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Know Your Urban Cyclist

A Concept to Enable Theory-Driven Evidence-Based Urban Cycling Policy Evaluation

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Samuel Hönle, BA
Registration Number 01624969

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Advisor: Assoc. Prof. Dr. Dipl.-Ing. Hilda Tellioğlu

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Samuel Hönle

Hilda Tellioğlu

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Ein Konzept zur theorieleiteten evidenzbasierten Evaluierung urbaner Fahrradpolitik

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Samuel Hönle, BA
Matrikelnummer 01624969

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Betreuung: Assoc. Prof. Dr. Dipl.-Ing. Hilda Tellioğlu

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Samuel Hönle

Hilda Tellioğlu

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Samuel Hönle, BA

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Abstract

Urban transport is a source of societal costs, for example in the form of greenhouse gas emissions. The bicycle as a mode of transport represents an opportunity for making urban transport healthier and more sustainable. Smart City strategies might prove effective in facilitating such a transition. This thesis investigates the possibility of using using cycling data collected by smartphones in such Smart City strategies to achieve this goal.

A literature review of evidence-based policy-making critically discusses its opportunities and risks. Scholars note that implementations should be driven by social science theory. Utilising research to evaluate policy in cooperative approaches emerges as a viable strategy. A review of literature on urban mobility shows that socio-demographic factors impact mobility behaviour. Furthermore, it is shown that targeted policy intervention can increase cycling rates.

In this thesis, I propose a theory-driven evidence-based urban cycling policy evaluation framework employing research-policy partnerships. Its core is the evaluation of pilot policy projects with the goal of improving future policy. Social science theory is explicitly included in the process. Evaluations of pilot policies should employ a mix of quantitative and qualitative methods. I introduce smartphone applications as one possible data source for quantitative evaluation. I then describe the implementation of a proof-of-concept software application for collecting and analysing such data. The application was developed in cooperation with Bike Citizens, a leading urban cycling smartphone application. The thesis concludes with avenues for further research.

Kurzfassung

Städtischer Verkehr führt zu gesellschaftlichen Kosten, zum Beispiel in Form von Treibhausgasemissionen. Das Fahrrad als alternative Fortbewegungsmethode stellt eine Chance dar, Stadtverkehr gesünder und nachhaltiger zu gestalten. Smart-City-Strategien könnten sich für so eine Umstellung wirksam zeigen. Diese Arbeit untersucht die Möglichkeit, mit dem Smartphone gesammelte Radverkehrsdaten in Smart-City-Strategien zu diesem Zweck zu verwenden.

In einer Literaturrecherche bezüglich evidenzbasierter Politikprozesse werden deren Chancen und Risiken kritisch diskutiert. Forscher*innen merken an, dass Implementierungen solcher Prozesse von sozialwissenschaftlicher Theorie angetrieben sein sollte. Eine Literaturrecherche bezüglich urbaner Mobilität zeigt, dass soziodemographische Faktoren Mobilitätsmuster beeinflussen. Weiters wird gezeigt, dass gezielte politische Maßnahmen die Radfahrquote erhöhen können.

In dieser Arbeit stelle ich ein Konzept zur theorieleiteten evidenzbasierten Evaluierung urbaner Fahrradpolitik mittels Forschung-Politik-Partnerschaften vor. Die Evaluierung von politischen Pilotprojekten mit dem Ziel, zukünftige Politik zu verbessern, stellt den Kern des Konzepts dar. Sozialwissenschaftliche Theorie ist explizit in den Prozess inkludiert. Evaluierungen von politischen Pilotprojekten sollten eine Mischung von qualitativen und quantitativen Methoden anwenden. Ich schlage vor, dass die Daten für quantitative Evaluierungen mittels Smartphones erhoben werden. Im Anschluss beschreibe ich die Implementierung einer Softwareanwendung im Rahmen einer Machbarkeitsstudie zur Erhebung und Analyse solcher Daten. Die Anwendung wurde im Kooperation mit Bike Citizens, einer führenden Smartphone-Applikation für urbanes Rafahren, entwickelt. Abschließend werden Möglichkeiten für fortführende Forschung präsentiert.

Contents

CHAPTER 1

Introduction

Cities are growing—not only in size, but also in importance. The share of the global population living in urban areas grew from around one third in 1950 to over half in 2018, and is expected to reach two thirds by 2050 [UN118]. Since urban areas have specific features, like high population density, distinct social structures, heterogenous economic activity, *et cetera*, specific problems arise in their context—impacting ever more and more people. Therefore, it is crucial to study and address these problems unique to the urban context.

One area where problems of the urban and rural context differ is mobility. Urban mobility differs from rural mobility in modes, infrastructure, and average trip length and speed. Consequently, the problems arising from it are different as well. Pollution, congestion, and accidents are only a few of the societal costs created by urban transport. It is worth highlighting the environmental cost in this regard: An estimated 23% of total transport greenhouse gas emissions in the European Union (EU) in 2017 occured in cities. Transport accounted for almost a quarter of all greenhouse gas emissions, and 43.5% of these transport greenhouse gas emissions were caused by cars [EEA20]. Urban transport also raises questions about the usage of public space, as roads and parking spaces take up a significant portion of urban surface land. Regarding trips in urban contexts, the European Environment Agency clearly states: 'Currently, the dominant mode for making a journey is the car.' [EEA20, 38] Hence, there is significant potential of reducing the societal cost of urban mobility by shifting away from the car as the primary mode of transport.

A switch to healthier and more sustainable urban mobility is necessary. One mode of transport that has the potential of playing a big role in that transition is the bicycle. Higher cycling rates have been linked to improved health outcomes [NK16, MRRS+18] while emitting zero greenhouse gases. Therefore, better positioning the bicycle as a viable mode of transport for short and medium-length journeys could be a key to unlocking a greener urban future. Cycling behaviour has shown to be influenced by socio-demographic

factors [CGM+13, NPR+16, SCD+13], suggesting that different population groups have different mobility needs. Therefore, one way to approach this objective is through targeted policy, specifically by improving cycling infrastructure [SCL15, MHHCSGC15, BD16].

An approach to tackling urban problems that has gained attention in recent years is the idea of a Smart City. While the term is hotly contested, at its core lies the idea of utilising information and communication technologies (ICTs) in a collaborative approach to improve the quality of life in a city [BAG+12, CMS16, FAFGG18, Gif16, GFK+07, MB16, MV14]. Smart City approaches can also by integrated into the urban policy process as a form of evidence-based policy-making. It has been estimated that applying Smart City approaches to make the modal split in urban mobility 'greener' could reduce greenhouse gas emissions from urban transport by 5% [ZP18]. As a result of the growing smartphone saturation in the population, one source of such ICT-based evidence could be data collected with smartphone applications. However, relying on empirical evidence in policy-making is theoretically complex and must be reviewed critically.

My recent analysis of the decision-making process behind designated cycling infrastructure projects in Vienna [Hön20] has revealed opportunities for further utilising evidence. The central conflict is usually over street real estate, with planners trying to square the needs of current traffic patterns with necessary change to reach strategic goals. Data is usually used to justify existing preferences or decide between variations. The central goal, however, is to look beyond current cyclists and animate those who are not yet using the bicycle (as much), and especially to reach groups who are hypothesised to tend to cycle less. User-generated project-specific cycling data could improve the process behind urban cycling policy by offering case studies to inform decisions with data relevant to the city's goals. Even though cycling data generated by users of urban cycling smartphone applications exist and city planners are generally aware of them, they are currently not being actively used. City planners argue that data about current cycling activity alone is of limited benefit to them. One of the main strategic goals of city planners in Vienna regarding cycling is to increase the bicycle's modal share by enabling and encouraging those who do not currently cycle to switch modes. They aspire to look into the future and enable future cycling traffic. In order for data to be useful to city planners, they need to be collected, analysed, and presented in a way that is more aligned with their goals. Therefore, one of the main results of this analysis was the recommendation to further investigate the possibility of using differentiated data about cycling journeys collected by smartphones to evaluate urban cycling policy on a case basis.

1.1 Research Questions

This thesis aims to close the gap between policy-makers and urban cycling data collected with smartphones. Considering the opportunities of Smart City approaches, the boundaries of evidence-based policy-making, the goal of improving the quality of life in a city by increasing bicycle's modal share, the opportunities brought about by smartphone usage, and the gap between city planners' goals and currently existing data and tools,

the following research questions emerge to be addressed in this thesis:

Research Question 1 *How can urban cycling data collected by smartphones be connected to socio-demographic data about their producers in order to effectively integrate them in the policy-making process for urban cycling policy?*

Research Question 2 *How can software to collect and present such data be developed in a way to enable this integration?*

CHAPTER 2

Theory

This chapter contains the theoretical basis for this thesis. It is separated into multiple thematic sections. The first two section concern aspects related to political science, namely the policy-making process (2.1) and evidence-based policy-making (2.2). Then, the relation of socio-demography with mobility needs is discussed (2.3). The final section regards Smart City approaches (2.5).

2.1 The Policy-Making Process

To consider the role of evidence in the policy-making process, the process itself must first be understood. This is easier said than done. Modelling policy-making processes is a central field of academic activity in political science. Therefore, a plethora of approaches can be found in the literature. This section contains a brief overview of the models and frameworks which are most relevant for this thesis.

There is no single, universally accepted definition of what 'policy' is. In this thesis, policy shall be understood to be 'the sum total of government action, from signals of intent to the final outcome' [Cai16, 2]. This definition recognises that government has multiple action avenues, not only the passage of laws and regulations, but also, for example, remaining inactive. Second, 'policy-makers' shall be understood as the people and organisations that influence and decide on policy. This can be elected politicians as well as unelected administration employees ('the people') or groups of people acting together guided by a common set of rules (institutions), either elected (e.g. a parliament) or unelected (e.g. an administrative division of a city government), as 'organisations' [Cai16, 3]. Here, the role of unelected policy-makers should not be underestimated. It has been argued [Lip80] that 'street-level bureaucrats' are central agents of policy-making, since it is impossible for them to implement every regulation exactly as intended. Instead, their discretionary implementation of regulation 'on the ground' makes them essential to policy.

Traditional, rational-linear models of the policy-making process are typically comprised of a few stages through which policy cycles in a regular order, e.g. [Cai12, 34]: (1) Agenda setting; (2) Policy formulation; (3) Legitimation; (4) Implementation; (5) Evaluation; and (6) Policy maintenance, succession, or termination. Such models are envisioned as heuristic devices, which are so abstract that all real-world processes are expected to diverge from them in some way. Scholars disagree if simple policy cycle models are at all useful. Some, like [How05], say that if they are applied loosely, recognising that policies might not cycle through all of the stages or not in the model's order, then such models can be useful analytical devices. Others, like [Cai16], argue that the top-down perspective on policy-making that such models portray is inaccurate and problematic. Policy-making is argued to be a much more complex and ambiguous process.

Actually, such linear models are subject to extensive critique beyond concerns about their practicality. As summarised in [NW07], multiple scholars ([Sim57, Lin68, CMO72, KS84], non-exhaustive) criticise that rational-linear models are bound by the limits of human rationality. They argue that policy-makers do not, and cannot, act rationally. Humans are (demonstrably) unable to approach such highly complex problems in a way that satisfies the demands of objective rationality. It is impossible for policy-makers to explore all possible solutions and find the objectively best one, they argue. Also, more pragmatically, policy-makers lack access to crucial information to extensively explore solutions and make rational decisions to begin with. The requirements that rational-linear policy-making models set out can simply not be met in the real world, since they exceed humans' analytical cognitive capabilities—in addition to the fact that policy-makers are operating with limited resources.

From this critique, multiple other models of the policy-making process arose. Simon [Sim57] shaped the notion that policy-makers aim to 'satisfice', i.e. to find solutions that are 'good enough' for policy stakeholders. Lindblom [Lin68] extended this notion and proposed an incremental model of the policy-making process. He argues that political feasibility dictates that policy-makers go for small-scale incremental policy change, resulting in a patchwork policy landscape.

Kingdon's [KS84] *multiple streams* framework extended the *garbage can* framework, a more radical critique of rational-linear models that argues that policy processes are in their core dynamic, unpredictable, chaotic and fundamentally irrational [CMO72]. Kingdon describes three streams that flow through the policy arena:

1. The *problem stream* contains problems in search of solutions.

2. The *policy stream* contains policy ideas and proposals, or 'solutions in search of problems'.

3. The *political stream* defines which problems and solutions end up on the agenda. It is dictated by power structures and political opportunities, such as external crises, political events, or the 'national mood'.

Policy change occurs when the three streams converge. This happens when *policy windows* or *windows of opportunity* open, e.g. because of an impactful event, a crisis, or mounting public pressure. *Policy entrepreneurs* play a special role in this process by skilfully advocating for a certain solution in the policy stream. When a policy window is open, political actors can take advantage of this combination of problems, solutions, and political opportunity by enacting policy change.

As is the nature of political theory, none of the theories described above can be ultimately considered right or wrong. They are tools that help researchers understand empirical processes, providing them with a lens through which they can view reality. These theories are also useful for proposing models of different political processes.

2.2 Evidence-Based Policy-Making

For this thesis' purpose, evidence-based policy-making shall be understood as using knowledge obtained by research when making policy. This concept is neither trivial in theory nor straightforward in practice. This section provides an overview over the theory of evidence-based policy-making, establishing the theoretical basis for solving the research questions at hand.

[San02] describes two modes of how evidence can increase governmental effectiveness. Evidence can be used for *accountability* by producing and releasing information about how government works. Second, evidence can be used for *improvement* of policy: Knowledge informs government about what works. This thesis is mainly concerned with the second form of evidence utilisation.

An excellent introduction to the field of using research for policy and practice can be found in [NW07]. The authors discuss not only the direct application of research findings for decision-making, but also conceptual applications where research shapes thinking about policy issues, or political applications where research is used justify an argument, action, or inaction. However, they highlight the irony that there is no solid and conclusive evidence that evidence-based policy actually leads to better outcomes. They suggest that the reason for this is that while there are studies of evidence-based practices themselves, there is a lack of studies specifically investigating the impact of such practices on policies. This is complicated by the fact that the impact of research is often subtle, complex, and difficult to trace. Often, no direct line can be drawn between a body of research and a specific decision.

2.2.1 Typologies of research use

What does it mean to use research evidence? The common image is research being used directly in developing policy options and deciding between them. However, reality is much more complicated [NW07]. Research use is also about shaping attitudes and ways of thinking. To organise this complexity, multiple research use typologies can be found in the literature. The critical reader must keep in mind that applying research

use typologies is often difficult because categories are usually not mutually exclusive and borders can be fluid.

[NW07] draw on other typologies and propose classifying research use into the following categories:

- *Instrumental use* is when research impacts policy decisions directly and immediately. Usually, this is what is imagined to be 'evidence-based policy-making'.
- *Conceptual use* is more ambiguous. It includes all the indirect and complex ways research is influencing policy in a non-linear fashion. This category is especially challenging for researchers, as it is less traceable and less demonstrable.
- *Strategic/tactical use* is mostly available to policy-makers. It describes research being instrumentalised for persuasion of others, for supporting an existing political position, or for challenging the position of others. Calling for more research can also be a tactic for stalling a discussion or decision on an issue.
- *Process use* means that the design and process of research rather than its findings improves policy because policy-makers learn from it and improve their own practices.

My recent analysis of the political process behind dedicated cycling infrastructure in Vienna [Hön20] suggests that evidence is mainly used strategically/tactically on the political level. On the administrational level, instances of instrumental and conceptual use can be found.

Research summarised by the authors [NW07] suggests that evidence is more likely to be used conceptually or tactically than instrumentally. However, conceptual use is hard to approach scientifically, which is why research has focused on the more tangible categories. A more elaborate typology is presented by [Wei79]. Because it is so elaborate, I selected only the most relevant categories for this thesis to be mentioned here:

- *The knowledge-driven model*: Research finds and tests knowledge potentially benefitting policy. Policy-makers act on this knowledge. This is the most direct form of influence.
- *The problem-solving model*: Problems and goals are already defined, research should help to achieve the set-out goals.
- *The political model*: Policy-makers' positions are fixed, research is used to support positions or attacks.

Again, research has shown that the knowledge-driven and problem-solving models, which put research at the forefront of policy-making, are rare on the ground [NW07]. Finally, other typologies classify research use in two-dimensional continuums (e.g. along the axes of 'Concrete'/'Conceptual' and 'Substantive'/'Elaborate'/'Strategic' in [GM91])

or as a series of stages (e.g. (1) Reception (2) Cognition (3) Reference (4) Effort (5) Adoption (6) Implementation (7) Impact in [KW80]).

2.2.2 Critique of evidence-based policy-making

Research and its use are not value-free. They depend on the power relations at play in the social contexts in which they occur. Postmodernists criticise that granting research too big of a role in policy-making poses a risk of researcher dominance [Wat94]. They also issue a reminder to be cognisant of the interplay of knowledge, politics, and power when using research in public policy. Knowledge does not exist in isolation of existing power structures, so policy-makers and researchers must be aware of the social context in which they are operating and which they might be reproducing. Scholars in the field highlight that it is crucial to engage in this debate (for examples, see [NW07, San02, HR10, Ric17]).

Using evidence for policy-making intuitively fits well with a rationalistic model of policy-making. Such an understanding of political decision-making makes it conceptually easy to include evidence in the process [San02]. Therefore, including evidence in the policy process includes an effort to rationalise the process [HR10]. Then, the focus is on improving the instrumental use of knowledge in policy-making. The mantra is 'what matters is what works' [San02].

This leads to potential pitfalls of involving evidence in policy-making. Evidence-based policy-making carries with it the risk of technocratisation and thus de-politicisation and de-democratisation of the policy-making process. Evidence must not eliminate room for discretion in a messy processes. It must be ensured that evidence informs political decision-making without dominating it [HR10]. Stakeholders who might not have the necessary resources to back their position with scientific data are especially vulnerable to this kind of crowding out.

It is necessary to adopt a critical lens on what constitutes 'knowledge' and what is meant with 'improving' the use of research. [San02] argues that policy-making and evaluation should not be technical exercises, but instances of practical reasoning. Constructivist or interpretivist positions challenge the rationalistic approach laid above, arguing that 'knowledge of the social world is socially constructed and culturally and historically contingent' [San02, 6]. In this understanding, the main features of a policy-making process are discursively and argumentatively inseparable from the social conditions surrounding the process. Evidence finds its way into this process in ambiguous, obscure, non-linear, and unsystematic ways, resulting in conceptual rather than instrumental use of knowledge [San02]. The mantra becomes a question: 'What works, for whom, in what circumstances, and why?' [PT97]

However, these concerns should not lead to the notion of including evidence into the policy-making process to be abandoned. Quite the opposite, 'if anything they increase this need as the sense of the complexity of the social world is heightened.' [San02, 7] It becomes central that practices of research use need to be well-designed and executed with awareness of these concerns [Ric17].

Evidence-based policy-making must be guided by social science theory. This is especially true for theory-based evaluation, as argued by [San02]. It helps understand the addressed societal problems and the reasons for different levels of effectiveness of policies. Theory-based evaluation is a major challenge, since the social problems addressed are highly complex. The core challenge of theory-based evaluation is that causal claims are difficult, even virtually impossible to make, since counterfactuals are difficult to establish. Rather, it should aim at understanding how effects were produced by using social science theory explanations. Therefore, improved policy-making processes must go hand in hand with improved theories of understanding the social problems tackled. Social science theory might receive less attention in this context, but it is certainly fundamental.

2.2.3 Reviewing evidence-based approaches in the policy areas of transport and urban policy

In a collection of reviews of the state-of-the-art of evidence-based policy-making in the United Kingdom (UK) from the year 2000, [DN00] offer an insight into which evidence-based approaches have been tried in the past. Although this work was produced before the advent of big data and data science, it can still serve as a starting point of assessing how the use of research in the policy areas of transport and urban policy is approached, since more recent methods were based on those described in it.

The chapter concerning transport policy [Ter00] solely focuses on UK transport policy, and even more narrowly on automobile road traffic only. In it, the nature of evidence in this policy area is described as statistics about car ownership and driving licences, as well as road usage. Extensive traffic models were constructed, allowing researchers to make forecasts using statistical methods. Additionally, road accident statistics were included in consultations. This exclusive focus on cars, combined with weak methodology and wrong assumptions and predictions (e.g. that the increase in wealth in the late 20^{th} century would distribute itself more evenly, that car ownership would reach 90% of the population, and that the UK would generally behave like the much less densely populated United States (US)) lead to policy failures. The author only mentions environmental benefits arising from use of evidence in transport policy in the context of rural town bypasses that would benefit the residents of that town. To me, this shows how research use *must* be guided by critical social science theory. Otherwise, existing power structures and social patterns are bound to reproduce themselves in an unchecked way. Moreover, if the same effort was put into other forms of mobility as it was into the automobile, our urban, and also global, landscape could look very differently. The grand total of two sentences in this chapter related to environmental issues, none of them mentioning greenhouse gases, show the massive lack of attention the issue of using evidence to make transport more sustainable received—an assessment that is probably not only true for the UK before the year 2000.

The chapter concerning urban policy [Har00] highlights the extraordinary complexity of urban problems. This complexity results in a variety of issues when using evidence in urban policy. One, since so many stakeholders are involved, the political component

in urban policy is stronger than in other policy areas, since many interests need to be balanced and many actors are at play. Two, the many different moving parts of a city make it difficult to isolate and assess the concrete impact of a single policy change. 'Urban policy is holistic and involves "joined-up" working.' [Har00, 208] The *evidence of need* is highlighted as a key form of evidence in evidence-based urban policy-making. For example, the Index of Deprivation, a UK measurement of socio-economic indicators by district, can identify pockets of deprivation. Such data can be used to both identify areas of need and to evaluate the impact of policy with the goal to address these needs. The chapter concludes that 'evidence-based' in the urban context must be defined differently than in other fields because of the high complexity of urban problems. Researchers should rely on pluralistic methodological approaches, since there are no standard methods up to the task of validly assessing urban policy impact. My conclusion from this chapter is that when evaluating any kind of urban policy, the complexity of the urban context should include a holistic impact assessment. This means that also a relatively targeted policy change, i.e. one in urban cycling policy, should be evaluated for its positive or adverse impact on other fields such as housing, income, crime, and health.

2.2.4 Effective strategies of evidence-based policy-making

From reviewing the literature, it appears that an effective strategy of evidence-based policy-making to tackle the research questions of this thesis might be *policy evaluation using research-policy partnerships.*

According to [San02], if the goal is the improvement of policy, policy evaluation should be at the core of generating knowledge for evidence-based policy-making. 'If policy is goal-driven, evaluation should be goal-oriented.' [San02, 5] One especially viable form of this strategy is argued to be the 'piloting' of policies on a local level, with an increased focus on evaluation. The evaluation should not only find out which policies worked, but also, crucially, *why* they worked. The result of evaluation should be concrete lessons to inform future improvements of policy. Piloting can also mean 'prototyping', where a focus is put on how a policy plays out rather than whether it is effective in achieving the defined goals. [San02] highlights pilot policies in the UK that were accompanied by two forms of evaluation:

- *assessment of impact*: 'Does it work?'—gathering feedback on the outcomes achieved by the policy.
- *analysis of implementation*: 'How can we best make it work?'—collecting lessons and good practices on how such policies can best be implemented.

The concrete research design must be adapted to the type and scope of policy to be studied. When very complex issues or very widespread programmes are concerned, impact assessment is difficult, because *ceteris paribus* requirements cannot be fulfilled, i.e. there is no counterfactual, no 'control group'. This problem appears especially prevalent for

urban policy, which is particularly complex. [San02] therefore suggests using pluralistic methods, both quantitative and qualitative, in combination with longitudinal designs.

[NW07] highlight that one important mechanism to improve the use of research in policy-making is *interaction*, meaning strong links and collaborations between the research and policy communities. The benefit of interaction mechanisms in research utilisation is bidirectional: policy-makers gain better knowledge of problems and solutions, and researchers gain better understanding of needs and perspectives. Interaction is usually realised with partnerships. A summary of research in the field [NW07] shows that formal organisational agreements about content and structure increase the quality of partnerships and their chances of success. Furthermore, parties to a partnership usually want to minimise their expenditures while maximising their reward from participation. However, successful partnerships are defined by the partners' willingness to invest into the collaboration. Since partners' professional contexts differ, mutual understanding is key.

Therefore, a concrete way of introducing evidence into the policy-making process are *research-policy partnerships* [Ric17]. They are defined as 'any lasting, regular, collegial interaction between a specific ministry, branch, or agency within government and a specific department, research group, or institute within academia.' [Ric17, 167] In the paper proposing such partnerships, seven potential short-term benefits are laid out:

1. *Necessary information is gathered more efficiently* by avoiding redundancies of research being done by governance and academic institutions simultaneously.
2. *Greater access to academic sources and interpretation* for policy-makers through regular interaction with academics in the field.
3. *Building capacity through coalitions and literacy* as the people involved learn from each other and knowledge travels within organisations.
4. *More relevant framing of research findings* by researchers who regularly interact with policy-makers.
5. *Opportunity for feedback* for all involved parties in the partnership.
6. *Greater ability to convene stakeholders* as researchers help policy-makers connect with other stakeholders, like industry, non-governmental organisations, activists, and other interest groups.
7. *Resources for joint projects* in other fields.

To conclude, this section lays out that research-policy partnerships for policy evaluation appear to be among the most effective ways of improving public policy with research. It has been argued that policy evaluation should take a central role in strategies to include research into policy processes with the goal of improving policy [San02]. Research

in the field, albeit limited, suggests that interactive approaches where policy-makers and researchers are in close partnerships are most likely to be effective [NW07]. Research-policy partnerships might be an effective framework for achieving exactly that [Ric17]. It is furthermore paramount that research is not misused as a tool of oppression by those with the necessary resources to create knowledge that supports their existing positions. The utilisation of research in the policy-making process must be founded on and guided by solid social science theory. Finally, the methodological landscape has changed and now includes new data science and big data methods. The challenges of evidence-based policy-making outlined in this section, however, remain prevalent.

2.3 The Impact of Socio-Demographic Factors on Mobility Needs

According to the literature, situational and personal factors, especially socio-demographic variables, influence mobility behaviour [CC05, LLCR+15, HS06, CGM+13, NPR+16, SDD02, BvO+08, dBKS+05, GSV02, PSV04, HHGB07]. Specifically, cycling behaviour has shown to be influenced by socio-demographic factors [CGM+13, NPR+16, SCD+13]. Some findings appear to be consistent across these studies, like that the prototypical cyclist is a young lean man. The effects of other variables appears to vary with context: [CGM+13], done in the UK, shows that the level of education is positively correlated with cycling, while in the US this effect appears to be reversed [NPR+16, SCD+13]. In contrast, a study of travel time in the Netherlands [SDD02] exemplified the messy and ambiguous nature of mobility needs by showing that while men are three times as likely to commute by car as women, women are twice as likely as men to shop by bicycle. Again, the authors note that socio-demographic attributes are highly relevant to explaining travel time [SDD02, 1505]. Also in the Netherlands, studies of adolescents found their ethnicity to be a strong predictor of their likelihood to use the bicycle [BvO+08, dBKS+05].

To highlight one specific study, [LLCR+15] have shown that the socio-demographic variables age, gender, and occupational status have a significant effect on mobility patterns. They did so by analysing credit card spending behaviour in two Spanish cities. Their main findings concern time and distance between two purchases [LLCR+15, 8]:

- Women travel shorter distances and spend less times between two purchases than men.
- With age, the time between two purchases increases and the distance decreases. This is intuitive, considering that the ageing process reduces a person's mobility.
- Women stay closer to what the authors call the 'center of mass' of their destinations (i.e. the gravitational center of their points of purchase). This means that men have a bigger radius of movement than women.
- Those classified as 'employed' travel longer distances and move further away from their center of mass.

- Gendered differences are less prevalent among students and retirees, suggesting that care work, especially child care, influences mobility.

This study is worth noting despite the fact that its results must be viewed critically due to the nature of the data it relies on (only trips where something was purchased by credit card are recorded, and no information about whether place of purchase was the actual destination). While the authors claim to have eliminated interaction effects between the socio-demographic indicators they studied, they acknowledge that a more disaggregated data set is necessary to draw robust conclusions. The authors found significant results based on ambiguous data—meaning that clearer data can be expected to yield even stronger indications of socio-demographic effects on mobility patterns.

A critical perspective on urban mobility needs might start with a reference to critical urban sociology [Hön20, 11ff]. Scholars of this field argue: Not only does the urban space shape its socio-economic environment, but also the features of the space itself are produced by the socio-economic environment. This complex interdependence must be acknowledged in order to study urban phenomena, they argue. [HS78] approach this relationship with a critical lens regarding disparities between social classes. Drawing the line back to mobility, it has been shown that transport improvements can reduce income inequality, one of the symptoms of class disparities [LD13].

Building on this, feminist scholars have criticised urban planning, especially urban transport planning, for reproducing gender disparities. Public space in cities often follows the androcentric 'functional' divide between spaces for living, working, recreation, and transport. This division does not recognise that the home, which falls into the 'living' category, is also usually a place of work for women [Bec08, Fra04]. Cities' transport 'function' though is generally optimised to fit men's needs: radial, non-stop, often motorised trips from home to work and back. Women, however, have more complex mobility needs, often chaining together care work and multiple errands, more likely resulting in circular journeys, that existing transport infrastructure is not built for [Bec08, Bus89, CP19, Fla92, Kla93].

In conclusion, mobility needs are heterogeneous and complex. A person's mobility needs might be shaped by their class, gender, age, ethnicity, and other socio-demographic factors. Existing transport infrastructure was not built to serve everybody's needs equally, so targeted improvements could benefit underserved communities especially. It was also shown that a regional approach must be taken when studying socio-demographic effects on mobility patterns in general and cycling behaviour specifically.

2.4 Cycling as a Healthy and Sustainable Mode of Urban Transport

To achieve a greener and healthier modal split in cities, promoting the use of the bicycle is a viable option [MRRCH+15, NK16]. Individual motorised transport, i.e. cars, is the source

of immense societal cost stemming from pollution, congestion, and accidents [EEA20, KWV+16, NK16]. On the other hand, cycling has been identified as an especially healthy and sustainable way of urban transport [DGVHAM08, MRRCH+15, GdNN+16]. While there may be use cases that are exclusive to these two modes of transport, there are certainly overlaps where either one can be used. The question then becomes, how to achieve higher usage of the healthier and more sustainable option.

[GSV02, PSV04] show that socio-demographic factors are the most reliable predictors of the ecological impact of a person's mobility. While [HHGB07] add that attitudinal variables are also significant in predicting economic impact of mobility, they do not refute previous findings about the impact of socio-demographic indicators. [HSZ05] proposes a targeted approach to facilitate the use of more ecological modes of transport, in this case, public transportation. Groups are defined based on socio-demographic characteristics. [GdNN+16] shows how health and sustainability approaches to urban mobility can be combined conceptually.

Furthermore, the kind of infrastructure available influences mobility patterns [HS06]. This is also true for the bicycle specifically, as summarised in [Hön20]. The literature suggests a strong link between the availability of designated cycling infrastructure, such as physically separated bicycle paths, and the modal share of the bicycle [BD16, MHHCSGC15, SCL15]. While this finding appears intuitive and trivial, it is worth highlighting because of the consequence that can be drawn from it: Mobility patterns can be influenced by modifying infrastructure. Evidence suggests that cycling is more likely to be the preferred mode of transport if such designated cycling infrastructure exists [DGVHAM08, HGCT15, MVCG+16]. This finding is further confirmed by an analysis of provisional dedicated cycling infrastructure, or 'pop-up bike lanes', which were installed in multiple cities in the summer of 2020, during the COVID-19 pandemic. The analysis shows that the intended pull-effect of infrastructure has worked: Cycling rates increased between 11 and 48% on average [KK21]. This effect can be partly explained by the increased sense of safety cyclists have on such infrastructure. Therefore, this effect is especially important when aiming to encourage more people to cycle [MVDG+16, SCD+13]. Overall, an investigation of expanding cycling networks in cities [MRRS+18] has shown to have positive effects on public health and economics.

In summary: Theory suggests that a targeted approach to improve dedicated cycling infrastructure to those populations currently underserved would impact mobility patterns. The result would be better access to a healthy and sustainable mode of transport for underserved communities.

2.5 Smart City and Smartphone Data

While there is no standard definition of what a Smart City is, a periodically found understanding is that in a Smart City, ICTs are utilised by multiple collaborating actors to improve the quality of life [BAG+12, CMS16, FAFGG18, Gif16, GFK+07, MB16, MV14]. The concrete meanings of the terms 'utilisation', 'ICT', 'improve', 'quality of life', and

'city' are, however, subject to extensive debate. Without diving too deep into semantics, in this thesis, a Smart City shall be understood in broad terms as one that applies strategies utilising ICTs to improve mobility, health, equity, and political participation [Hön20, 9f]. The considerations laid out earlier in this chapter about evidence-based policy-making are relevant to Smart City approaches if knowledge produced by ICTs is (not) influencing policy-making processes. Therefore, evidence-based policy-making theory and Smart City approaches need to be conceptually integrated.

One emerging source of ICT-based knowledge are data collected by smartphones. In 2018, almost nine out of ten people in Austria used a smartphone to access the internet [StA19]. In the methodological report underpinning the last big mobility survey in Austria [FHK+11, 162ff], location measurements via smartphone were mentioned as a possible *future* way of collecting mobility data. At the time of writing of that report (2011), the technology was not yet deemed ready. However, a recent investigation of the accuracy of locational data collected by smartphones in urban environments [MB19] concluded that the average horizontal error was between seven and thirteen metres. Therefore, such data are considered a viable analytical basis for the purpose of this thesis.

However, the utilisation of locational data comes with considerable privacy concerns. It has been shown that up to 95% of users can be uniquely identified in pseudonymised locational data by selecting just four data points [dMHVB13]. Multiple methods to increase data privacy have been proposed, but they all decrease service quality to different extents [GLBF17]. Data security must be ensured in addition to data privacy.

[Hön20] has shown that the Viennese city administration is hesitant to use location data produced by cyclists with their smartphones, because 'their target audience, new "clients", would not be represented in the data' [Hön20, 40]. However, actors in the political process expressed general interest in considering such data in concert with other sources of knowledge. City administration officials especially appeared open to the idea of utilising such data for evaluation purposes specifically.

CHAPTER 3

A Proposal of a Theory-Driven Evidence-Based Urban Cycling Policy Evaluation Framework Employing Research-Policy Partnerships

Addressing[1] research question 1 with the theory (2) in mind, I propose that city administrations establish research-policy partnerships for urban cycling policy evaluation. Other parties to such a partnership should be a diverse group from the public and private sector, extending [Ric17]'s definition of research-policy partnerships. I strongly recommend that at least one party be concerned explicitly with social science theory to ensure its consideration. Since size seems to be a factor in the partnership's probability of success, I recommend that a partnership contain *as many as necessary but as few as possible* members. The general goal of partnerships should be to bundle knowledge, data, and resources to evaluate urban cycling policy. Parties should bring a specific asset to the table, such as expertise or access to data. The concrete scope, tasks, and timeframe of a partnership should be part of a written partnership agreement.

When a partnership is established, I propose that its work be project-based and cyclic. The collaborating parties of a partnership (called 'working group' henceforth) could work as follows: First, it defines and ranks a set of targeted pilot policy interventions

[1] While there is a wide range of methodological literature about how to describe political processes *ex-post*, e.g. 'process tracing' [Sta15, for an introduction], the literature review did not yield specific methods to propose policy-making strategies. When scholars did that, they did so as part of the conclusions or recommendations resulting from their work, in prose without explicit methodological guidance.

with a defined goal related to urban cycling, e.g. improving safety, access, comfort, or travel time. For each intervention, it is defined how exactly it is implemented, what its goals are (i.e. which problem it solves and who stands to benefit from it), what possible side-effects might be expected, and how it should be evaluated. It is crucial that this step be guided by social science theory and that stakeholders be consulted directly. Pilot projects are encouraged to be differently sized regarding their time horizon, budget, and ambition. Second, an elected official or body decides which proposals are implemented. This provides democratic legitimacy and accountability in an effort to decrease the possibility of technocratisation and de-politicisation. Third, the decided-upon pilot projects are implemented. The first step of implementation should be to set up and start evaluation processes accompanying the implementation. Fourth, the implementation and its outcomes are analysed and evaluated. While evaluation might look differently for every project, the general approach should be holistic, aiming to catch unintended effects, and include a mix of quantitative and qualitative methods. Again, it is crucial that evaluation be strongly guided by social science theory. The findings are summarised and published, ideally in the form of a peer-reviewed scientific paper. Finally, recommendations resulting from the pilot project are 'released' into the policy stream to be applied to similar problems. In any case, the results of the evaluation should inform future pilot projects.

Partnerships should be publicly funded in order to minimise the impact of other interests besides the improvement of public policy. To decrease political pressure, which might result in tainted reports of 'success', working groups should be tasked with multiple projects in parallel so that some pilot policies are allowed to 'fail', increasing the quality and authenticity of evaluations. Additionally, it is essential to facilitate the understanding that a partnership's measure of success should not be the number of 'successfully' implemented pilots, but the amount of knowledge gained from their evaluation that can be applied to future policy.

This proposal follows the recommendation issued by [San02] to let policy evaluation be the heart of evidence-based policy-making. Empirical data should be used to evaluate which policies worked and why. It also acts on [Ric17]'s call for research-policy partnerships and follows [NW07]'s suggestion to rely on the mechanism of interaction to improve the use of research in policy-making. A deep integration of social scientists ensures that theoretical components, which are often overlooked, are not brushed aside. It is crucial to understand the problems in need of solutions, in order to avoid simply producing solutions in search of problems. A closer link between problems and solutions raises the possibility of good policy outcomes.

Put in terms of the multiple streams framework [KS84], the parties to the partnership, i.e. city administrations, researchers, and private actors, collaborate to impact the policy stream. They work together to develop policy proposals informed by social science theory and empirical analysis of data. Furthermore, they might create or take advantage of policy windows by acting as policy entrepreneurs.

Adequately describing a part of the policy-making process, before or after the fact, is

no trivial affair, for the reasons laid out in chapter 2. Political processes are messy and often do not appear to follow *any* exact rules. While the process I have described does indeed resemble a cycle, I make the conscious choice of not drawing a diagram to present it as such. Like other policy cycles, it would 'look useful, but remain misleading' [Cai16, 39]. This is to acknowledge that this process, once implemented in the real world, would likely behave in all sorts of unpredictable ways. Pilot projects would likely be influenced by other projects running simultaneously and by outside political forces. They might not pass through all the stages in the prescribed order or even skip over some of them. I am also cognisant of the fact that the process would be influenced by a force that is omnipresent and omnipotent: *chance*, further mixed other intangible and latent influences—in short: the process becomes incalculable in the real world. A simple graphic model would not do the complexity of policy processes justice.

But this is not to say that process models do not matter—after all, I am presenting one myself. However, it would be naïve to believe that a process such as the one proposed in this thesis could be implemented to the letter, or even that an exact implementation of a top-down process would be desirable. Rather, the proposed process should be viewed as a guideline to be implemented in good faith and with sound judgement. It will be up to the people implementing the process to make it work.

CHAPTER 4

Methodology of Developing the Proof-of-Concept Application

Research question 2 calls for the development of a proof-of-concept application. This chapter contains a detailed description of how developing this application and the socio-demographic used in it were approached. Relevant additional material can be found in appendices A through E.

4.1 The Socio-Demographic Survey

Designing a survey to collect socio-demographic user data is a central and non-trivial part of this thesis. In order for the proof-of-concept application to be valid, it must contain a survey that resembles one that would be deployed in a real-world scenario. City administrators, policy-makers and researchers would then design surveys tailored to the needs of their research. The survey composed for this thesis will additionally aim to serve as a model on which such surveys for subsequent studies can be based.

For the purpose of the proof-of-concept application, the survey should strike a good balance between the questions' level of detail and the survey's overall response cost. The goal is to get information that is as detailed as possible, while only requiring respondents to invest as much time and energy into responding as necessary. Therefore, the survey's level of detail should be high in questions that are deemed essential, but can be low in questions that are expected to reveal less elementary information to researchers.

I deem it more important for the survey to be compatible and comparable with other socio-demographic surveys than to be entirely tailored to the needs of urban cycling policy specifically. External socio-demographic data could be used to select, weigh, or otherwise adjust the data collected by this tool. To enable this use of the data, it is paramount that the socio-demographic indicators are compatible. Therefore, the

survey in this thesis follows standardisation guidelines and is guided by existing mobility surveys with a socio-demographic component. To achieve this, surveys in the EU, the German-speaking area, Austria, and Vienna—in that order—were considered especially relevant for compatibility and comparability.

The process to create the socio-demographic survey for this thesis was as follows: First, the variables to be captured by the survey were conceptualised based on literature about standardised socio-demographic surveys [HZW19]. Second, a methodologically sound survey was created by operationalising the variables by following standardised guidelines [Eur11]. Third, the survey was revised to achieve compatibility and comparability with existing mobility surveys in Austria by incorporating the latest big mobility survey [THS+16]. Finally, the survey was revised to minimise the cost of response for users, while keeping in mind all information gained throughout steps one to three, such as individual questions' relative importance.

The resulting survey questions are laid out in section 5.1. The survey as presented to users is attached in appendix D. A full export of the survey in JSON format is attached in appendix E.

4.1.1 International standards of socio-demographic surveys

Hoffmeyer-Zlotnik and Warner [HZW19] summarise the state of standardisation of socio-demographic surveys on a national as well as international level. They focus on Germany and the EU, making their contribution especially valuable for research in the German-speaking area. By comparing standards and surveys internationally, Hoffmeyer-Zlotnik and Warner identify gender, age and education as the variables representing the minimum information of sociological background necessary [HZW19, 875]. To analyse social structures, the necessary core variables are family status, occupation, income, household composition, and nationality and migration background [HZW19, 875].

Since variables in socio-demographic surveys often measure social concepts, international standardisation can be difficult to achieve [HZW19]. Social institutions such as a household or levels of education vary between and even within countries, making it challenging to achieve internationally compatible and comparable results. Variables can be harmonised in two different ways: input harmonisation and output harmonisation. Input harmonisation happens *ex-ante*, meaning before a variable is recorded, by using similar question stimuli and answer categories. Output harmonisation happens *ex-post*, so after a variable is recorded, by bringing responses from different surveys into the same format. Depending on the variable in question and which national instruments exist to measure it, researchers must use input or output harmonisation to achieve internationally compatible results. For socio-demographic core variables, nationally harmonised measurement instruments usually exist, leading to output harmonisation. Where no harmonised measurement instruments exist, input harmonisation is applied.

4.1.2 Methodological examples and orientation

The European standard for socio-demographic surveys is 'Implementing core variables in EU social surveys – Methodological guidelines' by the European Statistical Office (Eurostat), in the revised version of 2011 [Eur11]. It offers implementation guidelines for the core statistical variables recommended in 2007 by the Core Social Variables Task Force [Eur07]. The goal of the recommended core variables and the methodological guidelines was to achieve a common European standard for social surveys. The guidelines consist of definitions of core variables related to demographic, geographic, and socio-economic information as well as methodological guidelines on how to measure them. These guidelines are potent tools for researchers to develop methodologically sound social surveys, as the definitions and explanations are very detailed.

The current standard for mobility surveys in Austria is the latest extensive mobility survey conducted in 2013/14 called 'Österreich unterwegs' (in English: 'Austria on the way') [THS+16]. It was the first Austria-wide mobility survey since 1995 and was commissioned by the Austrian transportation ministry in concert with other state actors. In total, 17,070 households were surveyed, reporting 196,604 individual journeys. Results related to bicycle mobility were additionally published in a separate report called 'Österreich unterwegs... mit dem Fahrrad' [TS17].

One of the core elements of the mobility survey was a survey containing socio-demographic variables conducted per household [THS+16, Appendix A] with the explicit aim of being compatible with previous surveys of the same kind. The survey's methodological groundwork was laid by 'KOMOD – Konzeptstudie Mobilitätsdaten Österreichs' [FHK+11], which aims to be the methodological standard for mobility surveys in Austria. With the methodological literature in mind, the survey of 'Österreich unterwegs' and the underlying KOMOD standard were deemed fit to serve as basis for efforts to make the survey of this thesis compatible with other Austrian mobility surveys.

4.2 The Development of the Software to Collect and Analyse Data

The proof-of-concept application is the software project that forms the basis of this thesis. It was developed in close cooperation with Bike Citizens Mobile Solutions GmbH, an urban cycling service provider based in Graz, Austria (henceforth referred to as 'Bike Citizens').

The terms 'the project', 'the application', 'the software' and 'the proof-of-concept' shall all henceforth refer to the proof-of-concept software application project developed for this thesis.

4.2.1 Requirements

The first step in developing the application was defining its requirements. As described by [SDW+10a], software requirements can be separated into functional requirements, non-functional requirements, design constraints, and process constraints. Considering the scope of the project, the focus was put on functional requirements.

First, the basic requirements were collected colloquially as follows. The application was conceptually split into two components, one for collecting data and one for analysing data. The data collection component's purpose is to record survey responses of users participating in a study. Users' responses are then to be linked to their cycling data during the study period. The survey should be easily accessible from the application used by the user to record cycling data. Those issuing surveys for studies, e.g. researchers or research departments of city administrations, should be able to create and manage surveys on the component. They should be able to view a list of their surveys and detailed information about individual surveys. The application should also enable the exploration and initial analysis of the data to serve as a starting point for in-depth analysis.

The goal of functional requirement definition was to define the requirements in a way that could be fruitfully translated into tasks during development. To accomplish this, use cases were formulated based on the colloquial description of the application's envisioned functionality. A use case is 'a description of the possible sequences of interactions between the system under discussion and its external actors, related to a particular goal' [Coc01, 15]. The use cases followed a template based on Cockburn's 'fully dressed' use case [Coc01] containing the following elements:

- Identifier
- Title
- Story
- Primary Actor
- Stakeholders & Interests List
- Precondition
- Postcondition
- Success Scenario
- Extensions

There were three main actors identified. *Customers* are city administrations, researchers, or any other actors interested in conducting studies. *Service providers* offer the service enabled by the application to customers. They also offer some other service

to users, enabling to collect cycling data from them. For this thesis, this role is taken on by Bike Citizens. *Users* are urban cyclists using the service provider's service. Based on this, six main use cases were identified:

1. UC1: Create new study
2. UC2: Sign up for study
3. UC3: Edit study
4. UC4: Overview over all responses
5. UC5: Filter and compare
6. UC6: Download data as spreadsheet

These use cases cover the functionality of the proof-of-concept application exclusively. Other relevant functionality, such as the recording of a bicycle journey, are in the service provider's domain and are therefore not included in the requirements for this application. The full use cases are attached in appendix A.

Based on the use cases, user stories were formulated. A user story specifically describes an actor's interaction with the component and their expected benefit from that interaction. They are a more detailed format of the requirements of a software product, usually taking the form of a single sentence in active speech. Their purpose is to be directly actionable by a developer. User stories were based on the 'Connextra template': 'As a <role> I can <capability>, so that <receive benefit>' [Coh04]. The 'so that' clause was omitted if the benefit of the capability to the actor clear. User stories were then further grouped into epics, which grouped concrete functionalities into more abstract features that could serve multiple use cases. Full lists of user stories and epics are attached in appendix B.

4.2.2 Development process

The goal of the development process was to create a software component that was powerful yet small and easily maintainable and expandable. Best practices of software development, such as DRY ('Don't Repeat Yourself'), were followed. High value was placed on the thorough documentation of the project in order to establish good maintainability and extensibility.

The development process used elements of an agile Scrum process [Sch04], applied to a development team of one person. Scrum is a sophisticated agile software development process, in which software is changed incrementally and iteratively. In this cyclic process, development time is divided into Sprints. At the end of each Sprint, the software should show some kind of improvement. This process differs from the waterfall model in that the planning, design, implementation, and integration phases do not happen once for the whole product, but are part of each iteration [SDW+10c].

Work packages for developers are collected in the Product Backlog. The Product Backlog for this project were the user stories developed as requirements for the project. While user stories were further split into smaller tasks on the developer level, they were not transformed on the project management level. The Product Backlog was periodically revised. In revisions, user stories could be modified, added, or deleted; or their status or prioritisation could be changed.

Due to the size of the development team being one and the close collaboration with Bike Citizens, the roles within this adapted Scrum process were overlapping. I took on the role of developer. A representative of Bike Citizens and I shared the roles of ScrumMaster and Product Owner. In a Scrum process, the ScrumMaster leads the team through the Scrum process. Since the process was adapted and scaled down, process management did not require as many resources. The Product Owner is responsible for coordinating with the client and prioritising tasks in the Product Backlog. Since both Bike Citizens and I were stakeholders as well as actors in this project, we could influence the trajectory of the process directly.

The goal of the process is to deliver improvements with every Sprint. In this project, the duration of a Sprint was two weeks. Between Sprints, the Bike Citizens representative and I had a meeting that combined the Sprint planning meeting, the Sprint review meeting, and the Sprint retrospective. At this fortnightly meeting, the work of the past two weeks was presented, feedback was exchanged, and the remaining tasks were prioritised and selected for the next Sprint.

In addition to the agile Scrum process, project milestones were defined. The purpose of a milestone was to mark a deliverable objective in time with the goal to increase planability for all stakeholders. The introduction of this static element into the process reduced its agility. However, since the project had a due date and a limited feature set, this limitation in agility was beneficial to the overall process. The milestones can be found in appendix C.

In summary, the development process for this project constituted a semi-agile adapted Scrum process. The combination of static milestones, agile process elements, and close collaboration with Bike Citizens resulted in a solid development process for the purposes of this project.

4.2.3 Testing

Software testing occurs on different levels, is performed by various actors, and can serve distinct goals [SDW+10b, 133ff]. Since the application relies on many libraries which were assumed to be stable, testing was limited to:

- *Component tests of project-specific extensions of used libraries*: Testing a single software component in isolation from the rest of the system.

- *Integration tests*: Testing the integration of a software component into the rest of the system, focusing on interfaces and interactions between components.
- *System tests*: Testing the whole system in a holistic fashion.
- *Acceptance tests*: Testing whether the system fulfils the requirements.

Testing was done manually. After a given functionality was implemented, a component and integration test were usually done in concert. Once a whole use case was realised, a system test was performed to ensure functionality of the system as a whole.

The meetings with Bike Citizens were used to perform regular acceptance tests of recently developed functionality and the system as a whole. Since both the Bike Citizens representative and I acted as clients as well as Product Owners, we performed the acceptance test together by examining whether the application fulfilled the requirements we defined in the beginning.

Once development of the application was finished, a final, more extensive system test was performed with six external test subjects and myself. In this test, the test environment simulated a real-world deployment of the proof-of-concept application by activating its integration into the live production version of the Bike Citizens smartphone application for the test subjects. The subjects then provided the application with real-world data in the testing period of January through March 2021.

Since the purpose of the final system test was to prove the application's functioning rather than the usefulness of the data it produces, the group of test subjects was not a representative population sample. Instead, the main criterion for test subject selection was their likelihood to provide real-world data for the test.

4.2.4 Technologies

The application was developed in the Ruby[1] programming language (version 2.6.3) using the Ruby on Rails[2] framework. Ruby on Rails is one of the most popular frameworks for powering small and large scale web applications. It is characterised by its combination of functionality, scalability, and ease of use. Most notably, it follows the 'convention over configuration' paradigm, relieving the developer of a number of choices and configuration.

Ruby on Rails comes bundled with an SQLite[3] database and a Puma[4] web server. There was no need to divert from the standard setup or configurations.

To power the handling of surveys, the application builds on the Rapidfire[5] engine for Ruby on Rails. Rapidfire provides infrastructure to manage surveys out-of-the-box,

[1] https://www.ruby-lang.org/
[2] https://rubyonrails.org
[3] https://www.sqlite.org/index.html
[4] https://puma.io
[5] https://github.com/code-mancers/rapidfire

Gem	Version
rails	>= 6.0.3.4, < 6.0.4
rapidfire	4.0.0
jquery-rails	4.4.0
devise	4.7.3
bootstrap	4.5.3
bootstrap_form	4.5.0
faraday	1.3.0
faraday_middleware	1.0.0
caxlsx	3.0.4
caxlsx_rails	0.6.2

Table 4.1: All Ruby Gems and their versions

however the functionality had to be extended to serve the needs of this thesis. Most notably, multi-tenant support for managing surveys per user account had to be added[6]. For authentication, the application uses the Devise[7] library for Ruby on Rails.

For an out-of-the-box state-of-the-art user interface (UI) for the application, the Bootstrap[8] web UI library is used. Bootstrap allows web front end developers to easily style their interface using a grid system by applying classes to objects on their web page. Bootstrap relies on jQuery[9], a JavaScript library. To take advantage of Bootstrap form styles, the application uses the 'bootstrap_form'[10] library for Ruby on Rails.

The Faraday[11] HTTP client library enables queries to the Bike Citizens application programming interface (API) from within the application. To provide data export as Open Office XML spreadsheets that can also be read by Microsoft Excel, the 'caxlsx'[12] library is used.

Ruby libraries, or 'gems', are managed using the RubyGems[13] package manager. All project-specific libraries are listed with their respective version in table 4.1.

Ruby is released under the Ruby Licence[14]. All mentioned libraries are released under the MIT licence[15]. Both licences allow software to be used for the purposes of this thesis.

[6] At the time of writing, multi-tenant support for Rapidfire is listed as a 'to do' functionality in the GitHub repository. In the spirit of open source software, a pull request to share my implementation of this functionality is under development and will be submitted for review shortly after completion of this thesis.

[7] https://github.com/heartcombo/devise

[8] https://getbootstrap.com, https://github.com/twbs/bootstrap-rubygem

[9] https://jquery.com, https://github.com/rails/jquery-rails

[10] https://github.com/bootstrap-ruby/bootstrap_form

[11] https://lostisland.github.io/faraday/

[12] https://github.com/caxlsx/caxlsx

[13] https://rubygems.org

[14] https://www.ruby-lang.org/en/about/license.txt

[15] https://opensource.org/licenses/MIT

The application was then deployed to infrastructure provided by Bike Citizens. Integration of the application into the Bike Citizens smartphone application was in the domain of Bike Citizens and is not subject of this thesis.

CHAPTER 5

Implementation of the Proof-of-Concept Application

In this chapter, the implementation of the proof-of-concept software application is outlined, addressing research question 2.

5.1 The Survey

Based on the considerations, the literature, and the examples laid out in section 4.1, a concrete survey was composed. The following are the variables the survey captures. Their measurement follows Eurostat guidelines [Eur11] and international standards [HZW19]. The survey as presented to users is attached in appendix D. A full export of the survey in JSON format is attached in appendix E.

The variables inquired by the survey can be grouped into five themes: Core variables, migration status, household composition, economic status, and mobility. Each variable in these themes is measured by one or more indicators. Each indicator is represented by one or more concrete questions in the survey. If the variable is non-trivial, a more detailed description of indicators and concrete questions is given. If an indicator is measured using multiple questions, they are listed with numbers in parentheses ((1) ..., (2) ..., (3) ...). If respondents are asked in a question to choose from a number of options, the options are listed in brackets ([...; ...; ...]) if exactly one option must be selected, or braces ({...; ...; ...}) if multiple or no options can be selected.

The first group of variables of the survey are socio-demographic core variables as described before.

- *Gender*: In this survey, the social category 'gender' is recorded. This deviates from Eurostat guidelines and international standards, where the biological category 'sex'

is recorded. Since the theoretical basis of the research that is envisioned to be based on the data from this survey is more concerned with the social than with the biological category, it was deemed more relevant to be recorded. Respondents are asked to choose one out of [male; female; other].

- *Age*: Measured in full completed years of life. Respondents are asked for their month and year of birth.
- *Education*: Level of education is one of the central indicators for social inequality [HZW19, 878]. This variable represents certifications, degrees, and diplomas, not actual knowledge. Following Eurostat guidelines [Eur11, 45ff], only the highest certification is inquired, and those currently in education are not asked to respond with their aspired degree (contrary to the German standard [HZW19, 878]). The categories are identical to those used in 'Österreich unterwegs', which aggregate 'International Standard Classification of Education' (ISCED) categories: [No degree (yet); compulsory school with vocational education; compulsory school without vocational education; upper secondary degree (Matura); degree from university/other tertiary degree]. Respondents are asked to choose their highest completed certification.

Section two of the survey inquires about the respondent's migration status. Information about citizenship and migration status is necessary for analyses about social structures and social injustices [Hui14].

- *Migration status*: This variable is described by the following indicators:
  - *Citizenship*: Following the German standard, the question asks for 'citizenship' specifically, as 'nationality' brings with it connotations of ethnic and cultural belonging [HZW19, 877]. While the German standard also asks how the respondent's citizenship(s) was (were) acquired, this survey does not ask this to lower response cost. Respondents are asked to choose the country of their primary and secondary (if applicable) citizenship from a list of all countries and territories recognised by the United Nations as of 1 December 2020, modified for legibility and consistency, with an additional option 'other / don't know'.
  - *Country of birth*: Depending on the countries' citizenship laws (*ius soli* or *ius sanguinis*), the respondent's citizenship(s) and their country of birth can give information about the respondent's migration status. Respondents are asked to choose their country of birth from the same list of countries and territories as mentioned above.
  - *Country of birth of parents*: The combination of this indicator together with the respondent's citizenship(s) and their country of birth offers a comprehensive enough picture of the respondent's migration status. This indicator extends the Eurostat guidelines and follows Hoffmeyer-Zlotnik and Warner [HZW19,

883]'s suggestions to get more information about the respondent's migration status. Respondents are asked to choose both parents' countries of birth from the same list of countries and territories as mentioned above.

Section three of the survey inquires about the respondent's living situation. Specifically, questions measure the type and size of the respondent's household composition. The concept of a 'household' is neither trivial nor universal, and can differ significantly between and even within countries. For the purpose of this survey, a household is understood as defined by [Eur11] as a combination of people usually living together and sharing in household expenses, meaning contributing to or benefiting from them[1].

- *Household composition*: Since this variable is conceptually complex, it needs to be surveyed using multiple indicators. Strictly following Eurostat guidelines [Eur11, 19f], these are:
  - *Household size*: The number of people living in the respondent's household. In order to differentiate between groups of household members, this indicator is measured using multiple questions, asking the respondent to fill in the number of household members (1) aged 0-4; (2) aged 5-24, (3) the number of which are students; (4) aged 25-64; and (5) aged 65 and over.
  - *Household type*: Respondents are asked to attribute their household to one of the following types: [One-person household; single parent with children aged < 25; couple without children aged < 25; couple with children aged < 25; couple/single parent with children < 25 and other persons; other].
  - *Economic activity*: Respondents are asked to indicate the number of individuals in their household aged 16-24 who are (1) at work, (2) unemployed or economically inactive. 'Economic activity' is defined as in the variable 'Self-declared labour status'.

[1] 'The following persons, if they share in household expenses (including benefiting from expenses as well as contributing to expenses) shall be regarded as household members: 1. persons usually resident and related to other household members; 2. persons usually resident, not related to other household members; 3. resident boarders, lodgers, tenants, etc., with no private address elsewhere, actual/intended stay one year or more; 4. visitors, with no private address elsewhere, actual/intended stay one year or more; 5. live-in domestic servants, au-pairs, etc. , with no private address elsewhere, actual/intended stay one year or more; 6. persons usually resident but temporarily absent (for reasons of holiday travel, work, education or similar), with no private address elsewhere and actual/intended absence less than one year; 7. children of household members being educated away from home, with no private address elsewhere, continuing to retain close ties with the household; 8. persons absent for long periods but having household ties (eg. persons working away from home), child or partner of other household member, with no private address elsewhere, continuing to retain close ties with the household; 9. persons temporarily absent but having household ties (eg. persons in hospital, nursing homes or other institutions), with clear financial ties to the household, actual/prospective absence less than one year. A person shall be considered 'usually resident' if they spend most of their daily rest there evaluated over the past one year. Persons forming new households or joining existing households shall normally be considered as members at their new location if there is an intention to stay for more than one year. Similarly, those leaving to live elsewhere shall no longer be considered as members of their original household.' [Eur11, 20f]

Section four of the survey inquires about the respondent's economic status. A person's social status can be influenced by their economic activity, specifically by their employment status, sector, field of occupation and available income. The following variables aim to get a comprehensive picture of the respondent's economic status.

- *Self-declared labour status*: Respondents are asked to describe their labour status by self-attributing them to one of the following options: [Full-time employed, part-time employed, self-employed, solely fulfilling domestic tasks, on paid leave, unemployed, in education, in retirement, permanently disabled, compulsory military/civil service, inactive (other)]. This variable follows the Eurostat guidelines [Eur11, 33ff], relying more on self-perception, rather than the more granular German standard. Traineeships are to be counted as employment or education based on whether they are paid or not. The options 'self-employed' and 'on paid leave' are additions to the Eurostat guidelines taken from 'Österreich unterwegs' to achieve compatibility. When standardising, they would be attributed to 'full-time employed'.

- *Workplace*: Respondents are asked to select whether any of the following characteristics apply to their workplace: {flexible work hours; opportunity for home office}. This variable does not appear in the Eurostat guidelines or the German standard, but is taken from 'Österreich unterwegs' to better understand a respondent's mobility needs for work.

- *Occupation in employment*: This variable concerns the respondent's position at their employment. No answer is required if the respondent indicated that they were not economically active previously. The classification ISCO-08 ('International Standard Classification of Occupations') is used: [Managers; Professionals; Technicians and associate professionals; Clerical support workers; Service and sales workers; Skilled agricultural, fishery and forestry workers; Craft and related trades workers; Plant and machine operators and assemblers; Elementary occupations; Armed forces].[2,3]

- *Economic sector in employment*: This variable concerns the sector in which the respondent is employed. No answer is required if the respondent indicated that they are not economically active previously. A grouped version of the classification 'statistical classification of economic activities in the European Community' (NACE) in its second revision (NACE Rev. 2) is used, strictly following [Eur11, 43]: [Agriculture, forestry and fishing; Manufacturing, mining and quarrying and other

[2] In German: [Führungskräfte; Akademische Berufe; Techniker und gleichrangige nichttechnische Berufe; Bürokräfte und verwandte Berufe; Dienstleistungsberufe und Verkäufer; Fachkräfte in der Landwirtschaft und Fischerei; Handwerks- und verwandte Berufe; Anlagen- und Maschinenbediener und Montageberufe; Hilfsarbeitskräfte; Angehörige der regulären Streitkräfte]

[3] As these categories are relatively broad, self-attribution might not be straightforward. To help respondents, they are provided with the European Commission's recommendation on the use of ISCO-08, which includes a more detailed list of sub-categories. EN: https://ec.europa.eu/eurostat/documents/1978984/6037342/ISCO-08.pdf / DE: https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:292:0031:0047:DE:PDF

industry; Construction; Wholesale and retail trades, transport, accommodation and food service activities; Information and communication; Financial and insurance activities; Real estate activities; Business services; Public administration, defence, education, human health and social work activities; Other services].[4]

- *Net monthly household income*: The aim of this variable is to capture economic well-being and real spending power. This does not only depend on an individual's personal income, but also on the income of other people in their household [Eur11, 49]. Eurostat guidelines advise to let respondents write down an estimated currency value in order to respond to this question, and later equivalise the response by recording in which quintile of overall national household income the response is located. This survey deviates from these guidelines in two ways. First, the response cost of responding with a currency value is deemed to be too high, as respondents might be hesitant to answer exactly and truthfully. Therefore, respondents are asked to attribute their household to an income bracket. Second, the Austrian statistical office (Statistik Austria) does not publish net household income data in quintiles, but at cut-off points of 10%, 25%, 50%, 75%, and 90% [StA20]. Therefore, respondents are asked to choose from the following options, corresponding to the values of rounded cut-off points: [< €1 250; €1 250 - €2 000; €2 000 - €3 200; €3 200 - €4 800; €4 800 - €6 600; > €6 600]

The final section of the survey is comprised of questions that are not directly related to the respondent's socio-demography. Instead, these questions measure variables related to the respondent's access to different forms of mobility, especially the bicycle, and their use of the smartphone. These questions were asked similarly in 'Österreich unterwegs' and are designed to be compatible with other mobility surveys like 'Österreich unterwegs'.

- *Availability of transport*: This variable intends to capture which modes of transport are usually available to the respondent. The indicator combines different questions of 'Österreich unterwegs' into a single question by asking respondents to select which modes are usually available to them: {Public transport; bicycle; electronic bicycle; bike-sharing service; motorcycle; motorcycle sharing service; e-scooter; e-scooter sharing service; car; car-sharing service}. 'Usually available' is defined as having access to a mode of transport via ownership, a periodic ticket (e.g. annual pass), or an existing and usable account.

- *Household bicycle ownership*: Respondents are asked to indicate the number of (1) functional bicycles and (2) functional electronic bicycles in their household. These

[4] In German: [Land- und Forstwirtschaft, Fischerei; Warenherstellung, Bergbau, Energie-, Wasser-, Abfallversorgung; Baugewerbe/Bau; Handel, Verkehr, Lagerei, Gastgewerbe, Gastronomie; Information und Kommunikation; Erbringung von Finanz- und Versicherungsdienstleistungen; Grundstücks- und Wohnungswesen; Dienstleistungen (freiberuflich, wissenschaftlich, technisch, andere); Öffentliche Verwaltung, Verteidigung, Erziehung und Unterricht, Gesundheits- und Sozialwesen; anderer]

questions are also asked in 'Österreich unterwegs', albeit in a different context. However, the responses should be comparable.

- *Use of the smartphone for transport*: To determine how smartphone-savvy the respondent is in terms of urban mobility, they are asked to select for which modes of transport they usually use their smartphone in any capacity: {Car; bicycle; public transport; on foot; other}. This set of options extends the question asked in 'Österreich unterwegs' without jeopardising compatibility.

While the survey outlined above mostly follows Eurostat guidelines [Eur11], the German standard, guidelines for international standardisation [HZW19] and 'Österreich unterwegs' [THS+16], it contains some deviations from literature and examples. Such deviations were made when it was impossible or impractical to follow the guidelines to the letter, or when the guidelines stood in contradiction. Deviations within variables were explained in the variable description above. The following deviations concern variables not included in the survey:

- *Legal marital status* and *de facto marital status* [Eur11, HZW19] are not captured because it is not necessary to do so. None of the hypotheses in the literature reviewed for this thesis are directly linked to these variables, and they would bring no other additional information not already captured in the variable 'household composition'.

- The survey does not explicitly capture a respondent's *ethnicity*. Respondents are not asked to select their ethnicity from a pre-defined list as described in [HZW19, 883]. Therefore, the survey cannot capture whether respondents belong to an ethnic minority if it is not rooted in their migration status. This variable was omitted because there are no methodological guidelines for it in [Eur11] and recording it would put an additional burden on researchers because a data subject's ethnicity is regarded as a personal sensitive personal datum especially protected by Article 9 of the General Data Protection Regulation [GDP, Art. 9].

- *Net monthly income of respondent* [HZW19, 880] is not recorded because the variable 'net monthly household income' already describes the underlying concepts of financial well-being and real spending power.

- *Country of residence*, *region of residence* and *degree of urbanisation* [Eur11, 23ff] are not captured because they do not vary between respondents and can be derived from the location of the study when sharing data.

- *Status in employment* [Eur11, 36ff] can be partly derived from the variable 'self-declared labour status'. The resulting ambiguity of different statuses within employment is considered a trade-off for cutting one question from the survey.

5.2 The Proof-of-Concept Application

In order to show the viability of the policy-making procedure at the core of this thesis, it is necessary to show that it is possible to collect and analyse the data on which is relies. This section contains relevant details about the implementation of the proof-of-concept application. The development process was laid out in section 4.2. First, the application is described in regard to its functionality to collect data. Then, the application's data analysis functionality is described.

5.2.1 Data collection

As established earlier, the application is an HTTP web server written in Ruby on Rails. It allows customers to create surveys, building on the Rapidfire engine. When users fill in the survey from within the Bike Citizens smartphone application, their response is connected to their bicycle journeys recorded by Bike Citizens, or 'tracks', within the study period, using a unique, single-purpose token.

While the Rapidfire engine provides a solid foundation for realising the implementation, its components had to be extended to achieve all desired functionality. The way Rapidfire prefers this to be done is by using Ruby's `class_eval` method that is available on any Ruby class[5]. This method accepts a block of Ruby code and evaluates it in the context of the called class at runtime. In this case, this means that the passed attributes and methods are added to the class. These calls to `class_eval` are located in classes called like the class to be modified, with the suffix 'Decorator'. Placed in the appropriate folder, these decorator classes are automatically executed at the appropriate time. This pattern takes advantage of Ruby on Rails' 'convention over configuration' paradigm, meaning that no additional configuration is required as long as the classes are in the right place and have the right name. Even though this practice is not technically an implementation of the decorator pattern in object-oriented software development [ST02], it still enables achieving the desired outcome.

Data model

The application's data model is based on the Rapidfire survey engine. Customers (called 'Users' in the data model) can manage surveys that consist of multiple questions. Users (not represented in the model) can then create an attempt for a survey that consists of multiple answers, each related to a question of that survey. The complete data model of the application can be found in figure 5.1.

To enable integration with Bike Citizens, a survey stores information about a Bike Citizens campaign to enable the two to be connected. When a user creates an attempt from within the Bike Citizens smartphone application, a pseudonymised identifier token

[5] See Ruby documentation: https://ruby-doc.org/core-2.6.3/Module.html#method-i-class_eval

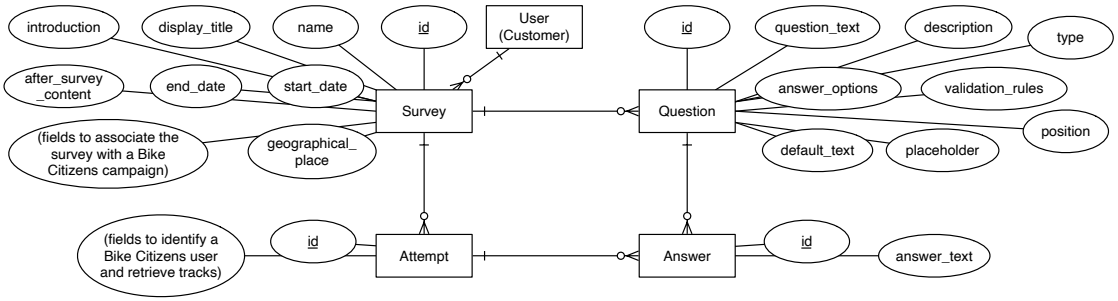

Figure 5.1: The entity-relationship diagram of the data model

is stored with the attempt to connect their answers with their tracks without revealing their identity.

Different question types are realised using inheritance from the `Question` model. In the `question` table of the database, the class name of the actual question subclass is saved in the field `type`. The available types are:

- Checkbox
- Date
- Long (a long text)
- Numeric
- Radio
- Select
- Short (a short text)

If required by the question type (checkbox, radio, select), answer options need to be provided (separated by line breaks). For questions with free-entry fields (date, long, numeric, short), a placeholder text can be specified. Questions also offer several validation options, which may be implemented differently depending on the question's type. Question answers can be validated for presence, for minimum and maximum length, and for being within a closed or half-closed interval[6].

The data model delivered by the Rapidfire survey engine had to be extended in multiple ways to enable the functionality set out in the requirements. First, the survey model had to be expanded. It needed to be associated with a customer in order to enable multi-tenant support. This enabled access control on the survey level, ensuring that only authorised customers can edit a survey and access data related to it. Also, fields had to

[6]This means that either a minimum value, a maximum value, or both can be specified. Comparisons happen with $\geq$ and $\leq$.

be added to tie a survey together with a campaign provided by Bike Citizens. Next, the survey's geographical place name had to be added, e.g. 'Wien' ('Vienna'), by which a user's tracks are selected. The survey also had to be expanded with a separate display title and a start and end date. Finally, the survey description and the text to be displayed after finishing the survey, which were conceptualised to contain longer, explanatory text, were extended to implement Rails' Action Text[7] component. Action Text allows for rich text to be edited, saved, and displayed, allowing advanced functionality such as the attachment of documents. To achieve this, the `SurveysController` and the `Survey` model with its corresponding table in the database, all provided by Rapidfire, had to be extended.

Second, the question model was extended with a description. This description allows survey creators to provide users with additional explanation of a question as well as instructions to fill it in, if necessary. To achieve this, the `Question` model with its corresponding table and the `QuestionForm` service provided by Rapidfire had to be extended.

Third, the attempt model had to be extended. Most importantly, it had to be expanded to save a pseudonymised token passed by Bike Citizens, uniquely identifying users and allowing access to their tracks. User tracks are never persisted in the application. Additionally, parameters further passed by Bike Citizens related to the user's context in their smartphone application are passed and stored. However, the application does not act on this information, therefore, they shall be disregarded in this thesis. For all this, Rapidfire's `AttemptsController`, `Attempt` model with its corresponding table, and `AttemptBuilder` service had to be extended.

User interface

The application provides two different interfaces for customers and users. Since the use cases with customers (UC1, UC3, UC4, UC5, UC6) as main actors are quite different from the one with users as main actors (UC2), the different interfaces have different requirements. Consequently, different designs are used.

Customers interact with the application to create and manage surveys. A customer is likely to spend multiple hours per survey interacting with the interfaces. Therefore, the customer priorities for the customer interface were to create a recognisable interface, present application elements in a structured way, and keep the design minimalistic and easy on the eye. To achieve this, the customer interface was based on the web design framework Bootstrap[8]. Bootstrap provides developers with an easy-to-implement grid system to structure elements on an HTML site and a plethora of built-in stylings that make sites look well-designed out-of-the-box. Recognisability is achieved with a navigation bar at the top of the site and by defining a custom primary and secondary colour for

[7] `https://edgeguides.rubyonrails.org/action_text_overview.html`

[8] urlhttps://getbootstrap.com. As mentioned previously, Bootstrap is released under the MIT licence (`https://getbootstrap.com/docs/4.6/about/license/`).

Bootstrap. The colours were taken from an old Puch Mistral bicycle and should transport this feeling of light and fast urban mobility to those who use it. The colours are presented in figure 5.2. The design of the customer interface be seen in figs. 5.3 to 5.6.

(a) The primary colour (b) The secondary colour

Figure 5.2: The colours of the customer interface

Users only interact with the application in a singular way: They view a survey page on a mobile device, fill in the questions, and expect a message indicating success or error after submitting the form. Since this user journey is quite different from the one of a customer, the requirements differ as well. Therefore, the focus was put on creating an interface that is easy to interact with on a mobile device. To this end, the designs of SurveyJS Library[9] (version 1.8.20) were applied on top of Bootstrap. SurveyJS is a powerful tool capable of generating and managing surveys, however, only the presentation aspect of the framework was used for this project.

Particular emphasis was placed on creating a good user experience in catching erroneous input. Luckily, the combination of Ruby on Rails, Bootstrap, and SurveyJS provide a good framework for catching and displaying input errors in a form. When the

[9] https://surveyjs.io/Overview/Library/. SurveyJS Library is released under the MIT licence (https://surveyjs.io/Licenses).

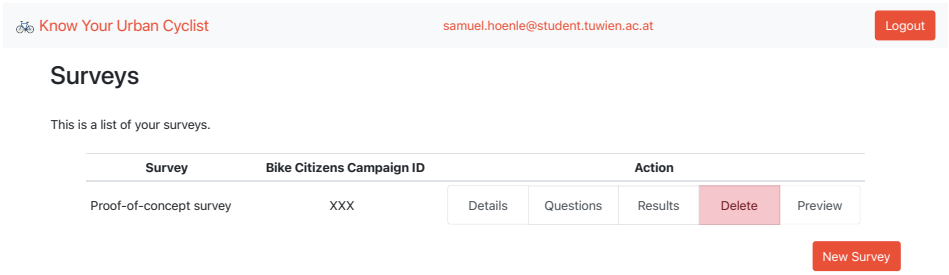

Figure 5.3: The list of surveys screen design

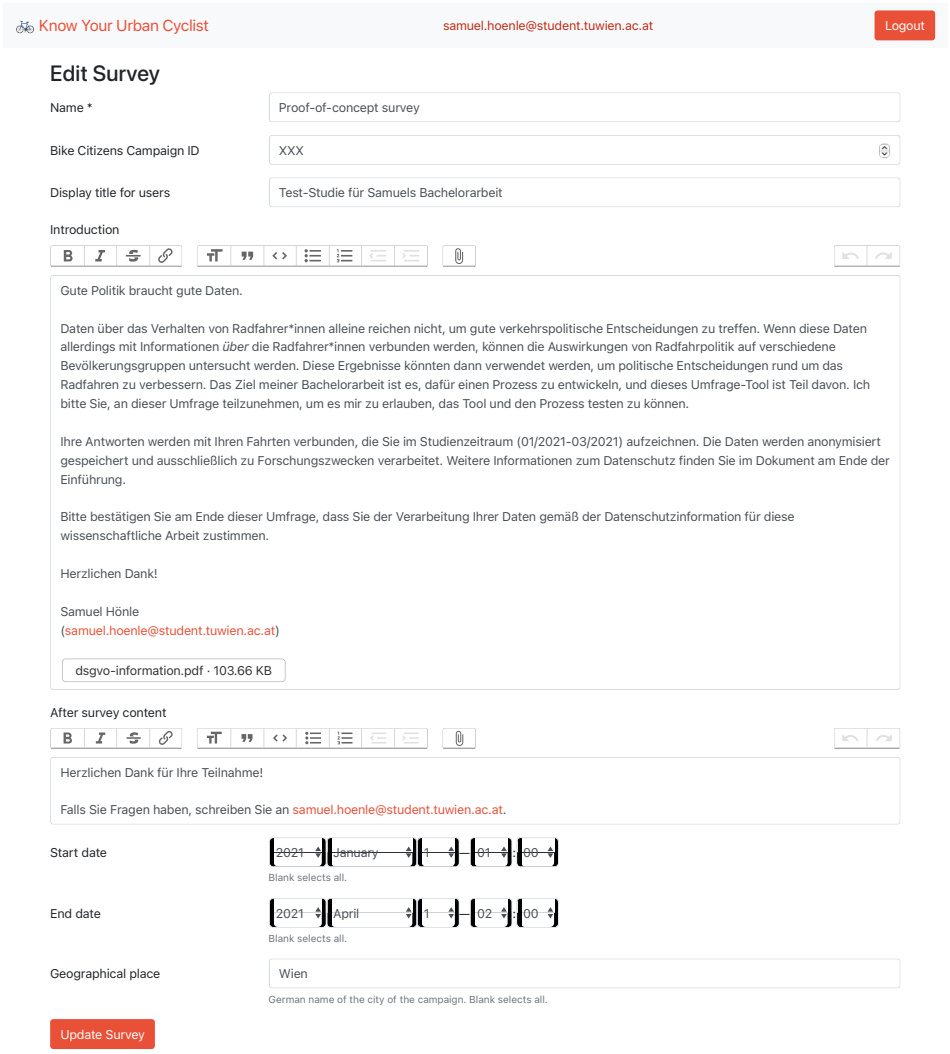

Figure 5.4: The edit survey screen design

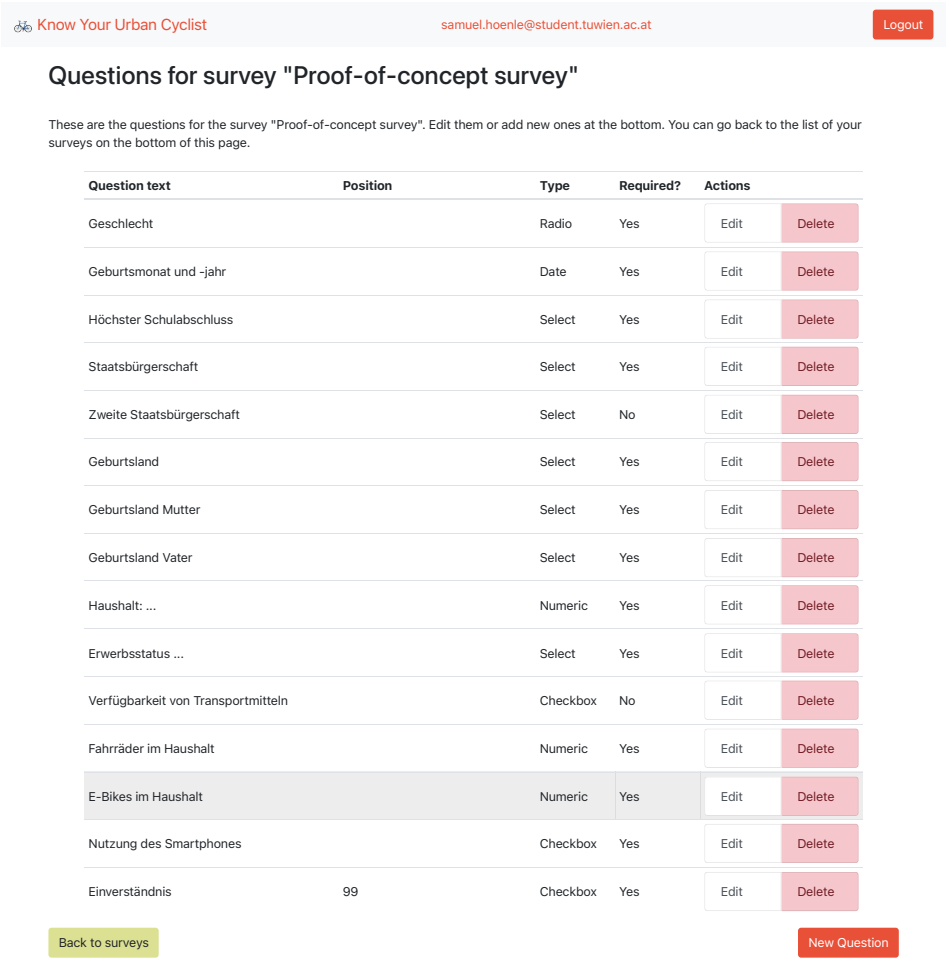

Figure 5.5: The list of questions screen design (some questions are omitted)

user submits the form, server-side validation is performed. If validation fails for at least one question, the form is redisplayed with the content initially submitted by the user, except for fields with errors. For text, numeric, and date inputs, fields with erroneous input are highlighted in red and error messages are displayed right next to the input field. For checkbox, radio, and select inputs, a list of errors related to the question is displayed above the question title.

A full export of the survey used in the proof-of-concept application can be found in appendix D. A sample of how the survey is displayed to the user within the Bike Citizens smartphone applications can be found in figure 5.7.

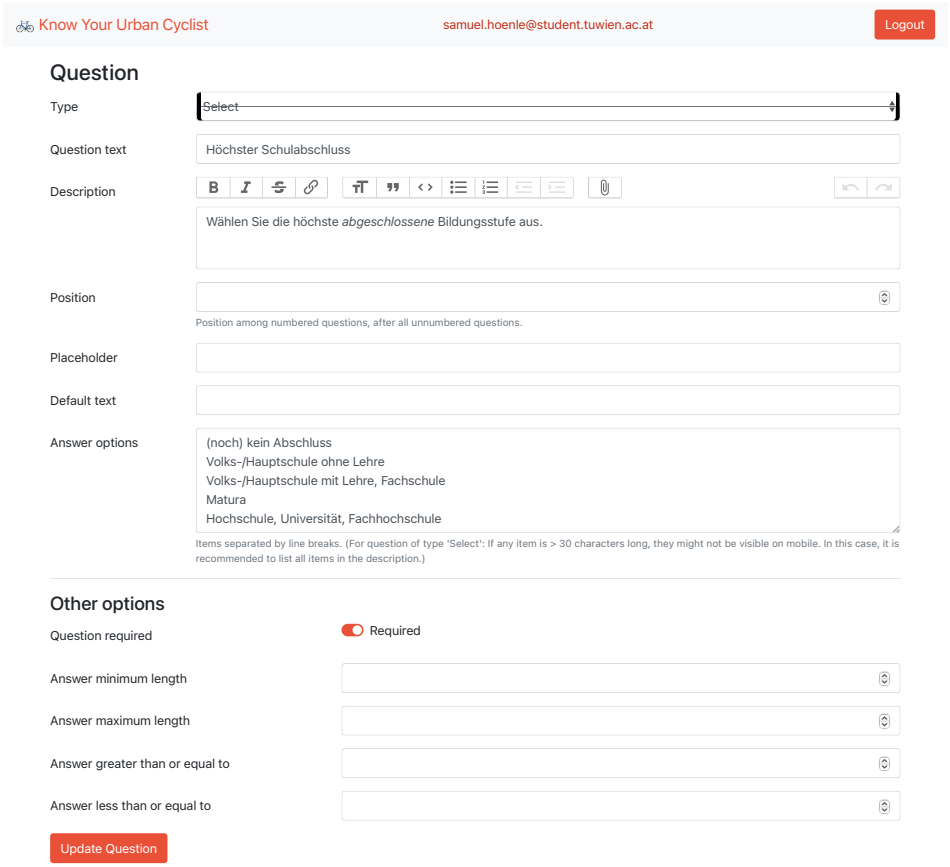

Figure 5.6: The edit question screen design

Routing

Due to the way the Bike Citizens smartphone application displays campaigns, it was necessary to differentiate between customer and user requests when requests to the application's root path are issued. The desired behaviour was that customers could visit the application's root path from their regular browser and be forwarded to their list of surveys if they are logged in, or to the login page if they are not. To enable users to view the survey from within the Bike Citizens smartphone application, which issues a request to the application's root path and passes several parameters, differentiated behaviour based on the request parameters had to be configured.

Specifically, an action `show_from_root` (controller methods are called 'actions' in Rails terminology) was added to Rapifire's `SurveysController`. This action was then tasked with handling any request issued to the root path of the application. If the request's parameters fulfil certain criteria, i.e. the request can be matched to a survey and carries a user token, the request is then forwarded to display the matched survey's user interface. If a user's response already exists in the database, the request is

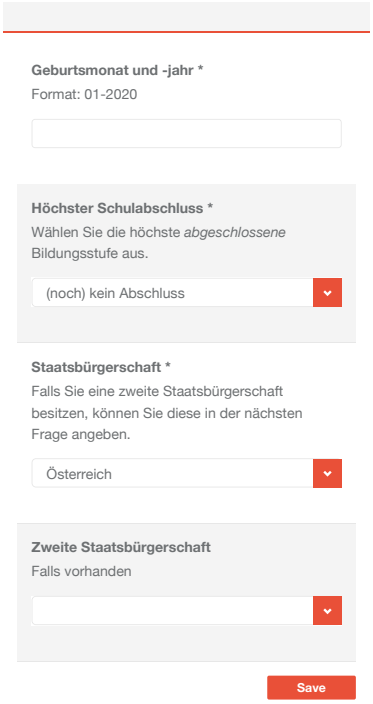

Figure 5.7: Displaying (part of) the survey on a mobile device

forwarded to display the survey's post-survey content. If the request parameters do not fulfil the criteria, e.g. because a customer's request is issued with no parameters at all, it is forwarded to the `index` action of `SurveysController`. Depending on whether a user is logged in, this action either displays the user's list of surveys or forwards the request to the login page. The implementation of this behaviour can be found as Ruby code in listing 1.

5.2.2 Data analysis

This application aims to provide insights into the data created by combining information gained from users' tracks with their response to socio-demographic surveys. As laid out before, use cases UC4, UC5, and UC6 are concerned with analysing the collected data. UC4 and UC5 call for the presentation of aggregate metrics, while UC6 calls for export functionality.

For users who have registered to the survey and consented to the experiment's privacy notice, tracks within the experiment's scope are available via an automated request from Bike Citizens. They consist of the following indicators: the track's start time, its end time, the distance covered in meters, the duration in seconds, the climb in meters, the descent in meters, and user-defined tags. While these variables do not allow for extremely finely grained data analysis, they do allow to compose metrics sufficient for the purpose of a proof-of-concept.

```ruby
class Controllers::Rapidfire::SurveysControllerDecorator
  Rapidfire::SurveysController.class_eval do
    def show_from_root
      if identify_survey_and_carry_user_token(params)
        survey = Rapidfire::Survey.find_by external_identifier:
        ↪  params[:external_identifier]
        if survey.attempts.exists?(user_token:
        ↪  params[:user_token])
          response = survey.attempts.find_by user_token:
          ↪  params[:user_token]
          redirect_to controller: "rapidfire/attempts", action:
          ↪  "show", id: response.id, survey_id: survey.id
        else
          redirect_to controller: "rapidfire/attempts", action:
          ↪  "new", survey_id: survey.id, params: params
        end
      else
        redirect_to controller: "rapidfire/surveys", action:
        ↪  "index"
      end
    end
  end
end
```

Listing 1: The controller action to handle routing from the application's root path

Let $\mathcal{R} = \{r_1, \ldots, r_n\}$, the set of all tracks (or 'records') recorded by all survey respondents within the study period in the defined geographical place. Then let an analysis set $R \subseteq \mathcal{R}$. Also, let s_r be the distance of track r in meters, and let t_r be the duration of track r in seconds. With this, the following metrics can be composed:

- S_R: The total distance of tracks in R

$$S_R = \sum_{r \in R} s_r \tag{5.1}$$

- T_R: The total duration of tracks in R

$$T_R = \sum_{r \in R} t_r \tag{5.2}$$

- $\bar{s}_R$: The average distance of tracks in R

$$\bar{s}_R = \frac{S_R}{|R|} \tag{5.3}$$

- $\bar{t}_R$: The average duration of tracks in R

$$\bar{t}_R = \frac{T_R}{|R|} \tag{5.4}$$

- $\bar{v}_R$: The average speed of tracks in R

$$\bar{v}_R = \frac{S_R}{T_R} \tag{5.5}$$

To process these values programmatically, they are handled in key-value analysis maps. Algorithm 5.1 shows how such an analysis map is constructed.

Algorithm 5.1: Analyse a track subset R

Input: A set of tracks R
Output: A result key-value map with the keys 'n_tracks', 'total_distance_meters', 'total_duration_seconds', 'avg_distance_meters', 'avg_duration_seconds', 'avg_speed_kmh'

$S_R \leftarrow 0$;
$T_R \leftarrow 0$;
$n \leftarrow 0$;
$res \leftarrow$ an empty key-value map;
foreach $r \in R$ **do**
    $n \leftarrow n + 1$;
    $S_R \leftarrow S_R + s_r$;
    $T_R \leftarrow T_R + t_r$;
end
res(n_tracks) $\leftarrow n$;
res(total_distance_meters) $\leftarrow S_R$;
res(total_duration_seconds) $\leftarrow T_R$;
res(avg_distance_meters) $\leftarrow S_R/n$;
res(avg_duration_seconds) $\leftarrow T_R/n$;
res(avg_speed_kmh) $\leftarrow 3.6 \times S_R/T_R$;
return *res;*

Filtering

UC5 requires that tracks can be filtered in order to compare different subsets of them. To achieve this, filters can be defined as a set of allowed answers for one or more questions. Tracks are then selected if they were recorded by a user whose answer to a question is one of the allowed ones (logical OR) for all filter questions (logical AND). Filters can also define start and end dates to filter tracks by date.

For a more detailed explanation of filtering, let

- $\mathcal{Q} = \{Q_1, \ldots, Q_n\}$, the set of all questions in the survey,
- $A_{Q_m} = \{a_{m1}, \ldots, a_{mn}\}$, the set of unique answers given by all users to question Q_m,
- b_{rn} be a concrete set of answers (since users can select multiple answers for at least one question type) to question Q_n provided by the user who recorded track r,
- and B_r be the set of sets of concrete answers provided by the user who recorded track r (5.6).

$$B_r = \{b_{rn} | r \in \mathcal{R} \wedge b_{rn} \subseteq A_{Q_n}]\} \tag{5.6}$$

Additionally, to allow filtering by time, let k be the start time of a track or a filter, and l be the end time of a track or a filter.

To now calculate metrics for a filter F containing subsets of selected answers for any number of questions[10]

$$F = \{f_1, \ldots, f_n | f_n \subseteq A_{Q_n}\} \tag{5.7}$$

let R_F be the analysis subset for F:

$$\begin{aligned} R_F &= \{r \in \mathcal{R} | (\forall f_n \in F\ \exists A'_{Q_n} \subseteq b_{rn} \setminus \emptyset)[A'_{Q_n} \subseteq f_n]\} \ \cap\ \{r \in \mathcal{R} | k_F \leq k_r \leq l_r \leq l_F\} \\ &= \{r \in \mathcal{R} | (\forall f_n \in F\ \exists x)[x \in b_{rn} \wedge x \in f_n] \wedge k_F \leq k_r \leq l_r \leq l_F\} \end{aligned} \tag{5.8}$$

In words: To be considered in the analysis subset for filter F, at least one of the answers associated with a track for a given question[11] must be included in F's set of selected answers for that question. This must be true for all questions that F has sets of selected answers for. Additionally, the track's start time must be after or equal to the start time set by the filter, and its end time must be before or equal to the end time set by the filter.

The subset of $\mathcal{R}$ obtained with this method can then be inserted into the equations for metrics defined above. This allows researchers to define and compare different population groups, using the socio-demographic survey, across different time periods.

[10] Note that a filter does not have to contain a set of selected answers for every question.

[11] Note that for most questions, the cardinality of the set of answers associated with a track for a given question will be 1, since most question types do not allow users to respond with multiple answers.

Display

To get an overview over the results, the metrics outlined before are displayed for every answer that has been given, for every question. This means that for every answer to a given question, all tracks of all users who responded with the same answer are analysed. Algorithm 5.2 shows an efficient way to fill a key-value analysis map that is then used in the view.

The data analysis component is located on a survey's results page. This page is kept in the general customer design and contains an overview of all results as well as a section to compare two filtered datasets side-by-side. Additionally, it contains download links to download the data as comma-separated values (CSV) file or Open Office XML spreadsheet that can also be read by Microsoft Excel (XLSX). The filtered data sets can also be sent to Bike Citizens for more in-depth analysis with the click of a button. Figure 5.8 shows the result page of the data by test subject of the proof-of-concept application, reduced to the questions of gender and education. A full printout of the test data results can be found in appendix G. The critical reader should keep in mind that the results are not representative and only serve the purpose of demonstrating the application's functioning.

Additional analysis with Bike Citizens

If customers want to analyse the data beyond the metrics provided in this application, they can send a filtered set of tracks to Bike Citizens for further analysis. Since Bike Citizens has much more information about every track than what is passed to this application, including exact locational information about the journey's trajectory, much more detailed analyses can be done. Using their powerful analysis tool, customers can for example inspect how many users in the filtered data set pass a given street, and in which frequency, or look at a heatmap of all tracks in the set. The tool can also be used to identify intersections with long waiting times for cyclists or streets that are more or less popular than predicted by Bike Citizens' routing service. This can point policy-makers to concrete opportunities for improvement. A more comprehensive introduction into Bike Citizens' analytics tool can be found at `https://cyclingdata.net`.

Export

As called for in UC6, the application shall have export functionality. This is implemented in the following way: The relation between a user's survey response, i.e. an attempt with all related answers, and a track is normalised into the first normal form (1NF). For survey answers, the text of the related question serves as column name. Therefore, a row in the export is composed of available information about a track combined with all answers comprising the survey response of the user who recorded that track.

The goal of the export functionality was to enable researchers to use the data for more sophisticated analysis methods beyond the metrics implemented in this proof-of-concept.

This data format, combined with the choice between CSV and XLSX file formats, enables this functionality.

5.3 Data Privacy

Personal data processing is regulated in the EU by the General Data Protection Regulation (GDPR, [GDP]). It regulates which type of personal data can be processed in what way and under which circumstances. The collection and processing of data for this thesis are, therefore, also regulated by the GDPR.

Even though the GDPR is a regulation and thus applies directly in all EU member states, it contains multiple provisions allowing member states to derive from it. One of the possible derogations, specified in Art. 89 GDPR [GDP], is related to the research use of data. § 7 of the Austrian data protection law (DSG, [DSG]) and the Austrian research organisation law (FOG, [FOG]) regulate how data can be used for research purposes in Austria.

Data for this thesis are collected in two ways. The first data source are the survey responses by the test subjects. In the survey, no data are inquired that can personally identify a respondent. All other personal data (gender, age, education, citizenship, country of birth, economic status) are pseudonymised. The second data source are tracks retrieved from Bike Citizens. Here, the *privacy by design* principle is applied. The token passed by Bike Citizens pseudonymised, i.e. only Bike Citizens can resolve a user identity from it. User tracks are never persisted on the system but always newly retrieved from Bike Citizens. No other information about the user can be retrieved. Data privacy considerations for this thesis are only concerned with transferring data between Bike Citizens and the proof-of-concept application. The legal basis for the collection of bicycle journeys lies in the domain of Bike Citizens.

Under GDPR, data processing requires a legal basis, such as the explicit consent of the data subject [GDP, Art. 4(11)]. Customers can include a required, non-pre-selected checkbox question in the survey to require data subjects to actively give consent by selecting it. However, independent of consent, § 80 of the Austrian university law (UG, [UG]) in connection with Art. 6 para. 1 lit. e GDPR [GDP] allows for the processing of data for Bachelor's theses independent of explicit consent.

Additionally, data subjects must be supplied with adequate information about the processing of their data and be made aware of their rights concerning their data [GDP, Art. 15-18] [GDP, Art. 13]. This is achieved by including a data protection notice document in the description of the survey. The document can be found in appendix F.

With this, all necessary precautions for the processing of data for this thesis have been taken. In accordance with Austrian law, the data collected for this thesis can now be stored for 30 years in an appropriate way [FOG, §2f para. 3].

5.4 Using the Software Tool Within the Proposed Framework

Within the process laid out in chapter 3, I propose that software tools like the one presented in this chapter be used to support evaluation. Working groups could collect socio-demographic data combined with locational data of bicycle journeys before and after a policy intervention. This would provide a basis for quantitative methods to evaluate the specific goals of the intervention. Examples of quantitative methods besides multivariate regression analysis that can be used with this kind of data are *regression discontinuity* (RD) and *difference-in-differences* (DiD) designs. RD designs on the one hand, first applied by [TC60], allow for the analysis of the impact of an intervention at a certain cut-off point. Subjects in close proximity to both sides of the cut-off point are then studied and compared. The assumption is that subjects in close proximity of the cut-off point behave similarly. Therefore, significant effects are most likely to be observed here [IL08, Gan10]. For example, if free helmets were given to everyone in a specific age group, researchers could closely study and compare the people born in a specific time span before and after the cut-off points for differences in cycling behaviour. DiD designs on the other hand are quasi-experimental, separating subjects into two groups with similar pre-intervention trends. One of the groups is then 'treated', and the difference in development of the groups over time is studied. Since the groups had similar trends before the intervention, the theory of DiD design claims that the difference can be causally attributed to the treatment. While causal claims based on RD design might be difficult to sustain, well-designed DiD analysis often provides a good basis for causal claims [Gan10]. The data produced by the software tool presented in this thesis are suitable for such designs.

Qualitative methods should complement such quantitative methods in order to understand not only *what* changes, but also *why*. While qualitative evaluation methods are not subject of this thesis, the data produced by the software tool can act as a basis of selecting subjects or methods for qualitative analysis.

Research question 2 was tackled by developing a proof-of-concept application that fulfils the requirements laid out in chapter 4. An evaluation of the application in chapter 5 shows that it fulfils the requirements laid out in detail in appendices A and B. Therefore, I consider research question 2 addressed.

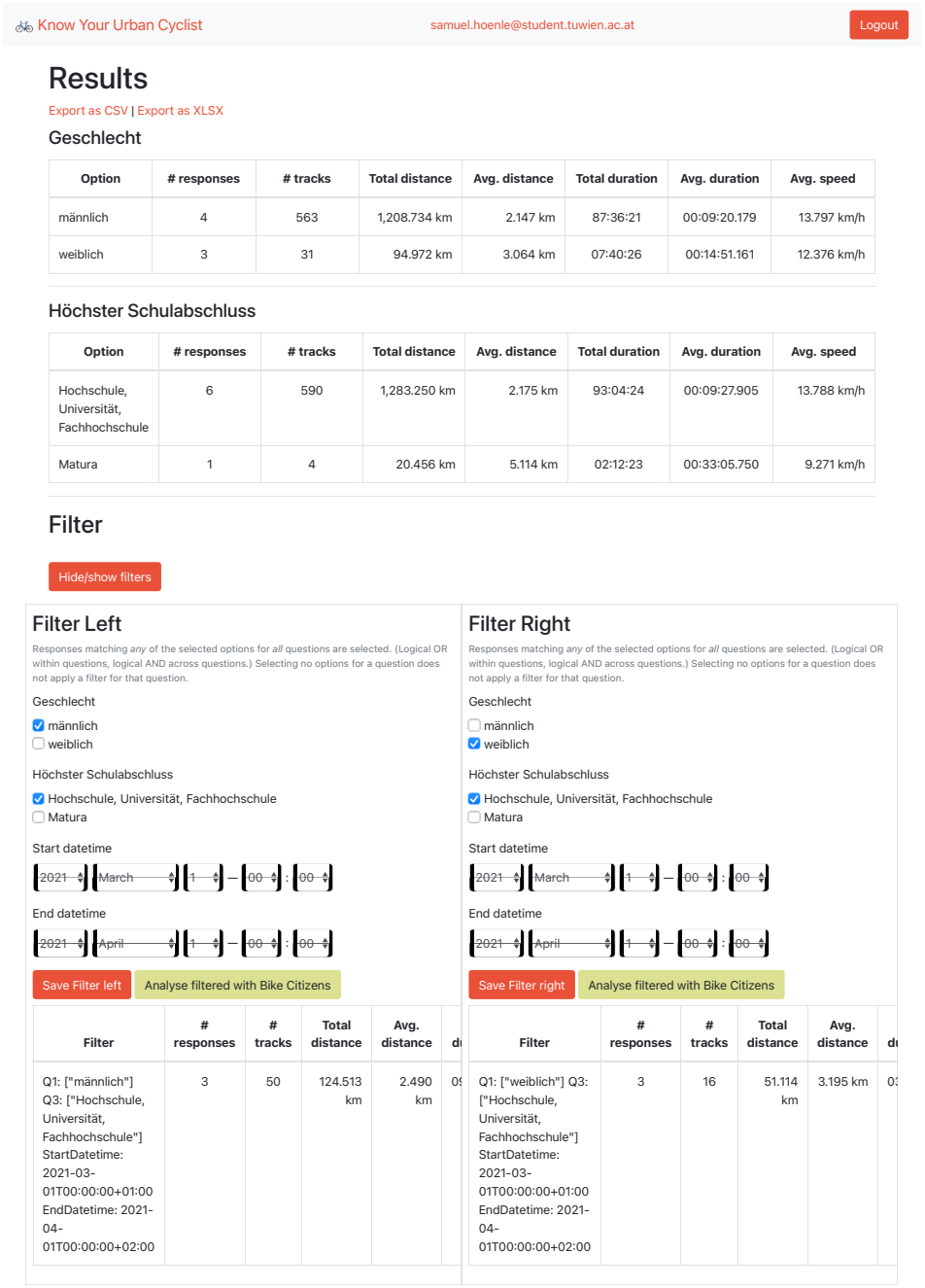

Figure 5.8: Displaying (part of) the results page of the survey with test data with filtering

Algorithm 5.2: Analyse all tracks, grouped by survey answer for each question

Input: The set $\mathcal{A} = \{A_{Q_1}, \ldots, A_{Q_n}\}$, the set of all given answers to all questions. The set $\mathcal{U} = \{U_1, \ldots, U_n | U_n \subseteq A_{Q_n}\}$, the set of all user responses, with $U_x = B_r$ if user x recorded track r.

Output: A nested key-value map, containing analysis key-value maps for all repsonses and for each answer given in the survey, grouped by question.

```
1  analysis ← an empty nested key-value analysis map;
2  per_record_keys ←
     ['n_tracks', 'total_distance_meters', 'total_duration_seconds', 'avg_distance_meters'];

3  foreach U ∈ 𝒰 do
4      u_res ← analyse track subset (algorithm 5.1) of set R_U ⊆ ℛ the set of all
         tracks related to the user response U;
5      if u_res(n_tracks) > 0 then
6          analysis(all)(n_responses) ← analysis(all)(n_responses) + 1;
7          foreach k ∈ per_record_keys do
8              analysis(all)(k) ← analysis(all)(k) + u_res(k);
9          end
10         foreach u ∈ U do
11             Q ← the question that u is an answer for;
12             foreach a ∈ A_Q do
13                 analysis(Q.id)(a.id)(n_responses) ←
                     analysis(Q.id)(a.id)(n_responses) + 1;
14                 foreach k ∈ per_record_keys do
                       analysis(Q.id)(a.id)(k) ← analysis(Q.id)(a.id)(k) + u_res(k);
15             end
16         end
17     end
18 end
19 S_all ← analysis(all)(total_distance_meters);
20 T_all ← analysis(all)(total_duration_seconds);
21 n_all ← analysis(all)(n_tracks);
22 analysis(all)(avg_distance_meters) ← S_all/n_all;
23 analysis(all)(avg_duration_seconds) ← T_all/n_all;
24 analysis(all)(avg_speed_kmh) ← 3.6 × S_all/T_all;
25 foreach A ∈ 𝒜 do
26     foreach a ∈ A do
27         S_a ← analysis(A.id)(a.id)(total_distance_meters);
28         T_a ← analysis(A.id)(a.id)(total_duration_seconds);
29         n_a ← analysis(A.id)(a.id)(n_tracks);
30         analysis(A.id)(a.id)(avg_distance_meters) ← S_a/n_a;
31         analysis(A.id)(a.id)(avg_duration_seconds) ← T_a/n_a;
32         analysis(A.id)(a.id)(avg_speed_kmh) ← 3.6 × S_a/T_a;
33     end
34 end
35 return analysis;
```

CHAPTER 6

Conclusion

This thesis commenced with an introduction to the topic of urban mobility and an explanation of its growing importance. A particular focus was put on environmental and public health considerations. The bicycle was presented as a key opportunity to combat problems stemming from urban transport. Smart City approaches to urban mobility policy were introduced as a way to act on this opportunity. For concrete proposals in this regard, a previous analysis of urban cycling policy processes in Vienna was consulted. These considerations resulted in the research questions addressed in the course of this thesis.

The first step of addressing the research questions was establishing a theoretical foundation. First, different understandings of the policy-making process were presented. It was noted that rational-linear models were criticised for failing to represent the complex, ambiguous, and irrational nature of the policy-making process. The multiple streams framework was highlighted as an alternative to take this complexity into account. Then, different aspects of evidence-based policy-making were laid out based on the established understanding of the policy-making process. A summary of research use typologies was followed by a discussion of different critiques of evidence-based policy-making. The potential pitfall of technocratisation and thus de-politicisation and de-democratisation was particularly emphasised, together with the necessity of integrating social science theory. After a short review of past approaches, proposals for effective future approaches were reviewed. Using evidence in theory-driven policy evaluation, and producing this evidence in research-policy partnerships, emerged as a promising strategy going forward. It was then established that socio-demographic factors influence mobility behaviour and needs, with a spotlight on feminist considerations. An overview of urban cycling theory concluded that *policy matters* by repeatedly demonstrating the pull-effect of good cycling infrastructure. The theoretical foundation was wrapped up by an introduction to Smart Cities and locational data collected with smartphones.

To address the first research question, I propose a framework for theory-driven evidence-based urban cycling policy evaluation employing research-policy partnerships. I provide guidelines for the composition of such a partnership and outlined its envisioned work. The partnership should serve the goal of bundling resources for better policy evaluation. Pilot projects should be implemented and evaluated in order to generate knowledge about what works for whom and under which circumstances. A core aspect of the proposed framework is the deep integration of social science theory, which must guide prioritisation, goal-setting, implementation, and evaluation. I make a point of not representing the proposed process as a graphical model to acknowledge the undrawable complexity inherent to all policy-making processes.

The second research question required a proof-of-concept application to be developed. First, the methodology behind the socio-demographic survey, which is part of the application, is laid out. The application's goal was to enable the collection of socio-demographic data and their combination with data about cycling journeys. These data are then envisioned to be utilised in policy evaluation processes like the one proposed in this thesis. The application was developed in close cooperation with a project partner, Bike Citizens, who provide one of the leading smartphone applications for urban cycling. Together with them, the requirements of the application were defined. Bike Citizens users can respond to a socio-demographic survey provided by the developed application, allowing that their cycling data be connected with their responses. After laying out the application's requirements, the development process is described, and an overview of the used technologies is given.

The proof-of-concept application was developed based on the defined requirements. First, a concrete socio-demographic survey was constructed. Second, the application itself was developed. For the data collection component, the spotlight was placed on the data model, the connection to the project partner, and the user interface. The data analysis component focused on filtering the data set as well as calculating and presenting metrics to showcase the functioning of the application. The application allows downloading the data for further analysis or requesting deeper insights from Bike Citizens. I conclude that the proof-of-concept application represents a viable data source for the previously outlined policy evaluation process.

Subsequently, this thesis opens up several avenues for further research. First and foremost, the proposed framework could be put to a test. Since it contains guidelines for multiple aspects within it, it would benefit from critical review and revision. An evaluation of an actual implementation would furthermore reveal critical information about its effectiveness under real-world conditions. The framework could also be extended with guidelines or recommendations for qualitative methods to be used for policy evaluation. Finally, the application developed for this thesis provides multiple extension points. For example, users could be asked to classify their journeys according to their purpose, which could represent a key variable in understanding mobility patterns. The application could also calculate more sophisticated metrics or be deeper integrated into existing analysis tools.

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Appendices

A Use Cases

Use Cases

Actors: Customer (City, Service Provider (Bike Citizens), User (Cyclist)

UC1: Create new study

Create New Study
Story: The Customer wants to study cycling traffic, maybe related to an upcoming policy change or infrastructure project. They want to collect cycling routes connected with additional information about the Users. To that end, they create a study to which Users can sign up and fill out a survey. All routes produced by Users participating in the study are associated with it to be analysed later. **Primary Actor:** Customer **Stakeholders & Interests List:** - Customer: Wants the process to be fast and intuitive - Service Provider: Wants data quality and integrity in the database and the Customer to be satisfied **Precondition:** The Customer is logged in. **Postcondition:** A study is saved in the database. **Success Scenario:** 1. The Customer takes action to create a new study (i.e. click a button). 2. The System displays a “new study” page. 3. The Customer enters basic information about the study: name, description, start of data collection phase, end of data collection phase. The Customer takes action to proceed to the next step. 4. The System saves the study and displays a page on which the study survey can be defined. 5. The Customer can specify the survey of the study: edit questions, define answer types, mark questions as required. The Customer takes action to save the study. 6. The System saves the study and displays a success message. **Extensions:** 5a. The Customer exits the edit page.

UC2: Sign up for study

Sign Up for Study

Story: A User wants / is recruited to participate in a study. They go to the campaign of the study and fill in the survey in order to participate.

Primary Actor: User

Stakeholders & Interests List:

- User: Has no direct benefit from signing up, wants the process to be as effortless as possible.
- Customer: Wants Users to respond as exactly and truthfully to the survey as possible.
- Service Provider: Wants to make sure the User understands the implications of participating in the study and provide them with a good experience.

Precondition: User is on the “Campaigns” view in the Bike Citizens app. The study is available for the User to sign up to.

Postcondition: The User's answers are recorded. The User is linked to the study as a participant. The study appears at the User’s “My campaigns”.

Success Scenario:

1. The User selects the study from a list of campaigns.
2. The System displays general information about the study, legal information about participating, and the study survey.
3. The User fills in the study survey, indicates that they have read and understood the legal information and continues.
4. The System saves the survey response and displays a success and “thank you” message.

Extensions:

7a. The User does not fill in the survey as required

1. The System re-displays the filled-in survey with an error message, marking the questions with errors.

UC3: Edit study

Edit Study
Story: A Customer has a study that they want to make changes to. They go to that study, make changes and save them. **Primary Actor:** Customer **Stakeholders & Interests List:** - Customer: Wants their study to reflect their wishes as closely as possible, even if they change over time. Also wants flexibility and error tolerance on their side. Wants high data quality. - Service Provider: Wants to provide a good experience to the Customer. Does not want changes in the study to result in database issues. **Precondition:** A study exists. Customer is logged in and has the rights to edit that study. **Postcondition:** Changes to the study are saved and appear to users. No database inconsistencies. **Success Scenario:** 1. The Customer selects the study from a list of studies and takes action to edit that study. 2. The System displays an “Edit” view of that study. 3. The Customer makes the changes and saves. 4. The System saves the changes to the database and displays a success message. **Extensions:** 3a. The Customer makes unpermitted changes. 1. The System does not save the changes and re-displays the edit view with hints to the Customer about which changes are not permitted.

UC4: Overview over all responses

Overview over all Responses
Story: Data has been collected within the context of a study. The Customer wants an overview over all provided answers including a variety of aggregate indicators (total trip length, total trip duration, average trip length, average trip duration, number of trips, average speed). **Primary Actor:** Customer **Stakeholders & Interests List:** - Customer: Wants to gain insights and understandable, presentable results they can use in planning processes. Wants a service that is fast and intuitive to use. - Service Provider: Wants to provide a good user experience for the Customer. **Precondition:** Customer is logged in and owns the study. **Postcondition:** The overview inquired by the Customer is displayed. **Success Scenario:** 1. The Customer selects study from an overview dashboard with a list of studies. 2. The System displays the results view of the study, on which results are grouped by responses and aggregate information per response is displayed. **Extensions:** –

UC5: Filter and compare

Filter and Compare
Story: Data has been collected within the context of a study. The Customer who owns the study wants to analyse the difference in cycling behaviour between time periods, i.e. between dates, and between user groups, i.e. according to their survey answers. The Customer wants to analyse a variety of aggregate indicators (total trip length, total trip duration, average trip length, average trip duration, number of trips, average speed) and may want to further analyse a filtered response set using the Customer's analysis software (behaviour according to time of day, behaviour on weekdays/weekends, waiting periods, maximum speed, purpose of trip, …). **Primary Actor:** Customer **Stakeholders & Interests List:** - Customer: Wants to gain insights and understandable, presentable results they can use in planning processes. Wants a service that is fast and intuitive to use. - Service Provider: Wants to provide a good user experience for the Customer. **Precondition:** Customer is logged in and owns the study. Customer views a study's result overview page. **Postcondition:** The information inquired by the Customer is displayed. **Success Scenario:** 1. The Customer navigates to the "Filter and Compare" section of the results page. 2. The Customer filters the data in one or two result panels by: a. Date (define a time frame) b. User-related survey response 3. The System filters the results according to the Customer's selection and displays aggregate indicators for the filtered result set(s) only (total trip length, total trip duration, average trip length, average trip duration, number of trips, average speed). **Extensions:** 4. The Customer forwards the filtered result set to the Service Provider for further analysis.

UC6: Download data as spreadsheet

Download Data as Spreadsheet
Story: The Customer wants to get access to the raw, disaggregated data, to perform their own analysis. To be able to do this, the Customer wants to download the data in a spreadsheet format (.csv, .xlsx) that can be read by other data analysis software. The data must be anonymous and must not contain information uniquely identifying any User. **Primary Actor:** Customer **Stakeholders & Interests List:** - Customer: Wants to get lower-level access to data provided by the study. - User: Wants their data privacy rights to be protected. **Precondition:** Customer is logged in and owns the study. Customer views a study's result overview page. **Postcondition:** A file has been offered for download containing a row with information (start time, end time, distance, elevation changes, speed, … but no location data) for each recorded track of a survey respondent, including their survey response. **Success Scenario:** 1. The Customer selects their preferred file format and starts the download with the click of a button. 2. The System offers the requested file for download. **Extensions:** –

B User Stories & Epics

ID	UC ID	Epic ID	User Story	Priority	Status	Comment
US1	-	E6	As a Customer, I can log in.	MUST	✓	
US2	UC1, UC3	E1	As a Customer, I can view a list of my studies in the study management backend.	MUST	✓	
US3	UC1	E1	As a Customer, I can create a new study.	MUST	✓	
US4	UC1, UC3	E1	As a Customer, I can edit basic information of a study (name, description).	MUST	✓	
US5	UC1, UC3	E1	As a Customer, I can edit the start and end date of registration for the study, so that data collected in the study period is comparable.	SHOULD	×	
US6	UC1, UC3	E1	As a Customer, I can edit the start and end date of the study period.	SHOULD	✓	
US7	UC1, UC3	E1	As a Customer, I can set an event marker on a day during the study period, so that important dates in my study are noted and can be used for analysis.	SHOULD	×	
US8	UC1, UC3	E1	As a Customer, I can edit the status of a study. (Inactive, Beta, Actice, Closed)	SHOULD	×	
US9	UC1	E7	As a Service Provider, I can define a default survey for new studies, so that study results are comparable.	CAN	×	
US10	UC1, UC3	E1	As a Customer, I can edit the survey of my study (order, question text, question type, anwer options, add/remove questions, required?)	MUST	✓	
US11	UC2	E2	As a User, I can get information about a study before signing up.	MUST	✓	
US12	UC2	E2	As a Customer, I can require Users to agree to the T&C of a study during signing up, so that I'm legally safe and allowed to use the collected data.	MUST	~	as survey question
US13	UC2	E2	As a User, I can fill in the study survey quickly, so that it is easy for me to provide accurate information.	MUST	✓	
US14	UC2	E2	As a User, I can view a list of present studies that I participate(d) in, so that I can get information about them.	MUST	BC domain	
US15	UC2	E8	As a Customer, I can reject incomplete or bad survey responses, so that data integrity and quality is ensured.	MUST	✓	
US16	UC3	E8	As a Service Provider, I can limit the kinds of changes that a Customer can make to a study depending on its status, so that data integrity and quality is ensured.	SHOULD	×	
US17	UC4		As a Customer, I can view a list of my studies in the analysis backend.	MUST	✓	
US18	UC4	E4	As a Customer, I can get an overview over data of a study (survey responses and recorded journeys) and look into it exploratively.	MUST	✓	
US19	UC5	E3	Aa a Customer, I can filter data by date.	MUST	✓	
US20	UC5	E3	Aa a Customer, I can filter data by users' answers to survey questions.	MUST	✓	
US21	UC5	E3	Aa a Customer, I can filter data by trip-related information.	CAN	×	
US22	-	E1	As a Customer, I can define questions that Users participating in my study should answer for each trip.	CAN	×	
US23	UC4, UC5	E4, E5	As a Customer, I can analyse data regarding trip length.	MUST	✓	
US24	UC4, UC5	E4, E5	As a Customer, I can analyse data regarding trip duration.	MUST	✓	
US25	UC4, UC5	E4, E5	As a Customer, I can analyse data regarding behaviour according to time of day.	SHOULD	✓	send to BC Analytics
US26	UC4, UC5	E4, E5	As a Customer, I can analyse data regarding behaviour on weekdays/weekends.	SHOULD	✓	send to BC Analytics
US27	UC4, UC5	E4, E5	As a Customer, I can analyse data regarding number of trips.	MUST	✓	
US28	UC4, UC5	E4, E5	As a Customer, I can analyse data regarding waiting periods.	SHOULD	✓	send to BC Analytics
US29	UC4, UC5	E4, E5	As a Customer, I can analyse data regarding speed.	MUST	✓	
US30	UC4, UC5	E4, E5	As a Customer, I can analyse data regarding indicators related to trip-related survey responses.	CAN	×	
US31	UC5	E5	As a Customer, I can define two data filters in a "Compare" mode.	MUST	✓	
US40	UC5	E3	As a Customer, I can save a filter configuration for fast future access.	CAN	×	
US41	-	E6	As a Customer, I can edit basic information about my account.	MUST	✓	
US42	-	E2	As a User, I can log a trip, so that my trip is recorded for the study.	MUST	BC domain	
US43	-	E2	As a User, I can answer a trip-related survey when recording a trip, so that additional information about my trip is collected.	SHOULD	BC domain	
US44	UC1	E7	As a Service Provider, I can define multiple default surveys for different kinds of studies, so that Customers can choose between them.	CAN	×	
US45	UC1	E7	As a Customer, I can define custom default surveys for my own studies.	CAN	×	
US46	UC6	E3	As a Customer, I can download an export of my study data (trips connected to survey responses) in a convenient file format.	MUST	✓	
US47	UC3	E1	As a Customer, I can delete a study and all the data that belongs to it.	MUST	✓	
US49	UC4	E4	As a Customer, I can view my study data in an analysis UI.	SHOULD	✓	send to BC Analytics
US50	-		As a User, I can view a list of past studies that I participate(d) in, so that I can get information about them.	SHOULD	BC domain	
US51	-		As a Service Provider, I can use a management account to manage Customers' surveys, including assigning campaign IDs.	CAN	×	

ID	*Epic*
E1	As a Customer, I can manage my studies.
E2	As a User, I can participate in studies.
E3	As a Customer, I can filter data for analysis.
E4	As a Customer, I can analyse my studies exploratively.
E5	As a Customer, I can analyse my studies comparatively.
E6	As a Customer, I can use and manage my account.
E7	As a Service Provider, I can encourage standardisation across studies.
E8	As a Service Provider, I can ensure data integrity and quality.

Milestones

Date	Titel	Description
30/10/2020	Requirements defined	The project's requirements are formulated and accepted by the project partners.
06/11/2020	Survey created	The survey for collecting additional socio-demographic context data about users is finished.
18/12/2020	Data collection tool developed	The data collection component is developed based on its requirements and modelling and is functional.
19/12/2020	Start Testing	The test phase of the data collection component begins with selected test subjects.
12/02/2021	Analysis tool developed	The data analysis component is developed based on its requirements and modelling and is functional.
12/03/2021	End Testing	The test phase of the data collection component is concluded and the data can be analysed using the data analysis component.

D Survey

Test-Studie für Samuels Bachelorarbeit

Gute Politik braucht gute Daten.

Daten über das Verhalten von Radfahrer*innen alleine reichen nicht, um gute verkehrspolitische Entscheidungen zu treffen. Wenn diese Daten allerdings mit Informationen *über* die Radfahrer*innen verbunden werden, können die Auswirkungen von Radfahrpolitik auf verschiedene Bevölkerungsgruppen untersucht werden. Diese Ergebnisse könnten dann verwendet werden, um politische Entscheidungen rund um das Radfahren zu verbessern. Das Ziel meiner Bachelorarbeit ist es, dafür einen Prozess zu entwickeln, und dieses Umfrage-Tool ist Teil davon. Ich bitte Sie, an dieser Umfrage teilzunehmen, um es mir zu erlauben, das Tool und den Prozess testen zu können.

Ihre Antworten werden mit Ihren Fahrten verbunden, die Sie im Studienzeitraum (01/2021-03/2021) aufzeichnen. Die Daten werden anonymisiert gespeichert und ausschließlich zu Forschungszwecken verarbeitet. Weitere Informationen zum Datenschutz finden Sie im Dokument am Ende der Einführung.

Bitte bestätigen Sie am Ende dieser Umfrage, dass Sie der Verarbeitung Ihrer Daten gemäß der Datenschutzinformation für diese wissenschaftliche Arbeit zustimmen.

Herzlichen Dank!

Samuel Hönle
(samuel.hoenle@student.tuwien.ac.at)

dsgvo-information.pdf · 104 KB

Geschlecht *

- ○ männlich
- ○ weiblich
- ○ anderes

Geburtsmonat und -jahr *

Format: 01-2020

Höchster Schulabschluss *

Wählen Sie die höchste *abgeschlossene* Bildungsstufe aus.

(noch) kein Abschluss

Staatsbürgerschaft *

Falls Sie eine zweite Staatsbürgerschaft besitzen, können Sie diese in der nächsten Frage angeben.

Österreich

Zweite Staatsbürgerschaft

Falls vorhanden

Geburtsland *

Das Land, in dem Sie geboren wurden. Falls unbekannt, bitte "unbekannt" auswählen (unterste Option).

Österreich

Geburtsland Mutter *

Das Geburtsland Ihrer Mutter. Falls unbekannt, bitte "unbekannt" auswählen (unterste Option).

Österreich

Geburtsland Vater *

Das Geburtsland Ihres Vaters. Falls unbekannt, bitte "unbekannt" auswählen (unterste Option).

Österreich

Haushalt: Anzahl Personen 0-4 Jahre *

Anzahl der Personen in Ihrem Haushalt, die bis inklusive 4 Jahre alt sind. Mit "Haushalt" ist die Menge der Personen gemeint, die üblicherweise mit Ihnen zusammen leben.

Haushalt: Anzahl Personen 5-24 Jahre *

Anzahl der Personen in Ihrem Haushalt, die 5 bis inklusive 24 Jahre alt sind.

Haushalt: Anteil jener Personen (5-24 Jahre) in Ausbildung *

Anzahl jener Personen von 5 bis inklusive 24 Jahren (vorherige Frage), die sich in Ausbildung befinden.

Haushalt: Anzahl Personen 25-64 Jahre *

Anzahl der Personen in Ihrem Haushalt, die 25 bis inklusive 64 Jahre alt sind.

Haushalt: Anzahl Personen über 65 Jahre *

Anzahl der Personen in Ihrem Haushalt, die 65 Jahre oder älter sind.

Haushalt: Kategorie *

Bitte ordnen Sie Ihren Haushalt einer dieser Kategorien zu.

Ein-Personen-Haushalt

Haushalt: Anzahl erwerbstätige Personen *

Anzahl der Personen in Ihrem Haushalt, die gerade eine auf wirtschaftlichen Erwerb gerichtete Tätigkeit ausüben. Dazu zählen auch Selbstständige und geringfügig beschäftigte Personen.

Haushalt: Anzahl nicht-erwerbstätige Personen *

Anzahl der Personen in Ihrem Haushalt zwischen 16 bis inklusive 64 Jahre, die gerade keiner auf wirtschaftlichen Erwerb ausgelegten Tätigkeit nachgehen. Dazu zählen etwa nicht-arbeitende Personen in Ausbildung, Personen im Ruhestand, oder Arbeitslose.

Erwerbsstatus *

Bitte ordnen Sie sich selbst einer dieser Kategorien zu.

erwerbstätig (Vollzeit)

Berufsgruppe

Falls Sie erwerbstätig sind, bitte wählen Sie Ihre Berufsgruppe aus. Die Optionen sind:

- Führungskräfte
- Akademische Berufe
- Techniker und gleichrangige nichttechnische Berufe
- Bürokräfte und verwandte Berufe
- Dienstleistungsberufe und Verkäufer
- Fachkräfte in der Landwirtschaft und Fischerei
- Handwerks- und verwandte Berufe
- Anlagen- und Maschinenbediener und Montageberufe
- Hilfsarbeitskräfte
- Angehörige der regulären Streitkräfte

Falls Sie sich nicht intuitiv einer Gruppe zuordnen können, finden Sie hier eine Aufschlüsselung der Gruppen mit Untergruppen und genaueren Berufsbezeichnungen (ab Seite 2).

Wirtschaftszweig

Falls Sie erwerbstätig sind, bitte wählen Sie Ihren Wirtschaftszweig aus. Die Optionen sind:

- Land- und Forstwirtschaft, Fischerei
- Warenherstellung, Bergbau, Energie-, Wasser-, Abfallversorgung
- Baugewerbe/Bau
- Handel, Verkehr, Lagerei, Gastgewerbe, Gastronomie
- Information und Kommunikation
- Erbringung von Finanz- und Versicherungsdienstleistungen
- Grundstücks- und Wohnungswesen
- Dienstleistungen (freiberuflich, wissenschaftlich, technisch, andere)
- Öffentliche Verwaltung, Verteidigung, Erziehung und Unterricht, Gesundheits- und Sozialwesen
- anderer

Monatliches Netto-Haushaltseinkommen *

Gefragt ist das **monatliche Netto-Einkommen** Ihres **gesamten Haushalts**. Zählen Sie alle Arten von Einkommen zusammen. Wenn Sie sich nicht sicher sind, schätzen Sie.

unter € 1.250

Arbeitsplatz

Bitte wählen Sie Eigenschaften, die auf Ihren Arbeitsplatz zutreffen.

- [ ] flexible Arbeitzeiten

- [ ] Möglichkeit zum Homeoffice

Verfügbarkeit von Transportmitteln

Bitte wählen Sie alle Transportmittel aus, die ihnen **üblicherweise** zur Verfügung stehen (z. B. durch Eigentum, regelmäßige Mitverwendung, Besitz eines Zeit-Tickets, bestehender Account, …)

- [ ] Fahrrad
- [ ] Öffentliche Verkehrsmittel
- [ ] E-Bike
- [ ] Fahrrad-Sharing-Dienst
- [ ] Motorrad
- [ ] Motorrad-Sharing-Dienst
- [ ] E-Scooter
- [ ] E-Scooter-Sharing-Dienst
- [ ] Auto
- [ ] Car-Sharing-Dienst

Fahrräder im Haushalt *

Bitte geben Sie die Anzahl der funktionstüchtigen Fahrräder (inkl. E-Bikes) in Ihrem Haushalt an.

E-Bikes im Haushalt *

Bitte geben Sie die Anzahl der funktionstüchtigen E-Bikes in Ihrem Haushalt an.

Nutzung des Smartphones *

Für welche Verkehrsmittel nutzen Sie das Smartphone, um sich über Routen, Verbindungen, Zeiten oder anderes bei Ihren Wegen zu informieren – egal ob vorab oder unterwegs?

- [ ] Fahrrad
- [ ] Öffentlicher Verkehr
- [ ] zu Fuß
- [ ] Auto
- [ ] andere
- [ ] keine

Einverständnis *

- [ ] Hiermit stimme ich der Verarbeitung meiner Daten für diese wissenschaftliche Arbeit gemäß der Datenschutzinformation zu.

Save

E Survey as JSON


```
{
  "name":"Proof-of-concept survey",
  "introduction":{
    "name":"introduction",
    "body":"<div>Gute Politik braucht gute Daten.<br><br>Daten über das Verhalten von
    ↪ Radfahrer*innen alleine reichen nicht, um gute verkehrspolitische
    ↪ Entscheidungen zu treffen. Wenn diese Daten allerdings mit Informationen
    ↪ <em>über</em> die Radfahrer*innen verbunden werden, können die Auswirkungen von
    ↪ Radfahrpolitik auf verschiedene Bevölkerungsgruppen untersucht werden. Diese
    ↪ Ergebnisse könnten dann verwendet werden, um politische Entscheidungen rund um
    ↪ das Radfahren zu verbessern. Das Ziel meiner Bachelorarbeit ist es, dafür einen
    ↪ Prozess zu entwickeln, und dieses Umfrage-Tool ist Teil davon. Ich bitte Sie,
    ↪ an dieser Umfrage teilzunehmen, um es mir zu erlauben, das Tool und den Prozess
    ↪ testen zu können.<br><br>Ihre Antworten werden mit Ihren Fahrten verbunden, die
    ↪ Sie im Studienzeitraum (01/2021-03/2021) aufzeichnen. Die Daten werden
    ↪ anonymisiert gespeichert und ausschließlich zu Forschungszwecken verarbeitet.
    ↪ Weitere Informationen zum Datenschutz finden Sie im Dokument am Ende der
    ↪ Einführung.<br><br>Bitte bestätigen Sie am Ende dieser Umfrage, dass Sie der
    ↪ Verarbeitung Ihrer Daten gemäß der Datenschutzinformation für diese
    ↪ wissenschaftliche Arbeit zustimmen.<br><br>Herzlichen Dank!<br><br>Samuel
    ↪ Hönle<br>(<a href=\"mailto:samuel.hoenle@student.tuwien.ac.at
    ↪ \">samuel.hoenle@student.tuwien.ac.at</a>)<br><br><action-text-attachment
    ↪ sgid=\"XXX\" content-type=\"application/pdf\"
    ↪ url=\"https://the-domain.com/.../dsgvo-information.pdf\"
    ↪ filename=\"dsgvo-information.pdf\"
    ↪ filesize=\"106148\"></action-text-attachment></div>"
  },
  "after_survey_content":{
    "name":"after_survey_content",
    "body":"<div>Herzlichen Dank für Ihre Teilnahme!<br><br>Falls Sie Fragen haben,
    ↪ schreiben Sie an <a href=\"mailto:samuel.hoenle@student.tuwien.ac.at
    ↪ \">samuel.hoenle@student.tuwien.ac.at</a>.</div>"
  },
  "display_title":"Test-Studie für Samuels Bachelorarbeit",
  "start_date":"2021-01-01T01:00:00.000+01:00",
  "end_date":"2021-04-01T02:00:00.000+02:00",
  "geographical_place":"Wien",
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      }
    },
    {
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      "default_text":"",
```

```
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      "answer_options":"",
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        "body":"<div>Format: 01-2020</div>"
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      "default_text":"",
      "placeholder":"",
      "position":null,
      "answer_options":"(noch) kein Abschluss\r\nVolks-/Hauptschule ohne
      ↪  Lehre\r\nVolks-/Hauptschule mit Lehre, Fachschule\r\nMatura\r\nHochschule,
      ↪  Universität, Fachhochschule",
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        "less_than_or_equal_to":""
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      "description":{
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        "body":"<div>Wählen Sie die höchste <em>abgeschlossene</em> Bildungsstufe
        ↪  aus.</div>"
      }
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        ↪  diese in der nächsten Frage angeben.</div>"
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      }
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      "answer_options":"List of all countries + option \"unbekannt\"",
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        "maximum":"",
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        "less_than_or_equal_to":""
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        "body":"<div>Das Land, in dem Sie geboren wurden. Falls unbekannt, bitte
        ↪  \"unbekannt\" auswählen (unterste Option).</div>"
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    },
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```

```
      "description":{
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        ↪  auswählen (unterste Option).</div>"
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        "body":"<div>Anzahl der Personen in Ihrem Haushalt, die bis inklusive 4 Jahre
        ↪  alt sind. Mit \"Haushalt\" ist die Menge der Personen gemeint, die
        ↪  üblicherweise mit Ihnen zusammen leben.</div>"
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    },
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      "position":null,
      "answer_options":"",
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      "description":{
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        "body":"<div>Anzahl der Personen in Ihrem Haushalt, die 5 bis inklusive 24
        ↪  Jahre alt sind.</div>"
      }
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      "question_text":"Haushalt: Anteil jener Personen (5-24 Jahre) in Ausbildung",
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      "answer_options":"",
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        "less_than_or_equal_to":""
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      "description":{
        "name":"description",
        "body":"<div>Anzahl jener Personen von 5 bis inklusive 24 Jahren (vorherige
        ↪  Frage), die sich in Ausbildung befinden.</div>"
```

```
    }
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    "description":{
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      "body":"<div>Anzahl der Personen in Ihrem Haushalt, die 25 bis inklusive 64
      ↪  Jahre alt sind.</div>"
    }
  },
  {
    "question_text":"Haushalt: Anzahl Personen über 65 Jahre",
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    "placeholder":"",
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    "answer_options":"",
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      "maximum":"",
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      "less_than_or_equal_to":""
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    "description":{
      "name":"description",
      "body":"<div>Anzahl der Personen in Ihrem Haushalt, die 65 Jahre oder älter
      ↪  sind.</div>"
    }
  },
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    "placeholder":"",
    "position":null,
    "answer_options":"Ein-Personen-Haushalt\r\nAlleinerziehende*r mit Kind(ern) < 25
    ↪  Jahre\r\nPaar ohne Kind(er) < 25 Jahre\r\nPaar mit Kind(ern) < 25
    ↪  Jahre\r\nPaar/Alleinerziehende*r mit Kind(ern) < 25 Jahre und anderen
    ↪  Personen\r\nAndere",
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    },
    "description":{
      "name":"description",
      "body":"<div>Bitte ordnen Sie Ihren Haushalt einer dieser Kategorien zu.</div>"
    }
  },
  {
```

```
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      "default_text":"",
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      "answer_options":"",
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        "maximum":"",
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        "less_than_or_equal_to":""
      },
      "description":{
        "name":"description",
        "body":"<div>Anzahl der Personen in Ihrem Haushalt, die gerade eine auf
        ↪  wirtschaftlichen Erwerb gerichtete Tätigkeit ausüben. Dazu zählen auch
        ↪  Selbstständige und geringfügig beschäftigte Personen.</div>"
      }
    },
    {
      "question_text":"Haushalt: Anzahl nicht-erwerbstätige Personen",
      "default_text":"",
      "placeholder":"",
      "position":null,
      "answer_options":"",
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        "maximum":"",
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        "less_than_or_equal_to":""
      },
      "description":{
        "name":"description",
        "body":"<div>Anzahl der Personen in Ihrem Haushalt zwischen 16 bis inklusive 64
        ↪  Jahre, die gerade keiner auf wirtschaftlichen Erwerb ausgelegten Tätigkeit
        ↪  nachgehen. Dazu zählen etwa nicht-arbeitende Personen in Ausbildung,
        ↪  Personen im Ruhestand, oder Arbeitslose.</div>"
      }
    },
    {
      "question_text":"Erwerbsstatus",
      "default_text":"",
      "placeholder":"",
      "position":null,
      "answer_options":"erwerbstätig (Vollzeit)\r\nerwerbstätig
      ↪  (Teilzeit)\r\nselbstständig\r\nausschließlich im Haushalt tätig\r\nin
      ↪  Karenz\r\narbeitslos\r\nin Ausbildung\r\nim Ruhestand\r\ndauerhaft
      ↪  arbeitsunfähig\r\nim Militär-/Zivildienst\r\nanderes",
      "validation_rules":{
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      "description":{
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        "body":"<div>Bitte ordnen Sie sich selbst einer dieser Kategorien zu.</div>"
      }
    },
    {
```

```
      "question_text":"Berufsgruppe",
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      "placeholder":"",
      "position":null,
      "answer_options":"Führungskräfte\r\nAkademische Berufe\r\nTechniker und
      ↪  gleichrangige nichttechnische Berufe\r\nBürokräfte und verwandte
      ↪  Berufe\r\nDienstleistungsberufe und Verkäufer\r\nFachkräfte in der
      ↪  Landwirtschaft und Fischerei\r\nHandwerks- und verwandte Berufe\r\nAnlagen-
      ↪  und Maschinenbediener und Montageberufe\r\nHilfsarbeitskräfte\r\nAngehörige
      ↪  der regulären Streitkräfte",
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      "description":{
        "name":"description",
        "body":"<div>Falls Sie erwerbstätig sind, bitte wählen Sie Ihre Berufsgruppe
        ↪  aus. Die Optionen sind:</div><ul><li>Führungskräfte</li><li>Akademische
        ↪  Berufe</li><li>Techniker und gleichrangige nichttechnische
        ↪  Berufe</li><li>Bürokräfte und verwandte
        ↪  Berufe</li><li>Dienstleistungsberufe und Verkäufer</li><li>Fachkräfte in
        ↪  der Landwirtschaft und Fischerei</li><li>Handwerks- und verwandte
        ↪  Berufe</li><li>Anlagen- und Maschinenbediener und
        ↪  Montageberufe</li><li>Hilfsarbeitskräfte</li><li>Angehörige der regulären
        ↪  Streitkräfte</li></ul><div>Falls Sie sich nicht intuitiv einer Gruppe
        ↪  zuordnen können, finden Sie <a
        ↪  href=\"https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009
        ↪  :292:0031:0047:DE:PDF\">hier</a> eine Aufschlüsselung der Gruppen mit
        ↪  Untergruppen und genaueren Berufsbezeichnungen (ab Seite 2).</div>"
      }
    },
    {
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      "placeholder":"",
      "position":null,
      "answer_options":"Land- und Forstwirtschaft, Fischerei\r\nWarenherstellung,
      ↪  Bergbau, Energie-, Wasser-, Abfallversorgung\r\nBaugewerbe/Bau\r\nHandel,
      ↪  Verkehr, Lagerei, Gastgewerbe, Gastronomie\r\nInformation und
      ↪  Kommunikation\r\nErbringung von Finanz- und
      ↪  Versicherungsdienstleistungen\r\nGrundstücks- und
      ↪  Wohnungswesen\r\nDienstleistungen (freiberuflich, wissenschaftlich,
      ↪  technisch, andere)\r\nÖffentliche Verwaltung, Verteidigung, Erziehung und
      ↪  Unterricht, Gesundheits- und Sozialwesen\r\nanderer",
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```

```
      "body":"<div>Falls Sie erwerbstätig sind, bitte wählen Sie Ihren
      ↪  Wirtschaftszweig aus. Die Optionen sind:</div><ul><li>Land- und
      ↪  Forstwirtschaft, Fischerei</li><li>Warenherstellung, Bergbau, Energie-,
      ↪  Wasser-, Abfallversorgung</li><li>Baugewerbe/Bau</li><li>Handel, Verkehr,
      ↪  Lagerei, Gastgewerbe, Gastronomie</li><li>Information und
      ↪  Kommunikation</li><li>Erbringung von Finanz- und
      ↪  Versicherungsdienstleistungen</li><li>Grundstücks- und
      ↪  Wohnungswesen</li><li>Dienstleistungen (freiberuflich, wissenschaftlich,
      ↪  technisch, andere)</li><li>Öffentliche Verwaltung, Verteidigung, Erziehung
      ↪  und Unterricht, Gesundheits- und Sozialwesen</li><li>anderer</li></ul>"
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  },
  {
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    "position":null,
    "answer_options":"unter € 1.250\r\n€ 1.250 - € 2.000\r\n€ 2.000 - € 3.200\r\n€
    ↪  3.200 - € 4.800\r\n€ 4.800 - € 6.600\r\nüber € 6.600",
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      "body":"<div>Gefragt ist das <strong>monatliche Netto-Einkommen</strong> Ihres
      ↪  <strong>gesamten Haushalts</strong>. Zählen Sie alle Arten von Einkommen
      ↪  zusammen. Wenn Sie sich nicht sicher sind, schätzen Sie.</div>"
    }
  },
  {
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    "description":{
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      "body":"<div>Bitte wählen Sie Eigenschaften, die auf Ihren Arbeitsplatz
      ↪  zutreffen.</div>"
    }
  },
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    "placeholder":"",
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    "answer_options":"Fahrrad\r\nÖffentliche Verkehrsmittel\r\nE-Bike\r
    ↪  \nFahrrad-Sharing-Dienst\r\nMotorrad\r\nMotorrad-Sharing-Dienst\r\nE-Scooter
    ↪  \r\nE-Scooter-Sharing-Dienst\r\nAuto\r\nCar-Sharing-Dienst",
    "validation_rules":{
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```
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      "description":{
        "name":"description",
        "body":"<div>Bitte wählen Sie alle Transportmittel aus, die ihnen
        ↪  <strong>üblicherweise</strong> zur Verfügung stehen (z. B. durch Eigentum,
        ↪  regelmäßige Mitverwendung, Besitz eines Zeit-Tickets, bestehender Account,
        ↪  ...)</div>"
      }
    },
    {
      "question_text":"Fahrräder im Haushalt",
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      },
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        ↪  E-Bikes) in Ihrem Haushalt an.</div>"
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      },
      "description":{
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        "body":"<div>Bitte geben Sie die Anzahl der funktionstüchtigen E-Bikes in Ihrem
        ↪  Haushalt an.</div>"
      }
    },
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      "placeholder":"",
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      "answer_options":"Fahrrad\r\nÖffentlicher Verkehr\r\nzu
      ↪  Fuß\r\nAuto\r\nandere\r\nkeine",
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```

```
            "maximum":"",
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            "less_than_or_equal_to":""
          },
          "description":{
            "name":"description",
            "body":"<div>Für welche Verkehrsmittel nutzen Sie das Smartphone, um sich über
            ↪  Routen, Verbindungen, Zeiten oder anderes bei Ihren Wegen zu informieren -
            ↪  egal ob vorab oder unterwegs?</div>"
          }
        },
        {
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          "placeholder":"",
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          ↪  wissenschaftliche Arbeit gemäß der Datenschutzinformation zu.",
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          }
        }
      ]
}
```

Listing all countries was omitted due to formatting reasons.

F Data protection notice

Information zur Erhebung und Verarbeitung personenbezogener Daten

Sehr geehrte_r Teilnehmer_in!

Im Rahmen meines Bachelor-Studiums „Software & Information Engineering“ an der Technischen Universität Wien (in der Folge kurz als „TU Wien“ bezeichnet) arbeite ich gerade an meiner Bachelorarbeit.

Das Verfassen dieser wissenschaftlichen Arbeit ist mit der Erhebung und Verwendung personenbezogener Daten verbunden.

Die Verarbeitung personenbezogener Daten hat in Entsprechung der geltenden Datenschutzbestimmungen zu erfolgen, daher darf ich gemäß Art 13 Datenschutz-Grundverordnung (DSGVO) über die Datenverarbeitung informieren wie folgt:

Verantwortlicher für die Datenverarbeitung

1. Interviewer, Verfasser der Bachelorarbeit und Verantwortlicher für die Datenverarbeitung iS von Art 4 Zif 7 DSGVO

   Samuel Hönle

2. Kontaktdaten

   samuel.hoenle@student.tuwien.ac.at

Gegenstand der Bachelorarbeit

1. Titel der Bachelorarbeit:

   „Know Your Urban Cyclist: A Process to Improve Bicycle Policy-Making by Connecting Mobility Micro-Data with Socio-Demographic Data About Cyclists“

2. Beschreibung der Bachelorarbeit:

   Gute Politik braucht gute Daten. Ziel dieser Arbeit ist es, einen Prozess zur evidenzbasierten Politikgestaltung im Bereich der urbanen Fahrradpolitik vorzuschlagen. Wenn Verantwortungsträger_innen politische Entscheidungen evidenzbasiert treffen wollen, reichen Daten über das Verhalten von Radfahrer*innen alleine reichen nicht aus. Wenn diese Daten allerdings mit Informationen *über* die Radfahrer*innen verbunden werden, können die Auswirkungen von Fahrradpolitik auf verschiedene Bevölkerungsgruppen untersucht werden. Diese Ergebnisse könnten dann verwendet werden, um politische Entscheidungen rund um das Radfahren zu verbessern. Der in dieser Arbeit vorgeschlagene Prozess soll von der Erhebung der Daten bis zur Entscheidung reichen.

Art der verarbeiteten personenbezogenen Daten

Folgende personenbezogene Daten zu Ihrer Person werden im Rahmen meiner wissenschaftlichen Arbeit verarbeitet:

Persönliche Angaben, nämlich:

- Geschlecht
- Alter
- Bildungsstand

- Staatsangehörigkeit
- Geburtsland (eigenes und der Eltern)
- berufliche Tätigkeit

Aufnahmen, nämlich:

- Standortdaten von Radfahrten (individuell, freiwillig)

Zweck der Datenverarbeitung

Zweck der Datenverarbeitung ist, zu überprüfen, ob die in der Bachelorarbeit erarbeitete Lösung der Datenerhebung und -verarbeitung zur Einbindung in einen politischen Prozess möglich ist. Mithilfe der angegebenen Daten soll untersucht werden, ob sich Bevölkerungsgruppen in ihrem Radfahrverhalten unterscheiden, und ob Änderungen in der Fahrradpolitik sich unterschiedlich auf verschiedene Bevölkerungsgruppen auswirken.

Beschreibung der Datenverarbeitung

Die Antworten auf den Fragebogen werden gemeinsam mit einem eindeutigen Schlüssel gespeichert. Mithilfe des Schlüssels kann auf Fahrtdaten, die ab dem Zeitpunkt der Beantwortung mittels der Bike-Citizens-Smartphone-Applikation aufgezeichnet wurden, zugegriffen werden. Es kann auf keine anderen Daten zugegriffen werden. Die Daten sind anonymisiert, das heißt sie sind nicht direkt einer natürliche Person zuordenbar. Die Daten werden nach der Erhebung auf Servern der Bike Citizens Mobile Solutions GmbH (info@bikecitizens.net) und Geräten des Verfassers gespeichert und analysiert. Die Daten werden nicht verändert. Alle Übertragungen sind verschlüsselt.

Rechtsgrundlage

Die Rechtsgrundlage zur Verarbeitung dieser personenbezogenen Daten stellt Art 6 Abs 1 lit e DSGVO in Verbindung mit § 80 UG dar.

Art 6 Abs 1 lit e DSGVO normiert die Verarbeitung personenbezogener Daten im öffentlichen Interesse.

§§ 80ff UG stellen die rechtliche Verpflichtung dar. Es wird je nach Art der wissenschaftlichen Arbeit unterschieden:

- § 80 UG betrifft die Bachelorarbeit (Art 6 Abs 1 lit e DSGVO iVm § 80 UG);
- § 81 UG betrifft Diplom- und Masterarbeiten (Art 6 Abs 1 lit e DSGVO iVm § 81 UG);
- § 83 UG betrifft Dissertationen (Art 6 Abs 1 lit e DSGVO iVm § 83 UG)

Die datenschutzrechtliche Rechtfertigung für die Verarbeitung der Daten ist nicht die Einwilligung der Betroffenen.

Übermittlungsempfänger_innen und Drittstaatenübermittlungen

Grundsätzlich haben nur autorisierte und zur Verschwiegenheit verpflichtete Personen im Zuge der Erarbeitung und Betreuung der Bachelorarbeit Zugang zu den verarbeiteten, personenbezogenen Daten, und dies nur in dem erforderlichen Umfang.

An folgende Empfänger_innen oder Kategorien von Empfänger_innen werden Ihre personenbezogenen Daten zulässigerweise übermittelt oder können übermittelt werden:

- an die betroffene Universität (TU Wien), insbesondere der/dem Betreuer_in der wissenschaftlichen Arbeit und dessen Mitarbeiterstab

- positiv beurteilte Bachelor-/Diplom-/Masterarbeit/Dissertation an die Universitäts-Bibliothek der TU Wien, Resselgasse 4, 1040 Wien, zum Zwecke der Veröffentlichung gemäß Art 6 Abs 1 lit e DSGVO iVm § 86 Universitätsgesetz (UG)

Speicherdauer

Zum Nachweis der guten wissenschaftlichen Praxis sowie für die Nachprüfbarkeit der gewählten Methode und der erzielten Ergebnisse, wird die Protokollierung und die Dokumentation des wissenschaftlichen Vorgehens auf haltbaren und gesicherten Datenträgern gespeichert. Dies erfolgt datenschutz-konform und gegenüber Dritten unzugänglich. Die Datenspeicherung richtet sich nach den gesetzlichen Bestimmungen und erfolgt entsprechend § 2f Abs 3 Forschungsorganisationsgesetz (FOG) für die Dauer von maximal 30 Jahren.

Betroffenenrechte

Gemäß der DSGVO stehen Ihnen als betroffene Person folgende Rechte zu:

- Recht auf **Auskunft** über die betreffenden personenbezogenen Daten (Art 15 DSGVO)
- Recht auf **Berichtigung** (Art 16 DSGVO) oder **Löschung** (Art 17 DSGVO) oder auf **Einschränkung der Verarbeitung** (Art 18 DSGVO) unter den in den angeführten Bestimmungen beschriebenen Voraussetzungen
- Recht auf **Beschwerde**, welche bei der Österreichischen Datenschutzbehörde, Barichgasse 40-42, 1030 Wien, Telefon: +43 1 52 152-0, E-Mail: dsb@dsb.gv.at als zuständige Aufsichtsbehörde einzubringen ist.

Artikel 11 DSGVO sieht zudem vor, dass eine separate Rückführbarkeit von Daten auf Personen nicht gewährleistet werden muss, nur um die Betroffenenrechte wahren zu können.

Art 11 DSGVO sieht zudem vor, dass eine zusätzliche Aufbewahrung von Daten zum Zwecke der Personen-Identifizierung nicht erfolgen muss, nur um Bestimmungen der DSGVO (z.B. Erfüllung von Betroffenenrechten) einhalten zu können.

Zur Geltendmachung Ihrer Rechte wenden Sie sich an mich wie folgt:

E-Mail an samuel.hoenle@student.tuwien.ac.at

G Full result page printout of test data

Results

Export as CSV | Export as XLSX

Geschlecht

Option	# responses	# tracks	Total distance	Avg. distance	Total duration	Avg. duration	Avg. speed
männlich	4	563	1,208.734 km	2.147 km	87:36:21	00:09:20.179	13.797 km/h
weiblich	3	31	94.972 km	3.064 km	07:40:26	00:14:51.161	12.376 km/h

Geburtsmonat und -jahr

Option	# responses	# tracks	Total distance	Avg. distance	Total duration	Avg. duration	Avg. speed
09-1995	1	73	183.354 km	2.512 km	14:13:30	00:11:41.506	12.890 km/h
10-1995	1	19	73.232 km	3.854 km	07:38:58	00:24:09.368	9.574 km/h
07-1996	1	3	6.180 km	2.060 km	00:32:38	00:10:52.666	11.363 km/h
11-1995	1	467	931.692 km	1.995 km	63:31:30	00:08:09.700	14.667 km/h
04-1996	1	20	49.468 km	2.473 km	03:41:18	00:11:03.900	13.412 km/h
07-1997	1	8	39.324 km	4.916 km	03:26:30	00:25:48.750	11.426 km/h
08-1998	1	4	20.456 km	5.114 km	02:12:23	00:33:05.750	9.271 km/h

Höchster Schulabschluss

Option	# responses	# tracks	Total distance	Avg. distance	Total duration	Avg. duration	Avg. speed
Hochschule, Universität, Fachhochschule	6	590	1,283.250 km	2.175 km	93:04:24	00:09:27.905	13.788 km/h
Matura	1	4	20.456 km	5.114 km	02:12:23	00:33:05.750	9.271 km/h

Staatsbürgerschaft

Option	# responses	# tracks	Total distance	Avg. distance	Total duration	Avg. duration	Avg. speed
Österreich	7	594	1,303.706 km	2.195 km	95:16:47	00:09:37.452	13.683 km/h

Zweite Staatsbürgerschaft

Option	# responses	# tracks	Total distance	Avg. distance	Total duration	Avg. duration	Avg. speed
Deutschland	1	73	183.354 km	2.512 km	14:13:30	00:11:41.506	12.890 km/h

Geburtsland

Option	# responses	# tracks	Total distance	Avg. distance	Total duration	Avg. duration	Avg. speed
Deutschland	1	73	183.354 km	2.512 km	14:13:30	00:11:41.506	12.890 km/h
Österreich	6	521	1,120.352 km	2.150 km	81:03:17	00:09:20.071	13.822 km/h

Geburtsland Mutter

Option	# responses	# tracks	Total distance	Avg. distance	Total duration	Avg. duration	Avg. speed
Österreich	6	574	1,254.238 km	2.185 km	91:35:29	00:09:34.440	13.694 km/h
Russland	1	20	49.468 km	2.473 km	03:41:18	00:11:03.900	13.412 km/h

Geburtsland Vater

Option	# responses	# tracks	Total distance	Avg. distance	Total duration	Avg. duration	Avg. speed
Deutschland	1	73	183.354 km	2.512 km	14:13:30	00:11:41.506	12.890 km/h
Österreich	4	497	1,050.428 km	2.114 km	75:09:36	00:09:04.418	13.976 km/h
Russland	1	20	49.468 km	2.473 km	03:41:18	00:11:03.900	13.412 km/h
Rumänien	1	4	20.456 km	5.114 km	02:12:23	00:33:05.750	9.271 km/h

Haushalt: Anzahl Personen 0-4 Jahre

Option	# responses	# tracks	Total distance	Avg. distance	Total duration	Avg. duration	Avg. speed
0	7	594	1,303.706 km	2.195 km	95:16:47	00:09:37.452	13.683 km/h

Haushalt: Anzahl Personen 5-24 Jahre

Option	# responses	# tracks	Total distance	Avg. distance	Total duration	Avg. duration	Avg. speed
2	3	80	209.990 km	2.625 km	16:58:31	00:12:43.887	12.370 km/h
0	2	486	1,004.924 km	2.068 km	71:10:28	00:08:47.218	14.119 km/h
1	2	28	88.792 km	3.171 km	07:07:48	00:15:16.714	12.453 km/h

Haushalt: Anteil jener Personen (5-24 Jahre) in Ausbildung

Option	# responses	# tracks	Total distance	Avg. distance	Total duration	Avg. duration	Avg. speed
1	2	93	232.822 km	2.503 km	17:54:48	00:11:33.419	12.997 km/h
0	3	494	1,044.248 km	2.114 km	74:36:58	00:09:03.761	13.995 km/h
2	2	7	26.636 km	3.805 km	02:45:01	00:23:34.428	9.685 km/h

Haushalt: Anzahl Personen 25-64 Jahre

Option	# responses	# tracks	Total distance	Avg. distance	Total duration	Avg. duration	Avg. speed
1	2	81	222.678 km	2.749 km	17:40:00	00:13:05.185	12.604 km/h
2	3	506	1,054.392 km	2.084 km	74:51:46	00:08:52.620	14.084 km/h
0	2	7	26.636 km	3.805 km	02:45:01	00:23:34.428	9.685 km/h

Haushalt: Anzahl Personen über 65 Jahre

Option	# responses	# tracks	Total distance	Avg. distance	Total duration	Avg. duration	Avg. speed
0	7	594	1,303.706 km	2.195 km	95:16:47	00:09:37.452	13.683 km/h

Haushalt: Kategorie

Option	# responses	# tracks	Total distance	Avg. distance	Total duration	Avg. duration	Avg. speed
Andere	4	579	1,237.746 km	2.138 km	89:05:16	00:09:13.913	13.894 km/h
Paar ohne Kind(er) < 25 Jahre	3	15	65.960 km	4.397 km	06:11:31	00:24:46.066	10.653 km/h

Haushalt: Anzahl erwerbstätige Personen

Option	# responses	# tracks	Total distance	Avg. distance	Total duration	Avg. duration	Avg. speed
3	1	73	183.354 km	2.512 km	14:13:30	00:11:41.506	12.890 km/h
0	2	22	79.412 km	3.610 km	08:11:36	00:22:20.727	9.692 km/h
1	2	471	952.148 km	2.022 km	65:43:53	00:08:22.405	14.485 km/h
2	2	28	88.792 km	3.171 km	07:07:48	00:15:16.714	12.453 km/h

Haushalt: Anzahl nicht-erwerbstätige Personen

Option	# responses	# tracks	Total distance	Avg. distance	Total duration	Avg. duration	Avg. speed
0	2	81	222.678 km	2.749 km	17:40:00	00:13:05.185	12.604 km/h
2	2	22	79.412 km	3.610 km	08:11:36	00:22:20.727	9.692 km/h
1	3	491	1,001.616 km	2.040 km	69:25:11	00:08:28.983	14.428 km/h

Erwerbsstatus

Option	# responses	# tracks	Total distance	Avg. distance	Total duration	Avg. duration	Avg. speed
erwerbstätig (Teilzeit)	2	540	1,115.046 km	2.065 km	77:45:00	00:08:38.333	14.341 km/h
in Ausbildung	3	26	99.868 km	3.841 km	10:23:59	00:23:59.961	9.603 km/h
erwerbstätig (Vollzeit)	2	28	88.792 km	3.171 km	07:07:48	00:15:16.714	12.453 km/h

Berufsgruppe

Option	# responses	# tracks	Total distance	Avg. distance	Total duration	Avg. duration	Avg. speed
Akademische Berufe	3	101	272.146 km	2.695 km	21:21:18	00:12:41.168	12.744 km/h
Hilfsarbeitskräfte	1	467	931.692 km	1.995 km	63:31:30	00:08:09.700	14.667 km/h

Wirtschaftszweig

Option	# responses	# tracks	Total distance	Avg. distance	Total duration	Avg. duration	Avg. speed
Dienstleistungen (freiberuflich, wissenschaftlich, technisch, andere)	1	73	183.354 km	2.512 km	14:13:30	00:11:41.506	12.890 km/h
Handel, Verkehr, Lagerei, Gastgewerbe, Gastronomie	1	467	931.692 km	1.995 km	63:31:30	00:08:09.700	14.667 km/h
Öffentliche Verwaltung, Verteidigung, Erziehung und Unterricht, Gesundheits- und Sozialwesen	1	20	49.468 km	2.473 km	03:41:18	00:11:03.900	13.412 km/h
Information und Kommunikation	1	8	39.324 km	4.916 km	03:26:30	00:25:48.750	11.426 km/h

Monatliches Netto-Haushaltseinkommen

Option	# responses	# tracks	Total distance	Avg. distance	Total duration	Avg. duration	Avg. speed
€ 3.200 - € 4.800	2	81	222.678 km	2.749 km	17:40:00	00:13:05.185	12.604 km/h
unter € 1.250	4	509	1,060.572 km	2.084 km	75:24:24	00:08:53.328	14.065 km/h
€ 1.250 - € 2.000	1	4	20.456 km	5.114 km	02:12:23	00:33:05.750	9.271 km/h

Arbeitsplatz

Option	# responses	# tracks	Total distance	Avg. distance	Total duration	Avg. duration	Avg. speed
flexible Arbeitzeiten	3	97	253.278 km	2.611 km	20:07:11	00:12:26.711	12.589 km/h
Möglichkeit zum Homeoffice	4	105	292.602 km	2.787 km	23:33:41	00:13:27.819	12.419 km/h

Verfügbarkeit von Transportmitteln

Option	# responses	# tracks	Total distance	Avg. distance	Total duration	Avg. duration	Avg. speed
Fahrrad	7	594	1,303.706 km	2.195 km	95:16:47	00:09:37.452	13.683 km/h
Öffentliche Verkehrsmittel	7	594	1,303.706 km	2.195 km	95:16:47	00:09:37.452	13.683 km/h
Fahrrad-Sharing-Dienst	2	540	1,115.046 km	2.065 km	77:45:00	00:08:38.333	14.341 km/h
E-Scooter-Sharing-Dienst	2	92	256.586 km	2.789 km	21:52:28	00:14:15.956	11.730 km/h
E-Bike	1	467	931.692 km	1.995 km	63:31:30	00:08:09.700	14.667 km/h
Car-Sharing-Dienst	1	4	20.456 km	5.114 km	02:12:23	00:33:05.750	9.271 km/h

Fahrräder im Haushalt

Option	# responses	# tracks	Total distance	Avg. distance	Total duration	Avg. duration	Avg. speed
1	2	77	203.810 km	2.647 km	16:25:53	00:12:48.220	12.404 km/h
3	3	489	1,011.104 km	2.068 km	71:43:06	00:08:47.987	14.098 km/h
4	1	20	49.468 km	2.473 km	03:41:18	00:11:03.900	13.412 km/h
2	1	8	39.324 km	4.916 km	03:26:30	00:25:48.750	11.426 km/h

E-Bikes im Haushalt

Option	# responses	# tracks	Total distance	Avg. distance	Total duration	Avg. duration	Avg. speed
0	7	594	1,303.706 km	2.195 km	95:16:47	00:09:37.452	13.683 km/h

Nutzung des Smartphones

Option	# responses	# tracks	Total distance	Avg. distance	Total duration	Avg. duration	Avg. speed
Fahrrad	7	594	1,303.706 km	2.195 km	95:16:47	00:09:37.452	13.683 km/h
Öffentlicher Verkehr	7	594	1,303.706 km	2.195 km	95:16:47	00:09:37.452	13.683 km/h
zu Fuß	6	127	372.014 km	2.929 km	31:45:17	00:15:00.133	11.715 km/h
Auto	5	119	332.690 km	2.796 km	28:18:47	00:14:16.529	11.750 km/h
andere	1	73	183.354 km	2.512 km	14:13:30	00:11:41.506	12.890 km/h

Einverständnis

Option	# responses	# tracks	Total distance	Avg. distance	Total duration	Avg. duration	Avg. speed
Hiermit stimme ich der Verarbeitung meiner Daten für diese wissenschaftliche Arbeit gemäß der Datenschutzinformation zu.	7	594	1,303.706 km	2.195 km	95:16:47	00:09:37.452	13.683 km/h

Filter

Hide/show filters

Filter Left

Responses matching *any* of the selected options for *all* questions are selected. (Logical OR within questions, logical AND across questions.) Selecting no options for a question does not apply a filter for that question.

Geschlecht

- ☐ männlich
- ☐ weiblich

Geburtsmonat und -jahr

- ☐ 09-1995
- ☐ 10-1995
- ☐ 07-1996
- ☐ 11-1995
- ☐ 04-1996
- ☐ 07-1997
- ☐ 08-1998

Höchster Schulabschluss

- ☐ Hochschule, Universität, Fachhochschule
- ☐ Matura

Staatsbürgerschaft

- ☐ Österreich

Zweite Staatsbürgerschaft

- ☐ Deutschland

Geburtsland

- ☐ Deutschland

Filter Right

Responses matching *any* of the selected options for *all* questions are selected. (Logical OR within questions, logical AND across questions.) Selecting no options for a question does not apply a filter for that question.

Geschlecht

- ☐ männlich
- ☐ weiblich

Geburtsmonat und -jahr

- ☐ 09-1995
- ☐ 10-1995
- ☐ 07-1996
- ☐ 11-1995
- ☐ 04-1996
- ☐ 07-1997
- ☐ 08-1998

Höchster Schulabschluss

- ☐ Hochschule, Universität, Fachhochschule
- ☐ Matura

Staatsbürgerschaft

- ☐ Österreich

Zweite Staatsbürgerschaft

- ☐ Deutschland

Geburtsland

- ☐ Deutschland

- [ ] Österreich

Geburtsland Mutter

- [ ] Österreich
- [ ] Russland

Geburtsland Vater

- [ ] Deutschland
- [ ] Österreich
- [ ] Russland
- [ ] Rumänien

Haushalt: Anzahl Personen 0-4 Jahre

- [ ] 0

Haushalt: Anzahl Personen 5-24 Jahre

- [ ] 2
- [ ] 0
- [ ] 1

Haushalt: Anteil jener Personen (5-24 Jahre) in Ausbildung

- [ ] 1
- [ ] 0
- [ ] 2

Haushalt: Anzahl Personen 25-64 Jahre

- [ ] 1
- [ ] 2
- [ ] 0

Haushalt: Anzahl Personen über 65 Jahre

- [ ] 0

Haushalt: Kategorie

- [ ] Andere
- [ ] Paar ohne Kind(er) < 25 Jahre

Haushalt: Anzahl erwerbstätige Personen

- [ ] 3
- [ ] 0
- [ ] 1
- [ ] 2

Haushalt: Anzahl nicht-erwerbstätige Personen

- [ ] 0
- [ ] 2
- [ ] 1

Erwerbsstatus

- [ ] erwerbstätig (Teilzeit)
- [ ] in Ausbildung
- [ ] erwerbstätig (Vollzeit)

Berufsgruppe

- [ ] Akademische Berufe
- [ ] Hilfsarbeitskräfte

Wirtschaftszweig

- [ ] Dienstleistungen (freiberuflich, wissenschaftlich, technisch, andere)
- [ ] Handel, Verkehr, Lagerei, Gastgewerbe, Gastronomie
- [ ] Öffentliche Verwaltung, Verteidigung, Erziehung und Unterricht, Gesundheits- und Sozialwesen
- [ ] Information und Kommunikation

Monatliches Netto-Haushaltseinkommen

- [ ] Österreich

Geburtsland Mutter

- [ ] Österreich
- [ ] Russland

Geburtsland Vater

- [ ] Deutschland
- [ ] Österreich
- [ ] Russland
- [ ] Rumänien

Haushalt: Anzahl Personen 0-4 Jahre

- [ ] 0

Haushalt: Anzahl Personen 5-24 Jahre

- [ ] 2
- [ ] 0
- [ ] 1

Haushalt: Anteil jener Personen (5-24 Jahre) in Ausbildung

- [ ] 1
- [ ] 0
- [ ] 2

Haushalt: Anzahl Personen 25-64 Jahre

- [ ] 1
- [ ] 2
- [ ] 0

Haushalt: Anzahl Personen über 65 Jahre

- [ ] 0

Haushalt: Kategorie

- [ ] Andere
- [ ] Paar ohne Kind(er) < 25 Jahre

Haushalt: Anzahl erwerbstätige Personen

- [ ] 3
- [ ] 0
- [ ] 1
- [ ] 2

Haushalt: Anzahl nicht-erwerbstätige Personen

- [ ] 0
- [ ] 2
- [ ] 1

Erwerbsstatus

- [ ] erwerbstätig (Teilzeit)
- [ ] in Ausbildung
- [ ] erwerbstätig (Vollzeit)

Berufsgruppe

- [ ] Akademische Berufe
- [ ] Hilfsarbeitskräfte

Wirtschaftszweig

- [ ] Dienstleistungen (freiberuflich, wissenschaftlich, technisch, andere)
- [ ] Handel, Verkehr, Lagerei, Gastgewerbe, Gastronomie
- [ ] Öffentliche Verwaltung, Verteidigung, Erziehung und Unterricht, Gesundheits- und Sozialwesen
- [ ] Information und Kommunikation

Monatliches Netto-Haushaltseinkommen

- [ ] € 3.200 - € 4.800
- [ ] unter € 1.250
- [ ] € 1.250 - € 2.000

Arbeitsplatz

- [ ] flexible Arbeitzeiten
- [ ] Möglichkeit zum Homeoffice

Verfügbarkeit von Transportmitteln

- [ ] Fahrrad
- [ ] Öffentliche Verkehrsmittel
- [ ] Fahrrad-Sharing-Dienst
- [ ] E-Scooter-Sharing-Dienst
- [ ] E-Bike
- [ ] Car-Sharing-Dienst

Fahrräder im Haushalt

- [ ] 1
- [ ] 3
- [ ] 4
- [ ] 2

E-Bikes im Haushalt

- [ ] 0

Nutzung des Smartphones

- [ ] Fahrrad
- [ ] Öffentlicher Verkehr
- [ ] zu Fuß
- [ ] Auto
- [ ] andere

Einverständnis

- [ ] Hiermit stimme ich der Verarbeitung meiner Daten für diese wissenschaftliche Arbeit gemäß der Datenschutzinformation zu.

Start datetime

End datetime

Save Filter left | Analyse filtered with Bike Citizens

Filter	# responses	# tracks	Total distance	Avg. distance	Total duration	d
	7	594	1,303.706 km	2.195 km	95:16:47	00:

- [ ] € 3.200 - € 4.800
- [ ] unter € 1.250
- [ ] € 1.250 - € 2.000

Arbeitsplatz

- [ ] flexible Arbeitzeiten
- [ ] Möglichkeit zum Homeoffice

Verfügbarkeit von Transportmitteln

- [ ] Fahrrad
- [ ] Öffentliche Verkehrsmittel
- [ ] Fahrrad-Sharing-Dienst
- [ ] E-Scooter-Sharing-Dienst
- [ ] E-Bike
- [ ] Car-Sharing-Dienst

Fahrräder im Haushalt

- [ ] 1
- [ ] 3
- [ ] 4
- [ ] 2

E-Bikes im Haushalt

- [ ] 0

Nutzung des Smartphones

- [ ] Fahrrad
- [ ] Öffentlicher Verkehr
- [ ] zu Fuß
- [ ] Auto
- [ ] andere

Einverständnis

- [ ] Hiermit stimme ich der Verarbeitung meiner Daten für diese wissenschaftliche Arbeit gemäß der Datenschutzinformation zu.

Start datetime

End datetime

Save Filter right | Analyse filtered with Bike Citizens

Filter	# responses	# tracks	Total distance	Avg. distance	Total duration	
	7	594	1,303.706 km	2.195 km	95:16:47	0(