E-Mobility-Hubs: Evaluation of Consumer Behavior and Design Principles

Masterarbeit

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Table of Content

1 Introduction

1.1 Relevance

On a global level, humanity has not only faced the start of a still ongoing pandemic (WHO, 2021) but is also struggling to cope with climate and weather extremes in all regions around the globe (IPCC, 2021, p. 10). These extremes are unlikely to decrease, as temperatures are expected to keep rising, as outlined in Figure 1. Here, all scenarios project a future temperature increase with varying magnitude and effect in the short term. Besides, only Scenario 1 and Scenario 2 show a turning point in this century, while all scenarios will have crossed a threshold of 1.5 °C in relative temperature change by 2035. The importance of this threshold relates to the Paris Agreement which set the goal to limit global warming to preferably 1.5 °C above pre-industrial levels in order to reduce risks associated with climate change (UNFCCC, 2015).

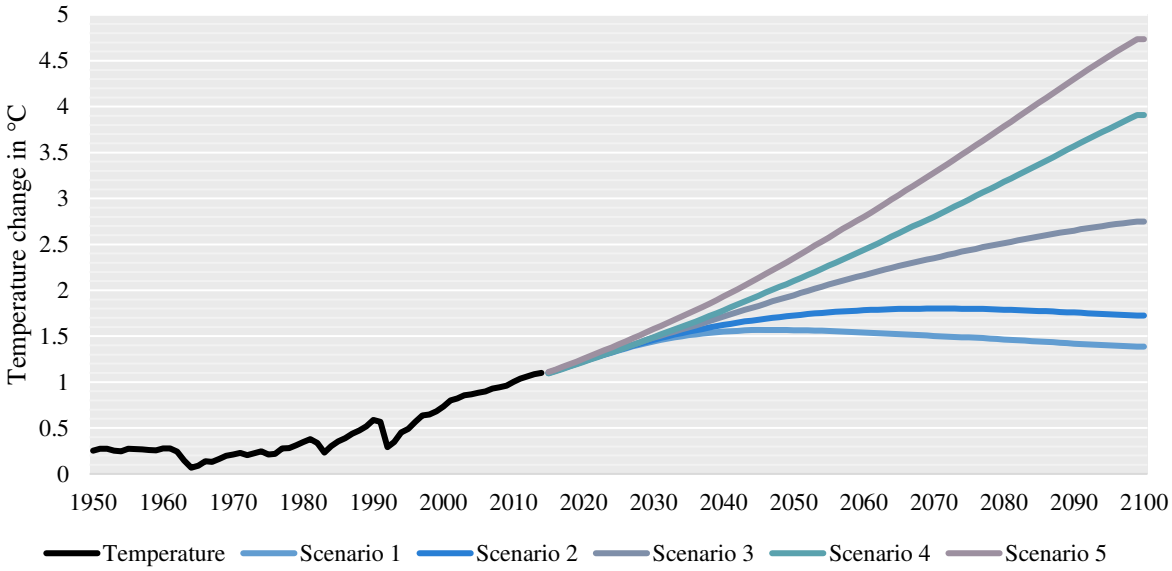

Figure 1: Global surface temperature change relative to 1850-1900
Source: Own illustration based on Fyfe *et al.* (2021)

If the projections are accurate, then even the best-case scenario warrants immediate action. The change requirements include limiting cumulative carbon dioxide (CO2) emissions to at least net zero, alongside reductions in other greenhouse gas (GHG) emissions (IPCC, 2021, p. 36). In contrast to the change requirements, the necessary actions are not as straightforward as they entail changing current practice across whole sectors.

Sectors are usually divided into four main clusters that are responsible for all GHG emissions, with each having several sub-clusters and sub-categories as portrayed in Figure 2 (Ritchie and Roser, 2020). The energy sector is responsible for almost three-quarters (73.2%) of total GHG emissions, followed by agriculture, forestry & land use (18.4%), industrial processes (5.2%),

and waste (3.2%). On the sub-sector level, transport contributes 16.2 percentage points to overall GHG emissions, mainly through fossil fuel combustion (Ritchie and Roser, 2020). In addition, transport accounted for approximately 24% of all energy-related CO2 emissions in 2018 (IEA, 2019, 2021). When referring back to the goal of reducing cumulative CO2 emissions as postulated by the IPCC (2021, p. 36), it becomes evident that this sector has strong leverage on overall emissions. In that respect, reducing traffic volumes and decarbonizing transport through electrification are two major ways. On the sub-category level, road transport encompasses 11.9 percentage points of all transportation, which is among the largest contributors at this level of resolution across all sectors. To further differentiate by purpose, road transport is split into passenger travel (cars, motorcycles, and buses) and road freight (lorries and trucks) which make up about sixty (7.14%) and forty percent (4.76%) respectively (Ritchie, 2020).

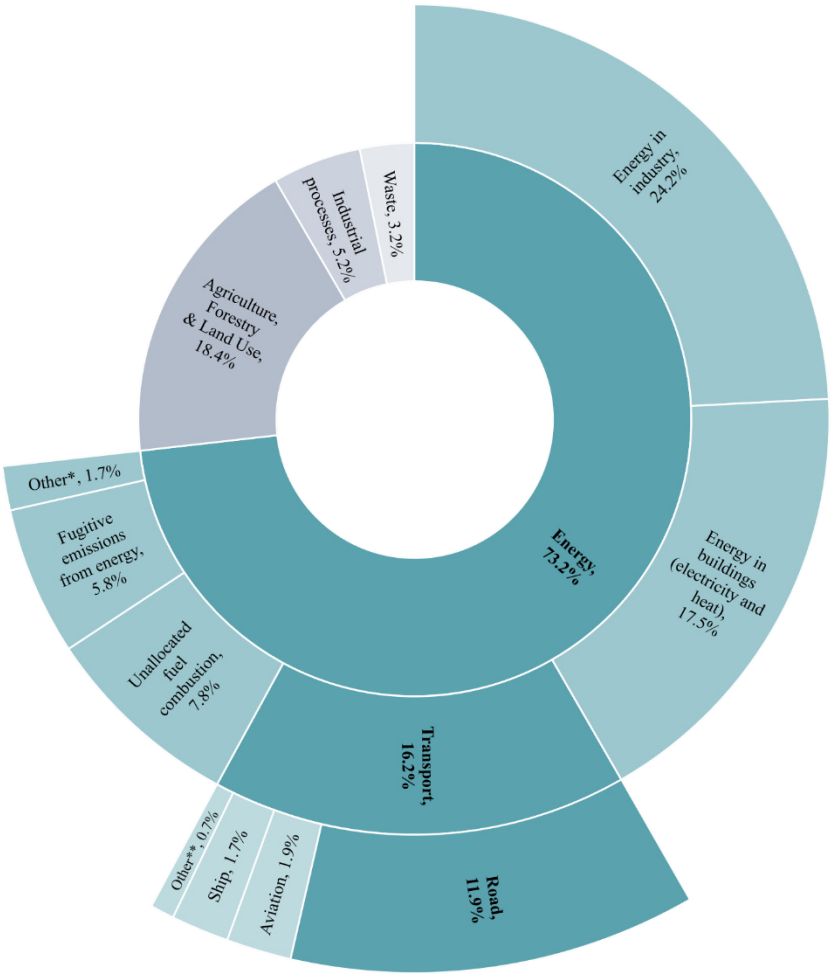

Figure 2: Global greenhouse gas emissions by sector for 2016
*Energy in Agriculture & Fishing (1.7%), **Rail (0.4%) and Pipeline (0.3%)
Source: Own illustration based on Ritchie and Roser (2020)

With the former amounting to 7.14% of all GHG emissions, this poses a unique opportunity to change one's travel patterns and behavior. The fact that individual action directly influences

the target state of less overall emissions, makes this sub-category particularly interesting. The direct individual impact is also in contrast to several other categories and sub-sectors where change usually involves one or several intermediaries. However, this is not to say that corporations, who do have an overall higher impact on GHG emissions, are left out of the equation for mitigating climate change.

In consideration of the aforementioned points, changing passenger travel for good appears both necessary and feasible but requires the implementation of measures that are conducive to the desired change. A shift towards more sustainable mobility options as well as reducing total vehicle ownership are considered crucial by researchers (Hoerler *et al.*, 2020, p. 13; Lyons, Hammond and Mackay, 2019, p. 25).

In this regard, so-called new mobility services (NMS) have recently entered the market, providing alternative modes of transportation. These services include but are not limited to ride hailing, ride pooling, ride sharing, car sharing, and micro mobility. All services have in common that they aim to reduce overall car ownership, while some services offer rides that do not cause emissions. However, these services are a point of contention and often do not integrate as seamlessly into public life as expected by providers and policymakers. Nevertheless, exploring pathways for increased adoption of NMS appears worthwhile and could, in the process, help to solve various other problems cities face at a local level.

The latter refers to the fact that cities around the globe suffer from increased congestion, pollution, and accidents caused by cars (Pishue, 2020). Considering that cities are predominantly designed for cars, these developments are not surprising, yet make safer, cleaner, and human-centered transportation even more desirable since most cities are faced with the opposite (Gehl, 2010, p. 3). However, the pandemic-induced shift towards private vehicles, as a result of avoiding risk of infection, further complicates the situation and does not help to alleviate the challenges at hand (Heineke *et al.*, 2020).

More information on individual motives and barriers for the use of NMS are required to anchor these options as preferable means of transport which appeal to the general public and not just to a minority of people.

1.2 Objective

As noted in chapter 1.1, passenger transport has a sizable impact on global GHG and CO2 emissions. Therefore, focusing on it can not only help to reach target climate goals but also help to solve local challenges such as congestion and poor air quality. For example, traffic congestion mainly occurs when there is too much demand for road space at which point the speed of travel decreases noticeably (OECD, 2021a, p. 8). Likewise, the same is true for

congestion in general, regardless of the space used. Reducing congestion would not only save time but also help to reduce emissions caused by fuel combustion. Emerging NMS pose a promising alternative to conventional transportation modes and could help to reduce congestion and improve air quality by shifting away demand from cars but struggle with adoption in the general public due to misguided policies and factors such as infrastructure and availability (Shaheen *et al.*, 2020, p. 248; Tran and Draeger, 2021, p. 11).

Striving to provide convenient, accessible, and sustainable mobility for everyone is, in theory, the right approach but must not neglect individual differences which are in the way of much-needed behavioral change. In this vein, several researchers have called for future research in this field (Bai and Jiao, 2020; Bao and Lim, 2021; Miramontes *et al.*, 2017).

Therefore, the overarching goal of this thesis is to further investigate NMS utilizing two different approaches. On the one hand, the goal is to form a better understanding of drivers for consumer behavior regarding NMS. On the other hand, the aim is to assess the role and design principles of so-called e-mobility hubs, or just mobility hubs if including all potential mobility modes, and whether they can facilitate more seamless integration of NMS into everyone's daily life or not. As of yet, these hubs have not been studied extensively but could help to increase accessibility to and connectivity between different modes of transportation (Bell, 2019, p. 6; Tran and Draeger, 2021, p. 3).

The following research questions (RQ) provide the framework to develop a more in-depth understanding of NMS and mobility hubs, and will help to close the preceding research gap:

RQ1: What are the characteristics of users and non-users of new mobility services?

RQ2: What are the design principles and characteristics of (electric) mobility hubs?

Before explaining the structure, the scope of this thesis needs to be more closely defined. While the focus is generally set to include developments and literature from across the world, two of the chosen methodologies, namely the empirical study and the data analysis, are by and large limited to Germany.

Moreover, a set of light constraints will affect the results of the thesis. Regarding mobility hubs, promising design principles and characteristics can only be theorized about as physically testing different features is not feasible. In addition, the process of generating well-founded answers for RQ2 will be dependent on the empirical results of RQ1 as consumer behavior will impact the design principles and characteristics of mobility hubs.

1.3 Structure

To comprehensively answer the research question, a solid and thought-out approach was developed which does not only build on existing findings in the literature but also derives new insights through distinct research methodologies.

Therefore, a rough structure with three main sections was carved out. The first frames the context, builds the theoretical foundations and provides insights into the research methodologies. The second focuses on applying the selected research methods to generate results, while the final and third section, focuses on discussing and connecting the different strings to form a well-founded synthesis.

On a more detailed level, the thesis was then partitioned into eight chapters as displayed in Figure 3.

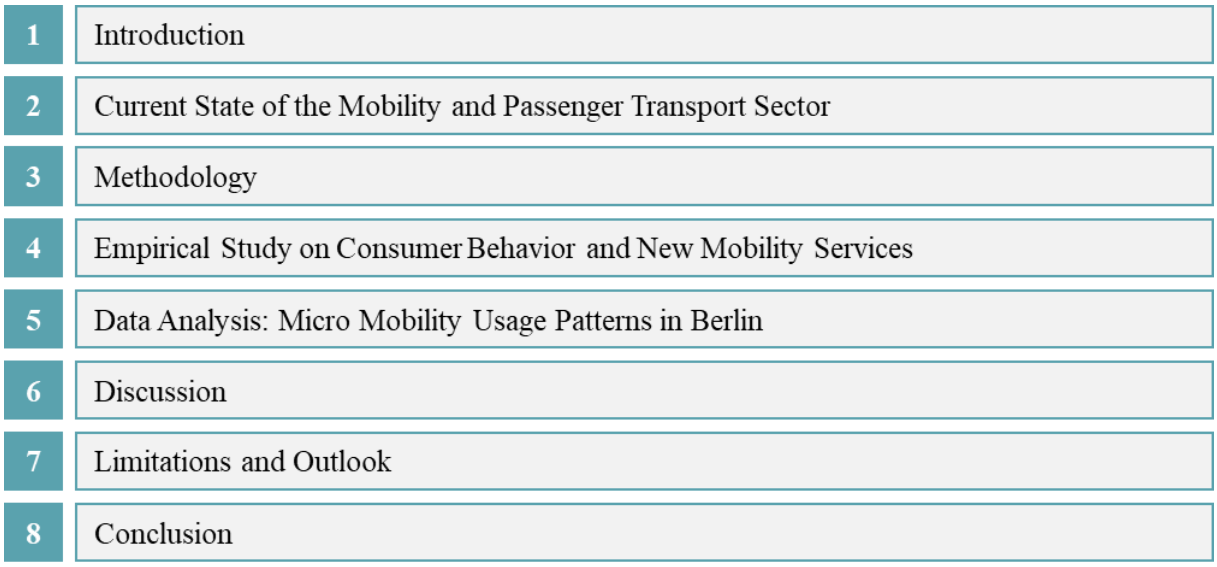

Figure 3: Structure of the thesis
Source: Own illustration

After the introduction, chapter 2 provides the foundation of this thesis in terms of definitions and general mobility-related developments. It provides an overview of macro-level developments in so-called functional urban areas and sheds light on traditional, new, and future mobility modes as well as related developments with a focus on Germany. This is complemented by a distinction between common mobility service terms. Then, a brief investigation of the political and private sector and their involvement in passenger transport concludes the chapter. The following chapter describes the procedure for the methodologies employed. These include a literature review based on Webster and Watson (2002), an empirical study on consumer behavior about NMS, and an analysis of electric scooter data. The main chapter of this thesis, chapter 4, focuses on the conduction of an empirical study to better understand users and non-users of NMS. In addition, the results will be used in conjunction

with the following chapter to allow for an in-depth discussion from multiple perspectives. Chapter 5 takes a quantitative approach and deals with the exploration of electric scooter data. Hereinafter, the next chapter fuses the different results from the literature review and the two previous chapters together and discusses the implications extensively. Chapter 7 discusses the limitations and provides an outlook on avenues for future research. Finally, chapter 8 concludes the findings and sums up the thesis.

8 Conclusion

NMS are still a novel field of research that has gained popularity and traction due to its potential to reduce GHG emissions and its capability to solve challenges such as congestion and poor air quality in cities. In addition, mobility hubs could be the catalyst to increase adoption of NMS as the results of the conducted empirical study suggest. However, the barriers which prevent a future of clean and accessible passenger transport are manifold. The current technological developments and the push towards sustainability alongside challenges imposed by the current pandemic provide both opportunity and challenge for society as a whole as well as for the political and private sector and sparked the idea for the thesis. Subsequently, three major pathways were explored throughout this thesis.

First, a literature review was conducted which provided the theoretical foundations for this thesis and the frame to answer the research questions in a well-founded manner. Besides, four common themes were identified in the literature surrounding NMS which helped to embed the overarching results in a broader context.

Second, an empirical study was conducted to form an understanding of consumer behavior with a focus on NMS and TM. As a result, usage intentions, motivations, and barriers corresponding to the different modes and services were uncovered. Moreover, a set of hypotheses, built upon the previously acquired knowledge, helped to test the whole sample as well the user and non-user groups of NMS for characteristics influencing their attitudes and preferences towards NMS and MHs. Correlation analysis revealed that age and income are significant predictors for how positive or negative participants viewed NMS and MHs. In addition, a general increase in effect size was observable for the non-user group. Besides, education appeared to only play a subordinate role.

Third, a data analytical approach was taken to infer insights from a data set containing various details about electric scooters such as time and distance of trips as well as geospatial information about the origin and destination of rides. In addition, two cluster algorithms were employed to portray and partition the data in order to unveil potential hub locations that are, in particular, suited for MM due to their proximity to the city center of Berlin. Moreover, a foundation is created on which other researchers and policymakers could build upon.

Notwithstanding its exploratory nature and its limitations, this thesis provides insights into consumer behavior and the role of MHs and equips researchers as well as private and political sector stakeholders with novel information about NMS and implications for what MHs need to offer.

The overarching results suggest that the current state of NMS is not yet at a point that facilitates widespread adoption, particularly for travel that extends beyond leisure activities. However, barriers that prevent adoption are not limited to personal attitudes and preferences but extend to insufficient availability, price, and infrastructure. Thus, external improvements to mobility services and their availability have strong leverage to increase adoption while well-developed MaaS and MOD systems could further increase their uptake. Therefore, the main contribution is a more in-depth understanding of the users and non-users of NMS while showing that MHs provide a promising way to engage both groups alike to use NMS more often and could, by that, lead to a net-positive impact in relation to climate change.

The challenge for future research will be to come up with more detailed solutions that require both more data and real-life testing to allow for exploratory analysis as well as prospective modeling of mobility usage to enable a future with a broad and accessible mobility service offering that is capable of replacing the private car as the main mode of transportation.