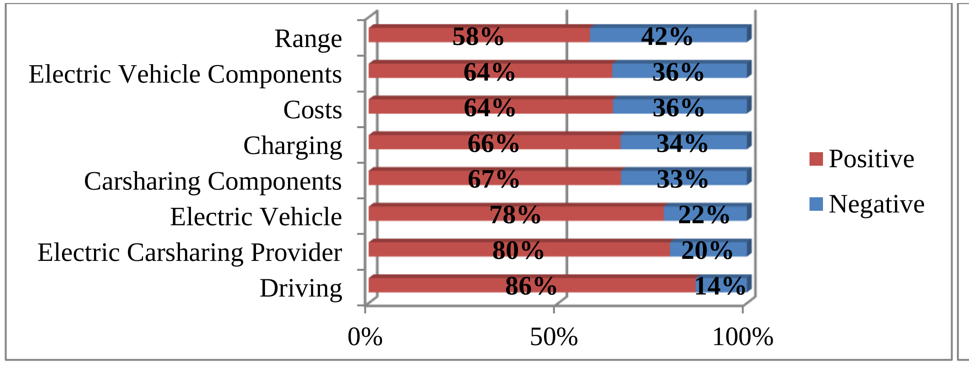
Appendix D: Main Process of Aspect-based Opinion Mining

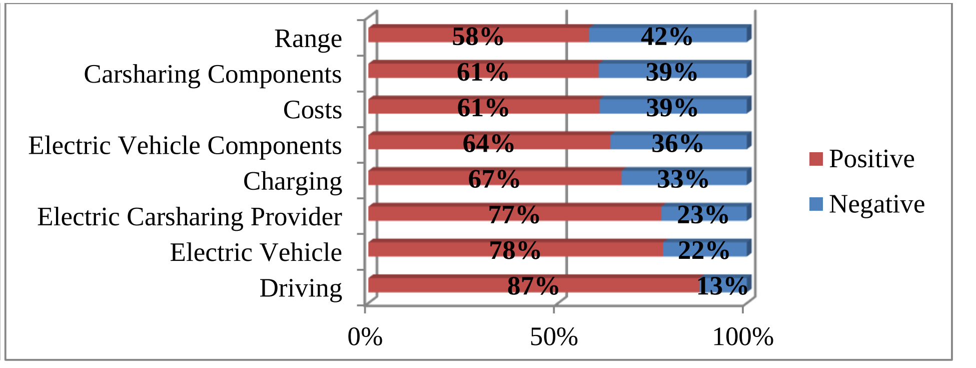




Process Docu...
wor
exa
wor
Generate Agg...
exa
ori
Select Attribu...
Join (3)
lef
rig
joi
Join (4)
Join (5)

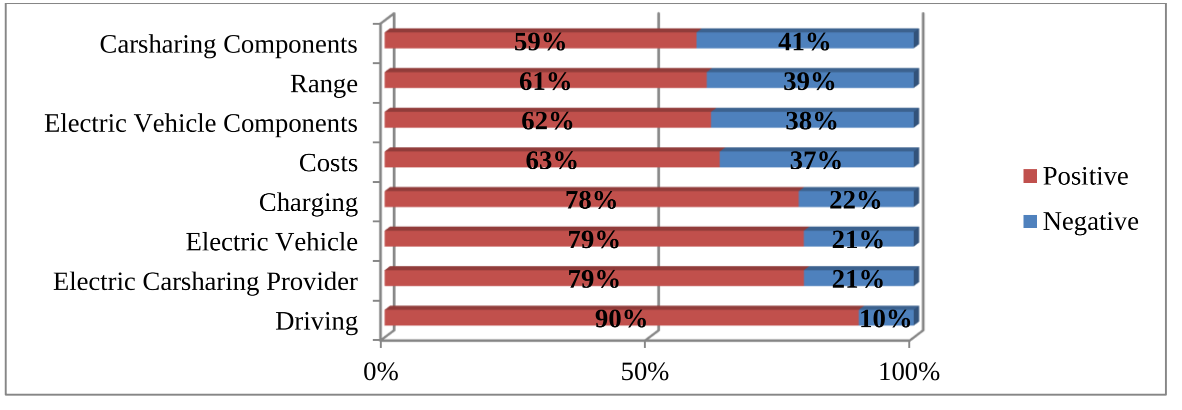
Appendix E: Comparison Aspect Occurrences in Sentences





Approach 1: All sentences
Source: Own depiction

Approach 2: Sentences with not more than 2 different aspects
Source: Own depiction



Approach 3: Sentences with only one aspect
Source: Own depiction

Approach 1	Total	Pos.	%	Neg.	%	Approach 2	Total	Pos.	%	Neg.	%	Approach 3	Total	Pos.	%	Neg.	%
Driving	183	158	86	25	14	Driving	159	139	87	20	13	Driving	77	69	90	8	10
Electric Carsha-ring Provider	166	132	80	34	20	Electric Vehicle	377	293	78	84	22	Electric Carsha-ring Provider	53	42	79	11	21
Electric Vehicle	452	352	78	100	22	Electric Carsha-ring Provider	123	95	77	28	23	Electric Vehicle	207	164	79	43	21
Carsharing Com-ponents	233	155	67	78	33	Charging	99	66	67	33	33	Charging	46	36	78	10	22
Charging	122	81	66	41	34	Electric Vehicle Components	160	102	64	58	36	Costs	30	19	63	11	37
Costs	59	38	64	21	36	Costs	46	28	61	18	39	Electric Vehicle Components	94	58	62	36	38
Electric Vehicle Components	179	115	64	64	36	Carsharing Com-ponents	178	108	61	70	39	Range	23	14	61	9	39
Range	60	35	58	25	42	Range	43	25	58	18	42	Carsharing Com-ponents	95	56	59	39	41

Pos. = Positive

Neg. = Negative

Appendix F: Survey about Carsharing with Electric Vehicles

Herzlich willkommen zur Online-Befragung im Rahmen meiner Masterarbeit an der Leibniz Universität Hannover, in der ich die Einstellungen zur Nutzung von Carsharing mit Elektroautos untersuche. Ich würde mich sehr freuen, wenn Sie sich ca. 5 - 10 Minuten Zeit für diese Umfrage nehmen. Die Daten werden anonym behandelt und nur im Rahmen dieser Masterarbeit verwendet. Vielen Dank vorab und beste Grüße, Mareike Thiessen

A) Carsharing mit Elektroautos	
Zunächst geht es um Ihre bisherige Nutzung von Carsharing mit Elektroautos. Dabei spielt es keine Rolle welchen Carsharing-Anbieter und welche Fahrzeug-modelle Sie nutzen. Auch wenn Sie gegebenenfalls Carsharing mit Elektroautos nicht (mehr) nutzen, haben Sie sicher eine Meinung dazu. Bei den Freitext Fragen reichen Stichworte völlig aus.	
A1. Wie häufig nutzen Sie Carsharing mit Elektroautos (als Fahrer/-in oder Mitfahrer/-in)?	
	(fast) täglich
	1-3 Tage pro Woche
	1-3 Tage pro Monat
	seltener als monatlich
	(fast) nie
	Ich habe noch nie Carsharing mit einem Elektroauto genutzt

A2. Bitte geben Sie stichwortartig an, welches Ihre Motive zur Nutzung von Carsharing mit Elektroautos sind oder waren:

A3. Bitte geben Sie stichwortartig an, was Ihnen bisher an Carsharing mit Elektroautos gefallen hat:

A4. Bitte geben Sie stichwortartig an, was Ihnen bisher an Carsharing mit Elektroautos nicht gefallen hat:

B) Fragen zum Mobilitätsverhalten					
B1. Bitte geben Sie die Reihenfolge an, welches der genannten Verkehrsmittel Sie am häufigsten nutzen:					
1 für das am häufigsten genutzte Verkehrsmittel und 5 für das am seltensten genutzte Verkehrsmittel:					
	Öffentliche Verkehrsmittel	Carsharing mit konventionell angetriebenen Autos (Diesel, Benziner)	Carsharing mit Elektroautos	Eigenes Auto	Fahrrad
1 (am häufigsten)					
2 (am zweithäufigsten)					
3 (am dritthäufigsten)					
4 (am vierthäufigsten)					
5 (am seltensten)					

B2. Welches Verkehrsmittel würden Sie nutzen, wenn es Carsharing mit Elektroautos nicht geben würde?

B3. Bitte geben Sie stichwortartig an, inwiefern sich Ihr Mobilitätsverhalten im Bezug auf die anderen Mobilitätsformen (z.B. eigenes Auto, öffentliche Verkehrsmittel oder Carsharing) seit der Nutzung von Carsharing mit Elektroautos verändert hat:
Gibt es beispielsweise Verkehrsmittel, die Sie seitdem häufiger, seltener oder gar nicht mehr nutzen?

C) Angaben zu Ihrer Person
Am Ende dieser Umfrage folgen nur noch 4 kurze Fragen zur Statistik.

C1. Welches Geschlecht haben Sie?					
	weiblich		männlich		sonstiges

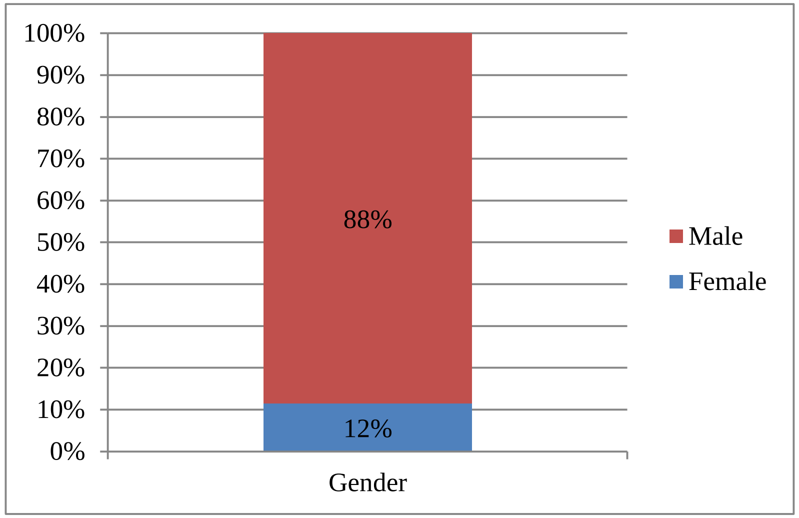
C2. Wie alt sind Sie?					
	Unter 18 Jahren		18-30 Jahre		31-40 Jahre
	41-50 Jahre		51-60 Jahre		Über 60 Jahre

C3. Wie ist Ihre aktuelle berufliche Situation?					
	Student/in, Auszubildende/r, Schüler/in		Vollzeitangestellt		Teilzeitangestellt
	Selbstständig		Sonstiges:		

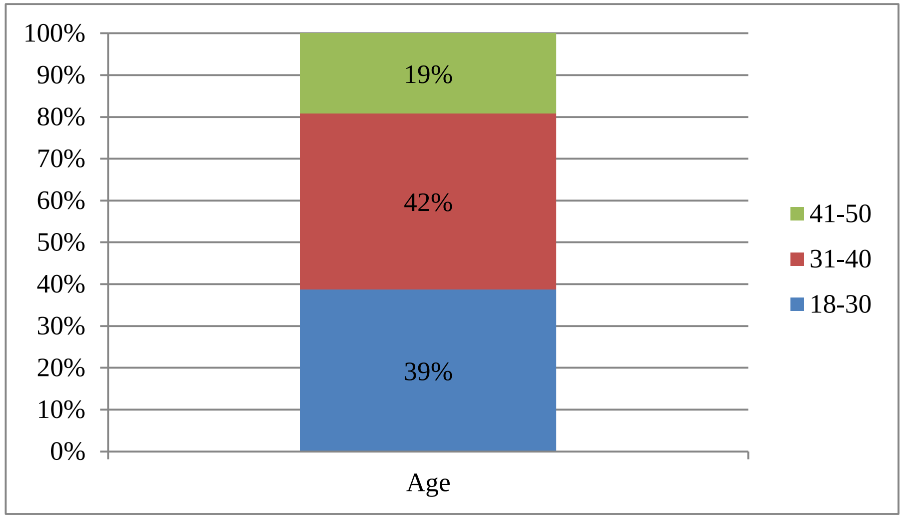
C4. Welcher ist Ihr zuletzt erworbener Bildungsabschluss?					
	(Noch) kein Abschluss		Haupt-/Volksschulabschluss		Realschulabschluss/Mittlere Reife
	Abitur/Fachhochschulreife		(Fach-) Hochschulabschluss		Sonstiger

Anmerkungen
C5. Möchten Sie zu dieser Umfrage noch abschließend etwas anmerken?

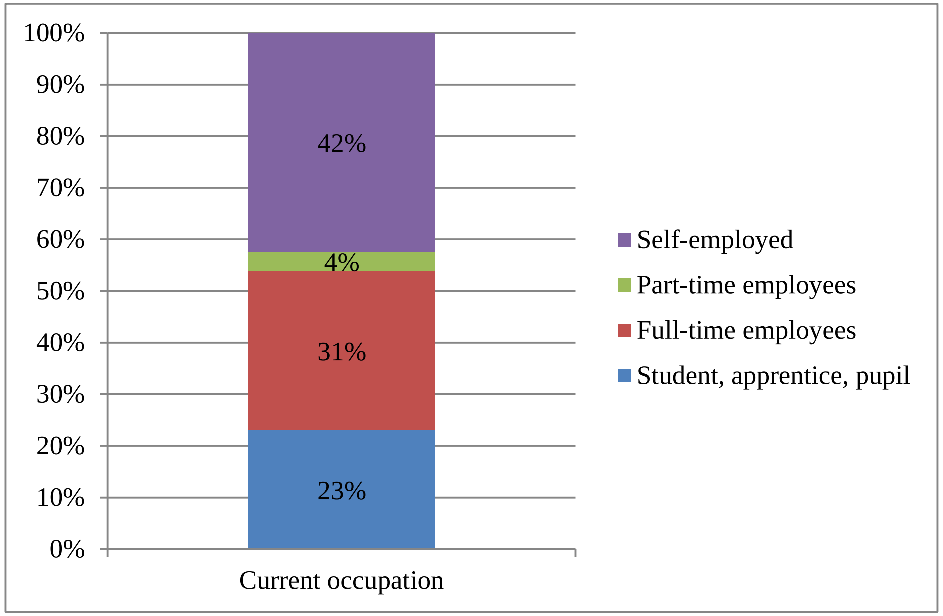
Appendix G: Socio-Demographics in Diagram Form

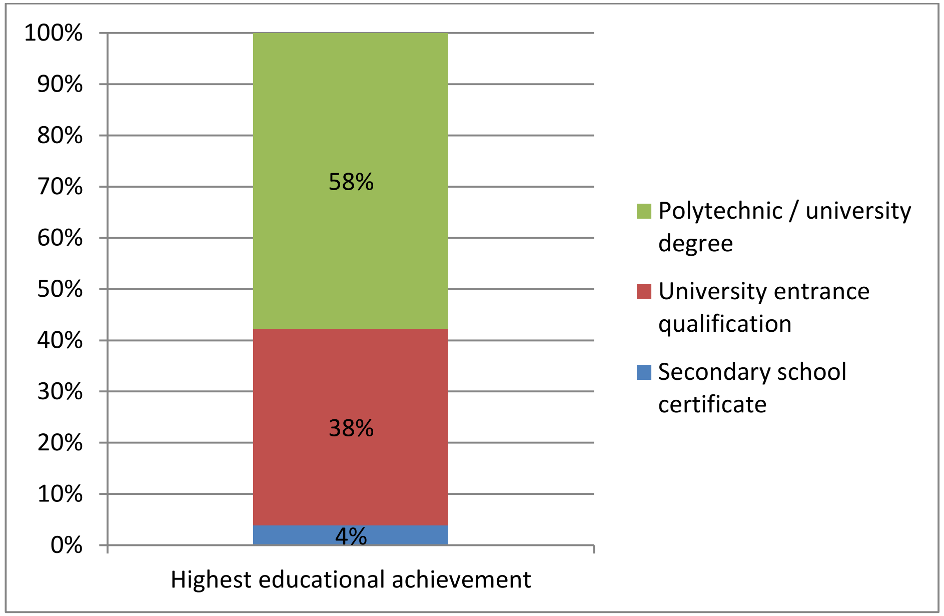


Question C1: What is your gender? (n = 26)
Source: Own depiction



Question C2: How old are you? (n = 26)
Source: Own depiction





Question C3: What is your current occupation? (n = 26)
Source: Own depiction

Question C4: Which is your last acquired educational achievement? (n = 26)
Source: Own depiction

Appendix H: Coding Agenda of Question A2

Please enter in note form, which are or were your motives of the use of carsharing with electric cars:

No.	main categories	sub-categories	definition	coding rules	anchor example	inductive categories	Number of mentions
1	testing and curiosity		Participant used the service due to testing or curiosity	Participant expresses testing, test drive or curiosity	"Wollte es mal testen"(1); "Testfahren"(24); "Neugier" (11); "Neugierde"(9)	K1, K2	9
2	environmental aspects		Motivation of usage due to environmental aspects	Environmental aspects are mentioned	"umweltfreundlich"(26); "Sauberes Autofahren"(23)	K4, K38, K9	12
		better air quality	Motivation of usage due to better air quality	Participant notes better air	"bessere Luft"(5); "Städtische Luftqualität"(8)	K9	2
3	financial reasons		Motivation of usage due to financial reasons	Financial reasons are expressed	"günstig"(6); "keine Parkgebühren"(12)	K10, K13, K22	6
4	convenience and comfort		Motivation of usage due to convenience and comfort	Participant notes convenience and comfort	"Bequem"(6); "Fahrkomfort"(26)	K11, K41, K43	4
5	interest in technological innovation		Motivation of usage due to interest in technological innovation	Participant expresses interest in technological innovation	"neue Technik"(10); "Faszination E-Antrieb"(24)	K17, K20, K30, K39	5
6	pleasing electric vehicle		Participant used the service because of the pleasing electric vehicle	Participant notes that the electric vehicle or aspects are pleasing	"Fahrgefühl"(23); "Spaß beim fahren"(14)	K37, K8, K16, K24	9
		low noise	Participant used it due to low noise	Participant expresses low noise	"weniger Lärm"(5); "nahezu lautlose Fortbewegung"(8)	K8	2
		acceleration	Participant used it due to the acceleration of the vehicle	Participant expresses acceleration	"enormes Beschleunigungsvermögen"(8)	K16	2
		driving fun	Motivation of usage due to driving fun	Participant expresses fun by driving	"Fahrspaß"(13)	K24	4

No.	main categories	sub-categories	definition	coding rules	anchor example	inductive categories	Number of mentions
7	flexibility		Motivation of usage due to flexibility	Participant expresses flexibility	"Flexibilität"(14)	K27, K40	4
8	pragmatic reasons		Motivation of usage due to pragmatic reasons	All statements in which participants note something as pragmatic, practical, useful, functional. S. subcategories	s. subcategories	s. subcategories	22
		no own car	Participant used it because of no own car	Participant notes that he/she has no own car	"kein eigenes Auto"(12)	K21	3
		at night and poor availability of public transport	Participant used it at a late hours or when public transport is not good available	Usage when public transport is not good available or it is late or dark	"Uhrzeit (keine Öffis verfügbar)"(15); "Späte Fahrt"(3)	K5, K7, K32	4
		good availability	Motivation of usage due to good availability	Participant notes good availability	"Verfügbarkeit nahebei"(22); "Verfügbarkeit in Reichweite"(2)	K3	3
		transport	Participant used it for transport	Transport is expressed	"Transport"(3)	K6	2
		bad weather	Motivation of usage due to bad weather	Participant expresses bad weather	"es regnet"(19); "draußen nass und kalt"(14)	K28	2
		time savings	Motivation of usage due to time savings	Participant expresses time savings or less time exposure	"Zeitersparnis"(15); "kein Zeitaufwand für Reparaturen(26)	K29, K42	2
		further practical / functional reasons	Motivation of usage due to practical and functional reasons	Participant mentions motives like practical, functional or applicable, which not fit in the other categories	"praktisch"(21); "Wenn etwas weit weg"(19) "jederzeit anmietbar und abstellbar"(20)	K35, K14, K23, K31, K33, K34	6
9	further symbolic and emotional motives		Motivation of usage due to further symbolic and emotional motives	Participant expresses further symbolic and emotional motives, which not fit in the other categories	"Gefühl etwas Gutes zu tun"(7); "Vorbild sein"(11); "Spaß"(11)	K15, K19, K26, K18	4

Appendix I: Coding Agenda of Question A3

Please enter in note form, what you liked about carsharing with electric cars so far:

No.	main categories	definition	coding rules	anchor example	inductive categories	Number of mentions
1	simplicity	The service or features of the service are perceived as simple	Participant expresses words like simple or uncomplicated	"leicht zu mieten"(25) "Unkompliziertheit beim Anmeldevorgang "(14)	K1, K6, K28, K29, K46, K47	7
2	environmental aspects	Participants likes environmental aspects	Environmental aspects are mentioned	"Umweltfreundlich"(1); "umweltfreundlicher als Verbrenner"(15)	K2, K17, K33	5
3	new experience	Participant likes the new experience	Participant expresses new experience and testing	"Neue Erfahrung"(19); "Modelle testen"(5)	K19, K8	3
4	parking	Participant likes the parking	Participant expresses parking	"bevorzugte Parkplätze"(26)	K31, K39, K49	3
5	prices	Participant likes the prices	Participant expresses that he/she likes prices	"Günstiger als klassisches Carsharing"(26)	K22, K48	2
6	offered vehicles	Participant likes the offered electric vehicles	Participant mentions the electric vehicle(s)	"Moderne Autos"(10); "schöne Modelle"(13)	K20, K26	4
7	driving fun	Participants likes the driving fun	Participant expresses driving fun	"Fahrspaß"(2)	K3	3
8	driving experience	Participant likes the driving experience	Participant expresses driving experience or pleasant drive	"gutes Fahrgefühl"(21); "angenehm zu fahren"(3)	K32, K7, K37	7
9	low noise	Participant likes the low noise	Participant expresses low noise	"leise Fahrweise"(13)	K4	6
10	acceleration	Participant likes the acceleration	Participant expresses acceleration	"Beeindruckende Beschleunigung"(25)	K18	5
11	further aspects of electric vehicle	Participant likes further aspects of electric vehicles	Participant expresses further aspects of electric vehicles, which not fit in the other categories	"keine Gangschaltung"(7); "dynamisches Fahren"(12); "guter Durchzug"(22)	K15, K16, K24, K40, K43 - 45	7
12	electric vehicle or features	Participant likes the electric vehicle or features	All statements about the electric vehicle or feature of the vehicle	s. main categories 6-11	s. main categories 6-11	32

Appendix J: Coding Agenda of Question A4

Please enter in note form, what you disliked about carsharing with electric cars so far:

No.	main categories	definition	coding rules	anchor example	inductive categories	Number of mentions
1	limited range	Participant dislikes the limited range	Participant expresses explicitly limited range	"geringe Reichweite"(3); "zu kurze Reichweite "(13)	K3, K39, K40	8
2	limited availability of electric carsharing or electric vehicles	Limited availability of electric carsharing or the vehicles	Participant complains about the limited availability of electric carsharing or the vehicles	"Verfügbarkeit" (3); "Zu wenige Autos verfügbar"(10)	K4, K16	8
3	limited number of charging stations	Low density of charging stations	Participant complains about the limited number of charging stations	"Zu wenige Lademöglichkeiten"(8); "allg. zu wenig Ladesäulen"(25)	K13, K36	6
4	pricing	Participant is dissatisfied with pricing	Participant mentions pricing	"Preis ist recht hoch"(21); "teuer"(6)	K20, K9, K27, K33	7
5	inaccessible charging station	Participant dislikes inaccessible charging stations	Participant mentions occupied and inaccessible charging station	"Ladesäule versperrt oder besetzt"(25); "Ladesäulen oft von normalen PKW zugeparkt"(20)	K15, K18	4
6	inoperative charging station	Participant dislikes inoperative charging stations	Participant mentions inoperative charging station	"Tanksäulen die nicht funktioneren"(5)	K8, K25	2
7	insufficient charge level	Participant dislikes insufficient charge level	Participant expresses insufficient charge level	"Waren nicht immer aufgeladen" (1); "leerer Akku im Stau"(3)	K1, K7, K10, K32	4
8	laborious charging	Participant dislikes laborious charging	Participant expresses charging as laborious or expensive	"umständliches Anschließen der Ladekabel"(15)	K17, K26, K31	3
9	electric vehicle or features	Participant has issues with the electric vehicle or features	Participant expresses issues with the vehicle or features	"Autos (fallen) unverhältnismäßig oft aus"(12); "zu langsames Heizen"(14); "'billige' Machart"(22)	K19, K21, K22, K30, K34, K37	6

Appendix K: Coding Agenda of Question B3

Please enter in note form, to what extent your mobility behavior in relation to the other forms of mobility (e. g., own car, public transport or carsharing) has changed since the usage of carsharing with electric cars:

No.	main categories	subcategories	definition	coding rules	anchor example	inductive categories	Number of mentions
1	no change		The mobility behavior of the participant has not changed	Participant expresses that nothing has changed	"Keine Auswirkungen"(7);"Gar nicht, die Auswahl ist viel zu gering"(9)	K7, K9, K27	6
		no change without justification	The mobility behavior of the participant has not changed without justification	Participant expresses that nothing has changed without justification	"Keine Auswirkungen"(7); "gar nicht"(16); "nichts"(23)	K7	3
		no change due to limited availability of electric carsharing	The mobility behavior of the participant has not changed due to limited availability of electric carsharing	Participant expresses that nothing has changed due to limited availability of electric carsharing	"Gar nicht, die Auswahl ist viel zu gering"(9)	K9	2
		no change due to rare usage	The mobility behavior of the participant has not changed due to rare usage	Participant expresses that nothing has changed due to rare usage	"…selten benutze, … nichts geändert"(19)	K27	1
2	barely		The mobility behavior of the participant has changed barely	Participant expresses that barely anything has changed	"So gut wie gar nicht"(24); "kaum"(2)	K2, K23, K35, K30	4
3	electric carsharing preferred over conventional		Participant prefers electric carsharing over conventional carsharing	Participant expresses preferring electric carsharing over conventional	"Elektrofahrzeuge beim Carsharing bevorzugt leihe"(15)	K17	4
4	own car is not necessary		Participant does not see any need owning a car	Participant expresses that he/she does not need an own car	"eigenes Auto nicht mehr nötig"(5); "kein Auto gekauft"(6)	K4, K6, K12, K13, K39	6

No.	main categories	subcategories	definition	coding rules	anchor example	inductive categories	Number of mentions
5	Flexibility		The mobility behavior of the participant is more flexible	Participant mentions flexibility	"Höhere Flexibilität"(10)	K10, K18, K22	3
6	weighting between carsharing and other transporta-tion means		Participant weights between carsharing and other transporta-tion means	Participant changes transportation means and weights the benefits	"aufgrund Kos-ten/Nutzen"(14); "Carsharing bisher nur bei unbedingter Notwendigkeit"(18)	K20, K16, K24, K31, K32	5
7	using less other transportation means		Participant uses other transpor-tation means less	Participant mentions reduced use of other transportation means	s. subcategories	s. subcatego-ries	7
		using less public transport	Participant uses public transport less	Participant mentions reduced use of public transport	"ÖVM deutlich weniger ge-nutzt"(17)	K5, K11, K21, K28	4
		using less bicycle	Participant uses bicycle less	Participant mentions reduced use of bicycle	"Nutze weniger das Fahr-rad"(1)	K1, K40	2
		using less con-ventional carshar-ing	Participant uses conventional carsharing less	Participant mentions reduced use of conventional carsharing	"Viel seltener konventionelles Carsharing"(8)	K8	1

Appendix L: Further Information about the Opinion Holder

Electric carsharing provider	Number	%	Electric vehicle	Number	%	City	Number	%	Year	Number	%
Multicity Carsharing	41	35%	Citroën C-Zero	46	39%	Berlin	70	60%	2011	2	2%
DriveNow	40	34%	BMW i3	21	18%	Stuttgart	11	9%	2012	9	8%
car2go	13	11%	BMW ActiveE	20	17%	Munich	11	9%	2013	54	46%
Flinkster	12	10%	smart ed	17	15%	Hamburg	8	7%	2014	21	18%
stadtmobil	3	3%	Fiat 500 Elektro	4	3%	Karlsruhe	3	3%	2015	29	25%
E-WALD	3	3%	Renault Zoe	2	2%	Osnabrück	2	2%	no specification	2	2%
Cambio	2	2%	Peugeot iOn	2	2%	Frankfurt	2	2%			
StadtTeilAuto Osnabrück	2	2%	E Ford Focus	1	1%	Cologne	1	1%			
teiauto	1	1%	e-Golf	1	1%	Ulm	1	1%			
			Mini-E	1	1%	Dresden	1	1%			
			no specification	2	2%	Marburg	1	1%			
						Aachen	1	1%			
						no specification	5	4%			

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