Bike Sharing Systems in Munich: 
A (non)users’ behavioural, socio-demographic 
and psychographic analysis.

Author:
Michael Stöckle

Supervised by:
Prof. Dr.-Ing. Gebhard Wulfhorst
M.Sc. David Durán Rodas
M.Sc. Maximilian Pfertner

January 24, 2020
Abstract

The operation of Bike Sharing Systems is associated with benefits like reducing emissions and improving the health conditions of the users. In order to further increase BSS ridership, marketing strategies and incentives have to be developed. This requires a detailed knowledge of both users and non-users of the systems. The purpose of this research was to gather this information by identifying the peoples’ attributes that are associated to BSS usage. For this purpose, a survey was developed based on market segmentation theory, containing questions on the socio-demographic, behavioural, attitudinal and psychographic attributes of the participants. The survey was executed in Munich, Germany from October 24 to December 16, 2019 and generated a sample of 408 responses. The attributes associated to BSS usage were explored with a multiple logistic regression and with the LASSO selection method. Attributes significantly associated to BSS usage were identified in all categories of the questionnaire. Attributes with a negative influence on BSS usage include, among others: being female, considering tradition important, having a high school education or never having used car sharing or e-scooters. Attributes with a positive influence on BSS usage include, among others: being between 30 to 39 years old, having a household net income of 6000 to 7000 Euro, using the private bike frequently, and having a rather negative opinion towards car driving.
## Contents

1 Introduction
   1.1 Problem statement .............................................. 1
   1.2 Need ............................................................ 1
   1.3 Objectives and research questions ............................. 2
   1.4 Thesis framework and report structure ........................ 2

2 Literature review
   2.1 Bike Sharing Systems (BSS) .................................... 5
      2.1.1 Bike Sharing Systems (BSS) in general .......................... 5
      2.1.2 BSS worldwide .............................................. 8
      2.1.3 BSS in Germany ............................................. 10
      2.1.4 Positive impacts of BSS .................................. 11
   2.2 Market segmentation ............................................ 13
      2.2.1 Introduction to market segmentation ........................ 13
      2.2.2 Types of market segmentation ............................... 14
   2.3 Attributes influencing the BSS usage .......................... 16
      2.3.1 Socio-demographic attributes ............................... 16
      2.3.2 Psychographic attributes .................................. 17
      2.3.3 Attitudinal attributes .................................... 18
      2.3.4 Behavioural attributes .................................... 18
      2.3.5 Geographic attributes ..................................... 19
   2.4 Related work ..................................................... 19

3 Methodology
   3.1 Data Collection: Survey ........................................ 23
      3.1.1 Definition of survey parameters .............................. 23
      3.1.2 Survey design ............................................... 25
      3.1.3 Pilot Survey ............................................... 30
      3.1.4 Online survey execution ................................... 33
      3.1.5 Offline survey design and distribution ...................... 34
   3.2 Data Analysis ..................................................... 35
      3.2.1 Data cleaning and BSS users determination .................. 35
      3.2.2 Survey statistics ........................................... 36
      3.2.3 Exploratory Data Analysis (EDA) ............................ 36
      3.2.4 Multiple Logistic Regression (MLR) .......................... 38
CONTENTS

3.2.5 LASSO ......................................................... 39

4 Case of study: Munich ............................................ 41
4.1 Key facts on Munich ............................................. 41
4.2 BSS in Munich .................................................. 42

5 Results ................................................................. 49
5.1 Data Collection: Survey .......................................... 49
5.1.1 Survey parameters ............................................ 49
5.1.2 Survey questionnaire .......................................... 50
5.1.3 Pilot survey .................................................... 50
5.1.4 Online survey execution ...................................... 51
5.1.5 Offline survey execution ...................................... 54
5.2 Survey data analysis ............................................. 55
5.2.1 Data cleaning and BSS users determination ................. 55
5.2.2 Survey statistics .............................................. 56
5.3 Exploratory Data Analysis (EDA) .............................. 60
5.3.1 General findings on BSS in Munich ......................... 61
5.3.2 Socio-demographic attributes and BSS usage ................ 63
5.3.3 Behavioural attributes and BSS usage ......................... 64
5.3.4 Trip purpose and BSS usage .................................. 66
5.3.5 Attitudinal attributes and BSS usage ......................... 68
5.3.6 Psychographic attributes and BSS usage ...................... 71
5.4 Multiple logistic regression (MLR) results ...................... 72
5.4.1 Socio-demographic attributes ............................... 72
5.4.2 Behavioural attributes ....................................... 75
5.4.3 Trip purpose ................................................... 77
5.4.4 Attitudinal attributes ........................................ 81
5.4.5 Psychographic attributes .................................... 84
5.5 LASSO results ..................................................... 86
5.5.1 Socio-demographic attributes ............................... 86
5.5.2 Behavioural attributes ....................................... 87
5.5.3 Trip purpose ................................................... 87
5.5.4 Attitudinal attributes ........................................ 88
5.5.5 Psychographic attributes .................................... 89

6 Discussion .............................................................. 91
6.1 Discussion of results ............................................. 91
6.1.1 Survey results ................................................ 91
6.1.2 Exploratory Data Analysis and Modelling results ............ 92
6.2 Strengths and Limitations of the research ...................... 93

7 Conclusions and further research ................................ 95
7.1 Conclusions ....................................................... 95
7.2 Recommendations for further research ......................... 96
Appendices

A  Residential location of BSS users and non-users in Munich

B  Online survey questionnaire
# List of Figures

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>Thesis structure</td>
<td>4</td>
</tr>
<tr>
<td>2.1</td>
<td>Overview of the different financing, ownership and operation concepts of BSS</td>
<td>8</td>
</tr>
<tr>
<td>2.2</td>
<td>Number of bikes in BSS worldwide</td>
<td>9</td>
</tr>
<tr>
<td>2.3</td>
<td>Worldwide market volume of bike sharing services 2013-2021</td>
<td>9</td>
</tr>
<tr>
<td>2.4</td>
<td>Share of onliners who used BSS through apps or websites during the last 12</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>months</td>
<td></td>
</tr>
<tr>
<td>2.5</td>
<td>Most frequently used BSS in Germany 2019</td>
<td>11</td>
</tr>
<tr>
<td>3.1</td>
<td>Methodology structure</td>
<td>22</td>
</tr>
<tr>
<td>3.2</td>
<td>Result of a MLR</td>
<td>39</td>
</tr>
<tr>
<td>3.3</td>
<td>Code used for the LASSO and the second MLR</td>
<td>40</td>
</tr>
<tr>
<td>4.1</td>
<td>DB Call a Bike bicycle</td>
<td>42</td>
</tr>
<tr>
<td>4.2</td>
<td>MVG Rad bicycle at a bike station</td>
<td>43</td>
</tr>
<tr>
<td>4.3</td>
<td>Donkey Republic bicycle</td>
<td>44</td>
</tr>
<tr>
<td>4.4</td>
<td>Jump Bike bicycle</td>
<td>44</td>
</tr>
<tr>
<td>4.5</td>
<td>Operation area of BSS in Munich</td>
<td>46</td>
</tr>
<tr>
<td>5.1</td>
<td>Residential location of survey participants</td>
<td>57</td>
</tr>
<tr>
<td>5.2</td>
<td>Brand awareness of the different BSS in Munich, N=408</td>
<td>61</td>
</tr>
<tr>
<td>5.3</td>
<td>Reasons for not using BSS</td>
<td>62</td>
</tr>
<tr>
<td>5.4</td>
<td>Socio-demographic attributes and BSS usage, N=408</td>
<td>63</td>
</tr>
<tr>
<td>5.5</td>
<td>Behavioural attributes and BSS usage, N=408</td>
<td>65</td>
</tr>
<tr>
<td>5.6</td>
<td>Trip purpose and BSS usage, N=408</td>
<td>67</td>
</tr>
<tr>
<td>5.7</td>
<td>Trip purpose and BSS usage, N=408</td>
<td>68</td>
</tr>
<tr>
<td>5.8</td>
<td>Attitudinal attributes and BSS usage, N=408</td>
<td>69</td>
</tr>
<tr>
<td>5.9</td>
<td>Psychographic attributes and BSS usage, N=408</td>
<td>71</td>
</tr>
<tr>
<td>5.10</td>
<td>MLR significant socio-demographic variables-part 1</td>
<td>73</td>
</tr>
<tr>
<td>5.11</td>
<td>MLR significant socio-demographic variables-part 2</td>
<td>74</td>
</tr>
<tr>
<td>5.12</td>
<td>MLR significant behavioural variables</td>
<td>76</td>
</tr>
<tr>
<td>5.13</td>
<td>MLR significant trip purpose variables - part 1</td>
<td>78</td>
</tr>
<tr>
<td>5.14</td>
<td>MLR significant trip purpose variables - part 2</td>
<td>79</td>
</tr>
<tr>
<td>5.15</td>
<td>MLR significant trip purpose variables - part 3</td>
<td>80</td>
</tr>
<tr>
<td>5.16</td>
<td>MLR significant attitudinal variables - part 1</td>
<td>82</td>
</tr>
<tr>
<td>5.17</td>
<td>MLR significant attitudinal variables - part 2</td>
<td>83</td>
</tr>
</tbody>
</table>
5.18 MLR significant psychographic variables .......................... 85
5.19 Socio-demographic attributes associated to BSS usage ............... 86
5.20 Behavioural attributes associated to BSS usage ........................ 87
5.21 Trip purpose attributes associated to BSS usage ........................ 87
5.22 Attitudinal attributes associated to BSS usage .......................... 88
5.23 Attitudinal variables influencing BSS usage ............................. 89

A.1 Residential location of survey participants in Munich .................. 110
List of Tables

3.1 Evaluation table for pilot survey ........................................... 32
4.1 BSS in Munich as of December 2019 ....................................... 47
5.1 Facebook groups where the survey was shared and member numbers ...... 52
5.2 Survey participation and response rate ...................................... 54
5.3 Impact of data cleaning on sample size .................................. 56
5.4 Comparison of the sample with MID and city of Munich data .......... 59
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AIO</td>
<td>Activities-Interests-Opinions</td>
</tr>
<tr>
<td>ASZ</td>
<td>Alten- und Servicezentrum</td>
</tr>
<tr>
<td>BSS</td>
<td>Bike Sharing Systems</td>
</tr>
<tr>
<td>DB</td>
<td>Deutsche Bahn AG</td>
</tr>
<tr>
<td>EDA</td>
<td>Exploratory Data Analysis</td>
</tr>
<tr>
<td>ESS</td>
<td>European Social Survey</td>
</tr>
<tr>
<td>FFBS</td>
<td>Free-floating Bike Sharing</td>
</tr>
<tr>
<td>GHG</td>
<td>Greenhouse Gases</td>
</tr>
<tr>
<td>GIS</td>
<td>Geographic Information System</td>
</tr>
<tr>
<td>GLM</td>
<td>Generalized Linear Model</td>
</tr>
<tr>
<td>HBS</td>
<td>Hybrid Bike Sharing</td>
</tr>
<tr>
<td>LASSO</td>
<td>Least absolute shrinkage and selection operator</td>
</tr>
<tr>
<td>MID</td>
<td>Mobilität in Deutschland</td>
</tr>
<tr>
<td>MLR</td>
<td>Multiple Logistic Regression</td>
</tr>
<tr>
<td>MVG</td>
<td>Münchner Verkehrsgesellschaft</td>
</tr>
<tr>
<td>MVV</td>
<td>Münchner Verkehrs- und Tarifverbund</td>
</tr>
<tr>
<td>PT</td>
<td>Public Transport</td>
</tr>
<tr>
<td>PVQ</td>
<td>Portraits Value Questionnaire</td>
</tr>
<tr>
<td>SBBS</td>
<td>Station-based Bike Sharing</td>
</tr>
<tr>
<td>SEPA</td>
<td>Single Euro Payment Area</td>
</tr>
<tr>
<td>SBI</td>
<td>Strategic Business insights</td>
</tr>
<tr>
<td>SVS</td>
<td>Schwartz Value Survey</td>
</tr>
<tr>
<td>SWM</td>
<td>Stadtwerke München</td>
</tr>
<tr>
<td>TUM</td>
<td>Technische Universität München</td>
</tr>
<tr>
<td>VSBBS</td>
<td>Virtually station-based Bike Sharing</td>
</tr>
<tr>
<td>WGS</td>
<td>World Geodetic System</td>
</tr>
</tbody>
</table>
Acknowledgements

First of all, I would like to thank my supervisors Prof. Dr.-Ing. Gebhard Wulfhorst, M.Sc. David Durán Rodas and M.Sc. Maximilian Pfertner for their big support during this thesis.

“Thank you!” also to everyone who helped spreading my survey. Without you, it would not have been possible to reach so many answers. In this context, special thanks go to the employees, the inhabitants and the guests of the “Alten- und Servicezentrum Maxvorstadt”, who made it possible for me to conduct a part of my survey there.

Furthermore, I am grateful to all the people who supported me during the thesis, my family and my friends.
Chapter 1

Introduction

1.1 Problem statement

Between 1995 and 2017, car traffic in Germany has increased by almost 18\% Umweltbundesamt (2019). Despite the fact, that cars nowadays emit much less CO\textsubscript{2}, the increase in traffic has not just equalized the technological progress, but the CO\textsubscript{2} emissions of car traffic have increased by 0.5\% Umweltbundesamt (2019). CO\textsubscript{2}, short for “Carbon dioxide”, is a so-called “greenhouse gas”, that is generated by burning fossil fuels as e.g. oil. Greenhouse Gases (GHG) are a part of the earth atmosphere and hinder the heat that is emitted by the sun from disappearing quickly to the outer space (May and Caron, 2009). In this sense, GHG are essential for life on earth. However, the burning of fossil fuels has led to a sharp increase of CO\textsubscript{2} concentration in the atmosphere during the past 150 years. Thus, less heat is emitted to the space, and the earth is heating up, similar to a greenhouse (May and Caron, 2009). This “greenhouse effect”, for which CO\textsubscript{2} is accountable for by 63\%, leads to a change in climate, being associated with problems as lack of rainfall or melting of glaciers (May and Caron, 2009). Due to the impacts of climate change, the German government has agreed on reducing the GHG emissions by 40\% until 2040 Umweltbundesamt (2019). However, CO\textsubscript{2} emissions in the transport sector have increased by 2.2\% in the last 25 years.

Apart from emissions, car traffic is associated to further negative impacts, for example taking much public space for parking lots and roads, competing with other groups of users as pedestrians or cyclists (Sommer et al., 2016). Randelhoff calculated that a parked car in average occupies a space of 13.5 square metres, more than 10 times the space that is needed by a parked bicycle.

1.2 Need

Due to the constantly high GHG emissions in car traffic, which contradict to the German objectives concerning the climate, and the negative impacts of private transport in the cities, there is a need to enhance sustainable modes of transport and to decrease car traffic at the same time. The bicycle is one of these modes, offering emission-free mobility (Shaheen et al., 2010) and improving the health of the riders (May and Caron, 2009).

Bike Sharing Systems (BSS), which “provide[ ] users with on-demand access to bicycles
at a variety of pick-up and drop-off locations[...]]” (Shaheen and Cohen, 2020), have been implemented in many cities worldwide during the last years. Studies concerning these systems have shown, that the operation of BSS brings many advantages for the cities, that can help mitigating the negative impacts of emissions and car traffic in the cities. A survey from the U.S. showed that users of BSS users drive their private car less and some of them postponed the purchase of a car due to BSS usage (Shaheen and Martin W, 2015). In Lyon, France, the mode share of private transport dropped by 7% after the implementation of a bike sharing system (Shaheen and Guzman, 2011). Several studies show savings in CO\textsubscript{2} emissions because of BSS, for example in Boston, U.S., where three million pounds of GHG emissions were avoided (Shaheen and Cohen, 2020).

Because of the positive impacts of BSS, it is desirable to further increase BSS usage, in other words, to encourage more people to use the systems. This goal can be reached with marketing measures, incentives as cheaper fares for some groups of people (McNeil et al., 2018), or pull-and-push measures as closing roads for private transport and allowing only non-motorized transport.

In order to design the measures for increasing BSS ridership efficiently and to implement them successfully, it is necessary to have a detailed knowledge on the people who are using the systems, but also of those who don’t. So far, most studies have focused on the socio-demographic attributes of the BSS users, but only few have incorporated non-users or other attributes. Fishman (2016) states that “[t]here is a paucity of research with large numbers of people who are not bike-share users”.

### 1.3 Objectives and research questions

The aim of this thesis is to contribute to the deep understanding of BSS users and non-users in Munich, Germany. Munich was selected as a case study because of the vital bike sharing market with currently four BSS systems operating in the city. To reach a better understanding of the target group, which consists of the whole population of Munich, and to fill the gap in research on non-users and attributes, the objective is to identify the socio-demographic, behavioural, attitudinal and psychographic attributes of the people with regards to BSS usage.

The objective can be formulated as the following research question, which has to be answered during the thesis:

**Research Question:**

Which are the people’s attributes influencing BSS usage in Munich?

To answer the research question, a survey for BSS users and non-users is developed and carried out in Munich and the survey results are analysed to identify the attributes influencing BSS usage.
1.4 Thesis framework and report structure

In figure 1.1 the structure of the thesis is depicted. Overall, it is split into seven chapters:

Chapter 1: Introduction
The first chapter starts with the problem statement, where the need for research is derived from. Subsequently, the research question, which is answered by the thesis, is formulated.

Chapter 2: Literature Review
In the second chapter, the results of the literature review concerning the thesis topic, BSS, are presented. Thus, the focus is at first on literature on BSS, in particular on the worldwide and German BSS market, the history of BSS and the positive impacts of BSS. The second part of the literature review deals with the different types of market segmentation. Based on these types, information on the people’s socio-demographic, behavioural and psychographic attributes influencing BSS usage is retrieved from literature and an overview is presented.

Chapter 3: Methodology
The methodology consists of two major parts, data collection and data analysis. At first, the process of designing of a survey for data collection is described. The survey is designed based on the findings from the literature review. The second part of the methodology describes the analysis of the survey data. Subsequently, the data obtained by the survey is analysed, first of all with an Exploratory Data Analysis (EDA) by displaying the survey data. Further steps include logistic regression modelling on all variables plus a LASSO selection.

Chapter 4: Case of Study
In chapter 4, the methodology from the previous chapter is applied by carrying out a survey for BSS users and non-users in Munich. First, a quick look on Munich is taken and the BSS market in the city is analysed. Then, the application of the methodology is described. A survey for all residents above 18 years old is carried out in Munich. It collects data on the attributes of BSS (non-)users influencing the usage of BSS in the city.

Chapter 5: Results
In this part, the results of the case study in Munich are presented, followed by the results of the data analysis.

Chapter 6+7: Discussion of results and conclusions
In chapter 6, the results are discussed and the limitations of the research are considered. In chapter 7, the conclusions are drawn and recommendations for further research are given.
Problem Statement and Need (Ch. 1)

- Problems associated with road traffic
- Impacts of climate change

Objectives and Research Questions (Ch. 1)

- To identify the most predominant attributes of users and non-users of BSS
- Which are the most predominant attributes of users and non-users of BSS?

Literature Review (Ch. 2)

- BSS in general
- Market segmentation theory
- Attributes of users and non-users influencing BSS usage

Methodology (Ch. 3)

- Data collection: Survey for BSS users and non-users
- Data analysis

Case of Study (Ch. 4)

- Carrying out a survey for BSS users and non-users in Munich

Results (Ch. 5)

- EDA Results
- Statistical modelling results

Discussion (Ch. 6)

- Strengths and limitations of the research

Conclusion (Ch. 7)

- Conclusions and Recommendations for further research

Figure 1.1: Thesis structure
Chapter 2

Literature review

The literature review was carried out to get a closer look on BSS, their development and worldwide expansion, and to identify socio-demographic, behavioural, attitudinal and psychographic attributes related to BSS usage. Based on these attributes, the questions of the survey are designed. The literature review is split into two main parts. The first part is about BSS, including general information on BSS, continuing with BSS in Germany. The second part focuses on market segmentation, which is the base for the categorization of attributes influencing BSS usage, which are retrieved from literature in the third part.

2.1 Bike Sharing Systems (BSS)

2.1.1 BSS in general

2.1.1.1 Definition

There is not one common definition of “Bike Sharing Systems”, also called “Bike Share Programs”, “Bike Share”, “Bike Sharing”, “Bike-Sharing”, or “Bikesharing”. Researchers use different ways to define them.

Shaheen and Cohen (2020) state that “bikesharing provides users with on-demand access to bicycles at a variety of pick-up and drop-off locations for one-way (point-to-point) or roundtrip travel”, whereas

Monheim (2012) defines BSS as a service where “publicly accessible bicycles are rented without personal contact to the operator and given back at another location after usage”.

In general, the public accessibility and the automated rental process distinguish BSS from other private bike rental services offered by bicycle shops, bike stations or hotels. Renting a bike often includes entering a private location and signing a contract in with the employees and returning it to the same place afterwards (Monheim, 2012).

2.1.1.2 History

The history of BSS can be divided into four generations of BSS (Reiss, 2017; DeMaio, 2009; Shaheen et al., 2010). More recent literature also names a new fifth generation (Roland Berger, 2018; Zug et al., 2019), but this addition does not seem to have prevailed yet.
In July 1965, the first generation of BSS was introduced in Amsterdam. It was possible to take a bike, ride it somewhere and leave it there for the next user (DeMaio, 2009). The 50 white-colour bikes of the system were free to use and permanently unlocked, what made them vulnerable to vandalism or theft (Shaheen et al., 2010). In Amsterdam, many were stolen or thrown into canals, which caused the system to collapse very soon (DeMaio, 2009; Shaheen et al., 2010). Despite the failure, in the following decades similar systems were introduced, for example in La Rochelle/France in 1974 or Cambridge/UK in 1993. This system failed, because most of the bikes were stolen (Shaheen et al., 2010).

The theft and vandalism problems led to the second generation of BSS. In 1995, the city of Copenhagen in Denmark introduced a BSS, where the bikes were locked at special bike racks and had to be unlocked with a coin deposit. It was refunded to the customer when returning the bike (Shaheen et al., 2010). Despite the system was and still is quite successful, there are some drawbacks: the operation is more expensive and the rental time is unlimited. Furthermore, the deposit is quite low, resulting in the issue that many bikes are rented for a long time or are never given back (Shaheen et al., 2010).

Developers soon noticed that a better tracking of the BSS customers was necessary to reduce the problems that were still existing (DeMaio, 2009). For the third generation of BSS, the customer is registered and smart technology like magnet stripe cards or mobile phones is used to unlock the bikes (Shaheen et al., 2010). An example for a third-generation BSS is DB Call-a-Bike introduced in 2000 in Munich, Germany, however, the breakthrough for these systems came in 2005 when an advertisement company successfully introduced the system in Lyon (DeMaio, 2009).

The fourth generation of BSS is a further development of the third generation with regards to bike rental, bike safety and connection to PT (Shaheen et al., 2010). Renting a bike is possible with a smartphone (Münchner Verkehrsgesellschaft mbH (MVG), 2018) or directly at the station at a touch display (Shaheen et al., 2010). Furthermore, the aspect of the redistribution of the bikes is considered (Shaheen et al., 2010). Another important innovation is that the Bikes are GPS-tracked. One advantage is that theft is reduced (Shaheen et al., 2010), another that the operation of free-floating BSS is easier, where bikes are not attached to a certain station (Reiss, 2017).

The most recent, fifth generation uses “predictive algorithms to maximize utilization of the bike fleet” (Roland Berger, 2018). Furthermore, the collection of customer data plays an important role. On the one hand, the goal is to enhance the customer experience, on the other hand, companies opt to generate commercial revenue with the customer data (Roland Berger, 2018; Huang, 2018). A third aspect is the full integration into mobility platforms, directly connecting with other modes of transport (Roland Berger, 2018). There is also another concept for the fifth generation. Within the “TRANSFORMERS” project, researchers form the University of Magdeburg work on a BSS with autonomous bikes, similar to autonomous cars. This a on-demand system should work as a feeder to Public Transport (PT) and transport freight (Zug et al., 2019).

2.1.1.3 Types of BSS

Based on the stations’ availability, different types of BSS can be categorized into different types. In literature, there are different categorizations. Roland Berger (2018) and Shaheen...
and Cohen (2020) name three types: Dock-based (or Station-based) bike sharing, Free-floating bike sharing, and Hybrid Bike Sharing. In her dissertation on mobility stations, Miramontes (2018) adds another category to Station-based BSS: Station-based without docking station. In this thesis, the four-type classification was used.

1. **Station-based Bike Sharing (SBBS)**
   In station-based systems, bikes can be rented and given back only at fixed docking stations. Examples for this type are the BSS in Copenhagen or Lyon mentioned above.

2. **Station-based bike sharing without docking stations**
   As for the second type, station-based systems without docking stations replace the station by an predefined area, in which the bike has to be given back after usage. This return area is usually marked in the map in the mobile phone app of the operator (ApS Donkey Republic Admin, 2019). So, there is not a physical, but a virtual docking station. To make naming easier, this type is called “**Virtually station-based Bike Sharing (VSBBS)**”. An example for the second type can be found in Munich, Germany, with the BSS operated by DonkeyRepublic since 2018.

3. **Free-floating Bike Sharing (FFBS)**
   In free-floating systems, it is possible to rent and give back the bikes at any position in the public space, within the operation area of the system (Reiss, 2017). DB Call-a-Bike, is one of the first free-floating BSS (Monheim, 2012; Reiss and Bogenberger, 2015).

4. **Hybrid Bike Sharing (HBS)**
   The fourth and last type of BSS, the hybrid system, is a mixture between station-based and free-floating systems. Bikes can be rented and given back either at the docking stations or at any position within the operation area (Shaheen and Cohen, 2020). If the customer returns the bike at a docking station, he or she may receive a small amount of money on his or her BSS rental account (Münchner Verkehrsgesellschaft mbH (MVG), 2018).

### 2.1.1.4 Financing, ownership and operation concepts of BSS

There are many different ways in which BSS can be financed, owned, or operated. Researchers have presented these business models differently, for example Shaheen et al. (2012b,a) or Monheim (2012). Based on Shaheen, Roland Berger (2018) presents a well-arranged overview (see figure 2.1), which is divided into three major levels: overall goals, financing and ownership and operations. Regarding the overall goals, BSS are split into for-profit and non-profit systems. While for-profit systems are owned and operated by a private company and have to raise private investments quickly for funding, non-profit systems are owned and operated by an agency and the funding comes from flexible sources, e.g. from the government or other local sources.

For the financing, there are also two options, private and public, which can be combined. Private financing includes private loans or grants, advertising, sponsorship or venture capital. Public financing consists of federal grants, state grants or city funds. For ownership and
operations, there are three different possibilities: both private ownership and operation, public ownership and private operation or both public ownership and operation (Roland Berger, 2018).

![Operating models table]

**Figure 2.1:** Overview of the different financing, ownership and operation concepts of BSS

Source: Roland Berger (2018)

### 2.1.2 BSS worldwide

Despite BSS have been existing for more than 50 years now, the worldwide number of systems stayed small for a long time. In 2004, only 13 cities worldwide operated a BSS (Fishman, 2016), most of them in Europe. The first stage of rapid expansion to the United States began in 2007 (Shaheen et al., 2014), and the first SBBS in China appeared not earlier than the same year (Huang, 2018). By 2014, China had already overtaken all other countries and had become world leader in Bike Sharing. By this time, more than three quarters of the approximately one million BSS bikes worldwide were located in China (Fishman, 2016). The growing trend continued during the next years, and from 2015 on the number of Bikes grew even faster as can be seen in Figure 2.2. Especially in China, BSS start-ups flooded the cities with bikes, causing troubles when the operators went bankrupt due to financing and profitability problems (Huang, 2018; Taylor, 2018). Figure 2.4 illustrates how widespread bike sharing was in China in 2018. More than 37% of the population with internet access have used a BSS during the last 12 months. In other countries, this share was much lower. According to the website [www.bikesharingmap.com](http://www.bikesharingmap.com), that shows all BSS worldwide, in early 2020, there are almost 18 million bikes available in more than 2100 BSS (Meddin and DeMaio, 2020). The map shows that most systems are located in China, Europe and
2.1. BIKE SHARING SYSTEMS (BSS)

the United States. However, Roland Berger (2018) states that the systems are available in 70 countries all over the world.

Figure 2.2: Number of bikes in BSS worldwide
Source: Roland Berger (2018)

Figure 2.3: Worldwide market volume of bike sharing services 2013-2021
Source: Roland Berger (2018)
Figure 2.4: Share of onliners who used BSS through apps or websites during the last 12 months

Source: Brandt (2018)

2.1.3 BSS in Germany

2.1.3.1 History

Bike sharing is present in Germany in the 1950s, when non-automated rental systems came up, where the customer had to fill a contract and leave a deposit ((Monheim, 2012; ?). This service was mainly available at train stations or hotels and served for tourist purposes and consisted of only a few rental bikes. In the 1960s, a system in Bremen came up with old bikes and no customer registration or fees. This system can be seen as a representative of the first-generation BSS in the previous chapter (Monheim, 2012). In the 1990s, the railway companies of Germany and the Netherlands upgraded their systems, putting Bike Stations at the railway stations, which included Bike Sharing. One advantage was the system architecture where the stations are connected, so the bike can be given back at any station, not just at the place where it was rented. But these stations were only available in tourist regions or large or medium-sized railway stations. An important step was the introduction of Call a Bike in Munich, founded in the year 2000 as a start-up ((Monheim, 2012), p.20) and pioneer of the third-generation BSS. Bikes were parked close to telephone cells and the customer had to call the number on the bike to unlock it. Payment was done by credit card. One year later, the German railway operator DB bought the company and expanded the systems to railway stations all over Germany. The successful introduction of Velib in Paris and the chance to use the bikes for advertisement led to a boom in third-generation BSS.

2.1.3.2 Current situation

As for BSS in Germany, the operators DB Call a Bike and nextbike are considered as the most dominant players on the market (Fahrrad-XXL.de GmbH & Co.KG, 2018). For a long
2.1. BIKE SHARING SYSTEMS (BSS)

time, the two German companies have been the only operators, but in recent years, others have appeared, such as Byke as a German start-up, Donkey Republic from Denmark, Lime Bike from the United States, and Mobike from China (Fahrrad-XXL.de GmbH & Co.KG, 2018). The market situation with two main players on the German BSS market is shown in figure 2.5. The German Statistical Office asked online, which BSS people used the most frequently during the last 12 months. Previously, they had answered that they had used BSS during that time. With being used most frequently by 47% of the participants, DB Call-a-Bike is clearly in the lead, followed by nextbike with 20%. The system on the third position, “StadtRad” belongs to Call-a-Bike (Frommeyer, 2019). The other operators have all numbers below 10%.

Figure 2.5: Most frequently used BSS in Germany 2019

Source: Kunst (2019)

The map from Meddin and DeMaio (2020) shows that in Germany, most of the BSS can be found in or nearby large cities or in agglomerations as Berlin, Munich, Hamburg, the Ruhr area or the Frankfurt and Mannheim areas. In rural areas, the systems are almost not present. In a survey for the “Bike monitor 2019”, by the Sinus-Institute, only 10% of the participants living in places with less than 20000 inhabitants stated that there is a BSS at their hometown, whereas the number for those living in cities with more than 500000 inhabitants was 81% (Borgstedt et al., 2019). Overall, 69% of the participants have heard of BSS, an increase by 7% since 2017 (Borgstedt et al., 2017, 2019), and 25% have already used BSS. This equals to 17% of the total population (Borgstedt et al., 2019).

2.1.4 Positive impacts of BSS

The implementation of BSS as an additional mode of transport brings along changes in the peoples’ mobility behaviour that affect mode share, emissions, or personal health. Several studies have researched on that topic, especially in the United States. In the following, the most important findings are collected.
• Reduction of car usage
A study carried out in US and Canadian cities found out that after implementation of the BSS the people using the systems drive by car less often (Shaheen and Martin W, 2015). Another survey showed that 5.5 % of BSS users sold their vehicle or postponed a purchase (Shaheen and Martin W, 2015), and in Mexico City, 50 % of BSS users reduced their car usage. In this context, further studies examined that car trips were substituted by Bike Sharing trips (Fishman et al., 2013), leading to a shift in transport modes. After the implementation of the “Velo’v” system in Lyon, France, the automobile mode share dropped by seven % (Shaheen and Guzman, 2011). German transport experts agree that Bike sharing has the possibility to make the second car of a household obsolete (Monheim, 2012). Bike share’s impact on car use: Evidence from the United States, Great Britain, and Australia (Fishman et al., 2014a).

• Increase of bike usage
Different studies and reports suggest a much healthier mobility behaviour after the introduction of a BSS. The “2016 Capital Bikeshare Member Survey Report” (L D A Consulting, 2017) found out that 44 % of BSS users make at least one “induced” trip per month with the system that they would not have made otherwise. Data from Europe suggests that after the launch of the “Vélib” BSS in Paris, the mode share of bike in the city increased from 1.5 to 2.5 %, while for Barcelona, the share more than doubled in only two years from 0.75 to 1.75 % (Shaheen and Guzman, 2011).

• Reduction of GHG emissions
The replacement of car trips by emission-free bike trips has the potential to reduce emissions of GHG (May and Caron, 2009). Since BSS have come up, operators have quantified the reduction of emissions. For example, in 2009, the city of Lyon, France, stated that its own BSS has saved 18.6 Million pounds of CO\textsubscript{2} pollution from the atmosphere (DeMaio, 2009). More recently, the American Boston BSS operator “Bluebikes” concluded that in 2019, its users avoided an estimate of three million pounds of GHG emissions (Shaheen and Cohen, 2020). Another evidence is from the city of Fort Worth. The operator concluded that a total of 251,000 pounds of GHG emissions were compensated in 2017 (Shaheen and Cohen, 2020) (Camareno and Brennan, 2017). For the emission reduction, it has to be considered that the bikes have to be repositioned inside the system as there is not the same demand in all directions of the city (Chemla et al., 2013). This is often done by trucks that cause emissions (Fishman et al., 2014a). Fishman et al. (2014a) compared the emissions and comes to the conclusion that in most cities, the emission reduction by BSS is much higher than the additional emissions caused by rebalancing. However, in London this is not the case (Fishman et al., 2014a).

• Health benefits trough increased bike usage
Many scientific studies have indicated a positive impact of riding a bike on health. In 2016, Oja et al. (2011) carried out a review on 16 studies on the health effects of cycling. They came to the conclusion that 14 studies identified health benefits from
cycling, such as improved fitness and lower cardiovascular disease or cancer mortality (Oja et al., 2011). Hence, an increase of bike usage leads to health benefits for the users. Martínez et al. (2019) expressed the total health benefits for BSS users of 13 European cities in monetary terms, calculating benefits through physical activity and losses through air pollution impacts and the risk of having an accident. The benefits summed up to more than 250 Million Euros, by far outweighing the losses that were about 20 Million Euros.

In the user survey on North American BSS by Shaheen et al. (2012b), 72% of participants stated that they ride a bicycle more whereas between 53 and 58% of the participants agree or strongly agree that they get more exercise since using BSS.

- Bridging of first-and-last-mile gaps

There are different studies that suggest that BSS work as a feeder mode for PT. In Washington, D.C, 71% of BSS users said that they use the city’s BSS occasionally to access a PT stop, 18% used the system for this purpose at least six times per month (LDA Consulting, 2017). Miramontes et al. (2017) found out in her Munich survey that PT connection is very important for 75% of the BSS users at the analysed Mobility Station. In the study conducted by Shaheen et al. (2012b), 67 to 83% of the participants, depending on the city, agreed or strongly agreed on the statement that BSS improved the connectivity of the PT systems in the cities (Shaheen et al., 2011). For Beijing, China, Li et al. (2018a) confirmed based on a data analysis, that the BSS by the operator “Mobike” works as a feeder mode to PT stations.

Further effects of BSS observed by researchers include an increase of helmet use and safety (Shaheen and Cohen, 2020), an increase of environmental awareness (Shaheen and Cohen, 2020) or a reduction of congestion and fuel use (Martínez et al., 2019).

## 2.2 Market segmentation

This chapter provides an overview on market segmentation theory, which is the basis for the classification of the people’s attributes into socio-demographic, behavioural, attitudinal and psychographic categories.

### 2.2.1 Introduction to market segmentation

Market segmentation is a marketing strategy whose aim is to “identify and delineate market segments or ‘sets of buyers’ which would then become targets for the company’s marketing plans” (Tynan and Dayton, 1987). It has been first introduced by (W. Smith, 1995), although its basics can be found in the 1930s, when it became obvious that the classical theory of perfect competition and pure monopoly was not sufficient to explain the market any more, due to an increased heterogeneity on the demand and supply sides (W. Smith, 1995). In addition, W. Smith (1995) found out that the heterogeneous markets were made up of smaller homogeneous sub-markets. The method is to divide the market into homogeneous segments, in which the customers share the same characteristics by assigning potential customers to
homogeneous groups (Tynan and Dayton, 1987; Vyncke, 2002). These groups can then be directly addressed with marketing measures. According to Tynan and Dayton (1987), the market segmentation brings many possibilities for companies:

- Offering products that fit the customer
  Market segmentation helps seeing the market from a customer’s point of view. It becomes possible to offer products that optimally fit the needs of the customer.

- Improving the sales and market share of a product
  New strategies for optimizing the performance of a product can be developed. For example, it becomes possible to increase the market share by “diverting buyers from competing brands or by attracting new customers” (Tynan and Dayton, 1987).

- To position ranges of brands and of product varieties (Tynan and Dayton, 1987).

- Identifying gaps in the market
  There are segments in the market where the needs of the customers may not be satisfied by any existing brand. Market segmentation helps to figure out these gaps, which can then be filled by expanding an existing product or launching a new product (Tynan and Dayton, 1987).

### 2.2.2 Types of market segmentation

The market segmentation can be done considering different sets of attributes of the customers. These sets of attributes are also called segmentation variables or bases (Tynan and Dayton, 1987). In literature, these variables are classified differently. In their papers, Tynan and Dayton (1987) name seven different groups of variables for segmentation, resulting in seven different types of market segmentation, Vyncke (2002) and Bug (2015) name three types, but with a wider definition. Subsequently, the most important types from the literature are collected:

- Geographic segmentation
  This type of segmentation divides markets into geographic units. It can be performed on a national, regional or local level. It is likely the oldest segmentation type (Tynan and Dayton, 1987).

- Demographic segmentation
  In demographic segmentation, the market is segmented with the help of (socio-)demographic attributes of the customers. These can include “age, sex, socio-economic group, family size, life cycle, income, occupation and education” (Tynan and Dayton, 1987). It is the most popular segmentation method.

- Psychographic segmentation
  This segmentation was developed because researchers found out that demographic and geographic segmentations failed to draw a complete picture of the customer (Bug, 2015), driven by the increased personalization in the customer behaviour patterns
2.2. MARKET SEGMENTATION

(González and Bello, 2002). The psychographic attributes can include “lifestyles, values, interests [and] social behavior (Bug, 2015)”. At first, the research on psychographic market segmentation started out with defining personality profiles. As this research was not very successful, the “lifestyle” concept was developed, which is usually based on an extensive survey of the customer (Vyncke, 2002).

Today, lifestyle is usually defined as the patterns in which people live and spend their time and money (Kaynak and Kara, 2001; Vyncke, 2002).

There are different approaches for lifestyle segmentation: The first was the Activities-Interests-Opinions (AIO) approach, measuring peoples’ activities, interests and opinions. The AIO approach was very extensive, with questionnaires of 250 or 300 items (Vyncke, 2002). This led to the second generation of lifestyle segmentation, the value systems approach, which offers a shorter and more elegant method (Vyncke, 2002). Values are “desirable, trans-situational goals, varying in importance, that serve as guiding principles in people’s lives.” (Vyncke, 2002). Researchers have developed different systems for the value-based lifestyle segmentation. In the following paragraph, the most well-known are named and the ones considered for this research are described:

- **VALS™-Method** *(Strategic Business Insights, 2020)*
  Launched in 1978, the VALS concept is “one of the most popular lifestyle market segmentation concepts” (Bug, 2015). Today, it has been redeveloped into a 35-item questionnaire (Bug, 2015) and is distributed by the U.S. American market research company Strategic Business insights (SBI) (Strategic Business Insights, 2020) and groups customers in eight different segments (Bug, 2015). The VALS survey is available for usage at the SBI website, but it is only “for use by people whose first language is American English” (Strategic Business Insights, 2020).

- **Sinus-Milieus ®**
  The Sinus-Milieus ® are a typology of society and target groups by the German “Sinus-Institut”. People are grouped according to their views of life values and attitudes (Calmbach and Hecht, 2020).

- **Schwartz Value Survey (SVS)**
  The survey was developed by Shalom Schwartz of the Hebrew University of Jerusalem (Schmidt et al., 2007; Schwartz, 2006). It is based on his theory of Basic Human Values, where he describes ten basic values, that “include all the core values recognized in cultures around the world” (Schwartz, 2006, 2012). As the original SVS consisted of 57 questions, Schwartz decided to develop a shorter version, the Portraits Value Questionnaire (PVQ) (Schmidt et al., 2007; Schwartz, 2006). There are two versions, one with 40 questions and a even shorter one with 21 questions (Schmidt et al., 2007; Schwartz, 2012). A comparison between the SVS and the PVQ by Schmidt et al. (2007) showed that despite the reduction of variables, the questionnaires nearly lead to the same results. Currently, the PVQ is used in the European Social Survey (ESS), a survey carried out in 38 European countries to monitor social change (ESS ERIC, 2019).

- **Rokeach Value Survey**
- List of Values
- The Euro-Socio-Styles
- GFK Roper Consumer Styles

- Behavioural segmentation
  Here, the segmentation takes place with respect to the customers’ use of a product or their response to the product (Tynan and Dayton, 1987). In transportation research, behavioural segmentation refers to the usage of means of transport (Sullivan and Fallon, 2004).

- Attitudinal segmentation
  Usually, attitudinal segmentation is part of psychographic segmentation (Sullivan and Fallon, 2004).

- Hybrid segmentation
  Combining two or more segmentation methods is called “Hybrid Segmentation”. In some cases, this method gives better results than using just one set of variables alone. For example, after dissatisfying results from demographic segmentation, it was found out that a better outcome can be generated when demographic and psychographic attributes were combined (Bug, 2015). The method is also frequently used in transport research (Sullivan and Fallon, 2004).

2.3 Attributes influencing the BSS usage

The following chapter presents the peoples’ attributes which are influencing BSS usage. The attributes were retrieved from different studies and are presented according to the different bases used in market segmentation.

2.3.1 Socio-demographic attributes

During the search for literature, a lot of studies were found focusing on socio-demographic attributes of the BSS users. All common socio-demographic variables turned out to influence BSS usage:

- Age
- Gender
- Education
- Employment status/occupation
- Income
- Ethnicity
2.3. ATTRIBUTES INFLUENCING THE BSS USAGE

Evidence from literature:

Fuller et al. (2011) analysed the BSS usage in Montreal, Canada carrying out a telephone survey and a multivariate logistic regression. As for the demographic attributes, it was found out that people of young age were more likely to use the BSS than old people. When it comes to education, people with a college or university degree were seven times more likely to use the BSS than people with high school degree or less. Students were very likely to use the BSS (odds ratio of 1.67), whereas retired people would use it very unlikely (odds ratio of 0.05, with an odds ratio of 1 for full-time employed people as a reference). Generally, the users of the BSS are very likely to be 18-24 years old (Fuller et al., 2011).

Ogilvie and Goodman (2012a) did a research on the inequalities of BSS usage in London, United Kingdom. The researchers obtained the registration data from the London BSS and used linear regression to determine how socio-demographic variables correlated with the number of trips made. In a second step, they determined with a logistic regression, which variables predicted if the BSS was “ever used”. They came to the conclusion that females made less BSS trips than males and that people from deprived areas actually use BSS more often than people from less-deprived areas.

In a case study in Nanjing, China, Du and Cheng (2018) identified ”the characteristics and influential factors of different travel patterns in FFBS” Du and Cheng (2018) with a Multinomial logit model. The researchers determined three different travel patterns and the factors influencing them. They concluded that occupation had an impact on the peoples’ BSS travel behaviour.

Further survey studies have proven the significant influence of socio-demographic attributes: Shaheen et al. (2014) investigated the BSS Systems in the U.S., Mexico, and in Canada. A survey was carried out among members of the BSS in five cities. The members of the BSS systems were generally higher educated than the overall population. More than 80 % of the members in U.S. cities had a Bachelor’s degree or higher (Shaheen et al., 2014).

L D A Consulting (2017) carried out a survey among the members of the Washington, D.C. BSS in the U.S. and compared their socio-demographics to the average demographic data from the census. The result was that males and “White” people were over-represented among the BSS members. While in the study area, according to census data, there were almost 50-50 male respectively female employees, a 58% of the BSS members were male and 42% female (L D A Consulting, 2017). The share of African Americans in the working population is 23 %, but only 4 % of BSS members belong to that group (L D A Consulting, 2017).

A study on BSS in different cities in the U.S. (McNeil et al., 2018), it was found that people of lower income generally use the systems less. Besides, the BSS users in Shaheen et al. (2014) tend to have an higher income: 26 % of the Toronto BSS users have an annual income of more than 150000 US Dollars, but only 13 % of the total population. The same study came to the conclusion that also “People of colour” use the BSS less (McNeil et al., 2018).

2.3.2 Psychographic attributes

The following psychographic attributes influencing BSS usage were found in literature:
• Social milieu (Expeditive, performance–oriented, traditional, precarious)

• Social norms

There have been numerous studies that identified a connection between norms and values and travel behaviour (Hunecke, 2015), but –to the best of the author’s knowledge– only a few which focused on that topic with regards to BSS. An important psychographic factor are the social norms (Hunecke, 2015), defined as the “expectations of social groups or people, which are considered as important for oneself” , for example the norm to show consideration for cyclists and pedestrians while driving a car (Hunecke, 2015). Boenigk et al. (2019) and Georgi et al. (2019) identified different factors that influence sharing behaviour, by carrying out a survey and a regression analysis. The analysed sharing patterns were eBike sharing, flat sharing and garden sharing. They found out that the social norm strongly affected the participation in eBike sharing. The more using eBike sharing is accepted, the more it is used. (Boenigk et al., 2019).

The German “bike monitor” (Borgstedt et al., 2019) investigated the BSS usage in Germany with a survey and assigned the users to the different SINUS®–Milieus. The result was that BSS usage is above average among the expeditive and the performance-oriented milieus, and below average for the traditional and precarious milieus (Borgstedt et al., 2019).

2.3.3 Attitudinal attributes

So far, the influence of attitudinal attributes on mobility behaviour have been mostly investigated for the usage of car (Hunecke, 2015). The following attributes were found for BSS usage:

• Perception of car driving as being convenient

• Perception of bike sharing as being dangerous

• Positive attitude towards cycling

• Perception of bike as being safe

Fishman et al. (2014a) identified the barriers to bike sharing in Melbourne and Brisbane, Australia by carrying out an online survey of members and non-members and performing a factor analysis. The biggest barriers to BSS membership was the convenience of car usage, and the perceiving of BSS as dangerous. The same survey Fishman et al. (2014b) showed with regards to the attitudes of the members, that members of BSS systems felt more safe about riding a bike than non-members, both on a bike lane and a road.

Shaheen et al. (2011) aimed to understand the “early adoption and behavioral response to bikesharing in Hangzhou, China” (Shaheen et al., 2011). For this purpose, questionnaires were distributed to the BSS members and non-members. One part of the study focused on attitudes of the members and non-members towards the conditions for cycling and environmental issues. Generally, the BSS members had a more positive attitude towards the cycling conditions than the non-members. For example, 83% of the members stated that “Cycling [was] safe in Hangzhou”, in comparison to 44% of the “Persistent non-members” (Shaheen et al., 2011).
2.4. RELATED WORK

2.3.4 Behavioural attributes

- Usage of bike
- Usage of PT
- Usage of car
- Multi-modal mobility behaviour

Next to attitudes, travel behaviour was the second key aspect in the Shaheen et al. (2011) study on Hangzhou. It was found that BSS non-members generally cycled less, and also used the bike less for certain trip purposes as going to work (Shaheen et al., 2011).

Apart from socio-demographics, Fuller et al. (2011) focused on travel behaviour. People who walked to work or drove to work by car or by PT, were much less likely to use BSS than people who cycled to work.

Guo et al. (2017) conducted research on factors influencing BSS usage and the degree of satisfaction with BSS. First, a survey was carried out in the city, then a bivariate ordered probit model was developed to identify the significant factors. One result was that the respondents who travel by bike or PT and bike tend to use the BSS more often (Guo et al., 2017).

Reiss et al. (2015) sent a survey questionnaire to all DB Call a Bike users in Germany. The data analysis of the responses showed that “Call a Bike users bike very often and show a multimodal mobility pattern” Reiss et al. (2015). Furthermore, they often combine bike and PT trips.

2.3.5 Geographic attributes

The geographic attributes that are influencing BSS usage were not the main focus of this research, thus there was just a quick literature review done. In their studies, Smith et al. (2015), Guo et al. (2017) and (Singla et al., 2015) identified the distance to the next BSS station as a relevant attribute. Duran-Rodas (2017) analysed data from car and bike sharing systems to identify spatio-temporal factors which affect the “arrivals and departures of shared vehicles” (Duran-Rodas et al., 2018). Distance to the city centre turned out to be a significant factor influencing the departures (Duran-Rodas et al., 2018).

2.4 Related work

In this chapter, further studies that are related to this research due to a similar methodology or purpose, are briefly presented.

- The project “INTERMODI” (Stolberg and Hoffmann, 2005) identified users’ segments of car sharing and DB Call a Bike.

- Fuller et al. (2011) conducted a survey in Montreal, Canada and used logistic regression to identify the socio-demographic attributes of BSS users.
• Ogilvie and Goodman (2012b) used registration data from the London/UK BSS and compared socio-demographic user data to census data by applying a logistic regression.

• Li et al. (2013) carried out a market segmentation based on the attitudes towards biking in Nanjing, China. First the data was collected with a survey, then the factors were explored with a factor analysis, and finally the market was clustered.

• The “German bike monitors” (Borgstedt et al., 2017, 2019) combined the SINUS milieus, to which the people belong, with their BSS usage.

• Du and Cheng (2018) identified the “Characteristics and Influential Factors of Different Travel Patterns in Free-Floating Bike Sharing” (Du and Cheng, 2018) in Nanjing, China. For this purpose, a survey was carried out to collect data and logistic regression was used to determine the factors.

• Li et al. (2018b) analysed “the factors affecting users’ behaviors in a free-floating bike sharing (FFBS) system in China”. For this research, a survey was carried out in a Chinese province and the significant factors influencing BSS usage were determined by applying a binary logistic model.

• Winters et al. (2019), conducted a survey in Vancouver, Canada, and determined travel characteristics of BSS regular users and “super-users” with a logistic regression model.

With regards to Munich, the following research on BSS related to this thesis was found:

• Reiss et al. (2015) analysed the DB Call a Bike system, including a user survey to identify the socio-demographic attributes and the general mobility patterns of the participants and the trip purposes for which they use the bike sharing system.

• Satow (2018) carried out a survey among students who use BSS, collecting socio-demographic data of the users and data about usage duration, use frequency and modal shift through BSS usage.
Chapter 3

Methodology

In this chapter, the methodological approach which has been developed to answer the research question is presented. The following figure 3.1 shows the structure. It consists of two main parts, the data collection by a survey and the analysis of the data obtained from it. The methodology part also includes findings from literature on these topics.

Before the survey is carried out, several steps are made. First of all, the target population of the survey is defined, the survey mode and the sampling concept are chosen, and the required sample size for the survey is determined. After that, the survey is designed. The design process itself consists of two steps: the selection of the survey questions based on the results of the literature review and the development of an online survey questionnaire. As the survey design is completed, a pilot survey is carried out to test the survey. The pilot survey feedback is collected and it is evaluated whether the proposed adoptions are helpful. If this is the case, the existing online survey is remodelled by including the feedback. The adopted survey can now be launched online. The survey link is distributed in different ways to reach a large number of participants. While the survey is available online, the survey statistics like participation and fulfilment rate are permanently checked. If participation is too low, the means of survey distribution are adopted, if the rate of fulfilment is too low, meaning that too many participants quit during the survey, the survey design is adopted. Apart from survey participation, also the socio-demographic attributes of the respondents are checked. If it turns out that some groups of people are under-represented in the survey sample, an offline survey is developed and is then distributed to these people. Later, the responses of the offline survey are transferred into the online survey.

After the required sample size has been reached, the survey is terminated and the results are exported. Now, the data analysis part can be carried out. First of all, the data is cleaned to prepare it for further analysis. In this context, cleaning consists of removing the incomplete answers and the answers that do not match the selected target population. After the data is cleaned, exploratory data analysis is carried out to get an overview of the data set characteristics and of the attributes that might influence the BSS usage. The further step is fitting all variables from the survey into a Multiple Logistic Regression (MLR) model, which predicts the significant socio-demographic, behavioural, psychographic and attitudinal attributes that are associated to BSS usage. In a second approach for data analysis, the significant attributes are selected with the Least absolute shrinkage and selection operator (LASSO) method, and the selected attributes are inserted again in an MLR model.
CHAPTER 3. METHODOLOGY

Data collection (Ch. 3.1)

Definition of survey parameters:

Survey design

Selection of questions

Development of an online survey

Pilot survey

Pilot survey feedback

Online survey of BSS users and non-users

Offline survey for people who could not be reached online

Raw data obtained from survey

Data Analysis (Ch. 3.2)

Data cleaning

EDA

Logistic regression modelling

LASSO selection

Logistic regression modelling

remodeling with feedback from pilot survey

permanent monitoring of survey participation and rate of fulfillment

Figure 3.1: Methodology structure
3.1 Data Collection: Survey

For the purpose of data collection, a survey is carried out. In this chapter, the design and executing process of the survey is described.

3.1.1 Definition of survey parameters

Before the survey is designed, some key parameters regarding the survey have to be determined based on the research objective (based on Kasunic (2005) and Richardson et al. (1995)):

1. Definition of the target population
2. Selection of the survey mode
3. Definition of the sampling strategy
4. Definition of the sample size

3.1.1.1 Definition of the target population

All the members of a specific group are called “population” (Kasunic, 2005). It can be defined by demographic, geographic, occupational, time factors or a combination of those (Kasunic, 2005). The “target audience” or “target population” is the part of the population of which the survey aims to collect information, thus the target population directly emerges from the aims of the survey (Kasunic, 2005; Richardson et al., 1995).

As the goal of the research in this study is to determine the attributes of BSS users and non-users, the target population consists of all people living in the study area.

3.1.1.2 Selection of the survey mode

First of all, the survey mode is selected. In survey research, the administration of survey questionnaires and the communication with the interviewee are called “survey modes” (Döhring and Bortz, 2016). Generally, there are four different survey modes (Döhring and Bortz, 2016; Nardi, 2018):

- Self-administered questionnaires or paper-pencil questionnaire

These questionnaires are completed by the participants on their own. They can be distributed by and returned to the interviewer by (e-)mail or in person, at classrooms or in meetings. This survey mode is suitable for describing “characteristics of a large population (like demographics)” (Nardi, 2018) as they can be distributed in large numbers.
• Computer-assisted, web-based surveys or online survey

Nardi (2018) defines online surveys as “self-administered questionnaires that are created and distributed with computers” (Nardi, 2018). A survey link leads the respondents to a website where the survey is hosted. Due to the technical progress, the online survey has become the most frequent survey mode in Germany along with telephone interviews, each representing 36% of all surveys in 2013 (Döhring and Bortz, 2016). Web-based surveys bring along several advantages compared to other survey modes, such as low costs, a fast response rate, easier data analysis as usually less errors are made by the interviewer, and the possibility to reach a large sample fast (Chelius et al., 2012; Kasunic, 2005). This makes the online survey suitable for exploratory research (Chelius et al., 2012). The main drawback of the online survey approach is that not all people have equal access to the Internet (Nardi, 2018). Especially old people have very limited access to online surveys (Döhring and Bortz, 2016).

• Personal interview

In a personal interview, the researcher is in a “face-to-face situation” with the interviewee and reads out the questions. The interview is more interactive and suitable for qualitative, in-depth research (Nardi, 2018).

• Telephone interview

The telephone interview is a personal interview conducted on the phone (Nardi, 2018). The advantages of the telephone survey are the lower costs and the more impersonal atmosphere, which makes it more likely that the people answer personal questions (Nardi, 2018).

Due to the advantages of the online survey approach regarding the data collection and the costs, but the disadvantages that not everybody has access to the Internet, a combination of the web-based and the paper-pencil survey is used. At first, a web-based survey is launched for data collection, and if it turns out while the survey is running, that some groups of the population are under-represented due to lack of Internet access, they are addressed separately by a paper-pencil questionnaire.

3.1.1.3 Definition of the sampling concept

In this case, the target population consists of a large number of people, and not every single one can be surveyed. Thus, a sample is selected out of the total population. Generally, one can distinguish between probability and non-probability sampling. In probability sampling, each person in the population has the same chance to participate in the survey. “In non-probability sampling, the participants are selected by human judgement, thus the chances of taking part are not equal” (Kasunic, 2005).

As the survey is carried out online and the questionnaire is distributed on the Internet, non-probability sampling is automatically used. As a sub-group of non-probability sampling, the sampling method is also referred to as “convenience sampling” (Nardi, 2018). Not everyone from the population has the same chance to participate, because only people with
3.1. DATA COLLECTION: SURVEY

Internet access and of those only the people who come across the survey website, can take part (Kasunic, 2005; Nardi, 2018).

For the paper-based survey, also non-probability sampling is used, as the survey is distributed to selected groups of the target population, e.g. to old people, of which it is known that they are under-represented in the sample. This sampling concept is called “purposive sampling” (Nardi, 2018).

As non-probability sampling is used for this study, the results only apply to the people that answered the survey and it is not possible to generalize them to the whole population (Kasunic, 2005; Nardi, 2018).

3.1.1.4 Calculation of the sample size

The required size of the sample is determined by the precision and the confidence interval the researcher is willing to accept (Kasunic, 2005). Cochran (1977) (in Kasunic (2005)) developed a formula for determining the sample size:

\[ n_0 = \frac{z^2pq}{e^2} \]  \hspace{1cm} (3.1)

where:

- \( n_0 \) is the sample size
- \( z \) is “a point on the abscissa of the standard normal curve that specifies the confidence level” (Kasunic, 2005)
  
  In transport surveys, often a confidence level of 95% is assumed, resulting in a \( z \) value of \( \pm 1.96 \) (Richardson et al., 1995). “If a 95% level of confidence is used, then implicitly it is being stated that [the researcher] is prepared to be wrong on 5% of occasions” (Richardson et al., 1995).
- \( p \) is an “estimated proportion of an attribute that is present in the population” (Kasunic, 2005).
- \( q \) is equal to \((1 - p)\)
  
  Usually, it is assumed that \( p = q = 0.5 \) (Kasunic, 2005). \( pq \) represents the maximum variance when a “questionnaire response attribute is evenly split among the population” (Kasunic, 2005).
- \( e \) specifies the desired level of precision, also called margin of error, where \( e = 1 - \text{precision} \). Often, a precision of 95% or 99% is used (Kasunic, 2005; Richardson et al., 1995). "Precision is a measure of how close an estimate resulting from survey data is to the actual characteristic in the population (Richardson et al., 1995)."

As can be seen from the variables, in this formula, the size of the population (for example the number of people) has no impact on the sample size required.

Apart from this formula, there is the possibility to calculate the sample size with tools offered by statistical websites such as Select Statistical Consultants (2019). In this case, it is also possible to enter the size of the target population.
CHAPTER 3. METHODOLOGY

3.1.2 Survey design

After the parameters concerning the survey are defined, the survey is designed based on the findings on the attributes influencing BSS usage from the literature review. During this process, the literature guidelines about how to design a survey are considered.

3.1.2.1 Types of questions

In parallel to the determination of the questions that are asked in the survey, it is decided which type of question is used. There are the following types of questions (Nardi, 2018; Kasunic, 2005):

- Open-ended questions:

  In open-ended questions, the respondent creates his or her own answer by entering a number or a text in the response field. The researcher does not provide answer categories where the respondent can chose from.

  The open-ended questions result in word-based responses, what can make data analysis more complicated if categorizing is necessary (Kasunic, 2005). Furthermore, the answering takes more time, and a participant might be unwilling to answer too many of these questions due to sensitivity issues (Nardi, 2018).

- Closed-ended questions

  In this case, a set of answer choices is provided, where the participant chooses his or her answer(s) from. There are two types of closed-ended questions:

    - with unordered choices
    - with ordered choices

    The answer choices are ordered based on a certain criterion, e.g. the perception of quality by the customers (Mazzocchi, 2008). A sub-group is the Likert scale question (Kasunic, 2005), where different attitudinal statements are rated by the respondents based on their level of agreement (Richardson et al., 1995).

- Hybrid questions

  This question type is a mixture between the open-ended and closed-ended questions, and is used if the researcher cannot estimate all answer possibilities. In this case, for example a free-text field is added to a closed-ended question (Kasunic, 2005).

Due to the disadvantages of the open-ended questions regarding answering and data analysis, this type of questions is generally avoided whenever possible. The focus is on closed-ended questions.
3.1.2.2 Selection of questions

The questions are selected and designed based on the results of the literature review on peoples’ socio-demographic, behavioural, attitudinal, and psychographic attributes influencing BSS usage. Some questions and answer possibilities are based on the “Mobility in Germany” report, in German “Mobilität in Deutschland (MID)”, a study that analyses the overall mobility behaviour in Germany (Infas et al., 2017; Nobis and Kuhnimhof, 2018). All questions except the question on the reasons for not using BSS and on residential location, are closed-ended questions. Furthermore, the participants have the possibility to refuse to answer in every question except in the conditional ones, where the answers are directly connected to the next question. The online questionnaire can be found in B.

The questionnaire is structured as follows:

**Part A+B: Awareness and usage of Bike Sharing Systems**
Part A+B consists of three questions, one on BSS awareness (Part A), one on BSS usage, and one on on barriers to BSS usage (both Part B):

1. Do you know the following Bike Sharing Systems?
2. How often do you use these Bike Sharing Systems?
   The first two questions are added to determine which BSS the participants know and which they use. The combination of these questions defines who of the participants is a user and who is a non-user. The answer possibilities are adapted from the part of the MID questionnaire that surveyed the trips made during a certain day (Infas, 2017).
3. Why don’t you use Bike Sharing Systems?
   The aim of this question is to determine the barriers to bike sharing in the study area, the reasons why people do not use BSS. The selection of the answer possibilities is based on Fishman et al. (2014a), who determined the barriers to bike sharing in Melbourne and Brisbane, Australia. It is only available for participants who state in question 1, that they know at least one BSS in the study area, but do not use BSS. This question is a hybrid question as a text field is added where the participants can enter their reason for not using the BSS, if it is not mentioned in the answer possibilities.

**Part C: Usage of different means of transport and trip purpose (behavioural questions)**
Part C consists of two questions, one on mode choice and one on trip purpose:

4. How often do you use the following means of transport?
5. For which trip purposes do you use every mode?
   With these two matrix questions, the travel behaviour of the participants was determined, which can have an impact on BSS usage (Shaheen et al., 2011; Fuller et al., 2011; Guo et al., 2017). With the first question, it is determined how often the participants use different modes of transport (mode choice), the second question determines
for which purposes the participants use the particular modes (trip purpose). The categories of transport modes, including the different answer possibilities on use frequency in the first question, and the trip purposes in the second question are also based on the MID trips questionnaire (Infas, 2017). Due to the introduction of “e-scooters” in Germany, the scooters were added as an answer possibility. The two questions were connected to each other conditionally, trip purposes could only be chosen for the modes that had been pre-selected in the previous question.

**Part D: Attitudes towards means of transport (attitudinal questions).**
Part D includes four questions on attitudes towards BSS, PT, car and cycling as means of transport.

6. How much do you agree or disagree with the following statements regarding Bike Sharing?

7. How much do you agree or disagree with the following statements regarding Public Transport?

8. How much do you agree or disagree with the following statements regarding cycling?

9. How much do you agree or disagree with the following statements regarding car driving?

Each question includes seven sub-statements on each means of transport, and participant states how much he/she agrees on the statement with a Likert scale from “I strongly agree” to “I strongly disagree”.

(a) (the mean of transport is) convenient
(b) (the mean of transport is) relaxing
(c) (the mean of transport is) fun
(d) (the mean of transport is) healthy
(e) (the mean of transport is) safe
(f) (the mean of transport is) environmentally friendly
(g) (the mean of transport is) accessible for everyone

With the questions 7 to 9, the attitudes of the participants towards different means of transport—and towards bike sharing—are surveyed. Researchers have found correlations between the usage of BSS and the attitude towards different means of transport, Shaheen et al. (2011) between BSS usage and attitude towards PT, Fishman et al. (2014a) between BSS usage and attitude towards car and bicycle. The question on attitude towards bike sharing is added for research purposes to get to know how people think about this mode of transport. The structure of the questions refers to Kroesen (2019), who constructed a “psychological network model” (Kroesen, 2019) to explain travel behaviour and measured the attitudes in a similar way.
3.1. DATA COLLECTION: SURVEY

Part E: Psychographic questions.

Part E consists of 21 statements describing people with different values, that are merged into three questions containing seven statements each.

10. In the following question, seven people are described to you. How much each person is or is not like you?

11. In the following question, seven people are described to you. How much each person is or is not like you?

12. In the following question, seven people are described to you. How much each person is or is not like you?

In the 21 statements (not printed here, can be found in the B, the participant rates on a scale from “Very much like me” to “not like me at all”, how similar the person described in the statement is to him/herself. The psychographic questions taken from PVQ developed by (Schwartz, 2006). The English and German versions used in the survey are those used in the ESS questionnaires for the United Kingdom and Germany, respectively (ESS ERIC, 2018, 2016). The purpose of using the PVQ in the survey is to determine the values and norms of the participants. The “German bike monitor” showed that BSS usage depends on the social milieu someone belongs to (Borgstedt et al., 2019). Boenigk et al. (2019) and Georgi et al. (2019) identified that social norm plays an important role for the decision to join a BSS.

Part F: Socio-demographic questions

The eight socio-demographic questions are asked at the end of the questionnaire, considering the recommendations in literature to put sensitive questions at the end of a survey (Nardi, 2018). A large number of studies found in the literature review indicated a big impact of socio-demographic attributes on BSS usage (see chapter 2.3.1)

13. How old are you? (Age)

Relevant literature: Fuller et al. (2011), Fishman et al. (2014b)

The ranges are taken from the Munich MID report Infas et al. (2019) and adapted.

14. What is your gender? (Gender)


The third gender “diverse” is added to the question.

15. What is your highest level of education? (Education)

Literature: Fuller et al. (2011), Shaheen et al. (2014)

The levels of education are based on the MID form where people report all the trips they make within one day (Infas, 2017).

16. What is your employment status at the moment? (Employment status)


The employment status answer possibilities are adopted from the MID household questionnaire (Infas et al., 2017).
17. What is your monthly household net income? (Income)

   Literature: Ogilvie and Goodman (2012a), Shaheen et al. (2014)

   This question is asked in the MID household questionnaire as an open-ended question (Infas et al., 2017). It is changed to a closed-ended question by introducing income levels based on the Munich poverty report (Kistler et al., 2017).

18. How many people are in your household, including yourself?

   This question is added upon recommendation from the pilot survey. The purpose is to get to know among how many people the household income is distributed. Furthermore, this question also appears in the MID household questionnaire (Infas et al., 2017). The answer possibilities are adopted from there.

19. Do you have a migration background?


   Research from the U.S. showed that ethnicity criteria (e.g. “African American” or “Whites”) have an impact on BSS usage (L D A Consulting, 2017; McNeil et al., 2018). This categories do not exist in Germany. Instead of ethnicity, the German criterion “Migration Background” is used. “A person has a migration background if they themselves or at least one parent is not born with German citizenship” (Referat für Stadtplanung und Bauordnung, 2017).

20. How long have you been living in Germany?

   This question is added because of the wide definition of migration background, to detect if people who moved to Germany recently, use BSS differently from people who have been born in Germany or lived here for a long time.

Part G: Geographic questions.

   The last part consists of a map where participants can indicate their living location directly by clicking at it in the map.

21. Please mark on the map (approximately) the neighbourhood where you live.

   This question is added because the location data, or the coordinates, are important for data cleaning because they allow to filter participants that are living outside of the study area. Moreover, additional data analysis like calculating the distances to the city centre can be performed.

3.1.2.3 Development of the online survey questionnaire

As the outline of the survey is clear now, the online survey is set up. This is done by transferring the questionnaire framework described in the previous chapter to an online survey tool. There are several guidebooks that describe how to design online surveys specifically. For the development of this online survey Sue and Ritter (2012), Chelius et al. (2012) and Krosnick (2018) are used.

Based on recommendation from the literature (Sue and Ritter, 2012), a welcome text is added, which is describing briefly the purpose of the survey and includes the privacy statement and contact data of the researcher.
3.1.3 Pilot Survey

As the (preliminary) design of the questionnaire is completed, a so-called “pilot survey” is carried out, a test-run of the survey implementation. The aim of the pilot survey is to test the following aspects of the survey (Kasunic, 2005; Nardi, 2018):

- **Questions**
  This includes testing if the questions and the instructions are understandable, if the order of questions makes sense and if the answer choices are sufficient.

- **Questionnaire layout**
  Here, it is tested if navigation through the questionnaire works well and if the font size is easy to read.

- **Process**
  This includes checking the time the participants need for completing the survey and whether it takes too long. For this purpose, the time-stamp of the survey fulfillment is recorded (Krosnick, 2018), but also, the personal opinion is asked. Furthermore, it is checked, if the interviewees are interested in the survey.

- **Technology**
  The last aspect refers to the performance of the online survey tool, testing if it runs smoothly, and if the data entered by the participants is fully and correctly recorded.

The pilot survey is performed with a small set people who are similar to the target population. (Kasunic, 2005; Nardi, 2018). As it includes all inhabitants of the place studied, people with different socio-demographic attributes, for example different occupation, education or different age groups, are selected for participation. They are not allowed to take part in the final survey, because they already know the questions what may lead to a bias (Krosnick, 2018). Furthermore, the participants are not informed that it is a pilot survey that is carried out, it is pretended that the final survey is carried out. (Krosnick, 2018).

For the launch of the pilot survey, two different approaches are selected, one if the participants are on-location and one if the people are off-site, based on Kasunic (2005):

- **On-location pilot survey**
  In this case, the researcher and the participants meet. After explaining the survey, the survey designer observes a participant while completing the pilot survey. During the process, the researcher is able to detect if there are any problems for the participant or with the technology. Moreover, the participant gives feedback regarding the pilot survey aspects named above, either during the survey or after the completion.

- **Off-site pilot survey**
  If a meeting is not possible, the pilot survey is distributed to the participant by e-mail including information the purpose of the survey. To make feedback easier, a survey evaluation form is designed which can be seen in table 3.1. Additionally, a free-text question is added to the questionnaire where participants can write down their recommendations.
Table 3.1: Evaluation table for pilot survey

**Survey evaluation table**

Please tell me what you think about the survey by ticking one of the three options below for each of the criteria. Please put recommendations about what to improve in the right column. Thanks!

<table>
<thead>
<tr>
<th>Criteria</th>
<th>good!</th>
<th>ok!</th>
<th>improvement needed</th>
<th>Recommended improvements</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>text</strong></td>
<td></td>
<td></td>
<td></td>
<td>Please tell question number!</td>
</tr>
<tr>
<td>Welcome text</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>formulation/relevant informations</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>given</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>instructions</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>clear/understandable</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>questions</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>order of questions</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>logical</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>answer choices</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>logical/complete</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>formulation/phrasing</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>translation English/German</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>layout</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>overall layout of questions</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>clear/eye-catching</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>navigating in survey</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>easy/smooth/no errors</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>font sizes</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>readability of questions</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>process</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time to complete survey</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>fine or too long</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
3.1. DATA COLLECTION: SURVEY

After the pilot survey is completed, the feedback is collected and summed up in one document. The researcher checks how often the feedback points have been mentioned and which parts of the feedback can be incorporated in the survey to improve it. After possible improvements have been detected, the survey questionnaire is readopted by inserting the feedback.

3.1.4 Online survey execution

3.1.4.1 Online survey distribution

As the survey questionnaire is now revised and ready for being filled, the survey is activated. Everyone with the survey link has the possibility to access it. First of all, the time is defined in which the calculated number of participants, the sample size, should be reached (Kasunic, 2005). To address the people from the target population, a strategy to distribute the survey link is developed. The channels of distribution are based on previous survey research done by Al Haddad (2018), Yeesakonu (2019) or Espinoza-Castro et al. (2019).

- E-mail
  This online method used is the distribution of the survey by e-mail. It is used to address people who do not have a Facebook account or organisations or companies where a more formal contacting is required. The e-mail usually consists of a detailed explanation of the survey purpose and the link.

- Facebook posts
  Furthermore, the survey description is posted on Facebook, initially on the author’s personal Facebook profile, then in different groups. The Facebook functions as sharing and liking posts help spreading the survey further and reaching a large number of people quickly. The posting consists of a text describing the purpose of the survey, the survey link and an image showing bikes of BSS to make the post more catchy.

- WhatsApp
  The third method used for survey distribution is sharing it on WhatsApp. As in Facebook, the survey link is shared on personal basis and in groups. As WhatsApp is used almost exclusively on mobile phones, there is only a very short introduction text.

- Snowball principle
  The information texts in all three methods includes one sentence inviting the people to further share the survey. This should build up a snowball system, where people pass the survey on to others, who share it again and so on.

- Flyers
  To attract attention from people who do not use Facebook or who did not receive an e-mail, the online survey is supported by the distribution of flyers. The flyers display
an image and the survey link. In addition, the QR code of the survey was given, providing direct access to the survey through scanning with a mobile phone.

3.1.4.2 Online survey monitoring

While the survey is online, some parameters are checked to ensure that the survey goals are met. These include:

- Number of responses
  It is checked if the number of responses moves towards reaching the desired sample size in the defined time corridor. If this is not the case, the distribution of the survey is intensified, for example by sharing it to more people, distributing more flyers, reminding people to answer or encouraging them to share the survey further.

- Response rate
  Furthermore, the researcher monitors the response rate, the share of completed online surveys. It is calculated by the following formula:

  \[
  r = \frac{\text{Number of completed survey answers}}{\text{Total number of survey answers}}
  \]  

  (3.2)

  If \( r \) drops below 50\%, the questions where most of the participants quit the survey are identified and adopted, e.g. by a reduction of answer possibilities.

- Socio-demographic attributes of respondents
  Another important size to monitor are the socio-demographic attributes of the respondents. Most online survey tools offer monitoring functions for this purpose. As the goal is to have a representative sample, attributes of the respondents obtained by the socio-demographic questions are compared to official statistics concerning the target population. For example, the age distribution or the employment status are compared to data from the registry office. If it turns out that some groups of people are under-, or overrepresented, the distribution of the survey has to be adopted, with the goal to address specifically the under-represented people.

3.1.5 Offline survey design and distribution

As stated previously, the share of people with Internet access is very small among older people (Döhring and Bortz, 2016), thus it may be likely that some parts of the target population are under-represented in the sample obtained from the online survey.

If this is the case, a classical paper-to-pencil questionnaire is developed based on the online questionnaire. This is done by exporting the online questionnaire from the online survey tool as a PDF document. Then, the PDF is adopted to serve as an offline survey.

- It is checked if all questions or answer possibilities are included, if not, they are added manually.
3.2. DATA ANALYSIS

- It is checked if the questions are readable on the printout, if not, the layout is adapted.
- Notes are made in front of conditional questions to indicate the condition for (not)answering.

After the design is complete, the survey is printed out and distributed directly to the under-represented groups of people. The filled-out questionnaires are then transferred again into the online questionnaire form. For this purpose, the researcher fills the online questionnaire with the answers from the paper-pencil question, while a second person is observing the procedure. This minimizes the risk of transmission errors and manipulation by the researcher.

3.2 Data Analysis

The analysis of the data obtained from the survey is done with the statistical software “R” (https://cran.r-project.org/). The completed survey answers are exported from the online survey tool in an SPSS format, which is then changed to an SAV format. The advantage of the SAV format is that the different answer possibilities of the questions are already saved as levels, this facilitates data analysis in R. The SAV format is then read in R with the function “read.spss”.

3.2.1 Data cleaning and BSS users determination

The first step of data analysis is the cleaning of the data and the adding of further relevant data which is done as follows:

1. Removal of incomplete survey answers

   The first step of data cleaning is to remove the answers where the participants quit the survey without completing it. There are actually ways to fill missing data, for example presented by Mazzocchi (2008), however this is a quite time-consuming process and the data can be omitted if the sample is large enough (Mazzocchi, 2008). The removal of the incomplete answers is done before the dataset is read in R, namely by exporting only complete survey answers from LimeSurvey.

2. Removal of unfitting data

   As the most part of the survey responses is generated online, where basically everyone is able to participate, it is likely that there are answers in the dataset that do not fit into the target population that was selected before, for example if a child answers a survey that is targeting adults (Mazzocchi, 2008). As this might affect the results of the research, these data have to be removed. To facilitate data cleaning, the question on the residential location was added to the survey. The coordinates can be displayed in a Geographic Information System (GIS) and people that do not fit into the target population, because they are living outside the study area, can be removed.

3. Determination of BSS users and non-users
Before further statistical research is carried out, the users and the non-users of BSS are determined, as the goal of the research is to determine attributes of these two groups. As there is no direct question in the survey asking if someone is a BSS user or not, this property is derived from the first two questions:

- A **BSS user** is a participant who
  - (in question 1:) answers to know at least one BSS AND
  - (in question 2:) answers to use at least one BSS at least “almost never”

- A **BSS non-user** is a participant who
  - (in question 1:) answers to know no BSS OR
  - (in question 2:) answers to use all BSS “never” or “not any more”

The conditions are transferred to R code, adding two columns to the dataset, identifying the participants as BSS users respectively non-users with a TRUE or FALSE variable called “User”.

### 3.2.2 Survey statistics

- **Sample size evaluation**

  After the data cleaning, the final sample is available. Now it is checked whether the required sample size could be reached. If this is not the case, the formula 3.1 is used again, now solved to the margin of error, with the sample size as an input. By this method, the new margin of error is determined, implying that the confidence interval stays the same at 95%.

  \[
  e = \sqrt{\frac{z^2pq}{n_0}}
  \]  

  (3.3)

- **Comparison of the sample to external data**

  To detect anomalies in the collected data, the sample is compared to external data, for example census or demographic data (Mazzocchi, 2008).

### 3.2.3 Exploratory Data Analysis (EDA)

Before advanced statistical analysis, an EDA is performed, also called “descriptive analysis”, which helps the researcher getting familiar with the dataset (Mazzocchi, 2008; Nardi, 2018). Furthermore, the displayed data make it possible to already roughly identify the attributes of the participants that are influencing their BSS usage. In this research, the EDA consists of graphical representations.

The plots for the EDA are mostly generated with the package “ggplot2” and the function “ggplot” included in the R programming language. There are many different types of graphical statistics for displaying data. The election of the most suitable type of graphic depends on the way the data is measured in the survey. There are four levels of measuring the data:
nominal, ordinal, interval and ratio. (Mazzocchi, 2008; Nardi, 2018). For all questions in the survey questionnaire except the living location, which is depicted in a GIS, nominal and ordinal measurement are used:

- **Nominal**
  
  Closed-ended questions with unordered choices and a fixed number of answer possibilities (categories) represent the nominal format. A number can be attached to represent each category, but this process is not required for modern data processing (Kasunic, 2005).

- **Ordinal**
  
  Ordinal measuring is also based on closed-ended questions, however this time, the answer possibilities are ranked according to a certain criterion (Mazzocchi, 2008). For example, Likert scale questions are ordinal.

The nominal and ordinal measurements result in a dataset with categorical variables that have a number of discrete values (Nardi, 2018), in this research the answer categories. Based on the recommendations from literature, the bar chart is selected to be the main instrument for EDA. For the question on the trip purpose, the data is displayed using a heat map.

Based on the survey results, the following topics are presented in the EDA:

1. Brand awareness of the different BSS in Munich
2. BSS users and non-users
3. BSS use frequency
4. Reasons for not using BSS
5. Socio-demographic attributes and BSS usage
6. Behavioural attributes and BSS usage
7. Trip purpose and BSS usage
8. Attitudinal attributes and BSS usage
9. Psychographic attributes and BSS usage

In the overview plots of the socio-demographic, behavioural, attitudinal and psychographic attributes, the share of the BSS users and non-users among the attributes of one variable is depicted with the help of small diagrams. One diagram represents one variable, and the y-axis depicts the attributes, based the answer possibilities from the survey questionnaire, for example “male” or “female” for the gender. The bars represent the share of users and non-users in the different attributes, based on the total number of respondents. The bars for the users and non-users sum up to 100% over all attributes. This layout is chosen to additionally represent the number of answers given in each category. By looking
at the diagrams, the differences between the prevalence of users and non-users can be identified. The larger the difference is, the more the attribute, and thus the variable influences the usage of BSS in Munich. For example, if 40% of the female participants would be BSS users, and 60% non-users, with a difference of 20%, it is assumed that the attribute “gender-female” is associated to the BSS usage of the participants, and that the variable “gender” has an impact on BSS usage. The variables that have an impact on BSS usage are highlighted in the diagrams and described.

In the trip purposes question, the heat map is chosen as an instrument for displaying the results, as there are three variables depicted: the mode of transport used for the trip, the trip purpose, and the number of respondents who chose the particular combination of transport mode and trip purpose. One heat map is plotted for the trip purposes of BSS users and one for the trip purposes of non-users. Then, the two heat maps are compared. The differences in the colouring of the heat maps allow to identify differences in travel behaviour between these two groups. Significant differences in colouring imply that the trip purpose is related to BSS usage.

### 3.2.4 Multiple Logistic Regression (MLR)

After the EDA provided a first overview on the variables and attributes influencing BSS usage, statistical modelling is used to obtain mathematical evidence on the attributes that are influencing BSS usage. The first modelling procedure which was applied to identify the significant attributes, is the MLR, also called “multinomial logit model” (Härdle and Simar, 2015). It has been used in previous studies to identify attributes of BSS users (Ogilvie and Goodman, 2012a) or different travel patterns (Du and Cheng, 2018). The MLR predicts a dichotomous (binary) outcome, based on multiple predictor variables (Hedderich and Sachs, 2018). It is part of the Generalized Linear Model (GLM), thus the “glm” package in R is used for this step (Hedderich and Sachs, 2018).

In this research, the predicted binary outcome is if someone is a BSS user or not. This is represented by the dependent variable “User” in the survey dataset, that can take the values “TRUE” or “FALSE”. The predictor variables are the attributes of the different socio-demographic, behavioural, attitudinal and psychographic variables in the dataset, e.g. “Age 30-39 years”. The model is run for each variable separately to avoid correlation between variables. The figure 3.2 shows the result of an MLR carried out on the variable “Age”, to predict the impact of age on someone being a BSS user or not, with the age categories as predictor variables. The p-values depicted in the right column of the coefficients table show the significances of the predictor variables for predicting the outcome (Hedderich and Sachs, 2018). Generally speaking, a prediction is significant if the p-value is smaller than 0.05 (Hedderich and Sachs, 2018). In R, the level of significance is also depicted by stars and dots, three stars mean very high significance, one dot low significance. Thus, in the model run in figure 3.2, the predictor variable, the attribute “Age 30-39 years”, is significantly associated to BSS usage. The MLR model always takes one predictor variable as a reference, in this case “Age 30-39 years”. The estimate gives a tendency if the attribute is positively or negatively associated to the outcome, here the attribute is positively associated to BSS usage as the estimate is positive. In other words, people with an age from 30 to 39 years use BSS more often. However, it is recommended to verify this tendency by checking the
3.2. DATA ANALYSIS

Figure 3.2: Result of a MLR

```
call:
glm(formula = socio_varAll_omit$User ~ socio_varAll_omit$Age,
     family = "binomial")

Deviance Residuals:
     Min      1Q  Median      3Q     Max
-1.5865  -0.9776  -0.6231   1.1972   1.8626

Coefficients:          Estimate Std. Error z value Pr(>|z|)
(Intercept)            -0.49002    0.15400  -3.182  0.00146 **
socio_varAll_omit$Age30-39 years  1.41428    0.28211   5.013  5.35e-07 ***
socio_varAll_omit$Age40-49 years   0.44330    0.34174   1.298   0.19437
socio_varAll_omit$Age50-59 years  -0.05652    0.40897  -0.138   0.89008
socio_varAll_omit$Age60-69 years  -1.05042    0.65458  -1.605   0.10855
socio_varAll_omit$Age69-79 years  -16.07605   979.61004  -0.016   0.98691
socio_varAll_omit$Age80 years and older -16.07605  1696.73435  -0.009   0.99244
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for binomial family taken to be 1)

Null deviance: 503.01  on 364  degrees of freedom
Residual deviance: 457.61  on 358  degrees of freedom
AIC: 471.61

Number of Fisher Scoring iterations: 15
```

absolute values of users and non-users within the attribute.

3.2.5 LASSO

One constraint of the logistic regression model used, might be collinearity, that the predictor variables within one model are correlated to each other (Hedderich and Sachs, 2018). Thus, “they cannot independently predict the value of the dependent variable” (Boyd Engers, 2013). The standard errors increase and the model becomes unstable (Hedderich and Sachs, 2018). As it is assumed that some of the predictor variables (the attributes from the questionnaire) are correlated, the LASSO method (Tibshirani, 1996) is applied as a second method to detect the most significant attributes.

The LASSO technique is applied to the groups of socio-demographic, behavioural, attitudinal and psychographic variables and returns, for each group, the attributes that are influencing BSS usage. As the LASSO does not display the significance of the selected parameters, a second MLR is carried out with the attributes selected by the LASSO. In this way, the significance can be displayed.

Figure 3.3 shows the code in R, with the LASSO in the first part and the second MLR in the second part.
#Lasso#

```r
y <- socio_varAll_omit[,10]
x <- model.matrix(~., socio_varAll_omit[, -10])
glmnet2 <- cv.glmnet(x=x, y=y, alpha=1, nfolds = 200, family = "binomial")
lambda <- glmnet2$lambda.1se
glmnet_fit <- glmnet(x=x, y=y, alpha=1, lambda = lambda, family = "binomial")

summary(glmnet_fit)

glmnet_fit_coef <- data.frame(glmnet_fit$beta[,1])
glmnet_fit_coef_var <- rownames(glmnet_fit_coef)
glmnet <- data.frame(glmnet_fit_coef[abs(glmnet_fit_coef$glmnet_fit.beta...1.) > 0,])
print(glmnet)
colnames(glmnet)[1] <- "%Dev"
var_glmnet <- rownames(glmnet)

c coef(glmnet_fit, lambda)

#second MLR#

x <- xi[, colnames(x)[in%Var_glmnet]
xy <- data.frame(cbind(y, x))
model_trip <- glm(y ~ ., x, family = "binomial") #model
summary(model_trip)

cor(x)
corrplot(cor(x))
```

**Figure 3.3:** Code used for the LASSO and the second MLR
Chapter 4

Case of study: Munich

In this chapter, the methodology described in chapter 3 is applied. The case study is carried out in the city of Munich, Germany, which was chosen because of its vital BSS market with currently four systems in operation. Furthermore, all different types of BSS systems that are currently available can be found in Munich. At first, key facts on Munich are presented, including information on transport in the city. Then, the focus is on the BSS market and the most important figures of the BSS in the city are presented.

4.1 Key facts on Munich

- The city of Munich

Munich is located in southern Germany, and is the capital of the Federal State of Bavaria. As of November 2019, the city had about 1.56 Million inhabitants (Statistisches Amt München, 2020), making it the third-largest in Germany (The Editors of Encyclopaedia Britannica, 2020). Today, Munich is an important industrial centre, especially of the light and aerospace industry, but also education and research, finance, and public administration play an important role. The beer festival “Oktoberfest” makes Munich one of the most well-known tourist attractions in the world (The Editors of Encyclopaedia Britannica, 2020).

- Transport in Munich

When it comes to transport, Munich is a hub for road and rail traffic in southern Germany (The Editors of Encyclopaedia Britannica, 2020). For inner-city transport, the Underground train system “U-Bahn” is the backbone of PT (Münchner Verkehrs-gesellschaft mbH (MVG), 2019).

- The “Münchner Verkehrs- und Tarifverbund (MVV)”

The MVV is a transport association coordinating the different means of transport in PT, founded in 1971. The purpose of the association is to establish a homogeneous PT timetable, network and fare system in the Munich region, covering all different means of PT (Dialogtext, 2016). In 2018, the city of Munich and eight surrounding counties (German: “Landkreise”) belong completely to the MVV, and six more partly, covering
an area of 5530 km\(^2\) or with more than 2.9 Million inhabitants (Münchner Verkehrs- und Tarifverbund (MVV), 2018)

### 4.2 BSS in Munich

Like all over the world, also in Munich, BSS have expanded rapidly over the last few years. Currently, there are four systems in the city: DB Call a Bike, MVG Rad, Donkey Republic and Jump Bike. In the following, the systems are briefly described according to different criteria and the information is shown in a table.

- **DB Call a Bike**

  ![DB Call a Bike bicycle](Image)

  **Figure 4.1:** DB Call a Bike bicycle

  Source: 4028mdk09 (2012)

  This system was founded in the year 2000 in Munich by a computer science student and was the first BSS in the city (Lotz, 2019). The bikes were positioned next to telephone booths, where people could call in the call-center to obtain a code for unlocking the bike. Due to the high cost of this concept, the company went insolvent soon (Lotz, 2019). In 2001, the 100 % state-owned German Rail operator Deutsche Bahn AG (DB) (Bundesministerium der Finanzen, 2015) purchased the company and expanded the system all over Germany (Monheim, 2012; Reiss and Bogenberger, 2015). Over the years, the basic concept stayed the same, adding the possibility to rent with a mobile phone app. Within the Munich central area, Call a Bike is designed as a free-floating system, where the bikes can be given back at any location (DB Rent GmbH, 2015). It is owned by “Deutsche Bahn Connect”, a DB daughter company (Deutsche Bahn Connect GmbH, 2020) and operates around 1500 bikes in Munich (Kowitz and Litzlbauer, 2019) with an estimated of 125000 users registered in the city (Lotz, 2019). The payment of the rental service works with the Single Euro Payment Area (SEPA) debit procedure or by credit card. The minimum age of registration is 18 years. It is possible that an
adult person rents the bicycle for a younger one, but if this person is younger than 16 years, he or she is only allowed to use the bike in company of an adult (Deutsche Bahn Connect GmbH, 2019).

- MVG Rad

Figure 4.2: MVG Rad bicycle at a bike station

In 2015, the PT operator Münchner Verkehrsgesellschaft (MVG), belonging to the public utility company of the city of Munich, the “Stadtwerke München (SWM)” (Referat für Arbeit und Wirtschaft, 2019), introduced a second system, called “MVG Rad” (Korte, 2015). For the set-up of the system, the MVG signed a five-year cooperation treaty with the German BSS operator “nextbike”. It includes “[t]he delivery of the entire infrastructure, the development and provision of the necessary software for the operation and use of the system as well as the service operation for the entire term of the contract” (Beckendorff, 2015). After starting with 1200 bikes, the system has been upgraded to 3200 bikes (Referat für Arbeit und Wirtschaft, 2019), becoming the largest BSS in Munich. Furthermore, the system has been expanded beyond the city borders to the county of Munich (“Landkreis München”), where 1100 bikes can be found, making it the first rural county in Germany with a comprehensive BSS (Sommer, 2019). In November 2018, the city council of Munich agreed on further upgrading the MVG Rad, with 1200 bikes and 125 stations in addition as well (Effern, 2019). Moreover, a test run with ten electrical pedelecs was agreed on (Beckendorff, 2019). In opposite to the Call a Bike system, for the largest part of the city of Munich, the MVG Rad is a mixture between a free-floating and a station-based BSS. Within the so-called “Return zone” (Referat für Arbeit und Wirtschaft, 2019), the bikes can be rented and dropped of at stations or in any other location (Münchner Verkehrsgesellschaft mbH (MVG), 2018). Outside of this area, the bikes can only be returned at the BSS stations. Due to the expansion of the system, the number of registered users rose rapidly, up to 160000 in June 2019 (Referat für Arbeit und Wirtschaft, 2019). However, due to high operational costs and costs for IT systems, personnel and administration, the system is not profitable, but is making losses (Referat für Arbeit und Wirtschaft, 2019). Since MVG
CHAPTER 4. CASE OF STUDY: MUNICH

Rad started operating until September 2019, the losses have accumulated to around 2.3 Million Euros (Referat für Arbeit und Wirtschaft, 2019; Effern, 2019). The city also sees no possibility that the system will become profitable during the next years (Referat für Arbeit und Wirtschaft, 2019; Effern, 2019). The minimum age for registration to the system is 18 years, and the minimum age for using the bikes without company of an adult is 14 years (Münchner Verkehrsgesellschaft mbH (MVG), 2018). Like for DB Call a Bike, the payment is options are credit card and SEPA.

- Donkey Republic

![Donkey Republic bicycle](image)

**Figure 4.3:** Donkey Republic bicycle

“DonkeyRepublic”, from the Danish capital Copenhagen, started operating in Munich in summer 2018 (Anfang, 2018). The privately owned and financed (Posetti, 2017) company “provides a digital platform that organizes and offers the rental of vehicles such as bicycles, e-bikes, e-scooters, trailers and scooters” (ApS Donkey Republic Admin, 2019). The system is operated by contractors that are also responsible for the maintenance of the bikes. These can be either owned half-half by Donkey Republic and the contractor or by the contractor alone (Posetti, 2017). After usage, the bikes have to be returned at pre-defined “Drop-off locations” that are shown in the app (ApS Donkey Republic Admin, 2019). This makes the system station-based, but –in opposite to MVG Rad– with virtual stations. With focus on the BSS, there are 800 bikes available in Munich (Kowitz and Litzlbauer, 2019). Furthermore, the map from the mobile phone app for renting the bikes shows that the bikes are mostly located in the city center, only a few outside the “Mittlerer Ring”. People are allowed to register for the service and use the bikes if they are at least 12 years old (ApS Donkey Republic Admin, 2019) and the payment works with credit card.

- Jump Bike
4.2. BSS IN MUNICH

The latest BSS in Munich started operating in September 2019 (Braun, 2019). The “Jump Bicycles GmbH”, a daughter company of private the U.S. American ride sharing provider “Uber” (Jump Bicycles GmbH, 2019c) brought the first 200 bikes to the city. While Jump Bicycles is responsible for the operation (Jump Bicycles GmbH, 2019a), the bikes are rented with the Uber app (Uber Deutschland, 2019a). Further extensions are planned in cooperation with the city of Munich (Braun, 2019). In December 2019, the system has been extended to the mobility stations around the new built area “Domagkpark” (Uber Deutschland, 2019b). As the bikes can be dropped off anywhere in the operational area after usage (Jump Bicycles GmbH, 2019a), Jump Bike is a free-floating BSS. In opposite to all other BSS active in Munich, the whole fleet of Jump Bike consists of pedelecs powered by an electric motor. The company names the fast acceleration and the riding comfort as positive aspects (Jump Bicycles GmbH, 2019a). The minimum age for registration and usage is 18 years and the payment is only possible with credit card (Uber Deutschland, 2019a).

• oBike (defunct)
In Summer 2017, the Singapore-based bike sharing company “oBike” installed around 7000 bikes in Munich, introducing basically overnight the largest BSS in the city. Quite soon, complaints came up on the bad quality of the bikes and the fact that they were parked randomly all over the city, blocking side-walks and green areas. Only one year later, it was announced that the company was bankrupt, and that it would withdraw completely from Europe (Nefzger, 2018). Nevertheless, the bikes stayed in Munich until 2019, as oBike failed in removing them (Deutsche Presse Agentur, 2018). A new “trend” came up: putting the bikes in unusual positions, e.g. on trees or traffic signs, but also vandalising and damaging them (dpa / muenchen.de, 2019). Some bikes were collected by bicycle stores or other companies that repaired and sold them again. In the end, oBike managed to get most of the bikes removed by April 2019 (Stinglwagner, 2019). oBike was a free-floating system where the bikes could be rented with the oBike app (Deutsche Presse Agentur, 2018).

• Summary
With the currently four BSS in Munich, there is a vital Bike Sharing market in the city,
despite the withdrawal of oBike. Particularly interesting are the different concepts of the systems, from station-based over virtually station-based to free-floating. As for the number of bikes and users, it is apparent that MVG Rad and DB Call a Bike are the two dominating players at the moment. In table 4.1, the most important characteristics of the systems are collected, while the 4.5 shows the operation areas of MVG Rad, DB Call a Bike and Jump bike.

**Figure 4.5:** Operation area of BSS in Munich

Source: Münchner Verkehrsgesellschaft mbH (MVG) (2020); DB Rent GmbH (2015); Jump Bicycles GmbH (2019b)
### Table 4.1: BSS in Munich as of December 2019

<table>
<thead>
<tr>
<th></th>
<th>DB Call-a-Bike</th>
<th>MVG Rad</th>
<th>Donkey Republic</th>
<th>Jump Bike</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Launched</strong></td>
<td>2000</td>
<td>2015</td>
<td>2018</td>
<td>2019</td>
</tr>
<tr>
<td><strong>Type of BSS</strong></td>
<td>FFBS</td>
<td>HBS / SBBS</td>
<td>VSBBS</td>
<td>FFBS</td>
</tr>
<tr>
<td><strong>Financing</strong></td>
<td>public</td>
<td>public</td>
<td>private</td>
<td>private</td>
</tr>
<tr>
<td><strong>Ownership</strong></td>
<td>public</td>
<td>public</td>
<td>private</td>
<td>private</td>
</tr>
<tr>
<td><strong>Operations</strong></td>
<td>public</td>
<td>private</td>
<td>private</td>
<td>private</td>
</tr>
<tr>
<td><strong>Type of bikes</strong></td>
<td>conventional bikes</td>
<td>conventional bikes planned: Pedelecs</td>
<td>conventional bikes</td>
<td>Pedelecs</td>
</tr>
<tr>
<td><strong>Number of bikes</strong></td>
<td>1500</td>
<td>3200 (+1100 county) planned: +1200</td>
<td>800</td>
<td>200+</td>
</tr>
<tr>
<td><strong>Number of registered users</strong></td>
<td>125.000</td>
<td>160.000+</td>
<td>no information</td>
<td>no information</td>
</tr>
<tr>
<td><strong>Operational area</strong></td>
<td>inside ”Mittlerer Ring”</td>
<td>City of Munich, county of Munich</td>
<td>mostly inside ”Mittlerer Ring”</td>
<td>mostly inside ”Mittlerer Ring”</td>
</tr>
<tr>
<td><strong>Booking process</strong></td>
<td>phone call, app-based</td>
<td>app-based</td>
<td>app-based</td>
<td>app-based</td>
</tr>
<tr>
<td><strong>Payment options</strong></td>
<td>credit card, SEPA</td>
<td>credit card, SEPA</td>
<td>credit card</td>
<td>credit card</td>
</tr>
<tr>
<td><strong>Age for usage</strong></td>
<td>below 16 years only in company of an adult</td>
<td>below 14 years only in company of an adult</td>
<td>12 years</td>
<td>18 years</td>
</tr>
<tr>
<td><strong>Age for registration</strong></td>
<td>18 years</td>
<td>18 years</td>
<td>12 years</td>
<td>18 years</td>
</tr>
</tbody>
</table>
Chapter 5

Results

In this chapter, the results are presented. It is divided into five parts. The first part describes the implementation of the survey for BSS users and non-users in Munich. The second part is about the sample obtained the survey and about the data cleaning process. In the third part, the results of the EDA are depicted, followed by the results of the data modelling to identify the most predominate attributes of users and non-users in parts four and five.

5.1 Data Collection: Survey

A survey was carried out based on the steps from the methodology in chapter 3 to collect data on the users and non-users of BSS systems for the identification of their most predominant attributes.

5.1.1 Survey parameters

- Target group
  The survey was designed to target the whole adult population of Munich, all people living within the city boundaries and being at least 18 years old. The reason for this decision was that for three of the four BSS in Munich, the minimum age of registration is 18 years, as it can be seen in table 4.1.

- Survey mode
  For the survey mode, a mixed approach was used including an online survey and a classical paper-pencil survey for the parts of the target population that could not be reached online.

- Sampling concept
  As stated in the methodology, non-probability sampling was used for the survey, with its sub-groups convenience sampling for the online survey and purposive sampling for the offline, paper-pencil survey.

- Sample size
The sample size was calculated according to the formula presented in the methodology part:

\[ n_0 = \frac{z^2 pq}{e^2} \]  

(5.1)

with:

- \( z = \pm 1.96 \): a confidence interval of 95%  
- \( p = q = 0.5 \)  
- \( e = 1 - \text{precision} = 1 - 0.95 = 0.05 \): a margin of error of 5%

This resulted in a total required sample size of \( n_0 = 385 \)

\[ n_0 = \frac{1.96^20.25}{0.05^2} = 384.16 \approx 385 \]  

(5.2)

### 5.1.2 Survey questionnaire

The survey was designed based on the process described in the methodology. For surveying, the questionnaire described in the same part was used. The online questionnaire was designed using the “LimeSurvey” software provided by the chair of Urban Structure and Transport Planning at Technische Universität München (TUM). As the case study takes place in Germany, an English and a German version of the questionnaire were created. It can be found in B.

### 5.1.3 Pilot survey

#### 5.1.3.1 Pilot survey running

After the survey parameters were fixed and the questionnaire was designed, a pilot survey was conducted to test the survey regarding the questions, the layout and the process of answering, but also to test the functionality if the LimeSurvey tool. Before the pilot survey was distributed, a text field question was added to the questionnaire to give participants the possibility to state their feedback of the survey.

To draw a representative sub-sample of the target population, the survey was distributed to people with different socio-demographic attributes, e.g. of different age, gender or occupation.

The pilot survey was carried out in the following ways:

- **On-location**

  Here, the researcher met with the participant, observed the answering of the survey and received direct feedback from the participant.

- **Off-site** In this case, the survey was sent to the participants by e-mail with further information on the survey. Furthermore, an evaluation table was attached.
5.1. DATA COLLECTION: SURVEY

5.1.3.2 Pilot survey results

In total, 16 people completed the pilot survey. There were two on-site and 14 off-site surveys carried out, and six people completed the survey evaluation table. In that way, feedback was received on all of the points that were tested. Then, it was collected into one document and ordered by the question and the by the part of the survey it concerned to facilitate incorporating it into the survey.

In the next step, it was checked which recommendations from the pilot survey helped improving the final survey. These items were then incorporated in the survey questionnaire.

Changes that were made based on the pilot questionnaire included, among others:

- Adding an additional question about the number of people in an household
- Adding the answer option “E-Scooter” to the travel behaviour questions
- Renaming of answer options for better understandability
- Grammatical improvements in the welcome text and the questions

5.1.4 Online survey execution

5.1.4.1 Online survey distribution

After the final version of the questionnaire was completed, the survey was launched on October 23, 2019. With the goal to reach the sample size calculated, for generating an adequate sample of the target population, four different methods were used to distribute the URL that provides access to the online survey.

- **E-mail**
  The first method was the distribution of the survey by e-mail. The survey link was included in the e-mail message, which also contained an information text. E-mails were sent for example to staff from the Technical University, to members of the city administration, to computer clubs or to working colleagues of the researcher and the researcher’s parents.

- **Postings on Facebook**
  The second method was posting the survey on Facebook. Therefore a post including the survey URL, a short information text, and a picture was set up. Initially, it was posted on the author’s personal Facebook profile, then in different groups. Apart from groups with many members, also groups that deal with biking in Munich were selected, such as “Things on Munich Bike Lanes”, as it was assumed that the members in these groups might have a greater interest in the topic. The following table provides an overview to which groups the survey link was posted.

- **WhatsApp**
  The third method used for survey distribution was sharing it on WhatsApp. Here, it
### Table 5.1: Facebook groups where the survey was shared and member numbers

<table>
<thead>
<tr>
<th>Name of group</th>
<th>approx. number of group members/likes (Dec. 2019)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Critical mass München</td>
<td>3400</td>
</tr>
<tr>
<td>Foodsharing München</td>
<td>4400</td>
</tr>
<tr>
<td>Jakob-Balde-Haus München</td>
<td>210</td>
</tr>
<tr>
<td>Kleinanzeigen München, Bayern</td>
<td>17400</td>
</tr>
<tr>
<td>M.Sc. Transportation Systems</td>
<td>580</td>
</tr>
<tr>
<td>Maxvorstadt München</td>
<td>110</td>
</tr>
<tr>
<td>Munich International Friends</td>
<td>63500</td>
</tr>
<tr>
<td>Radfahren in München</td>
<td>870</td>
</tr>
<tr>
<td>Studentenstadt Munich</td>
<td>11500</td>
</tr>
<tr>
<td>Things on Munich Bike Lanes</td>
<td>830</td>
</tr>
<tr>
<td>TS at TUM-10th intake</td>
<td>60</td>
</tr>
<tr>
<td>TUM Transportation Systems</td>
<td>640</td>
</tr>
<tr>
<td>Umfragen für Studienarbeiten</td>
<td>11000</td>
</tr>
<tr>
<td>Verkaufe/Suche München</td>
<td>72900</td>
</tr>
<tr>
<td>Verkaufs München</td>
<td>52400</td>
</tr>
<tr>
<td>Total members</td>
<td>239800</td>
</tr>
</tbody>
</table>
was passed mostly to the researcher’s friends living in Munich. Like in Facebook, the link was shared on personal basis and in WhatsApp groups. As WhatsApp is used almost exclusively on mobile phones, there was only a very short introduction text.

- **Flyers**
  The fourth method was the distribution of flyers. They consisted of a catchy title and an image related to BSS in Munich to attract attention, the survey link and the QR code for accessing the survey. In total, around 250 flyers were printed and distributed at the following locations, among others:
  - MVG Rad BSS stations
  - Munich underground stations
  - TUM university library
  - TUM Garching Research Campus
  - “Olympia-Einkaufszentrum” shopping centre
  - Shops in “Maxvorstadt”
  - Alten- und Servicezentrum (ASZ), service centre for old people, Maxvorstadt

**5.1.4.2 Online survey monitoring**

As described in the methodology, the number of responses and the response rate were tracked and the socio-demographic attributes of the respondents were compared to census data during the survey. The following observations were made:

- **Number of responses**
  The survey participation turned out high in the first three weeks, with more than 150 responses in the first week alone. After that, there was a sharp decline participation. Due to that, the survey was reposted on Facebook, more flyers were printed and people were told to share the survey. Still, in weeks four and five, just around 45 people completed the survey, before the participation fell down further to less than 10 people per week. As the required sample size was reached, data collection ended on December 16, 2019.

- **Response rate**
  In opposite to the number of responses, the response rate stayed nearly constant during the time the survey was carried out, standing at 70% or above. Due to this rather high response rate, no counter-measures had to be taken and the questionnaire was not changed.

  The table 5.2 shows the basic data of survey participation and response rate.

- **Socio-demographic attributes of respondents**
  Two weeks after the survey was launched, the socio-demographic attributes of the respondents were checked and compared with statistics from the city of Munich. As already expected, it turned out that some groups of people were under- or overrepresented.
### Table 5.2: Survey participation and response rate

<table>
<thead>
<tr>
<th>Week</th>
<th>Completed surveys</th>
<th>Total number of answers</th>
<th>Rate of fulfilment</th>
<th>Completed per week</th>
<th>Total per week</th>
</tr>
</thead>
<tbody>
<tr>
<td>Week 1</td>
<td>150</td>
<td>197</td>
<td>76,1%</td>
<td>150</td>
<td>197</td>
</tr>
<tr>
<td>Week 2</td>
<td>257</td>
<td>358</td>
<td>71,8%</td>
<td>107</td>
<td>161</td>
</tr>
<tr>
<td>Week 3</td>
<td>350</td>
<td>499</td>
<td>70,1%</td>
<td>93</td>
<td>141</td>
</tr>
<tr>
<td>Week 4</td>
<td>389</td>
<td>556</td>
<td>70,0%</td>
<td>39</td>
<td>57</td>
</tr>
<tr>
<td>Week 5</td>
<td>433</td>
<td>614</td>
<td>70,5%</td>
<td>44</td>
<td>58</td>
</tr>
<tr>
<td>Week 6</td>
<td>439</td>
<td>623</td>
<td>70,5%</td>
<td>6</td>
<td>9</td>
</tr>
<tr>
<td>Week 7</td>
<td>442</td>
<td>627</td>
<td>70,5%</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Week 8</td>
<td>451</td>
<td>636</td>
<td>70,9%</td>
<td>9</td>
<td>9</td>
</tr>
</tbody>
</table>

- Students were overrepresented
- People with migration background were under-represented
- People older than 60 years were under-represented

Here, the under-representation was the most drastic. As more than 200 people had participated, only two of them were older than 60 years, a share of one percent, while the share in the target population is more than 20% (Referat für Stadtplanung und Bauordnung, 2017)

With regards to these findings, the goal was set to recruit people from the groups that were under-represented. For example, the survey was posted in a Facebook group of people from abroad that are new to Munich or flyers were distributed in areas with lower income. Computer clubs for seniors in Munich were contacted and flyers were distributed in old people’s homes. Nevertheless, the share of participants older than 60 stayed low. Thus, it was decided to specifically address this group of people with an offline, paper-pencil survey, allowing them to access the survey without internet access.

#### 5.1.5 Offline survey execution

The questionnaire for the offline survey was developed from the online survey as described in the methodology chapter. After that, the survey was printed out and distributed to the target group, people older than 60 years.

This was done by first contacting the ASZ, where the flyers had been distributed previously, and asking for the permission to carry out the survey offline in the place. As the people responsible for the ASZ agreed, the researcher visited the ASZ on two days to personally distribute the survey to guests and residents in the place. While the people who were
willing to participate filled the questionnaire, the researcher was on-site to help if there were ambiguities.

After the offline survey was completed, the results of the paper-pencil questionnaire were copied into the online survey form in LimeSurvey. To do this, the online questionnaire was filled by the researcher with the answers obtained from the offline survey. In order to avoid transmission errors, the researcher was supervised by a second person during the process.

5.2 Survey data analysis

For the data analysis, the completed survey answers were exported from LimeSurvey to R, as described in the methodology. After reading in R, the data were displayed as a data frame, that was consisting of 451 observations of 199 variables.

451 observations: Number of survey answers

199 variables: They are based on the survey questions, e.g. “Gender” is a variable that has three attributes: “male”, “female” and “diverse”. Thus, every survey answer consists of 199 variables.

5.2.1 Data cleaning and BSS users determination

As a first step of data analysis, the data was cleaned. The answers who met the following criteria were removed:

Answers by participants below 18 years old

As stated before, the survey addressed people who were at least 18 years old at the time they answered the questionnaire. Thus, the participants who stated in the age question that they were 0-17 years old, were filtered and their answers removed. As all participants stated their age group, no further deletions were necessary.

Answers where residential location was not given

The second variable used for filtering was the living location of the participants. Some people did not state their living location, so, it is possible that they live outside of the study area and do not belong to the target population. Thus, the answers with empty living location were filtered and removed.

Answers by participants living outside the MVV area

In the questionnaire welcome text and in the information texts for the survey distribution, it was stated that it is designed for Munich residents. However, due to the online distribution of the most questionnaires, it was expected that people from outside the city would participate, leading to the development of a methodology to remove these participants. The data from the living location question was saved by LimeSurvey as decimal coordinates in the World Geodetic System (WGS) 1984 format. These coordinates were depicted in the “ArcGIS” GIS. In the next step, the administrative
boundaries of the city of Munich were and the surrounding counties were imported as a layer.

By looking at the distribution of the living locations, it became obvious that the largest part of the participants were living in the city, however, a lot also lived in the areas close to the city boundaries, most of them in the surrounding county of Munich. Due to the fact that the bike sharing system MVG Rad expanded its service area to this county and assuming that people living in the Munich region also have the possibility to use the BSS systems in the city, it is decided to filter and delete only the answers of participants living outside the MVV area. The MVV area was added as a layer to the map in the GIS and then intersected with the participants coordinates.

In the next step, it was determined which of the participants were users and which non-users. This was done accordingly to the definition of users and users in the methodology. An additional column was added to the R dataset to identify users and non-users and the additional information was also displayed in the GIS map with the living locations. The final map can be seen in figure 5.1.

5.2.2 Survey statistics

5.2.2.1 Sample obtained from the survey

In the following table 5.3, the impact of the data cleaning procedure on the data-set is shown. In total, 636 people participated in the survey, whereof 451 completed the survey. Data cleaning removed one answer by a person below 18 years old, 26 answers of participants who did not indicate their living location and 16 answers of people who indicated a residence outside the MVV area. The final sample that was reached and used for further data analysis, consisted of 408 people, among them 178 BSS users and 230 BSS non-users.

By comparing the final sample size \( N = 408 \) to the required sample \( n_0 = 385 \) size calculated before, it becomes clear that the required sample has been overreached. This slightly reduces the margin of error \( e \), which is calculated as follows:

\[
e = \sqrt{\frac{z^2pq}{n_0}}
\]

with:

- \( z = \pm 1.96 \): a confidence interval of 95%
- \( p = q = 0.5 \)
- \( N = 408 \)

\[
e = \sqrt{\frac{1.96^2 \cdot 0.25}{408}} = 0.485
\]
5.2. SURVEY DATA ANALYSIS

Residential location of survey participants

![Residential location of survey participants](image)

Legend:
- Munich city centre
- BSS non-user
- BSS user
- County or city border
- Municipality border
- MVV area

**Figure 5.1:** Residential location of survey participants
Table 5.3: Impact of data cleaning on sample size

<table>
<thead>
<tr>
<th>Data cleaning: removed answers</th>
<th>Numbers</th>
<th>Accumulated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total number of answers</td>
<td>636</td>
<td>636</td>
</tr>
<tr>
<td>Completed surveys</td>
<td>451</td>
<td>451</td>
</tr>
<tr>
<td>1) Participant below 18 years old</td>
<td>1</td>
<td>450</td>
</tr>
<tr>
<td>2) Residential location not given</td>
<td>26</td>
<td>424</td>
</tr>
<tr>
<td>3) Residence outside the MVV area</td>
<td>16</td>
<td>408</td>
</tr>
<tr>
<td>Final sample</td>
<td></td>
<td>408</td>
</tr>
<tr>
<td>BSS Users</td>
<td></td>
<td>178</td>
</tr>
<tr>
<td>BSS Non-users</td>
<td></td>
<td>230</td>
</tr>
</tbody>
</table>

5.2.2.2 Summary of final sample and comparison to MID

To assess how well the final sample of the survey represents the target population, the socio-demographic attributes of the people in the final sample were compared to external data. As the socio-demographic part of the questionnaire was mostly based on the MID study, including the answer categories, the intention was to compare the attributes to the MID dataset for the city of Munich (Infas et al., 2019). However, these data were not available yet at the time the survey was carried out, thus the sample data were compared to the standard dataset from the MID for Germany (Infas et al., 2018), which was filtered by the state of Bavaria and the spatial type “Metropolis” (Munich and Nuremberg). As there were generally less answer categories in the metropolitan MID study than in the questions of the survey for this thesis, some of the survey categories had to be merged for comparison. Furthermore, some socio-demographic data, for example the education or the income, were not part of the metropolitan MID. The MID data were multiplied with a correctional factor that was used in the study. The data on migration background and income were retrieved from the Munich poverty report (Kistler et al., 2017) and city of Munich statistical data (Referat für Stadtplanung und Bauordnung, 2017). Due to the different datasets, no comparison was possible for income levels above 2000 Euro.

The results of this comparison are presented in table 5.4. The following observations could be made:

- Age: The age group from 18-29 years was strongly overrepresented. The age group of 30-49 years was well-represented. Despite that the offline survey was launched and other measures were taken to address people older than 60 years, these age groups stayed under-represented in the sample.

- Gender: Males were slightly over-represented in comparison to females. The category
Table 5.4: Comparison of the sample with MID and city of Munich data

<table>
<thead>
<tr>
<th></th>
<th>MID / city of Munich data</th>
<th>Final sample</th>
<th>Difference</th>
<th>Difference based on MID/city data</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18-29 years</td>
<td>17.2%</td>
<td>46.8%</td>
<td>29.6%</td>
<td>172.3%</td>
</tr>
<tr>
<td>30-49 years</td>
<td>31.0%</td>
<td>36.3%</td>
<td>5.3%</td>
<td>17.1%</td>
</tr>
<tr>
<td>50-69 years</td>
<td>22.6%</td>
<td>13.2%</td>
<td>-9.3%</td>
<td>-41.3%</td>
</tr>
<tr>
<td>70 years and older</td>
<td>14.0%</td>
<td>3.7%</td>
<td>-10.3%</td>
<td>-73.7%</td>
</tr>
<tr>
<td><strong>Gender</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>48.8%</td>
<td>56.1%</td>
<td>7.3%</td>
<td>15.0%</td>
</tr>
<tr>
<td>Female</td>
<td>51.2%</td>
<td>43.7%</td>
<td>-7.6%</td>
<td>-14.8%</td>
</tr>
<tr>
<td>Diverse</td>
<td>0.2%</td>
<td>0.2%</td>
<td>0.0%</td>
<td>0.0%</td>
</tr>
<tr>
<td><strong>Employment status</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>employed</td>
<td>50.7%</td>
<td>56.4%</td>
<td>5.7%</td>
<td>11.3%</td>
</tr>
<tr>
<td>Student (school, university), Apprentice</td>
<td>16.0%</td>
<td>35.0%</td>
<td>18.9%</td>
<td>118.0%</td>
</tr>
<tr>
<td>Housewife/man</td>
<td>3.5%</td>
<td>0.7%</td>
<td>-2.8%</td>
<td>-78.8%</td>
</tr>
<tr>
<td>Retiree/Pensioner</td>
<td>18.1%</td>
<td>5.4%</td>
<td>-12.7%</td>
<td>-70.1%</td>
</tr>
<tr>
<td>other</td>
<td>11.7%</td>
<td>2.5%</td>
<td>-9.2%</td>
<td>-79.0%</td>
</tr>
<tr>
<td><strong>People in Household</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 person</td>
<td>26.4%</td>
<td>35.6%</td>
<td>9.2%</td>
<td>34.7%</td>
</tr>
<tr>
<td>2 people</td>
<td>31.7%</td>
<td>33.8%</td>
<td>2.2%</td>
<td>6.8%</td>
</tr>
<tr>
<td>3 people</td>
<td>18.2%</td>
<td>14.7%</td>
<td>-3.5%</td>
<td>-19.4%</td>
</tr>
<tr>
<td>4 and more people</td>
<td>23.7%</td>
<td>15.9%</td>
<td>-7.8%</td>
<td>-32.8%</td>
</tr>
<tr>
<td><strong>Migration background</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>42.6%</td>
<td>23.3%</td>
<td>-19.3%</td>
<td>-45.4%</td>
</tr>
<tr>
<td>No</td>
<td>57.4%</td>
<td>76.7%</td>
<td>19.3%</td>
<td>33.7%</td>
</tr>
<tr>
<td><strong>Income</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less than 500 EUR</td>
<td>1.5%</td>
<td>8.2%</td>
<td>6.7%</td>
<td>448.2%</td>
</tr>
<tr>
<td>500 to less than 900 EUR</td>
<td>6.4%</td>
<td>12.7%</td>
<td>6.3%</td>
<td>98.9%</td>
</tr>
<tr>
<td>900 to less than 1500 EUR</td>
<td>15.4%</td>
<td>11.9%</td>
<td>-3.5%</td>
<td>-22.5%</td>
</tr>
<tr>
<td>1500 to less than 2000 EUR</td>
<td>15.4%</td>
<td>7.2%</td>
<td>-8.2%</td>
<td>-53.5%</td>
</tr>
</tbody>
</table>
“diverse” was not part of the MID study.

- Employment status: While the employed population (full-time and part-time) was well-represented, students were strongly overrepresented, while housewives or -men were under-represented.

- People in household: One-person households were overrepresented, while the households with three or more people are under-represented. The households with two people are well-represented.

- Migration background: People with migration background were strongly under-represented.

- Income: In this case, the monthly household net incomes below 900 Euro were over-represented. The further categories up to 2000 Euro are under-represented. Due to a lack of comparable data, the income levels above 2000 Euro were not compared.

The further results of the survey data analysis are presented in the results chapter.

5.3 Exploratory Data Analysis (EDA)

The EDA is carried out on the cleaned dataset, which consisted of 408 observations of 199 variables. As described in the methodology part, the EDA relies on bar charts and a heat map for graphical representation and on tables for tabular representation. Referring to the structure if the questionnaire, and the relevance of the attributes, The EDA is structured as follows:

1. BSS awareness in Munich
2. BSS users and non-users
3. Reasons for not using BSS
4. Socio-demographic attributes and BSS usage
5. Behavioural attributes and BSS usage
6. Trip purpose and BSS usage
7. Attitudinal attributes and BSS usage
8. Psychographic attributes and BSS usage
5.3.1 General findings on BSS in Munich

5.3.1.1 BSS awareness in Munich

Figure 5.2: Brand awareness of the different BSS in Munich, N=408

Figure 5.2 shows the percentages of the participants who know or do not know the four different BSS in Munich. MVG Rad and DB Call a Bike are the most well-known systems with more or almost 90% of the respondents knowing them.
5.3.1.2 Reasons for not using BSS

![Figure 5.3: Reasons for not using BSS](image)

This figure 5.3 shows the results of question 2, which was asked to identify the barriers to bike sharing in Munich. Most of the non-users who answered that multiple-choice question, stated that they use their own bike instead. The second-most chosen answer is that they see no need for using BSS, followed by the statement that car is used instead. 30 people stated that BSS in Munich are too costly, while some use PT instead of bike sharing. Further answers have not been chosen that frequently, but people also think that the technology is too complex, they do not like the systems, or they think BSS are dangerous. Even though the BSS are generally used by younger people, only one non-user agrees on the statement that BSS is only for young people. The text field where people could enter answers manually, included the following answers more than once:

1. With children, it is not possible to use the systems.

2. I prefer walking instead.
5.3.2 Socio-demographic attributes and BSS usage

Figure 5.4: Socio-demographic attributes and BSS usage, N=408
Figure 5.4 gives an overview of how the users and non-users are distributed along the socio-demographic variables and attributes that have been studied in the survey. The variables that have been identified to have an impact on BSS usage, based on the difference between the share of BSS users and non-users within the attributes, are highlighted. The socio-demographic variables are briefly described in the following:

- **Age**  The share of BSS users among the participants that are 30-39 years old, is extremely high, and it decreases the older the participants are. There are no BSS users in the age groups from 70 years upwards.

- **Gender**  
  There are more BSS users among the male respondents then among the females.

- **Education**  
  The share of BSS users within the higher levels of education (e.g. Master’s degree) is higher than within the lower levels (e.g. technical school degree).

- **Employment status**  
  The share of BSS users is high among the fully employed people, but low among the retirees or pensioners.

- **Household net income**  
  The share of BSS users is high among the fully employed people, but low among the retirees or pensioners.

- **People in household**  
  People living in single-person households are using BSS more than people living in two-person households.
  
  For migration background, the migration background combined with the time the person is living in Germany, and the survey language variables, the usage of BSS is evenly distributed within the attributes, thus they do not influence BSS usage.

**5.3.3 Behavioural attributes and BSS usage**
Figure 5.5: Behavioural attributes and BSS usage, N=408
For the travel behaviour, the use frequency of the following means of transport has turned out to affect BSS usage in Munich:

- **Car Sharing.** Among people who have never used car sharing, the share of BSS users is lower than among people who use car sharing more often.

- **E-Scooter.** The observation for car sharing also applies to e-scooters.

- **Private bicycle.** People who use a private bicycle daily or almost daily, are more likely to be BSS users than people who use the private bike less often.

- **Private car.** Almost none of the people who use private car daily, use BSS in Munich. In opposite to that, the share of BSS users is higher among groups of people that do not use the car any more or have never used it.

- **Bus.** The share of BSS users among people who are using the bus daily or almost daily is very low, and the share increases when it comes to people using bus less often.

### 5.3.4 Trip purpose and BSS usage

The trip purposes and the modes of transport that are used for those purposes, are depicted in two heat maps. The first heat map displays the trip purposes of BSS users, the second one of BSS non-users. The color of the fields in the center represents the number of respondents, but based on a percentage share. The brighter the color, the higher the number of participants using a mode of transport for the different trip purposes. By comparing the heat maps, it is possible to identify differences in travel patterns between the BSS users and non-users:

- **Usage of private bike for going to work**
  
  BSS users use their private bike more often for basically all trip purposes, but the difference is especially large for the trip purpose of going to work.

- **Usage of PT for going to work**
  
  BSS users use all modes of PT except bus (U-Bahn, Tram, S-Bahn) more frequently for the purpose of going to work.

- **Usage of car sharing for shopping and for leisure**
  
  A further, slight difference that can be observed in travel behaviour, is the more frequent use of car sharing for leisure and shopping purposes.
5.3. EXPLORATORY DATA ANALYSIS (EDA)

Figure 5.6: Trip purpose and BSS usage, N=408
CHAPTER 5. RESULTS

Figure 5.7: Trip purpose and BSS usage, N=408

5.3.5 Attitudinal attributes and BSS usage
Figure 5.8: Attitudinal attributes and BSS usage, N=408
The next dataset analysed was the attitudinal values. It was asked, how accessible, convenient, eco-friendly, fun, healthy, relaxing and safe the participants estimated the different modes of transport to be. The following attitudinal variables have an impact on BSS usage:

For the first mode of transport, the BSS, it is clear that the attitudes towards the systems influence their usage.

- BSS are convenient

Among the people who think that BSS are convenient, the share of BSS users is much higher than the share of non-users. Generally speaking, people who do not think that BSS is convenient, do not use it.

Further attributes are briefly named:

- BSS are fun, BSS are relaxing, BSS are safe

- car driving is accessible, car driving is convenient, car driving is fun, car driving is relaxing

- cycling is convenient, cycling is fun, cycling is relaxing
5.3.6 Psychographic attributes and BSS usage

Figure 5.9: Psychographic attributes and BSS usage, N=408
In the EDA, the following psychographic variables influencing the BSS usage were detected:

- **Equity**
  People who think that everyone should be treated equally are more likely to be use BSS than people who do not agree on that statement.

- **Security**
  People who think it is important to live in secure surroundings usually use BSS less than people who do not consider security to be important.

- **Strong State**
  People who think that the state must be strong to defend its citizens, use BSS less than people who do not think like that.

- **Tradition**
  The share of BSS users among people who consider Tradition to be important is lower than among people that do not think like that.

### 5.4 Multiple logistic regression (MLR) results

In the following chapter, the results of the MLR are presented. The tables show the variables which include at least one attribute that shows a significant association to BSS’s usage. One MLR has been carried out per variable. The significant variables are significantly associated to the use of BSS at a confidence level of 95%.

#### 5.4.1 Socio-demographic attributes
### Figure 5.10: MLR significant socio-demographic variables-part 1

| Variable               | Attribute   | BSS Users | BSS non-users | Estimate  | Std.Error | zvalue | Pr(>|z|) |
|------------------------|-------------|-----------|---------------|-----------|-----------|--------|---------|
| **Age**                |             |           |               |           |           |        |         |
| 18-29 years            | 72 (40.4%)  | 119 (51.7%) |             | -0.49002  | 0.154     | -3.182 | 0.00146 ** |
| 30-39 years            | 68 (38.2%)  | 30 (13%)   |             | 1.41428   | 0.28211   | 5.013  | 5.35E-07 *** |
| 40-49 years            | 22 (12.4%)  | 28 (12.2%) |             | 0.4435    | 0.34174   | 1.298  | 0.19437 |
| 50-59 years            | 13 (7.3%)   | 24 (10.4%) |             | -0.05652  | 0.40897   | -0.138 | 0.89008 |
| 60-69 years            | 3 (1.7%)    | 14 (6.1%)  |             | -1.05042  | 0.65458   | -1.605 | 0.10855 |
| 69-79 years            | 0 (0%)      | 10 (4.3%)  |             | -16.07605 | 979.61004 | -0.016 | 0.98691 |
| 80 years and older     | 0 (0%)      | 5 (2.2%)   |             | -16.07605 | 1696.73435 | -0.009 | 0.99244 |
| **Gender**             |             |           |               |           |           |        |         |
| Male                   | 116 (55.5%) | 110 (48.5%) |             | 0.08912   | 0.1402    | 0.7    | 0.484   |
| Female                 | 60 (34.1%)  | 116 (51.1%) |             | -0.6357   | 0.21565   | -2.948 | 0.0032 ** |
| Diverse                | 0 (0%)      | 1 (0.4%)   |             | -13.66418 | 535.41119 | -0.026 | 0.9796  |
| **Employment Status**  |             |           |               |           |           |        |         |
| Full-time employed     | 99 (55.6%)  | 80 (34.9%) |             | 0.3895    | 0.1632    | 2.387  | 0.017 * |
| Part-time employed     | 22 (12.4%)  | 28 (12.2%) |             | -0.7409   | 0.341     | -2.172 | 0.0298 * |
| Apprentice/Trainee      | 2 (1.1%)    | 2 (0.9%)   |             | -0.3895   | 1.0132    | -0.384 | 0.7007  |
| Unemployed             | 1 (0.6%)    | 3 (1.3%)   |             | -1.4881   | 1.1656    | -1.276 | 0.2019  |
| Student (school)       | 0 (0%)      | 2 (0.9%)   |             | -16.9555  | 1696.7344 | -0.01  | 0.992   |
| Student (university)   | 48 (27.1%)  | 88 (38.4%) |             | -0.9797   | 0.2458    | -3.986 | 6.73E-05 *** |
| Housewife/-man         | 3 (1.7%)    | 0 (0%)     |             | 16.1766   | 1385.3778 | 0.012  | 0.9907  |
| Retiree/Pensioner      | 0 (0%)      | 22 (9.6%)  |             | -16.9555  | 619.5598  | -0.027 | 0.9782  |
| Other                  | 2 (1.1%)    | 4 (1.7%)   |             | -1.0826   | 0.8813    | -1.228 | 0.2193  |
| Variable                  | Attribute          | BSS Users | BSS non-users | Estimate  | Std.Error | zvalue | Pr(>|z|) |
|--------------------------|--------------------|-----------|---------------|-----------|-----------|--------|---------|
| **Household net income** |                    |           |               | (Intercept) | -0.23947  | 0.12414 | -1.929  | 0.0537  |
| Less than 500 €          | 5 (3%)             | 26 (12.4%)|               | 17.7314   | 0.44359   | 3.997   | 6.41E-05*** |
| 500 to less than 900 €   | 15 (6.9%)          | 33 (15.8%)|               | -0.78581  | 0.42612   | -1.844  | 0.0652  |
| 900 to less than 1500 €  | 17 (10.1%)         | 28 (13.4%)|               | -0.20988  | 0.42328   | -0.496  | 0.62    |
| 1500 to less than 2000 € | 6 (3.6%)           | 21 (10%)  |               | -0.27449  | 0.39513   | -0.695  | 0.4873  |
| 2000 to less than 3000 € | 36 (21.4%)         | 35 (16.7%)|               | 0.4747    | 0.40891   | 1.161   | 0.2457  |
| 3000 to less than 4000 € | 31 (18.5%)         | 18 (8.6%) |               | -0.35046  | 0.37457   | -0.936  | 0.3495  |
| 4000 to less than 5000 € | 19 (11.3%)         | 20 (9.6%) |               | -0.0353   | 0.35474   | -0.099  | 0.9207  |
| 5000 to less than 6000 € | 20 (11.9%)         | 10 (4.8%) |               | 0.94755   | 0.37202   | 2.547   | 0.0109 * |
| 6000 to less than 7000 € | 9 (5.4%)           | 8 (3.6%)  |               | -0.04628  | 0.31862   | -0.145  | 0.8845  |
| more than 7000 €         | 10 (6%)            | 10 (4.8%) |               |           |           |        |         |
| **People in household**  |                    |           |               | (Intercept) | -0.6592   | 0.1836  | -3.59   | 0.00033 *** |
| one person               | 49 (27.7%)         | 94 (41.8%)|               | 0.8534    | 0.2574    | 3.315   | 0.000017 *** |
| two people               | 72 (40.7%)         | 64 (28.4%)|               | 0.47      | 0.3315    | 1.418   | 0.156197 |
| three people             | 26 (14.7%)         | 33 (14.7%)|               | 0.4479    | 0.3744    | 1.196   | 0.231509 |
| four people              | 16 (10.2%)         | 26 (11.6%)|               | 2.7387    | 1.0764    | 2.544   | 0.01095 *   |
| five people              | 8 (4.5%)           | 2 (0.9%)  |               | 0.4361    | 0.6955    | 0.627   | 0.530635 |
| six or more people       | 4 (2.3%)           | 6 (2.7%)  |               |           |           |        |         |

**Figure 5.11:** MLR significant socio-demographic variables-part 2
The figure 5.10 shows the socio-demographic variables and attributes that are significantly associated to BSS usage. In the left column, the variable is shown, then the attribute. The next two columns show how many BSS users and non-users have this attribute. The share in brackets refers to the total number of BSS users and non-users. The next five columns show the MLR results, in particular, the estimate and the p-value that indicates the significance. The last column includes the R coding of significance. As depicted in the following variables and attributes are associated to BSS usage with a 95% confidence interval:

- Age - 30-39 years:
  This attribute is positively associated with BSS usage, implying that people in these age groups are more likely to use BSS.

- Gender - Female:
  For this attribute, the estimate is negative, thus females use BSS less.

- Employment status - part-time employed
  Being part-time employed has a negative influence on BSS usage.

- Employment status - student (university): Being a student strongly related to BSS usage, however, it has a slightly negative influence on BSS usage.

- Household net income - 500 to less than 900 Euro
  Having a household income of 500 to less than 900 Euro is negatively associated to BSS usage. Despite the intercept being positive, the columns with the percentage of BSS users and non-users tell that there are more non-users than among the people with that attribute

- Household net income - 6000 to less than 7000 Euro
  A household net income of 6000 to 7000 Euro is positively associated to BSS usage, people use BSS more frequently.

- People in household - two people
- People in household - five people
  People living in households including two or five people use BSS more.

### 5.4.2 Behavioural attributes

The following figure 5.12 depicts the behavioural variables that are including attributes significantly associated to BSS usage.
### Figure 5.12: MLR significant behavioural variables

| Variable                                      | Estimate | Std. Error | z value | Pr(>|z|) | Variable                                      | Estimate | Std. Error | z value | Pr(>|z|) |
|-----------------------------------------------|----------|------------|---------|----------|-----------------------------------------------|----------|------------|---------|----------|
| (Intercept)                                   | 0.3401   | 0.1472     | 2.310   | 0.02087  | (Intercept)                                   | 0.00662  | 0.34832    | 0.174   | 0.8618   |
| UF_PrivateSikeOne to three days a week       | -0.7921  | 0.2030     | -3.926  | 0.00012  | UF_TrainOne to three days a week              | 0.23964  | 0.42397    | 0.553   | 0.5801   |
| UF_PrivateSikeOne to three days a month      | -1.2956  | 0.4002     | -3.241  | 0.00121  | UF_TrainOne to three days a month             | -0.10764 | 0.39032    | -0.275  | 0.7857   |
| UF_PrivateSikeLess than monthly              | -2.1318  | 0.7778     | -2.710  | 0.00613  | UF_TrainLess than monthly                     | -0.55706 | 0.42282    | -1.317  | 0.1877   |
| UF_PrivateSikeI almost never use              | -0.6278  | 0.7778     | -0.807  | 0.41962  | UF_TrainI almost never use                    | -1.04145 | 0.53355    | -1.989  | 0.0467   |
| UF_PrivateSikeI do not use it anymore         | -1.8803  | 0.6510     | -2.880  | 0.00398  | UF_TrainI do not use it anymore               | -14.62469 | 0.125999   | -0.023  | 0.9813   |
| UF_PrivateSikeI have never used it            | -2.4195  | 1.0708     | -2.660  | 0.02385  | UF_TrainI never used it                       | -0.75877 | 0.39345    | -0.808  | 0.4194   |
| (Intercept)                                   | -2.4423  | 0.7368     | -3.315  | 0.000937 | (Intercept)                                   | -0.8755  | 0.3073     | -2.849  | 0.00439  |
| UF_PrivateCarDriveOne to three days a week    | 2.4423   | 0.7873     | 3.102   | 0.001920 | UF_BusOne to three days a week                | 1.0761   | 0.3807     | 2.827   | 0.00470  |
| UF_PrivateCarDriveOne to three days a month   | 2.2600   | 0.7850     | 2.879   | 0.003988 | UF_BusOne to three days a month               | 1.1020   | 0.3642     | 3.028   | 0.00246  |
| UF_PrivateCarDriveLess than monthly           | 2.0389   | 0.8423     | 2.418   | 0.015600 | UF_BusLess than monthly                      | 0.6206   | 0.3835     | 1.593   | 0.1109   |
| UF_PrivateCarDriveI almost never use           | 1.4615   | 0.8787     | 1.663   | 0.096240 | UF_BusI almost never use                      | -0.1361  | 0.5147     | -0.264  | 0.79140  |
| UF_PrivateCarDriveI do not use it anymore      | 2.6037   | 0.7787     | 3.359   | 0.000542 | UF_BusI do not use it anymore                 | 0.3108   | 1.1995     | 0.241   | 0.80953  |
| UF_PrivateCarDriveI have never used it         | 2.5206   | 0.7630     | 3.304   | 0.000953 | UF_BusI have never used it                    | -13.6906 | 0.241939   | -0.022  | 0.98250  |
5.4.3 Trip purpose

The figures 5.13, 5.13 and 5.15 depict the trip purpose variables that are including attributes significantly associated to BSS usage.
**Figure 5.13:** MLR significant trip purpose variables - part 1

| Estimate | Std. Error | Z value | Pr(>|z|) |
|----------|------------|---------|----------|
| Intercept | -0.66951   | 0.26151 | -2.560   | 0.0105 * |
| TP_Walkingwork1 | 0.48930   | 0.23743 | 2.061    | 0.0393 * |
| TP_Walkingun1 | -0.61778   | 0.25501 | -2.399   | 0.0164 * |
| TP_WalkingShopping1 | 0.16000   | 0.27590 | 0.580    | 0.5620 |
| TP_WalkingPrivate1 | 0.16402   | 0.25833 | 0.635    | 0.5255 |
| TP_WalkingLeisure1 | 0.20729   | 0.24544 | 0.845    | 0.3984 |
| TP_WalkingHome1 | 0.05184    | 0.23285 | 0.223    | 0.8238 |
| TP_WalkingOther1 | 0.05625    | 0.31655 | 0.178    | 0.8590 |
| TP_WalkingNA1 | -12.89656  | 533.41123 | -0.024   | 0.9808 |

| Estimate | Std. Error | Z value | Pr(>|z|) |
|----------|------------|---------|----------|
| Intercept | -0.45077   | 0.11170 | -4.036   | 5.45e-05 *** |
| TP_Escooterwork1 | 1.02650   | 1.31107 | 0.783    | 0.43366 |
| TP_Escooterun1 | 0.59687    | 1.38087 | 0.432    | 0.66559 |
| TP_EscooterShopping1 | -0.62207  | 1.04024 | -0.598   | 0.54983 |
| TP_EscooterPrivate1 | 0.44420   | 0.70050 | 0.634    | 0.52600 |
| TP_EscooterLeisure1 | 1.12835   | 0.39658 | 2.845    | 0.00444 ** |
| TP_EscooterHome1 | 0.50262    | 0.60189 | 0.835    | 0.40368 |
| TP_EscooterOther1 | -0.07062   | 0.66381 | -1.060   | 0.27959 |
| TP_EscooterNA1 | 1.36706    | 0.60206 | 2.271    | 0.02317 * |

| Estimate | Std. Error | Z value | Pr(>|z|) |
|----------|------------|---------|----------|
| Intercept | -0.5436    | 0.1265  | -4.327   | 3.75e-06 *** |
| TP_Carsharingwork1 | 1.0814    | 1.1952  | 0.905    | 0.365675 |
| TP_Carsharingun1 | -15.7014   | 605.5432 | -0.026   | 0.979195 |
| TP_CarsharingShopping1 | 1.2717    | 0.4916  | 2.587    | 0.009687 ** |
| TP_CarsharingPrivate1 | -0.0783   | 0.3759  | -0.208   | 0.839977 |
| TP_CarsharingLeisure1 | 1.1802    | 0.3130  | 3.770    | 0.000163 *** |
| TP_CarsharingHome1 | 0.9350     | 0.7341  | 1.274    | 0.202782 |
| TP_CarsharingOther1 | 0.7365     | 0.3769  | 1.954    | 0.050664 . |
| TP_CarsharingNA1 | 0.5382     | 0.4766  | 1.129    | 0.258760 |

| Estimate | Std. Error | Z value | Pr(>|z|) |
|----------|------------|---------|----------|
| Intercept | -1.36147   | 0.26142 | -5.208   | 1.91e-07 *** |
| TP_PrivateBikeWork1 | 1.50661   | 0.25645 | 5.873    | 4.29e-09 *** |
| TP_PrivateBikeUn1 | 0.05824    | 0.24321 | 0.239    | 0.811 |
| TP_PrivateBikeShopping1 | -0.05971  | 0.29708 | -0.201   | 0.841 |
| TP_PrivateBikePrivate1 | 0.30365   | 0.32365 | 0.938    | 0.348 |
| TP_PrivateBikeLeisure1 | 0.11620   | 0.33478 | 0.347    | 0.729 |
| TP_PrivateBikeHome1 | -0.12450   | 0.27742 | -0.449   | 0.654 |
| TP_PrivateBikeOther1 | 0.16663    | 0.31426 | 0.530    | 0.596 |
| TP_PrivateBikeNA1 | -13.20460  | 509.65219 | -0.026  | 0.979 |
### Figure 5.14: MLR significant trip purpose variables - part 2

| Variable                        | Estimate | Std. Error | z value | Pr(>|z|) |
|--------------------------------|----------|------------|---------|---------|
| (Intercept)                     | -0.26388 | 0.10387    | -2.541  | 0.0111  |
| TP_PrivateMotorbikeWork1       | -0.20288 | 1.05476    | -0.192  | 0.8475  |
| TP_PrivateMotorbikeUni1        | -0.78028 | 1.50761    | -0.518  | 0.6048  |
| TP_PrivateMotorbikeShopping1   | -0.02620 | 1.07117    | -0.024  | 0.9805  |
| TP_PrivateMotorbikePrivate1    | 0.07409  | 1.02407    | 0.072   | 0.9423  |
| TP_PrivateMotorbikeLeisure1    | -0.42272 | 0.60687    | -0.697  | 0.4861  |
| TP_PrivateMotorbikeHome1       | 2.97739  | 1.49256    | 1.995   | 0.0461  |
| TP_PrivateMotorbikeOther1      | -0.72460 | 1.96519    | -0.369  | 0.7123  |
| TP_PrivateMotorbikeNA1         | -0.42927 | 1.22914    | -0.349  | 0.7269  |

| Variable                        | Estimate | Std. Error | z value | Pr(>|z|) |
|--------------------------------|----------|------------|---------|---------|
| (Intercept)                     | -0.07469 | 0.13257    | -0.563  | 0.5732  |
| TP_PrivateCarDriveWork1         | -0.76014 | 0.33989    | -2.236  | 0.0253  |
| TP_PrivateCarDriveUni1          | -0.51537 | 0.71003    | -0.726  | 0.4679  |
| TP_PrivateCarDriveShopping1     | -0.24391 | 0.34827    | -0.700  | 0.4837  |
| TP_PrivateCarDrivePrivate1      | 0.22313  | 0.33730    | 0.662   | 0.5083  |
| TP_PrivateCarDriveLeisure1      | 0.16487  | 0.28404    | 0.580   | 0.5616  |
| TP_PrivateCarDriveHome1         | -0.58159 | 0.35569    | -1.635  | 0.1020  |
| TP_PrivateCarDriveOther1        | 0.13526  | 0.36025    | 0.375   | 0.7073  |
| TP_PrivateCarDriveNA1           | -1.03554 | 0.67960    | -1.524  | 0.1276  |
### Figure 5.15: MLR significant trip purpose variables - part 3

| Variable               | Estimate | Std. Error | z value | Pr(>|z|)  |
|------------------------|----------|------------|---------|-----------|
| (Intercept)            | -0.69839 | 0.24118    | -2.896  | 0.003783 ** |
| TP_Ubahnwork1          | 0.72459  | 0.21907    | 3.308   | 0.000941 *** |
| TP_Ubahnnum1           | -0.41291 | 0.23137    | -1.785  | 0.074321 . |
| TP_UbahnShopping1      | 0.09689  | 0.25471    | 0.380   | 0.703651 . |
| TP_UbahnPrivate1       | 0.02840  | 0.24278    | 0.117   | 0.906867 . |
| TP_UbahnLeisure1       | 0.21247  | 0.23894    | 0.889   | 0.373871 . |
| TP_UbahnHome1          | 0.13711  | 0.24098    | 0.569   | 0.579389 . |
| TP_UbahnOther1         | -0.18547 | 0.34131    | -0.545  | 0.587804 . |
| TP_UbahnNA1            | -1.38754 | 1.09463    | -1.268  | 0.204947 . |

| Variable               | Estimate | Std. Error | z value | Pr(>|z|)  |
|------------------------|----------|------------|---------|-----------|
| (Intercept)            | -1.02609 | 0.23210    | -4.421  | 9.83e-06 *** |
| TP_SbahnRegwork1       | 1.08052  | 0.25512    | 4.235   | 2.28e-05 *** |
| TP_SbahnRegnum1        | -0.34251 | 0.34844    | -0.983  | 0.32562   |
| TP_SbahnRegShopping1   | 0.47093  | 0.33882    | 1.390   | 0.16436   |
| TP_SbahnRegPrivate1    | -0.12641 | 0.24243    | -0.523  | 0.59833   |
| TP_SbahnRegLeisure1    | 0.72101  | 0.25207    | 2.853   | 0.00433 ** |
| TP_SbahnRegHome1       | 0.11707  | 0.25318    | 0.462   | 0.64381   |
| TP_SbahnRegOther1      | 0.05899  | 0.31348    | 0.188   | 0.85074   |
| TP_SbahnRegNA1         | 0.90774  | 0.47654    | 1.905   | 0.05680 . |

| Variable               | Estimate | Std. Error | z value | Pr(>|z|)  |
|------------------------|----------|------------|---------|-----------|
| (Intercept)            | -0.86058 | 0.21383    | -4.025  | 5.71e-05 *** |
| TP_Trainwork1          | 1.22790  | 0.28961    | 4.240   | 2.24e-05 *** |
| TP_Trainnum1           | -0.55393 | 0.38139    | -1.452  | 0.14640  |
| TP_TrainShopping1      | 0.05631  | 0.32103    | 0.175   | 0.86076  |
| TP_TrainPrivate1       | -0.09370 | 0.24568    | -0.381  | 0.70291  |
| TP_TrainLeisure1       | 0.64350  | 0.24120    | 2.668   | 0.00763 ** |
| TP_TrainHome1          | 0.26215  | 0.27546    | 0.952   | 0.34228  |
| TP_TrainOther1         | 0.34907  | 0.32625    | 1.070   | 0.28463  |
| TP_TrainNA1            | -0.77059 | 0.50006    | -1.541  | 0.12332  |
5.4.4 Attitudinal attributes

The figures 5.16 and 5.17 depict the attitudinal variables that are including attributes significantly associated to BSS usage.
### Figure 5.16: MLR significant attitudinal variables - part 1

| Estimate | Std. Error | z value | Pr(>|z|) |
|----------|------------|---------|---------|
| (Intercept) | 1.0179 | 0.1779 | 5.721 | 1.00e-08 *** |
| ATT_BSS_convenientI somewhat agree | -1.6288 | 0.2688 | -6.059 | 1.37e-09 *** |
| ATT_BSS_convenientI neither agree nor disagree | -18.5840 | 824.9206 | -0.023 | 0.982027 |
| ATT_BSS_convenientI somewhat disagree | -3.5028 | 1.0519 | -3.317 | 0.000909 *** |
| ATT_BSS_convenientI strongly disagree | -18.5840 | 1769.2576 | -0.011 | 0.991619 |

| Estimate | Std. Error | z value | Pr(>|z|) |
|----------|------------|---------|---------|
| (Intercept) | 0.0923 | 0.3702 | -2.683 | 0.007204 ** |
| ATT_BSS_relaxingI somewhat agree | -0.3850 | 0.4159 | -0.926 | 0.354585 |
| ATT_BSS_relaxingI neither agree nor disagree | -1.5580 | 0.4263 | -3.671 | 0.000241 *** |
| ATT_BSS_relaxingI somewhat disagree | -1.5041 | 0.4937 | -3.047 | 0.002313 ** |
| ATT_BSS_relaxingI strongly disagree | -2.8631 | 0.8450 | -3.391 | 0.000697 *** |

| Estimate | Std. Error | z value | Pr(>|z|) |
|----------|------------|---------|---------|
| (Intercept) | 1.2528 | 0.3273 | 3.827 | 0.000130 *** |
| ATT_BSS_funi somewhat agree | -0.7221 | 0.3632 | -2.0184 | 0.059909 |
| ATT_BSS_funi neither agree nor disagree | -2.0305 | 0.3874 | -5.241 | 1.59e-07 *** |
| ATT_BSS_funi somewhat disagree | -1.4604 | 0.4966 | -2.941 | 0.003271 ** |
| ATT_BSS_funi strongly disagree | -3.6507 | 1.0941 | -3.337 | 0.000848 *** |

| Estimate | Std. Error | z value | Pr(>|z|) |
|----------|------------|---------|---------|
| (Intercept) | 0.3223 | 0.1558 | 2.068 | 0.03864 * |
| ATT_BSS_healthyI somewhat agree | -0.3438 | 0.2594 | -1.325 | 0.18511 |
| ATT_BSS_healthyI neither agree nor disagree | -1.0154 | 0.3864 | -2.628 | 0.00859 ** |
| ATT_BSS_healthyI somewhat disagree | -2.1140 | 1.0913 | -1.937 | 0.05272 . |
| ATT_BSS_healthyI strongly disagree | -1.9317 | 1.1065 | -1.746 | 0.08084 . |
### MULTIPLE LOGISTIC REGRESSION (MLR) RESULTS

**Figure 5.17:** MLR significant attitudinal variables - part 2

| Estimate | Std. Error | z value | Pr(>|z|) |
|----------|------------|---------|----------|
| Intercept | 0.3069     | 0.1298  | 2.364    | 0.018066 * |
| ATT_cycling_convenience somewhat agree | -1.0846 | 0.3205 | -3.364 | 0.000713 *** |
| ATT_cycling_convenience neither agree nor disagree | -2.5041 | 1.0621 | -2.358 | 0.018383 * |
| ATT_cycling_convenience strongly disagree | -15.8730 | 840.2742 | -0.019 | 0.984920 |
| ATT_cycling_relaxing somewhat agree | 0.3185 | 0.1756 | 1.813 | 0.0698 |
| ATT_cycling_relaxing neither agree nor disagree | -0.2749 | 0.2439 | -1.134 | 0.2605 |
| ATT_cycling_relaxing strongly disagree | -1.7047 | 0.6690 | -2.548 | 0.0108 * |
| ATT_cycling_funI somewhat agree | 0.2787 | 0.1446 | 1.927 | 0.0539 |
| ATT_cycling_funI neither agree nor disagree | -0.3868 | 0.2341 | -1.657 | 0.1209 |
| ATT_cycling_funI strongly disagree | -6.8488 | 979.6100 | -0.017 | 0.984195 |

| Estimate | Std. Error | z value | Pr(>|z|) |
|----------|------------|---------|----------|
| ATT_carDriving_convenience somewhat agree | 0.3485 | 0.2681 | 1.300 | 0.193598 |
| ATT_carDriving_convenience neither agree nor disagree | 1.3863 | 0.4020 | 3.448 | 0.000364 *** |
| ATT_carDriving_convenience strongly disagree | 1.1532 | 0.4485 | 2.520 | 0.011720 * |
| ATT_carDriving_relaxing somewhat agree | 0.2495 | 0.5525 | 0.452 | 0.651605 |
| ATT_carDriving_relaxing neither agree nor disagree | -0.6931 | 0.4330 | -1.601 | 0.1094 |
| ATT_carDriving_relaxing strongly disagree | 1.1492 | 0.4731 | 2.429 | 0.0151 * |
| ATT_carDriving_funI somewhat agree | 0.3873 | 0.3450 | -2.456 | 0.01406 * |
| ATT_carDriving_funI neither agree nor disagree | 0.9426 | 0.2985 | 3.177 | 0.001744 * |
| ATT_carDriving_funI strongly disagree | 1.2781 | 0.4727 | 2.692 | 0.007377 ** |
5.4.5 Psychographic attributes

The figure 5.18 shows the psychographic variables that are including attributes significantly associated to BSS usage.
### Table of MLR Results

| Variable                          | Estimate | Std. Error | z value | Pr(>|z|) | Variable                          | Estimate | Std. Error | z value | Pr(>|z|) |
|----------------------------------|----------|------------|---------|----------|----------------------------------|----------|------------|---------|----------|
| Intercept                        | 0.2296   | 0.1701     | 1.349   | 0.17725  | Intercept                        | -0.5031  | 0.2484     | -2.025  | 0.0429   |
| PSY3_EqualLike me                | -0.6728  | 0.2460     | -2.735  | 0.00624 ** | PSY12_HelpfulLike me             | 0.4571   | 0.2911     | 1.571   | 0.1163   |
| PSY3_EqualSomewhat like me       | -0.4302  | 0.3103     | -1.387  | 0.16559  | PSY12_HelpfulSomewhat like me    | 0.2154   | 0.3322     | 0.649   | 0.5186   |
| PSY3_EqualA little like me       | -1.1459  | 0.6156     | -1.861  | 0.06269  | PSY12_HelpfulA little like me    | 0.4290   | 0.4583     | 0.936   | 0.3493   |
| PSY3_EqualNot like me            | -1.6159  | 0.8087     | -1.998  | 0.04570 * | PSY12_HelpfulNot like me        | 1.1963   | 0.9010     | 1.328   | 0.1843   |
| PSY3_EqualNot like me at all     | -0.9227  | 0.8826     | -1.045  | 0.29580  | PSY12_HelpfulNot like me at all  | -0.1900  | 1.2497     | -0.152  | 0.8791   |

### Table of MLR Results (continued)

| Variable                          | Estimate | Std. Error | z value | Pr(>|z|) | Variable                          | Estimate | Std. Error | z value | Pr(>|z|) |
|----------------------------------|----------|------------|---------|----------|----------------------------------|----------|------------|---------|----------|
| PSY5_SecureLike me               | 1.3011   | 0.5877     | 2.214   | 0.026836 * | PSY14_StrongStateLike me        | 0.3296   | 0.4049     | 0.814   | 0.4157   |
| PSY5_SecureSomewhat like me      | 1.9042   | 0.5803     | 3.281   | 0.001033 ** | PSY14_StrongStateSomewhat like me | 0.2870   | 0.3911     | 0.734   | 0.4630   |
| PSY5_SecureA little like me      | 1.8577   | 0.5794     | 3.206   | 0.001344 ** | PSY14_StrongStateA little like me | 0.6286   | 0.4060     | 1.548   | 0.1215   |
| PSY5_SecureNot like me           | 1.7918   | 0.6005     | 2.984   | 0.002848 ** | PSY14_StrongStateNot like me    | 0.9822   | 0.4180     | 2.350   | 0.0188 *  |
| PSY5_SecureNot like me at all    | 1.5686   | 0.7188     | 2.182   | 0.029089 * | PSY14_StrongStateNot like me at all | 0.6568   | 0.5388     | 1.219   | 0.2228   |

### Table of MLR Results (continued)

| Variable                          | Estimate | Std. Error | z value | Pr(>|z|) | Variable                          | Estimate | Std. Error | z value | Pr(>|z|) |
|----------------------------------|----------|------------|---------|----------|----------------------------------|----------|------------|---------|----------|
| PSY11_OwnDecisionLike me         | 0.1728   | 0.2404     | 0.719   | 0.4722   | PSY20_TraditionLike me           | 0.3808   | 0.8413     | 0.453   | 0.6508   |
| PSY11_OwnDecisionSomewhat like me| -0.1133  | 0.3270     | -0.347  | 0.7289   | PSY20_TraditionSomewhat like me  | 1.2646   | 0.8064     | 1.568   | 0.1168   |
| PSY11_OwnDecisionA little like me| 1.1676   | 0.5608     | 2.082   | 0.0373 * | PSY20_TraditionA little like me  | 1.4424   | 0.8099     | 1.781   | 0.0749   |
| PSY11_OwnDecisionNot like me     | 0.2921   | 0.7288     | 0.401   | 0.6885   | PSY20_TraditionNot like me       | 1.9117   | 0.8069     | 2.369   | 0.0178 * |
| PSY11_OwnDecisionNot like me at all| -13.2739| 535.4112   | -0.025  | 0.9802   | PSY20_TraditionNot like me at all | 1.9889   | 0.8153     | 2.439   | 0.0147 * |

**Figure 5.18:** MLR significant psychographic variables
5.5 LASSO results

In this chapter, the results of the combination between the LASSO method and the MLR are presented. The attributes that are significantly associated to BSS usage are briefly explained.

5.5.1 Socio-demographic attributes

As can be seen in figure 5.19, “Age - 30-39 years” and “Household income - 6000 to 7000 Euro”, are positively associated positively to BSS usage, while “Gender - Female” and “Education - High school degree” are negatively associated.
5.5.2 Behavioural attributes

The results in 5.20 can be described as follows: people who have never used car sharing or e-scooters, are using BSS less. In the opposite, the daily or almost daily use of private bike is positively associated with BSS usage. The daily or almost daily use of private car is negatively associated with BSS usage.

5.5.3 Trip purpose

The results in 5.21 can be described as follows: people who have never used car sharing or e-scooters, are using BSS less. In the opposite, the daily or almost daily use of private bike is positively associated with BSS usage. The daily or almost daily use of private car is negatively associated with BSS usage.
For the trip purposes in 5.21, the usage of carsharing for leisure, the usage of private bike for going to work, and the usage of bus for private purposes are positively associated to BSS usage. The usage of the private car for going to work is negatively associated to BSS usage.

### 5.5.4 Attitudinal attributes

All attitudinal attributes in 5.22 are significantly associated with BSS usage: People who are undecided whether PT is convenient, use BSS less, whereas people who somewhat agree that PT is accessible, use BSS more. People who somewhat agree that cycling is convenient or are undecided, use BSS less. People who are not sure if car driving is convenient or who disagree on that statement, use BSS more, while people who somewhat agree that driving by car is accessible, use BSS less.

![Figure 5.22: Attitudinal attributes associated to BSS usage](image-url)
5.5.5 Psychographic attributes

As can be seen in figure 5.23, tradition is strongly associated to BSS use in a negative way. People who agree that traditions are important for them, use BSS less.
Chapter 6

Discussion

In this chapter, the results of the research are discussed and explanations for the results are given. First, the focus is on the survey results, then on the results of the modelling procedure. Furthermore, the significance of the research is described and the limitations of the research are explained.

6.1 Discussion of results

6.1.1 Survey results

The sample of participants obtained in the survey shows some significant differences from the MID dataset or census data. Especially young people, students, and people with an household net income up to 900 Euro were strongly over-represented. In opposite to that, older people, retirees and people with migration background were under-represented. One reason for this could be, that the survey was conducted for a Master’s thesis at a university and a that the survey was, among other groups, distributed to the researcher’s friends, who are mostly students and or younger people. Furthermore, people knowing the researcher in person might be more willing to answer the survey than those who don’t. Another cause for the unbalanced survey sample is the survey method. The largest part of the responses was received from an online survey. The share of “onliners” is low among older people (Döhring and Bortz, 2016), making it very difficult to reach people from that age groups with that survey mode. The under-representation could be significantly reduced by the offline survey, that was designed specifically to address older people, but a realistic representation was not reached, because it was not possible to generate the amount of answers offline that would have been needed. Generally speaking, the remarks from literature, that it usually takes more effort and more time to collect answers offline than online (Chelius et al., 2012), applied to the survey. Another group that is under-represented are people with migration background. This is quite unexpected at first, because a lot of students at TUM who received the survey do have migration background. One possible reason for that could be the definition of “migration background” in Germany (if someone or at least one of someone’s parents is born with a foreign citizenship (Referat für Stadtplanung und Bauordnung, 2017), which applies to a lot of people. Despite the definition was given in the survey, some people might
not have considered themselves as having a migration background.

Another interesting result is the brand awareness among the BSS in Munich. More than 95% of the participants know MVG Rad and 90% Call a Bike, which corresponds to the leading position of the two systems in the Munich BSS market and to the timespan for which the systems have been operating, namely almost 5 and almost 20 years. Concerning the two other systems, more people know Jump bike than Donkey Republic, which is unexpected because Jump Bike started operating in September 2019 (see chapter 4.2), short before the survey was launched, Donkey Republic started one year earlier (see chapter 4.2). One reason might be the design of the Jump bikes, which is quite eye-catching, but it could also be that the participants confuse the bikes to Call a Bike bicycles due to similar colouring.

6.1.2 Exploratory Data Analysis and Modelling results

The EDA and the different modelling approaches lead to similar results concerning the people’s attributes which are influencing the usage of BSS. In this context, the results of the EDA and the MNL are more similar to each other than the results of the LASSO selection approach. This is because they were based on the same approach: comparing the shares of users and non-users within one attribute. The overall results can be summarized as follows:

- **socio-demographic attributes:**
  Younger people, people with a rather high household income and people living in bigger households use BSS more, while females use BSS less.

  Most findings on the socio-demographic attributes are similar to the results from previous studies (Fuller et al., 2011; Shaheen et al., 2014; Ogilvie and Goodman, 2012b). Migration background does not have an influence on BSS usage in Munich, but it cannot be directly compared to the ethnicity, which influences BSS usage in the U.S. (L D A Consulting, 2017).

- **behavioural attributes:**
  People who use carsharing or e-scooters less, or use the private car frequently, use BSS less, while people who use the private bike frequently, use BSS more.

  These results are also supported by previous research, e.g. (Reiss et al., 2015; Fuller et al., 2011; Guo et al., 2017), which found out that BSS users tend to have a more multi-modal travel behaviour and tend to use their private bike more. To the best of the author’s knowledge, the relationship between the usage of e-scooters to BSS usage has not been checked before, but this observation can be explained with the more multi-modal travel behaviour of BSS users.

- **Trip purpose:**
  Generally speaking, the results for trip purposes are related to the observations on travel behaviour, e.g. people using car sharing for leisure are using BSS more. Moreover, summing the different means of transport up, the trip purpose “to work”, how people commute to their workplace, seems to be strongly associated to BSS usage. The MLR found a positive association between BSS usage and going to work by PT.
This is contradictory to studies like Fuller et al. (2011), that found out that people who used PT for commuting, were less likely to use BSS. However, there are different results from researchers, e.g. Guo et al. (2017) examined a positive relationship. In this context, the survey carried out by Reiss et al. (2015) showed that Munich Call a Bike users used both bike and PT very frequently.

- Attitudinal attributes
  People with a rather positive attitude towards biking, and a rather negative attitude towards car driving use BSS more.
  This result goes in a row with (Fishman et al., 2014b) and (Shaheen et al., 2011), who found a positive attitude towards cycling.

- Psychographic attributes
  Considering the LASSO results, tradition is negatively associated to BSS usage. MLR and EDA identified further psychographic attributes, for example that people who prefer to live in secure surroundings and prefer a strong state use BSS less and people who consider equity as important use it more.

  The finding, that people from traditional milieus use BSS less, was also made by the “German bike monitor” (Borgstedt et al., 2019). It is assumed, that the three attributes named above all account to people in traditional milieus. A reason for this result could be that traditional people might generally be less eager to try out new things.

6.2 **Strengths and Limitations of the research**

The methodology how the research was carried out includes to strengths and limitations, which are described in the following section:

- **Strength: Survey design**
  The survey for data collection was developed based on findings from scientific studies concerning bike sharing and based on recommendations from literature on survey design. The survey includes questions regarding all important peoples’ attributes that are used for market segmentation. The psychographic attributes of the BSS users and non-users, which have, to the best of the author’s knowledge, not been investigated by many studies, can be examined with the survey. The psychographic questions are based on the PVQ by Schwartz (2006). It is possible transfer the methodology and to execute the survey in different cities.

- **Strength: Survey participation**
  The survey was carried out in Munich, Germany. Due to a high participation in the survey, the final sample consisted of 408 people, resulting in a margin of error below 5% at a 95% confidence interval, while the required sample could be overreached. Despite the extensive questionnaire, the fulfilment rate was constantly above 70%, .
Limitation: Survey method, sample

The survey method used was a double approach of online and offline survey. This led to a convenience sample (Nardi, 2018), thus the results of this survey cannot be generalized onto the whole population (Kasunic, 2005), in this case the Munich population. Furthermore, some groups of people are over- or under-represented.

Limitation: Data modelling

The data modelling consisted of two approaches, the MLR on the one hand and the LASSO. The MLR results have two general limitations: the variables are associated with a confidence level of 95%, thus, there is a margin of error of 5% that for each variable, that the model is giving the wrong results. A further aspect that has to be taken into consideration with the MLR is collinearity, implying that the predictor variables in one model are correlated to each other. Due to the size of the dataset obtained from the survey, and the complex survey design, the data analysis was carried out on a basic level and further optimizations should be made to improve the results. For example, the attributes in the MNL could be merged or their order changed, to obtain more significant attributes. The LASSO method can be improved by selecting a different alpha value.
Chapter 7

Conclusions and further research

In the last chapter, the conclusions are drawn and recommendations for further research on the topic of the thesis are given.

7.1 Conclusions

Regarding the problems associated with road traffic and the impacts of climate change, it is considered to be important to enhance environmentally friendly modes of transport. BSS provide emission-free mobility (Shaheen et al., 2010), and include other advantages, as health benefits for their users (Martínez et al., 2019). To get more people to use BSS, marketing measures or incentives have to be developed. This requires more detailed information on the users and the non-users of BSS, which to collect the aim of this research was. For data collection, a survey was designed based on the principles of market segmentation to identify the socio-demographic, behavioural, attitudinal and psychographic attributes of the users and non-users. After a pilot survey test run, the final survey was carried out in a mixed online-offline approach and 451 people completed the questionnaire. Further data cleaning led to a final sample of 408 people which was used for further investigation. Due to a high participation and a high fulfilment rate, the questionnaire has turned out to be a suitable method for data collection. However, the some groups of people were under- or overrepresented in the sample. In the next step, MLR and LASSO were used in the data analysis to identify the people’s attributes influencing BSS usage. Further data modelling is recommended to optimize the model outcomes. It was possible to identify numerous attributes that are influencing BSS usage. Most of the findings, which were briefly summarized in the chapters 5.5, and 5.4, correspond with the results from previous studies. As the survey was designed on the basis of market segmentation, and as detailed information on the BSS users and non-users was collected, the results of the study can be used to develop measures to increase BSS ridership.
7.2 Recommendations for further research

The survey carried out for this research has generated a large dataset of variables. It offers a lot of possibilities for further research.

The following recommendations can be given for further research on BSS:

- Create a profile of users and non-users by combining the attributes
  This thesis has determined socio-demographic, behavioural, attitudinal and psychographic attributes of people. It is known, which attributes influence BSS usage in a negative way, for example being female and using the private car to go to work. By combining attributes from different categories, e.g. socio-demographic and trip purpose attributes, detailed profiles of users and non-users can be generated. This would generate more possibilities for marketing and research.

- Define different types of users
  In this research, a person was defined as a user if he or she uses the at least one BSS in Munich at least “almost never”. This is a very wide definition of the term “user”. As the use frequency is known by the results of question 2 of the survey, distinctions can be made and the users can be further segmented, for example into “frequent users” and “occasional users”. A similar research has been conducted by (Winters et al., 2019) on Vancouver BSS users.

- Investigate the influence of system conceptualization on BSS usage
  As described in the literature review, there are four different BSS in Munich with three different operation concepts: FFBS, HBS and VSBBS. It is also possible to distinguish the respondents according to which BSS or which type of BSS they use and compare their attributes.

- Execute the research methodology in other cities
  The method developed for this research is applicable in every German city with BSS, as the travel behaviour and the socio-demographic questions are based on the MID study, which is carried out throughout Germany. With slight changes in the questionnaire, for example in the socio-demographic questions, the method can also be transferred to cities abroad.
Bibliography


DB Rent GmbH (2015). Call a Bike – eine starke Idee für München!


ESS ERIC (2016). Gesellschaft und Demokratie in Europa Deutsche Teilstudie im Projekt "European Social Survey" (Welle 8).


Fahrrad-XXL.de GmbH & Co.KG (2018). Bike Sharing Anbieter in Deutschland – Invasion oder Mobilitätssegen?


Infas, DLR, IVT, and Infas360 (2017). Mobilität in Deutschland Ihr Haushaltsfragebogen.


Sommer, A. (2019). In der Vorreiterrolle.


Yeesakonu, S. P. (2019). What are the true-costs associated with the provision of on-street parking spaces analysed by the case study of the Maxvorstadt area in Munich?

Appendices
Appendix A

Residential location of BSS users and non-users in Munich
Figure A.1: Residential location of survey participants in Munich
Appendix B

Online survey questionnaire

Hallo zusammen!

Vielen Dank für die Teilnahme an dieser Umfrage. Sie ist Teil meiner Masterarbeit, die ich an der Professur für Siedlungsstruktur und Verkehrsplanung der Technischen Universität München verfasse.

Ihre Antworten tragen dazu bei, nachhaltige Verkehrsmittel in München, wie Fahrradverleihsysteme, besser zu verstehen und weiterzuentwickeln.


Wenn Sie weitere Fragen zur Umfrage oder zu den Ergebnissen haben, können Sie sich gerne an mich wenden (michael.stoeckle@tum.de).

Indem Sie auf "Weiter" klicken, stimmen Sie zu, dass Ihre Antworten von uns für wissenschaftliche Zwecke genutzt werden.

Vielen Dank für Ihre Unterstützung!

Michael Stöckle
Student M.Sc. Transportation Systems

M.Sc. David Duran Rodas
Doktorand Professur für Siedlungsstruktur und Verkehrsplanung
APPENDIX B. ONLINE SURVEY QUESTIONNAIRE

### Kenntnis von Fahrradverleihsystemen

<table>
<thead>
<tr>
<th></th>
<th>Kenne ich</th>
<th>Kenne ich nicht</th>
</tr>
</thead>
<tbody>
<tr>
<td>MVG Rad</td>
<td><img src="image" alt="MVG Rad" /></td>
<td><img src="image" alt="MVG Rad" /></td>
</tr>
<tr>
<td>DB Call a Bike</td>
<td><img src="image" alt="DB Call a Bike" /></td>
<td><img src="image" alt="DB Call a Bike" /></td>
</tr>
<tr>
<td>Donkey Republic</td>
<td><img src="image" alt="Donkey Republic" /></td>
<td><img src="image" alt="Donkey Republic" /></td>
</tr>
<tr>
<td>Jump Bike</td>
<td><img src="image" alt="Jump Bike" /></td>
<td><img src="image" alt="Jump Bike" /></td>
</tr>
</tbody>
</table>

### Nutzung von Fahrradverleihsystemen

<table>
<thead>
<tr>
<th></th>
<th>Täglich oder fast täglich</th>
<th>Ein bis drei Mal pro Woche</th>
<th>Ein bis drei Mal pro Monat</th>
<th>Sel tener als monatlich</th>
<th>Ich nutze es fast nie</th>
<th>Ich habe es früher genutzt</th>
<th>Ich habe es noch nie genutzt</th>
</tr>
</thead>
<tbody>
<tr>
<td>MVG Rad</td>
<td><img src="image" alt="MVG Rad" /></td>
<td><img src="image" alt="MVG Rad" /></td>
<td><img src="image" alt="MVG Rad" /></td>
<td><img src="image" alt="MVG Rad" /></td>
<td><img src="image" alt="MVG Rad" /></td>
<td><img src="image" alt="MVG Rad" /></td>
<td><img src="image" alt="MVG Rad" /></td>
</tr>
<tr>
<td>DB Call a Bike</td>
<td><img src="image" alt="DB Call a Bike" /></td>
<td><img src="image" alt="DB Call a Bike" /></td>
<td><img src="image" alt="DB Call a Bike" /></td>
<td><img src="image" alt="DB Call a Bike" /></td>
<td><img src="image" alt="DB Call a Bike" /></td>
<td><img src="image" alt="DB Call a Bike" /></td>
<td><img src="image" alt="DB Call a Bike" /></td>
</tr>
<tr>
<td>Donkey Republic</td>
<td><img src="image" alt="Donkey Republic" /></td>
<td><img src="image" alt="Donkey Republic" /></td>
<td><img src="image" alt="Donkey Republic" /></td>
<td><img src="image" alt="Donkey Republic" /></td>
<td><img src="image" alt="Donkey Republic" /></td>
<td><img src="image" alt="Donkey Republic" /></td>
<td><img src="image" alt="Donkey Republic" /></td>
</tr>
<tr>
<td>Jump Bike</td>
<td><img src="image" alt="Jump Bike" /></td>
<td><img src="image" alt="Jump Bike" /></td>
<td><img src="image" alt="Jump Bike" /></td>
<td><img src="image" alt="Jump Bike" /></td>
<td><img src="image" alt="Jump Bike" /></td>
<td><img src="image" alt="Jump Bike" /></td>
<td><img src="image" alt="Jump Bike" /></td>
</tr>
</tbody>
</table>
Warum nutzen Sie keine Fahrradverleihsysteme? (Mehrere Antworten möglich)

Bitte wählen Sie die zutreffenden Antworten aus:

- [ ] Kein Bedarf
- [ ] Ich nutze mein eigenes Fahrrad
- [ ] Ich fahre nicht gerne Fahrrad
- [ ] Fahrradfahren ist zu gefährlich
- [ ] Zu teuer
- [ ] Es gibt keine Fahrradverleihsysteme, wo ich normalerweise unterwegs bin
- [ ] Fahrradverleihsysteme sind nur etwas für jüngere Leute
- [ ] Die Handhabung ist zu kompliziert
- [ ] Andere Leihsysteme (z.B. Carsharing, E-Tretroller) sind praktischer
- [ ] Autofahren ist praktischer
- [ ] ÖPNV ist praktischer
- [ ] Ich habe schlechte Erfahrungen gemacht
- [ ] Andere Gründe:
### Nutzungshäufigkeit von Verkehrsmitteln

4 Wie oft nutzen Sie die folgenden Verkehrsmittel?

<table>
<thead>
<tr>
<th></th>
<th>Täglich oder fast täglich</th>
<th>An ein bis drei Tagen pro Woche</th>
<th>An ein bis drei Tagen pro Monat</th>
<th>Seltener als monatlich</th>
<th>Ich nutze es fast nie</th>
<th>Ich habe es früher genutzt</th>
<th>Ich habe es noch nie genutzt</th>
<th>Keine Antwort</th>
</tr>
</thead>
<tbody>
<tr>
<td>zu Fuß</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carsharing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E-Tretroller (E-Scooter)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eigenes Fahrrad</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eigenes Moped/Motorrad</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eigener Pkw als Fahrer(in)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pkw als Mitfahrer(in)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>U-Bahn</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Straßenbahn (Tram)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S-Bahn/Regionalzug</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stadtbus</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Reisezweck

5 Zu welchen Reisezwecken benutzen Sie die folgenden Verkehrsmittel? (Mehrfache Antworten möglich)

<table>
<thead>
<tr>
<th></th>
<th>Zur Arbeit</th>
<th>Zur Schule / Ausbildung / Universität</th>
<th>Einkauf</th>
<th>Private Erledigung</th>
<th>Freizeitaktivität</th>
<th>Nach Hause</th>
<th>Anderer Zweck</th>
<th>keine Antwort</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zu Fuß</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carsharing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E-Tretroller (E-Scooter)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fahrradverleihsysteme (Bike Sharing)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eigenes Fahrrad</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eigenes Moped/Motorrad</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eigener Pkw als Fahrer(in)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pkw als Mitfahrer(in)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>U-Bahn</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Straßenbahn (Tram)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S-Bahn/Regionalzug</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stadtbus</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(*) Private Erledigungen: Erledigungen, die im Gegensatz zu Freizeitaktivitäten stehen (z.B. Arztbesuche, zur Post)
6. Wie sehr stimmen Sie den folgenden Aussagen zu Fahrradverleihsystemen (Bike Sharing) zu?

<table>
<thead>
<tr>
<th>Aussage</th>
<th>stimme voll zu</th>
<th>stimme teilweise zu</th>
<th>stimme weder zu noch nicht zu</th>
<th>stimme teilweise nicht zu</th>
<th>stimme überhaupt nicht zu</th>
<th>Keine Antwort</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bike Sharing ist praktisch</td>
<td>otch</td>
<td>otch</td>
<td>otch</td>
<td>otch</td>
<td>otch</td>
<td>otch</td>
</tr>
<tr>
<td>Bike Sharing ist entspannend</td>
<td>otch</td>
<td>otch</td>
<td>otch</td>
<td>otch</td>
<td>otch</td>
<td>otch</td>
</tr>
<tr>
<td>Bike Sharing macht Spaß</td>
<td>otch</td>
<td>otch</td>
<td>otch</td>
<td>otch</td>
<td>otch</td>
<td>otch</td>
</tr>
<tr>
<td>Bike Sharing ist gesund</td>
<td>otch</td>
<td>otch</td>
<td>otch</td>
<td>otch</td>
<td>otch</td>
<td>otch</td>
</tr>
<tr>
<td>Bike Sharing ist sicher</td>
<td>otch</td>
<td>otch</td>
<td>otch</td>
<td>otch</td>
<td>otch</td>
<td>otch</td>
</tr>
<tr>
<td>Bike Sharing ist umweltfreundlich</td>
<td>otch</td>
<td>otch</td>
<td>otch</td>
<td>otch</td>
<td>otch</td>
<td>otch</td>
</tr>
<tr>
<td>Bike Sharing kann von allen genutzt werden</td>
<td>otch</td>
<td>otch</td>
<td>otch</td>
<td>otch</td>
<td>otch</td>
<td>otch</td>
</tr>
</tbody>
</table>

7. Wie sehr stimmen Sie den folgenden Aussagen zum Öffentlichen Personennahverkehr (ÖPNV) zu?

<table>
<thead>
<tr>
<th>Aussage</th>
<th>stimme voll zu</th>
<th>stimme teilweise zu</th>
<th>stimme weder zu noch nicht zu</th>
<th>stimme teilweise nicht zu</th>
<th>stimme überhaupt nicht zu</th>
<th>Keine Antwort</th>
</tr>
</thead>
<tbody>
<tr>
<td>ÖPNV ist praktisch</td>
<td>otch</td>
<td>otch</td>
<td>otch</td>
<td>otch</td>
<td>otch</td>
<td>otch</td>
</tr>
<tr>
<td>ÖPNV ist entspannend</td>
<td>otch</td>
<td>otch</td>
<td>otch</td>
<td>otch</td>
<td>otch</td>
<td>otch</td>
</tr>
<tr>
<td>ÖPNV macht Spaß</td>
<td>otch</td>
<td>otch</td>
<td>otch</td>
<td>otch</td>
<td>otch</td>
<td>otch</td>
</tr>
<tr>
<td>ÖPNV ist gesund</td>
<td>otch</td>
<td>otch</td>
<td>otch</td>
<td>otch</td>
<td>otch</td>
<td>otch</td>
</tr>
<tr>
<td>ÖPNV ist sicher</td>
<td>otch</td>
<td>otch</td>
<td>otch</td>
<td>otch</td>
<td>otch</td>
<td>otch</td>
</tr>
<tr>
<td>ÖPNV ist umweltfreundlich</td>
<td>otch</td>
<td>otch</td>
<td>otch</td>
<td>otch</td>
<td>otch</td>
<td>otch</td>
</tr>
<tr>
<td>Der ÖPNV kann von allen genutzt werden</td>
<td>otch</td>
<td>otch</td>
<td>otch</td>
<td>otch</td>
<td>otch</td>
<td>otch</td>
</tr>
</tbody>
</table>
### APPENDIX B. ONLINE SURVEY QUESTIONNAIRE

8. Wie sehr stimmen Sie den folgenden Aussagen zum Fahrradfahren zu?

<table>
<thead>
<tr>
<th>Stimme voll zu</th>
<th>Stimme teilweise zu</th>
<th>Stimme weder zu noch nicht zu</th>
<th>Stimme teilweise nicht zu</th>
<th>Stimme überhaupt nicht zu</th>
<th>Keine Antwort</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fahrradfahren ist praktisch</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Fahrradfahren ist entspannend</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Fahrradfahren macht Spaß</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Fahrradfahren ist gesund</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Fahrradfahren ist sicher</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Fahrradfahren ist umweltfreundlich</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Das Fahrrad kann von allen genutzt werden</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>

9. Wie sehr stimmen Sie den folgenden Aussagen zum Autofahren zu?

<table>
<thead>
<tr>
<th>Stimme voll zu</th>
<th>Stimme teilweise zu</th>
<th>Stimme weder zu noch nicht zu</th>
<th>Stimme teilweise nicht zu</th>
<th>Stimme überhaupt nicht zu</th>
<th>Keine Antwort</th>
</tr>
</thead>
<tbody>
<tr>
<td>Autofahren ist praktisch</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Autofahren ist entspannend</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Autofahren macht Spaß</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Autofahren ist gesund</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Autofahren ist sicher</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Autofahren ist umweltfreundlich</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Das Auto kann von allen genutzt werden</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>
### Psychographische Fragen (Teil 1)

In den folgenden Fragen werden sieben Personen beschrieben. Wie ähnlich oder unähnlich ist Ihnen jeweils die beschriebene Person?

<table>
<thead>
<tr>
<th>Ist mir sehr ähnlich</th>
<th>Ist mir ähnlich</th>
<th>Ist mir etwas ähnlich</th>
<th>Ist mir nur ein kleines bisschen ähnlich</th>
<th>Ist mir nicht ähnlich</th>
<th>Ist mir überhaupt nicht ähnlich</th>
<th>Ich weiß nicht</th>
<th>Keine Antwort</th>
</tr>
</thead>
<tbody>
<tr>
<td>Der Person ist es wichtig, neue Ideen zu entwickeln und kreativ zu sein. Sie macht Sachen gerne auf ihre eigene originelle Art und Weise.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Der Person ist es wichtig, reich zu sein. Sie möchte viel Geld haben und teure Sachen besitzen.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Die Person hat es für wichtig, dass alle Menschen auf der Welt gleich behandelt werden sollten. Sie glaubt, dass jeder Mensch im Leben gleiche Chancen haben sollte.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Der Person ist es wichtig, ihre Fähigkeiten zu zeigen. Sie möchte, dass die Leute bewundern, was sie tut.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Der Person ist es wichtig, in einem sicheren Umfeld zu leben. Sie vermeidet alles, was ihre Sicherheit gefährden könnte.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Die Person mag Überraschungen und hält immer Ausschau nach neuen Aktivitäten. Sie denkt, dass im Leben Abwechslung wichtig ist.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Die Person glaubt, dass die Menschen tun sollten, was man ihnen sagt. Sie denkt, dass Menschen sich immer an Regeln halten sollten, selbst dann, wenn es niemand sieht.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>

*Die psychographischen Fragen dienen dazu, die grundlegenden Einstellungen und Werte der Nutzer und Nicht-Nutzer von Fahrradverleihsystemen zu ermitteln.*
### Psychographische Fragen (Teil 2)

11 In den folgenden Fragen werden sieben Personen beschrieben. Wie ähnlich oder unähnlich ist Ihnen die beschriebene Person?

<table>
<thead>
<tr>
<th></th>
<th>Ist mit sehr ähnlich</th>
<th>Ist mir ähnlich</th>
<th>Ist mir etwas ähnlich</th>
<th>Ist mir nur ein kleines bisschen ähnlich</th>
<th>Ist mir nicht ähnlich</th>
<th>Ist mir überhaupt nicht ähnlich</th>
<th>Ich weiß nicht</th>
<th>Keine Antwort</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Der Person ist es wichtig, Menschen zuzuhören, die anders sind als sie selbst. Auch wenn sie anderer Meinung ist als andere, will sie die anderen trotzdem verstehen.</em></td>
<td>☐</td>
<td>☒</td>
<td>☐</td>
<td>☒</td>
<td>☒</td>
<td>☒</td>
<td>☒</td>
<td>☒</td>
</tr>
<tr>
<td><em>Der Person ist es wichtig, zurückhaltend und bescheiden zu sein. Sie versucht, die Aufmerksamkeit nicht auf sich zu lenken.</em></td>
<td>☒</td>
<td>☒</td>
<td>☒</td>
<td>☒</td>
<td>☒</td>
<td>☒</td>
<td>☒</td>
<td>☒</td>
</tr>
<tr>
<td><em>Der Person ist es wichtig, Spaß zu haben. Sie gönnt sich selbst gerne etwas.</em></td>
<td>☒</td>
<td>☒</td>
<td>☒</td>
<td>☒</td>
<td>☒</td>
<td>☒</td>
<td>☒</td>
<td>☒</td>
</tr>
<tr>
<td><em>Der Person ist es wichtig, selbst zu entscheiden, was sie tut. Sie ist gern frei und unabhängig von anderen.</em></td>
<td>☒</td>
<td>☒</td>
<td>☒</td>
<td>☒</td>
<td>☒</td>
<td>☒</td>
<td>☒</td>
<td>☒</td>
</tr>
<tr>
<td><em>Der Person ist es sehr wichtig, den Menschen um sich herum zu helfen. Sie will für deren Wohlfahrt sorgen.</em></td>
<td>☒</td>
<td>☒</td>
<td>☒</td>
<td>☒</td>
<td>☒</td>
<td>☒</td>
<td>☒</td>
<td>☒</td>
</tr>
<tr>
<td><em>Der Person ist es wichtig, sehr erfolgreich zu sein. Sie hofft, dass die Leute ihre Leistungen anerkennen.</em></td>
<td>☒</td>
<td>☒</td>
<td>☒</td>
<td>☒</td>
<td>☒</td>
<td>☒</td>
<td>☒</td>
<td>☒</td>
</tr>
<tr>
<td><em>Der Person ist es wichtig, dass der Staat ihre persönliche Sicherheit vor allen Bedrohungen gewährleistet. Sie will einen stären Staat, der seine Bürger verteidigt.</em></td>
<td>☒</td>
<td>☒</td>
<td>☒</td>
<td>☒</td>
<td>☒</td>
<td>☒</td>
<td>☒</td>
<td>☒</td>
</tr>
</tbody>
</table>
Psychographische Fragen (Teil 3)

12 In den folgenden Fragen werden sieben Personen beschrieben. Wie ähnlich oder unähnlich ist Ihnen die beschriebene Person?

<table>
<thead>
<tr>
<th>Schilderung</th>
<th>ist mir sehr ähnlich</th>
<th>ist mir ähnlich</th>
<th>ist mir etwas ähnlich</th>
<th>ist mir nur ein kleines bis schnees ähnlich</th>
<th>ist mir nicht ähnlich</th>
<th>ist mir überhaupt nicht ähnlich</th>
<th>ich weiß nicht</th>
<th>Keine Antwort</th>
</tr>
</thead>
<tbody>
<tr>
<td>Die Person sucht das Abenteuer und geht gern Risiken ein. Sie will ein aufregendes Leben haben.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Der Person ist es wichtig, sich jederzeit korrekt zu verhalten. Sie vermeidet es, Dinge zu tun, die andere Leute für falsch halten könnten.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Der Person ist es wichtig, dass andere sie respektieren. Sie will, dass die Leute tun, was sie sagt.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Der Person ist es wichtig, seinen Freunden gegenüber loyal zu sein. Sie will sich für Menschen einsetzen, die ihr nahe stehen.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Die Person ist fest davon überzeugt, dass die Menschen sich um die Natur kümmern sollten. Umweltschutz ist ihr wichtig.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Der Person ist Tradition wichtig. Sie versucht, sich an die Sitten und Gebrauche zu halten, die ihr von seiner Religion oder ihrer Familie überliefert wurden.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Die Person lässt keine Gelegenheit aus. Spaß zu haben. Es ist ihr wichtig, Dinge zu tun, die ihr Vergnügen bereiten.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>
Sozio-demographische Fragen (Teil 1)

13 Wie alt sind Sie?

Bitte wählen Sie eine der folgenden Antworten:

○ 0-17 Jahre
○ 18-29 Jahre
○ 30-39 Jahre
○ 40-49 Jahre
○ 50-59 Jahre
○ 60-69 Jahre
○ 70-79 Jahre
○ 80 Jahre und älter
○ Keine Antwort

14 Zu welchem Geschlecht fühlen Sie sich zugehörig?

Bitte wählen Sie eine der folgenden Antworten:

○ Männlich
○ Weiblich
○ Divers
○ Keine Antwort
15 Was ist Ihr höchster Bildungsabschluss?

Bitte wählen Sie eine der folgenden Antworten:

- noch Schüler/in/(noch) ohne Abschluss
- Volks- oder Hauptschulabschluss, POS 8. Klasse
- Mittlere Reife, Realschulabschluss, POS 10. Klasse
- Bachelor-Abschluss
- Master/Diplom-Abschluss
- Doktortitel
- Anderer Abschluss
- Keine Antwort
Sozio-demographische Fragen (Teil 2)

16 Was ist Ihr momentaner Beschäftigungsstatus?

Bitte wählen Sie eine der folgenden Antworten:

- Vollzeit berufstätig
- Teilzeit berufstätig
- Auszubildende/r
- Zurzeit arbeitslos
- Schüler(in)
- Student(in)
- Hausfrau-/mann
- Rentner(in)/Pensionär(in)
- Anderes
- Keine Antwort
17 Wie hoch ist Ihr monatliches Haushalts-Nettoinkommen?

Bitte wählen Sie eine der folgenden Antworten:

- Unter 500 €
- 500 bis unter 900 €
- 900 bis unter 1500 €
- 1500 bis unter 2000 €
- 2000 bis unter 3000 €
- 3000 bis unter 4000 €
- 4000 bis unter 5000 €
- 5000 bis unter 6000 €
- 6000 bis unter 7000 €
- mehr als 7000 €

Keine Antwort


18 Wie viele Personen umfasst Ihr Haushalt, inklusive Kindern?

Bitte wählen Sie eine der folgenden Antworten:

- eine Person
- zwei Personen
- drei Personen
- vier Personen
- fünf Personen
- sechs oder mehr Personen

Keine Antwort

Sozio-demographische Fragen (Teil 3)

19 Haben Sie einen Migrationshintergrund?

Bitte wählen Sie eine der folgenden Antworten:

- Ja
- Nein

Keine Antwort

Definitions:

"Eine Person hat dann einen Migrationshintergrund, wenn sie selbst oder mindestens ein Elternteil nicht mit deutscher Staatsangehörigkeit geboren ist." (Quelle: Statistisches Bundesamt)
**Geographische Fragen**

(Wenn die Karte nicht lädt, Internetadresse (URL) markieren und Eingabetaste drücken)

[Map Image]

Klicken Sie, um die Position einzustellen oder ziehen Sie den Stift. Sie können auch Koordinaten eingeben.

Wenn Sie keine Angaben machen wollen, einfach auf "Absenden" klicken.

Vielen Dank für Ihre Antworten!
Wenn Sie sich weiter über die Auswertung der Umfrage informieren wollen, können Sie sich gerne an mich wenden. Meine E-Mail-Adresse lautet: michael.stoeckle@tum.de

Über weitere Rückmeldungen zur Umfrage freue ich mich ebenfalls.

Michael Stöckle
Declaration concerning the Master’s Thesis

I hereby confirm that the presented thesis work has been done independently and using only the sources and resources as are listed. This thesis has not previously been submitted elsewhere for purposes of assessment.

Munich, January 24, 2020