A Data-Mining Analysis and a Survey of Electric Carsharing Usage

Masterarbeit

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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[1] (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

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

(cf. Oliver 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[2] 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

[2] 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).

young people and particularly 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[3] 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

[3] 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).

services is created in 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

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 carsharing 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 trans-

portation 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.