# Surveying and analysing peoples' perception of the new bike-sharing system in Wiesbaden

Hauke Reckermann, Rafael Kistner, Matthias Kowald, Till Dannewald, André Bruns
Departments for architecture and civil engineering, Wiesbaden Business School
RheinMain University of Applied Sciences
e-mail: haucke.reckerman@student.hs-rm.de
matthias.kowald@hs-rm.de

**Keywords:** Bike-sharing, sustainable mobility, cognitive perception

## 1 Introduction

The mobility of Wiesbaden's citizens is about to change in the coming years. The urgency of this change is the result of general challenges in transportation, including stagnating greenhouse gas emissions for the transport sector, increasing congestions, and a poor air quality in cities. As a result, many new transport supplies and services are discussed and introduced to solve these challenges or at least reduce their impact in the city. Most of them aim to shift people from private motorised transport (PMT) to public transport (PT) or human-powered mobility (HPM). In the case of Wiesbaden, those new supplies and services include bike- and car-sharing as well as a tram system.

The introduction of new supplies and services is often accompanied by economic analyses, which are partly mandatory to achieve an approval of infrastructural measures and funding, for example the standardised evaluation for rail systems in Germany (Intraplan Consult GmbH). These analyses often include an estimation of user numbers, pricing arrangements, and gains in terms of travel time. Customers' perceptions, however, are rarely studied, although the use of a specific transport mean or a mobility service is clearly influenced by peoples' individual perception (Bamberg 1995, Bamberg *et al.* 2003a, Ellaway *et al.* 2003). An analysis of these cognitive perceptions can be employed to identify target group-specific and motivational challenges for using new offers and opportunities and increase their acceptance. Thus, such an analysis can help to promote a modal shift and must be considered as an important contribution to solve challenges in terms of transportation and mobility behaviour (Hunecke *et al.* 2010).

A survey study on the cognitive perception of new transport supplies and mobility services in the city of Wiesbaden aims to show the benefits and potentials of such an analysis. It exemplarily focuses on a new mobility opportunity, a bike-sharing system, and a potential future service called Mobility-as-a-Service (MaaS). The remainder of this paper describes this survey study and is structured as following: Chapter 2 shortly introduces related research and the Theory of Planned Behaviour as the theoretical background of the survey. Chapter 3 provides an overview on new mobility opportunities und transport services. An overview on the survey methodology and –instrument is given in Chapter 4. Chapter 5 presents the data analysis and results. Finally, Chapter 6 concludes and presents an outlook on future research.

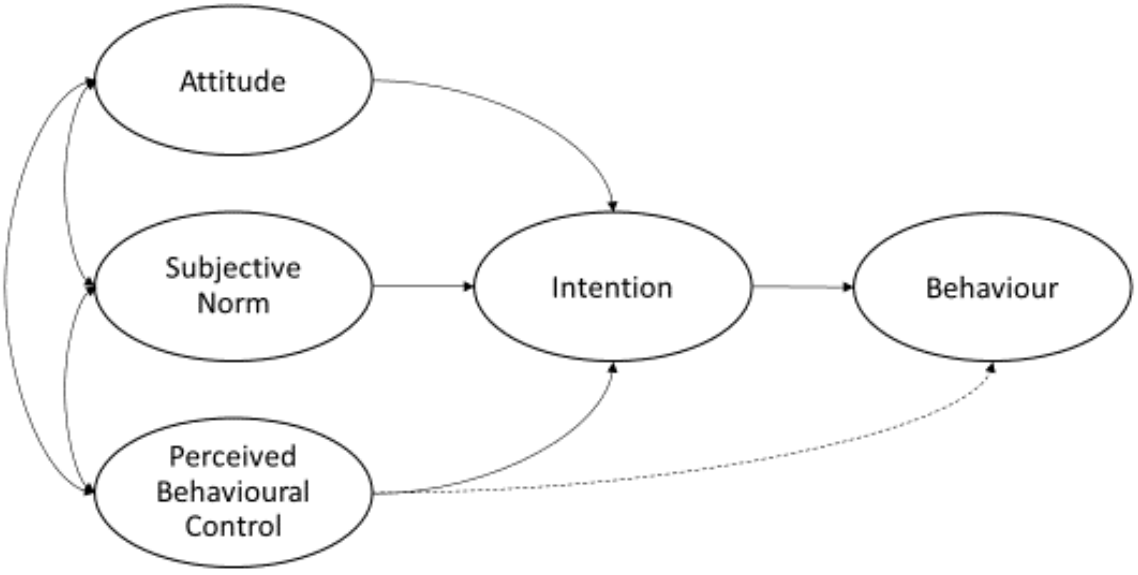
## 2 Related Research

Employing the theory of planned behaviour (TPB), a social-psychological theory introduced by Ajzen (1991), aims to understand the motivation for using the bike-sharing system. The TPB is an enhancement of the Theory of Reasoned Action. Like this earlier approach, the

TPB attempts to predict a behavioural intention, the choice of a certain behaviour between several behavioural alternatives. This behavioural intention is influenced by three latent constructs: Attitudes, subjective norms, and perceived behavioural control.

Attitudes include judgements towards subjects, objects, and ideas, e.g. they inform whether a respondent thinks that using a shared bike is appropriate for herself, if it is hygienic or cost-efficient. Subjective norms, however, inform about ways of behaviour that a respondent thinks are expected by others. Humans tend to correspond to such expectations, especially when these "others" play an important role for them. Perceived behavioural control expresses the individual belief to be able to perform a certain behaviour with the available resources. These three constructs and the relationship between them influence the rating of behavioural intentions to reach a certain goal and satisfy a specific need. The implementation of a behavioural option is finally based on the rating of the intentions as well as the strength of the perceived behavioural control, which also has a direct influence on the implemented behaviour (Ajzen 1991). For an illustration of TPB see Figure 1.

Figure 1: Theory of Planned Behaviour




Own illustration following Ajzen (1991)

In recent years, TPB was employed in transport planning to highlight cognitive influences on the usage of different transport means (Bamberg *et al.* 2003a, Bamberg *et al.* 2003b). In addition, Möser and Bamberg (2008) employed TPB to focus on so-called "soft" transport policy measures. It was furthermore employed by Thorhauge *et al.* (2016) to examine the departure time choice of car commuters in the city of Copenhagen. Combining a discrete choice model with a structural equation model for the TPB, they found that the explanatory power of the discrete choice model increases with an integration of latent effects. Using an extended version of the TPB, Hunecke *et al.* (2010) were able to form target groups based on the cognitive attitudes and the ecological impact of the target groups.

However, socio-psychological theories like TPB and others focus on peoples´ cognition and perception of specific supplies and are thus not limited to real-world challenges and existing

transport means but can also help to analyse fictive and future projects (for research concerning the potential future mobility service MaaS and motivational mechanisms behind the adaptation to use it, see Schikofsky *et al.* (2019)). People's perception of a future MaaS-supply, however, is in the present study exclusively employed as a proxy for technical affinity and helps to identify respondents who are early adopters and employ new offers as soon as they appear on the market.

## 3 Research topic and theoretical background

In this chapter, the considered transport supplies and mobility offers are introduced. The study had to be restricted to certain offers due to a limited budget and to ensure a deep understanding of peoples' cognition of these supplies and offers. The study focussed on the bike-sharing system of *ESWE meinRad* and the potential future mobility service *MaaS*.

During the year 2018, *ESWE Verkehr*, Wiesbaden´s communal traffic supplier, introduced a new bike-sharing system, following a resolution by the city's parliament (ESWE Verkehr 2019, Landeshauptstadt Wiesbaden 2019). This system, in its first stage, consists of 500 bikes distributed over roughly 50 stations in the city. In a later stage, the system is supposed to become compatible with the system of the neighbouring city of Mainz, allowing a free flow and an exchange of bikes and users between these two cities. As our research study was in the field at the same time the bike-sharing system was introduced, it provided the opportunity to accompany this transport supply and peoples' corresponding perceptions from the beginning on. However, it must be kept in mind that most perceptions in the study will rather be the result of medial depictions and chats with others than being based on own experiences.

The cognitive influences towards the usage of MaaS were registered by using central elements of the modified Technology Acceptance Model (TAM) used by Schikofsky *et al.* (2019) and further used as a proxy for technical affinity. The remainder of this paper, however, exclusively focusses on the work on the bike-sharing system and TPB.

## 4 Survey methodology and -instrument

In this chapter, sampling design and target groups are presented. Additionally, the structure of the survey instrument and items on the bike-sharing system are introduced in detail.

### 4.1 Methodology

The survey population of 600 respondents was split into two sub-populations. This step was necessary to cover the heterogeneity of Wiesbaden's inhabitants in terms of mode choice and experience with the new bike-sharing system. Employing a simple random sample of the population would potentially include bias, as not all inhabitants use public transport (PT) means to travel in the city. This would result in a sample in which a minority of respondents are potential users of the new transport supply. Due to the fact that the bike-sharing system was introduced only shortly before the interviews were in the field, this would furthermore potentially have resulted in a sample in which only a small number of private motorized transport (PMT) users had already heard of the new bike-sharing system. To reduce this bias, the two sub-populations were recruited with different sampling strategies and survey designs but identical survey instruments.

The first sub-population was recruited randomly on the phone. Interviews were conducted as computer assisted telephone interviews (CATI) by a company for commercial survey research[1]. To ensure representativeness, the 26 local districts of Wiesbaden were aggregated into 9 city districts. Proportional sample sizes were calculated, after which random interviews were conducted using the last birthday-method. The obtained data were weighted after the field phase to meet the official statistics of Wiesbaden in terms of age, sex, and household size.

The second sub-population aimed to interview people who regularly use public transport. This target group was selected because it was assumed that people who often use public transport were more open minded to offers such as the bike-sharing system than people who regularly use PMT. Additionally, it was assumed that these inhabitants had a higher chance of being in contact with the bike-sharing system, as it was implemented by the city's PT-supplier and its stations are almost always situated next to bus stops. Respondents for this second sub-sample were thus recruited at bus stops, which have a station for rental bikes close by. This sub-sample was recruited and interviewed by students via computer-assisted personal interviews (CAPI), using tablets with an internet connection. The electronic survey instrument was created with the open-source software *Limesurvey* (www.limesurvey.org). Initially, all bus stops near bike-sharing stations were considered for interviews. To reduce potential interview points and create a sufficient amount of responses, highly frequented bus stops and bike-sharing stations in the centre of the city were chosen. Another aspect for this decision was the star-shaped arrangement of the public transport in Wiesbaden. The participants were almost exclusively people waiting for a bus at stations. Due to that, people waiting for busses in a short headway had a lower interest to be interviewed, to avoid missing their bus. However, both sub-samples focussed on Wiesbaden inhabitants with a minimum age of 18 years.

During the week, the interviews with the second sub-sample (CAPI) were conducted during traffic peak times: 07:00 to 09:00, 12:00 to 14:00, and 16:00 to 18:00. On Saturdays, interviews were conducted from 12:00 to 14:00 and from 18:00 to 20:00 to also include leisure travel. 64 interview shifts were conducted under the week and 12 on Saturdays. On weekdays (Monday to Friday), the most respondents were recruited between 16:00 and 18:00. A reason could be that people being on their way from work in the afternoon are more willing to participate than people on their way to work in the morning. Table 1 provides an overview on the survey methodology and design.

[1] The contracted company was the *IFAK Institut GmbH & Co. KG.*

Table 1: Survey Methodology and Design

| Survey group | Representative | PT-users /affected |
|---|---|---|
| Sample | random / quota | random / arbitrarily |
| Quantity | 300 Interviews | 300 Interviews |
| Comment | representative, presumably unaffected | presumably affected, not representative |
| Carried out by: | commercial survey research company | students |
| Method | CATI | CAPI |

### 4.2 Questionnaire

The questionnaire included five item batteries. Those were sociodemographic statistics, ownership of mobility tools and use of transport means, cognitive influences towards the bike-sharing system, and cognitive influences towards MaaS. Where ever possible and especially in terms of sociodemographic items, the wording of MiD-questions was employed to allow comparisons to this national travel survey (infas GmbH 2008, 2019). After each interview the interviewer was asked to judge if the respondent had understood the concept of both, the bike-sharing system and MaaS. This question aimed to increase data quality as unreliable observations could have been removed from the analysis.

To generate items on the cognition of the bike-sharing system and MaaS, a qualitative pre-study would have been the standard procedure. However, this step was skipped because of budget constraints and the fact that similar surveys were conducted in other cities in the past. All socio-psychological items were Likert-scaled and respondents were asked to report the strength of their perception on a six-level rating schema. Additionally, respondents were asked to report if they understood the concept of the bike-sharing system and MaaS after the items on each specific transport offer. Again, this was done to increase data quality in the analysis. Table 2 provides an overview over the (translated) statements that were used for the bike-sharing system and match the constructs of TPB.

Table 2: Questionnaire Items and Statements for the TPB

| Item | Statement |
|---|---|
| | **Attitudes** towards thematic focuses |
| Data Privacy | I see a strong risk in reporting personal data to use the bike-sharing system. |
| Environment | By using the bike-sharing system I help to improve the environment. |
| Hygiene | Using the bike-sharing system is unhygienic. |
| Comfortability | Using the bike-sharing system is uncomfortable. |
| Personal Health | Using the bike-sharing system is good for physical and mental health |
| | **Subjective Norms** |
| Family | People in my immediate personal surrounding promote using the bike-sharing system. |
| Peer Group | People who are important to me think I should use the bike-sharing system. |
| | **Perceived Behavioural Control** concerning selected focal points |
| Expected Cost | The price for using the bike-sharing system is high. |
| Ability to Use | Using the bike-sharing system is accompanied by challenges in technic regards. |
| Infrastructure | Using the bike-sharing system is too dangerous for me due to the bad quality of road infrastructure in Wiesbaden. |
| Probability of Availability | It will be hard to find an available bike or a free slot at a station. |
| Speed | The rented bike will be the fastest transport mean in daily traffic in Wiesbaden. |
| | **Behavioural Intentions** concerning selected focal points |
| Comfortability | For everyday life travel, I will use the bike-sharing system, because it is comfortable. |
| Expected Cost | For everyday life travel, I will use the bike-sharing system, because it is cost-efficient. |
| Personal Health | For everyday life travel, I will use the bike-sharing system, because it is good for my health. |
| Fun / Enjoyment | For everyday life travel, I will use the bike-sharing system, because I enjoy riding the bike. |

## 5 Data Analysis and Interpretation

In this chapter, a first analysis approach of the data will be presented. First, a descriptive analysis of the data is conducted, after which the data are analysed using regression models. It has to be kept in mind that the CATI-sample presumably includes an increased-share of PMT-users whilst the CAPI-sample consists almost exclusively out of PT-users.

### 5.1 Descriptive Analysis

Descriptive analysis aims to provide an overview over the data. In terms of representativeness, the CATI-sample is weighted to match the Wiesbaden distribution in terms of age, sex, and household income. In terms of sex, the distribution is comparable between the CATI- and the CAPI -sample. The age distribution, however, is different between the two samples: It is far younger in the CAPI-sample of PT-users. It might be assumed that this distribution is influenced by people in education and students, people who do not own a car very often. Differences in household income-distributions between the two samples can be explained by looking at other studies, such as the MiD (BMVI 2018). These studies show that people from households with a lower net income are less likely to own an own car and more likely to use public transport means. Also, as the CAPI-sample is systematically younger, it can be assumed that many respondents are still living alone, studying, or new in their job and thus in a lower income class, resulting in a lower net household income.

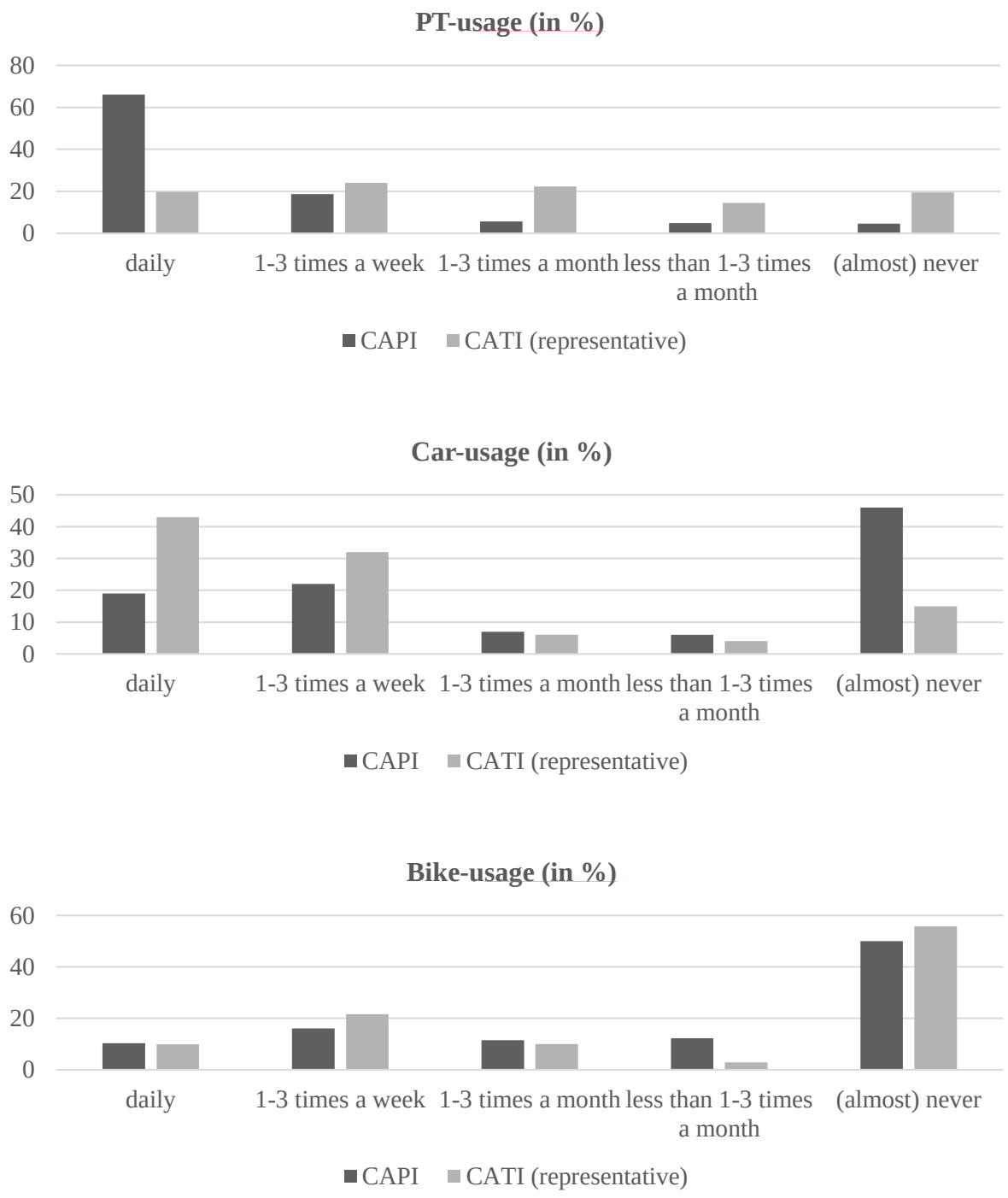
Table 3: Descriptive analysis of sex, age and income distribution

| Attribute | CAPI | CATI (representative) |
|---|---|---|
| **N [abs.]** | 264 | 303 |
| **Sex [%]** | | |
| Male | 50 | 48 |
| Female | 50 | 52 |
| **Age [years]** | | |
| Mean | 34 | 50 |
| Median | 28 | 49 |
| **Net Household Income [%]** | | |
| <500 € | 2 | 1,6 |
| 500 - <2000 € | 37,1 | 19,5 |
| 2000 - <4000 € | 40,1 | 41,3 |
| 4000 - <6000 € | 17,8 | 25,1 |
| 6000+ € | 3 | 12,5 |

Focussing on transport means shows that in the CAPI-Sample the PT-usage is significantly higher than in the CATI-sample, while the car-usage is lower. Meanwhile, the CATI-sample's

car- and PT-usage reflects the usage of those transport means also seen in the modal split in official statistics of Wiesbaden (Landeshauptstadt Wiesbaden - Amt für strategische Steuerung, Stadtforschung und Statistik 2015). The same is observed for the bike-usage, where both samples have comparably low numbers, with the bike-usage of the CAPI-sample being even lower than in the representative sample.

Figure 2: PT-, Car- and Bike-usage



## 5.2 Regression Analysis – Approach

Inferential analyses are ongoing. First and temporary results are already available, however. Estimating regression models aims to analyse the causal relationship between the dependent and one or several independent variables (Jann 2005). In a first step, linear regression models are built to explain peoples' intention to use the new bike-sharing system. This intention is measured on an ordinary scale, for which differences between the factor levels specify an order but do not allow an interpretation of the distances between them. Thus, an application of numerical operations like addition, division etc. does not make sense and means, as the basis of linear regression modelling techniques, cannot be computed reasonably (Stahel 2009). Although it would be appropriate to estimate an ordered regression model, the linear model can help to obtain a first impression on the causal relationship between the dependent variable and the independent effects (Snijders and Bosker 1999). However, it has to be kept in mind that the presented linear models treat the dependent factor as a continuous variable. Increasing data quality was the aim by exclusively considering people who said they understood the concept of the bike-sharing system. Regression models were estimated for several target groups.

## 5.3 Regression Analysis – Results

First results of the regression analysis are reported in Table 4. The table is split into the two sub-populations (CATI and CAPI), whereby between group comparisons are extraordinarily interesting. In addition, target groups are separated for age and sex. The threshold for age is based on the age means and thus differs between the two sub-populations (35 years for the CAPI-sample and 50 years for the CATI-sample). Furthermore, Table 4 shows the $R^2$-values for each target group-specific regression model, indicating the amount of variation of the dependent variable that is explained by the independent side of the model. The sign for each effect shows if a factor has a positive or a negative influence on the intention to use the bike-sharing system, which is employed as the dependent variable. Numerical parameter estimates, however, are not reported, as the model is not specified correctly anyway (see above).

Strong influences are observed for the influence of other people and health improvements resulting from bike usage. The comfortability of using the bike-sharing system and anticipated usage costs also are important influences. However, looking at differences between the influences of several target groups, the results allow to deduct target group-specific measures to encourage motivation towards using the bike-sharing system and to relieve doubts or prejudices. For example, if the target group are female PT-users, one could employ influences from their social environment and significant others. In addition, it would be good to explain the price system and mention that others do not experience it as too expensive. Furthermore, it could help to offer training sessions to get familiar with the bike-sharing system and experience its convenience and comfort personally. However, if the target group were females with less PT-experience, it would be necessary put emphasis on the system's transparency in terms of data security and privacy issues.

Table 4: Overview over first regression analysis results

| | CAPI | CATI (representative) |
|---|---|---|
| **Sex** | **Male (n = 111; $R^2$ = 0,201)** | **Male (n = 133; $R^2$ = 0,297)** |
| | + Influence of other people | + Influence of other people |
| | + "Body & Spirit" (Health) | + "Body & Spirit" (Health) |
| | **Female (n = 113; $R^2$ = 0,245)** | **Female (n = 129; $R^2$ = 0,263)** |
| | + Influence of other people | + Influence of other people |
| | - Anticipation of high usage costs | - Risk of giving away personal data |
| | - Comfortability | - Comfortability |
| **Age** | **Under 35 (n = 148; $R^2$ = 0,184)** | **Under 50 (n = 150; $R^2$ = 0,199)** |
| | + Influence of other people | + Influence of other people |
| | - Comfortability | + "Body & Spirit" (Health) |
| | **Over 35 (n = 78; $R^2$ = 0,292)** | **Over 50 (n = 115; $R^2$ = 0,321)** |
| | + "Body & Spirit" (Health) | + Influence of other people |
| | + Influence of other people | + "Body & Spirit" (Health) |
| | - Anticipation of high usage costs | - Comfortability |
| | | - Bike/Slot availability |

## 6 Further Research and Outlook

Linear models can help to get a first impression of causal relationships in the data. However, to analyse effects on a dependent ordinal variable more reliable, ordered regression techniques have to be employed. In addition, the data allow an application of further analysis techniques and promise interesting results. It is planned to apply data mining techniques like cluster analysis and decision trees. An explorative cluster analysis aims to reduce the heterogeneity and complexity of the data by identifying groups with homogeneous characteristics within the groups and heterogeneity between them. These empirically generated target groups allow further analysis and help to develop marketing campaigns to promote a use of the bike-sharing system. Decision trees visualize decisions and show how and where in a decision process people are influenced by certain effects like significant others or characteristics of a given supply (for an introduction to cluster analysis and decision trees see Backhaus *et al.* (2015, 2018) and Stahel (2009)). Finally, it is planned to model the intention of using the bike-sharing system in structural equation models (SEM). SEM allow to estimate complex causal relationships between the variables. Unlike regression models, they are not limited to dependent and independent variables but allow a consideration of intermediary effects that are affected by one or more variables and themselves effect other variables (Weiber and Mühlhaus 2014). Estimating SEM helps to test if TPB-assumptions are valid for the application of a bike-sharing system and help to identify the items and latent constructs that influence peoples' perception of this new transport supply.

## Acknowledgement

Acknowledgement: We appreciate the support of *ESWE Verkehr*, *ivm GmbH*, *RMV*, the department for mobility of the city of Wiesbaden and the *Rhein Main University of applied sciences* who founded this survey study.

## References

Ajzen, I., 1991. The theory of planned behavior. *Organizational Behavior and Human Decision Processes*, 50 (2), 179–211.

Backhaus, K., *et al.*, 2018. *Multivariate Analysemethoden: Eine anwendungsorientierte Einführung.* 15th ed. Berlin: Springer Gabler.

Backhaus, K., Erichson, B., and Weiber, R., 2015. *Fortgeschrittene Multivariate Analysemethoden: Eine anwendungsorientierte Einführung*. 3rd ed. Berlin, Heidelberg: Springer Gabler.

Bamberg, S., 1995. When does the car-user change to the bus?: Problems and results of an application of the theory of planned behaviour in the context of practical traffic-planning. *Zeitschrift für Sozialpsychologie* (26 (4)), 243–262.

Bamberg, S., Ajzen, I., and Schmidt, P., 2003a. Choice of Travel Mode in the Theory of Planned Behavior: The Roles of Past Behavior, Habit, and Reasoned Action. *Basic and Applied Social Psychology*, 25 (3), 175–187.

Bamberg, S., Rölle, D., and Weber, C., 2003b. Does habitual car use not lead to more resistance to change of travel mode? *Transportation* [online], 30 (1), 97–108. Available from: https://doi.org/10.1023/A:1021282523910.

BMVI, 2018. *Mobilität in Tabellen (MiT 2017)* [online]. Available from: https://test1.q-dot.de/mit/login.html [Accessed 15 Jan 2019].

Ellaway, A., *et al.*, 2003. In the driving seat: psychosocial benefits from private motor vehicle transport compared to public transport. *Transportation Research Part F: Traffic Psychology and Behaviour*, 6 (3), 217–231.

ESWE Verkehr, 2019. *„meinRad" - flexibler unterwegs mit „meinRad" von ESWE Verkehr* [online]. Available from: https://www.eswe-verkehr.de/service/meinrad-fahrradvermietsystem.html [Accessed 18 Dec 2018].

Hunecke, M., *et al.*, 2010. Attitude-Based Target Groups to Reduce the Ecological Impact of Daily Mobility Behavior. *Environment and Behavior*, 42 (1), 3–43.

infas GmbH, 2008. *Mobilität in Deutschland 2008 - Erhebungsunterlagen* [online]. Available from: http://mobilitaet-in-deutschland.de/pdf/MiD2008_Erhebungsunterlagen.pdf [Accessed 22 Jan 2019].

infas GmbH, 2019. *Mobilität in Deutschland 2017 - Erhebungsunterlagen* [online]. Available from: http://www.mobilitaet-in-deutschland.de/publikationen2017.html [Accessed 3 Jun 2019].

Intraplan Consult GmbH. *Standardisierte Bewertung von Verkehrswegeinvestitionen im schienengebundenen ÖPNV: Version 2016* [online]. Available from: https://www.intraplan.de/standardisierte-bewertung-von-verkehrswegeinvestitionen-im-schienengebundenen-oepnv-version-2016-in-referenzen [Accessed 1 Jun 2019].

Jann, B., 2005. *Einführung in die Statistik.* 2nd ed. München: Oldenbourg.

Landeshauptstadt Wiesbaden, 2019. *Schnell, flexibel, umweltfreundlich: „meinRad" ist in Wiesbaden gestartet* [online]. Available from: https://www.wiesbaden.de/leben-in-wiesbaden/verkehr/radfahren/eswe-mein-rad.php [Accessed 15 Jan 2019].

Landeshauptstadt Wiesbaden - Amt für strategische Steuerung, Stadtforschung und Statistik, 2015. *Wiesbadener Stadtanalysen - Daten zum Verkehrsverhalten der Wiesbadener Bevölkerung: Ergebnisse des SrV 2013* [online]. Available from: https://www.wiesbaden.de/medien-zentral/dok/leben/stadtportrait/2015_05_Bericht_SrV2013.pdf [Accessed 8 Jan 2019].

Schikofsky, J., Dannewald, T., and Kowald, M., 2019. Exploring motivational mechanisms behind the intention to adopt mobility as a service (MaaS): Insights from Germany. *accepted for the special issue on Mobility as a Service in Transportation Research Part A: Policy and Practice 2019, edited by Professors David Hensher and Corinne Mulley*.

Snijders, T.A.B. and Bosker, R.J., 1999. *Multilevel network analysis for the social sciences: Theory, methods and applications*. London: SAGE Publications Ltd.

Stahel, W.A., 2009. *Statistische Datenanalyse: Eine Einführung für Naturwissenschaftler.* 5th ed. Wiesbaden: Vieweg.

Thorhauge, M., Haustein, S., and Cherchi, E., 2016. Accounting for the Theory of Planned Behaviour in departure time choice. *Transportation Research Part F: Traffic Psychology and Behaviour*, 38, 94–105.

Weiber, R. and Mühlhaus, D., 2014. *Strukturgleichungsmodellierung: Eine anwendungsorientierte Einführung in die Kausalanalyse mit Hilfe von AMOS, SmartPLS und SPSS.* 2nd ed. Berlin: Springer Gabler.