Dynamics of Shared Micromobility: An In-Depth Analysis of Integration, System Design, and User Behavior

Insights from the Real-World Lab MORE Sharing

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Statutory Declaration

I hereby solemnly declare that I have produced the dissertation presented to the Faculty of Civil Engineering and Environmental Sciences at the University of the Bundeswehr Munich on the topic of

“Dynamics of Shared Micromobility: An In-Depth Analysis of Integration, System Design, and User Behavior”

without unauthorized assistance, have used no other resources than those cited in the bibliography, and have independently achieved the scientific work.

The dissertation was supervised by Univ.-Prof. Dr.-Ing. Silja Hoffmann.

I have not yet published the dissertation.

I have not submitted a request for admission to a doctorate at any domestic or foreign academic university, nor have I presented the present work as a dissertation elsewhere.

I am familiar with the doctoral regulations of the University of the Bundeswehr Munich.

Munich, 1.10.2024

Maryna Oleksandrivna Pobudzei

Abstract

This dissertation explores the shared micromobility systems, particularly in non-urban university settings, extending the focus beyond the commonly studied metropolitan environments. The research highlights how shared micromobility, facilitated through smartphone applications, is increasingly adopted in smaller communities and campuses. While urban areas face challenges related to accessibility, safety, and social equity, these issues are less pronounced in university settings, which benefit from a concentrated user demographic and limited geographic spread.

The study examines the MORE Sharing system, a micromobility service launched at a university in March 2023, which integrated 100 shared vehicles equipped with IoT devices for real-time tracking and app-based interactions. The analysis, covering data from March 2023 to March 2024, provides insights into user behavior, system engagement, and the potential for micromobility to transform transportation in diverse settings. Key findings emphasize the importance of tailoring micromobility solutions to the specific needs of different environments, which is crucial for broader adoption and effective implementation.

The research also delves into how weather, time of day, and user demographics influence micromobility usage. It reveals that financial incentives, such as a mobility budget, significantly boost initial user registration, though ongoing engagement requires continuous improvement and user feedback monitoring. The study categorizes user segments based on usage frequency, identifying strategies to increase engagement and reduce churn. Additionally, it highlights the diverse transportation needs within a community, suggesting the necessity of maintaining a varied fleet of vehicles.

Machine learning techniques were applied to predict usage patterns, demonstrating the impact of vehicle type, weather, and temporal variables on system utilization. The findings underscore the importance of multimodal platforms in addressing a wide range of transportation needs, particularly in non-urban settings where such systems can enhance connectivity and resilience.

User feedback from various surveys indicates the need for adaptations to engage underrepresented demographics, such as older users and women. The study also underscores the importance of integrating micromobility with existing public transport networks to maximize utility. Technical challenges, like GPS inaccuracies and connectivity issues, were identified, suggesting areas for improvement to enhance user satisfaction.

In conclusion, this thesis offers insights for organizations seeking to implement or refine shared micromobility systems. By understanding user demographics, optimizing system user experience, and maintaining effective communication, these systems can successfully implement and sustain user engagement in urban and non-urban environments. The research also points to the need for future studies to continue refining these systems to meet evolving transportation demands.

Kurzfassung

Diese Dissertation untersucht Shared-Micromobility-Systeme – insbesondere in nicht-urbanen Universitätskontexten – und erweitert damit den bisher überwiegend auf Metropolräume fokussierten Forschungsansatz. Die Arbeit zeigt, wie sich geteilte Mikromobilitätsangebote, vermittelt über Smartphone-Apps, zunehmend auch in kleineren Gemeinden und auf Hochschulgeländen durchsetzen. Während in städtischen Gebieten vor allem Themen wie Zugänglichkeit, Sicherheit und soziale Gerechtigkeit im Vordergrund stehen, treten diese Herausforderungen in Universitätsumgebungen weniger stark auf. Dort profitieren die Systeme von einer konzentrierten Nutzergruppe und einem begrenzten geografischen Raum.

Untersucht wird das „MORE Sharing"-System, ein Mikromobilitätsdienst, der im März 2023 an einer Universität eingeführt wurde. Es wurden 100 Fahrzeuge mit IoT-Technologie ausgestattet, um Echtzeit-Tracking und appbasierte Interaktionen zu ermöglichen. Die Analyse basiert auf Nutzungsdaten von März 2023 bis März 2024 und liefert Erkenntnisse zum Nutzerverhalten, zur Systemnutzung und zum Potenzial von Mikromobilität als Transformationsfaktor für Mobilität in unterschiedlichen Kontexten. Zentrale Ergebnisse betonen die Notwendigkeit, Mikromobilitätslösungen an die spezifischen Bedingungen des jeweiligen Einsatzortes anzupassen – eine Voraussetzung für eine breite Akzeptanz und effektive Umsetzung.

Die Studie untersucht außerdem den Einfluss von Wetter, Tageszeit und Nutzerprofilen auf die Nutzung. Sie zeigt, dass finanzielle Anreize – wie ein Mobilitätsbudget – die anfängliche Anmeldung deutlich fördern, während eine langfristige Nutzung kontinuierliche Verbesserungen und ein aktives Feedbackmanagement erfordert. Nutzergruppen werden anhand ihrer Nutzungsfrequenz segmentiert und Strategien zur Steigerung der Nutzung sowie zur Reduktion von Abwanderung abgeleitet. Darüber hinaus wird auf den vielfältigen Mobilitätsbedarf innerhalb einer Gemeinschaft hingewiesen, der eine diversifizierte Fahrzeugflotte notwendig macht.

Mittels Machine-Learning-Methoden wurden Nutzungsmuster prognostiziert und der Einfluss von Fahrzeugtyp, Wetterbedingungen und zeitlichen Variablen auf die Systemauslastung analysiert. Die Ergebnisse unterstreichen die Bedeutung multimodaler Plattformen zur Erfüllung unterschiedlichster Mobilitätsbedürfnisse – gerade in nicht-urbanen Räumen, in denen Mikromobilität zur besseren Anbindung und Resilienz beitragen kann.

Rückmeldungen aus Nutzerbefragungen zeigen zudem den Bedarf an Anpassungen, um bislang unterrepräsentierte Gruppen wie ältere Menschen und Frauen stärker einzubinden. Ebenso wird die Relevanz einer Integration von Mikromobilität in bestehende öffentliche Verkehrssysteme hervorgehoben, um den Nutzen zu maximieren. Technische Herausforderungen wie GPS-Ungenauigkeiten und Verbindungsprobleme wurden identifiziert und liefern Ansatzpunkte für Verbesserungen im Sinne der Nutzerzufriedenheit.

Zusammenfassend liefert diese Arbeit praxisnahe Erkenntnisse für Organisationen, die Shared-Micromobility-Systeme einführen oder optimieren möchten. Wer Zielgruppen versteht,

die Nutzererfahrung verbessert und eine effektive Kommunikation aufrechterhält, kann Mikromobilitätslösungen nachhaltig und erfolgreich gestalten – sowohl in urbanen als auch in nicht-urbanen Räumen. Die Studie zeigt zudem auf, dass es weiterer Forschung bedarf, um diese Systeme kontinuierlich an sich wandelnde Mobilitätsbedürfnisse anzupassen.

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Maryna Oleksandrivna Pobudzei

1 Introduction

The car needs competition.
We must not only develop environmentally friendly cars.
We must think about new mobility concepts.

Horst Köhler, 2010

1.1 Research Motivation and Objectives

In recent years, shared micromobility has emerged as a transformative force in urban transportation, offering flexible, economical, and environmentally friendly alternatives to traditional vehicular travel. This paradigm shift is characterized by the proliferation of on-demand transportation options such as bicycles, scooters, mopeds, and cargo bikes, which users can access via smartphone applications. Primarily concentrated in dense urban environments, these systems are celebrated for alleviating traffic congestion, reducing carbon emissions, and enhancing urban mobility.

However, the application and study of shared micromobility systems have predominantly focused on large cities, where accessibility, safety, and social equity present complex challenges. These metropolitan areas, with their diverse populations and extensive geographic spread, provide a fertile ground for analyzing the dynamics of shared micromobility. However, this urban-centric focus leaves a significant gap in the literature and understanding of how these systems operate in and benefit smaller, more contained environments such as non-urban communities and university campuses.

Unlike their urban counterparts, these compact settings offer different advantages and challenges for implementing shared micromobility. For instance, university campuses and small towns often feature a more homogeneous demographic and less geographical sprawl, which can simplify the operational aspects of these systems and limit their scope and the variety of user needs they can meet. Additionally, the safety and social equity concerns that heavily influence the deployment and management of urban micromobility systems are typically less pronounced in these smaller settings. Different strategies and models may be necessary to realize the full potential of shared micromobility in such environments.

Given this backdrop, there is a need to explore how shared micromobility systems can be tailored to fit the unique contexts of smaller communities and academic institutions. These environments provide opportunities to enhance transportation infrastructure, improve connectivity, and promote sustainable travel behaviors among a concentrated user base. The potential for micromobility to support campus-based activities, reduce dependency on personal vehicles, and integrate with existing public transport systems presents a compelling case for more targeted research.

This thesis aims to bridge this gap by focusing on the intricacies of implementing and managing shared micromobility systems in non-urban and campus settings. Through an in-depth case study of the MORE Sharing system at a university, this research will explore user engagement, system dynamics, and the broader implications of micromobility in such environments. By analyzing operational data and user feedback, the study will uncover how these systems can be optimized to meet the specific transportation needs of smaller communities, providing a blueprint for future implementations and expansions.

As more colleges, universities, business campuses, and small towns consider introducing or updating their transportation options with technologically advanced, efficient micromobility systems, the insights gained from this research will be invaluable. They will inform not only the operational strategies and technological implementations suited to these settings but also contribute to a broader understanding of the role of shared micromobility in diversifying and enriching the transportation landscape beyond major urban centers.

1.2 Dissertation Overview

This dissertation delves into the dynamics of shared micromobility systems, focusing on their application within non-urban and campus environments, a relatively underexplored area in current micromobility research. The dissertation spans several chapters and analyses the conceptualization of shared micromobility, its implementation, and user interaction within specific contexts.

Chapter 2 “Shared Micromobility: State of the Art” reviews the existing literature and practices in shared micromobility. It begins with a general discussion of the concept of shared micromobility. The chapter then explores various aspects, including user experiences, business models, technological innovations, and these systems’ broader benefits and challenges. A significant focus is expanding these systems beyond typical urban environments into communities, neighborhoods, and university campuses, analyzing how different settings impact system implementation and operation. Detailed analyses include reservation durations, travel distances, the impact of weather and time on usage, and the origins and destinations of trips. Additionally, the chapter delves into modeling user choices and discusses demographic characteristics, shedding light on who uses these services and how.

Chapter 3 outlines the methodology employed to explore the intricacies of the MORE Sharing system at the University of the Bundeswehr Munich. We introduce the case study of MORE Sharing, setting the stage for a detailed investigation into its user engagement. Then, we describe the data collection approach used in the study, which includes collecting backend data from the MORE Sharing system, conducting post-trip surveys to gather immediate user feedback, registering initial user data through dedicated surveys, and assessing long-term user experience and satisfaction through subsequent surveys. Each data collection type aims to capture a different dimension of user interaction and system performance. Further, we delve into the data analysis methods applied. These include examining the origins and destinations of trips, analyzing hourly booking counts, booking distances, and durations, revealing user choices

within the multimodal shared micromobility system, and segmenting users based on usage frequency.

Chapter 4 “Impact of Weather, Time, and User Traits on Shared Micromobility Usage” delves into how external conditions and user characteristics influence the usage of the MORE Sharing system. The chapter presents the distribution of bookings, reservation durations, and distances, looking at how these elements vary under different conditions. Subsequently, the chapter discusses the results obtained from modeling the impacts of weather, time of day, and user demographics on hourly booking counts, durations, and distances traveled.

Chapter 5 “Trip Origins and Destinations in a Multimodal Shared Micromobility Framework” focuses on the dynamics of trip origins and destinations in MORE Sharing. It analyses the distribution of trip origins and destinations within the MORE Sharing system. We also examine the different types of trips made using the system and the various purposes behind these trips, offering insights into how and why users engage with the micromobility options available.

Chapter 6 “Micromobility Choice Patterns in Non-Urban Landscapes” explores micromobility choice patterns in non-urban landscapes, drawing insights from the MORE Sharing system. It uncovers user preferences by analyzing data from the reservations backend app, offering a detailed look into how users select and interact with various micromobility options. The chapter then delves into shared micromobility choices, as revealed by the MORE Sharing post-trip survey, which provides additional context and understanding of user behavior and decision-making processes.

Chapter 7 “User Segmentation based on Usage Frequency” presents a case study on user segmentation based on usage frequency within a multimodal shared micromobility system. It segments customers according to how frequently they use the system, identifying distinct user groups and their behaviors. The chapter then explores vehicle preferences across these customer groups, shedding light on the micromobility options favored by different segments. This analysis is followed by examining the trip characteristics associated with each group, providing insights into their travel patterns. The chapter also addresses customer churn and analyzes user retention and turnover factors.

Chapter 8 “User Characteristics, Feedback on User Experience, and System Setup” explores user characteristics and feedback on the system’s user experience and setup. It compares the characteristics of those who use the MORE Sharing system with those who do not, providing insights into the demographic and behavioral differences between these groups. The chapter then moves on to a detailed analysis of the system’s user experience, focusing on user experience and the availability and quality of information provided. This section also examines the vehicles used within the MORE Sharing system, assessing their impact on overall user satisfaction. Additionally, the chapter explores user attitudes toward free-floating versus station-based models of micromobility, highlighting preferences and challenges associated with each approach.

Finally, we provide a comprehensive conclusion and outlook for the study. We summarize the key conclusions drawn from the research, emphasizing these findings’ implications for other shared micromobility projects. This section highlights the broader lessons that can be applied to

similar initiatives in different settings. The chapter then looks forward, discussing the outlook for shared micromobility systems and identifying areas where further research is needed. It underscores the importance of continued exploration to address emerging challenges and refine these systems for future success.

2 Shared Micromobility: State of the Art

As people's access to the internet grows, we see the sharing economy boom.
Our obsession with ownership is at a tipping point,
and the sharing economy is part of the antidote.

Richard Branson, 2017

2.1 Use It, Do not Own It: Shared Micromobility Context

Shared mobility falls under the larger concept of the sharing economy, which is about renting and borrowing goods and services rather than owning them (Shaheen & Chan, 2016). In a broader sense, shared mobility refers to transportation services users use simultaneously or sequentially (Shared-Use Mobility Center, 2015), allowing individuals to access different modes of transportation as needed (Shaheen et al., 2015).

As transportation authorities focus on increasing the system's efficiency and reducing the negative impact of traffic on the environment, innovative technologies such as shared mobility are gaining momentum. For example, the German Federal Transport Infrastructure Plan 2030 aims to improve mobility and quality of life, including reducing noise pollution and enhancing transport safety in urban and suburban areas (Federal Ministry of Transport and Digital Infrastructure, 2016). To achieve these goals, traditional transportation systems, including public and private transport, could be improved through innovative solutions such as shared mobility services, which require strategic integration into transport planning and operations (Gallo & Marinelli, 2020; Horjus et al., 2022; Machado et al., 2018).

The central goal of shared mobility is to address the underutilization of vehicles during idle times (Karbaumer & Metz, 2021). Like traditional rental, shared mobility focuses on short-term use and streamlined transactions. Since anything that can be owned can also be shared, there is a limitless spectrum of shared mobility types. The main categories include vehicles, rides, and space (Metz, 2021) (Figure 2-1).

For example, there are various models of shared vehicle use, including cars and micromobility options such as bicycles, scooters, mopeds, and cargo bikes, all of which are either human-powered or equipped with electric motors (Machado et al., 2018; Metz, 2021; Shaheen et al., 2015). Each type of shared mobility has its subcategories, including parking arrangements (station-based or within a specific operating area in free-floating mode) and fleet models (managed by an operator, community, or through peer-to-peer systems) (Figure 2-1).

Ride sharing includes ridesharing, on-demand services, and public transportation (Shaheen et al., 2015). The third cluster is delivery sharing, divided into private delivery services and paired with on-demand ride and courier services (Shared-Use Mobility Center, 2015). As the shared mobility market develops rapidly, new shared mobility variations are constantly emerging, and existing forms often converge into combined solutions on a single platform.

The types of shared mobility differ in their social impact: Some are widely recognized for their benefits to the community, while others are more controversial (Ali et al., 2019; Schofield, 2023). Nonetheless, these modes collectively promote a shift from ownership to access, leading to significant implications for individual mobility behavior (Aliari et al., 2020). For instance, vehicle ownership frequently results in routine usage, as individuals rely on their vehicles out of habit (Karbaumer & Metz, 2021). In contrast, those without personal vehicles need to make more considered and intentional decisions about their transportation for each trip. This situation encourages a more considered travel approach, as individuals weigh various factors such as cost, convenience, and environmental impact before choosing their mode of transport (Karbaumer & Metz, 2021; Vega-Gonzalo et al., 2024).

This study explores shared micromobility, encompassing the shared use of small, light vehicles such as bicycles, scooters, mopeds, and cargo bikes. These services provide users short-term access to vehicle fleets via a smartphone application. This chapter discusses users' interactions with shared micromobility, business models, technical requirements for operating shared micromobility, and innovations in the field.

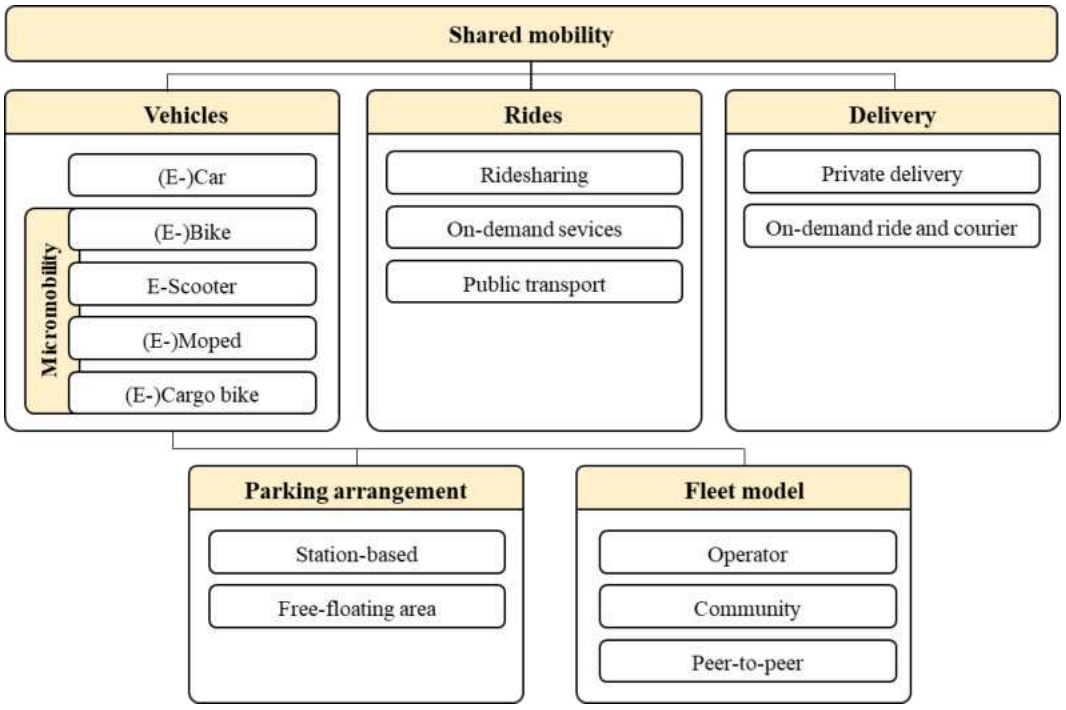

Figure 2-1: Categorization of shared mobility

2.2 Shared Micromobility User Experience

The user experience of shared micromobility involves several stages that must reflect the convenience and efficiency of micromobility services. A user-friendly app must ensure a smooth and efficient user experience by simplifying signing up, finding, accessing, and paying for shared vehicles, thus encouraging more frequent and continued service use (Pobudzei, Kemmerzehl, et al., 2023). If individuals choose to join a shared micromobility service that suits their needs, they must complete the registration process (Figure 2-2). This typically involves filling out an online form with personal details, including credit card and driver's license information. The operating software processes this information and verifies age to confirm that all membership criteria have been met (INVERS, 2021).

Once approved, users are notified by email that they have access to the vehicle fleet. Confirmed members can then start using the service. After logging into the shared micromobility app, users can access their account details and reserve vehicles (evhcle, 2023a). The app synchronizes with the operating system in real time to display accurate vehicle availability (Wunder Mobility, 2023). When the reservation is made, the app communicates with the vehicle's hardware to ensure a valid reservation and unlock the vehicle (Figure 2-2).

When users start their ride, the system records trip details. To end the ride, users confirm the end of their trip via the app, typically taking a photo of the parked vehicle for verification (Movelo, 2021; movmi, 2021). This action signals the end of the journey to the system and releases the vehicle for the following user. At the end of the journey, the system records the start and end locations and the journey duration (Pobudzei, Kemmerzehl, et al., 2023). It automatically calculates the total cost and charges it to the user's registered credit card to provide a seamless end-to-end user experience (Pobudzei, Kemmerzehl, et al., 2023).

If at any point the user encounters problems or has questions, they need the option to contact customer service via the app or website (Figure 2-2). Therefore, a seamless and user-friendly experience is crucial at every stage of shared micromobility, from registration to ride completion, ensuring customer satisfaction and fostering long-term service engagement.

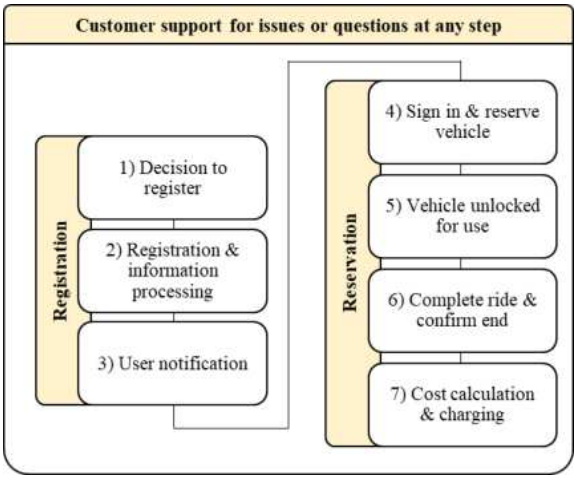

Figure 2-2: User experience in shared micromobility

2.3 Launching Shared Micromobility Business

When initiating a shared micromobility business, it is essential to understand the market and target groups in the context of local regulations (Figure 2-3). Operators must first engage with local authorities to understand the regulatory landscape, which varies from region to region (Aba & Esztergár-Kiss, 2023; Pobudzei, Kemmerzehl, et al., 2023; Schofield, 2023). The recent spread of micromobility has prompted many cities to introduce more strict barriers to entry (NACTO, 2019; Olabi et al., 2023; Schofield, 2023).

A critical aspect currently under discussion concerns the parking of shared mobility vehicles when not in use (Brown et al., 2020; Olabi et al., 2023). Operators must ensure that their fleets align with existing infrastructure (NACTO, 2019; Schofield, 2023; Staff, 2023) and actively collaborate with cities beyond legal compliance. This involves establishing data-sharing agreements and implementing safety measures (Schreier et al., 2022; Tießler et al., 2023). Proactive cooperation like this leads to better compliance and fosters an integrated, community-focused approach to shared micromobility services.

Furthermore, shared micromobility operators must consider architectural layouts, cultural norms, and user needs, influencing the vehicle type choices (Figure 2-3). Potential users' interest in the service is not only determined by socio-economic and demographic factors, such as age, gender, income, and occupation, but also by psychographic characteristics, including values, attitudes, and lifestyles (Fuchs et al., 2021; Pobudzei, Wichmann, et al., 2023a; Winters et al., 2019). Therefore, operators need to identify the pain points unique to each area, as the different starting conditions lead to varying motivations among potential users for adopting shared mobility solutions (Pobudzei, Wegner, et al., 2022a). This involves a continuous dialogue with stakeholders, a deep understanding of local mobility patterns, and the flexibility to adapt operational strategies accordingly (Bjørgen et al., 2021).

To cater to different demographics and business goals, including multiple vehicle types on a single platform can be beneficial (INVERS, 2021). For instance, Lime added e-bikes and e-mopeds to its e-scooter service (Lime, 2021), Revel introduced bike subscriptions and ride-hailing (Hawkins, 2021), and TIER expanded its e-scooter fleet with e-mopeds (TIER, 2020). This strategy acknowledges that one solution only meets some travel needs (Pobudzei, Wegner, et al., 2022a; Pobudzei, Wichmann, et al., 2023a) and offers diverse mobility solutions. Starting with fewer vehicles helps gain experience and refine processes, avoiding early mistakes (Wunder Mobility, 2021a). Scaling can be based on learned insights and established processes (Pobudzei, Kemmerzehl, et al., 2023).

Choosing between a free-floating or station-based model is crucial for shared micromobility providers, as each has advantages and challenges (Figure 2-3). The free-floating model offers users flexibility and accessibility by allowing vehicles to be parked anywhere, which can boost demand but increase risks of damage and theft (Wunder Mobility, 2021b). Conversely, the station-based model, requiring dedicated pick-up and return stations, improves vehicle security and can lower operating costs, but it limits user convenience (INVERS, 2021). A hybrid model blending free-floating and station-based elements can also be considered (MVG, 2024).

Shared micromobility providers require a comprehensive understanding of incurring costs, future revenue forecasts, and a strategic funding plan, particularly in the initial phase, to ensure financial viability, manage risks, and navigate competitive landscapes effectively (Pobudzei, Kemmerzehl, et al., 2023) (Figure 2-3). Most expenses typically include vehicle purchase or leasing costs, maintenance, repair, and cleaning (MOQO, 2020). On average, around 10-20% of the fleet will require ongoing maintenance at any given time (ATOM, 2023b). Other costs include equipment, fuel and charging costs, depreciation, wages for in-house or external staff, software, IT and telematics units, rent, insurance, taxes, marketing expenses, and banking fees (Pobudzei, Kemmerzehl, et al., 2023).

Shared micromobility services generate revenue through per-kilometer rates, time-based fees, and booking charges, balancing direct trip costs with overhead contributions (Soppert, 2022). Competitive pricing is crucial, informed by route simulations and customer cost analyses (ATOM, 2023b). Standard pay-per-minute models can be diversified with ignition fees or parked vehicle rates, while time interval pricing allows dynamic cost variations across different time slots (Soppert, 2022).

Launching a shared mobility service demands advanced technology, including a user-friendly, customizable app for ride booking and a dashboard for fleet management (Pobudzei, Kemmerzehl, et al., 2023) (Figure 2-3). Providers face the choice of developing mobility software in-house, offering full customization at higher costs and time investment, or outsourcing for industry expertise with possible limits on customization and control (ATOM, 2023b; movmi, 2021; Wunder Mobility, 2021a).

Furthermore, shared micromobility businesses need a well-structured team for operational efficiency and customer satisfaction, encompassing in-field tasks (battery swapping, maintenance, vehicle transport), facility operations (battery charging, vehicle repair), and strategic operations for long-term growth (Cataneo, 2023; evhcle, 2023a; Gauquelin, 2020). Effective pre-launch, including branding and fleet deployment, is vital (Figure 2-3). Post-launch, close fleet and customer support monitoring are crucial for data-driven optimized operations (Pobudzei, Kemmerzehl, et al., 2023) (Figure 2-3).

In launching a shared micromobility business, operators must comprehensively grasp market dynamics, regulatory landscapes, and customer preferences, ensuring local norms and infrastructure alignment. From strategic vehicle selection to choosing operational models, the key lies in balancing innovation with practicality, ensuring financial sustainability while maintaining a user-centric focus. This holistic approach, coupled with continuous stakeholder engagement and adaptive strategies, lays the foundation for a successful and sustainable shared micromobility venture.

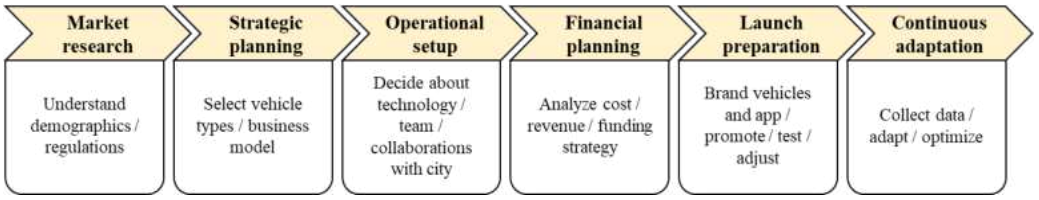

Figure 2-3: Launching shared micromobility

2.4 Technology and Innovations in Shared Micromobility

Shared micromobility's technological core is crucial for seamless trips. Therefore, shared vehicles are equipped with GPS and IoT for tracking, remote control, and data monitoring (evhcle, 2023a). Reliable telematics and network connectivity are essential for the glitch-free trip starts and ends and interaction with cellular networks or mobile apps (movmi, 2021). This system underpins precise billing and real-time vehicle status updates on location, activity, and power levels, which are vital for operational efficiency and customer satisfaction (INVERS, 2021). Additionally, motion sensors are essential for lighter vehicles like scooters and bikes, alerting operators to accidents or mishaps (movmi, 2021; Superpedestrian, 2024), while sensor fusion improves vehicle positioning for monitoring and geofencing, crucial for recovering vehicles and managing speed in specific zones (ATOM, 2023a).

For a comprehensive service, the operational platform must integrate various third-party services like driver license verification, marketing tools, customer support, and standards compliance like MDS (Mobility Data Specification) and GBFS (General Bikeshare Feed Specification) (ATOM, 2023a). It should be compatible with multiple vehicle manufacturers and IoT providers to manage different vehicle types and adopt new technologies (Pobudzei, Kemmerzehl, et al., 2023; Pobudzei, Wichmann, et al., 2023a). Additionally, ongoing updates and expansion in integrations with vehicle manufacturers and IoT providers are crucial for robust multi-vehicle support and adapting to changing needs (Whim, 2024).

Rapid innovations in shared micromobility enhance user experience, operational efficiency, safety, and sustainability. Key user experience developments include electric and hybrid vehicles like widespread e-scooters (e.g., Lime, TIER, Bolt, Voi, Bird), high-end e-bikes (e.g., VanMoof), e-cargo bikes (e.g., Cargoroo), and e-mopeds (e.g., NIU), transforming transit with accessible, faster, and less physically demanding rides. Smart locks and dockless systems add convenience by allowing smartphone vehicle unlocking and flexible parking within designated areas (Sentinel, 2024).

Geofencing technology in shared micromobility manages vehicle usage and parking by setting slow-speed and no-ride zones, ensuring responsible use and designated parking (Herbert, 2023), reducing sidewalk clutter, and increasing safety. Advances in battery technology and operations, like swappable batteries (Gogoro, 2023) and solar-powered charging stations (EIT, 2023), have enhanced vehicle range, reduced downtime, and streamlined processes, boosting operational efficiency in fleet management. Safety is tackled through innovations like helmets with built-in lights and signals (Lumos, 2024), rider education, and safety tutorials (Anke et al., 2023). Sustainability efforts include using recycled materials for vehicles, proper battery disposal, and recycling programs (Lime, 2020; TIER, 2022).

Vehicle telematics data provides insights into user behavior, helping operators identify usage patterns and optimize service offerings, vehicle placement, and the type or timing of vehicles using predictive analytics (ATOM, 2023a; movmi, 2021; Wunder Mobility, 2023). This data also facilitates partnerships with insurance companies for fee adjustments based on driving

behavior (movmi, 2021). While mindful of privacy concerns, data sharing with cities supports infrastructure planning for shared mobility, aiding in dedicated space allocation and balancing needs between pedestrians and users (European Commission, 2023; International Transport Forum, 2018). It also informs the implementation of bike lanes and charging stations (Zhang et al., 2021).

Operators can further aid sustainable development by gathering environmental data through vehicle sensors and supporting city planning without direct municipal investment in vehicles (Alyavina et al., 2020). With these innovations, shared micromobility is evolving into a sophisticated ecosystem that enhances mobility and actively contributes to living areas' sustainable and intelligent transformation.

2.5 Benefits and Challenges of Shared Micromobility

In shared micromobility, a collaborative approach between the public and private sectors aims to bridge gaps in the current transportation systems (Friedel, 2023). These efforts transform transportation systems traditionally managed by government entities. The adoption of shared micromobility is acclaimed for its multiple benefits, including enhancing health and well-being, advancing sustainable communities, and promoting responsible consumption (Aliari et al., 2020; Schwing, 2023; Shaheen et al., 2016).

From a health and environmental perspective, shared micromobility may contribute significantly to transport decarbonization, a key factor for public health (Peng et al., 2022). Supporting this, Krauss et al. (2022) conducted a study in six global cities, finding a transition from motorized transportation modes to shared micromobility, leading to reduced emissions. Moreover, micromobility users tend to be more physically active than non-users, improving health outcomes (Aliari et al., 2020; Bretones & Marquet, 2023).

In terms of sustainable development, shared micromobility plays a crucial role in augmenting public transportation usage, particularly for first and last-mile connectivity (Aliari et al., 2020; Tießler et al., 2023; K. Wang et al., 2023; Yin et al., 2024). It provides flexibility and convenience, especially in areas with limited public transport or where owning a personal vehicle is impractical or expensive (Schwing, 2023; UITP, 2023).

Moreover, decreasing reliance on individual motorized transportation fosters the growth of sustainable transport modes, like bike lanes (Aliari et al., 2020; Hossein Sabbaghian et al., 2023; Hosseinzadeh, Algomaiah, et al., 2021; Laa & Leth, 2020). Furthermore, shared mobility services are reducing the demand for personal vehicle ownership, thereby diminishing the perceived necessity for future car acquisition, particularly among non-car owners (Gebhardt et al., 2021; Vega-Gonzalo et al., 2024; K. Wang et al., 2023). This trend encourages a shift toward a shared resource model in mobility, which aligns with sustainable and responsible consumption patterns (Holden et al., 2020; Karbaumer & Metz, 2021).

Despite advantages, shared micromobility faces challenges, including safety concerns, regulatory complexities, and issues with maintenance and vandalism. For example, the rapid

increase in shared e-scooters in Paris led to reckless riding, improper usage, and pedestrian accidents (Staff, 2023). This prompted the city to enforce stricter regulations: In April 2023, Paris held a referendum where a majority, though from a low voter turnout, favored banning shared e-scooters (Schofield, 2023). However, this ban did not include shared electric bikes or private e-scooters (Staff, 2023). Paris's measures reflect a broader trend in cities like Madrid (Carey, 2023) and Copenhagen (Dodds, 2021; VisitCopenhagen, 2024), where restrictions have been implemented, though complete bans are still uncommon.

Interestingly, other shared micromobility modes like city bikes, e-bikes, e-mopeds, and e-cargo bikes tend not to evoke such polarized opinions compared to e-scooters. This is primarily because these modes are perceived as safer, better integrated with existing urban infrastructure, and more helpful for various purposes, including commuting and cargo transportation (Filipe Teixeira et al., 2023). Consequently, public sentiment tends to be more favorable toward bikes and e-bikes than the more controversial e-scooters (Caspi, 2021; Filipe Teixeira et al., 2023).

Data security is another concern regarding shared micromobility platforms (Schwing, 2023). As platform-based online services, shared mobility services need personal information for registration (Appt, 2020). This requirement raises privacy concerns, as these services can track user location and provide route and traffic information (Affia & Matulevičius, 2022). Such privacy concerns are viewed as a barrier to adopting sharing-based consumption models (Huang, 2022). Lastly, there are debates regarding the actual impact of vehicles used in shared mobility. Some studies suggest that rather than replacing private cars, shared micromobility might create additional trips or replace trips that would otherwise be made using more sustainable modes of transport (Hollingsworth et al., 2019; K. Wang et al., 2023).

In conclusion, shared micromobility marks a transformative shift in transportation, offering benefits such as the potential for enhanced public health, environmental sustainability, and support for sustainable development. However, it faces safety concerns, regulatory issues, and data privacy matters. Balancing these advantages and addressing the challenges is crucial for realizing the full potential of shared micromobility as a sustainable transportation solution.

2.6 Beyond the City: Shared Mobility in Communities, Neighbourhoods, Campuses

Accessibility refers to the ability of individuals to meet their everyday social, health, personal, and economic needs in a safe, comfortable, and convenient way (Federal Ministry of Transport and Digital Infrastructure, 2016). A major problem in transportation is the dependence of many households, both in urban and non-urban areas, on car mobility for their daily activities (EIT, 2021; Mounce et al., 2020; Selzer, 2022; W. Wang et al., 2023). The widespread use and parking of vehicles significantly burden public space, affect the livability and sustainability of communities, hinder pedestrian traffic, and complicate the operation of municipal services (Karbaumer & Metz, 2021).

Most shared mobility services in Germany (and worldwide) are concentrated in urban areas, with significantly less availability in rural regions. While 99% of large cities in Germany with

over 100,000 inhabitants have shared mobility services, this drops to 49% in towns with 20,000 to 50,000 residents and only 5% in places with fewer than 20,000 residents (MOQO, 2022). Establishing and making these services profitable in small communities is challenging, partly because public transport is often less developed in rural areas, leading more people to rely on personal vehicles (Hult et al., 2021; Mounce et al., 2020). These areas' lower building and population density also reduce parking pressure, diminishing some critical arguments for shared mobility (Hult et al., 2021).

Rural shared mobility services are frequently run as volunteer-based associations, fostering a community-centric approach (Dörpsmobil SH, 2023). They are often supported by local governments seeking sustainable transport solutions, which offer incentives like public parking spaces in the center of the communities (Borcherding, 2023; Karbaumer & Metz, 2021; Matthijs, 2022; Mer Germany, 2023). Partnerships with consistent users such as municipal entities or local organizations ensure reliable usage and revenue while boosting the service's visibility and community trust (Die Energie, 2023; Matthijs, 2022).

The examples of shared mobility projects are in Table 2-1. In Germany, Lohr, Karlstadt, and Veitshöchheim have implemented a station-based car-sharing service operated by the regional energy provider (Die Energie, 2023). This service, available at three stations, is primarily utilized by city, municipal staff, and companies during business hours. Outside these hours, the public can access these vehicles for activities like family outings and shopping, with a reservation option in advance (Die Energie, 2023).

Similar station-based car-sharing models are in Klixbüll and Schäftersheim, Germany (Dörpsmobil SH, 2023), Barnim, Germany (Borcherding, 2023), and various locations in Belgium including Peer, Rijkevorsel, Brasschaat, Schoten, Herent (Karbaumer & Metz, 2021), and Hill Country (Matthijs, 2022). In France, Luitré-Dompierre has a "mobility hub" with two shared electric cars with a charging station, car wash, caravan park, carpooling meeting point, and a fleet of electric bikes (Automotive World, 2021). Generally, these operations are station-based, with a few vehicles available. They are often used to potentially replace secondary or tertiary vehicles rather than eliminate private car usage in households.

Shared micromobility initiatives are relatively scarce in smaller, non-urban regions (Audikana et al., 2017; Regio.Mobil, 2023), but some examples still exist. A case in point is Heuweiler, where the Bürgerrunde Heuweiler (2021) launched a project offering a free e-cargo bike for public use. Local authorities positioned this shared e-cargo bike in a central location and tried to familiarize the locals with this transport option (Bürgerrunde Heuweiler, 2021).

On a broader scale, the Ortenau district in Baden-Württemberg has embarked on a pioneering project to foster eco-friendly travel across multiple communities (Schnase, 2023). The initiative plans to establish approximately 150 rental stations for shared e-cars, e-bikes, and e-cargo bikes. This aligns with Baden-Württemberg's ambitious target of setting up 1,000 such stations (Schnase, 2023). A feature of this project is the provision for vehicle sharing between communities, enabling one-way journeys for residents (Schnase, 2023).

Another example of shared micromobility in residential areas is start-up sigo (2023), which provides a shared e-cargo bike mobility solution for neighborhoods, covering site analysis,

service and support, stations, an app, and a marketing package. They are already present in 75 real estate sites in Germany (sigo, 2023). E-scooters are available in medium-sized cities like Lichtenrade and Zehlendorf (Ellenbeck & Aykal, 2022) and cities like Meppen, Lingen, Bruchsal, and Norden (share2move, 2023). However, by the end of 2024, we found no e-scooter projects in locations with fewer than 10,000 residents.

Campus micromobility is a form of shared micromobility that focuses on overcoming the limitations of public transport and navigating sprawling campuses (Aliari et al., 2020; Schwing, 2023). The term "campus shared mobility" was first used to describe bike sharing systems found at places like universities and office campuses for those who work or study there (Shaheen & Chan, 2016). In our study, we focus on shared micromobility services, such as bikes, e-scooters, e-cargo bikes, and e-mopeds, specifically intended for and used by members of a particular organization.

Several initiatives have been implemented to provide shared micromobility options to campus communities. For example, the Portland Bureau of Transportation reduced the costs of its bike share system for college students and low-income individuals (PBOT, 2021). E-scooter provider Spin highlights the significance of campus programs in their operations (NABSA, 2022), as campuses have high population density, short travel distances, and a keen student base (Spin, 2024). Spin's operation extends to over 25 universities across the United States, varying in size, enrollment, and environment (Spin, 2024). Bird has established a university-specific team to develop tools for the unique needs of colleges and universities operating over 130 U.S. campuses (NABSA, 2022). Bird and Spin report that minimal marketing is required to increase service usage, focusing instead on promoting safe use and education (NABSA, 2022; Spin, 2024).

A study at Texas A&M University showed that a substantial portion of the university's population, nearly one-third, adopted a bike share program launched on campus (Kellstedt et al., 2019). Similarly, at the University of Colorado Boulder, the Boulder BCycle bike share program saw significant engagement (Boulder BCycle, 2018), offering students free access to shared e-bikes and a 50% discount for staff. By the end of 2021, the program had attracted nearly 10,000 active student users from the University of Colorado Boulder and recorded over 250,000 trips annually (Boulder BCycle, 2018). Capital Bikeshare also partnered with higher education institutions in Washington, D.C., offering discounted memberships to students at major universities (NABSA, 2022).

In Manila, Philippines, the UP Bike Share has evolved from a social enterprise into a significant part of the broader sustainability advocacy movement (Sunio et al., 2020). Unlike earlier unsuccessful attempts by the local government, international development organizations, and public transport agencies to launch a bike sharing program in Metro Manila, UP Bike Share stands out as the Philippines' first bike sharing initiative that was not only successfully piloted but also effectively implemented and sustained (Sunio et al., 2020).

Another example of shared micromobility on campus is DHBW Drive, the real-world laboratory for micromobility at DHBW Stuttgart (Kuhn et al., 2021). It offers a free shared e-scooter service to all students, lecturers, and staff across its Stuttgart locations (Kuhn et al., 2021;

Schwing, 2023). By analyzing daily e-scooter usage patterns, the project seeks to uncover insights into how micromobility functions in a closed environment like the DHBW campus (Grimme et al., 2023; Schwing, 2023).

Research on shared micromobility has primarily focused on large urban systems, often sidelining those in smaller communities and university campuses (Audikana et al., 2017; Sunio et al., 2020). Despite similar benefits across different scales, such as promoting active transportation (Fishman, Washington, & Haworth, 2015) and enhancing first- and last-mile transit solutions (Aliari et al., 2020; Schwing, 2023), the objectives and challenges of implementing shared micromobility in smaller versus larger areas differ significantly (Aliari et al., 2020; Audikana et al., 2017; Sunio et al., 2020).

While metropolitan areas face issues related to accessibility, safety, and social equity (Fishman et al., 2012; Goralzik et al., 2022), these are less pronounced in university settings due to unique user demographics and smaller geographic coverage (Aliari et al., 2020; Audikana et al., 2017; Sunio et al., 2020).

Although examples of shared micromobility in non-urban areas are sparse, emerging cases (Table 2-1) indicate a growing adoption potential in these environments (Sunio et al., 2020). The increasing collaboration between micromobility providers and local institutions points to a concerted effort to enhance community transportation. Distinct differences in usage patterns, health impacts, and effects on transportation infrastructure, such as parking, traffic, and public transit, exist between large city systems and those in smaller or academic settings (Aliari et al., 2020).

Therefore, a context-specific analysis of shared micromobility in small communities and university campuses is crucial (Pobudzei, Wichmann, et al., 2023a; Sunio et al., 2020). This approach allows for understanding their varied impacts on travel behavior and transportation systems. The resulting insights can significantly aid in the development, planning, and scaling of these systems, especially as more educational institutions consider introducing or updating their programs with newer, more efficient models, including dockless options (Pobudzei, Kemmerzehl, et al., 2023).

Table 2-1: Shared mobility projects in non-urban areas

Location	Project Type	Examples	Usage	Notes
Germany	Station-based car sharing	Lohr, Karlstadt, Veitshöchheim (Die Energie, 2023)	City, municipal staff, and companies; public for personal use outside business hours	Operated by regional energy provider
Germany	Station-based car sharing	Klixbüll, Schäftersheim (Dörpsmobil SH, 2023), Barnim (Borcherding, 2023)	Community-centric, volunteer-run services	Supported by local governments
Belgium	Station-based car sharing	Peer, Rijkevorsel, Brasschaat, Schoten, Herent (Karbaumer	Few station-based shared vehicles	Supported by local governments

Location	Project Type	Examples	Usage	Notes
		& Metz, 2021), Hill Country (Matthijs, 2022)		
France	Station-based car and bike sharing	Luitré-Dompierre (Automotive World, 2021)	Mobility hub with shared e-cars and e-bikes	Includes a charging station, car wash, caravan park
Germany	Residential e-cargo bike sharing	sigo (sigo, 2023)	Shared e-cargo bikes for neighborhood use	Present in 75 real estate sites in Germany
USA	Campus bike sharing	Texas A&M University (Kellstedt et al., 2019), University of Colorado Boulder (Boulder BCycle, 2018), Capital Bikeshare (NABSA, 2022), UMD Bike Share (Aliari et al., 2020)	College students and staff can use free of charge or reduced fee bike sharing	Significant engagement and usage at universities
Philippines	Campus bike sharing	UP Bike Share (Sunio et al., 2020)	Part of broader sustainability movement; available for public use	First successful bike sharing initiative in the Philippines
Germany	Campus e-scooter sharing	DHBW Drive (Grimme et al., 2023; Kuhn et al., 2021; Schwing, 2023)	Free service for students, lecturers, and staff	Real-world laboratory for micromobility; analyses usage patterns

2.7 Reservation Duration and Travel Distance of Shared Micromobility Modes

Shared micromobility systems typically offer only one mode per provider (e.g., city bikes, e-bikes, e-scooters), requiring users to register with multiple services for different options. Integrating multiple shared micromobility modes in one application is not widespread (Pobudzei, Wegner, et al., 2022a). Therefore, micromobility usage patterns differ by provider and location (Pobudzei, Wichmann, et al., 2023a). While many studies have focused on shared micromobility in urban locations (Krauss et al., 2022; Reck et al., 2022; K. Wang et al., 2023), few have examined shared micromobility as a distinct transportation alternative in non-urban areas or campuses (Audikana et al., 2017; Nikitas, 2018).

University campuses feature a unique mix of population demographics, travel behaviors, and irregular working hours. Students, who often have more control over their schedules and fewer family or income responsibilities, differ in their travel habits from the general public (Engelen et al., 2019). This flexibility often allows them to avoid peak traffic times (Nikiforiadis et al., 2023). Typically younger, single, and with less car access, students are more inclined to choose public transport and non-motorized travel options daily (De Vos & Alemi, 2020). Additionally, the dynamic educational environment of colleges and universities positions them as prime

venues for advancing sustainable mobility by transforming societal travel norms and promoting active transportation methods (Aliari et al., 2020).

This chapter examines trip durations, distances, and factors influencing shared micromobility in urban and rural environments. The average trip lengths and durations of shared micromobility modes are summarized in Table 2-2. In the U.S., commercial city-wide bike share program members generally have rides lasting around 15 minutes, spanning distances up to 3 kilometers (NACTO, 2022). Conversely, station-based urban bike sharing users embark on lengthier trips, typically between 24 and 28 minutes, covering distances of around 5 kilometers (NACTO, 2022).

Aliari et al. (2020) conducted a study on the bike sharing program at the University of Maryland (UMD), examining ridership trends and the factors influencing demand on campus. This analysis utilized the program's data and historical weather records, elevation, and transit service locations. The study found that the average bike trip on UMD's campus lasts 6.8 minutes, suggesting brief rides within the campus. In contrast, trips from on-campus to off-campus locations average 8.5 minutes, while those from off-campus to on-campus and between off-campus locations average around 9 minutes. During weekends, these trip durations increase slightly, consistent with findings that larger bike share systems see longer weekend rides, typically for leisure purposes (Fishman, 2016).

Aliari et al. (2020) found that a significant portion of the bike sharing trips lasted nine minutes or less, indicating their use for short distances. However, they also observed many longer journeys, with an average duration of 41 minutes, primarily round trips where bikes were taken from and returned to the same station. This pattern suggests a notable demand for bike sharing among individuals undertaking off-campus trips and returning to the starting point.

Guidon et al. (2019) studied a free-floating e-bike sharing system in Zürich, Switzerland. On an average day, 305 trips were made, with a high standard deviation because the system grew strongly. The mean trip distance was 2.5 kilometers, with a mean duration of 10.3 minutes. E-bike sharing provider Dott (2022) also reported similar statistics: the average e-bike trip is 2.2 kilometers long and lasts 11 minutes.

Regarding shared e-scooter usage, the average trip distance routed in 44 European cities was around 1.84 kilometers (Tack et al., 2019). Grimme et al. (2023) studied a multi-location organization's closed-campus e-scooter sharing service in Stuttgart, Germany. In this setup, the average trip length was 25 minutes and 4.3 kilometers, ranging from 1 minute to 3 hours, and distances up to 27 kilometers. The most common distances were under 1 kilometers (23%) and between 1-2 kilometers (19%), aligning with the idea that e-scooters excel in "first/last mile" scenarios (Liao & Correia, 2020; Smith & Schwieterman, 2018). In such settings, e-scooters, free for university members and faster than walking, offer more advantages than public transport or short commutes (Grimme et al., 2023).

A study at Virginia Tech's Blacksburg, VA campus analyzed 120,636 shared e-scooter trips, averaging 794 daily trips (Buehler et al., 2021). The average e-scooter trip was about 1.2 kilometers long, lasting 7.3 minutes. By calculating travel speeds using GPS data and assuming linear travel, it was found that e-scooters typically moved at speeds between 9.7 to 12

kilometers per hour (km/h), averaging approximately 9.9 km/h. Speeds over 16 km/h were observed in only a small fraction of the trips (Buehler et al., 2021).

Academic literature on the usage patterns of shared e-cargo bikes still needs to be expanded (Pobudzei, Kemmerzehl, et al., 2023). Present research primarily concentrates on e-cargo bikes in the context of small businesses (Malik et al., 2023) and private ownership (Carracedo & Mostofi, 2022). Malik et al. (2023) focused on the e-cargo bike pilot scheme, a joint effort by the county council, a bike share operator, and local businesses in Dun Laoghaire-Rathdown, Ireland.

This scheme offered local businesses discounted access to e-cargo bikes for six months, allowing them to replace van or car deliveries and services with e-cargo bikes. Participants used three different models of electric cargo cycles, each with different cargo capacity and electric ranges. Among these participants, the average trip length was 3.3 km, while the average trip time was 14 minutes (Malik et al., 2023). Privately owned e-cargo bikes cover daily, on average, 14.4 km (Carracedo & Mostofi, 2022). In the free cargo bike sharing domain, most trips are less than 10 km (Becker & Rudolf, 2018).

Regarding e-moped sharing, Aguilera-García et al. (2021) found that 70.6% travel alone by shared moped. 50% of the respondents indicated that their travel time by shared e-moped is 10-15 minutes. 84.3% reported walking less than 500 meters to pick up an e-moped (Aguilera-García et al., 2021). Wortmann et al. (2021) observed that the average distance traveled with a shared e-moped in Berlin is between 3.6 and 4.1 km. The modeling study of

Table 2-2: Shared micromobility average trip lengths and durations

Shared Mode	Average Trip Length (km)	Average Trip Duration (min)	Reference
City-wide free-floating urban bike share (USA)	3	15	(NACTO, 2022)
Station-based urban bike share (USA)	5	<28	(NACTO, 2022)
Closed-campus bike share (USA)	On-campus: <1, Off-campus: <3	<9	(Aliari et al., 2020)
Free-floating e-bike share (Switzerland)	2.5	10.3	(Guidon et al., 2019)
E-bike share (internationally)	2.2	11	(Dott, 2022)
E-scooter share (internationally)	1.84	-	(Tack et al., 2019)
Closed-campus free e-scooter share (Germany)	4.3, but most trips under 2 km	25	(Grimme et al., 2023)
Closed-campus e-scooter share (USA)	1.2	7.3	(Buehler et al., 2021)
E-cargo bike (small businesses in Ireland)	3.3	14	(Malik et al., 2023)
E-cargo bike (private ownership internationally)	14.4	-	(Carracedo & Mostofi, 2022)
E-cargo Bike (free sharing program in Germany and Austria)	<10	-	(Becker & Rudolf, 2018)
E-moped share (Germany)	3.6-4.1	10-15	(Aguilera-García et al., 2021)

Fiorini et al. (2022) also noted that trips over 5 km with shared e-mopeds have a very low probability.

Across different modes and contexts (Table 2-2), there is a preference for short and quick trips. This is evident in the popularity of micromobility for trips averaging less than 5 km and typically under 15 minutes. This trend suggests a significant role for micromobility in facilitating efficient, short-distance travel.

2.8 Impact of Weather and Time on Shared Micromobility

The increasing preference for shared micromobility as a transportation option has drawn considerable attention in recent years, prompting a detailed investigation by researchers, service providers, and policymakers into the usage patterns of these services (Pobudzei, Sellaouti, et al., 2022). One focus of these studies is the understanding of how time-sensitive factors, such as weather conditions and temporal variables, affect travel behavior, including trip distances, durations of booking, and the number of reservations (Pobudzei, Sellaouti, et al., 2022) (Table 2-3).

Within the context of bike sharing, Kutela and Teng (2019) explored the impact of campus characteristics and weather conditions on the daily use of bike sharing services across 25 university campuses in the United States from 2014 to 2018. Their findings indicated a positive correlation between the presence of faculty, staff, and students, as well as the overall size of the campus, with the frequency of bike sharing trips within a university setting. In contrast, they observed a negative relationship between the proximity of a campus to a central business district and severe weather events with the demand for bike sharing services.

A study conducted at the University of Maryland (Aliari et al., 2020) examined campus bike sharing system from spatial, temporal, and environmental perspectives, finding that factors such as weather, time of day, day of the week, and station locations significantly influenced bike share demand, similar to trends observed in city-wide systems (Gebhart & Noland, 2014). This research revealed that bike sharing usage peaked during spring and summer, correlating with favorable weather conditions and higher temperatures.

The study particularly noted a substantial increase in usage when temperatures ranged between 13 and 30 degrees Celsius, especially during the summer, September, and October (Aliari et al., 2020). However, despite spring temperatures falling within this optimal range, bike sharing demand was comparatively lower, suggesting the influence of other factors beyond weather, such as academic schedules and campus activities (Aliari et al., 2020).

Additionally, Aliari et al. (2020) identified significant temporal variations in station usage for on-campus trips at a university, with usage increasing from noon to midnight. This pattern aligns with the rhythm of campus activities and contrasts with typical urban travel peaks. Furthermore, they observed varying demand patterns for trips from on-campus to off-campus locations and vice versa.

In the context of e-bike sharing in Zürich, Switzerland, Guidon et al. (2019) noted peak usage times between 6-8 p.m. and a morning surge between 7-8 a.m., suggesting a primary use for commuting. They also found that weather conditions substantially impacted e-bike bookings, with precipitation notably reducing demand. Other studies have also reported increased usage of shared city bikes and e-bikes on weekdays, particularly during peak commuting hours (Fishman, Washington, & Haworth, 2015; Fishman, Washington, Haworth, et al., 2015; Rérat, 2021).

According to Becker & Rudolf (2018), e-cargo bikes are predominantly used for commercial and delivery purposes during weekdays. Malik et al. (2023) studied using e-cargo bikes among small businesses for goods delivery. Their findings indicate a preference for e-cargo bikes in warmer, drier conditions, particularly for longer delivery routes. The study underscored a significant interaction between weather conditions and distance, noting that wet and colder weather tended to reduce the attractiveness of e-cargo bikes for deliveries. Additionally, the timing of the trip, reflecting traffic conditions, emerged as another crucial factor affecting e-cargo bike usage (Malik et al., 2023).

Several studies have examined the impact of weather conditions on using various micromobility options. For instance, Reck et al. (2022) found in Zurich that precipitation led to a shift in transportation preferences, with a notable decrease in micromobility options like e-bikes and e-scooters favoring public transport and cars. Similarly, adverse weather conditions, such as snow, rain, wind, and freezing temperatures, negatively affected e-scooter usage in Indianapolis (Mathew et al., 2019).

In Washington, humidity, wind speed, and precipitation reduced the frequency of e-scooter trips, whereas warmer temperatures and clear visibility were linked to increased usage (Younes et al., 2020). Tuli et al. (2021) reported higher e-scooter demand in Chicago on days with higher average temperatures, lower wind speeds, and less precipitation, especially during weekends. In Kelowna, e-scooter demand was higher during summer, mid-day on weekends, weekday afternoons, and days without rainfall (Orvin et al., 2021). In contrast, in Washington, there was a decrease in e-scooter bookings during weekends (Hawa et al., 2021).

In Louisville, Noland (2019) reported reduced e-scooter use during rain and snow. Interestingly, changes in average temperature and wind speed did not significantly alter daily trip counts, although travel distances were shorter in windy conditions and longer in warmer weather. Most e-scooter trips occur on Saturdays, with longer average trip distances and slower speeds on weekends (Noland, 2019).

A Louisville study by Hosseinzadeh, Karimpour, et al. (2021) analyzed e-scooter and dockless bike sharing trip frequency using a negative binomial generalized additive model. This study revealed that weather-related factors such as rainfall, mist, glaze, higher wind speeds, and higher temperatures decreased the number of shared micromobility trips. Conversely, usage increased on Mondays, Thursdays, Fridays, and Saturdays (Hosseinzadeh, Karimpour, et al., 2021).

In Austin, distances and durations of shared micromobility modes were lower in colder, rainier, and windier conditions (Noland, 2021). Extreme heat and high relative humidity also adversely affected usage. Docked bicycles and dockless e-bikes were more sensitive to adverse weather conditions than e-scooters. Local events, like festivals, were associated with increases in

micromobility sharing trips (Noland, 2021). Similarly, rainfall and high temperatures in Singapore suppressed the usage of docked bike sharing and dockless shared e-scooters (Zhu et al., 2020).

In Munich, usage patterns for shared e-scooters peaked on Friday and Saturday afternoons, with riders taking longer trips on weekends and holidays than on workdays (Pobudzei, Sellaouti, et al., 2022; Schreier et al., 2022; Sellaouti et al., 2023; Tießler et al., 2023). The use of shared e-scooters increased in number and duration from July to November compared to the winter months, highlighting seasonal variations in usage patterns (Pobudzei, Sellaouti, et al., 2022; Sellaouti et al., 2023).

The research on shared micromobility (Table 2-3) provides insights into the dynamics of this emerging mode of transportation. It underscores the significant influence of weather conditions, seasonality, and time on the usage patterns of various shared transportation options. These studies highlight the complex interplay between environmental factors and human behavior. Studying time-variant factors contributes to the understanding of mobility trends and their implications for future transport planning and policy development.

Table 2-3: Overview of studies on time-variant impacts on shared micromobility based on Pobudzei, Sellaouti, et al. (2022)

Mode	Environment	Weather	Time	Explain	Statistical Tool
Bike	25 university campuses, USA (Kutela & Teng, 2019)	Snow, precipitation, fog, temperature	Month, weekday, holiday, year	Number of trips per day	Negative binomial, mixed effect negative binomial
Bike	University of Maryland's campus, USA (Aliari et al., 2020)	Temperature, wind speed, precipitation	Month, weekday, hour	Number of trips per day, duration	Spearman rank correlation
E-bike	Zürich, Switzerland (Guidon et al., 2019)	Temperature, solar radiation, precipitation	Weekend	Number of trips per day	Negative binomial
E-cargo bike for small business	Dún Laoghaire-Rathdown, Ireland (Malik et al., 2023)	Temperature, precipitation	Month, weekday, hour	Trip length	Back propagation, neural network classifier
E-bike, e-scooter,	Zürich, Switzerland (Reck et al., 2022)	Rain, wind speed	Hour	Hourly bookings	Mixed logit
Bike, e-scooter,	Louisville, USA (Hosseinzadeh, Karimpour, et al., 2021)	Temperature, wind, rain, mist, glaze	Weekday, holiday, local event	Daily trips	Negative binomial generalized additive
Bike, e-scooter	Washington, USA (Younes et al., 2020)	Temperature, wind, humidity, visibility	Local event, weekday, hour	Hourly trips, median booking duration	Negative binomial

Mode	Environment	Weather	Time	Explain	Statistical Tool
Bike, e-bike, e-scooter,	Austin, USA (Noland, 2021)	Temperature, wind, rain	Holiday, weekday, local event	Daily trips, distance, speed	Prais-Winsten, negative binomial, random forest
E-scooter	Munich, Germany (Pobudzei, Sellaouti, et al., 2022)	Rain, wind chill index	Year, month, weekday, holiday, hour	Hourly bookings, median hourly distance, and duration	Poisson, negative binomial, random forest
E-scooter	Chicago, USA (Tuli et al., 2021)	Temperature, wind, rain	Weekday	Daily trips	Random effects negative binomial
E-scooter	Indianapolis, USA (Mathew et al., 2019)	Temperature, wind, rain, snow, visibility	-	Hourly trips	Poisson negative binomial
E-scooter	Louisville, USA (Noland, 2019)	Temperature, wind, rain, snow	Weekday	Daily trips, distance, speed	Ordinary least square
E-scooter	Washington, USA (Hawa et al., 2021)	Temperature, rain	Weekday	Hourly trips	Multilevel mixed effects linear
E-scooter	Kelowna, USA (Orvin et al., 2021)	Rain, wind, humidity	Season, weekend, weekday, hour	Hourly trips	Zeroinflated negative binomial

2.9 Origins and Destinations of Shared Micromobility Trips

Shared micromobility has been extensively researched in dense urban areas. Studies show that in city centers and business districts, with their high density of workplaces, retail centers, and entertainment venues, these services are in high demand (Bai & Jiao, 2020; Heumann et al., 2021; König et al., 2022; McKenzie, 2019; Tießler et al., 2023). This demand is primarily driven by the numerous short-distance trips made by workers, residents, and tourists, which align with the intended use of micromobility options (Heumann et al., 2021).

However, the use of shared micromobility extends beyond busy urban cores. In residential areas, which are typically less densely populated, locals often use these services for neighborhood errands or accessing nearby facilities (Henriksson et al., 2020; Wilson, 2017). Similarly, university campuses demonstrate significant adoption of micromobility solutions. Studies indicate that both students and staff frequently use these services for their daily commutes and intra-campus travel (Aliari et al., 2020; Buehler et al., 2021; Cao et al., 2021; Dongxue, 2019; Moosavi et al., 2022).

Critical area of micromobility usage is near transportation hubs like train stations, bus terminals, and subway stations (Aliari et al., 2020; ARUP, 2020; Intertraffic, 2023; Montes et al., 2023; Oeschger et al., 2020; Tießler et al., 2023). Here, micromobility services play an essential role in bridging the first and last mile of a journey, thereby enhancing the accessibility and connectivity of the public transport system (Bösehans et al., 2021; T. Ma et al., 2019; Montes et al., 2023; Oeschger et al., 2020; Younes et al., 2020).

For instance, a pilot e-scooter program in Portland revealed that shared e-scooters effectively addressed transportation gaps when public transport was insufficient (PBOT, 2018). Moreover, a study in Singapore found that shared e-scooter services could substitute for short public transit trips that would otherwise involve multiple transfers and detours (Cao et al., 2021). These micromobility modes also facilitate connections to other forms of transportation. Buehler et al. (2021) reported that around 30% of respondents in a campus-based shared e-scooter program used e-scooters to access parking lots or public transport services. In campus-based bike sharing program (Aliari et al., 2020), stations near significant transportation hubs had the highest demand, indicating that university bike shares, like larger bike share systems, can complement existing transit systems by providing first-mile/last-mile accessibility (T. Ma et al., 2019; Younes et al., 2020).

The operational models of shared micromobility services vary. Free-floating services, for example, allow users to pick up a vehicle at one location and leave it at another, obviating the need to return to the starting point (Heumann et al., 2021). However, round trips are common, particularly when providers establish hubs or stations for vehicle pick-up and drop-off. This is often seen in bike-sharing programs where users must return bikes to designated stations after use (SWM, 2022). In Stuttgart, a study on shared e-scooters found a predominance of round trips, with most users picking up and returning scooters to the same campus location (Grimme et al., 2023). Another factor is topography: trips tend to occur more frequently from higher to lower elevations (Aliari et al., 2020).

While there is abundant research on micromobility in urban settings, there needs to be more understanding of these systems in non-urban environments and how different micromobility modes integrate within a single shared mobility system. This study addresses this gap by exploring the origins and destinations of trips in a multimodal shared micromobility system situated on a non-urban university campus. The insights gained will be crucial in understanding the potential of these systems in similar non-urban settings.

2.10 Modeling Shared Micromobility Choices

Choice modeling has been employed to study individuals' inclinations toward shared micromobility encompassing city bikes, e-bikes, e-cargo bikes, e-mopeds, and e-scooters. While some researchers delved into individual services, others contrasted multiple modes (Table 2-4). For instance, time and cost heavily swayed students' transport decisions (Nikiforiadis et al., 2023). E-scooters became a top choice for short journeys (Nikiforiadis et al., 2023). The mode previously used, perceptions of infrastructure safety, and attitudes toward e-scooters also played substantial roles (Nikiforiadis et al., 2023).

Furthermore, Montes et al. (2023) suggested that shared micromobility could substitute metro journeys. Shared bicycles aligned with metro usage, whereas shared e-mopeds were apt for extended solo trips. Preferences were shaped by factors such as public transport frequency, prior micromobility exposure, and age (Montes et al., 2023).

Analyzing Beijing's preference between shared bicycles and e-bikes, factors like trip length and environmental conditions impacted shared city bike demand (Campbell et al., 2016). Interestingly, shared e-bikes exhibited resilience to these factors (Campbell et al., 2016). Socio-demographic traits were pivotal in shaping demand, with specific societal groups showing a clear preference for e-bikes (Campbell et al., 2016).

Multinomial logit regression and text networks (Kutela et al., 2022) identified discrepancies between the desire and actual use of micromobility. Males showcased higher e-scooter interest, whereas the elderly showed reduced enthusiasm for e-scooters and dockless bikes (Kutela et al., 2022). High-income individuals expressed interest in e-scooters or docked bikes but did not confirm using these modes (Kutela et al., 2022).

Buehler et al. (2021) conducted two surveys, one before and one after introducing a shared e-scooter service at Virginia Tech in Blacksburg, VA. The research revealed that the initial intention to use the e-scooters was higher before launch than the actual usage observed post-launch (Buehler et al., 2021). The decline in usage from the pre-launch intention to actual post-launch usage was more pronounced among older individuals, women, and university staff (Buehler et al., 2021). The primary motivations for using e-scooters on campus included their travel speed and enjoyment (Buehler et al., 2021).

Employing nested logit models (Luo et al., 2023), it was found that shared bikes and e-scooters rivaled green modes for non-work-related trips. Out-of-vehicle travel time, like walking to pick up shared bikes and e-scooters, significantly influenced the probability of using shared mobility (Luo et al., 2023). Behavioral intentions toward city bikes, e-bikes, and e-scooters were assessed among young, technologically-savvy groups (Gkartzonikas & Dimitriou, 2023). Employment status, household composition, travel habits, and awareness levels influenced intentions to use these services (Gkartzonikas & Dimitriou, 2023). The findings of a survey of free cargo bike sharing reveal that 46% of those surveyed indicated they would have opted for car travel if a cargo bike sharing service was not available, suggesting a potential for cargo-bike sharing to diminish car usage (Becker & Rudolf, 2018).

On the front of revealed preference, research in San Francisco (Lazarus et al., 2020) drew contrasts between docked and dockless e-bike trips. E-bikes stood out for leisure, while docked bikes were commuter favorites. Another study (Reck et al., 2021) also described docked modes as popular choices for commuting, suggesting infrastructure expansion could position micromobility as a private car alternative during peak hours. The researchers also focused on estimating a first-choice model among shared e-scooters, shared e-bikes, personal e-scooters, and personal e-bikes (Reck et al., 2022). They found that trip distance, precipitation, and distance to access the vehicle influenced transport preferences.

Using machine learning (Ren et al., 2021), factors determining mode choice among four micromobility options were analyzed. E-scooters stood out for education-related trips, with trip

specifics and spatial characteristics influencing mode decisions (Ren et al., 2021). Docked bike sharing services were more likely to be used for trips to public facilities (Ren et al., 2021).

Diving into dockless e-scooter and docked bike patterns in Washington, D.C. (McKenzie, 2019; Younes et al., 2020), e-scooter rides demonstrated a pronounced mid-day peak. Docked bike usage, on the other hand, exhibited evident commuting trends (McKenzie, 2019; Younes et al., 2020). E-scooters had a more compact and denser distribution than bikes, particularly around attractions, metros, and dormitories (Zhu et al., 2020).

Despite the insightful studies (Table 2-4), three significant gaps were identified in the literature. Firstly, specific micromobility combinations, especially e-mopeds and e-cargo bikes, still need to be explored. Secondly, comparative revealed preference studies did not assess multiple micromobility types unified under a single app. Lastly, urban settings dominate the research, sidelining non-urban contexts where travel dynamics differ.

This study examines the usage, competition, and preferences related to shared micromobility in a non-urban university area using actual user data from a multimodal shared micromobility platform. We model the choices for five distinct shared micromobility options: city bikes, e-bikes, e-cargo bikes, e-mopeds, and e-scooters to explore the patterns and distinctions in micromobility utilization.

Table 2-4: Literature on modeling shared micromobility

Study	Modes	Method	Data
Nikiforiadis et al., 2023	E-scooters	Discrete choice	Stated
Montes et al., 2023	Bikes, e-mopeds	Multinomial logit, mixed logit	Stated
Campbell et al., 2016	Bikes, e-bikes	Multinomial logit	Stated
Kutela et al., 2022	Bikes, e-scooters	Multinomial logit and text networks	Stated
Luo et al., 2023	Bikes, e-scooters	Nested logit	Stated
Gkartzonikas & Dimitriou, 2023	Bikes, e-bikes, e-scooters	Multivariate ordered probit	Stated
Lazarus et al., 2020	Docked bikes, dockless e-bikes	Destination choice modeling	Revealed
Reck et al., 2021	Docked bikes, docked e-bikes, dockless e-bikes, dockless e-scooters	Multinomial logit model, normal error component logit-mixture model	Revealed
Reck et al., 2022	Shared e-scooters, shared e-bikes, personal e-scooters, personal e-bikes	Mixed logit model	Revealed
Ren et al., 2021	Docked bikes, docked e-bikes, dockless e-bikes, dockless e-scooters	Random Forest, Support Vector Machine, Artificial Neural Network, and Logistic Regression	Revealed
McKenzie, 2019	Docked bikes, dockless e-scooters	Spatiotemporal usage patterns analysis	Revealed
Younes et al., 2020	Docked bikes, dockless e-scooters	Negative-binomial	Revealed

Study	Modes	Method	Data
Zhu et al., 2020	Dockless bikes, dockless e-scooters	Spatiotemporal usage patterns analysis	Revealed

2.11 Characteristics of Users and Usage of Shared Micromobility

Analyzing the travel patterns of shared micromobility users is crucial for enhancing the user experience through tailored operational strategies. Classifying users based on the regularity of their travel can provide insights into specific user needs and habits (X. Ma et al., 2013). This user-centric approach facilitates adapting service types, revenue optimization, and demand forecasting improvement. Operators can use these insights to refine their strategies, focusing on retaining existing users, offering attractive discounts, attracting new users, and implementing effective fare adjustments.

Members of shared micromobility systems typically display distinct socio-demographic traits and attitudes (Liao & Correia, 2020). They are predominantly male, aged between 25 and 45, well-educated, and have above-average incomes (Buehler et al., 2021; Fuchs et al., 2021; Grimme et al., 2023; Raux et al., 2017; Reck & Axhausen, 2021; Vogel et al., 2014; K. Wang & Akar, 2019). These users are generally strongly concerned about environmental issues and prefer environmentally friendly mobility options (Fuchs et al., 2021). Before adopting micromobility sharing, they often preferred public transport and bicycles and demonstrated a flexible, multimodal approach to transportation (Fuchs et al., 2021; Liao & Correia, 2020).

However, membership in a shared micromobility system does not necessarily equate to active use (Reck & Axhausen, 2021; Winters et al., 2019). It is essential to distinguish between “members” who may be active or dormant and “users” actively engaging with the service (Reck & Axhausen, 2021). Studies indicate a substantial difference in activity levels among users of shared micromobility systems. Members of docked bike schemes exhibit the highest activity, with 92% actively using the service. In contrast, in dockless e-bike and e-scooter schemes, only 53% and 44% use the service. This discrepancy underscores the existence of inactive members within these latter systems (Reck & Axhausen, 2021).

Additionally, there is a gap between the declared intention to use and the actual usage of shared micromobility services (Buehler et al., 2021; Eccarius & Lu, 2020). This discrepancy was observed in the case of the e-scooter program at the Virginia Tech campus (Buehler et al., 2021), where the initial interest in riding significantly exceeded the actual ridership post-launch. This divergence between anticipated and actual e-scooter usage was most pronounced among older individuals, women, and university staff (Buehler et al., 2021).

Regarding usage frequency, research primarily focuses on (e-)bike sharing (docked and dockless) and dockless e-scooter sharing. For instance, a study in Sacramento (Mohiuddin et al., 2022) used regression models to analyze factors affecting bike-share adoption and usage frequency. The findings suggest that low-income, carless residents use the service, generally paying per trip rather than using subsidized passes. The study also noted a gender gap, with

women less likely to use bike-sharing, indicating the need for further research into potential barriers specific to women (Mohiuddin et al., 2022). In Lyon, K-Means clustering was used to examine bike sharing usage based on actual movements and personal characteristics (Vogel et al., 2014), revealing that gender impacts usage intensity.

Meanwhile, a study from Nanjing, China (Ji et al., 2020) analyzed docked and dockless bike-sharing systems, differentiating regular users from occasional users. This analysis showed that while riding times and distances were similar for both user types, significant spatio-temporal differences existed between the systems. Morning peak hour usage positively correlated with regular usage, whereas longer travel distances were negatively associated with regularity in both systems (Ji et al., 2020). Vancouver's bike-share scheme (Winters et al., 2019) identified "super-users" (20 or more trips/month) as predominantly young, male, and more likely to use bikes as their primary transportation. These users, constituting 16% of registered users but accounting for 47% of trips, typically had lower incomes and fewer transportation options.

E-scooter usage patterns also vary. Only 6% of riders use them daily, with the majority using them less than weekly, primarily once per month (Badia & Jenelius, 2023). This usage is often influenced by trip purpose, with daily users employing e-scooters for commuting and leisure. However, less frequent users use e-scooters sporadically, mainly for social or recreational activities (Guo & Zhang, 2021). Many users choose e-scooters for impromptu trips or when other transport modes are unavailable (Badia & Jenelius, 2023).

Significant numbers of "curious one-time users," primarily young and educated, try e-scooters for novelty (Curl & Fitt, 2020; Dibaj et al., 2021; Fitt & Curl, 2020; Laa & Leth, 2020). For example, most first-time users in New Zealand were young, educated, and influenced by peers (Fitt & Curl, 2020). In Vienna, a notable percentage of users tried e-scooters as a one-off experience (Laa & Leth, 2020). Additionally, casual usage patterns are evident, with many users opting for e-scooters occasionally or opportunistically, leading to varied usage frequencies (Bieliński & Ważna, 2020; Tuncer & Brown, 2020).

In the United States, a study (Yang et al., 2023) comparing shared e-scooter usage in four cities found Miami with the highest frequency, where nearly one-third of users rode e-scooters three to four times weekly, and over 14% used them five or more times per week. In contrast, Washington, D.C., had the lowest usage frequency, with over 41% of users riding less than once weekly. Birmingham reported the highest proportion of users riding "1 to 2 times per week."

A South Korean study (Park et al., 2023) classified e-scooter users into irregular, spatially regular, and regular users, analyzing their travel regularity, distances, and preferences for particular times of the day. Regular users, for instance, were found to use e-scooters more often, typically for shorter distances and mainly during morning peak hours.

The study in two German cities (Degele et al., 2018) used clustering methods to analyze e-scooter user behavior, revealing distinct user groups. Among them, a small but prominent group of "power users" mainly used e-scooters on weekdays, likely for commuting. In contrast, most users were "casual users," showing diverse usage patterns influenced by age and day of the week, primarily for weekend leisure activities. These casual users were further categorized into

two age groups: “GenX+,” with an average age of 48, and “GenY,” averaging 28 years old, with GenY renting more frequently. Another notable group was “one-time users,” who tried the service primarily out of curiosity. Despite being just 4.4% of the total, the “power users” were significant contributors to revenue, highlighting their consistent and frequent usage.

Grimme et al. (2023) classified users of a closed-campus e-scooter sharing service into six consumer types, which could overlap. The researchers identified 18% of users as “occasional users” who engaged with the service just once. The largest group, “registrants without usage,” accounted for 48% and registered but never used the service. “Frequent consumers” in this study used the service at least three times during the project, constituting 23%. “Worktime consumers,” active mainly on weekdays between 8 AM to 12 PM and 2 PM to 5 PM, represented 56%. “Free-time consumers,” who preferred using the service on weekdays after 5 PM, made up 42%. Lastly, “food catchers,” utilizing the service for lunchtime round trips between 12 PM and 2 PM, comprised 22% of the sample.

In Barcelona (Roig-Costa et al., 2023), a travel survey using clustering techniques analyzed micromobility usage across different modes, including bicycle-sharing, private e-scooters, and moped-style scooters. The study found that most users typically relied on a single transport mode weekly, but those using shared services demonstrated more multimodal behavior than private e-scooter users.

Despite the insightful studies, we identified several research gaps in the existing literature. Most studies on usage frequency and segmentation in shared micromobility have primarily centered around (e-)bike or e-scooter sharing programs. Little attention has been given to understanding the usage patterns of e-mopeds or e-cargo bikes within this context. Furthermore, many of these studies have relied on data from individual shared micromobility providers, which does not account for the availability of multimodal shared micromobility options within a single mobile application. Additionally, there appears to be a gap in longitudinal studies tracking users’ engagement from registration onwards, leading to a limited understanding of the evolution of a customer’s engagement over time.

Our study aims to fill these gaps by investigating a shared micromobility system that includes city bikes, e-bikes, e-cargo bikes, e-mopeds, and e-scooters tailored for a university community. This community benefits from a free monthly mobility budget, providing a unique context to study user behaviors and patterns from their initial registration on the platform.

3 Methodology

3.1 Case Study: MORE Sharing at the University of the Bundeswehr Munich

The University of the Bundeswehr Munich in Munich is one of Germany's largest campus-based educational institutions, covering an area of 140 hectares and with a community of approximately 5,300 people. This includes students (72%), academic staff (16%), non-academic staff (8%), and professors (4%) (UniBw, 2023). The university has a diverse student demographic, consisting of military and civilian individuals aged 20 to 30, mostly earning middle-income, with many residing on campus. Female representation is 27% among students and 25% among academic staff (UniBw, 2023).

In March 2023, the university launched MORE Sharing, a micromobility sharing system, to provide a sustainable alternative to private vehicles (evhcle, 2023c; MORE Sharing, 2023a; Pobudzei, Kemmerzehl, et al., 2023). The initiative involves a fleet of 100 shared micromobility vehicles, selected based on prior research (Table 3-1, Figure 3-1) (Pobudzei, Wegner, et al., 2022b; Pobudzei, Wichmann, et al., 2023b).

The university appointed a contractor (evhcle, 2023b) to establish and operate the shared micromobility fleet through a public tendering process. The vehicles are integrated into the sharing system through IoT devices, allowing booking and access through the app. The real-time GPS location of each vehicle is transmitted to ensure the operator and customer have up-to-date information.

All vehicles have been approved for road use and have third-party liability insurance of the highest category, with the contractor handling any damage claims. Short instructions and a customer service number are provided in the MORE Sharing app's FAQ section and on the project website. The seats are adjustable for the comfort of the drivers. The vehicles are added to the sharing system through a process that includes delivery, technical checks, assembly, onboarding, branding, and final testing.

On-site at the University of the Bundeswehr Munich in Munich, a service person ensures that the vehicles are functional and available by replacing batteries, performing minor repairs, cleaning, and maintaining them. The goal is to have at least 80% of the vehicles ready for use at any time. The operators can control the fleet through an operation platform (Figure 3-2). On this platform, they maintain an overview of the vehicle statuses, energy levels, and pending tasks.

They also control the platform through an integrated control panel (Figure 3-2). Furthermore, the operator offers a 24/7 customer hotline and a website with FAQs and instructional materials (MORE Sharing, 2023b). Geofencing technology creates virtual pick-up and drop-off points (Figure 3-2), avoiding the need for permanent mobility stations. The virtual stations can be adjusted, expanded, or combined during the project period. This way, decisions on further investments or installations can be based on usage data and experience.



Figure 3-1: MORE Sharing vehicle types

Table 3-1: Technical characteristics of MORE Sharing vehicle types

Type	Number of vehicles	Details
City Bike	25	3-speed hub gear, LED lights front and rear, luggage rack, bell, digital lock
E-Bike	25	250-watt motor, max. rider weight: 120 kg, max. range: up to 60 km, quick-change battery mechanism, LED lights front and rear, bicycle basket, bell
E-Cargo Bike	10	250-watt motor, max. load: 100 kg + weight of the driver, max. range: up to 40 km, quick-change battery mechanism, hydraulic brake, parking brake, LED lights front and rear, LCD, bell
E-Scooter	30	Max. speed: 20 km/h, max. rider weight: 100 kg, max. range: up to 65 km, quick-change battery mechanism, drum brake (front), electric with regeneration (rear), driving modes: Eco, Drive, Sport LED lights front and rear, bell
E-Roller	10	Max. speed: 45 km/h, max. 2 passengers; max. range: up to 130 km, storage: 5 liters under the seat and 5 liters in the helmet compartment, USB charging port, LED lights front and rear, driver display, horn, helmet, and hygiene protection covers

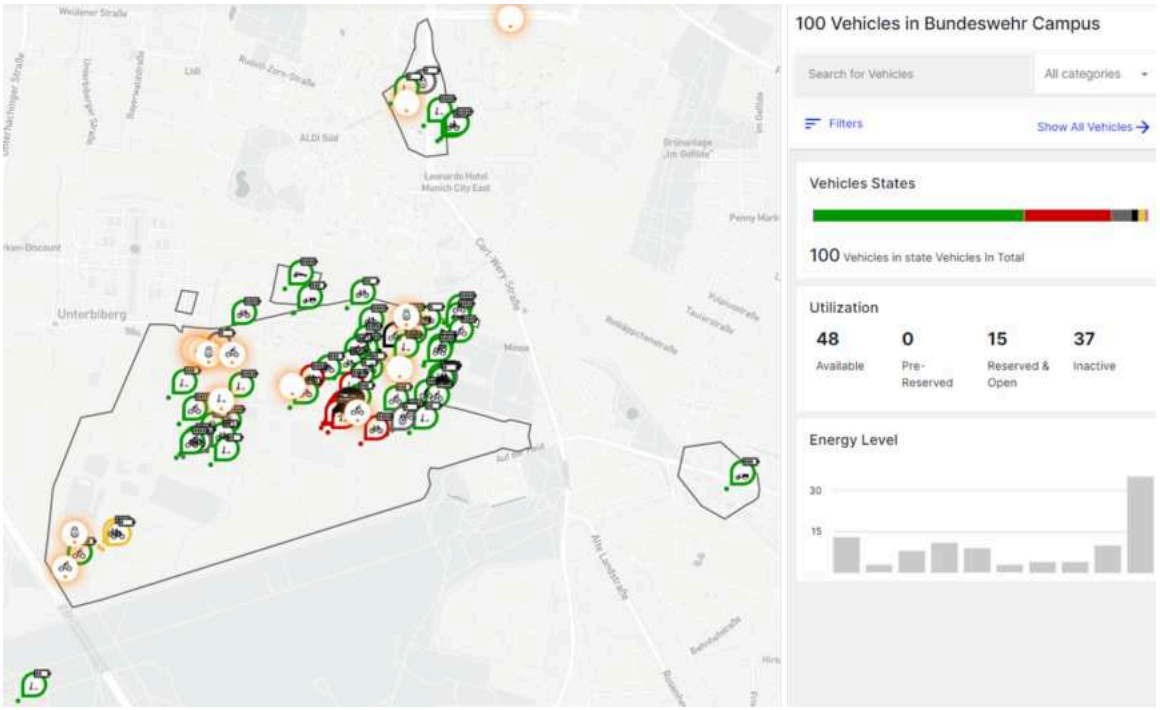

Figure 3-2: MORE Sharing operation platform

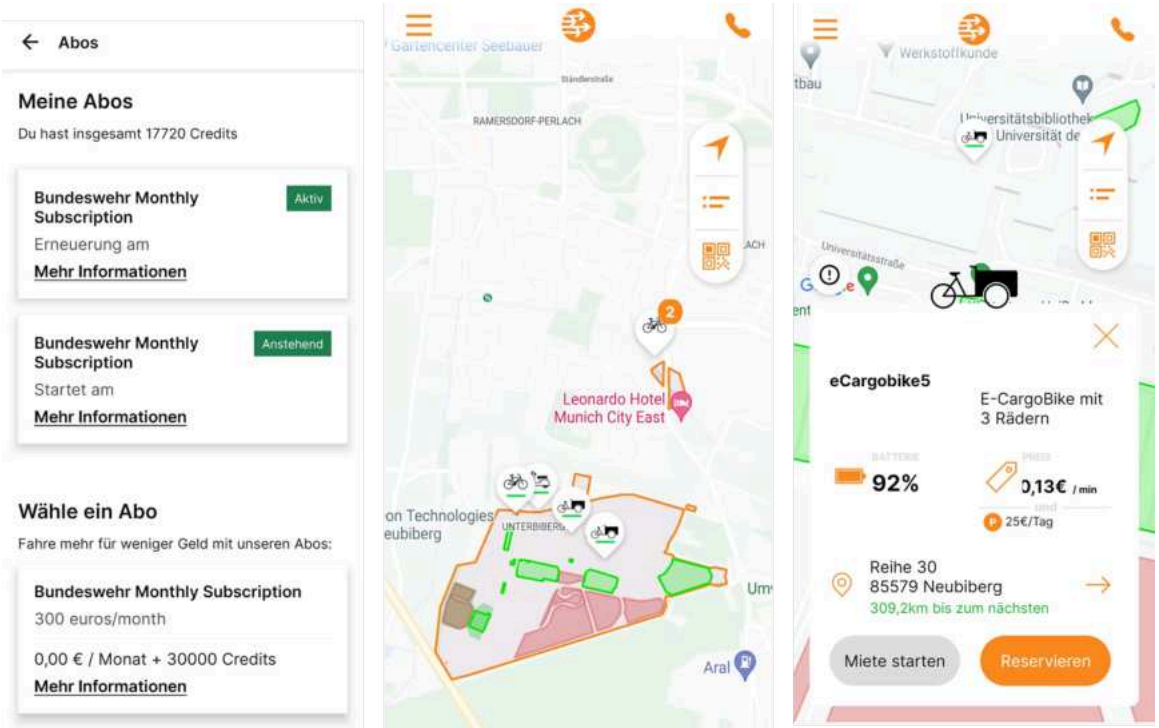

Figure 3-3: MORE Sharing booking platform

On the operational platform (Figure 3-2), a separate client was created for the MORE Sharing user application (Figure 3-3), where vehicles, users, rental conditions and prices, and the design of the end-user app are integrated. MORE Sharing, aimed at students and staff, is accessible

once users register and provide payment details. Users download the app for free and enter their personal data and payment information during registration (Figure 3-3). A mobility budget is created for each user, and the credit amount can be adjusted during the project (Figure 3-3). The registration process takes only a few minutes, with an in-app driver's license validation if users want to use e-mopeds requiring a driver's license.

The project began with a preparation phase involving ordering, technical checks, assembly, onboarding, branding, final testing, and marketing to prepare for user recruitment (Figure 3-4). MORE Sharing was announced to the university on March 6, 2023, per email. We organized a launch event on March 15, which provided help with app installation and demonstrations of the vehicle features (Figure 3-5). The app also offers FAQs and tutorial videos for further user guidance (MORE Sharing, 2023a).

Users are eligible for a monthly mobility allowance of up to €300 and can earn extra credits by participating in surveys. Initially, the service charged €0.13 per minute for usage and parking, with a daily cap of €25 for all vehicle types. However, starting from September 2023, the pricing was revised. City bikes are charged at €0.13 per minute or €25 for a full day, while e-bikes and e-scooters cost €0.26 per minute or €50 for daily rental. The e-mopeds and e-cargo bikes are the most expensive, at €0.39 per minute or €75 per day. Users can reserve a vehicle for 15 minutes free of charge before starting their ride.



Figure 3-4: MORE Sharing preparation phase



Figure 3-5: MORE Sharing launch

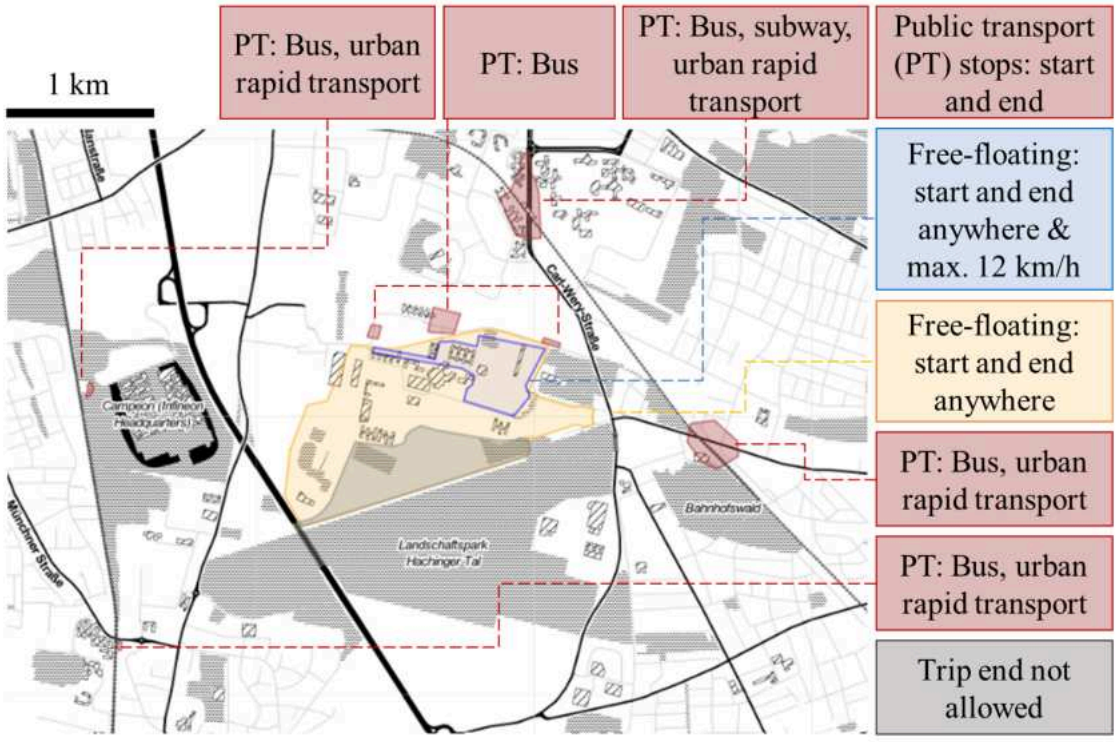

Figure 3-6: MORE Sharing operational area

To use a vehicle, riders can scan its QR code or select it from the app's map. City bikes and e-cargo bikes require manual locking to end a ride or activate parking mode. On the other hand, e-bikes, e-scooters, and e-mopeds automatically lock upon user confirmation. E-moped riders must verify their driver's license through the app and wear helmets during their rides (Figure 3-6).

MORE Sharing service operates within the university campus and extends to specific public transport stops within a 3-kilometer radius. Users can start or finish their rides at these stops. However, they must finish their trips within the designated operational area, even if they travel beyond the 3-kilometer radius. Users can activate the parking mode if they need to park their vehicles outside the operational area (MORE Sharing, 2023a; Pobudzei, Kemmerzehl, et al., 2023). For safety reasons, a speed reduction area was introduced on campus. IoT devices force e-bikes and e-scooters to reduce their speed to 12 km/h within this area (Figure 3-6). This rule does not apply to city bikes, e-cargo bikes, and e-mopeds due to technical incompatibility with their hardware.

3.2 Data Collection and Project Timeline

We evaluated the impact of shared mobility services by analyzing the operational data of MORE Sharing, a multimodal transport service, from March 2023 till March 2024. The project timeline is illustrated in Figure 3-7. MORE Sharing was launched on March 6, 2023, and provided a range of vehicles, including city bikes, e-bikes, e-scooters, e-mopeds, and e-cargo bikes. The initial pricing structure offered a free 15-minute reservation window, after which users were charged €0.13 per minute for all vehicle types, with a daily rate of €23 for 24 hours.

We collected data through a series of surveys to obtain a view of user demographics, mobility patterns, and preferences. The first survey was deployed immediately upon registration to the MORE Sharing platform and aimed to gather baseline data on users' demographics, campus mobility, and initial transport preferences.

The MORE Sharing post-trip survey was conducted at the end of each trip to capture real-time user feedback on their experience, the purpose of the trip, and the mode of transport replaced by the shared vehicle. The data from these surveys provided valuable insights into the users' immediate reactions to the service and their specific use cases.

On March 15, 2023, a MORE Sharing launch event was organized to facilitate users' app installation and showcase the features of the available vehicles. On March 23, 2023, in line with the service's commitment to safety, a speed reduction zone was implemented, restricting e-bikes and e-scooters to a maximum speed limit of 12 km/h in designated areas.

The MORE Sharing user experience survey was initiated six weeks after user registration to further understand long-term user engagement and satisfaction. This ongoing survey provided a longitudinal view of the user experience and helped identify areas for improvement.

On September 1, 2023, the pricing structure underwent changes, which were important considerations in our analysis of user behavior in response to pricing incentives. Detailed rates

for the reservation, riding per minute, and per calendar day were adjusted for each type of vehicle, potentially affecting user choice and service accessibility.

From October 1 to October 31, 2023, we conducted a MORE Sharing subsequent survey to assess the service's user experience, satisfaction, and preferences over a longer term. The data set from MORE Sharing, encompassing both operational metrics and user-reported experiences, provided a multifaceted view of the role of shared mobility services in transport ecosystems. Our analysis aims to enhance our understanding of shared mobility dynamics and user engagement with sustainable transportation options.

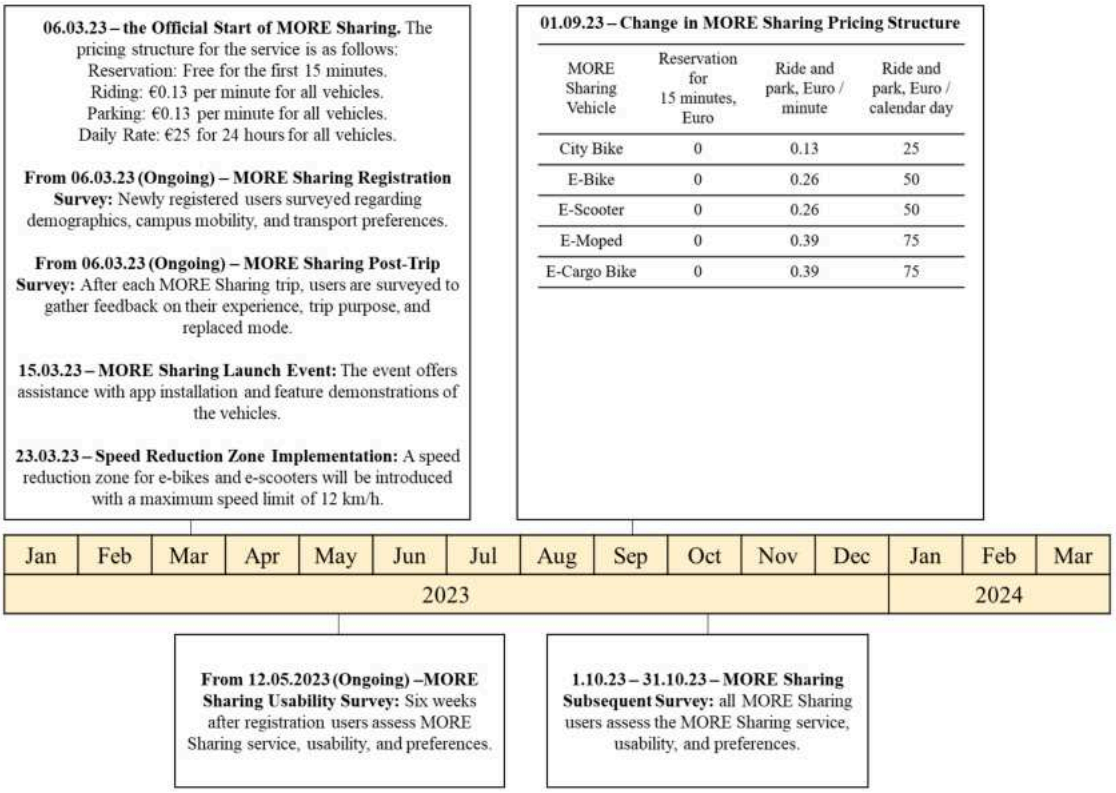

Figure 3-7: MORE Sharing timeline

3.2.1 MORE Sharing Backend Data

Users who wish to access the MORE Sharing service must first download the MORE Sharing app and register by providing personal details and a payment method (evhcle, 2023c; Pobudzei, Kemmerzehl, et al., 2023). The app records the registration date, gender, age, and whether the user has submitted a driver's license (Figure 3-8). Users must activate a monthly mobility budget of €300 in their account. By participating in travel surveys, users can earn credit vouchers for MORE Sharing that can be added to their accounts.

After each use, the app generates a unique reservation ID linked to the user's ID. It tracks whether the vehicle was pre-reserved, the type of vehicle, the trip's start and end times and

locations, the vehicle's mileage at the start and end, and the duration of parking mode if activated (Figure 3-8). This data allows us to determine the day of the week, season, trip duration (including drive and parking times), and total distance driven. Trips are categorized as round trips if they start and end within a 150-meter radius and as one-way trips otherwise. We also categorize trips based on their start or end locations, such as on-campus or at public transport stops. Users can rate their trip experience after each ride (Figure 3-8).

We utilized data of one year from March 6, 2023, to March 6, 2024. The MORE Sharing service was not operational on May 17-18 and June 24, 2023. Furthermore, throughout the study period, the MORE Sharing fleet comprised 99 vehicles, including 25 city bikes, 25 e-bikes, 10 e-cargo bikes, 10 e-mopeds, and 29 e-scooters. However, the availability of these vehicles was a significant factor that influenced our findings. Technical issues and maintenance requirements led to fluctuations in the number of accessible vehicles. A notable disruption occurred starting in October 2023, with most of the e-scooter fleet becoming unavailable due to defects in IoT devices. Furthermore, adverse weather conditions from December 6, 2023, resulted in both e-mopeds and e-scooters being removed from service.

Our study focused on analyzing data from reservations that resulted in actual usage, identifying trips with both a non-zero usage time and driven distance, yet not exceeding 1000 kilometers (Figure 3-9). We only considered trips that users concluded independently, without needing intervention from MORE Sharing's service personnel (Figure 3-9). Reservations that did not lead to subsequent trips or were terminated by service personnel were excluded from our analysis (Figure 3-9). These exclusions were primarily due to technical difficulties or external factors, such as connectivity issues between the user's mobile device and the shared vehicle. These challenges not only impacted the ability of users to end their rentals autonomously but also influenced the overall duration of reservations.

In addition to the reservation data, we obtained weather data from weather station ID 3,379 (Munich-City), located at a latitude of 48.16 and a longitude of 11.54, 515 meters above sea level (Figure 3-8). This data encompassed average hourly temperature, relative humidity, wind speed, and precipitation amounts (DWD, 2023). We computed the wind chill index (W) using Equation

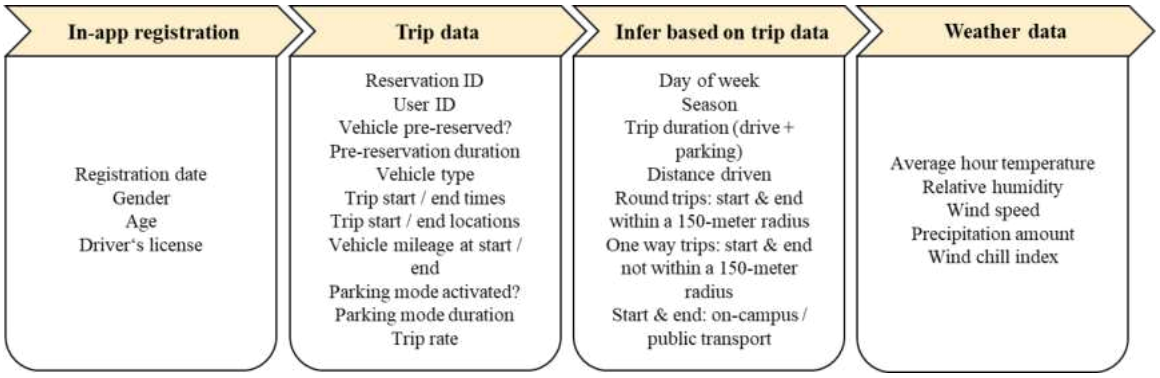

Figure 3-8: Data collected for each MORE Sharing trip

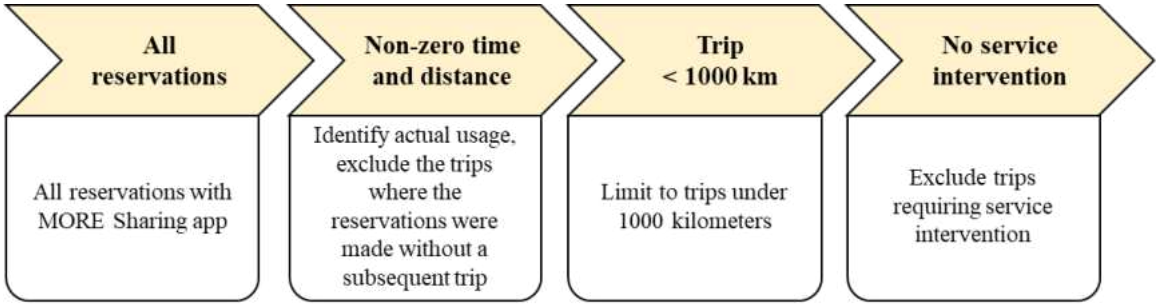

Figure 3-9: Data filtering for the valid MORE Sharing trips

3.1, which takes into account the air temperature in Celsius (T) and wind speed in kilometers per hour (V) (Groen, 2009).

$$W = 13.12 + 0.6215 * T - 11.37 * V^{0.16} + 0.3965 * T * V^{0.16} \quad (3.1)$$

3.2.2 Post-Trip Survey

After the trip, MORE Sharing users receive an email containing a summary of their journey, and we invite them to participate in a survey. The post-trip survey in German is available in Appendix 1, and the questions and items are summarized in Table 3-2. We asked the users which MORE Sharing mode they used for their trip when they started their trip, the total rental duration (including reservation and parking), and the distance covered. We also asked them about their satisfaction with the journey and if they encountered any problems during their last ride.

We ask MORE Sharing users to provide feedback on their recent experiences with MORE Sharing to gather insights into their transportation choices and preferences. Specifically, we ask if they would have taken their last trip if MORE Sharing services were unavailable. In a hypothetical scenario where MORE Sharing does not exist, we seek to understand which alternative mode of transport our users would have preferred for their journey. They can choose from using a private car, walking, biking with their bicycle, leveraging public transportation, or any other means. We also ask if they would select MORE Sharing for future trips under similar circumstances and if they prefer the same mode of transportation or a different one from the MORE Sharing offerings.

We invite users to identify the primary purposes of their journey, recognizing that trips can often serve multiple objectives. We encourage our users to select all applicable options, whether their trip was for commuting to work or education, conducting official or private errands, shopping, engaging in leisure activities, connecting to public transport, returning home, enjoying a recreational ride, dropping off or picking up someone, or any other reasons.

We want to understand the factors influencing our users' decision to opt for MORE Sharing for this journey. We offer a range of reasons to our users, acknowledging that various considerations can influence their choice. These include the availability of our service in their area, the accessibility of their destination, the enjoyment derived from using our sharing vehicles, motivations related to health and fitness, weather conditions, environmental concerns, the

potential for cost and time savings, comfort, or any other motivations that prompted their choice.

We also inquired about the urgency of our users' trip, asking whether punctuality was a critical factor and if they experienced any time pressure. This question is designed to understand the range of our users' experiences, from having no time constraints to feeling a significant urgency to be punctual. We also ask our users whether they wore a helmet during their ride and if their journey involved transporting people or heavy items, such as luggage. Users who complete at least 70% of the questionnaire receive a 2 Euro credit voucher, which they can insert in the MORE Sharing app for their rides.

Table 3-2: Post-trip MORE Sharing survey

No.	Question	Item	Multiple selection
1	MORE Sharing vehicle for the last trip	city bike; e-bike; e-cargo bike; e-moped; e-scooter	-
2	Start date	open text box	-
3	Start time	open text box	-
4	Duration of the total rental (reservation + parking)	open text box	-
5	Distance covered	open text box	-
6	Trip satisfaction	1=very dissatisfied; 5=very satisfied	-
7	Problems during the last trip	no; finding the vehicle in the app after initially seeing it in reality; locating the vehicle in reality after seeing and selecting it in the app; booking/reserving the vehicle; unlocking; using the vehicle; parking; ending rental; cleanliness; technical condition of the vehicle	-
8	Trip if MORE Sharing did not exist	yes; no	-
9	If 8 "yes": an alternative mode of transport for this trip?	car; on foot; own bike; public transport; other	-
10	MORE Sharing again in the future for the same or a similar trip	yes, with the same mode of transport; yes, but different MORE Sharing vehicle; no	-
11	If 10 "yes, but different MORE Sharing vehicle": preferred MORE Sharing vehicle	city bike; e-bike; e-cargo bike; e-moped; e-scooter	-
12	Trip purpose	commute to work / education; work errand; private errand; shopping; recreation; reaching public transport; way home; joyride; drop off / pick up someone; other	yes
13	Trip reason	availability in the vicinity; reachability of the destination; enjoyment of driving with sharing vehicles; health and fitness; weather conditions; environmental reasons; cost savings; time savings; comfort; other	yes
14	A trip under time pressure	1=no, not at all; 5=yes, very	-
15	Wear a helmet	yes; no	-

No.	Question	Item	Multiple selection
16	Transport people or heavy items	yes, people; yes, heavy items or luggage; no	-

3.2.3 MORE Sharing Registration Survey

Users who register in the MORE Sharing application provide personal information, payment, and contact details. After registration, they receive an email inviting them to participate in the "MORE Sharing Registration Survey." The survey collects users' demographic, socioeconomic, and transportation habits and attitudes toward transportation-related concerns. Appendix 2 provides details on the survey, and Table 3-3 summarizes the survey questions.

The survey covers demographic and socioeconomic information such as age, gender, education level, driver's license status, marital status, household composition, personal income, and professional and academic affiliation. The transportation-related questions focus on participants' commuting distance, modes of transport to campus, and transportation habits. The survey also seeks to gather participants' ratings on campus accessibility by different modes and the frequency of their use. Additionally, the survey investigates car ownership status and transportation-related subscriptions, such as public transport passes and sharing services, with multiple selections permitted. Questions about public transport use in Munich, including ticket types and subscriptions, are also included.

Participants are asked about their experience and usage frequency of various sharing services, including car-sharing, bike-sharing, moped-sharing, and e-scooter sharing. This question allows multiple selections to provide an overview of participants' engagement with sharing economies. The survey includes several statements that gauge participants' attitudes toward new means of transportation. These statements assess their interest in introducing new transportation modes, their propensity to be early adopters, their belief in the future increase of new transportation means, their comfort compared to conventional transportation, and their habits and beliefs regarding walking and its health benefits.

The survey measures participants' perceptions, intentions, and preferences regarding the MORE Sharing service. It includes questions on MORE Sharing impact on campus mobility, expected usage frequency, reasons for or against its use, and the nature of anticipated journeys. Finally, the survey delves into participants' attitudes toward transportation-related environmental concerns. The questions are designed to measure the agreement or disagreement on a scale from 1 (do not agree at all) to 5 (agree completely), addressing various perspectives on car traffic's impact on the environment, personal responsibility toward reducing car usage, and the role of individual actions in mitigating environmental damage. Users who complete at least 70% of the questionnaire are entitled to a 50 Euro credit voucher, which they can use for their MORE Sharing rides.

Table 3-3: MORE Sharing registration survey

No.	Question	Item	Multiple selection
1	Year of the birth	open text box	-
2	Gender	male; female; diverse	-
3	Highest education	intermediate school; completed vocational training; high school diploma; Bachelor's degree; Master's degree; PhD/ habilitation	-
4	Driver's license	A (moped, trike, quad); B (car); M (motorcycle); I don't have a driver's license	yes
5	Marital status	single; married; widowed; divorced	-
6	Household	single adult, no child; single adult, with child; multiple adults, no child; multiple adults, with child(ren)	-
7	Personal income	under 500€; 500 to 1,000€; 1,000 to 2,000€; 2,000 to 3,000€; 3,000 to 4,000€; 4,000 to 5,000€; 5,000€ and more	-
8	Postal code	open text box	-
9	Affiliation	student; employee in technology / administration; scientific staff; professor; other	-
10	Distance between campus and residence	open text box	-
11	Transport to campus	exclusively on foot; bike; car; regional bus; regional train; subway / S-Bahn; motorcycle; e-scooter; long-distance train; long-distance bus; other	yes
12	Campus accessibility by a) car; b) bike; c) public transport	1=very poor; 5=very good	-
13	Usage frequency a) car; b) bike; c) motorcycle; d) e-scooter; e) public transport	(almost) never; less than monthly; 1-3 days per month; 1-3 days per week; (almost) daily; I do not have access	-
14	Car ownership	yes, always available for use; yes, available for use by arrangement; no	-
15	Annual mileage by car	less than 12,000 km; 12,000 to 20,000 km; 20,000 to 30,000 km; more than 30,000 km; I do not drive a car	-
16	Subscriptions	49€ ticket; job ticket; monthly pass for public transport; BahnCard; car sharing membership; bike sharing membership; e-scooter sharing membership; other	yes
17	Public transport Munich	single ticket / short-distance ticket / day pass; travelcard; weekly / monthly ticket without subscription; monthly / annual season ticket with subscription; semester ticket / job ticket; I never travel by public transport in Munich	-
18	Reimbursement for public transportation costs from the employer	yes; no	-
19	Likely to purchase 49€ ticket	1=very likely; 5=very unlikely	-
20	Experience with sharing services	(e-)car-sharing; (e-)bike sharing; (e-)moped sharing; e-scooter sharing; I have not yet used a sharing service	yes

No.	Question	Item	Multiple selection
21	Sharing frequency of use a) (e-)car sharing (e.g., StattAuto, Flinkster, DriveNow, Car2Go, FREE NOW, SIXT, Miles); b) (e-)bike sharing (e.g., MVG Rad, Call a Bike); c) (e-)moped sharing (e.g., emmy, TIER); d) e-scooter sharing (e.g., TIER, Lime, Bird, Voi)	(almost) never; less than monthly; 1-3 days per month; 1-3 days per week; (almost) daily	-
22	I am very interested in the introduction of new means of transportation	1=do not agree at all; 5=agree completely	-
23	I am always one of the first to use new means of transportation	1=do not agree at all; 5=agree completely	-
24	I believe that new means of transportation will gradually increase in the future	1=do not agree at all; 5=agree completely	-
25	New means of transportation will be more comfortable than conventional means of transportation	1=do not agree at all; 5=agree completely	-
26	If I'm traveling a short distance, I usually walk	1=do not agree at all; 5=agree completely	-
27	Walking is good for my health	1=do not agree at all; 5=agree completely	-
28	MORE Sharing improves mobility on and around campus	1=do not agree at all; 5=agree completely	-
29	Assumed MORE Sharing usage frequency	(almost) never; less than monthly; 1-3 days per month; 1-3 days per week; (almost) daily	-
30	Assumed reasons against MORE Sharing use	hygiene concerns; safety concerns; physical or health reasons; carrying luggage is too uncomfortable; the use is too inconvenient; the availability of vehicles is too uncertain; generally, don't like sharing vehicles; no need; other reasons	yes
31	Assumed reasons for MORE Sharing use	curiosity; convenience; saving money; saving time; environmental protection; health and fitness; other	yes
32	Assumed distribution of MORE Sharing journeys a) on campus; b) off campus	1=0%, 100=100%	-
33	Assumed purposes for MORE Sharing trips a) city bike; b) e-bike; c) e-cargo bike; d) e-moped; e) e-scooter	commute to work / education; work errand; private errand; shopping; recreation; reaching public transport; way home; joyride; dropping off / picking up someone; other	yes
34	The increase in car traffic is a significant problem for environmental protection.	1=do not agree at all; 5=agree completely	-
35	The media unnecessarily exaggerates the share of car traffic in environmental destruction	1=do not agree at all; 5=agree completely	-

No.	Question	Item	Multiple selection
36	I worry when I think about the environmental destruction caused by driving	1=do not agree at all; 5=agree completely	-
37	For environmental reasons, I feel obliged to travel by car as little as possible in my free time	1=do not agree at all; 5=agree completely	-
38	For environmental reasons, I feel obliged to use the bicycle or public transport for trips into the city center	1=do not agree at all; 5=agree completely	-
39	I am responsible for ensuring that my car use does not impair the quality of life in my area	1=do not agree at all; 5=agree completely	-
40	I feel responsible for preserving the environment in my everyday choice of transportation	1=do not agree at all; 5=agree completely	-
41	Transport-related environmental problems can only be solved with the involvement of individual citizens	1=do not agree at all; 5=agree completely	-
42	Individuals play a significant role in solving traffic-related environmental problems	1=do not agree at all; 5=agree completely	-
43	I can contribute to environmental protection by a) choosing an environmentally friendly means of transportation; b) using public transportation	1=do not agree at all; 5=agree completely	-

3.2.4 MORE Sharing User Experience and Subsequent Surveys

Starting on May 12, 2023, we conducted a “MORE Sharing User Experience” survey aimed at registered users using our platform for over six weeks. Once the users reached the six-week registration period, we emailed them survey invitations. The survey was designed to gather feedback on the users’ experience with MORE Sharing services. Appendix 3 provides details on the survey, and Table 3-4 summarizes the survey questions.

We asked respondents about significant life events they may have experienced since registering with MORE Sharing. These events could include professional changes, private changes, and changes in residence. We also asked respondents to rate their knowledge of MORE Sharing and share their positive or negative experiences. We wanted to understand how often respondents utilized MORE Sharing services, offering options from almost never to almost daily.

We also inquired about the purposes for which respondents used MORE Sharing services, including commuting, errands, shopping, recreation, and more. We requested respondents to provide the distribution of their MORE Sharing journeys on and off-campus as a percentage. We wanted to know the motivations behind using MORE Sharing services, including curiosity, convenience, cost savings, and other factors. We also inquired about respondents’ concerns about not using MORE Sharing services, such as hygiene, safety, and convenience.

Participants could rate their overall experience with MORE Sharing from very negative to very positive. We asked respondents to share specific positive and negative experiences with MORE Sharing in an open text box. Participants were asked to share their views on different aspects of MORE Sharing, such as ease of use, cost-saving, expansion of mobility options, and others, using a rating scale ranging from strongly disagree to strongly agree.

Respondents were also prompted to estimate how frequently they anticipate using MORE Sharing services within the next three months and the following year. They were also asked about their frequency of using different sharing services on a scale ranging from almost never to almost daily. Participants were asked to compare the usage frequency of other sharing providers before and after registering with MORE Sharing.

We asked respondents about their usage frequency of specific MORE Sharing vehicles, such as city bikes, e-bikes, e-cargo bikes, e-mopeds, and e-scooters. Participants were also prompted to indicate whether they tried out specific types of vehicles for the first time due to their experience with MORE Sharing. Respondents were asked to rate the variety or mix of vehicles available in MORE Sharing and rank the types of MORE Sharing vehicles.

Participants were asked to indicate their preferred MORE Sharing vehicle type for bad weather conditions or traveling long distances. Respondents were also asked to specify the purposes for using different MORE Sharing vehicles. They were then asked to evaluate specific MORE Sharing vehicles regarding attributes such as comfort, flexibility, and safety on a scale from 1 (very poor) to 5 (very good). Participants were asked whether they wore helmets using different MORE Sharing vehicle types. They were also prompted to express their opinions on the user-friendliness of MORE Sharing and identify any difficulties they encountered while using it.

Respondents were asked to specify their mode of transportation when traveling to and on campus and to rate the accessibility of the campus using different modes of transportation. We also collected demographic information regarding age, gender, highest education, driver's license, marital status, household size, and personal income. If the users filled out at least 70% of the questionnaire, they would receive a 50 Euro credit voucher, which they could use for their MORE Sharing rides through the MORE Sharing app.

In October 2023, we surveyed all registered users of MORE Sharing to capture their current attitudes toward the service. In the subsequent survey, we added questions regarding attitudes toward free-floating and station-based operation models (Table 3-5). During October 2023, we used the free-floating system at MORE Sharing, meaning users could park their vehicles anywhere on the UniBw campus. We considered introducing additional mobility stations where users could pick up, park, and charge vehicles.

We asked users about their preferences regarding the operation model of MORE Sharing and whether they would like mobility stations to be introduced. Respondents were invited to express their opinions about establishing mobility stations as part of MORE Sharing and how their frequency of using the service might change if mobility stations were introduced. Participants were encouraged to highlight their advantages and concerns with implementing mobility stations.

Users were asked to rate the importance of having the capability to charge vehicles at these mobility stations and how far they would be willing to walk to reach one of these stations. Response options included less than 5 minutes, 5-10 minutes, 10-15 minutes, or more than 15 minutes. Respondents were also asked whether they believed the introduction of mobility stations would positively impact the overall MORE Sharing user experience. To incentivize users to participate in the survey, we offered a 50 Euro credit voucher to those who completed at least 70% of the subsequent questionnaire. This credit voucher could be used for their MORE Sharing rides through the MORE Sharing app.

Table 3-4: MORE Sharing user experience survey

No.	Question	Item	Multiple selection	Subsequent survey (Oct 2023)
1	Events since registering with MORE Sharing	professional changes (start of studies, job change); private changes (marriage, separation, child arrival); moving to another apartment; no	yes	yes
2	Well-informed about MORE Sharing	1=very poor; 5=very good	-	yes
3	What was unclear	open text box	-	yes
4	MORE Sharing in general	1=very poor; 5=very good	-	yes
5	What was good	open text box	-	yes
6	What was bad	open text box	-	yes
7	MORE Sharing usage frequency	(almost) never; less than monthly; 1-3 days per month; 1-3 days per week; (almost) daily	-	-
8	MORE Sharing usage purposes	commute to work / education; work errand; private errand; shopping; recreation; reaching public transport; way home; joyride; drop off / pick up someone; other	yes	-
9	Distribution of MORE Sharing journeys a) on campus; b) off campus	1=0%, 100=100%	-	yes
10	Reasons for MORE Sharing use	curiosity; convenience; saving money; saving time; environmental protection; health and fitness; other	yes	yes
11	Reasons against MORE Sharing use	hygiene concerns; safety concerns; physical or health reasons; carrying luggage is too uncomfortable; the use is too inconvenient; the availability of vehicles is too uncertain; generally, don’t like sharing vehicles; no need; other reasons	yes	yes
12	Overall experience with MORE Sharing	1=very negative; 5=very positive	-	-
13	Positive experience with MORE Sharing	open text box	-	-

No.	Question	Item	Multiple selection	Subsequent survey (Oct 2023)
14	Negative experience with MORE Sharing	open text box	-	-
15	MORE Sharing a) is easy to use; b) saves costs; c) expands mobility options; d) useful addition to existing means of transportation; e) an alternative to other means of transportation (e.g., car); f) improves the connection of the campus to public transportation; g) improves general campus mobility; h) app is easy to use and understand; i) is fun	1=strongly disagree; 5=strongly agree; cannot judge	-	yes
16	MORE Sharing aspects a) operation zone; b) app; c) number of vehicles; d) parking facilities; e) price; f) comfort while driving; g) reliability; h) flexibility; i) cleanliness; j) safety and security; k) sustainability	1=very bad; 5=very good	-	yes
17	MORE Sharing usage in the future	1=very unlikely; 5=very likely	-	yes
18	Estimate MORE Sharing usage in a) 3 months; b) 1 year	1=much rarer; 5=much more often	-	yes
19	Sharing frequency of use a) (e-)car sharing (e.g., StattAuto, Flinkster, DriveNow, Car2Go, FREE NOW, SIXT, Miles); b) (e-)bike sharing (e.g., MVG Rad, Call a Bike); c) (e-)moped sharing (e.g., emmy, TIER); d) e-scooter sharing (e.g., TIER, Lime, Bird, Voi)	(almost) never; less than monthly; 1-3 days per month; 1-3 days per week; (almost) daily	-	yes
20	Usage frequency of other sharing providers since registering with MORE Sharing	1=much less frequently; 5=much more often	-	yes
21	Usage frequency of MORE Sharing vehicles a) city bike; b) e-bike; c) e-cargo bike; d) e-moped; e) e-scooter	(almost) never; less than monthly; 1-3 days per month; 1-3 days per week; (almost) daily	-	yes
22	Tried out for the first time because of MORE Sharing	city bike; e-bike; e-cargo bike; e-moped; e-scooter	yes	-
23	A mix of vehicles in MORE Sharing	1=very poor; 5=very good	-	yes
24	Ranking of MORE Sharing vehicles a) city bike; b) e-bike; c) e-cargo bike with 2 wheels; d) e-cargo bike with 3 wheels; e) e-scooter	Ranking from 1 to 6	-	yes
25	Rating of MORE Sharing vehicles a) city bike; b) e-bike; c) e-cargo bike with 2 wheels; d) e-cargo bike with 3 wheels; e) e-scooter	1=very poor; 5=very good	-	yes
26	I prefer to take … a) if all MORE Sharing vehicles are available in my area; b) the weather is bad; c) not allowed to be late; d) to travel longer distances; e) to transport something or go shopping; f)	city bike; e-bike; e-cargo bike; e-moped; e-scooter; no MORE Sharing	-	-

No.	Question	Item	Multiple selection	Subsequent survey (Oct 2023)
	travel to work / education; g) to do/get something on business; h) on the way to a leisure activity; i) reach public transport; j) drive home; k) drive for fun			
27	Purposes for MORE Sharing trips by a) city bike; b) e-bike; c) e-cargo bike; d) e-moped; e) e-scooter	commute to work / education; work errand; private errand; shopping; recreation; reaching public transport; way home; joyride; dropping off / picking up someone; other	yes	yes
28	Evaluation of a) city bike; b) e-bike; c) e-cargo bike; d) e-moped; e) e-scooter regarding a) comfort during the ride; b) maneuverability; c) reliability; d) transportation of things; e) flexibility; f) availability; g) cleanliness; h) safety; i) sustainability	1=very poor; 5=very good	-	-
29	Wear a helmet while using MORE Sharing a) city bike; b) e-bike; c) e-cargo bike; d) e-moped; e) e-scooter	yes; no	-	-
30	User-friendliness: MORE Sharing a) meets my requirements; b) is a frustrating experience; c) is easy to use; d) requires too much of my time to overcome difficulties	1=strongly disagree; 7=strongly agree	-	-
31	Difficulties with MORE Sharing	add payment method; error message: mobile phone reception too poor; problem unlocking the vehicle; problem locking the vehicle; app not compatible with cell phone; other problems	yes	-
32	MORE Sharing FAQ helpful	1=not at all; 5=very helpful	-	-
33	Transport to campus	Exclusively on foot; bike; car; regional bus; regional train; subway/ S-Bahn; motorcycle; e-scooter; long-distance train; long-distance bus; MORE Sharing; other	yes	yes
34	Transport on campus	Exclusively on foot; bike; car; motorcycle; e-scooter; MORE Sharing; other	yes	yes
35	Campus accessibility by a) car; b) bike; c) public transport; d) MORE Sharing	1=very poor; 5=very good	-	yes
36	MORE Sharing improves mobility on and around campus	1=strongly disagree; 5=strongly agree	-	yes
37	Year of birth	open text box	-	yes
38	Gender	male; female; diverse	-	yes
39	Highest education	intermediate school; completed vocational training; high school	-	yes

No.	Question	Item	Multiple selection	Subsequent survey (Oct 2023)
		diploma; Bachelor's degree; Master's degree; PhD / habilitation		
40	Driver's license	A (moped, trike, quad); B (car); M (motorcycle); I don't have a driver's license	yes	yes
41	Marital status	single; married; widowed; divorced	-	yes
42	Household	single adult, no child; single adult, with child; multiple adults, no child; multiple adults, with child(ren)	-	yes
43	Personal income	under 500€; 500 to 1,000€; 1,000 to 2,000€; 2,000 to 3,000€; 3,000 to 4,000€; 4,000 to 5,000€; 5,000€ and more	-	yes
44	Postal code	open text box	-	yes

Table 3-5: Questions from subsequent MORE Sharing survey in October 2023

No.	Question	Item	Multiple selection
1	Preferred operation model	free-floating (as at present); mixed: there are fixed mobility stations, but vehicles can also be parked outside these stations; station-based	-
2	Opinion about the establishment of MORE Sharing mobility stations	1=very negative; 5=very positive	-
3	Change in MORE Sharing frequency use if mobility stations were available	1=much less often; 5=much more often	-
4	Advantages of MORE Sharing mobility stations	easier to find vehicles; guarantee of vehicle availability; better maintenance and condition of vehicles; possibility to recharge vehicles; increased safety; other	yes
5	Concerns about MORE Sharing mobility stations	stations could be overcrowded; limited flexibility compared to free-floating; other; no concerns	yes
6	It is important to charge vehicles at these mobility stations	1=not important at all; 5=very important	-
7	How far would you walk to reach one of these stations?	less than 5 minutes; 5-10 minutes; 10-15 minutes; more than 15 minutes	-
8	Mobility stations would have a positive impact on the overall user experience	yes; no	-

3.3 Data Analysis Methods

3.3.1 Examining Origins, Destinations, Hourly Booking Counts, Booking Distances, and Durations in a Shared Micromobility System

We analyze the patterns of hourly booking counts, booking distances and durations, reservation origins, and destinations observed during the initial twelve months of operating a micromobility sharing system deployed on a university campus. The study's main objectives are to gain insights into user behaviors, evaluate the system's effectiveness, and understand usage patterns.

The study utilized the app's data to track each vehicle booking's start and end locations. Heatmaps were created to identify high-demand areas based on each vehicle type's start and endpoints. Bookings with start and end points within a 150-meter radius were classified as round bookings, while bookings with starts and ends outside this range were categorized as one-way bookings. The top ten common start and end locations were analyzed for each vehicle type, distinguishing between one-way and round bookings. Furthermore, the booking purposes associated with each type of micromobility option in MORE Sharing were investigated.

In addition to descriptive methods, the study analyzed the hourly booking counts, booking distances, and durations using Negative Binomial Regression (NBR), Random Forests (RF), Gradient Boosted Regression Trees (GBRTs), and Neural Networks (NN) (Pobudzei & Hoffmann, 2024a). The models were trained using 80% of the dataset and tested on the remaining 20%. The random seed was set to 42 to ensure consistent results.

The NBR model is suitable for counting data that shows overdispersion, where the variance exceeds the mean. It can handle categorical and continuous predictor variables (Noland, 2021; Pobudzei, Sellaouti, et al., 2022). It was used to examine the influences of weather, time, and usage characteristics on hourly booking counts, reservation durations, and booking distances in MORE Sharing.

RF constructs numerous decision trees by leveraging random data subsets and combines the predictions of individual trees to produce a final forecast. This approach mitigates overfitting and enhances the model's robustness by selecting random feature subsets for each tree. RF demonstrates proficiency in handling continuous and categorical variables, allowing it to model complex non-linear relationships (Breiman, 2001).

GBRTs adopt an iterative approach, initially fitting a simple decision tree to the data and then concentrating on the areas where the model exhibits weaknesses. These problematic instances are assigned higher weights, prompting the training of new decision trees to refine the model's predictions. GBRTs typically excel when dealing with smaller datasets, although they demand more computational resources for training compared to other methods (Davis, 2014).

Lastly, NN leverages a multilayered architecture comprising numerous interconnected neurons. During training, the weights that control the strength and direction of signal transmission between neurons are adjusted to enhance the model's predictive capabilities. NNs are proficient

in modeling complex non-linear relationships and can handle diverse input data types, including images, text, and numerical data. However, they come with higher computational demands, mainly when applied to larger datasets (Analytics Vidhya, 2023).

3.3.2 Revealing Choices in Multimodal Shared Micromobility System

We investigate the key factors influencing the selection of shared micromobility options. Although our app data and post-trip surveys provide valuable insights into user preferences and vehicle choices, they do not present all available options and attributes for each decision-making scenario. To address this, we employ the Multinomial Logit Model (MNL) and machine learning algorithms such as the Random Forest Classifier (RFC), Gradient Boosting Classifier (GBC), and Neural Network Classifier (NNC) (Pobudzei et al., 2024).

MNL quantifies each option's likelihood, illuminating how factors shape user decisions. RFC, an ensemble method, capitalizes on multiple decision trees and is proficient at accommodating a wide array of features and non-linear relationships. GBC operates as another ensemble method that builds decision trees sequentially, each correcting its predecessor's errors. While RFC and GBC effectively address non-linear complexities, they lack probabilistic interpretation. NNC stands out for its ability to recognize complex patterns, making it a formidable tool for choice modeling. However, its efficacy is maximized with extensive data, and its complex architecture compromises transparency compared to more straightforward models like MNL.

We examine the reservation data and survey responses separately to understand preferences within the shared micromobility landscape. To enhance the reliability of our findings, we partitioned our datasets, using 80% for training the models and the remaining 20% for testing. We maintained consistency by employing a fixed random seed 42 across all analyses. In our machine learning experiments, we selected hyperparameters for each model to optimize performance. For RFC, we set the number of trees in the forest (n_estimators) to 100 and controlled the maximum depth of each tree with max_depth = 3. For GBC, we used n_estimators=100 to specify the number of boosting stages, combined with a learning_rate of 0.1 and a maximum depth of each tree (max_depth) of 3. In the case of the NNC, we chose max_iter=30 to define the maximum number of iterations for the optimizer to converge. To validate our models, we evaluated their accuracy and feature importance, thereby spotlighting the key influencing factors in shared micromobility choices.

3.3.3 Segmenting Shared Micromobility Users Based on Usage Frequency

Analyzing the user engagement, we aggregate the total number of trips per registered customer and calculate the mean number of trips per customer per month, considering their registration dates. We filter the customers who have made zero trips since registration and assign them to a user category with no trips (Reck & Axhausen, 2021). Further, using K-Means clustering (X. Ma et al., 2013; Tabianan et al., 2022), we segment users by trip frequency into user categories: one-time (Mohiuddin et al., 2022), infrequent (Park et al., 2023), frequent (Park et al., 2023),

and super users (Degele et al., 2018). We monitor each customer's status from registration and calculate the average monthly trip frequency during Spring, Summer, and Autumn of 2023. In our reservation dataset, we account for seasonal categorization by assigning the appropriate user group based on when the trip occurred and the usage frequency during that period (Pobudzei & Hoffmann, 2024b). We further analyze the MORE Sharing vehicle preferences by the user groups. We also compute churn rates, considering users inactive if they have not used the service in the past three months (Hu et al., 2021).

To understand the characteristics of trips by different user groups, we employ the Multinomial Logit Model (MNL) and machine learning algorithms such as the Random Forest Classifier (RFC), Gradient Boosting Classifier (GBC), and Neural Network Classifier (NNC) (Pobudzei & Hoffmann, 2024b). The MNL helps quantify the likelihood of each option, shedding light on factors affecting user decisions. RFC and GBC, both ensemble methods, handle features and non-linear relationships effectively, focusing on sequential error correction. While they address non-linear complexities well, their probabilistic interpretation is limited. The NNC excels in pattern recognition, which is beneficial for choice modeling, though it requires extensive data, and its complexity can reduce transparency compared to simpler models like MNL. We split our dataset, using 80% for training and 20% for testing, maintaining a fixed random seed across all analyses. We assessed our models' accuracy and feature importance to identify factors influencing shared micromobility usage rates.

4 Impact of Weather, Time, and User Traits on Shared Micromobility Usage

4.1 Distribution of MORE Sharing Bookings, Reservation Durations, and Distances

In our study examining the effects of weather conditions, temporal factors, and user characteristics on utilizing a multimodal shared micromobility system within a non-urban campus environment, we used data from March 6, 2023, to March 6, 2024 (Chapter 3.2). It is important to note that the MORE Sharing service experienced interruptions on the 17th and 18th of May and June 24, 2023, due to local events on campus. By March 2024, marking a year since MORE Sharing's inception, registered users reached 3,161. This figure represents individuals who downloaded the MORE Sharing mobile application, completed the registration process by submitting their details, and linked valid payment methods within the app.

The launch of MORE Sharing in March 2023 was met with a notable spike in user registrations, indicative of a strong initial interest in the service (Figure 4-1) (Pobudzei & Hoffmann, 2024a). Over the subsequent months, the user base saw a steady increase, further buoyed by the influx of new students in October 2023, contributing to an uptick in registrations. MORE Sharing offers a unique proposition to its registered users - a monthly mobility budget of 300 euros. This budget is automatically refreshed monthly, provided users opt-in for this feature within their mobile app accounts. However, it is essential to note that the unused portion of this mobility budget does not roll over to the next month (Pobudzei & Hoffmann, 2024a).

Figure 4-2 shows that most of MORE Sharing's users are in their 20s, with 76% being younger than 30. The gender distribution among users is predominantly male, accounting for 82%, while females represent 18% of the user base, mirroring the demographic composition of the university community. Additionally, the preference for language usage within the application reveals that 89% of interactions are conducted in German, with the remaining 11% in English. Between March 6, 2023, and March 6, 2024, MORE Sharing facilitated 52,435 distinct bookings, an average of approximately 143 daily. 70% of registered users utilized the service during this time, and 2,218 unique customers engaged with the service by taking at least one booking. 30% of persons registered at MORE Sharing did not take any bookings.

Table 4-1 and Figure 4-3 show that MORE Sharing experienced a decline in active customers and total bookings over four consecutive periods. From March to May 2023, they had the highest engagement in the first period, with 1,453 active customers and 21,647 total bookings. The mean number of bookings per customer was 15, with half of the customers taking 9 bookings or fewer and the most active 25% taking between 21 and 171 bookings.

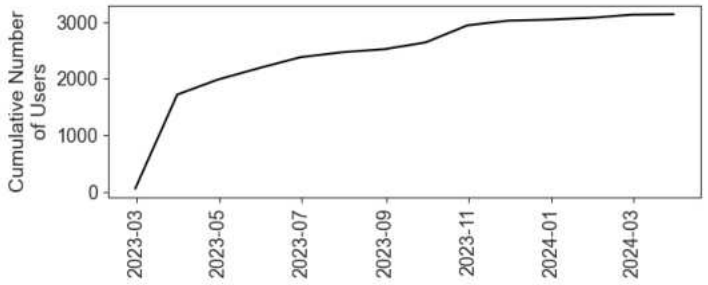

Figure 4-1: Cumulative number of MORE Sharing registered users

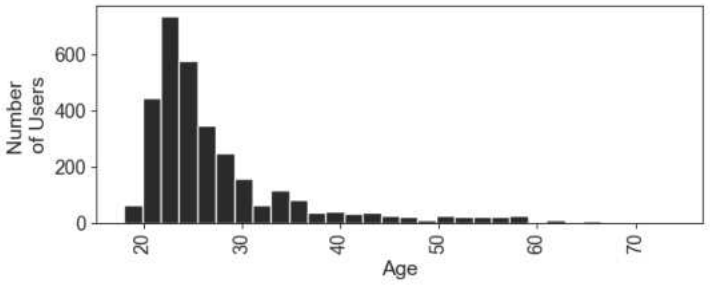

Figure 4-2: Age of MORE Sharing users

As we move through subsequent periods, there is a notable decrease in active customers and total bookings, concluding with 1,012 active customers and 6,716 bookings from December 2023 to February 2024. The average bookings per customer also decreased, ending at 7 bookings per customer, with half of the customers taking 3 or fewer bookings and the top 25% taking between 8 and 130 bookings.

Regarding reservation duration, we see an initial average of 980 minutes per customer, peaking in the second period at 1,100 minutes. However, this figure then declines to 426 minutes by the last period. Like the driven distance, the reservation duration suggests an overall reduction in usage intensity (Table 4-1, Figure 4-3).

The data suggests that customers make fewer bookings as time goes on, travel fewer kilometers, and book for shorter durations. The peak figures in driven distance and reservation duration in the second period could indicate a seasonal variation or a temporary change in user behavior. However, overall, the trend is toward lesser engagement.

As highlighted by the maximum recorded values (Table 4-1, Figure 4-3), some individuals within the user base consistently exhibit usage patterns far exceeding the norm, with extended distances and reservation durations across all timeframes. This trend suggests that a distinct segment of dedicated users consistently relies heavily on the service despite a downward shift in overall user activity. These individuals appear to utilize MORE Sharing for extended travel beyond the immediate area surrounding the campus. Moreover, some users prefer longer vehicle reservations, potentially for activities or events that necessitate sustained access to transportation. The tendency for longer reservations corresponds with a monthly mobility allowance of 300 euros for MORE Sharing users, which may encourage more prolonged service use.

Table 4-1: Cumulative sum of bookings, driven distance, and reservation duration per customer

Parameters				Cumulative sum per customer					
Parameter	Period	Active customers	Total bookings	Min	25%	Mean	50%	75%	Max
Bookings	3. - 5.2023	1,453	21,647	1	3	15	9	21	171
	6. - 8.2023	1,388	12,696	1	2	9	5	11	152
	9. - 11.2023	1,378	11,376	1	2	8	5	10	120
	12.2023 - 2.2024	1,012	6,716	1	2	7	3	8	130
Driven distance, kilometers	3. - 5.2023	1,453	21,647	0.1	6	35	18	44	499
	6. - 8.2023	1,388	12,696	0.1	4	26	12	31	425
	9. - 11.2023	1,378	11,376	0.1	3	19	8	23	374
	12.2023 - 2.2024	1,012	6,716	0.1	2	13	6	15	280
Reservation duration, minutes	3. - 5.2023	1,453	21,647	0.5	49	980	223	749	29,674
	6. - 8.2023	1,388	12,696	0.5	27	1,100	149	720	24,209
	9. - 11.2023	1,378	11,376	0.5	18	671	84	442	19,554
	12.2023 - 2.2024	1,012	6,716	0.5	14	426	52	243	18,900

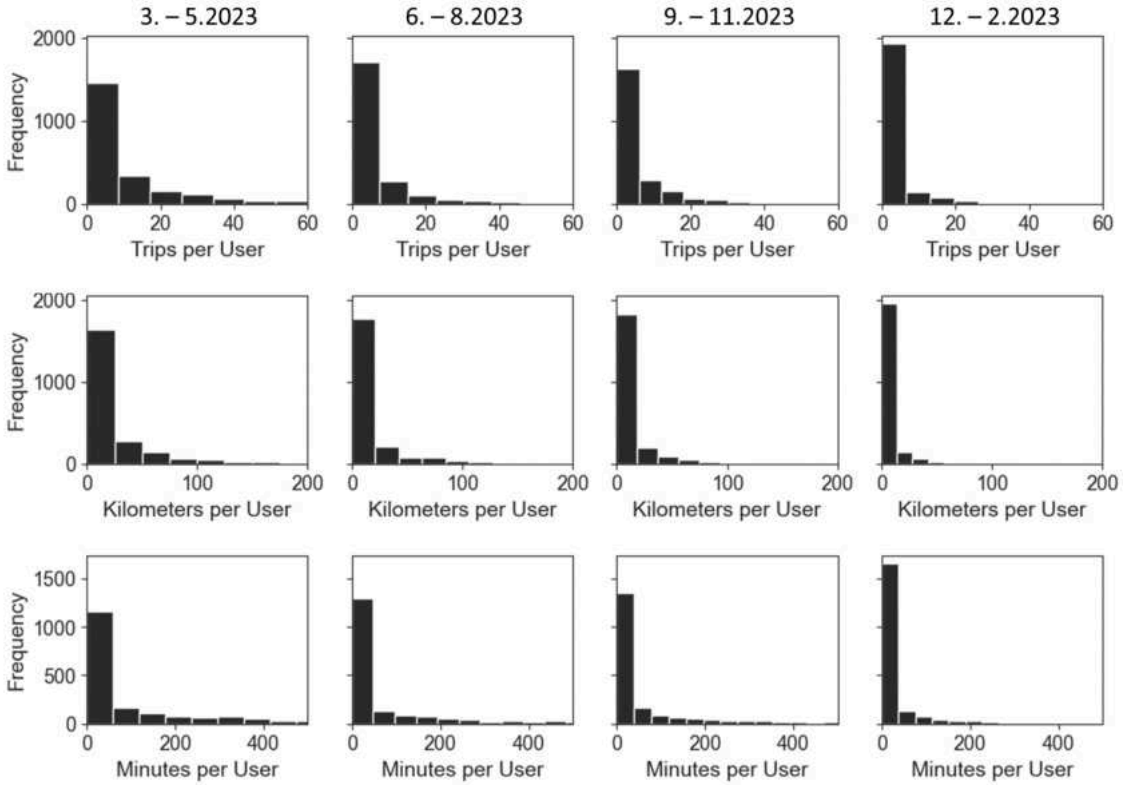

Figure 4-3: Distribution of the cumulative number of bookings, driven distance, and reservation duration per customer

During our research, the MORE Sharing service had a fleet of 99 vehicles, comprising 25 city bikes, 25 e-bikes, 10 e-cargo bikes, 10 e-mopeds, and 29 e-scooters. The accessibility of these vehicles significantly impacted our observations. Variability in vehicle availability was primarily due to technical malfunctions, the need for regular maintenance, or weather conditions (Figure 4-4). A significant disruption began in October 2023, when a large portion of the e-scooter segment was rendered out of service because of defects in IoT devices (Figure 4-5). Additionally, starting December 6, 2023, adverse weather conditions necessitated the withdrawal of e-mopeds and e-scooters from operation (Figure 4-5), as we wanted to avoid dangerous accidents with these vehicle types.



Figure 4-4: Variability in vehicle availability due to technical malfunctions of weather conditions

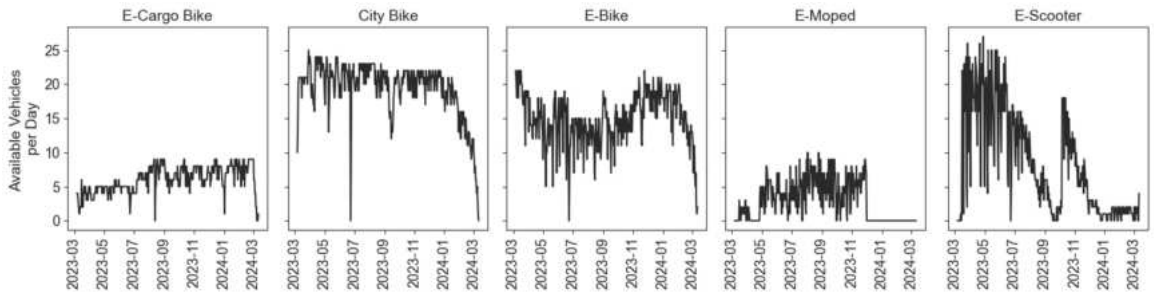

Figure 4-5: Available MORE Sharing vehicles per day

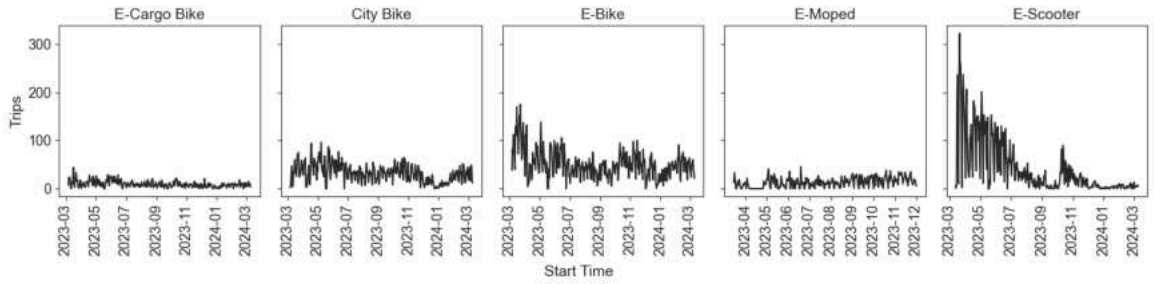

Figure 4-6: Daily booking counts by vehicle type

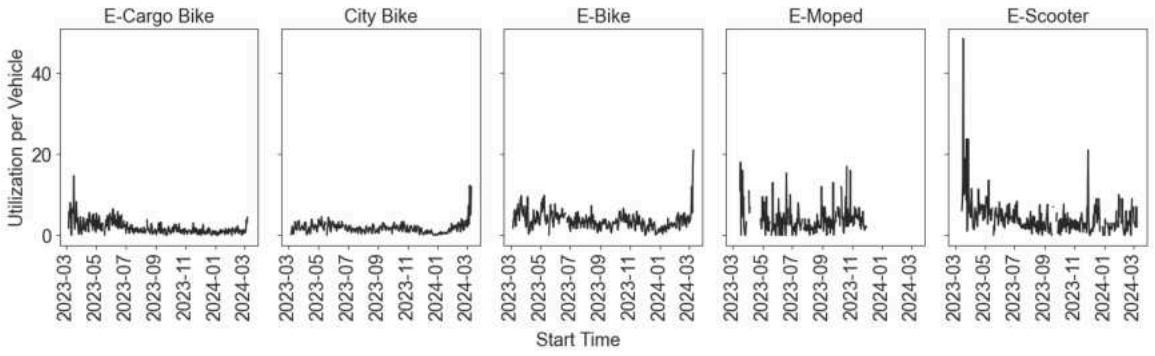

Figure 4-7: Daily vehicle utilization: the ratio of bookings to available vehicles for each type

To gauge the utilization rates for each vehicle type (Figure 4-7), we calculated the ratio of daily bookings (Figure 4-6) to the number of available vehicles of that particular type (Figure 4-5). For instance, e-cargo bikes experienced an initial surge in utilization, possibly driven by curiosity and the novelty of this new mode of transport. The early adopters and more adventurous users may have been eager to test the capabilities of e-cargo bikes for their transportation or delivery needs. This is evident from the higher early peaks shown in Figure 4-7, which suggest interest following the service launch. However, as the novelty wore off, the data indicated a decline in the average daily use of e-cargo bikes, with the mean daily utilization rate settling at around 1.81. This declining trend reflects a shift in customer behavior as the service continued, emphasizing the need for continuous monitoring.

On the other hand, city bikes demonstrated a slightly lower average daily use but more consistency in demand, as evidenced by both the lower standard deviation and the fewer spikes in Figure 4-7. Over the year, city bikes maintained a steady utilization rate, which might indicate their role as a reliable mode of transport for regular short-distance travel. This consistent usage pattern suggests a strong and steady user base, highlighting the potential for further growth.

E-bikes present a higher average utilization (Figure 4-7), indicating that they have been well-received by customers seeking a balance between convenience and physical effort. The consistent use and occasional high-demand days observed in the graph could point toward a growing preference for e-bikes for daily commutes and longer bookings that benefit from the electric assist feature.

E-moped utilization began vigorously and maintained a strong demand pattern across the year, barring winter when the service was suspended (Figure 4-7). The significant daily fluctuations in usage suggest that e-mopeds enjoy popularity but are subject to seasonal preferences and possibly the initial allure of a new service. Throughout the year, notable surges in utilization likely align with specific events or optimal weather that promotes the use of e-mopeds.

E-scooters exhibit the most vibrant usage trends, with the highest mean daily utilization and considerable variability (Figure 4-7). In this inaugural year, the pronounced peaks and overall high use indicate a strong preference for e-scooters for impromptu, brief journeys. The fluctuating usage patterns could indicate customers sampling the new service to determine its fit

with their transportation routines. Initially, e-scooters experienced a surge in daily usage, likely propelled by their novelty and the campus community's eagerness to test these new vehicles.

Table 4-2 reveals patterns for each vehicle type in the MORE Sharing service, focusing on booking distances and reservation durations. E-mopeds have the highest average booking distance at 5.1 kilometers, indicating their preference for longer journeys. Despite this, the median distance for e-mopeds is 3.0 kilometers, suggesting a balanced mix of short and long bookings among users. E-bikes, e-cargo bikes, and e-scooters show similar average distances, around 2.2 to 2.4 kilometers, supporting their use for moderate distances. City bikes, with the lowest average distance of 1.6 kilometers, are predominantly used for the shortest bookings, highlighting their convenience for quick errands or short commutes within or near campus areas.

E-mopeds also feature the most extended average reservation duration (Table 4-2), significantly exceeding that of other vehicles at 218.1 minutes, which aligns with their use for extended bookings. This is further evidenced by the median duration of 15.6 minutes, suggesting that while there are many shorter reservations, the average is pulled up by many longer bookings. E-cargo bikes follow, with an average reservation of 109 minutes, indicative of their use for tasks requiring more extended periods, such as deliveries or errands requiring cargo space. E-scooters and e-bikes display moderate reservation durations (Table 4-2), suitable for quick to medium-length bookings. City bikes, with the shortest average duration, are chosen for brief journeys, aligning with their role in facilitating quick, convenient travel around the campus.

The variance in average distances and durations across vehicle types reflects a diverse range of user needs and preferences, from quick commutes to longer exploratory rides or specific tasks requiring more time or special vehicle features. While e-mopeds are favored for longer bookings, reflecting their capability to cover greater distances and support longer reservations, city bikes are the go-to option for the shortest journeys. E-bikes, e-scooters, and e-cargo bikes occupy the middle ground, offering flexibility for various use cases, from moderate distances to tasks needing cargo capacity.

Figure 4-8 further offers an overview of booking distribution across distance and duration categories for each vehicle type. Short duration and distance bookings dominate the usage patterns across all vehicle types within MORE Sharing. This observation underscores the primary utilization of the service for brief journeys within the campus vicinity or nearby areas.

Extended reservation durations do not necessarily correlate with greater distances traveled, as these often involve extended idle times rather than continuous movement (Figure 4-8). This observation suggests that users reserve vehicles for longer durations to accommodate their needs, including extended breaks or multiple stops during their journeys, rather than solely focusing on covering longer distances. E-mopeds, e-cargo bikes, and e-bikes are utilized for longer distances during longer-duration rentals (Figure 4-8), indicating that users prefer these vehicle types for more extensive journeys or tasks requiring greater distances.

Kernel density estimate (KDE) plots (Figure 4-9) depict the distribution of bookings across different micromobility modes throughout the week and at various times of the day. Most bookings, irrespective of vehicle type, occur on weekdays, which aligns with the primary user

base of students, faculty, and staff members who are more active on campus during the weekdays.

Booking numbers rise between 6 AM and 8 AM, corresponding to the morning commute on campus (Figure 4-9). From 8 AM to 6 PM, the booking counts for all micromobility modes remain consistently high. After 7 PM, the number of bookings declines, indicating reduced demand during the evening hours when users likely conclude their campus activities. E-mopeds exhibit a distinct peak in usage between 1 PM and 6 PM, possibly due to various reasons, such as using e-mopeds for longer bookings, leisure activities, or running errands during the mid-afternoon period.

Table 4-2: Reservation duration (minutes) and driven distance (kilometers) per vehicle type

Parameter	Vehicle type	Number of bookings	Min	25%	Mean	50%	75%	Max
Booking distance, kilometers	City Bike	11,706	0.1	0.6	1.6	1.1	1.9	69.6
	E-Bike	18,781	0.1	0.9	2.2	1.4	2.6	57.0
	E-Cargo Bike	3,504	0.1	0.6	2.3	1.3	2.7	63.5
	E-Moped	3,492	0.1	1.0	5.1	3.0	7.0	58.0
	E-Scooter	15,011	0.1	0.9	2.4	1.6	3.0	38.3
Reservation duration, minutes	City Bike	11,706	0.5	4.6	96.0	8.2	33.1	16,024.7
	E-Bike	18,781	0.5	4.7	57.1	8.0	29.7	8,924.7
	E-Cargo Bike	3,504	0.5	5.3	109.0	11.2	45.6	9,910.7
	E-Moped	3,492	0.5	4.8	218.1	15.6	91.2	16,919.0
	E-Scooter	15,011	0.5	4.4	64.5	8.3	33.3	10,197.8

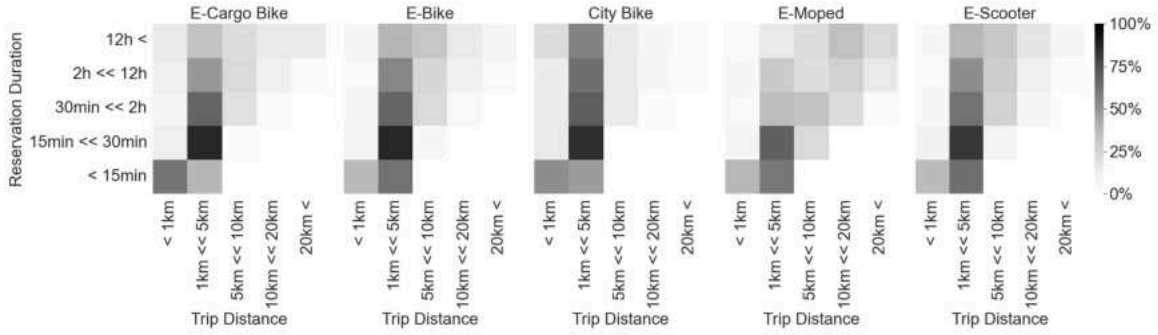

Figure 4-8: Distribution of MORE Sharing bookings across distance and duration categories

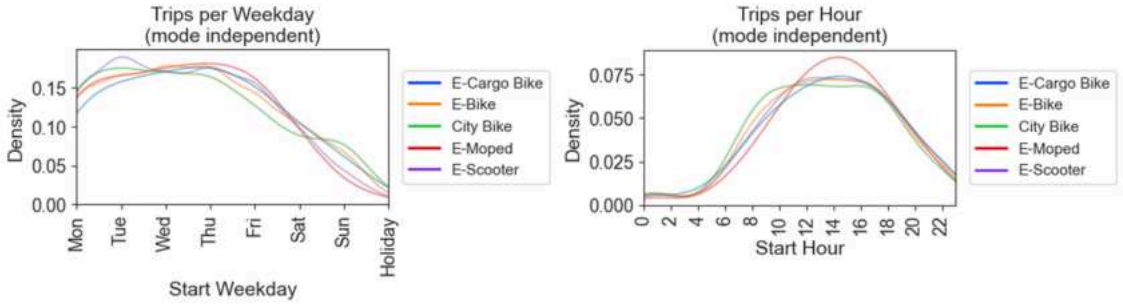

Figure 4-9: Kernel density plots (mode independent): distribution of MORE Sharing bookings

4.2 Modeling Hourly Booking Counts, Booking Durations, and Distances

The research explored how factors such as time, weather conditions, user demographics, and types of vehicles influence the hourly booking counts, duration of bookings, and distances covered in MORE Sharing's services. To model these aspects, we utilized Negative Binomial Regression (NBR). This approach was chosen because the variance in hourly booking rates, durations of bookings, and distances driven were statistically significantly greater than the mean, making NBR suited for analyzing our data.

Results from the Negative Binomial Regression (NBR) model for hourly trip counts (Table 4-3, Figure 4-10) revealed that higher precipitation and humidity have a negative impact on the number of shared micromobility hourly bookings, as unfavorable weather conditions or safety concerns may decrease trip counts during wet conditions. In contrast, the windchill index, which affects how warm it feels, positively affects bookings. This indicates that warmer perceived temperatures slightly increase the likelihood of making a booking.

The coefficients for different vehicle types are positive and significantly affect the booking counts. The coefficients indicate that, compared to the base vehicle type, e-cargo bike, all other vehicle types are more likely to be booked, with e-scooters showing the highest increase in hourly bookings.

Analysis of the hourly trip rates throughout the day (Table 4-3) revealed an increase in trip counts between 6 AM and 11 AM compared to the period between 0 and 2 AM. This indicates higher demand during the morning hours, likely related to commuting and the start of daily activities. Most bookings occurred between 12 PM and 5 PM, reflecting lunchtime and mid-afternoon activities. After 6 PM, the trip rate started to decline, suggesting reduced campus activity during the evening hours.

Compared to Monday, the coefficients for day types (from Tuesday to Sunday and holiday) generally show a negative association with hourly booking counts. Significantly fewer trips were observed on Fridays, weekends, and holidays than on Mondays. This pattern suggests that MORE Sharing experiences reduced usage during non-working days and weekends when the campus community may have fewer obligations or different transportation needs. Seasonal variations also play a significant role, with spring showing a substantial positive effect on booking counts. This is followed by autumn and summer, indicating that seasonality significantly influences booking behaviors (Table 4-3).

When modeling hourly trip counts, the Random Forest (RF), Gradient Boosted Regression Trees (GBRTs), and Neural Networks (NN) models exhibited similar performance but varied in feature importance rates (Figure 4-11). RF placed considerable importance on parameters such as the time of day, vehicle type, weekday type, and season when predicting hourly booking counts. GBRTs also considered vehicle type and time-related parameters as priorities. NN assigned the highest importance to wind chill index and temperature, followed by vehicle type and season. These disparities in feature importance highlight the factors influencing booking counts and the potential of different models to capture and predict these patterns.

Table 4-3: Modeling hourly trip counts, reservation durations, and trip distances with Negative Binomial Regression (NBR)

	Hourly booking counts		Log Booking duration, minutes		Booking distance, kilometers	
N	14,786		42,088		42,088	
RMSE	2.32		1.48		3.19	
Variable	coef	z	coef	z	coef	z
Vehicle pre-reserved, minutes			**0.02**	**10.57**	**0.04**	**21.66**
Current age, years			**0.01**	**6.22**	**0.01**	**5.75**
User registered since, days			**0.03**	**10.73**	**0.01**	**4.58**
Female			0.01	0.39	0.03	1.51
Humidity, %	**-0.06**	**-9.48**	**0.02**	**6.08**	0.00	0.88
Precipitation index	**-0.06**	**-2.14**	-0.02	-0.99	**-0.05**	**-2.86**
Wind chill index	**0.02**	**7.98**	0.00	-0.84	**0.01**	**6.88**
E-Bike	**0.79**	**25.40**	0.03	1.22	**0.05**	**2.03**
City Bike	**0.51**	**15.60**	0.05	1.94	**-0.24**	**-9.54**
E-Moped	**0.20**	**4.61**	**0.16**	**5.29**	**0.79**	**26.15**
E-Scooter	**0.85**	**25.25**	0.02	0.85	**0.08**	**3.51**
Early morning (6-9AM)	**0.48**	**12.57**	**0.31**	**10.16**	**0.20**	**6.34**
Late morning (10AM-1PM)	**0.65**	**18.18**	**0.36**	**12.56**	**0.31**	**10.75**
Afternoon (2-5PM)	**0.61**	**16.82**	**0.36**	**12.56**	**0.35**	**11.74**
Evening (6-9PM)	**0.40**	**10.63**	**0.32**	**10.97**	**0.24**	**7.98**
Late evening (10-12PM)	**0.12**	**2.40**	**0.23**	**6.09**	0.05	1.21
Tuesday	-0.06	-1.63	0.03	1.40	**-0.04**	**-1.98**
Wednesday	**-0.07**	**-2.00**	0.04	1.93	-0.02	-0.79
Thursday	**-0.08**	**-2.33**	0.01	0.66	**-0.07**	**-3.58**
Friday	**-0.16**	**-4.53**	-0.01	-0.40	-0.03	-1.30
Saturday	**-0.42**	**-11.48**	**0.05**	**1.97**	**0.10**	**4.40**
Sunday	**-0.56**	**-13.87**	0.00	-0.11	0.03	1.07
Holiday	**-0.64**	**-6.93**	0.04	0.62	**0.17**	**2.74**
Spring, 2023	**0.53**	**16.85**	**-0.05**	**-2.36**	-0.01	-0.57
Summer, 2023	**0.13**	**2.97**	0.01	0.19	0.03	1.18
Autumn, 2023	**0.14**	**3.88**	-0.02	-1.08	**-0.10**	**-4.09**

* Bolded values indicate statistical significance at p <= 5%

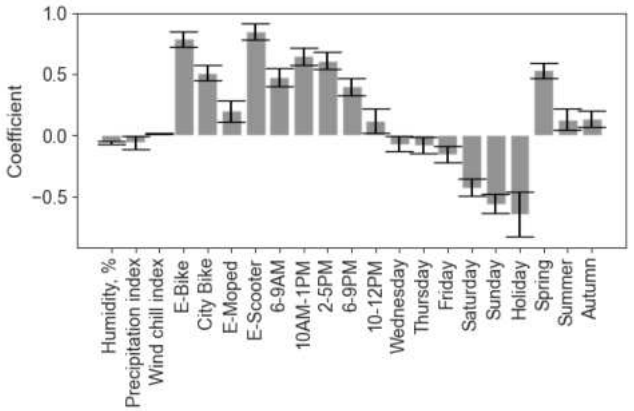

Figure 4-10: NBR: significant parameters (p <= 5%) for predicting hourly booking count

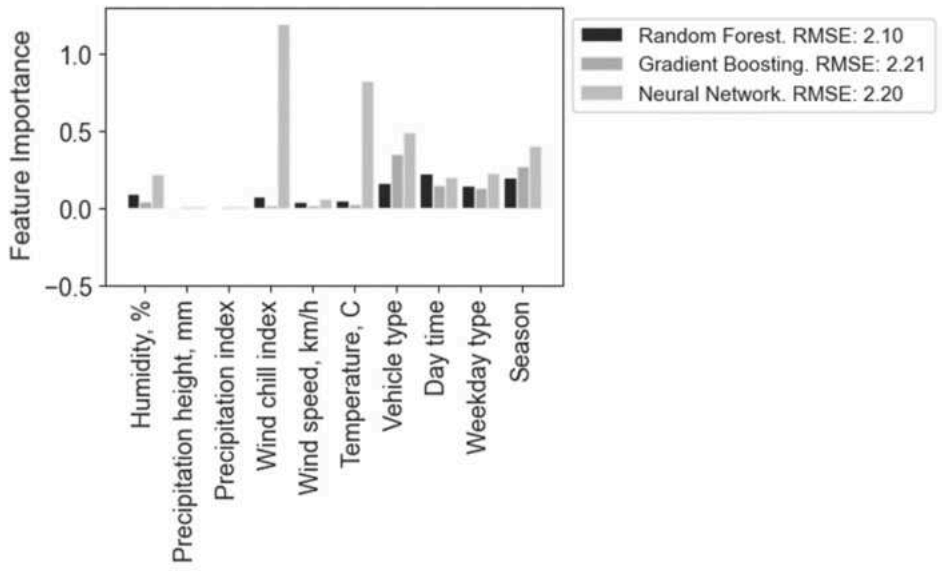

Figure 4-11: RF, GBRTs, NN: feature importance for hourly booking count models

Additional parameters like pre-reservation duration in minutes, user age, and the length of user registration on MORE Sharing were included to estimate booking durations and traveled distances (Table 4-3). The NBR model (Table 4-3, Figure 4-12) indicated a positive relationship between bookings and pre-reservation duration. If the vehicle is reserved in advance, the booking would last longer. Both current age and the number of months a user has been registered positively influence reservation duration, suggesting older and longer-registered users tend to make longer bookings. The coefficient for female users is not statistically significant, indicating no strong evidence that gender influences reservation duration in this context.

Absolute humidity positively affects reservation duration, whereas precipitation and windchill indexes have no significant impact. Different vehicle types show varied effects, with e-mopeds significantly increasing the reservation duration. Other vehicle types' effects range from insignificant to marginal (Table 4-3, Figure 4-12).

The time of day at the start of the reservation significantly affects its duration, with start times in the morning to early afternoon (AM10-PM1, PM2-5) associated with the most extended booking durations. The day of the week shows mixed effects, with Saturdays showing a marginal positive impact, suggesting marginal variations in booking duration across different days. In spring 2023, the bookings tended to be shorter than in winter 2024, even though the prices for bookings were increased in September 2023 (Table 4-3, Figure 4-12).

Figure 4-13 displays feature importance scores for predicting reservation duration, as determined by three different machine learning models: Random Forest (RF), Gradient Boosting (GBRTs), and Neural Network (NN). The results show that factors like pre-reservation duration, user age, and months registered are given importance in the RF and GB models.

Weather-related features like humidity and wind chill index also contribute to prediction accuracy, with the wind chill index being more significant than wind speed and temperature.

Vehicle type is another predictor in both RF and GB models, suggesting it distinctly impacts how long users reserve vehicles. The NN model, however, does not highlight any specific features as being particularly influential for prediction, as evidenced by its more uniform distribution of importance across features. The RMSE scores indicate that RF and GB models perform equally well, while the NN model has a slightly higher error rate.

Concerning driven distances, users who pre-reserved vehicles tended to cover longer distances compared to those who made spontaneous reservations (Table 4-3, Figure 4-14). This suggests that individuals who plan their trips may have specific destinations or longer journeys in mind, resulting in increased distances traveled. A slight but significant positive correlation exists between user age and distance driven. A longer registration period with the service also leads to longer distances driven. Female users travel slightly longer distances than males, although this result is not statistically significant.

Rainy weather is associated with shorter distances. Conversely, a higher wind chill index correlates with longer distances. Distinct vehicle types show different effects, with e-mopeds being the most strongly associated with driving longer distances and city bikes with shorter distances per booking (Table 4-3, Figure 4-14). Starting a trip in the morning or afternoon is associated with increased distances, particularly between 10 AM and 5 PM. Specific day types have varying impacts, with Saturdays and holidays showing a positive relationship, indicating longer trips on these days. In autumn 2023, the driven distances per booking were the shortest in comparison to winter 2024 (Table 4-3, Figure 4-14).

RF and GBRTs underscored the significance of vehicle type in predicting the distance traveled (Figure 4-15). The wind chill index emerged as a significant distance predictor in the NN model, representing the combined influence of temperature and wind speed. Additionally, NN substantially relied on the temperature in distance predictions.

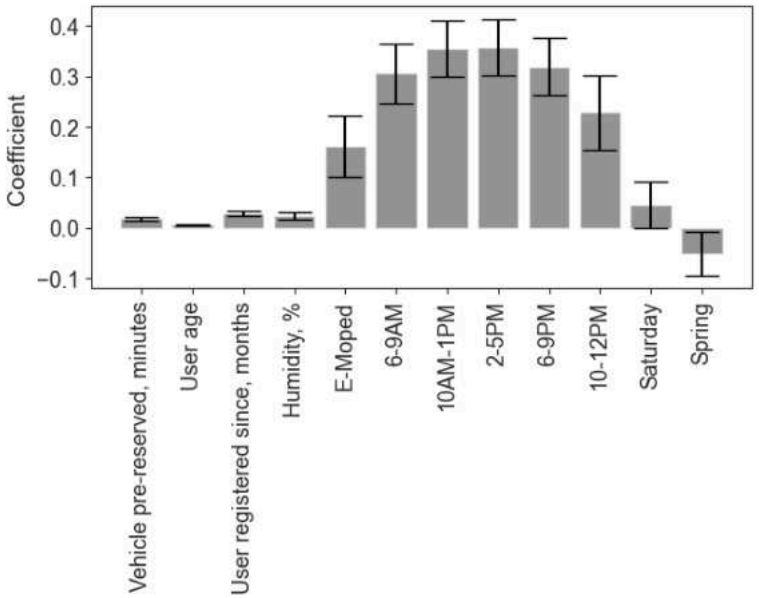

Figure 4-12: NBR: significant parameters (p <= 5%) for predicting booking duration

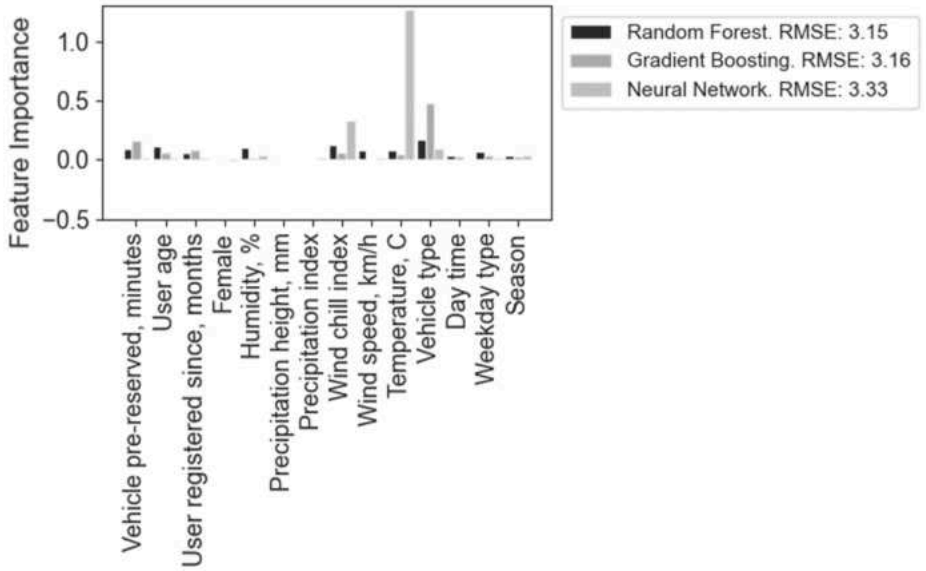

Figure 4-13: RF, GBRTs, NN: feature importance for booking duration models

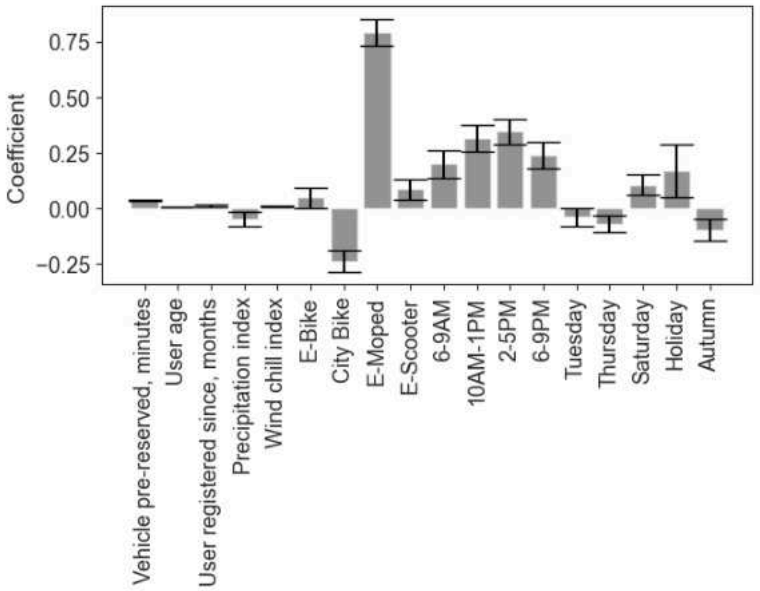

Figure 4-14: NBR: Significant parameters (p <= 5%) for predicting booking distance

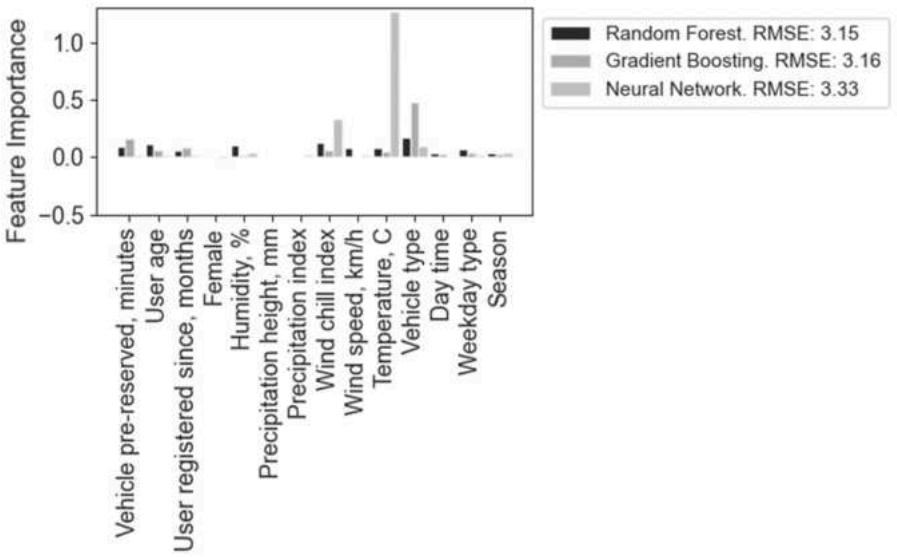

Figure 4-15: RF, GBRTs, NN: feature importance for booking distance models

4.3 Conclusion

The objective of this chapter was to study how weather conditions, temporal factors, and user characteristics influence hourly booking counts, booking durations, and distances traveled within MORE Sharing - a multimodal shared micromobility system in a non-urban campus environment. Utilizing data from March 2023 to March 2024, we identified trends and influences that enrich our understanding of shared micromobility systems and contribute valuable insights for operators and urban planners.

During the study period, MORE Sharing saw an expansion in its user base, with significant registration growth in the first months of operation and coinciding with the arrival of new students. This trend reflects the service's appeal to the campus community, aided by an enticing 300-euro monthly mobility budget offer. Analysis of user demographics revealed a youthful user base predominantly composed of males, reflecting the university's demographic profile. An examination of booking data showed an initial enthusiasm for MORE Sharing, with a gradual decline in active customers and bookings over time. Despite the overall downward trend, a core group of users exhibited consistently high engagement levels, relying heavily on the service for extended travel and longer reservation durations, hinting at a strong dependency on the system.

In studying the vehicle fleet's usage, we found that each vehicle type catered to distinct user needs: e-cargo bikes for transporting goods, e-mopeds for swift travel over longer distances, and city bikes for short commutes. The user interaction with the fleet was dynamic, with initial surges in usage for particular vehicles reflecting curiosity or event-driven demand and overall consistent demand for reliable city bikes for everyday transit needs.

Using Negative Binomial Regression models helped us delve into the intricacies of user behavior and system interaction. We learned that weather plays a pivotal role, with precipitation reducing booking counts and driving distances, while warmer wind chill temperatures encouraged more frequent and longer trips. These findings underline the impact of environmental conditions on the viability and attractiveness of shared micromobility services.

Moreover, the study illuminated the effect of vehicle types on usage patterns. Distinct preferences emerged, with e-scooters and e-bikes being the most popular, reflecting their utility for various trip lengths and purposes. Vehicle type was a critical factor in booking counts and distances, an insight crucial for fleet management and service offerings. Additionally, the time of day, day of the week, and seasonal changes were significant determinants of usage, with clear peaks during mornings and mid-afternoons and dips on weekends and holidays. Such temporal patterns provide essential cues for demand forecasting and resource allocation.

Our study also employed machine learning models - Random Forest, Gradient Boosted Regression Trees, and Neural Networks - to predict usage patterns. These models varied in identifying influential factors, but collectively, they underscored the importance of vehicle type, weather conditions, and temporal factors in predicting usage.

This research underscores the significance of understanding local contexts and community needs when implementing shared micromobility systems in non-urban settings. Policymakers, urban planners, and transportation providers can leverage these insights to enhance the design and implementation of shared micromobility systems in various microenvironments, such as campuses, residential neighborhoods, and corporate settings. This study contributes to the broader objective of promoting sustainable transportation initiatives and environmentally friendly mobility options across diverse settings. Examining and optimizing shared micromobility solutions in various contexts can pave the way for more efficient and accessible mobility solutions.

5 Trip Origins and Destinations in a Multimodal Shared Micromobility Framework

5.1 Distribution of MORE Sharing Trip Origins and Destinations

This chapter analyzes the real-world data on the starting and ending points of the MORE Sharing trips and the routes taken (Chapter 3.2.1). We differentiate between round and one-way trips based on the type of vehicle used. The study also summarizes the purposes of trips associated with different micromobility modes. These insights can support operational decisions related to infrastructure placement and overall system optimization. Administrators and transportation managers can use the findings to implement or improve shared micromobility systems on their premises.

To briefly recap from the previous chapter, from March 2023 till March 2024, MORE Sharing at the University of the Bundeswehr Munich recorded 52,435 unique bookings. 3,161 users were registered on the platform out of 5,500 university affiliates who could use the MORE Sharing service. E-bikes were used in 36% of the cases. E-scooters accounted for 28% of the bookings, city bikes for 22%, e-cargo bikes for 7%, and e-mopeds for 7%. We already discussed the details of booking counts, trip distances, and durations in Chapter 4.

The MORE Sharing trips predominantly started and ended within the university campus (Figure 5-1 - Figure 5-12). On the other hand, approximately one-fifth of the MORE Sharing trips started and ended at public transport stops. E-bikes had the highest percentage of public transport-related trips, with 21% of starts or ends (Figure 5-8, Figure 5-9, Figure 5-12).

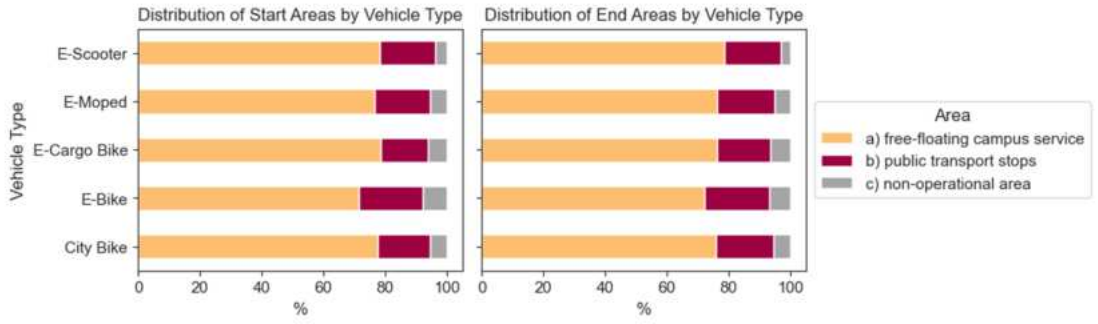

Figure 5-1: Start and end areas by vehicle type

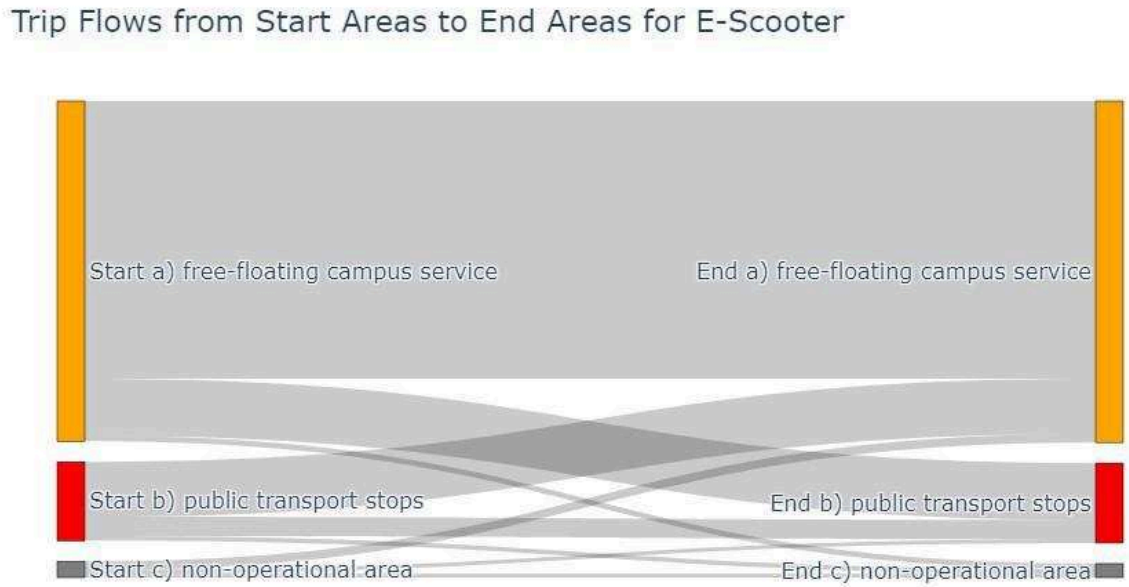

Figure 5-2: E-scooter trip flows from start areas to end areas

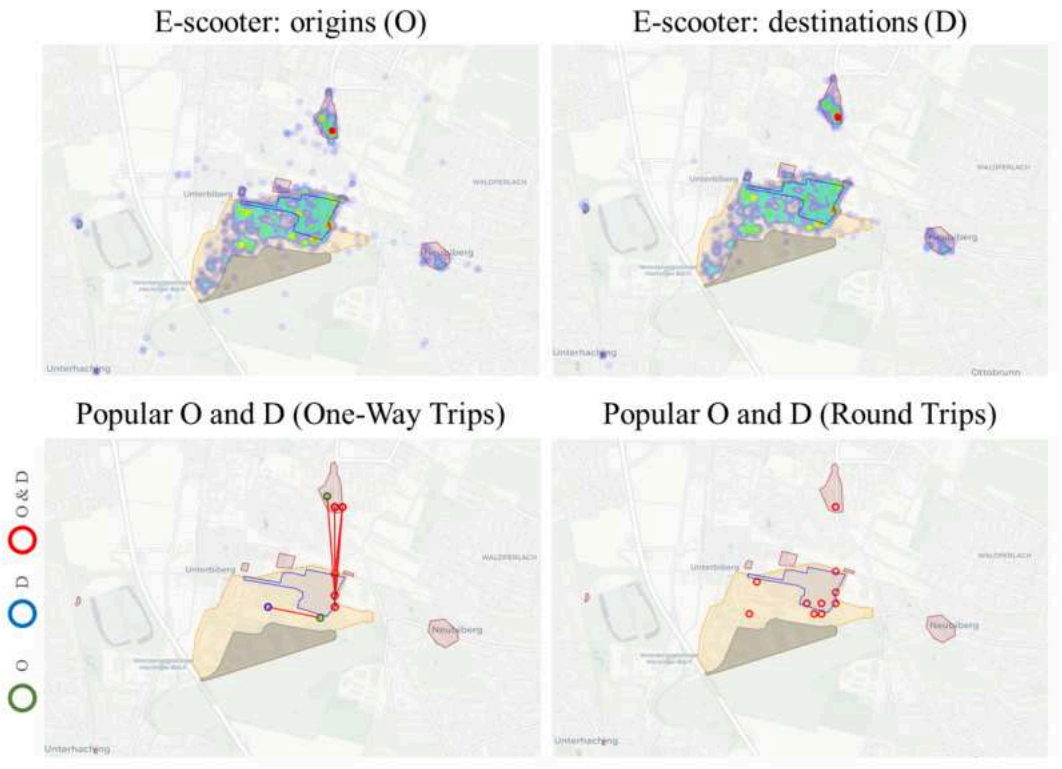

Figure 5-3: E-scooter trips

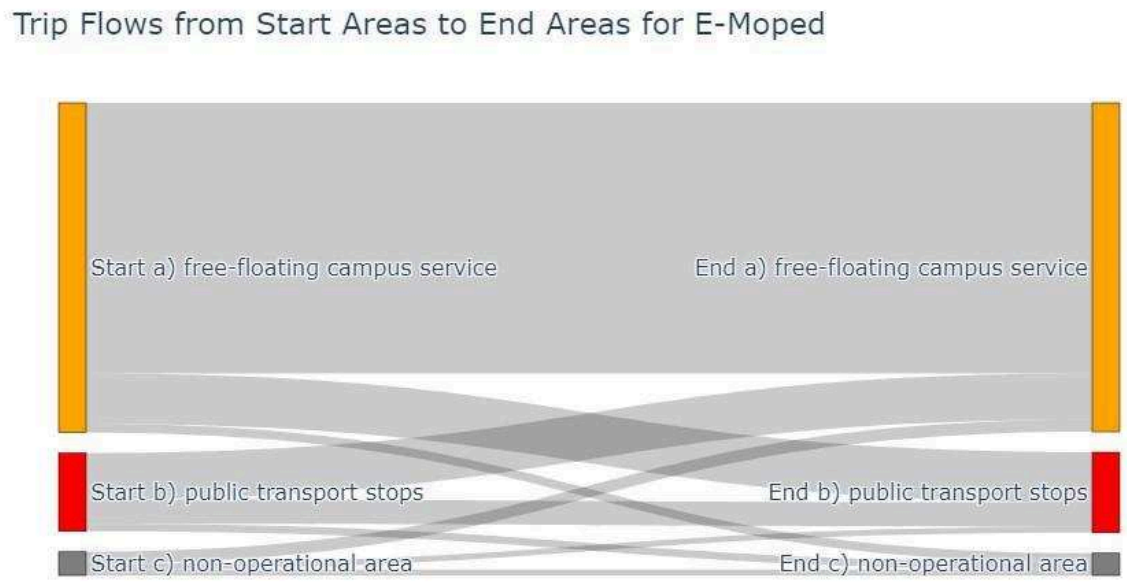

Figure 5-4: E-moped trip flows from start areas to end areas

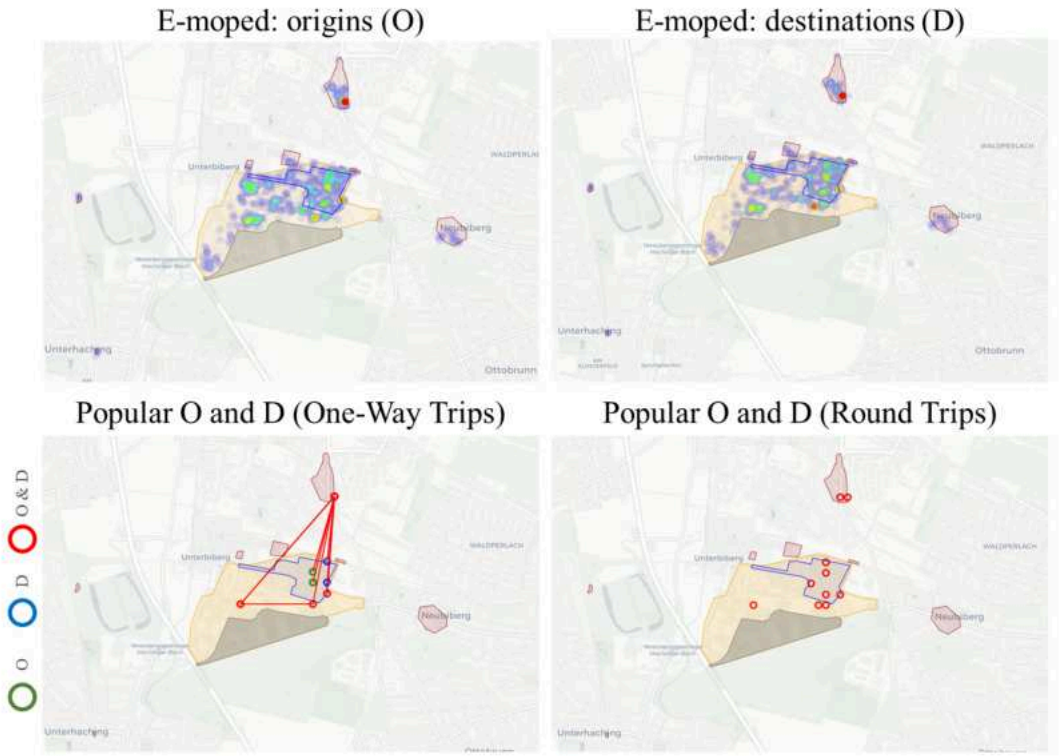

Figure 5-5: E-moped trips

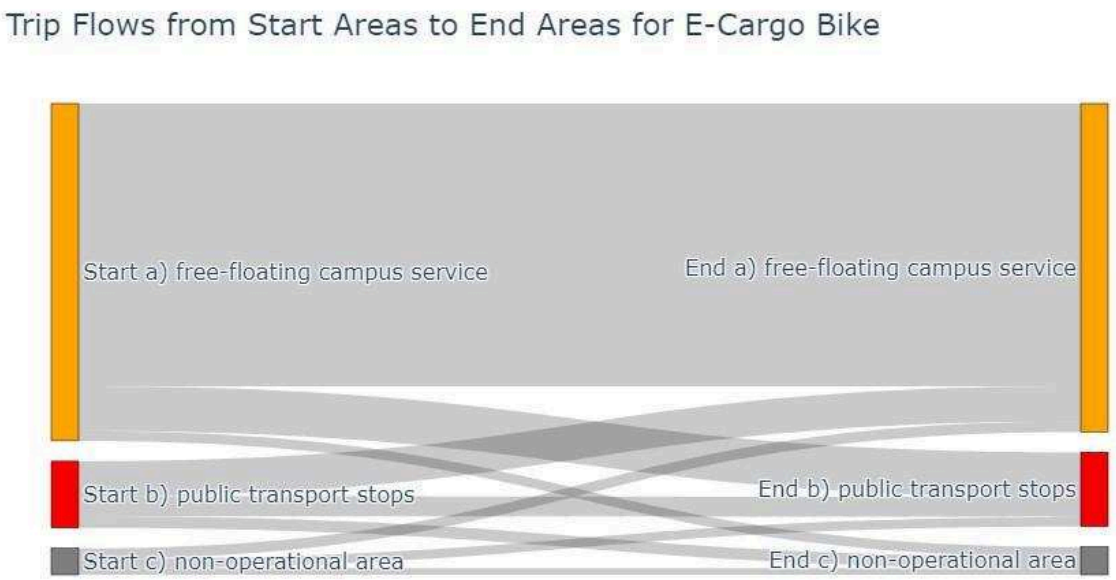

Figure 5-6: E-cargo bike trip flows from start areas to end areas

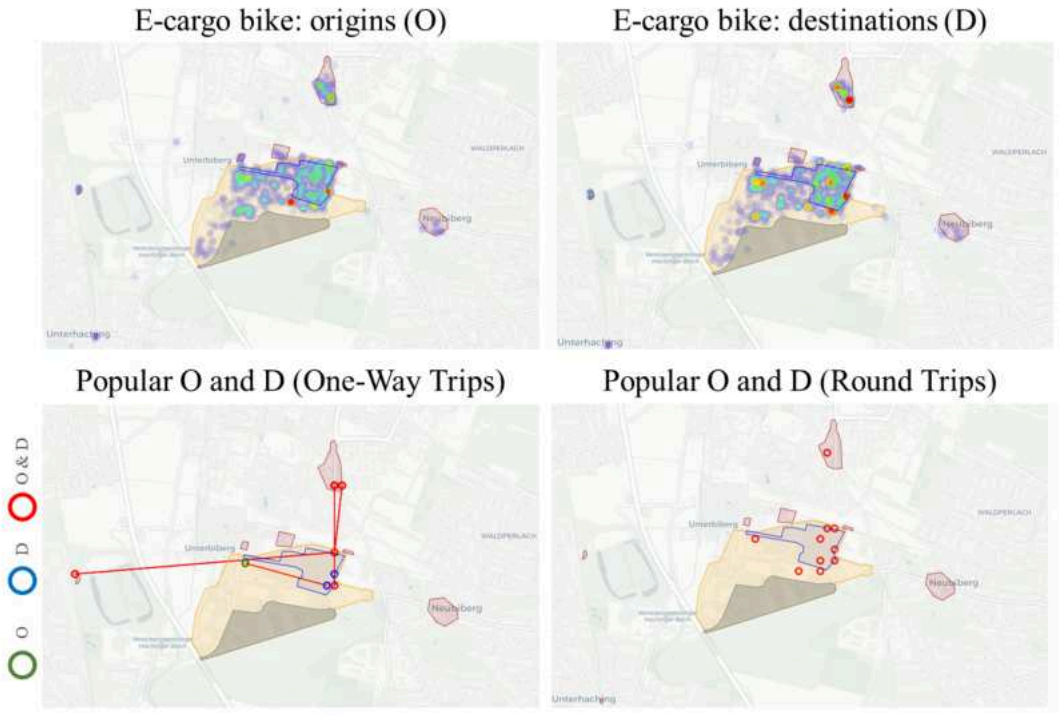

Figure 5-7: E-cargo bike trips

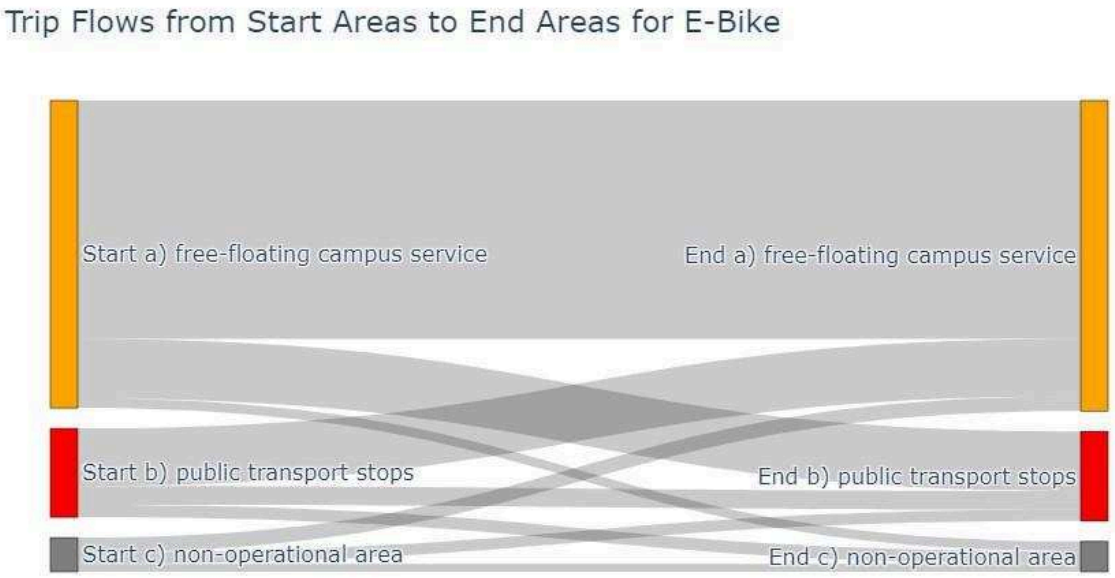

Figure 5-8: E-bike trip flows from start areas to end areas

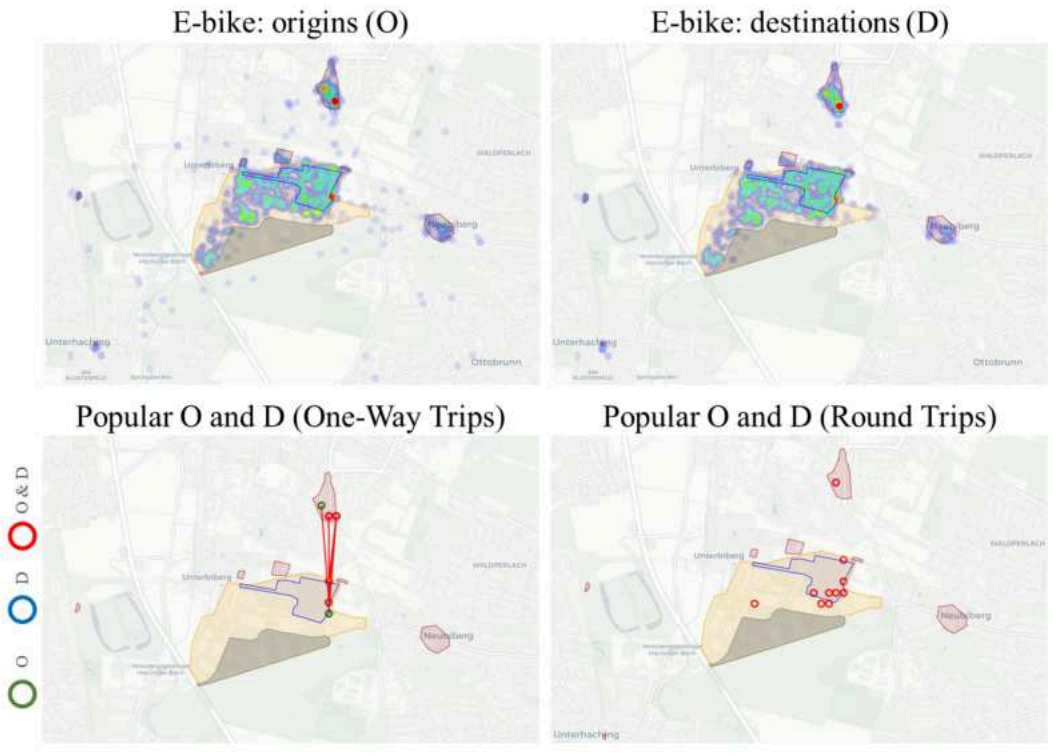

Figure 5-9: E-bike trips

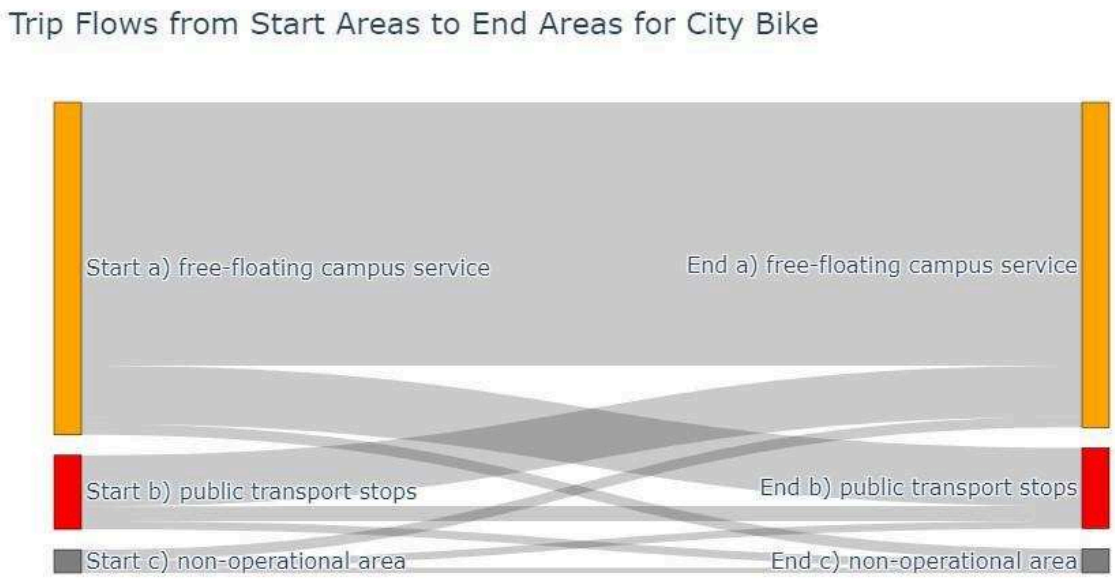

Figure 5-10: City bike trip flows from start areas to end areas

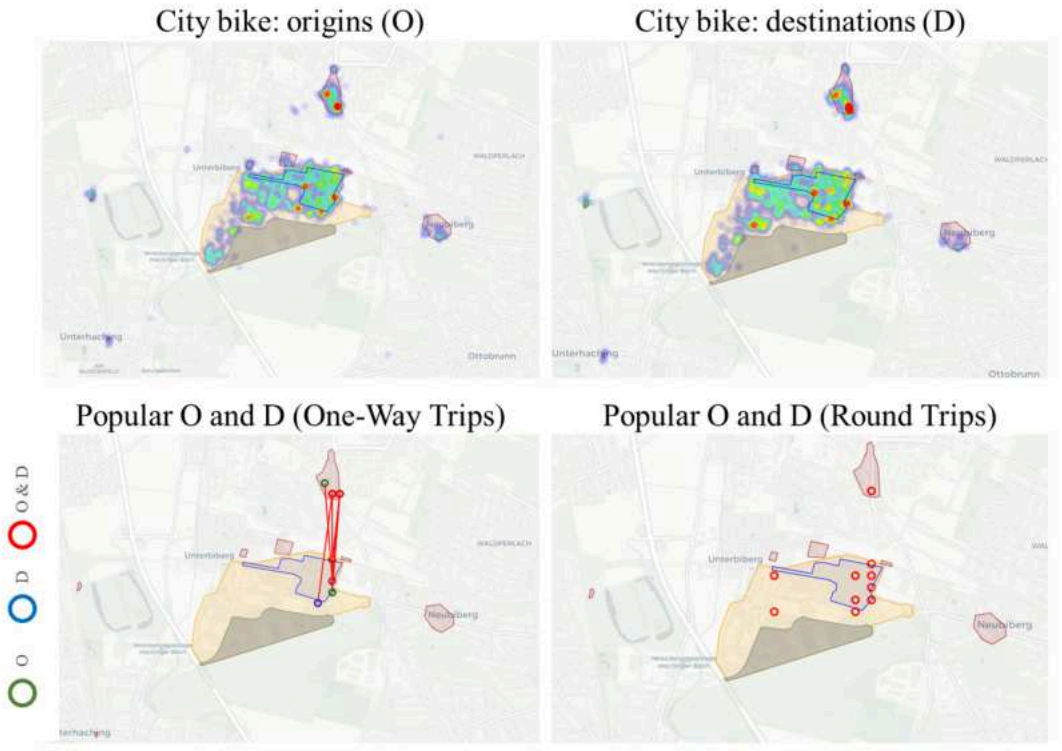

Figure 5-11: City bike trips



Figure 5-12: E-bikes and city bikes parked at the public transport station Neuperlach Süd

E-scooters (Figure 5-2, Figure 5-3), city bikes (Figure 5-10, Figure 5-11), and e-mopeds (Figure 5-4, Figure 5-5) also had 18% of their trips start or end at public transport stops. This underscores their role in providing last-mile solutions that connect the campus with the public transport hubs. E-cargo bikes had a slightly less pronounced connection with public transport stops, with 15% of the trips starting or ending near public transport (Figure 5-6, Figure 5-7). Of all trips, about 2% started and concluded outside the operational areas for all modes (Figure 5-1 - Figure 5-10). This could be attributed to factors like low battery levels or technical issues.

5.2 MORE Sharing Trip Types and Trip Purposes

The usage patterns revealed that city bikes, e-bikes, and e-scooters had mainly one-way trips, constituting 70% of their total trips (Figure 5-13). Compared to city bikes, e-bikes, and e-scooters, the tendency for one-way trips was noticeably lower among e-cargo bikes and e-mopeds (65% and 60%, respectively), suggesting that users of these modes preferred round trips, which started and ended at the same location.

After each trip, the users could fill out the post-trip survey (see Chapter 3.2.2). Analyzing the data on trip purposes by different modes of transport (Figure 5-14), we can draw several conclusions regarding the usage patterns of various types of vehicles. City bikes are heavily used for travel to work or education (23%) and work-related errands (18%). They seem to be a popular choice for daily commutes. E-bikes show a more balanced distribution across several categories but are notably used for shopping (12%) and reaching leisure activities (9%), compared to city bikes.

E-cargo bikes stand out for their high use in specific tasks such as work-related errands (20%) and shopping (20%), likely due to their capacity to carry heavy or bulky loads. E-mopeds are preferred for work-related errands (18%) and have relatively high usage for leisure (8%), indicating their suitability for quicker, possibly more enjoyable rides compared to other MORE Sharing modes (Figure 5-14).

E-scooters are a flexible mode used evenly across many categories but are particularly noted for private errands (15%) and fun trips (8%). E-mopeds and e-scooters show relatively high percentages for trips made for fun, which might be attributed to the ease of use and the enjoyment of riding these vehicles. City bikes and e-bikes also have their share of use for reaching leisure activities, which may point to their use in more relaxed or scenic contexts, perhaps in areas with dedicated bike paths or scenic routes (Figure 5-14).

Except for e-cargo bikes and e-mopeds, which have a small percentage (2%) for dropping off/picking up someone, this category generally sees very low to zero usage across other vehicle types, as other micromobility modes are for single-person use, and it is prohibited to use these vehicles for transporting others (Figure 5-14).

These results depict that each mode within the MORE Sharing program has unique strengths and usage patterns that serve the diverse needs of its users. Compact modes like city bikes, e-bikes, and e-scooters effectively bridge public transport and are favored choices for one-way travel. In contrast, e-cargo bikes and e-mopeds have emerged as preferred options for round trips. They are

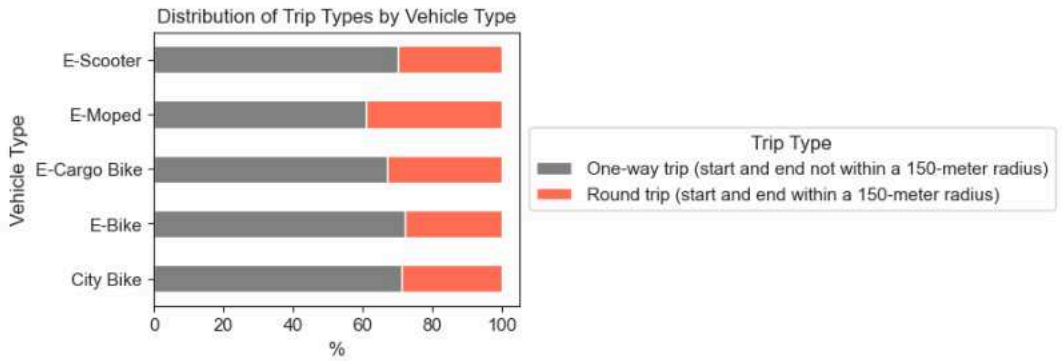

Figure 5-13: One-way and round trips by vehicle type

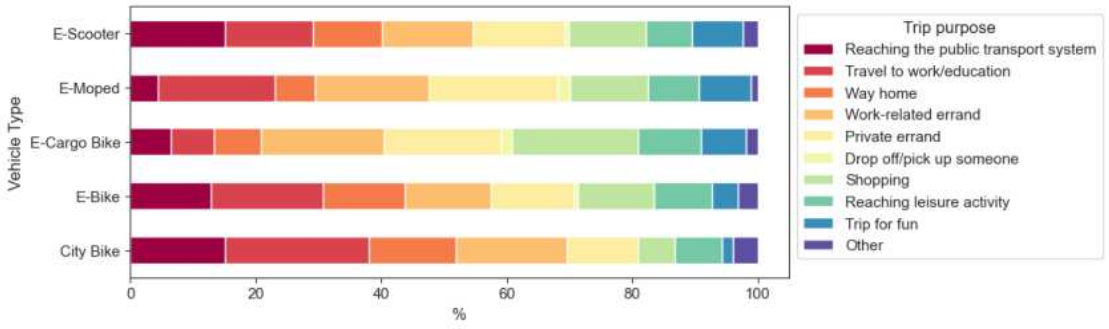

Figure 5-14: Trip purposes by vehicle type

particularly effective for tasks that require the transportation of bulkier items and for leisure activities. These insights provide an understanding of user behavior and preferences, which is crucial for further development and optimization of shared micromobility services.

5.3 Conclusion

Our study reveals a complex landscape of shared micromobility utilization within a non-urban university campus. By examining real-world usage patterns and trip purposes of various shared micromobility modes within a single platform, we contribute to the literature on shared micromobility. This study bridges a research gap, providing an in-depth analysis of the interplay between multiple micromobility options within a confined ecosystem of a university campus, a microenvironment yet to be explored in current literature.

The multifaceted user behavior patterns highlight the potential of shared micromobility in serving a diverse set of travel needs. Consistent with previous research on urban settings (ARUP, 2020; Intertraffic, 2023; Montes et al., 2023; Oeschger et al., 2020; Tießler et al., 2023), we found that shared micromobility modes were used to provide last-mile solutions, linking the campus to the broader public transport network, thereby enhancing overall connectivity. The prevalence of one-way trips using these modes reinforces their role in enabling efficient, direct travel to specific destinations.

With e-cargo bikes and e-mopeds, the users exhibited a higher tendency for round trips. This echoes findings in other studies that report round trips as common in systems with station-based models (SWM, 2022). These modes' larger capacity and suitability for transporting heavier items shaped their use cases within the campus community. These modes were preferred for work-related tasks, personal errands, shopping, and leisure activities.

These findings demonstrate the complementary roles of different micromobility modes within a shared system. Each mode caters to unique travel needs, contributing to the system's overall utility. Our study underscores the importance of such multimodal platforms, especially in microenvironments like residential neighborhoods, non-urban communities, campuses, and corporate settings where various transport demands require flexible and diverse solutions.

The example of the shared micromobility initiative at the University of the Bundeswehr Munich suggests that such multimodal platforms can be potent solutions to mobility challenges in non-urban, confined environments. They serve a wide range of travel needs, enhance connectivity, and contribute to the broader goals of sustainability and resilience in transportation. When applying these findings to other settings, it is essential to consider local contexts. Future research could examine shared micromobility in other microenvironments and the possible influence of variables like geography, cultural factors, existing public transport infrastructure, and the built environment on user behavior and system efficacy.

6 Micromobility Choice Patterns in Non-Urban Landscapes

6.1 Uncovering Micromobility Preferences with the Reservations Backend App Data

Existing research on shared micromobility demonstrates varied focus for various micromobility modes (Pobudzei et al., 2024). For example, bike sharing, e-bike sharing, and e-scooter sharing have been extensively studied (Campbell et al., 2016; Gkartzonikas & Dimitriou, 2023; Kutela et al., 2022; Lazarus et al., 2020; Luo et al., 2023; McKenzie, 2019; Montes et al., 2023; Nikiforiadis et al., 2023; Reck et al., 2021, 2022; Ren et al., 2021; Younes et al., 2020; Zhu et al., 2020).

However, the literature needs to be more extensive on e-cargo bikes and e-mopeds (Montes et al., 2023; Pobudzei et al., 2024; Pobudzei, Wichmann, et al., 2023a). Furthermore, traditional micromobility systems have primarily been single-mode, meaning service providers offer one transportation type (Luo et al., 2023; Reck et al., 2021). Therefore, there needs to be more insights into users' preferences where multiple micromobility choices are available within a unified shared mobility platform (Pobudzei et al., 2024; Pobudzei, Wichmann, et al., 2023a).

To our current knowledge, no existing literature addresses the use, competition, and choice of micromobility - such as city bikes, e-bikes, e-scooters, e-cargo bikes, and e-mopeds - within a unified shared micromobility system (Pobudzei et al., 2024). Bridging this knowledge gap is pivotal for seamless integration into transport networks, especially in areas with emerging large-scale micromobility. Gaining such insights is instrumental for efficient and effective transportation policies that encourage sustainable mobility choices. Therefore, our research sheds light on the usage patterns, competitive landscape, and mode selection for these micromobility options, leveraging real-world preference data from a multimodal shared micromobility system in a non-urban setting.

We investigate the key factors influencing the selection of shared micromobility options. Although our app data (Chapter 3.2.1) and post-trip surveys (Chapter 3.2.2) provide valuable insights into user preferences and vehicle choices, they do not present all available options and attributes for each decision-making scenario. To address this, we employ the Multinomial Logit Model (MNL) and machine learning algorithms such as the Random Forest Classifier (RFC), Gradient Boosting Classifier (GBC), and Neural Network Classifier (NNC) (Chapter 3.3.2).

We analyzed 52,435 individual MORE Sharing trips facilitated between March 2023 and March 2024. In our study, the MORE Sharing service utilized a total of 99 vehicles, which included 25 city bikes, 25 e-bikes, 10 e-cargo bikes, 10 e-mopeds, and 29 e-scooters. City bikes represented 22% of the trips, e-bikes 36%, e-cargo bikes 7%, e-mopeds 7%, and e-scooters 28%. Regarding

vehicle availability, there were 467 trips for each city bike, 751 for one e-bike, 349 for one e-cargo bike, 349 for one e-moped, and 517 for one e-scooter.

Males dominated the usage of all vehicle types, with the mean age converging around 25 years, as presented in Figure 6-1-1 and Figure 6-1-2. As discussed in Chapter 4, the availability of the vehicles greatly influenced our findings. Fluctuations in vehicle availability were mainly attributed to technical issues, routine maintenance, or weather conditions. A significant disruption occurred in October 2023, when many e-scooters were taken out of service due to defects in IoT devices. Furthermore, severe weather conditions have been observed since December 2023, and e-mopeds and e-scooters have been suspended to prevent potential accidents (Figure 4-4).

The data demonstrates how the usage rates of different vehicle types fluctuate significantly across seasons. For example, due to safety concerns related to adverse weather conditions, e-scooters and e-mopeds were suspended during the winter months. In contrast, these vehicles experience increased usage in warmer months, with e-scooters peaking in spring and e-mopeds in autumn, as illustrated in Figure 6-1-3. The significant decrease in e-scooter usage during autumn 2023 is linked to a significant disruption in October 2023, when many of these vehicles were rendered inoperable due to IoT device defects. This incident underscores how technical issues affect vehicle availability and utilization patterns (Figure 6-1-3).

E-bikes, e-cargo bikes, and city bikes demonstrate more stable usage throughout the year. However, usage is at its lowest during the winter months. Notably, the highest booking numbers were recorded in spring 2023, coinciding with the system's introduction to the university community. Although bike reservation numbers slightly declined in summer and autumn, e-mopeds saw increased reservations during these seasons (Figure 6-1-3).

The usage patterns across different week segments highlight varying behaviors for each vehicle type (Figure 6-1-4). City bikes and e-scooters show their highest usage early in the week, particularly on Monday and Tuesday, suggesting a solid start to the week for these vehicles. On the other hand, e-bikes, e-cargo bikes, and e-mopeds reach their peak usage midweek, specifically on Wednesday and Thursday, indicating a possible preference for these vehicles for midweek errands or commuting.

There is a noticeable dip in usage for all vehicle types on Friday and Saturday (Figure 6-1-4), reflecting a potential shift in the travel needs of the campus community as the weekend approaches. Interestingly, there is a slight rebound in usage on Sundays and holidays for city bikes, e-bikes, and e-cargo bikes. This suggests that these vehicles are favored for activities during the weekends, underscoring their role in recreational rather than purely utilitarian travel during these days. Another reason could be that students return to the campus facilities on Sundays and use these shared micromobility modes for transportation.

All vehicle types show high usage from midday to afternoon. However, e-mopeds and e-cargo bikes peak in the afternoon (Figure 6-1-5). City bikes and e-bikes show a more balanced use across the day but are less preferred in the early morning and late at night. E-scooters show a relatively high utilization late at night, possibly indicating recreational or late-night commuting use. Regarding geographical contexts (Figure 6-1-6, Figure 6-1-7), most trips initiate and end in

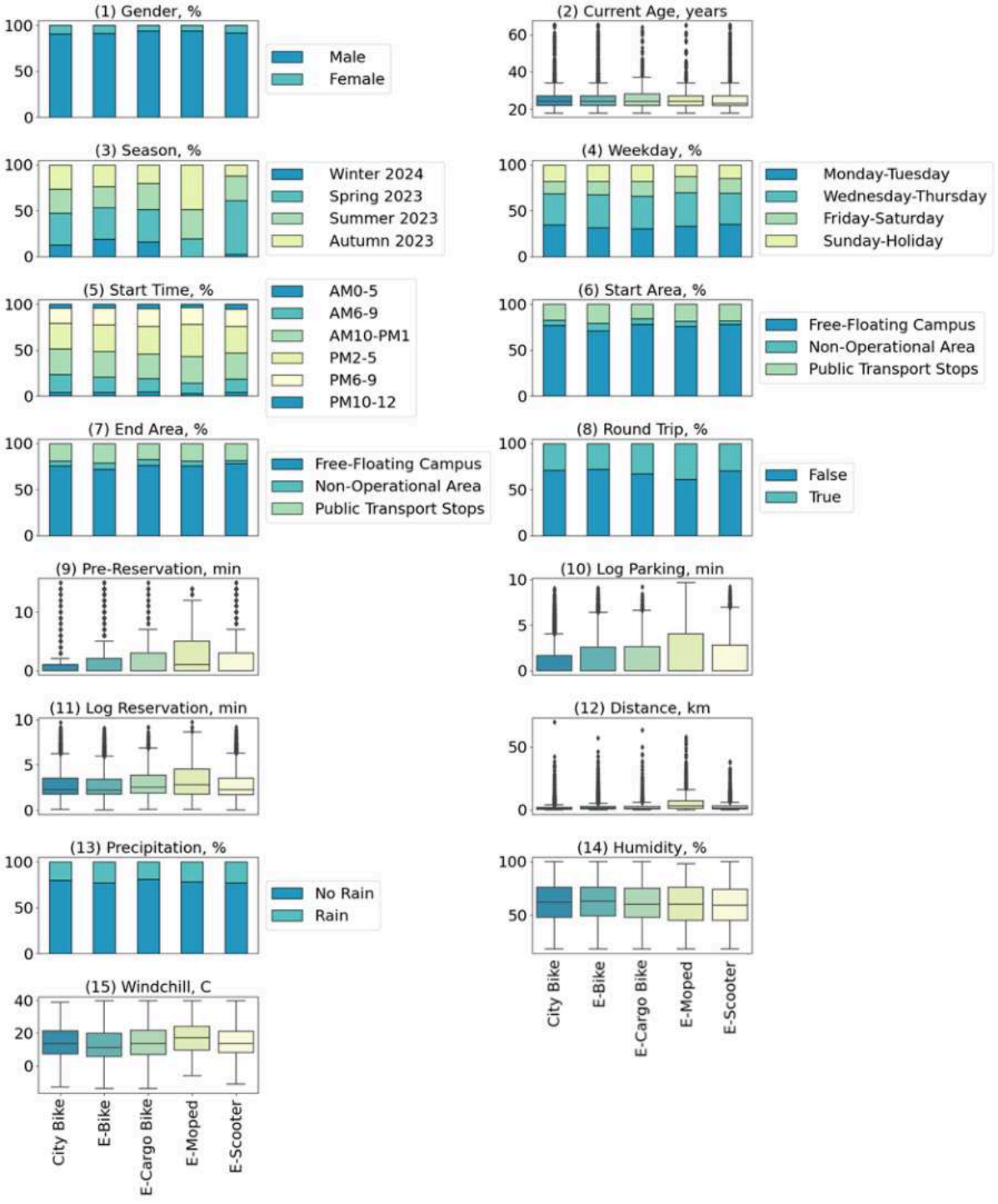

Figure 6-1: Backend statistics (March 2023 – March 2024)

free-floating campus areas, suggesting a high need for mobility within sprawled campus-like environments. Public transport stops see moderate usage, highlighting the role of shared micromobility in mixed-mode commuting, likely as a last-mile solution.

E-mopeds and e-cargo bikes exhibit higher round trip rates than other vehicle types (Figure 6-1-8). This could indicate that these vehicles are preferred for tasks or routes that are looped,

such as deliveries or errands. City bikes, e-bikes, and e-scooters show round trip rates below 30%, suggesting they are more commonly used for point-to-point travel. This may reflect their use in commuting or more spontaneous travel needs where the return journey might not necessarily involve the same route or mode (Figure 6-1-8).

E-mopeds are reserved the furthest in advance, whereas city bikes have the shortest average pre-reservation time (Figure 6-1-9). E-mopeds also register the most extended parking times and reservation durations (Figure 6-1-10, Figure 6-1-11). By contrast, city bikes exhibit the lowest in these categories, possibly because users often secure them with built-in manual locks, bypassing the need for formal parking. Regarding distance traveled (Figure 6-1-12), e-moped users cover an average of approximately 5 kilometers per trip, while city bikes have an average distance of roughly 1.6 kilometers. E-bikes, e-cargo bikes, and e-scooters average trips of 2.2, 2.3, and 2.4 kilometers respectively.

The data suggests that most vehicles are predominantly used in clear weather conditions (Figure 6-1-13, Figure 6-1-14), which is understandable given the general preference for outdoor activities in favorable weather. As for other weather parameters, e-mopeds are associated with the highest average windchill levels, while e-bikes have the lowest, presumably as they were extensively used in autumn and winter (Figure 6-1-15).

We modeled the micromobility choice using backend data with MNL, where city bikes were the reference category, achieving 42.4% accuracy (Table 6-1). We also applied RFC and achieved 54.8% accuracy, GBC 57.9% accuracy, and NNC 36.9% accuracy. The MNL results for backend data (Table 6-1) depict a strong preference for e-bikes and e-scooters compared to city bikes when all other variables are constant. On the other hand, e-mopeds and e-cargo bikes are less frequently used than city bikes.

The coefficients from the MNL show varying preferences for different types of electric micro-mobility among females compared to males, with statistically significant negative preferences for e-cargo bikes, e-mopeds, and e-scooters, suggesting lower preferences for these modes (Table 6-1). Specifically, females show a notably lower preference for e-cargo bikes and e-mopeds and a less pronounced but still significantly lower preference for e-scooters. In contrast, the slight negative coefficient for e-bikes is not statistically significant, indicating no apparent difference in preference between genders for e-bikes. Older individuals tend to slightly prefer e-cargo bikes while showing a reduced preference for e-scooters (Table 6-1).

As described in Chapter 3.2, we started operating MORE Sharing in spring 2023. In September 2023, we increased the minute and day prices for e-bikes, e-cargo bikes, e-mopeds, and e-scooters. Due to technical issues, e-scooters have been less available since the autumn of 2023 (Figure 4-4). Since December 2023, e-mopeds have been unavailable due to weather conditions and safety concerns. We analyze the preferences for different micromobility vehicles compared to city bikes in spring 2023 (Table 6-1). In summer 2023, there was a pronounced preference for e-mopeds during summer, while e-scooters saw a decline in usage compared to spring 2023, when the MORE Sharing service started operating.

Table 6-1: MNL results for backend (March 2023 – March 2024)

	E-bike			E-cargo bike			E-moped			E-scooter		
	coef	z	P>|z|	coef	z	P>|z|	coef	z	P>|z|	coef	z	P>|z|
const	**1.85**	**14.62**	**0.00**	**-1.95**	**-9.82**	**0.00**	**-2.57**	**-11.17**	**0.00**	**2.41**	**17.82**	**0.00**
Female	-0.02	-0.47	0.64	**-0.54**	**-5.86**	**0.00**	**-0.47**	**-4.89**	**0.00**	**-0.21**	**-4.10**	**0.00**
Current age, years	0.00	-1.47	0.14	**0.01**	**2.94**	**0.00**	0.00	-0.79	0.43	**-0.01**	**-3.61**	**0.00**
June – August 2023	0.07	1.64	0.10	0.10	1.39	0.17	**0.74**	**9.51**	**0.00**	**-0.46**	**-9.83**	**0.00**
September – November 2023: reservation price increased; e-scooters less available due to technical issues	-0.03	-0.75	0.45	**-0.16**	**-2.68**	**0.01**	**1.29**	**20.36**	**0.00**	**-1.26**	**-30.41**	**0.00**
December 2023 – February 2024: e-mopeds not available, e-scooters less available due to technical issues	**0.20**	**4.62**	**0.00**	**0.16**	**2.26**	**0.02**	**-4.17**	**-7.18**	**0.00**	**-2.33**	**-32.98**	**0.00**
Wednesday-Thursday	**0.17**	**5.34**	**0.00**	**0.20**	**3.83**	**0.00**	**0.18**	**3.24**	**0.00**	0.05	1.33	0.18
Friday-Saturday	**0.23**	**5.20**	**0.00**	**0.51**	**7.37**	**0.00**	**0.56**	**7.98**	**0.00**	**0.35**	**7.52**	**0.00**
Sunday-Holiday	**0.09**	**2.14**	**0.03**	0.12	1.86	0.06	**-0.38**	**-5.02**	**0.00**	**-0.28**	**-6.14**	**0.00**
Early morning (AM0-5)	**0.39**	**4.92**	**0.00**	**0.67**	**5.49**	**0.00**	**0.52**	**3.40**	**0.00**	**0.64**	**7.58**	**0.00**
Late morning (AM10-PM1)	**0.17**	**3.97**	**0.00**	**0.27**	**3.66**	**0.00**	**0.65**	**7.98**	**0.00**	**0.23**	**4.95**	**0.00**
Afternoon (PM2-5)	**0.22**	**5.08**	**0.00**	**0.43**	**5.85**	**0.00**	**0.84**	**10.43**	**0.00**	**0.29**	**6.06**	**0.00**
Evening (PM6-9)	**0.26**	**5.72**	**0.00**	**0.48**	**6.33**	**0.00**	**0.77**	**9.12**	**0.00**	**0.41**	**8.20**	**0.00**
Late evening (PM10-12)	**0.38**	**5.14**	**0.00**	**0.67**	**5.64**	**0.00**	**0.77**	**5.65**	**0.00**	**0.73**	**9.31**	**0.00**
Start at public transport stops	**0.33**	**8.80**	**0.00**	**-0.18**	**-2.83**	**0.01**	**0.29**	**4.52**	**0.00**	**0.32**	**7.88**	**0.00**
End at public transport stops	**0.17**	**4.89**	**0.00**	**-0.18**	**-3.07**	**0.00**	0.11	1.83	0.07	**0.15**	**3.77**	**0.00**
Round trip	**-0.24**	**-7.46**	**0.00**	**0.14**	**2.88**	**0.00**	**0.19**	**3.64**	**0.00**	**-0.19**	**-5.52**	**0.00**
Pre-reservation, min	**0.05**	**11.51**	**0.00**	**0.09**	**14.09**	**0.00**	**0.13**	**19.70**	**0.00**	**0.08**	**17.03**	**0.00**
Log Parking, min	**0.39**	**24.38**	**0.00**	**-0.05**	**-2.88**	**0.00**	**0.51**	**17.32**	**0.00**	**0.49**	**27.16**	**0.00**
Log Reservation, min	**-0.65**	**-28.59**	**0.00**	0.03	1.35	0.18	**-0.84**	**-20.65**	**0.00**	**-0.77**	**-30.71**	**0.00**
Distance, km	**0.23**	**23.81**	**0.00**	**0.16**	**13.35**	**0.00**	**0.37**	**34.61**	**0.00**	**0.24**	**24.86**	**0.00**
Rain	**0.17**	**4.37**	**0.00**	-0.07	-1.05	0.30	0.13	1.89	0.06	**0.24**	**5.62**	**0.00**
Humidity, %	**-0.01**	**-7.38**	**0.00**	**0.00**	**-2.36**	**0.02**	**0.01**	**3.06**	**0.00**	**-0.01**	**-8.08**	**0.00**
Windchill, C	**-0.03**	**-11.54**	**0.00**	**-0.01**	**-3.00**	**0.00**	0.00	0.37	0.71	**-0.02**	**-7.36**	**0.00**

* Reference category: city bike.

** Bolded values indicate statistical significance at p <= 5%.

In autumn 2023, the reservation price increased for e-bikes, e-scooters, e-mopeds, and e-cargo bikes, and there was a reduced availability of e-scooters. There were fewer bookings with e-cargo bikes. The number of e-scooter bookings also decreased significantly due to decreased availability. On the other hand, there was a significant increase in e-moped preference, likely as users shifted from less available e-scooters (Table 6-1). The availability or technical issues of e-mopeds and e-scooters significantly affect the preferences for other types of vehicles. For example, when e-mopeds are not available in winter and e-scooters are less available, there is a significant shift toward e-bikes and e-cargo bikes (Table 6-1).

Considering a Monday – Tuesday benchmark (Table 6-1), there is a general increase in preference for all types except e-scooters on Wednesdays and Thursdays, which do not show a significant change. The highest preferences are observed on Fridays and Saturdays, with e-cargo bikes and e-mopeds showing solid increases, suggesting these vehicles are popular for weekend activities such as recreational outings or errands. Conversely, Sundays and holidays show a decline in preference for e-mopeds and e-scooters, indicating reduced usage, possibly due to different leisure activities that may not require these forms of transportation.

Regarding the time of the day (Table 6-1), e-bikes and e-cargo bikes are generally used throughout the day, with slightly higher activity in the early morning and late evening. E-scooters also show consistent usage throughout the day but with a significant preference for late evening hours, possibly due to recreational activities. E-mopeds show a strong preference for afternoon and evening usage, which might suggest their use in commuting or leisure activities that align with these times.

MNL results in Table 6-1 also illustrate how starting and ending rides at public transport stops and the nature of the trips (round trip or one-way) affect the preferences for different types of electric micromobility vehicles. E-bikes and e-scooters show strong preferences for starting and ending trips at public transport stops, which may indicate their use as a first- or last-mile solution in conjunction with public transport. On the other hand, e-cargo bikes consistently show disfavor for both starting and ending at public transport stops. There is a clear divide between e-bikes and e-scooters, which are disfavored for round trips, whereas e-cargo bikes and e-mopeds are preferred for round trips.

All electric modes tend to be reserved longer in advance compared to city bikes (Table 6-1). Additionally, parking modes of e-bikes, e-mopeds, and e-scooters are typically activated longer than city bikes. However, city bikes dominate overall reservation duration. Distances traveled using electric modes exceed those of city bikes, with e-mopeds having the highest value, suggesting they are the preferred choice for longer distances than other types (Table 6-1). E-bikes and e-scooters are used more frequently when it rains than city bikes. On the other hand, an uptick in humidity deters e-bike and e-scooter use but slightly enhances the appeal of e-mopeds. Higher windchill leads to a decreased preference for e-bikes, e-cargo bikes, and e-scooters, possibly due to more trips in colder conditions (Table 6-1).

Regarding machine learning algorithms (Figure 6-2), RFC emphasizes distance, reservation duration, windchill, humidity, and age as significant predictors of mode choice. In GBC, distance, reservation duration, and season are the most decisive factors. In NNC, reservation

duration and distance stand out. Temporal features such as start time or weekday and spatial categories such as start or end area and round trip have low importance across models. This suggests that time and reservation space are not significant differentiators for mode choice prediction.

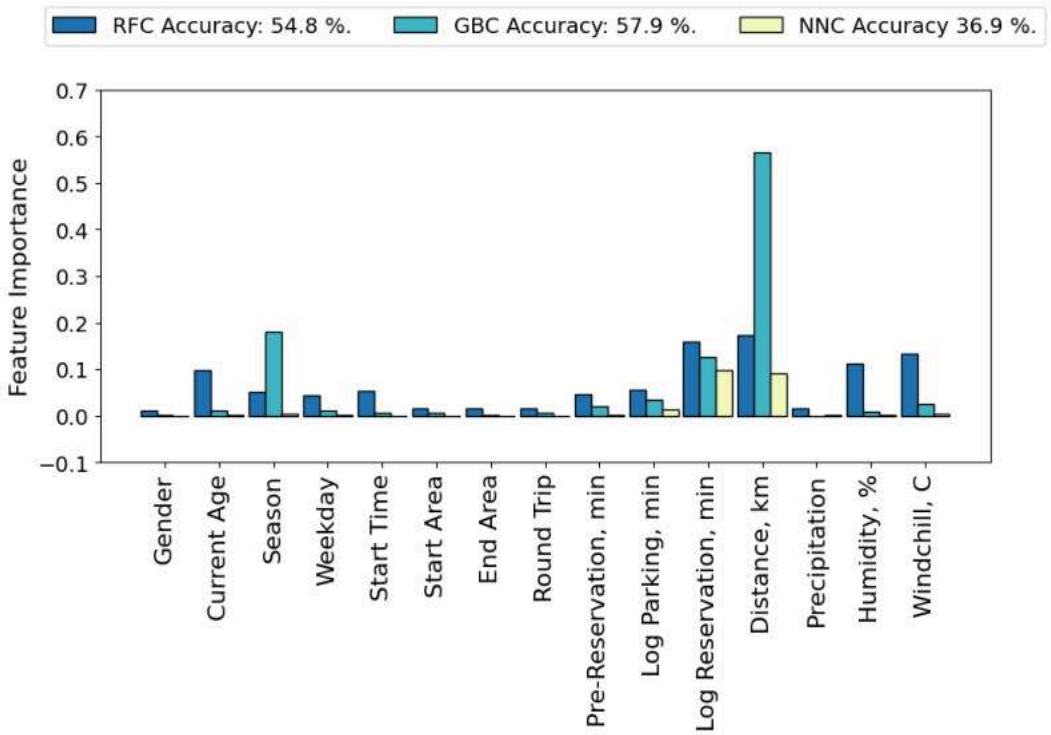

Figure 6-2: RFC, GBC, NNC feature importance for backend (March 2023 - March 2024)

6.2 Revealing Shared Micromobility Choices with the MORE Sharing Post-Trip Survey

We analyzed 2,239 valid responses from the MORE Sharing post-trip survey (Chapter 3.2.2): 21% of the trips were by city bikes, 33% by e-bikes, 9% by e-cargo bikes, 9% by e-mopeds, and 28% by e-scooters. Figure 6-3 demonstrates the descriptive post-trip survey statistics. When asked whether users would make their trip if MORE Sharing was unavailable, 60% of city bike users, 62% of e-bike users, 52% of e-cargo bike users, 56% of e-moped users, and 50% of e-scooter users claimed they would have made the trip.

Regarding their backup travel modes (Figure 6-3-1), walking was a popular alternative among city bike, e-bike, and e-scooter users (45%, 31%, and 40%, respectively), followed by personal bikes (31%, 38%, and 32%) and public transport (17%, 17%, and 13%). E-cargo bike and e-moped users displayed a greater inclination toward using cars (30% and 20%) but still showed a strong preference for personal bikes (43% and 53%) or walking (19% and 21%). A higher preference for cars among e-cargo bike and e-moped users may suggest a preference for speed or cargo space.

User satisfaction levels are relatively high (Figure 6-3-2), with e-mopeds leading at 80%. They are closely followed by e-scooters and e-bikes, with 72% and 70% satisfied users, respectively. While city bikes and e-cargo bikes have high satisfaction rates of 66% and 62%, respectively, they also show room for improvement with a 23% and 25% low satisfaction rate, respectively.

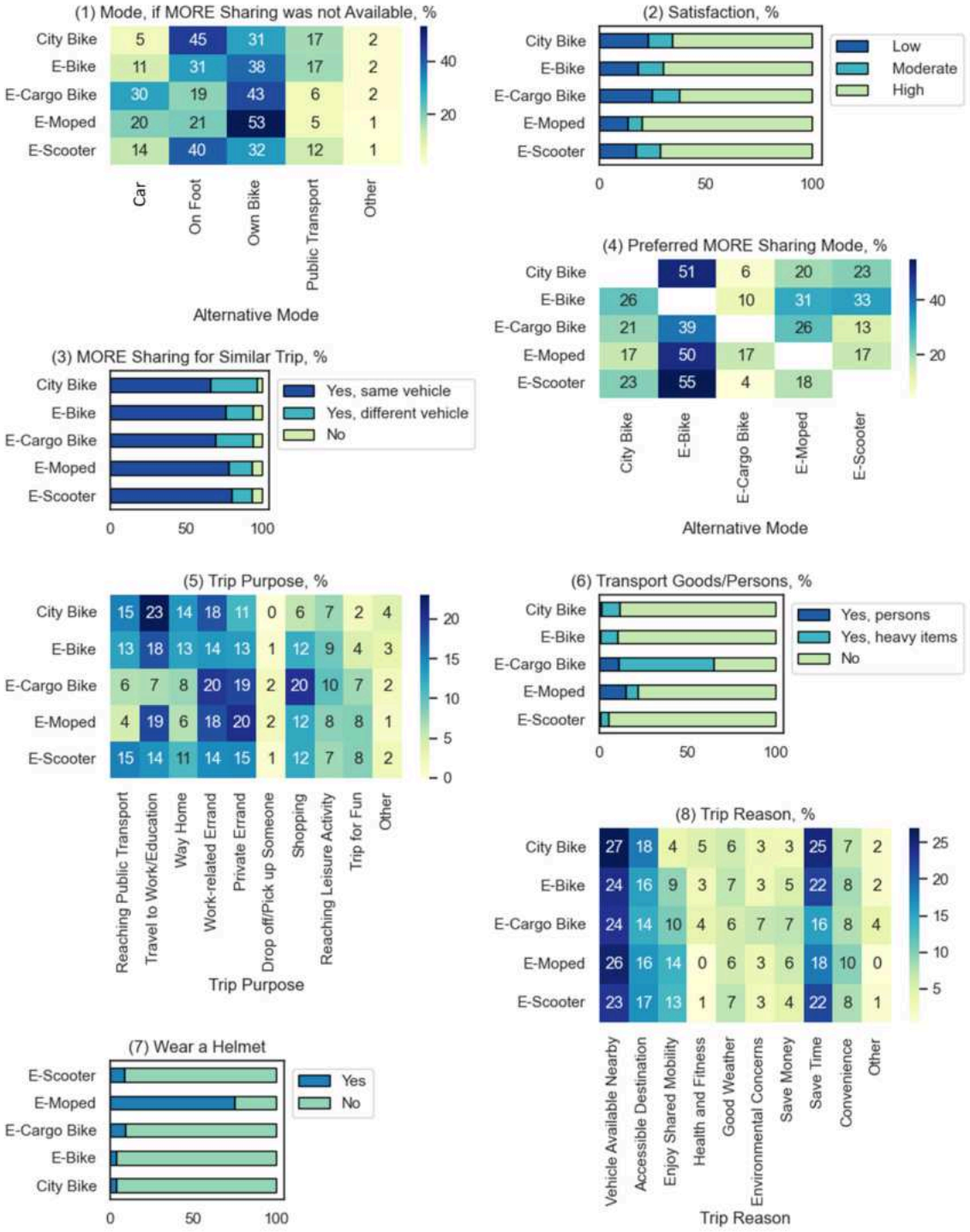

Figure 6-3: Post-trip survey statistics (March 2023 – March 2024)

Regarding using MORE Sharing for similar trips (Figure 6-3-3), most respondents indicated they would again select the same vehicle type, signaling high satisfaction with their initial choices. E-scooter users displayed the highest loyalty with 80%. E-mopeds followed closely with 78%. In contrast, city bike users were the most amenable to switching, with 30% indicating they would choose a different vehicle type for a similar trip.

We further examined the preferred MORE Sharing modes (Figure 6-3-4). E-bikes were a popular alternative across different vehicle categories. Specifically, 51% of city bike users, 50% of e-moped users, and 55% of e-scooter users would opt for an e-bike for their next ride, potentially due to its hybrid nature, combining traditional cycling with electric assistance.

Each MORE Sharing vehicle type serves distinct user needs and situational factors (Figure 6-3-5). City bikes, e-bikes, and e-scooters are frequently used for journeys that connect to public transport. Specifically, 15% of city bike users, 13% of e-bike users, and 15% of e-scooter users use these modes for reaching public transport. City bikes, e-bikes, and e-mopeds are commonly used for reaching work or educational sites, with 23%, 18%, and 19% of users, respectively. E-cargo bikes are often chosen for shopping trips (20%), underscoring their cargo capacity. Private and work-related errands are evenly distributed across all vehicle types, suggesting that the selection often depends on personal preferences and specific situations.

Most trips are undertaken solo, without transporting heavy items (Figure 6-3-6). However, e-cargo bikes are uniquely positioned to serve those carrying heavy goods or an additional passenger, as evidenced by 54% of trips involving heavy items and 11% involving an extra person. MORE Sharing bookings seldom involved helmet usage during rides with city bikes, e-bikes, and e-cargo bikes (Figure 6-3-7). Only 10% of the bookings included helmet usage for e-cargo bikes or e-scooters. However, 75% of the bookings involved helmet usage for e-mopeds, as helmets were provided and wearing them was mandatory for e-moped usage.

Regarding underlying motivators (Figure 6-3-8), vehicle proximity, time savings, and approachable destinations are significant factors in decision-making across all categories. E-mopeds, e-scooters, e-cargo bikes, and e-bikes cater to those valuing the shared mobility experience. Health considerations play some role for city bikers. E-cargo bikes are chosen by individuals who express environmental concerns and prefer to save money during their trips.

In our model evaluation, the MNL model exhibited the lowest accuracy on the test set, with only 16% of predictions matching the actual data (Table 6-2). In contrast, machine learning models displayed superior performance: RFC achieved 40.6% accuracy, GBC 45.5%, and NNC 40.4% (Figure 6-4). MNL results depicted that individuals who own a bike are likelier to choose a MORE Sharing e-bike or e-moped over a city bike (Table 6-2). Users who resort to cars as an alternative to their MORE Sharing ride are more inclined to select e-bikes. Those who would have walked if MORE Sharing was not available are likelier to use city bikes rather than e-cargo bikes, e-mopeds, or e-scooters. E-bike, e-moped, and e-scooter users tend to choose the same mode for subsequent similar journeys. On the other hand, e-cargo bikers would prefer another micromobility type for their next MORE Sharing trip (Table 6-2).

E-mopeds or e-scooters do private errands (Table 6-2). E-scooters were the prominent reported option for reaching public transport. Shopping increases the likelihood of choosing motorized

Table 6-2: MNL results for post-trip survey (March 2023 – March 2024)

	E-bike			E-cargo bike			E-moped			E-scooter		
	coef	z	P>|z|	coef	z	P>|z|	coef	z	P>|z|	coef	z	P>|z|
Const	0.23	1.07	0.28	**-0.85**	**-2.85**	**0.00**	**-1.05**	**-3.48**	**0.00**	0.14	0.60	0.55
Alternative mode: auto	**0.72**	**1.99**	**0.05**	0.04	0.08	0.93	0.74	1.68	0.09	0.53	1.42	0.16
Alternative mode: on foot	-0.18	-0.99	0.32	**-0.95**	**-2.85**	**0.00**	**-0.65**	**-2.12**	**0.03**	**-0.39**	**-2.03**	**0.04**
Alternative mode: own bike	**0.43**	**2.28**	**0.02**	0.12	0.43	0.67	**0.51**	**1.96**	**0.05**	-0.22	-1.03	0.31
Alternative mode: public transport	0.29	1.18	0.24	-0.45	-0.81	0.42	-0.55	-1.04	0.30	-0.38	-1.32	0.19
MORE Sharing again & same vehicle type	**0.35**	**2.26**	**0.02**	**-0.48**	**-1.97**	**0.05**	**0.60**	**2.49**	**0.01**	**0.51**	**3.03**	**0.00**
Purpose: leisure activity	0.06	0.24	0.81	0.44	1.31	0.19	-0.11	-0.32	0.75	-0.48	-1.76	0.08
Purpose: private errand	0.20	0.96	0.34	0.46	1.59	0.11	**0.67**	**2.39**	**0.02**	**0.43**	**1.98**	**0.05**
Purpose: reaching public transport	-0.04	-0.20	0.84	-0.28	-0.79	0.43	-0.62	-1.63	0.10	**0.41**	**2.01**	**0.05**
Purpose: shopping	**0.55**	**2.16**	**0.03**	**0.65**	**1.98**	**0.05**	0.58	1.73	0.08	**0.73**	**2.75**	**0.01**
Purpose: travel to work/education	-0.07	-0.37	0.71	**-0.95**	**-2.75**	**0.01**	0.23	0.86	0.39	-0.33	-1.63	0.10
Purpose: trip for fun	0.81	1.84	0.07	**1.36**	**2.65**	**0.01**	**1.30**	**2.60**	**0.01**	**1.35**	**3.06**	**0.00**
Purpose: way home	0.02	0.08	0.93	-0.25	-0.70	0.49	-0.51	-1.41	0.16	-0.16	-0.73	0.46
Purpose: work errand	-0.22	-1.08	0.28	**0.64**	**2.26**	**0.02**	0.35	1.27	0.20	0.16	0.78	0.44
Reason: accessible destination	**-0.30**	**-1.96**	**0.05**	-0.32	-1.33	0.18	-0.15	-0.66	0.51	0.11	0.70	0.48
Reason: convenience	0.01	0.04	0.97	-0.12	-0.41	0.68	0.34	1.34	0.18	-0.14	-0.70	0.48
Reason: enjoy shared mobility	**1.04**	**4.86**	**0.00**	**1.26**	**4.24**	**0.00**	**1.50**	**5.49**	**0.00**	**1.68**	**7.66**	**0.00**
Reason: environmental concerns	-0.13	-0.44	0.66	0.61	1.59	0.11	-0.11	-0.24	0.81	0.06	0.21	0.84
Reason: good weather	0.21	1.03	0.30	-0.24	-0.74	0.46	-0.09	-0.31	0.76	0.21	0.97	0.33
Reason: health and fitness	**-0.92**	**-3.51**	**0.00**	**-1.01**	**-2.56**	**0.01**	**-3.20**	**-4.19**	**0.00**	**-2.76**	**-7.12**	**0.00**
Reason: save money	**0.72**	**2.87**	**0.00**	**0.93**	**2.66**	**0.01**	**0.74**	**2.16**	**0.03**	0.39	1.40	0.16
Reason: save time	-0.11	-0.68	0.50	**-0.85**	**-3.56**	**0.00**	**-0.58**	**-2.57**	**0.01**	-0.06	-0.38	0.70
Reason: vehicle nearby	-0.07	-0.41	0.68	-0.15	-0.61	0.54	-0.21	-0.88	0.38	-0.32	-1.91	0.06
Transport heavy items	-0.05	-0.21	0.83	**2.77**	**9.75**	**0.00**	-0.27	-0.69	0.49	**-0.84**	**-2.81**	**0.01**
Transport persons	-0.87	-1.32	0.19	**2.32**	**3.94**	**0.00**	**1.95**	**3.52**	**0.00**	**-1.56**	**-2.02**	**0.04**
Trip satisfaction	-0.03	-0.80	0.42	-0.04	-0.83	0.41	-0.08	-1.81	0.07	-0.05	-1.38	0.17

* Reference category: city bike.

** Bolded values indicate statistical significance at p <= 5%

options over city bikes. This might be due to these modes' convenience or carrying capacity, especially e-bikes, e-cargo bikes, and e-scooters. E-cargo bikes are favored for work-related errands due to their ability to carry more items. E-cargo bikes were less commonly chosen for work or educational commutes. E-cargo bikes, e-mopeds, and e-scooters were preferred for trips for fun (Table 6-2).

Motivational factors also varied. Across all modes, enjoying shared mobility is a strong predictor for choosing electric vehicles over city bikes (Table 6-2). This reason has a significant negative association across electric modes, possibly due to the perceived lack of physical activity when using motorized transport (Table 6-2). On the other hand, city bikers prioritized health benefits the most. Financial considerations also played a role: cost savings were cited as significant by e-bike, e-cargo bike, and e-moped users, but not time-saving. E-cargo bikes were preferred for transporting heavy items, and both e-cargo bikes and e-mopeds were commonly used for carrying passengers (Table 6-2).

Machine learning models shed light on shared micromobility user decision factors (Figure 6-4). RFC emphasized the significance of trip satisfaction, vehicle proximity, money savings, and accessible destination, suggesting that overall user experience and convenience are critical in transport choices. GBC pointed to the importance of transporting heavy items, trip satisfaction, and enjoying shared mobility, emphasizing the practicality and enjoyment of specific vehicle types. The NNC model also underscored the role of transporting heavy items. Trip satisfaction was a recurring theme in RFC and GBC models while transporting heavy items emerged as a crucial factor in GBC and NNC models. Some values of negative importance in the NNC model indicated that certain factors could either negatively impact or be irrelevant to user choice.

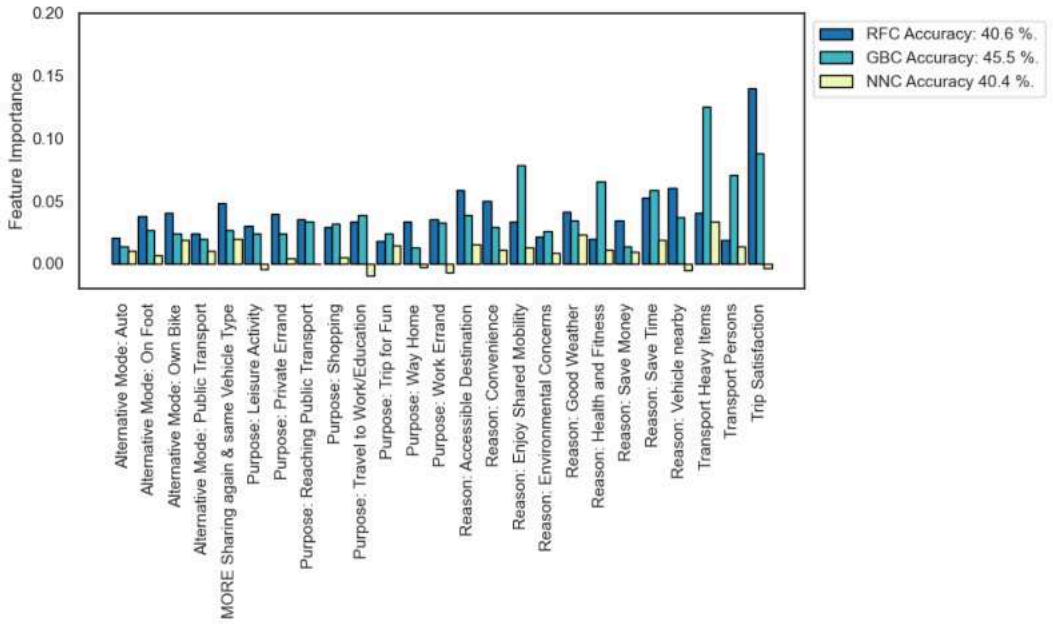

Figure 6-4: RFC, GBC, NNC feature importance for post-trip survey (March 2023 – March 2024)

6.3 Conclusion

We analyzed the usage patterns, preferences, and determinants of micromobility choices in MORE Sharing, a multimodal shared micromobility system, from March 2023 to March 2024. Demographically, males, primarily those around 25, were the predominant users across all vehicle categories.

We have demonstrated through the application of the Multinomial Logit Model (MNL) and machine learning techniques such as Random Forest (RFC), Gradient Boosting (GBC), and Neural Network Classifiers (NNC), that particular vehicle types like e-bikes and e-scooters exhibit strong preferences. E-scooters saw a spike in popularity during the MORE Sharing's initial launch in spring. In contrast, e-mopeds gained traction in summer, indicating a possible adaptation curve. Our findings also highlight the influence of external factors, such as weather and technical disruptions, on vehicle usage. Such dynamics underline the importance of robust system management to ensure the availability and reliability of service, especially during adverse weather conditions or technical failures.

E-mopeds and e-cargo bikes are preferred for looped routes, whereas city bikes and e-scooters are predominantly chosen for point-to-point travel, reflecting their role in everyday commuting. A recurring trend was trips associated with public transport stops, particularly involving city bikes, e-bikes, and e-scooters, reinforcing their role in bridging the last-mile gap. Consistent MORE Sharing usage was observed from Monday to Thursday. However, e-mopeds and e-cargo bikes experienced increased demand on Fridays and Saturdays, hinting at potential recreational or weekend-specific tasks.

Alternative modes of transport differed by vehicle type. City bikes, e-bikes, and e-scooters mostly replaced walking and using private bikes, while e-cargo bikes and e-mopeds replaced cars the most - likely due to their carrying capacity and speed. User satisfaction was predominantly high, with e-mopeds topping at 80%. Nonetheless, city bikes and e-cargo bikes presented room for enhancement.

E-scooters and e-bikes are seeing notable trends in usage, suggesting that electric transport plays a role in urban and suburban transportation. Analyzing these patterns might indicate a consideration for fleet adjustments for these vehicles. E-cargo bikes, with their ability to transport larger items, present an opportunity for specialized promotions emphasizing their specific use cases. When considering the patterns of round trips for e-mopeds and e-cargo bikes, there might be a potential for providers to set up dedicated hubs to facilitate such trips. A transportation planning perspective considering these micromobility choices could be relevant, particularly in public transport intersections and community areas such as campuses. This study aims to understand mobility behaviors and preferences comprehensively. As global communities consider more sustainable transport methods, the data presented here could offer valuable insights for policymakers, transportation planners, and micromobility stakeholders to understand and plan for evolving transportation trends.

7 User Segmentation based on Usage Frequency

7.1 Customer Segmentation Based on Usage Frequency

Membership in shared micromobility systems does not guarantee usage. Therefore, optimizing the operation through user-centric approaches like user segmentation can help understand usage patterns and improve adoption. Segmenting users by their travel habits not only sharpens the focus on unique customer requirements but also plays a crucial role in guiding the evolution of products and services. Additionally, the segmentation aids in streamlining inventory and managing resources more efficiently, ensuring that business operations are as responsive as they are customer-centric.

However, existing shared micromobility user segmentation research primarily focuses on (e-)bike sharing (Ji et al., 2020; Vogel et al., 2014; Winters et al., 2019) and e-scooter sharing (Degele et al., 2018; Park et al., 2023), leaving a gap in understanding the usage patterns and frequency of multimodal shared micromobility platforms, especially in non-urban environments. Additionally, longitudinal studies tracking changes in user behavior over time using data from multimodal platforms are sparse.

This study addresses these gaps by a user-centric analysis of shared micromobility in a non-urban university campus setting. This research explores several dimensions using a multimodal shared micromobility system, where users are allocated a free monthly mobility budget of 300 Euros. Our methodology analyzes individual trip records to categorize users by their travel regularity, ranging from one-time to super users. We further analyze the user lifetime development, vehicle preferences, and trip characteristics of the customer segments. We also investigate the churn rate and characteristics of the churned customers. The outcomes of this research provide insights for operators and governments, enabling them to enhance or establish multimodal shared micromobility systems more effectively, tailored to user needs and preferences.

As of March 2024, the MORE Sharing app was downloaded by 3,161 customers. Significant download upticks were observed in March, coinciding with the service's launch, and in October, corresponding with the influx of new students (Figure 7-1). Of these customers, 2,615 (82%) have linked payment methods to their accounts, a prerequisite for booking services. This specific group of customers has been the focus of further detailed analysis.

From March 2023 to March 2023, these customers cumulatively undertook 52,435 trips. We calculated the average number of trips per customer monthly, ensuring that the average was adjusted for the actual time customers could book trips (Figure 7-2). Additionally, we have

segregated those who have not taken any trips since registering, categorizing them as “no-trip customers.”

Our analysis, leveraging the K-Means clustering algorithm, determined that the optimal number of customer clusters is four (Figure 7-2). This finding aligns with the user categories identified in our literature review: one-time (Mohiuddin et al., 2022), infrequent (Park et al., 2023), frequent (Park et al., 2023), and super users (Degele et al., 2018). According to our clustering statistics, one-time users have taken more than 0 but up to 1.7 trips per month. Infrequent users fall into more than 1.7 but up to 5.5 monthly trips. Frequent users are those taking more than 5.5 but up to 13.2 trips per month, while super users exceed 13.2 trips per month.

Our analysis focused on monthly trip frequencies per customer, segmented by season (Figure 7-3). The MORE Sharing user base grew in spring 2023, reaching 1,927 users. In spring 2023, the distribution was 26% no-trip, 17% one-time, 32% infrequent, 18% frequent, and 7% super users. Summer saw changes: no-trip users rose to 35%, one-time to 24%, infrequent dropped to 28%, frequent to 10%, and super users dropped to 2%. By autumn, the no-trip user’s group rose to 47%, one-time at 22%, infrequent at 22%, and frequent and super users combined at 9%. In winter, the majority (66%) were no-trip users, 18% were one-time users, 13% were infrequent users, 3% were frequent, and only 0.4% super users. In winter, only a few new customers registered with MORE Sharing, and most users did not make trips.

In the “no trips” category, most users remained inactive. 18% of users in summer, 14% in autumn, and 8% in winter transitioned from no trips to being one-time users. Transition to infrequent usage was 10% in summer, 6% in autumn, and 2% in winter. Less than 1% of users with no trips moved to frequent or superuser status. The “one-time users” group saw around 50% discontinuing, 30% maintaining one-time usage, and 19% becoming infrequent users, with under 2% progressing to higher levels. For “infrequent users,” 21% in summer, 26% in autumn, and 38% in winter stopped using the service, 32% reduced to one-time usage, 39% in summer, 33% in autumn, and 25% in winter stayed infrequent, and around 5% became frequent users. Among “frequent users,” 12%

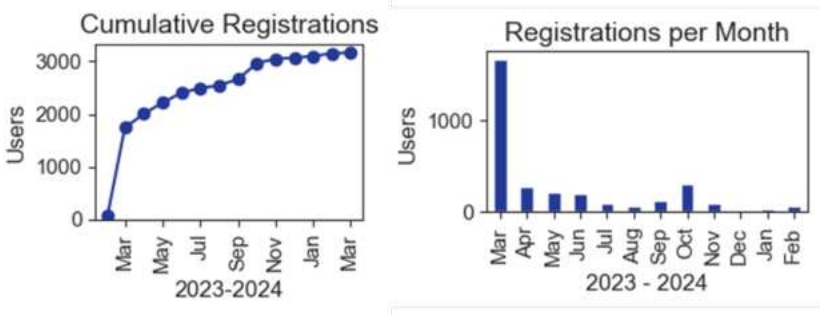

Figure 7-1: Cumulative registrations with MORE Sharing per month

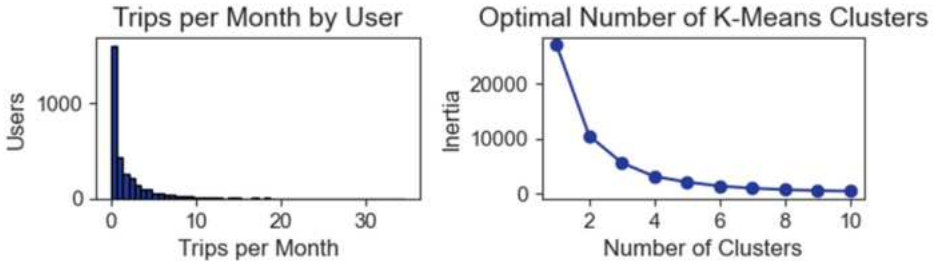

Figure 7-2: Monthly trips per customer and the optimal number of K-Means clusters

became inactive, 18% in summer, 13% in autumn, 21% in winter downshifted to one-time users, around 50% to infrequent users, around 21% remained frequent, and 3% rose to super users. "Super users" experienced 4% inactivity in summer and 8% in autumn and winter, with 6% in summer, 14% in autumn, and 6% in winter, reducing to one-time usage. Many shifted to infrequent (26% in summer, 35% in autumn, and 30% in winter) or frequent (42% in summer, 22% in autumn, and 35% in winter) usage, while around 20% continued as super users. These trends suggest fluidity in customer engagement levels over time and a relative reduction in customer activity with time.

Customers exhibit diverse behaviors while engaging with the MORE Sharing service, prompting us to use a seasonal approach for user categorization. This method involves grouping customers based on their trip timings and service usage frequency within each season. Such a classification helps track and understand customer engagement patterns over time.

Regarding travel frequency, one-time users show the most extended intervals between trips, while super users engage in trips almost daily (Table 7-1). Our analysis reveals that frequent and super users, though smaller in number, account for the highest number of trips (Table 7-1), aligning with findings from previous studies (Degele et al., 2018). Conversely, infrequent users tend to have used the highest mobility budget, suggesting they opt for slightly longer booking periods (Table 7-1).

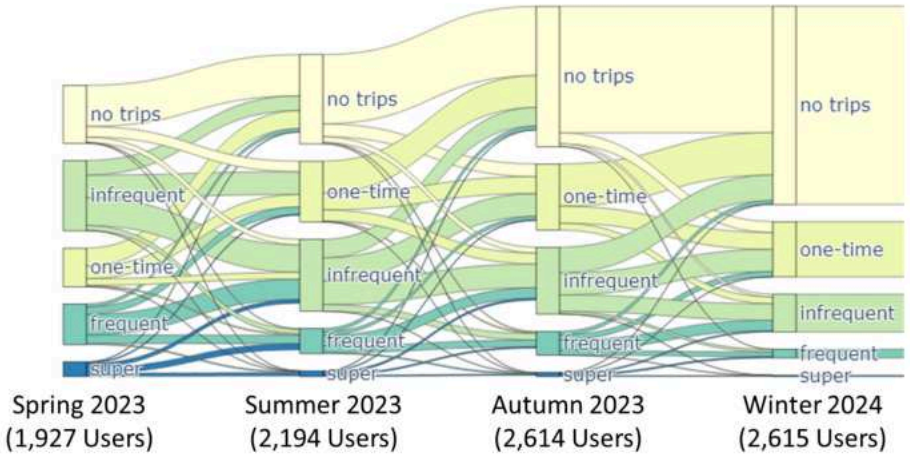

Figure 7-3: Evolution of user categories across seasons

Table 7-1: MORE Sharing user groups: service utilization

Customer group	Days between trips	Out of 52,435 trips taken (%)	Out of 328,074 euros of utilized free mobility budget (%)
One-time	39.7	6.5	6
Infrequent	10.6	32.3	36.3
Frequent	3.7	37.7	39
Super	1.5	23.5	17.2

7.2 Vehicle Preferences by Customer Groups

Our analysis of MORE Sharing user groups found that new users typically start with e-bikes and e-scooters (Figure 7-4), viewing these as accessible entry points. Following initial experiences, users also utilize city bikes, indicating a growing interest in exploring the service's more comprehensive array of vehicles or the necessity to utilize readily accessible vehicles nearby (Figure 7-4). More specialized vehicles like e-cargo bikes and e-mopeds are chosen as users become more familiar with the system (Figure 7-4). This underscores a step-wise approach within the MORE Sharing ecosystem. At first, users gravitate toward the most straightforward and accessible options, such as e-bikes, e-scooters, and city bikes. Over time, they expand their horizons, delving into a broader and more diverse array of specialized mobility modes like e-cargo bikes and e-mopeds, which they have yet to try.

We observed specific vehicle preferences across user groups by examining MORE Sharing's booking data (Figure 7-5). One-time users (up to 1.7 trips monthly) typically choose e-bikes, e-scooters, or city bikes (or their combinations), with 12% preferring e-bikes, 14% e-scooters, 13% choosing both e-bikes and e-scooters, and 13% having experience with city bikes, e-bikes, and e-scooters. For one-time users, using e-cargo bikes and e-mopeds is rare. Infrequent users (up to 5.5 trips monthly) often use a combination of city bikes, e-bikes, and e-scooters, with 27% following this pattern. About 27% also use e-cargo bikes, and 16% have tried all vehicle types (Figure 7-5).

Frequent users (up to 13.2 trips monthly) exhibit a more comprehensive range of vehicle usage, with 36% trying all types; however, some still exclude certain vehicles, such as e-mopeds or e-cargo bikes (Figure 7-5). Super users (over 13.2 trips monthly) demonstrate the most diverse usage patterns, with 54% using every vehicle type (Figure 7-5). This trend indicates that more engaged users explore a broader array of vehicles.

Our modal split analysis per user group (Figure 7-6) shows that one-time users predominantly favor e-scooters and e-bikes, with minimal use of e-cargo bikes and e-mopeds. Infrequent users mainly choose e-bikes and e-scooters, with city bikes being moderately popular. For frequent and super users, e-bikes and e-scooters remain the top choices, with city bikes moderately used and a growing preference for e-mopeds over e-cargo bikes (Figure 7-6). This pattern suggests an evolution in vehicle preferences correlating with increased engagement with the micromobility platform.

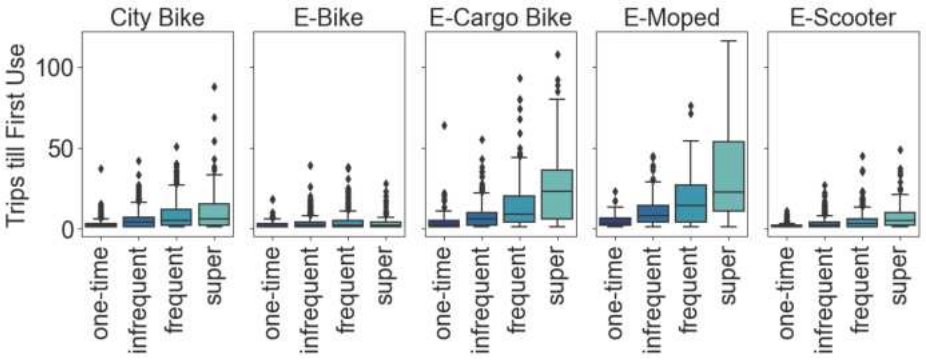

Figure 7-4: Distribution of the number of trips till first use by vehicle type and user group

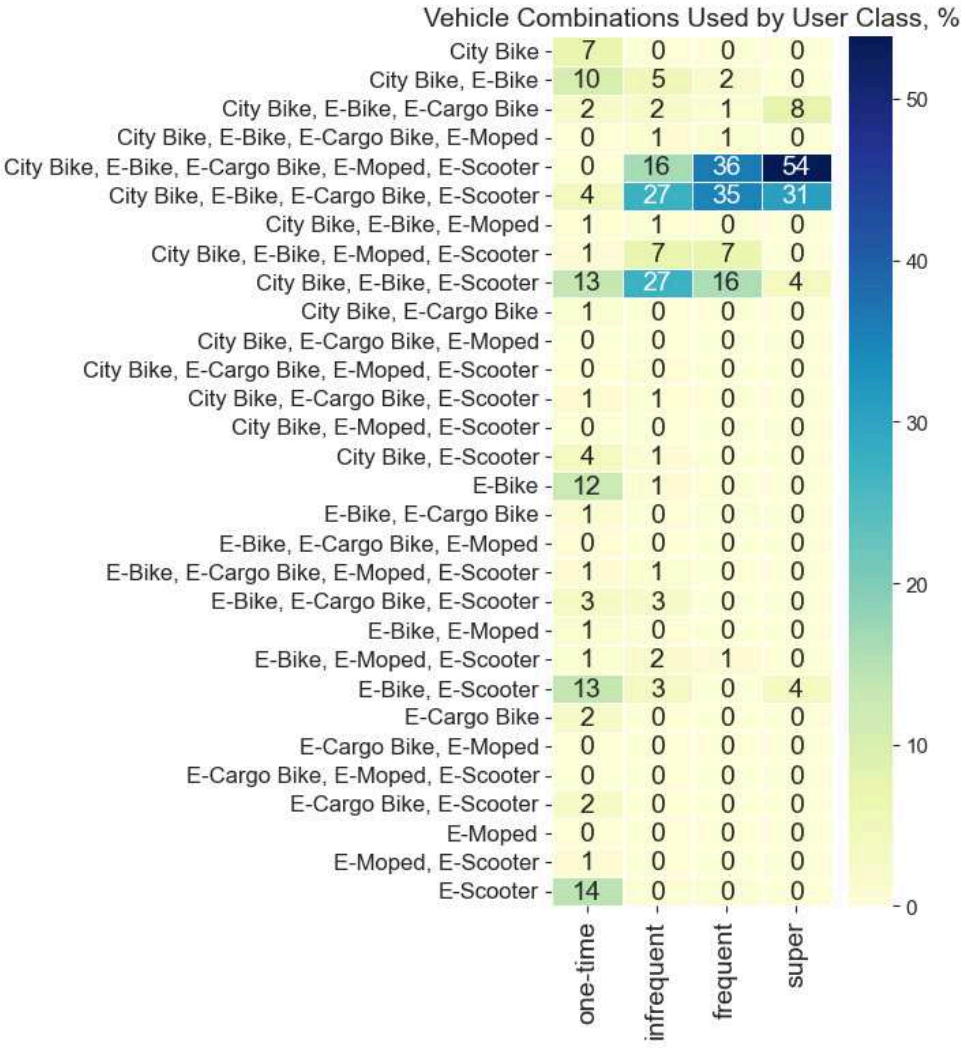

Figure 7-5: Vehicle combinations by user group (%)

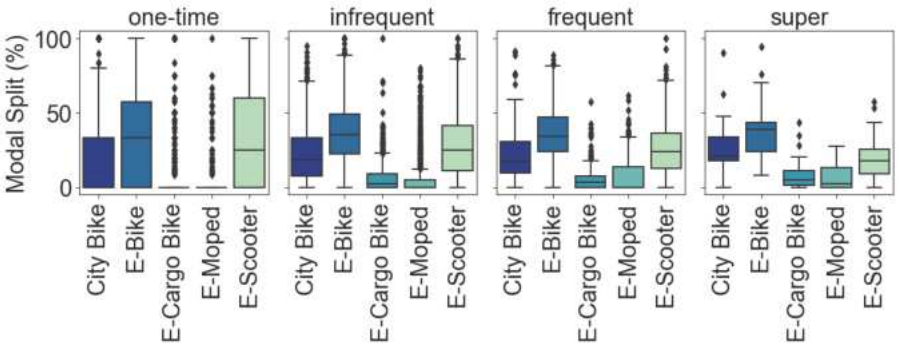

Figure 7-6: MORE Sharing modal split by user group (%)

7.3 Trip Characteristics of Customer Groups

In our analysis of MORE Sharing's user groups – one-time, infrequent, frequent, and super users – we accounted for seasonal variations in customer behavior. We utilized the Multinomial Logit Model (MNL) to model travel frequency groups, analyzing 52,435 trips with a prediction accuracy of 41.7%, using one-time users (1.7 trips per month or fewer) as the reference category (Table 7-2).

Consistent with prior shared micromobility studies (Mohiuddin et al., 2022; Vogel et al., 2014; Winters et al., 2019), being female is negatively associated with falling into higher usage categories than one-time users (Table 7-2). Higher age was negatively associated with being an infrequent or frequent user but not with being a super user, suggesting age is less influential among the most active users. Newer users, indicated by shorter registration duration, are more likely to be frequent users (Table 7-2).

Vehicle choices varied by user groups (Table 7-2). One-time users preferred e-bikes or e-scooters, with no significant link between e-cargo bike usage and user group. However, e-moped usage was associated with more frequent user groups. Infrequent, frequent, and super users reported higher trip satisfaction than one-time users (Table 7-2).

One-time users of MORE Sharing utilized the service throughout all seasons (Table 7-2). In contrast, infrequent, frequent, and super users showed increased activity in spring 2023, with a subsequent decline in summer, autumn, and winter (Table 7-2).

Frequent and super users tend to use the service less in the middle of the week or on Sundays and holidays compared to Mondays and Tuesdays (Table 7-2). Infrequent and super users are significantly less likely to travel till 5 AM than one-time users. Super users are less likely to travel between 10 AM and 1 PM than one-time users. Frequent users are more likely to make their trips in the evening than one-time users. Super users are significantly less likely to travel in the late evening compared to one-time users (Table 7-2).

Regarding travel patterns, one-time users started and ended their trips more commonly at public transport stops, unlike higher-frequency users who intensively used free-floating campus areas (Table 7-2). Longer pre-reservation times were positively associated with higher usage, with

significance increasing with user frequency. Additionally, longer parking durations were associated with higher usage, suggesting that frequent users tend to park for extended periods. Consistent with previous studies (Ji et al., 2020), shorter booking times and trip distances were expected among frequent and super users (Table 7-2).

While precipitation had no notable impact on user group classification, higher humidity levels showed a positive association with super users. As higher windchill has a negative and significant impact on being in higher usage groups, cooler conditions deter frequent users less (Table 7-2).

In our analysis, we employed Random Forest Classifier (RFC), Gradient Boosting Classifier (GBC), and Neural Network Classifier (NNC) to categorize users based on frequency of usage within MORE Sharing (Figure 7-7). RFC achieved the highest accuracy at 56.5%, with key predictive features including age, windchill index, humidity, trip distance, and booking duration. With a 48.6% accuracy, GBC predominantly used age, registration duration, gender, and trip season for its predictions. NNC, the least accurate at 44.2%, found the trip season and age to be the most critical features. Each model demonstrated a unique approach to feature importance, influenced by their distinct data handling and learning algorithms. RFC's superior performance suggests that its ensemble method, utilizing multiple decision trees, was most effective for this task.

Table 7-2: Trip characteristics of MORE Sharing user groups: MNL results (March 2023 – March 2024)

	Infrequent (up to 5.5 trips/month)			Frequent (up to 13.2 trips/month)			Super (more than 13.2 trips/month)		
	coef	z	P>|z|	coef	z	P>|z|	coef	z	P>|z|
const	**3.32**	**17.15**	**0.00**	**4.92**	**25.24**	**0.00**	**3.64**	**17.30**	**0.00**
Female	**-0.59**	**-9.88**	**0.00**	**-1.23**	**-19.55**	**0.00**	**-2.35**	**-27.89**	**0.00**
Current age, years	**-0.02**	**-4.49**	**0.00**	**-0.03**	**-7.43**	**0.00**	0.00	0.93	0.35
Registered since, months	-0.01	-0.97	0.33	**-0.06**	**-5.64**	**0.00**	**-0.03**	**-2.99**	**0.00**
E-Bike	**-0.25**	**-4.26**	**0.00**	**-0.32**	**-5.40**	**0.00**	**-0.33**	**-5.36**	**0.00**
E-Cargo Bike	0.11	1.14	0.25	-0.10	-0.97	0.33	-0.04	-0.41	0.68
E-Moped	**0.44**	**3.62**	**0.00**	**0.51**	**4.18**	**0.00**	**0.62**	**4.90**	**0.00**
E-Scooter	**-0.39**	**-5.92**	**0.00**	**-0.48**	**-7.26**	**0.00**	**-0.45**	**-6.45**	**0.00**
Low satisfaction	**-0.26**	**-2.75**	**0.01**	**-0.22**	**-2.38**	**0.02**	**-0.60**	**-5.81**	**0.00**
Summer 2023	**-0.45**	**-5.82**	**0.00**	**-0.94**	**-12.13**	**0.00**	**-1.43**	**-17.72**	**0.00**
Autumn 2023	**-0.79**	**-11.56**	**0.00**	**-1.45**	**-21.11**	**0.00**	**-2.11**	**-28.98**	**0.00**
Winter 2024	**-1.26**	**-16.41**	**0.00**	**-2.30**	**-29.37**	**0.00**	**-3.03**	**-34.53**	**0.00**
Wednesday-Thursday	-0.05	-0.88	0.38	**-0.13**	**-2.36**	**0.06**	**-0.11**	**-2.01**	**0.06**
Friday-Saturday	0.02	0.22	0.83	-0.01	-0.15	0.88	0.00	-0.01	1.00
Sunday-Holiday	-0.10	-1.58	0.12	**-0.21**	**-3.21**	**0.00**	**-0.13**	**-1.90**	**0.05**
Early morning (AM0-5)	**-0.23**	**-2.03**	**0.04**	-0.19	-1.67	0.10	**-0.29**	**-2.45**	**0.01**
Late morning (AM10-PM1)	-0.11	-1.49	0.14	-0.12	-1.69	0.09	**-0.24**	**-3.16**	**0.00**
Afternoon (PM2-5)	0.04	0.58	0.56	0.09	1.11	0.27	0.13	1.57	0.12

	Infrequent (up to 5.5 trips/month)			Frequent (up to 13.2 trips/month)			Super (more than 13.2 trips/month)		
Evening (PM6-9)	0.02	0.31	0.76	**0.18**	**2.26**	**0.02**	0.13	1.49	0.14
Late evening (PM10-12)	-0.17	-1.56	0.12	-0.07	-0.61	0.54	**-0.26**	**-2.23**	**0.03**
Start at public transport stops	**-0.12**	**-2.26**	**0.02**	**-0.31**	**-5.74**	**0.00**	**-0.29**	**-5.07**	**0.00**
End at public transport stops	-0.06	-1.15	0.25	**-0.12**	**-2.19**	**0.03**	-0.02	-0.28	0.78
Round trip	-0.01	-0.29	0.77	-0.09	-1.66	0.10	-0.09	-1.69	0.09
Pre-Reservation, min	**0.04**	**5.51**	**0.00**	**0.06**	**8.48**	**0.00**	**0.08**	**10.72**	**0.00**
Log Parking, min	**0.10**	**4.37**	**0.00**	**0.18**	**8.05**	**0.00**	**0.17**	**6.88**	**0.00**
Log Reservation, min	-0.03	-1.12	0.27	**-0.09**	**-2.96**	**0.00**	**-0.17**	**-5.29**	**0.00**
Distance, km	**-0.02**	**-2.11**	**0.04**	**-0.03**	**-3.32**	**0.00**	**-0.03**	**-3.24**	**0.00**
Rain	0.03	0.54	0.59	0.07	1.19	0.24	0.08	1.26	0.21
Humidity, %	**-0.03**	**-2.37**	**0.02**	-0.01	-0.86	0.39	**0.05**	**3.13**	**0.00**
Windchill, C	0.00	-0.36	0.72	**-0.02**	**-2.96**	**0.00**	**-0.02**	**-3.91**	**0.00**

* Reference category: one-time users (up to 1.7 trips per month).

** Bolded values indicate statistical significance at p <= 5%

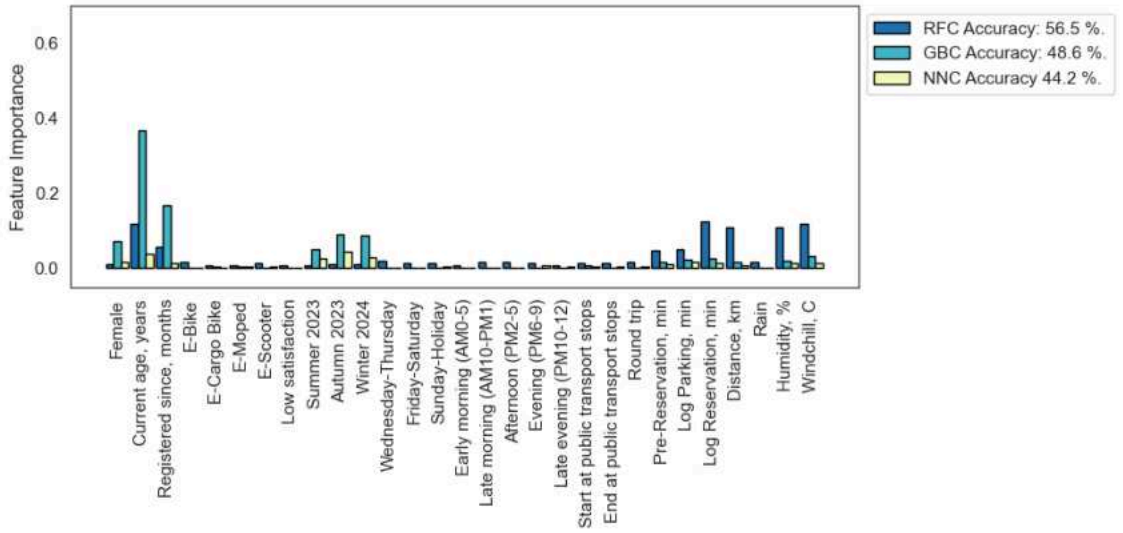

Figure 7-7: RFC, GBC, NNC feature importance of trip characteristics for user group prediction (March 2023 – March 2024)

7.4 Customer Churn

Among 2,615 MORE Sharing customers with a payment method in March 2024, 34.8% were active, with recent trips in the last three months, while 53.3% did not travel, classified as inactive (18.4%, never used the service post-registration) or churned (46.8%, ceased usage after initial activity). These high churn numbers might be because the last trip records were in March 2024, meaning that the churn rate was calculated based on low trip activity in winter. A 79%

churn rate in “one-time” users suggests initial service trials often do not lead to repeat use, whereas “infrequent” users show better retention (53% active) (Figure 8). Regular and “super” users demonstrate higher loyalty, with 20% and 19% churn rates, respectively, underscoring the value of regular engagement.

Analyzing 52,435 trips using a Multinomial Logit Model (MNL), with 80% of data for training, revealed a 64% accuracy in predicting churn (Table 7-3). Being female and of a higher age is associated with a higher likelihood of churning. Furthermore, the longer a customer has been registered with a service, the greater the chance they will churn (Table 7-3). Dissatisfied customers had a higher probability of churn. Customers who start or end their trips at a public transport stop are less likely to churn (Table 7-3). Churned customers have spent less time parking during their trips than those who remained active. On the other hand, churned customers tended to have bookings that were longer in the distance (Table 7-3).

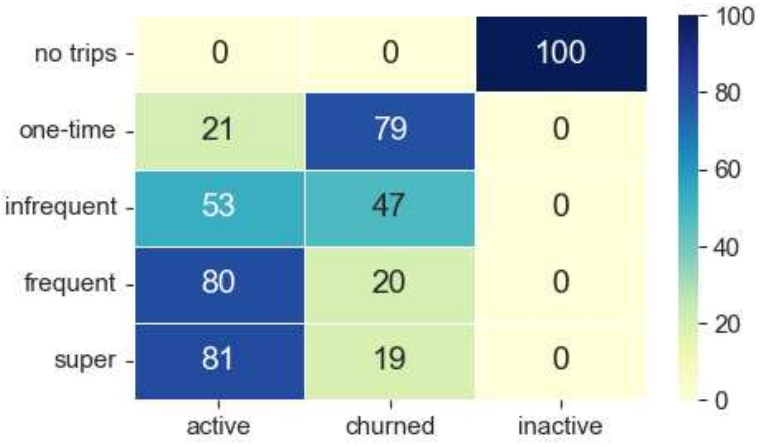

Figure 7-8: MORE Sharing churn rate vs. user group (%)

Table 7-3: Characteristics of churned MORE Sharing customers: MNL results (March 2023 - March 2024)

	Churned customers (no trips in the last 3 months)		
	coef	z	P>|z|
const	**-2.12**	**-28.02**	**0.00**
Female	**0.64**	**17.55**	**0.00**
Current Age, years	**0.01**	**3.15**	**0.00**
Registered Since, months	**0.13**	**24.54**	**0.00**
Low Satisfaction	**0.18**	**3.58**	**0.00**
Start at Public Transport Stop	**-0.16**	**-5.85**	**0.00**
End at Public Transport Stop	**-0.24**	**-8.73**	**0.00**
Round Trip	0.03	1.05	0.29
Pre-Reservation, min	0.00	-1.00	0.32
Log Parking, min	**-0.04**	**-3.95**	**0.00**
Log Reservation, min	0.01	0.69	0.49
Distance, km	**0.02**	**5.74**	**0.00**

* Reference category: active users (trips in the last 3 months).

** Bolded values indicate statistical significance at p <= 5%

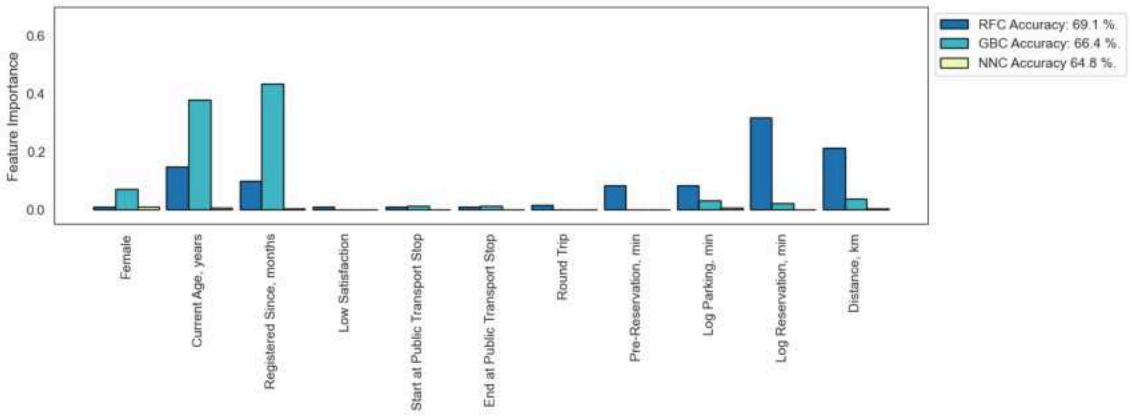

Figure 7-9: RFC, GBC, NNC feature importance of trip characteristics for user churn prediction (March 2023 - March 2024)

To predict customer churn, we employed three classification models: a Random Forest Classifier (RFC), a Gradient Boosting Classifier (GBC), and a Neural Network Classifier (NNC), as illustrated in Figure 7-9. The RFC model demonstrated an accuracy of 69.1%, identifying distance traveled, duration of booking, and customer age as the most influential features for predicting churn. The GBC model had an accuracy of 66.4%, primarily leveraging customer age, length of registration, and gender as its decisive predictive features. The NNC achieved an accuracy of 64.8%, yet it did not exhibit any particular features as significantly influential in its churn predictions.

7.5 Conclusion

Between March 2023 and March 2024, we analyzed user engagement with a non-urban campus micromobility sharing system known as MORE Sharing, designed for students and staff who register and receive a mobility allowance of up to €300 monthly. The system boasts an array of transportation options, including city bikes, e-bikes, e-cargo bikes, e-mopeds, and e-scooters. To understand usage patterns, we segmented registered individuals into five categories based on their trip frequency: non-users, one-time users, infrequent users, frequent users, and super users. This categorization was achieved through K-Means clustering, utilizing the monthly trip data for insights into user behavior.

Our findings highlight significant inactivity among registered users, with a meager transition rate to higher active use levels. A pronounced drop-off rate among one-time users indicates that initial engagement only sometimes translates into repeated use. Moreover, there is only a minimal uptick in users progressing to more frequent usage brackets. Behavioral trends among users evolve, suggesting that engagement levels are dynamic rather than static. Predominantly, the user base comprises infrequent and one-time users alongside a sizable contingent of inactive but registered individuals.

In terms of preferences for modes of transportation, one-time and infrequent users have a predilection for e-bikes and e-scooters. On the other hand, the more engaged user segments, particularly super users, show a propensity to utilize a diverse array of vehicles, indicating that

higher engagement correlates with a willingness to experiment with different types of vehicles offered by the service.

Crucially, demographic factors and trip patterns play a significant role in classifying user groups and the likelihood of service churn. Understanding these elements is vital for targeted marketing and service improvement strategies to reduce churn and increase user activity. Given the study's context - a non-urban campus system where users do not pay directly for services but receive a mobility allowance - our findings' applicability to other settings without such incentives may be limited, suggesting the need for cautious interpretation when extrapolating results to broader micromobility contexts.

8 User Characteristics, Feedback on User Experience, and System Setup

8.1 Characteristics of MORE Sharing Users and Non-Users

Individuals who sign up for the MORE Sharing app submit personal information, payment details, and contact information. Following their registration, they receive an email invitation to participate in the "MORE Sharing Registration Survey" (Chapter 3.2.3). This survey gathers data on user demographics, socioeconomic status, transportation behaviors, and perspectives on transportation-related issues (Chapter 3.2.3).

Chapter 7 analyzed user segmentation based on usage frequency, using dynamic seasonal assignment to categorize customers into segments: no-trips (registered, 0 trips), one-time (up to 1.7 trips per month), infrequent (up to 5.5 trips per month), frequent (up to 13.2 trips per month), and super (more than 13.2 trips per month) user groups. Chapter 8 analyzes the socio-demographic traits, transportation preferences and habits, and environmental attitudes of individuals registered with MORE Sharing.

Since these traits are relatively static and do not change due to seasonality, we decided to assign the MORE Sharing users an "average" status since their registration to combine the usage data with the registration data. We calculated the average monthly trips for each customer by dividing their total trip count by the number of months they have been registered. We accounted for the customers with no recorded trips.

After filling out the "MORE Sharing Registration Survey," users could receive a voucher worth 50 Euros for their participation. This voucher could be used for MORE Sharing services. If the user pasted the voucher code into the MORE Sharing app, we could combine the anonymous user ID with the responses from the registration survey.

Between March 2023 and March 2024, we received 1,246 responses to the "MORE Sharing Registration Survey." We combined 849 of these responses with customer IDs and the survey dataset, thus integrating information about usage frequency, segmentation, and survey responses. Further, we focus on the dataset with the customer IDs we could identify. Among the survey respondents, we had 17% of registered users with no trips, 28% were one-time users, 40% were infrequent users, 13% were frequent users, and 2% were super users.

The registration survey respondents represent the MORE Sharing user base regarding age and gender (Figure 8-1). Users with no trips tend to be older with a broader age range, whereas more frequent users tend to be younger with a narrower age range (Figure 8-1). Males dominate

across all usage levels, increasing their portion as usage frequency increases. Females are consistently present in all categories but in lower percentages, and the diverse gender category has minimal representation across all groups (Figure 8-1).

Single users dominate across all usage levels, with married users forming a significant portion and divorced users being the smallest group (Figure 8-2). The proportion of single users increases in higher usage categories (Figure 8-2). Adults without children are the majority in all groups, with multiple adults (with and without children) forming significant portions in various groups except super users. Families with children are more common in lower usage categories (Figure 8-2).

Middle-income users (1,000€ - 3,000€) dominate the infrequent, frequent, and super user groups. On the other hand, higher-income individuals are more represented in lower usage categories (Figure 8-2). This correlates with employment type, as professors and technical and administrative staff are more represented in the lower usage groups, and students and research staff are the major categories in more frequent usage levels categories (Figure 8-2).

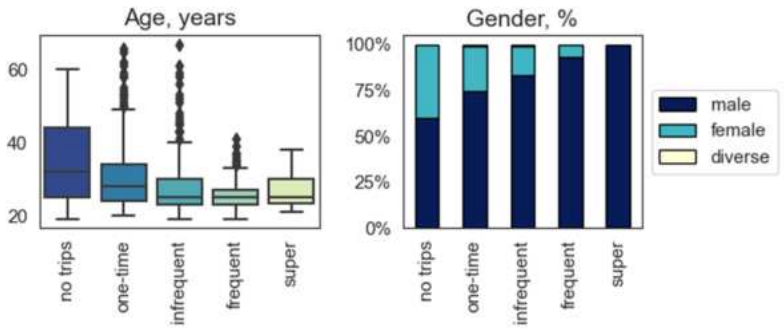

Figure 8-1: Age and gender of the MORE Sharing registration survey respondents

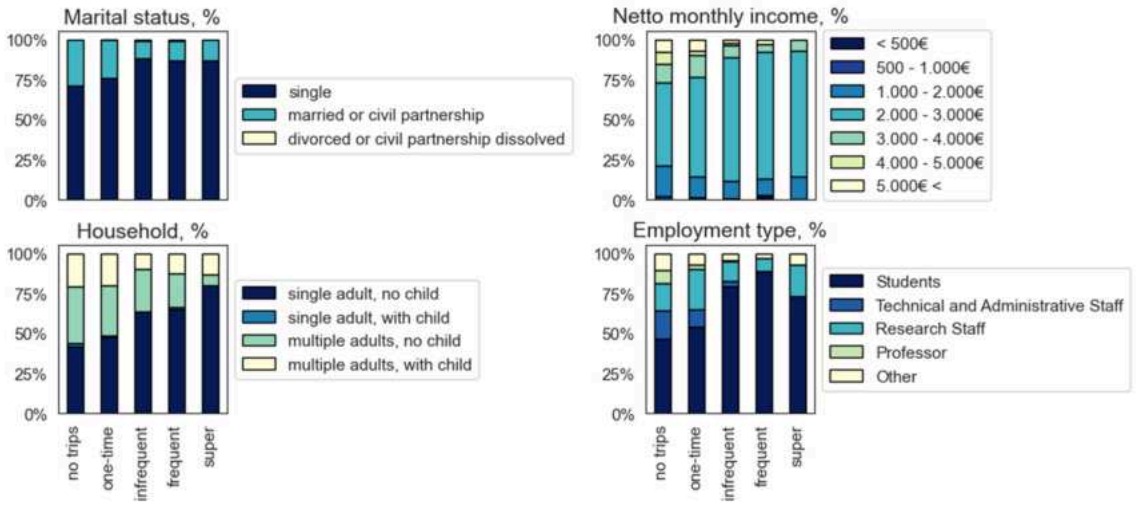

Figure 8-2: Distribution of marital status, household size, income level, and employment type across MORE Sharing user groups

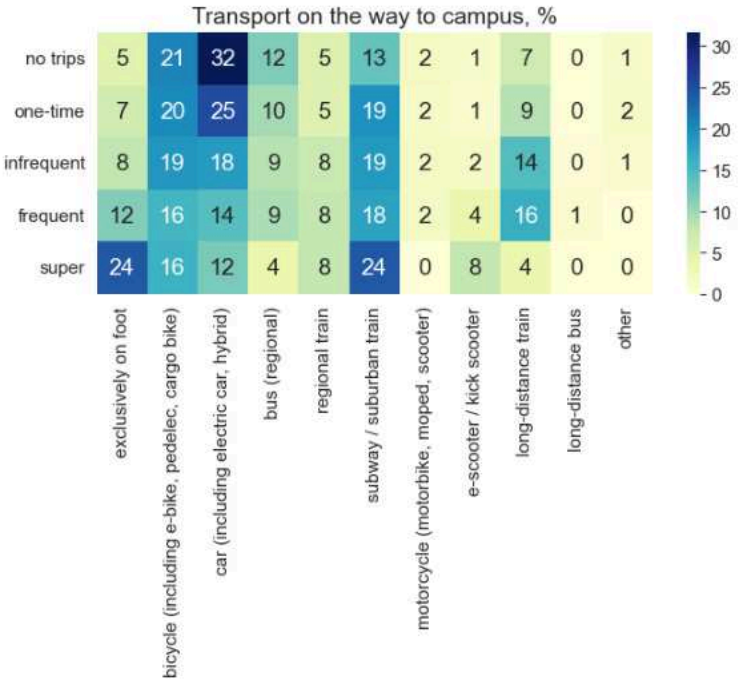

Figure 8-3: Transport of MORE Sharing user groups on the way to campus

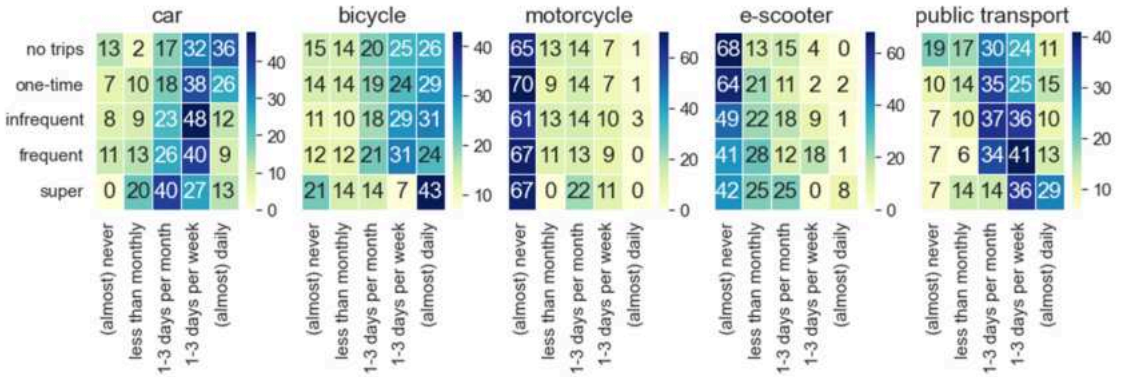

Figure 8-4: Usage frequency of car, bicycle, motorcycle, e-scooter, and public transport of MORE Sharing user groups

We asked the registered users which mode of transport they usually use to get to campus (Figure 8-3). Users in the no-trips category primarily use cars (32%), with significant use of bicycles (21%) and public transport such as buses (12%) and subway (13%). People in this segment rely less on other modes of transport. The one-time users also predominantly use cars (25%), followed by bicycles (20%) and public transport (buses 10% and subway 19%). The infrequent users show a more distributed pattern, with cars (18%), bicycles (19%), subways (19%), and long-distance trains (14%) being common choices. Frequent and super users travel to campus by car less frequently than other users. For frequent users, there is a distribution across several modes: cars (14%), bicycles (16%), subway (18%), and walking on foot (12%). The super user group primarily walks (24%) or uses the subway (24%). They also use bicycles (16%) and cars

(12%), but to a lower extent than persons with no trips or one-time MORE Sharing users (Figure 8-3).

The usage frequency of different transport modes among the MORE Sharing user groups is depicted in Figure 8-4 and Figure 8-6. Super users exhibit the highest daily usage of bicycles and public transport. Motorcycle and e-scooter usage remains low across all groups, with most users never utilizing these modes. Car usage is the highest among MORE Sharing registered users with no trips and one-time users.

Before joining MORE Sharing, the individuals who became frequent and super users already had experience using other shared micromobility modes (Figure 8-5). However, the MORE Sharing registered users rarely use other shared mobility offers daily (Figure 8-6). E-moped sharing is the least popular across all user groups (Figure 8-5, Figure 8-6). On the other hand, frequent and super MORE Sharing users show a more diverse usage pattern of shared mobility of other providers. They use shared (e-)bikes and e-scooters less than monthly or 1-3 days per month (Figure 8-6).

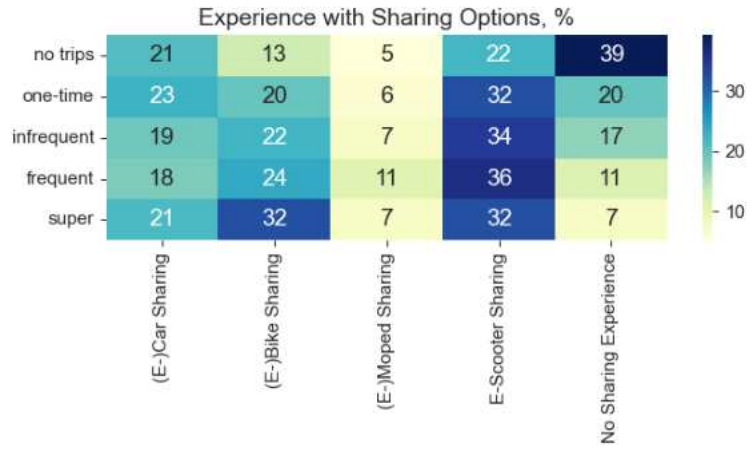

Figure 8-5: Experience with other sharing options (%)

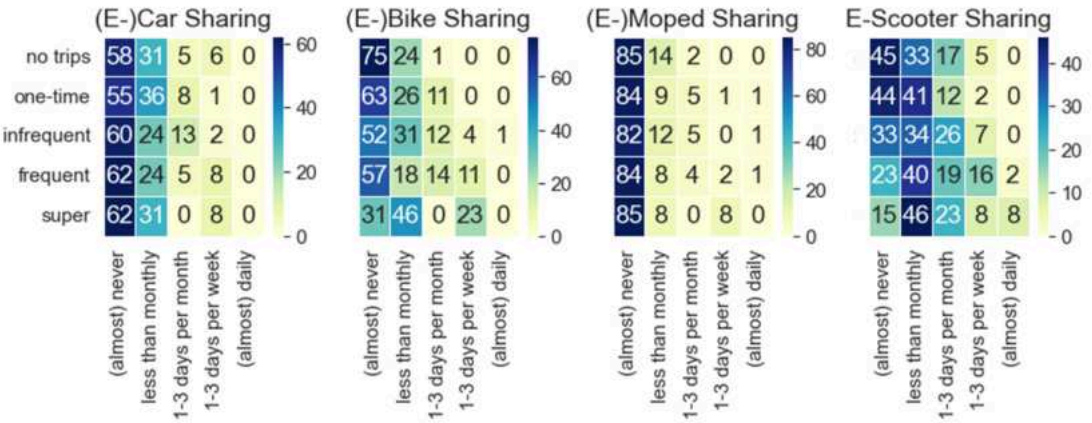

Figure 8-6: Usage frequency of other car, bike, moped, and scooter sharing services among MORE Sharing registered users

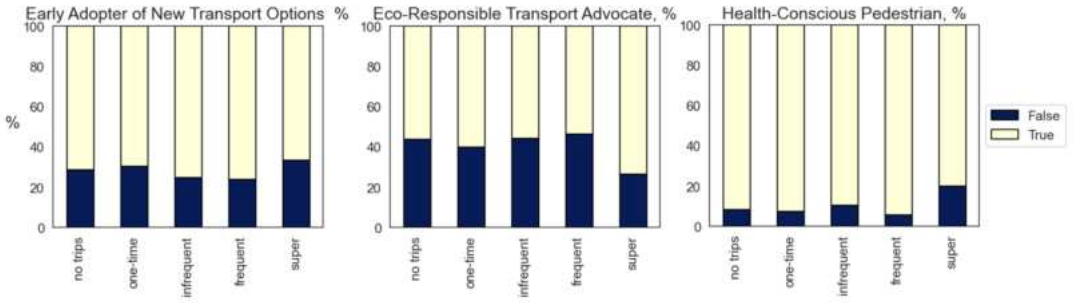

Figure 8-7: Opinions of MORE Sharing user groups

Based on this data (Figure 8-4 - Figure 8-6), we classified respondents into frequent usage categories for various transport modes if they reported utilizing these modes more often than 1-3 days per week. Respondents could be assigned to multiple frequent transport usage categories based on their responses. Furthermore, we identified people who had already experienced other shared mobility options before joining MORE Sharing (Figure 8-5).

We asked survey respondents to rate their agreement or disagreement with several statements about transportation on a scale from "strongly disagree" (1) to "strongly agree" (5). The statements included: "I am very interested in the introduction of new means of transportation," "I am always among the first to use new means of transportation," "I believe that new means of transportation will increase in the future," and "New means of transportation will be more convenient than traditional ones." We calculated a median value using these responses to gauge opinions about eagerness to adopt new transport modes (Figure 8-7).

We also asked respondents to agree or disagree with the following statements about environmental concerns: "Increasing car traffic is a major problem for environmental protection," "I worry when I think about the environmental destruction caused by driving," "For environmental reasons, I feel obligated to use my car as little as possible in my free time," "For environmental reasons, I feel obligated to use a bicycle or tram for trips to the city center," "I feel responsible for not degrading the quality of life in my neighborhood through my car usage," "I feel responsible for choosing environmentally friendly modes of transport in my daily life," "Without the participation of individual citizens, traffic-related environmental problems cannot be solved," "Individuals play a significant role in solving traffic-related environmental problems," "By choosing environmentally friendly modes of transport, I can contribute to environmental protection," and "I believe that by using public transportation, I can contribute to environmental protection." We calculated a median value based on these responses to understand opinions about environmental concerns (Figure 8-7).

The third category we explored was attitudes toward active transport modes, such as walking. The indicators were: "When I travel a short distance, I mostly walk" and "Walking is good for my health." We calculated the median opinion about walking from these responses. If the median opinion was "agree" or "strongly agree" with these statements, we categorized individuals into groups: "early adopters of new transport options," "eco-responsible transport advocates," and "health-conscious pedestrians" (Figure 8-7).

We explored why people wanted to register with MORE Sharing (Figure 8-8). Curiosity as a reason for registration decreases as the frequency of MORE Sharing usage increases, starting at 30% for those with no trips and dropping to 20% for super users. This suggests that less frequent users are more likely to try out MORE Sharing out of curiosity. The percentage of users citing convenience remains relatively consistent across all categories, ranging from 18% to 22%, indicating that convenience is a stable reason for using MORE Sharing regardless of usage frequency. Saving money is cited by 10-20% of users, with frequent and super users being more motivated by cost savings than one-time and infrequent users. Saving time is slightly more important to those who use MORE Sharing more often, with a peak at 28% for frequent users, suggesting that regular users value time savings. Environmental protection, health, and fitness are less frequently cited reasons to join the service across all groups (Figure 8-8).

The bar chart (Figure 8-8) presents the selected reasons why respondents are not using the MORE Sharing program, with the number of responses indicated for each reason. The most cited reason is the uncertainty about the availability of vehicles, indicating that users are concerned about the reliability of finding available vehicles when needed. The second most common reason, “no need,” suggests that some respondents do not find a need for the services offered by MORE Sharing in their daily routines or existing transport options. Additionally, some respondents find the program inconvenient to use, possibly due to factors like accessibility, technical issues, or other constraints. The service may also not accommodate those needing to transport goods or personal items comfortably. A moderate number of respondents are deterred by concerns over the cleanliness and sanitation of the shared vehicles. Some individuals find the service physically unsuitable.

While not a significant factor for most, a segment of the population prefers not to share vehicles for various personal reasons. The least cited reason was safety concerns, although it still represents a barrier for those worried about the safety of using the shared micromobility service (Figure 8-8). We will discuss the user experience of MORE Sharing in the next chapter.

Using the Multinomial Logit Model (MNL), we analyzed the user characteristics of MORE Sharing user groups (Table 8-1). The reference group in the model is the category of registered users with no trips. The model achieved an accuracy of 47.3% in predicting user class. The analysis revealed that females are significantly less likely than males to be in the one-time, infrequent, and frequent user groups than the “no trips” group. Additionally, as age increases, the likelihood of being in the one-time or infrequent usage categories decreases relative to the “no trips” group. These findings are consistent with the results presented in Chapter 7.

Being a student increases the likelihood of belonging to the infrequent or frequent usage groups compared to the “no trips” group (Table 8-1). Infrequent MORE Sharing users tend to be frequent private bike users. There is a significant increase in the likelihood of being a frequent or super MORE Sharing user among those who frequently use micromobility sharing, compared to the “no trips” group. Furthermore, advocating for eco-responsible transport increases the likelihood of being in more frequent MORE Sharing usage categories compared to not making trips (Table 8-1).

To predict customer category, we employed three classification models: a Random Forest Classifier (RFC), a Gradient Boosting Classifier (GBC), and a Neural Network Classifier (NNC), as illustrated in Figure 8-9. The RFC model demonstrated an accuracy of 31.7%, and the GBC model had an accuracy of 38.9%, primarily leveraging customer age as a decisive predictive feature for customer groups. The NNC achieved an accuracy of 47.3%, highlighting belonging to the student group as an important predictive factor for categorizing customers.

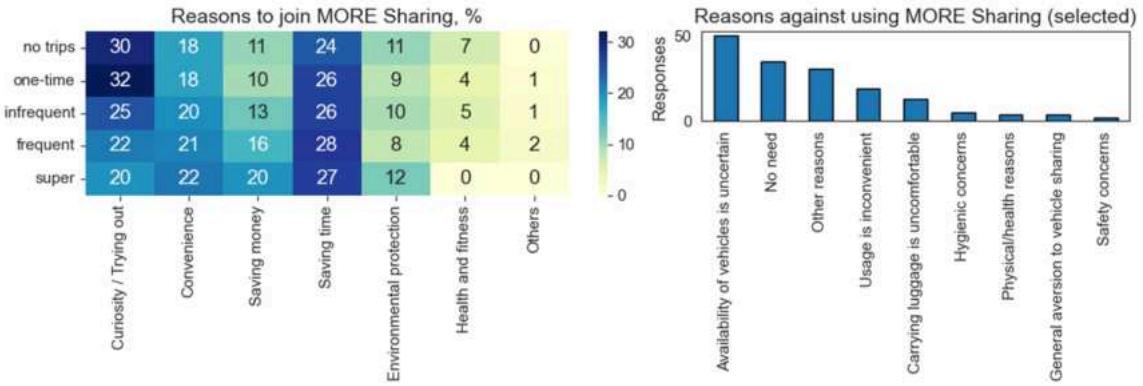

Figure 8-8: Reasons to join MORE Sharing and reasons against using MORE Sharing

Table 8-1: Characteristics of MORE Sharing user groups: MNL results (March 2023 – March 2024 based on the "MORE Sharing Registration Survey")

	One-time (up to 1.7 trips/month)			Infrequent (up to 5.5 trips/month)			Frequent (up to 13.2 trips/month)			Super (more than 13.2 trips/month)		
	coef	z	P>|z|	coef	z	P>|z|	coef	z	P>|z|	coef	z	P>|z|
const	**2.16**	**2.65**	**0.01**	1.28	1.55	0.12	-0.93	-0.70	0.49	1.58	0.63	0.53
Female	**-0.98**	**-3.62**	**0.00**	**-1.14**	**-4.20**	**0.00**	**-2.20**	**-4.20**	**0.00**	-23.38	0.00	1.00
Age	**-0.05**	**-3.13**	**0.00**	**-0.04**	**-2.15**	**0.03**	-0.04	-1.26	0.21	-0.12	-1.77	0.08
Household with Child	0.20	0.57	0.57	-0.22	-0.62	0.54	0.09	0.18	0.86	0.75	0.77	0.44
Student	-0.34	-0.99	0.32	**0.95**	**2.71**	**0.01**	**1.60**	**3.04**	**0.00**	0.07	0.08	0.94
Frequent Car User	0.11	0.39	0.70	0.04	0.15	0.88	-0.49	-1.41	0.16	-0.75	-1.06	0.29
Frequent Bike User	0.07	0.29	0.77	**0.55**	**2.24**	**0.03**	-0.09	-0.26	0.79	0.13	0.20	0.85
Frequent E-Scooter User	0.14	0.18	0.86	0.44	0.62	0.53	0.66	0.82	0.41	-0.23	-0.17	0.87
Frequent Public Transport User	0.01	0.04	0.97	0.30	1.10	0.27	0.28	0.81	0.42	0.79	1.12	0.27
Frequent Micromobility Sharing User	-0.01	-0.01	0.99	0.93	1.32	0.19	**1.84**	**2.42**	**0.02**	**3.30**	**3.31**	**0.00**
Early Transport Adopter	-0.32	-1.12	0.26	0.00	0.00	1.00	0.00	0.01	0.99	-0.84	-1.12	0.26
Health-Conscious Pedestrian	0.40	0.83	0.41	-0.34	-0.78	0.44	0.75	1.04	0.30	-1.19	-1.28	0.20
Eco-Responsible Transport Advocate	**0.57**	**2.08**	**0.04**	**0.62**	**2.32**	**0.02**	0.43	1.26	0.21	**1.74**	**2.17**	**0.03**

* Reference category: registered users with no trips (0 trips).

** Bolded values indicate statistical significance at p <= 5%

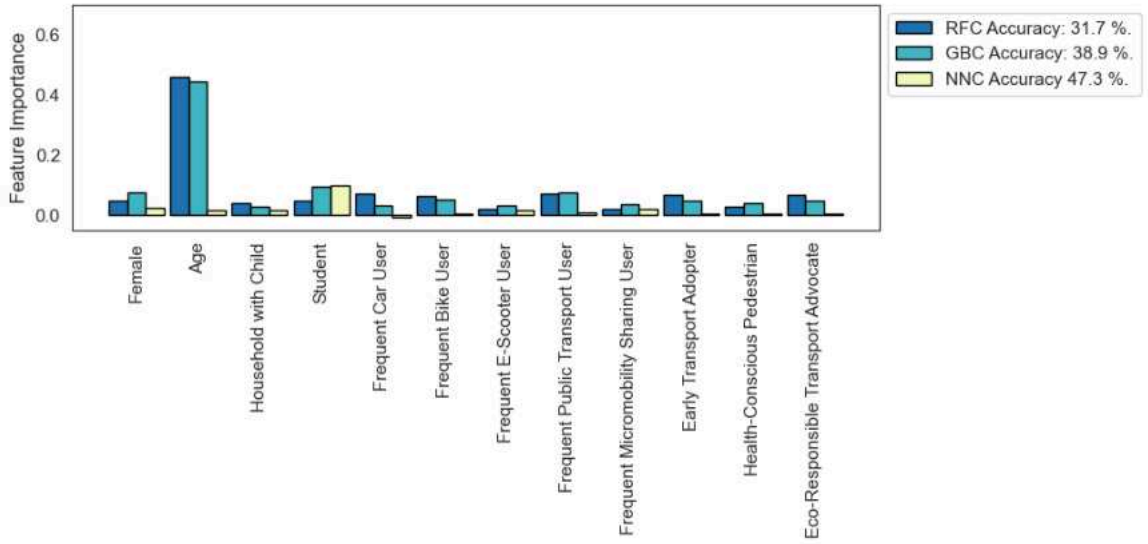

Figure 8-9: RFC, GBC, NNC feature importance of characteristics for user group prediction (March 2023 – March 2024 based on the "MORE Sharing Registration Survey")

8.2 Analyzing MORE Sharing User Experience

Beginning on May 12, 2023, we initiated the "MORE Sharing User Experience" survey, targeting registered users using our platform for over six weeks. When users reached this six-week registration milestone, they received survey invitations via email. The purpose of the survey was to collect feedback on user experience with MORE Sharing services (Chapter 3.2.4). Upon completing the "MORE Sharing User Experience Survey," participants could receive a voucher valued at 50 Euros for their involvement. This voucher was redeemable for MORE Sharing services. By entering the voucher code into the MORE Sharing app, we linked the anonymous user ID with the responses from the registration survey.

The response rate to the "MORE Sharing User Experience Survey" was relatively low, with 347 responses between May 2023 and March 2024. Out of these, 187 responses were combined with customer IDs and the survey dataset to integrate information about usage frequency, segmentation, and survey responses. Among the respondents, 8% were registered customers with no trips, 23% were one-time users, 46% were infrequent users, 20% were frequent users, and 3% were super users. For further analysis, we will consider all the responses (347 responses), including the cases when we could not identify the usage frequency group.

8.2.1 MORE Sharing User Experience and Information

We evaluated the overall experience with MORE Sharing (Figure 8-10). The data show a generally positive response, with the majority of respondents rating their experience as either "average," "good," or "very good" (Figure 8-10-1). Figure 8-10-2 depicts the percentage distribution of reasons users opt for the service. The primary reason for using MORE Sharing is time saving, indicating that users greatly value the time efficiency provided by the service.

Convenience is the second most common reason, showing that users appreciate the ease and practicality of the service. Many users join the service out of curiosity and want to try it out. Saving money also has a notable percentage, highlighting the importance of cost savings for users. Environmental protection and health and fitness are less prominent but still suggest that some users are motivated by sustainability and personal health benefits.

We received free-text comments regarding which aspects of the MORE Sharing System users consider positive and categorized the responses accordingly (Figure 8-10-3). For example, the category "Mobility Options and Accessibility" (Figure 8-10-3) emphasizes the ease and variety of transportation options available. Respondents appreciated the simple mobility as a complement to public transit, citing low costs that significantly enhance attractiveness. Comments highlighted the benefit of not needing a personal bicycle on campus, the quick access away from university settings without using a car, and the diversity in the types of vehicles available. They noted the freedom to park these vehicles and the extension of transportation options around the university area provided by MORE Sharing. Other positive notes included additional transport options to local train stations, enhanced mobility across the campus, and the

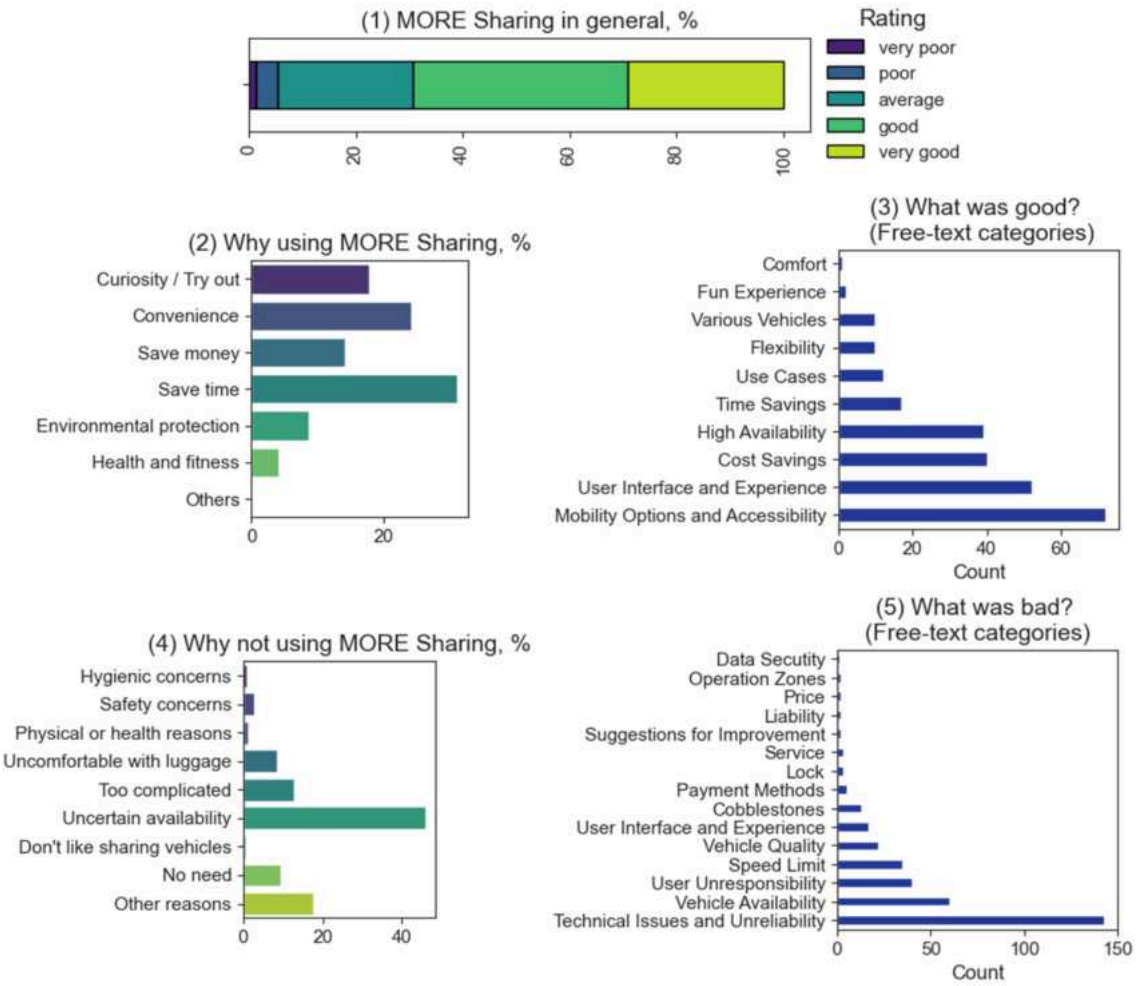

Figure 8-10: MORE Sharing positive and negative experience

broad availability of different transport means, which allowed for a simplified commute on and around campus.

Under the category “User Interface and Experience” (Figure 8-10-3), users expressed high satisfaction with the app’s design and functionality. The app was praised for featuring clear FAQs and a map that effectively shows available rides. Users appreciated the simplicity of battery swapping for charging and found the overall usage user-friendly. The straightforward registration process enabled quick access to services, including special credits. Comments also highlighted the quickness of booking transport, the availability of free mobility services even on weekends, and reliable customer service. Additionally, the condition of vehicles and parking spots at the public transport stops around the university were well-received, enhancing the overall user experience with the MORE Sharing system.

For the “Cost Effectiveness” category (Figure 8-10-3), the positive feedback centered around the free or highly affordable nature of the service. Users celebrated the concept of a free sharing option, ideal for quick, spontaneous trips, emphasizing how valuable it is to have access to vehicles at no cost. Several remarks highlighted the no-cost policy, specifically mentioning a €300 budget that covers most needs, effectively making the service free within this limit.

In the “Availability” category (Figure 8-10-3), many users noted the good availability of transport options, both on and off campus. This flexibility allows vehicles to be easily found and used spontaneously, which is especially appreciated by users. Comments emphasize that even outside university grounds, vehicles can be parked at designated spots, enhancing convenience. This extensive availability ensures that users can almost always find a vehicle when needed, significantly enhancing the practicality and appeal of the MORE Sharing system.

In the “Time Savings” category (Figure 8-10-3), the feedback frequently highlighted the convenience and efficiency of moving quickly from one location to another on campus, specifically noting how the availability of vehicles substantially cuts down travel time. Users valued the ability to reach destinations faster, especially when timing is crucial, and appreciated the direct impact on reducing commute times to work or connecting to public transportation.

Practical benefits such as easier transportation of goods and improved shopping were highlighted under “Use Cases.” “Flexibility” was praised for allowing spontaneous and adaptable mobility on campus, making trips convenient with readily accessible micromobility options. Additionally, the overall sharing concept contributed to a “Fun Experience”, enhancing campus life by making transportation practical and enjoyable. These aspects collectively underscore the positive impact of the service on user satisfaction and mobility (Figure 8-10-3).

On the other hand, there were reasons why people did not use the MORE Sharing service. The most significant reason for not using MORE Sharing is uncertain availability, with the highest percentage, indicating that users are primarily concerned about the reliability of finding available vehicles when needed (Figure 8-10-4). Other reasons also have a notable percentage, suggesting a variety of unspecified concerns that deter users from using the service (Figure 8-10-4). Some users found the service difficult to understand or use (Figure 8-10-4). Some users were deterred by the inconvenience of carrying luggage, and some simply did not require the service (Figure 8-10-4).

We also received negative free-text feedback about the MORE Sharing service which we categorized (Figure 8-10-5). The most common issue was technical problems that caused unreliability in the service. Users reported numerous technical issues and reliability concerns with the MORE Sharing system (Figure 8-10-5), primarily centered on the app's performance and vehicle functionalities. Key issues include GPS inaccuracies that make it challenging to locate vehicles or end rentals accurately, frequent software bugs, and problems with vehicle locking and unlocking. Users have expressed frustration over the unreliability of vehicle availability and network connectivity, which often impedes the starting or ending of rides. Furthermore, problems with the app's responsiveness and persistent errors in vehicle reservation and return have been noted, leading to user dissatisfaction and doubts about the system's dependability for regular use. These issues could be solved by using a Bluetooth connection between the vehicles and mobile devices instead of relying solely on a GPS connection.

We faced challenges due to user irresponsibility associated with the €300 free mobility budget. Users often misused the service by unnecessarily blocking vehicles, resulting in low availability for others (Figure 8-10-5). For instance, vehicles were frequently reserved but left unused for extended periods, effectively hoarding these resources and preventing their availability to other users. In response to these issues, we adjusted the pricing structure to discourage such behavior and improve vehicle turnover and availability. This adjustment aimed to mitigate the misuse and ensure that the vehicles were more accessible to all users who needed them.

Users have expressed dissatisfaction with the speed restrictions implemented on campus (Figure 8-10-5). However, we have decided to maintain these limits to enhance safety, accommodate shared spaces, and effectively navigate the challenges posed by cobblestone surfaces, thus helping prevent incidents. Furthermore, users have raised concerns about the quality of the vehicles in the MORE Sharing system, particularly noting the impracticality of vehicles due to their lack of adequate suspension and unsuitable seat positions for taller individuals (Figure 8-10-5). Additionally, there are issues with the durability of the vehicles, which users believe may stem from careless usage rather than the vehicles' inherent quality. Electric vehicles often have a low remaining range, making them unreliable for longer trips (Figure 8-10-5).

We evaluated how well-informed the users feel about MORE Sharing. Most users were well-informed about the system, how to use it, and about the shared micromobility project overall (Figure 8-11). In the free-text fields, we inquired about what was unclear to users of MORE Sharing (Figure 8-11). The most common area of confusion revolved around the general project details, including what MORE Sharing is and its goals. Furthermore, users were puzzled by the speed limits imposed on the vehicles within the university campus. They also faced significant issues with vehicle availability, often finding it difficult to locate an available vehicle. Connectivity issues were another primary concern, with frequent network-related problems affecting the use of the service. The mobility budget was unclear, especially its proper activation (Figure 8-11).

Users frequently encountered error messages and found reporting damage or errors cumbersome, suggesting the need for a quicker reporting system. Parking costs and procedures and issues with the correct display of battery performance were also highlighted. Some users needed clarification about liability and the operational zones for the vehicles. The reservation

process and how to handle specific vehicle functionalities, like locks, were sometimes confusing (Figure 8-11). Additionally, users mentioned a lack of clarity about who to contact for technical issues, how to activate the subscription for free usage, and the specifics of using payment methods.

The necessity of a mobility budget and its related costs, as well as the results and updates of the project, were other points of concern. Furthermore, the process for the daily reservation of vehicles, data protection policies, and the exact locations for parking and returning vehicles needed a better explanation (Figure 8-11). There were queries about future projects, the exact size and operation of the MORE Sharing team, and the project's funding source. Users were also curious about the use of alternative payment methods like Google Pay or PayPal, and whether it would be possible to drive MORE Sharing in the future. To conclude, information about vehicle locks, speed changes, and general user-relevant updates during system upgrades were areas where users sought more detailed explanations (Figure 8-11).

We further gathered feedback on MORE Sharing (Figure 8-12). Many users find the service easy to use and believe its capabilities meet their requirements. However, a considerable number of users also agree or strongly agree that using the service is frustrating and that too much time is spent on difficulties (Figure 8-12). The most frequently encountered problems are related to poor mobile reception, which affects connectivity between the vehicle and the cellphone, leading to difficulties in locking and unlocking the vehicle. These issues significantly impact the overall user experience (Figure 8-12). Therefore, while MORE Sharing meets the requirements and is easy to use for many users, connectivity issues are significant areas that need addressing to improve the user experience.

We asked the users to evaluate various aspects of MORE Sharing (Figure 8-13). Overall, users have a positive view of the MORE Sharing service, with a majority agreeing or strongly agreeing that it is fun, improves campus mobility, and is a valuable addition to existing transportation options. It also expands mobility options, saves costs, and is easy to use (Figure 8-13). Users rate the service highly in terms of environmental protection, sustainability, safety, and cleanliness (Figure 8-13). There is room for improvement in flexibility, independence, spontaneity, reliability, and predictability, as a noticeable portion of users rated these areas as average or below. These low ratings are likely related to technical issues within the system.

Users highly rate comfort during the ride, the pricing model, parking options, the mix of vehicles in the shared micro-mobility system, the MORE Sharing app, and the operating zone area. On the other hand, the number of available vehicles needs to be increased, possibly due to issues with user misbehavior and hoarding of vehicles.

We asked users about their likelihood of using the service in the future (Figure 8-14). Approximately 84% of survey respondents indicated they are likely or very likely to use MORE Sharing in the future. Meanwhile, 10% of respondents were neutral, and 6% reported that they would unlikely use MORE Sharing again. To prevent customer churn, it is crucial to address the issues and improve the service's reliability. Additionally, seeking regular user feedback is essential to ensure the system operates properly and to make necessary adjustments in the operation strategy.

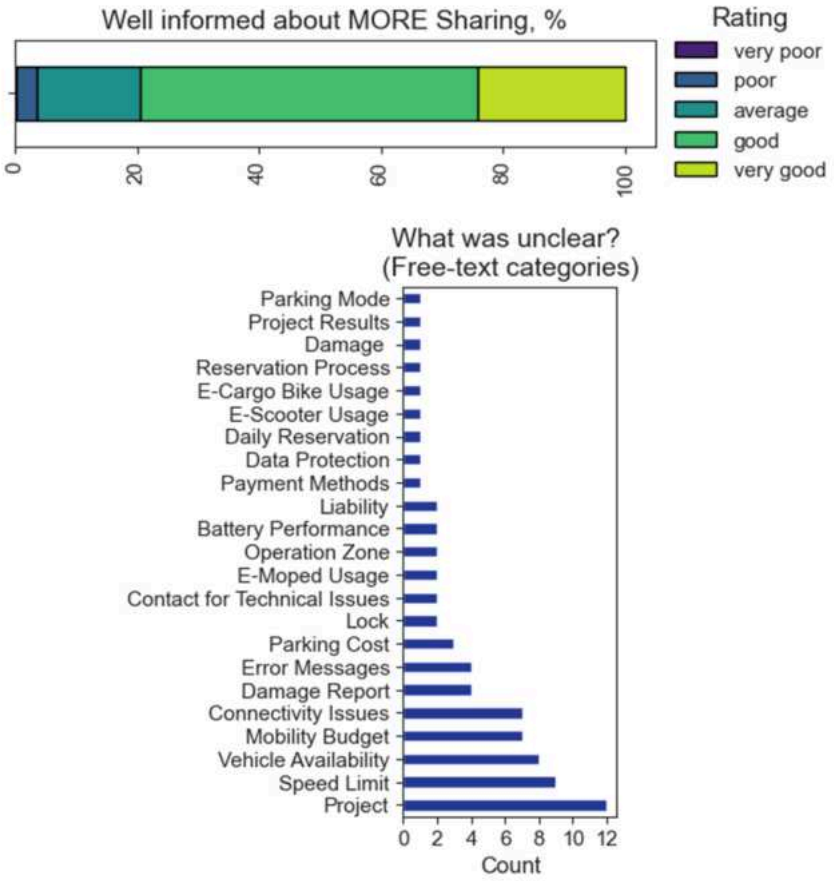

Figure 8-11: User informedness and feedback about unclear issues

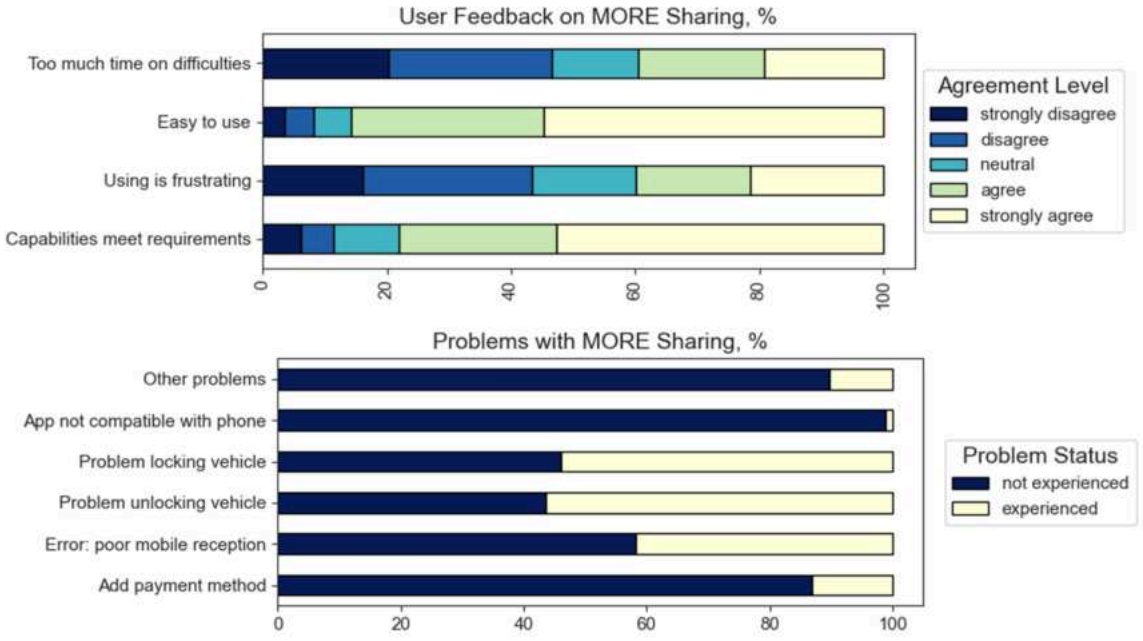

Figure 8-12: User feedback and problems with MORE Sharing

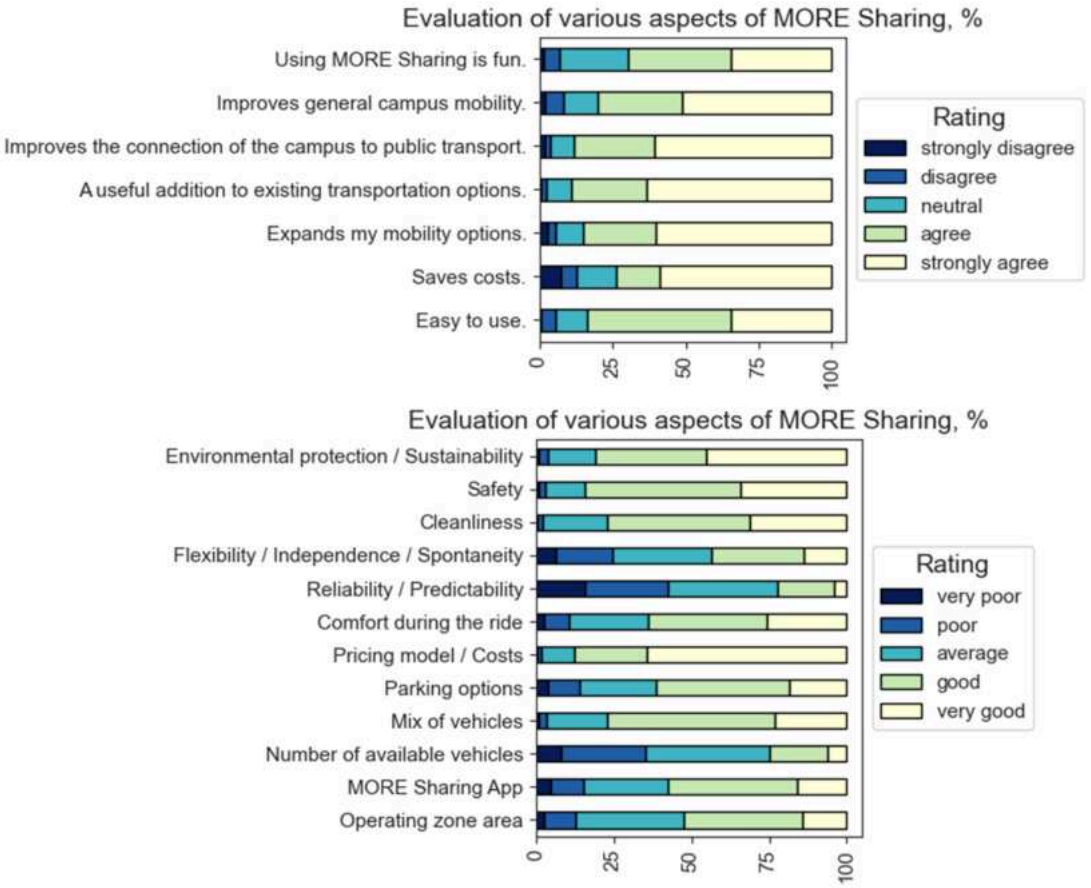

Figure 8-13: Evaluation of various aspects of MORE Sharing

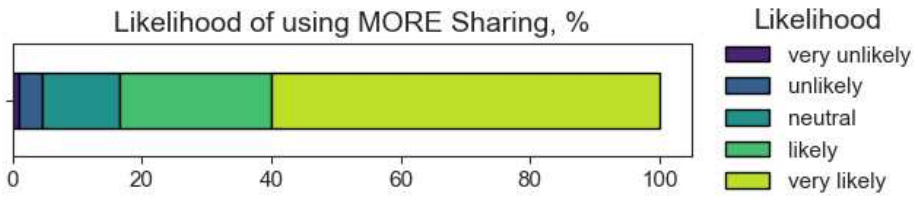

Figure 8-14: Likelihood of using MORE Sharing in the future

8.2.2 User experience with MORE Sharing vehicles

We wanted to understand if users' behavior regarding other shared mobility modes changed after using the MORE Sharing system (Figure 8-15). The availability and experience of using MORE Sharing did not lead to an increased usage of other shared mobility options daily for most users. About half of the respondents reported no change in their usage of other shared modes, while a significant portion indicated they use other shared mobility options less frequently. Only a small percentage reported using other shared modes more frequently. Despite the limited impact on overall shared mobility usage, MORE Sharing has successfully introduced

a notable portion of users to new modes of transportation. This indicates that MORE Sharing effectively promotes awareness and trial of new mobility options, which could lead to diversified usage patterns over time (Figure 8-15).

We asked users about their favorite vehicle in the MORE Sharing system (Figure 8-16). E-bikes and e-scooters emerged as the most preferred vehicles, with a higher percentage of users ranking them as their top choice. Preferences for e-cargo bikes (both 2-wheeled and 3-wheeled) were more evenly distributed across all ranks, indicating that while some users find these vehicles useful, they are not universally preferred. City bikes are also distributed evenly across all ranks, reflecting mixed preferences. This suggests that although city bikes are helpful, they may not be as appealing as e-bikes and e-scooters. E-mopeds received a moderate preference, with many users ranking them highly, indicating that while valued, they are not the top choice for most users. These observations are coherent with the results from Chapter 6 and Chapter 7.

We analyzed the use cases for different MORE Sharing vehicles (Figure 8-17). Users drive for fun with e-scooters and e-mopeds. These observations align with the findings from Chapter 6 and Chapter 7. Many users prefer not to use any shared vehicle to go home (Figure 8-17). This corresponds to the fact that the start and end of the MORE Sharing ride is possible on campus or at specific public transport stops around the campus. Therefore, the users could not drive home outside of the campus and leave the vehicle there, but needed to return the vehicle to the operation zone. Some users reside on campus and have chosen city bikes, e-bikes, and e-scooters to reach their homes.

City bikes, e-bikes, and e-scooters are chosen for reaching public transport, on the way to a leisure activity, for work-related tasks, or when timeliness is crucial (Figure 8-17). We obtained similar results in Chapter 5 and Chapter 6. On the other hand, e-cargo bikes are preferred for transporting goods (Figure 8-17). E-mopeds and e-bikes are preferred for longer distances (Figure 8-17). Ensuring these vehicles have a good battery range and are strategically placed is important. E-scooters and e-bikes are preferred in bad weather, but many users prefer not to use shared vehicles at all (Figure 8-17). When all vehicle types are available, the e-scooter is the favorite vehicle type for most respondents (Figure 8-17). This aligns with the results in Chapter 6 and Figure 8-16.

We asked survey respondents to evaluate various aspects of MORE Sharing vehicles (Figure 8-18). The results indicate that city bikes are perceived as the most sustainable vehicles, while e-mopeds are seen as the least environmentally friendly (Figure 8-18). City bikes received the highest ratings in availability, flexibility, independence, spontaneity, reliability, and predictability, whereas e-mopeds and e-cargo bikes scored lower in these categories (Figure 8-18). This discrepancy is related to the fact that there were three times fewer e-mopeds and e-cargo bikes in the MORE Sharing system, and the problem of vehicle hoarding, previously described, predominantly affected these types of vehicles. E-bikes and e-mopeds are considered the safest options, while e-scooters and e-cargo bikes are considered less safe (Figure 8-18). E-cargo bikes excel in transporting things, while e-scooters are deemed unsuitable for this purpose. Conversely, e-cargo bikes are rated as less maneuverable, whereas e-scooters and e-mopeds receive the highest ratings for maneuverability. E-mopeds are also rated the best for cleanliness and comfort during the ride (Figure 8-18).

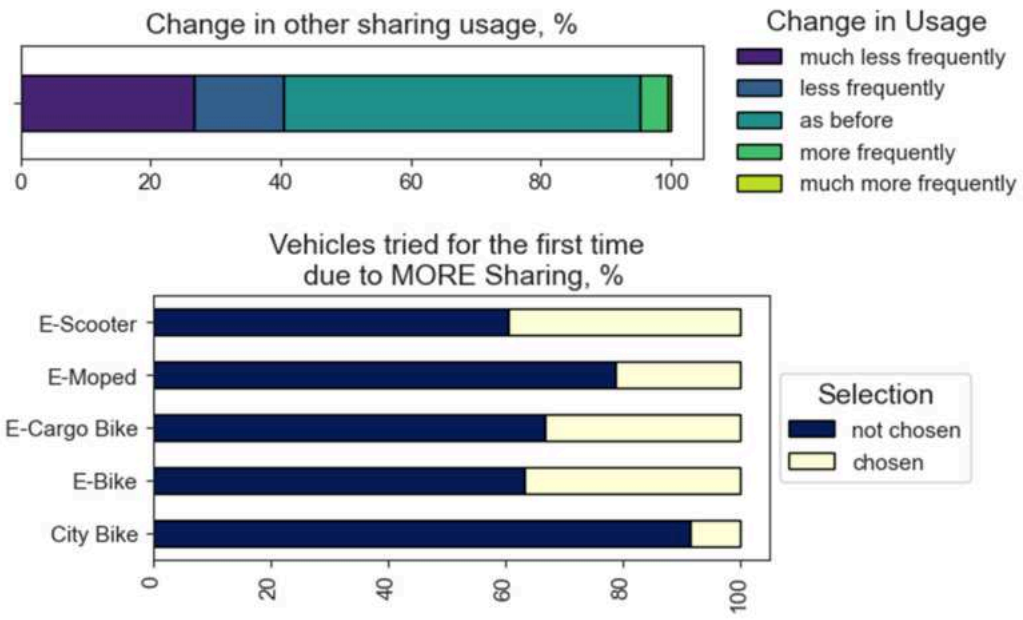

Figure 8-15: Change in usage of other shared mobility modes and vehicles tried for the first time due to MORE Sharing

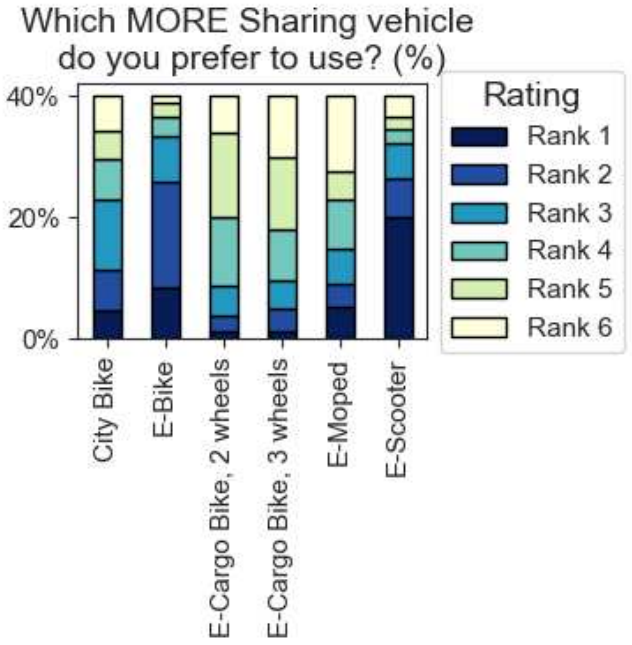

Figure 8-16: Preferred MORE Sharing vehicles

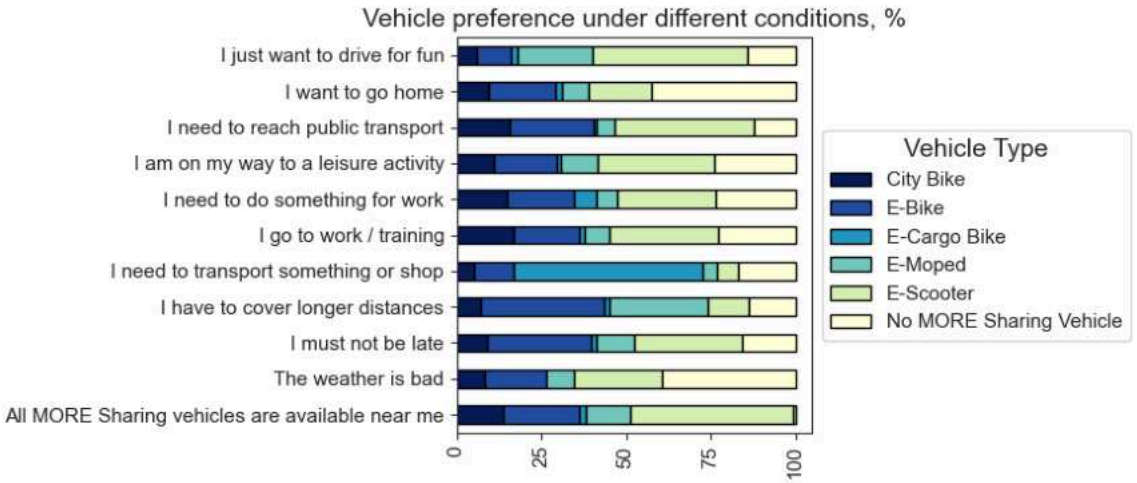

Figure 8-17: Use cases for different MORE Sharing vehicles

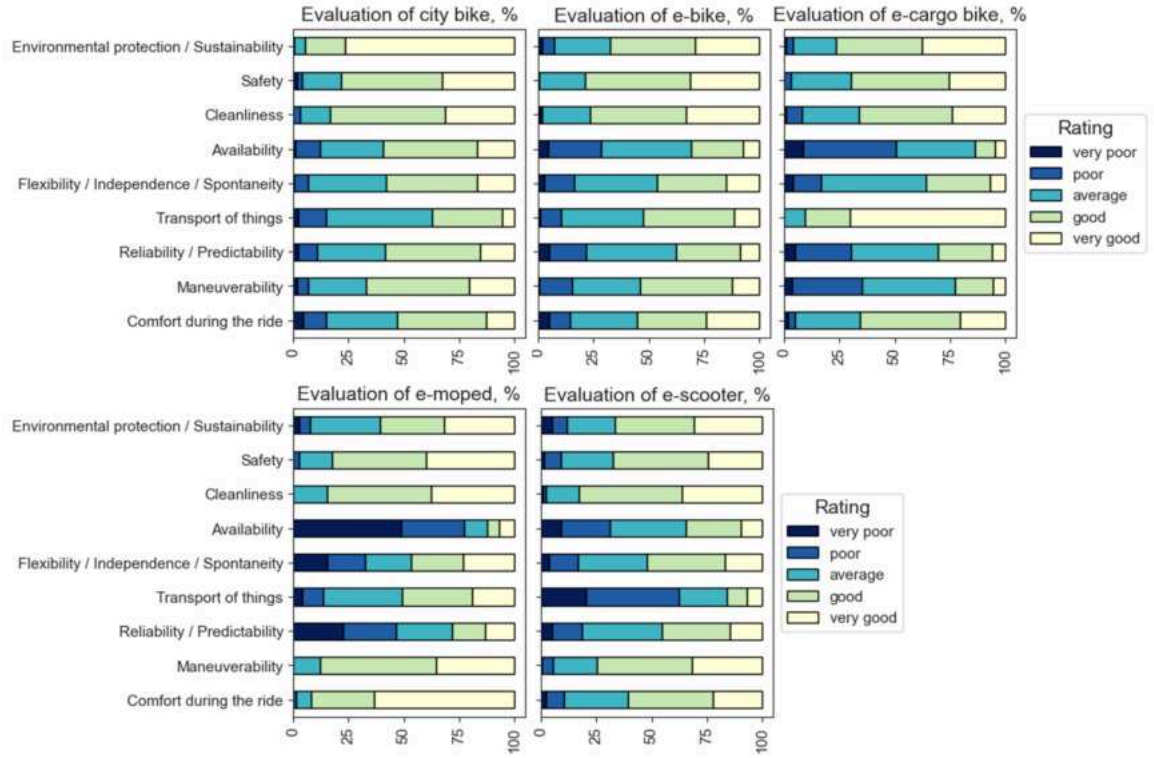

Figure 8-18: Evaluation of various aspects of MORE Sharing vehicles

8.3 Free-Floating vs. Station-Based: Attitudes of MORE Sharing Users

Selecting between a free-floating or station-based model is essential for shared micromobility providers, as each has benefits and challenges. The free-floating model is believed to enhance user flexibility and accessibility by permitting vehicles to be parked anywhere, which can

increase demand but also raise the risk of damage and theft. On the other hand, the station-based model, which requires vehicles to be picked up and returned to the designated stations, enhances vehicle security and can reduce operating costs, though it restricts user convenience.

In October 2023, we surveyed all registered users of MORE Sharing to understand their current attitudes toward the service (Chapter 3.2.4). The goal was to gather user preferences regarding the operational model of MORE Sharing, whether free-floating, station-based, or hybrid. At that time, MORE Sharing utilized a free-floating system on the UniBw campus, allowing users to park their vehicles anywhere. However, we were considering the introduction of mobility stations on campus where users could pick up, park, and charge vehicles. Additionally, outside the campus at public transport stops, we implemented a station-based system with virtual stations visible in the MORE Sharing app.

We collected data between October and November 2023, receiving 170 valid responses. The survey inquired about users' opinions on introducing mobility stations on the university campus to replace the free-floating operation (Figure 8-19). Most respondents had a favorable view, with over 40% expressing a positive opinion and a notable portion indicating a very positive response. Neutral opinions were also significant, while negative and very negative responses were relatively low. This feedback suggests that most users are open to or supportive of the transition to mobility stations.

Additionally, most users believed that introducing mobility stations on campus would positively impact the user experience (Figure 8-19). Furthermore, most users indicated that their usage of MORE Sharing would either remain unchanged or increase with the introduction of mobility stations instead of the free-floating model (Figure 8-19). This indicates potential solid support for the new system, suggesting it could enhance user satisfaction and service utilization.

The most frequently mentioned benefit of introducing mobility stations on campus was the increased ease of finding vehicles (Figure 8-20). Users had experienced technical issues related to GPS signals and the connection between mobile devices and vehicles. Often, users would see a vehicle's location on the app map but could not find it due to faulty mobile signals. Therefore, users believed transitioning from the free-floating model to a station-based one on campus would solve this problem. Other advantages of the station-based model include the guarantee of vehicle availability and improved maintenance and condition of the vehicles (Figure 8-20). Some users also see charging capabilities as a significant benefit. Security improvements are valued, though slightly less than other benefits. In the free-text fields, users expressed a preference for vehicles to be clustered together. They emphasized the convenience of not having to search for vehicles extensively, preferring to go to a station and find a vehicle ready for use. Users also noted that vehicles should not be scattered around everywhere.

The most significant concern regarding the introduction of a station-based model is the potential for overcrowded stations and the limited flexibility compared to the free-floating operation (Figure 8-20). These issues could be addressed by establishing geofenced mobility stations and providing a buffer zone that allows users to leave a vehicle near the station. Additionally, increasing the number of stations would enhance flexibility and accessibility for users. This is supported by the fact that the majority of users prefer stations to be conveniently located within

a short walking distance (Figure 8-21). Therefore, providing sufficient coverage with pick-up and drop-off points (or mobility stations) is crucial to ensuring the service's user experience.

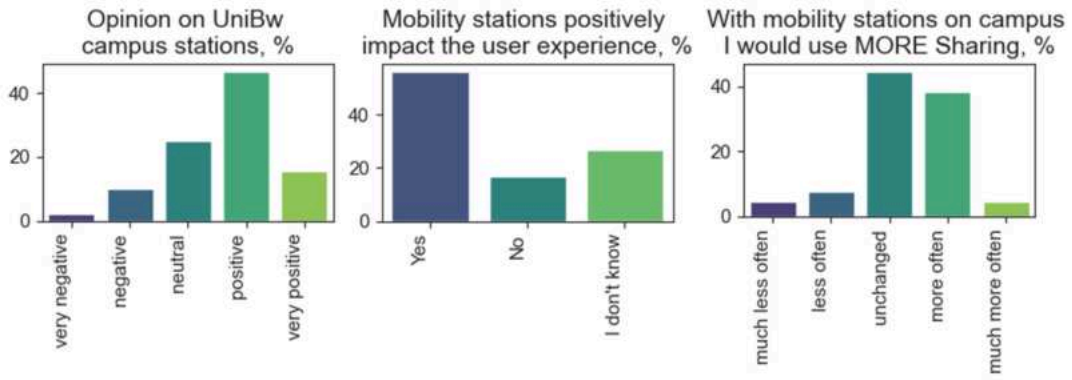

Figure 8-19: Opinion about introducing mobility stations on the UniBw campus

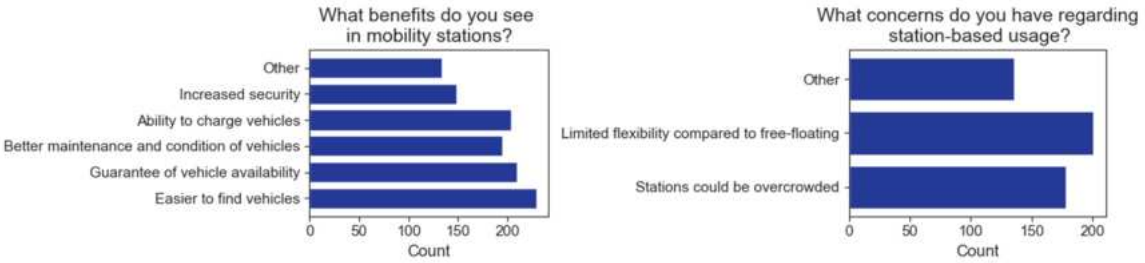

Figure 8-20: Advantages and concerns regarding mobility stations on campus

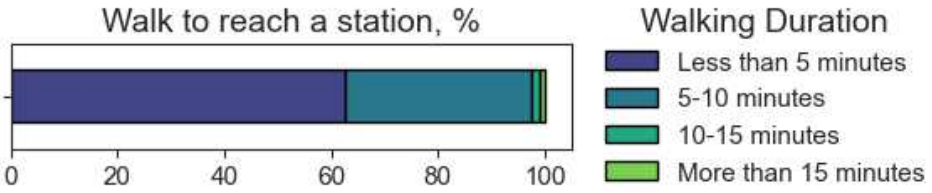

Figure 8-21: How far would you walk to reach a MORE Sharing mobility station?

8.4 Conclusion

This chapter discussed the user characteristics, feedback on system user experience, and operational setup of MORE Sharing. The data was collected through several surveys: "MORE Sharing Registration Survey," "MORE Sharing User Experience Survey," and "MORE Sharing Subsequent Survey," which took place at different times during March 2023 and March 2024. The registration survey revealed that users with no trips tend to be older, whereas more frequent users are typically younger. Females are less likely to be in more frequent user groups compared to males. Therefore, strategies must be developed to increase female participation and support diverse gender categories to ensure a more balanced user base.

Adults without children constitute the majority in all groups, with families with children being more prevalent in lower usage categories. Introducing features that appeal to families with children may increase their engagement and usage of the service. Middle-income users are the most prevalent across infrequent, frequent, and super user groups, while higher-income individuals are more represented in lower usage categories. Employment type also correlates with usage frequency, with students and research staff predominant in higher usage categories.

Super users have the highest daily usage of bicycles and public transport. Car usage is most prevalent among users with no trips and one-time users. Therefore, ensuring extensive and flexible integration with public transit and expanding the availability of vehicles in proximity to public transport stops can increase the attractiveness of the shared micromobility service.

The "MORE Sharing User Experience" survey provided insights into user experiences and perceptions of the MORE Sharing service. Overall, users had a generally positive experience with MORE Sharing. Time savings and convenience were the primary reasons for using the service, followed by curiosity and cost savings. Environmental protection and health benefits were less prominent motivations.

Positive MORE Sharing feedback highlighted the variety and accessibility of transportation options, ease of use, and cost-effectiveness. Users appreciated the integration of MORE Sharing with public transit and the availability of different types of vehicles. The app's design and functionality, straightforward registration process, and customer service were also well-received. However, several challenges were identified. The most significant concern was the reliability of vehicle availability, with users often facing technical issues related to GPS inaccuracies, software bugs, and connectivity problems. Improving the technical infrastructure would enhance user satisfaction and trust in the service, and reduce the customer churn. For example, the connectivity issues could be solved by using a Bluetooth connection between the vehicles and mobile devices instead of relying solely on a GPS connection. Furthermore, misuse of the service, such as vehicle hoarding by some users due to the €300 free mobility budget, was also a concern. Implementing stricter measures to prevent such misuse and ensuring a higher turnover of vehicles can improve availability. This could include adjusting the pricing structure or implementing penalties for blocking vehicles.

Some users expressed needing clarification about the project details, vehicle usage, and operational procedures. Enhancing user education through clearer communication, comprehensive FAQs, and tutorials can help alleviate these issues. Regular updates and transparent communication about system changes and improvements can also build user trust.

MORE Sharing has successfully introduced a notable portion of users to new modes of transportation. E-bikes and e-scooters emerged as the most preferred vehicles within the MORE Sharing system. The use cases for different vehicles varied: e-scooters and e-mopeds were preferred for fun, city bikes and e-bikes for reaching public transport and work-related tasks, and e-cargo bikes for transporting goods. E-scooters and e-bikes were also favored in bad weather, while many users preferred not to use shared vehicles in such conditions.

City bikes were perceived as the most sustainable and highly rated for availability, flexibility, independence, spontaneity, reliability, and predictability. E-mopeds and e-cargo bikes scored

lower, partly due to their fewer numbers and the problem of vehicle hoarding. E-bikes and e-mopeds were considered the safest, while e-scooters and e-cargo bikes were viewed as less safe. E-cargo bikes excelled in transporting goods, while e-scooters were deemed unsuitable for this purpose but rated high for maneuverability. E-mopeds were rated the best for cleanliness and comfort during the ride. To cater to varied user preferences and use cases, MORE Sharing should maintain a diverse fleet of vehicles, including city bikes, e-bikes, e-scooters, and e-cargo bikes. Ensuring good battery range and strategic placement of these vehicles is essential.

There was a generally positive attitude towards introducing mobility stations on the university campus, replacing the existing free-floating model. The most frequently cited benefit of mobility stations is the increased ease of finding vehicles and addressing issues related to faulty GPS signals. Other noted advantages include guaranteed vehicle availability, improved maintenance and condition of vehicles, charging capabilities, and enhanced security. The primary concerns about station-based models were potential overcrowding and reduced flexibility compared to free-floating systems.

Mobility stations should be conveniently located within a walking distance for most users to maximize user satisfaction. Sufficient coverage with pick-up and drop-off points is crucial for ensuring the user experience and appeal of the service. Proactively addressing concerns about overcrowded stations by increasing the number of stations and managing the distribution of vehicles can prevent potential issues and enhance the overall user experience.

These results show that regularly seeking user feedback and making iterative improvements based on this input is crucial. Implementing a system for ongoing user surveys and feedback can help identify emerging issues and areas for enhancement, ensuring the service remains responsive to user needs.

9 Conclusion and Outlook

9.1 Conclusions and Implications for Other Shared Micromobility Projects

This thesis explored the intricacies of shared micromobility made available for short-term access through smartphone applications. While existing research has centered mainly on large urban environments, our investigation extended into smaller communities and university campuses, revealing how shared micromobility caters to these settings. Despite the shared benefits of promoting active transportation and improving first- and last-mile connections, the challenges and objectives of implementing such systems vary significantly between metropolitan areas and smaller or academic communities. Metropolitan areas grapple with issues of accessibility, safety, and social equity. In contrast, these concerns are less pronounced in university settings, which benefit from a unique user demographic and limited geographic spread.

The emerging cases of shared micromobility in non-urban settings suggest a growing potential for adoption, driven by increasing collaboration between service providers and local institutions. This indicates a shift towards enhancing community transportation infrastructure. A pivotal part of this research was the case study of the MORE Sharing system implemented at a university in March 2023. This system integrated 100 shared vehicles into a fleet operated through a public tendering process by a contractor. These vehicles, equipped with IoT devices, facilitated real-time location tracking and app-based interactions, providing an alternative to private vehicle use.

Through analyzing operational data from MORE Sharing from its inception in March 2023 until March 2024, this thesis explored shared mobility dynamics, user engagement, and the transformative potential of micromobility in diverse settings. The insights gleaned from this context-specific analysis are helpful for developing, planning, and scaling micromobility systems, particularly as institutions look to modernize and expand their transportation options with efficient, technologically advanced systems. This research underscores the importance of tailoring shared micromobility solutions to meet the specific needs and characteristics of various environments, paving the way for broader adoption and optimized utility in urban and non-urban settings.

In Chapter 4, we delved into how specific factors such as weather conditions, times of day, and user demographics impact the usage patterns of a shared micromobility system in a non-urban academic setting. This analysis provides actionable insights for organizations looking to launch similar initiatives in non-urban areas or on campuses. During the initial phase of MORE Sharing, we observed a significant increase in user registration, primarily driven by an attractive 300-euro monthly mobility budget. This initial surge demonstrates the effectiveness of tailored financial incentives, suggesting that similar strategies could encourage early adoption. However,

as initial enthusiasm tends to wane over time, it becomes essential to implement continuous engagement strategies. Regular updates, improvements in service, and proactive monitoring of user feedback and system performance are crucial to sustaining user interest and satisfaction.

Understanding the demographic profile of potential users is also crucial. Our study identified a predominantly young male demographic showing high levels of engagement, indicating a need for marketing strategies and service offerings tailored to this group's preferences. At the same time, there is an opportunity to broaden the appeal of these services to include a broader demographic, thus enhancing inclusivity and expanding the user base. Engaging local stakeholders during the planning and implementation phases can help build a sense of ownership and community support, vital for the adoption and long-term sustainability of these services in close-knit non-urban and campus communities.

Our analysis of fleet usage indicated that different vehicle types - e-bikes, e-cargo bikes, e-mopeds, e-scooters, and city bikes - cater to diverse transportation needs. E-scooters and e-bikes were popular due to their versatility for various trip lengths and purposes. E-mopeds had the longest trips. This points to the importance of maintaining a diverse fleet to meet the varied transportation needs of the community effectively.

Deeper insights were gained using Negative Binomial Regression models, which revealed that adverse weather conditions typically reduce usage, whereas milder, warmer conditions encourage more frequent and extended trips. This underscores the need to plan around seasonal weather patterns to optimize service availability and usage. Significant temporal factors such as time of day, day of the week, and seasonal changes influenced mobility patterns, with peaks during weekday mornings and mid-afternoons and dips during weekends and holidays. These temporal insights are crucial for forecasting demand and optimizing resource allocation.

Furthermore, the application of machine learning techniques, including Random Forest, Gradient Boosted Regression Trees, and Neural Networks, provided predictive insights into usage patterns. These tools highlighted the significant roles of vehicle type, weather, and temporal variables in influencing system utilization and can enhance fleet management and operational efficiency. Employing these advanced analytical methods allows for a more nuanced anticipation of demand, enabling better vehicle deployment and overall service improvement.

Chapter 5 presented an analysis of the starting and ending points of trips and the routes taken within the MORE Sharing system. By examining the usage patterns and trip purposes across various shared micromobility modes within the platform, our study explores the interactions between multiple micromobility options. Our research confirmed that shared micromobility modes are critical for providing last-mile solutions that enhance connectivity to the broader public transport network. Notably, the prevalence of one-way trips suggests these modes are crucial for enabling efficient, direct travel to specific destinations. With e-cargo bikes and e-mopeds, we observed a tendency for users to engage in round trips. This pattern aligns with studies of station-based systems where round trips are typical due to the vehicles' capacity to transport heavier items, making them suitable for work-related tasks, personal errands, shopping, and leisure activities on campus.

These insights into the complementary roles of different micromobility modes within a shared system highlight the importance of multimodal platforms, especially in microenvironments like residential neighborhoods, non-urban communities, campuses, and corporate settings. These platforms can address a wide range of transport demands with flexible and diverse solutions, enhancing overall connectivity and contributing to resilience in transportation systems. For organizations considering launching similar shared micromobility projects in non-urban areas or campuses, it is vital to tailor the micromobility offerings to the specific travel patterns and needs of the local population, considering the typical trip purposes and preferred routes. Furthermore, aligning micromobility solutions with existing public transport networks can significantly enhance the utility of both services, providing a seamless travel experience for users.

In Chapter 6, we analyzed the usage patterns, preferences, and factors influencing micromobility choices within the MORE Sharing system from March 2023 to March 2024. We discovered that males, predominantly around the age of 25, were the primary users across all vehicle categories. Utilizing analytical tools such as the Multinomial Logit Model (MNL) and machine learning techniques like Random Forest (RFC), Gradient Boosting (GBC), and Neural Network (NNC) Classifiers, we pinpointed strong vehicle preferences. E-scooters saw a spike in popularity during the system's initial launch in spring, whereas e-mopeds gained traction in the summer, reflecting an apparent seasonal adaptation curve.

Our findings also highlighted the significant impact of external factors, such as weather conditions and technical disruptions, on vehicle usage. These findings underscore the necessity for robust system management to ensure consistent service availability and reliability, especially during adverse conditions or technical failures. E-mopeds and e-cargo bikes, often utilized for looped routes, proved beneficial for tasks requiring substantial cargo capacity or extended use durations. Implementing dedicated hubs for these vehicles could lead to more efficient trips, improving accessibility and convenience, thus potentially attracting a broader user base. Conversely, e-bikes, city bikes, and e-scooters were predominantly chosen for point-to-point travel, effectively serving as links in bridging the last-mile gap, especially near public transportation stops. Strategic placement of these vehicles, informed by an understanding of popular routes and destinations, could further enhance last-mile connectivity with public transportation systems.

Vehicle choice also influenced the replacement of traditional transport modes. City bikes, e-bikes, and e-scooters mainly replaced walking and the use of private bikes, while e-cargo bikes and e-mopeds substituted for car travel, attributed to their higher speed and greater carrying capacity. Marketing strategies could be crafted to emphasize the unique benefits of each vehicle type, such as the cargo capacity of e-cargo bikes for shopping trips or the convenience of e-scooters for quick commutes. Overall, user satisfaction was high across all vehicle types, with e-mopeds registering an 80% satisfaction rate. However, there remains room for improvement, particularly with city bikes and e-cargo bikes, suggesting potential areas for service enhancement.

In Chapter 7, we studied user engagement within MORE Sharing, where we segmented registered users into five categories based on their trip frequency: non-users, one-time users, infrequent users, frequent users, and super users. This categorization, facilitated through

K-Means clustering and analysis of monthly trip data, helped us understand the dynamics of user behavior. Our study revealed significant inactivity among registered users, with a notably low transition rate from initial to more active use levels. The data indicated a substantial drop-off rate among one-time users, suggesting that initial engagement only sometimes leads to sustained use. To counter this, developing targeted engagement strategies for different user segments could enhance overall system utilization. Furthermore, there was only a minimal increase in users progressing to higher frequency usage brackets, highlighting the need to effectively segment users to tailor services accordingly and potentially increase user retention and satisfaction.

Behavioral trends suggest that user engagement levels are dynamic and evolve, predominantly consisting of infrequent and one-time users alongside a considerable number of registered but inactive individuals. Regarding transportation preferences, one-time and infrequent users favored e-bikes and e-scooters. Offering a variety of vehicles can appeal to a broader user base and encourage experimentation with different modes of transportation, which may increase overall system engagement. In contrast, more engaged segments, particularly frequent and super users, were likely to utilize a diverse array of vehicles, suggesting that higher levels of engagement correlate with a willingness to explore different vehicle options provided by the service.

Demographic factors and trip patterns were significant in classifying user groups and determining the likelihood of service churn. Understanding these demographic and behavioral patterns can inform more effective service offerings, adapting to the specific needs of different user groups. Given that the system operates on a non-urban campus where users receive a mobility allowance rather than paying directly for services, the applicability of our findings to other settings without such incentives might be limited. This context underscores the importance of creating and optimizing incentive structures that align with user behaviors and preferences in systems where direct user payment is not applicable. Such insights necessitate a cautious approach when extrapolating these results to broader micromobility contexts, ensuring that incentive structures and user engagement strategies are as inclusive and efficient as possible.

Chapter 8 focused on the user characteristics, system user experience feedback, and operational setup of MORE Sharing, utilizing data from multiple surveys conducted between March 2023 and March 2024. The insights provided a deep dive into the demographic trends, engagement levels, and user preferences that are crucial for other shared micromobility projects aiming to optimize user engagement and system efficiency.

The results depicted that younger users are more actively engaged, while older demographics tend to participate less frequently. This demographic trend suggests that micromobility systems need service adaptations to better engage older users. Additionally, females were found to be less likely than males to be frequent users, highlighting the need for initiatives aimed at increasing female participation, such as enhancing safety features or designing programs specifically to appeal to women to ensure a more balanced user base.

We also noted that families, particularly those with children, often fall into lower usage categories. By introducing family-friendly features or discounts, micromobility systems could

increase engagement from this demographic. Furthermore, middle-income users dominate the active user groups, suggesting that pricing strategies should be carefully considered to effectively engage different economic groups. Employment type, particularly among students and research staff, correlates strongly with higher usage, indicating that promotional activities and service features should align with academic and research schedules.

Frequent and super users showed high usage of bicycles and public transport, underscoring the importance of integrating micromobility systems with existing transit networks. Enhancing vehicle availability near public transport stops could make these services more attractive and accessible, increasing usage.

Feedback from the "MORE Sharing User Experience Survey" was generally positive, with time savings and convenience cited as primary benefits. However, significant challenges such as GPS inaccuracies and connectivity issues were concerns. Improving the technical infrastructure, such as adopting Bluetooth connectivity to enhance location accuracy and reliability, could mitigate these issues. Addressing service misuse and increasing vehicle turnover through pricing adjustments or penalties for hoarding could also improve service reliability. Some confusion among users about project details and operational procedures indicates the need for better user education. Enhancing communication through comprehensive FAQs, tutorials, and regular updates can help clarify usage protocols and increase user comfort and trust in the system.

Feedback on vehicle types showed a clear preference for diverse options, with e-bikes and e-scooters emerging as favorites. Maintaining a diverse fleet that includes city bikes for practical daily travel and e-cargo bikes for transporting goods is essential. Strategic placement of these vehicles, ensuring they are readily accessible, particularly near public transportation hubs, is also critical.

The introduction of mobility stations was generally viewed positively, as it addressed issues of vehicle availability and maintenance. However, there were concerns about the potential for overcrowding and reduced flexibility. Proactively managing the number and location of these stations can prevent these issues and enhance the overall user experience.

Regularly collecting user feedback is vital for iterative improvements. Implementing a structured feedback mechanism can help identify and address emergent issues, ensuring the service adapts to changing user needs and expectations.

The insights from this thesis are instrumental for other organizations aiming to implement or improve shared micromobility services. Understanding and responding to user demographics, integrating services with public transport, ensuring robust system user experience, and maintaining open communication are key strategies that can lead to successful implementation and sustained user engagement in shared micromobility projects.

9.2 Outlook and Need for the Future Research

This thesis has explored the nuances of shared micromobility. While prior research has primarily focused on large urban environments, this study extends into smaller communities and

university campuses, unveiling how shared micromobility suits these settings. One of the primary limitations of this study is its focus on a specific non-urban university setting, which may only partially represent other non-urban or differently scaled environments. The generalizability of the findings might be limited as factors such as local policy, community engagement, and geographical layout, which can significantly influence the success and utilization of micromobility systems, vary widely across different settings. Additionally, the reliance on data from a single system and a limited one-year timeframe may not capture long-term trends or the impact of external variables like economic shifts or long-term infrastructural changes.

The emergence of shared micromobility in non-urban settings indicates a growing potential for adoption, spurred by increasing collaborations between service providers and local institutions. This trend underscores a shift toward enhancing community transportation infrastructures and suggests a fertile ground for future research. Future studies could expand the scope to include multiple micromobility systems across various non-urban settings to compare and contrast the factors influencing their success or failure.

Furthermore, applying advanced analytical methods such as Negative Binomial Regression models and machine learning techniques like Random Forest, Gradient Boosted Regression Trees, and Neural Networks has highlighted the significant roles of vehicle type, weather, and temporal variables in influencing system utilization. This approach can be further refined to include real-time data processing and predictive analytics, enabling dynamic system adjustments and improved user experience.

Future research should consider longitudinal studies that track user engagement over several years to better understand the long-term viability and impact of micromobility systems. Additionally, exploring the economic impacts of these systems on local communities could provide deeper insights into their role in urban development and sustainability.

Expanding the demographic scope to include a broader range of user groups and conducting comparative studies between urban and non-urban settings could also provide more comprehensive insights into the adaptability and scalability of shared micromobility systems. Moreover, integrating qualitative research methods, such as user interviews or focus groups, could enrich the understanding of user satisfaction and system user experience.

Given the identified challenges related to system reliability and vehicle availability, further research could also focus on technological innovations that enhance system integrity and user trust. Exploring alternative vehicle tracking and data transmission technologies, or studying the impacts of different incentive models on user behavior and system efficiency, could provide practical solutions to some of the challenges identified in this thesis.

This thesis lays a foundation for understanding shared micromobility in non-urban settings. It opens up avenues for future research to build upon, ensuring that shared micromobility continues to evolve as a viable and sustainable component of urban and non-urban transportation ecosystems.

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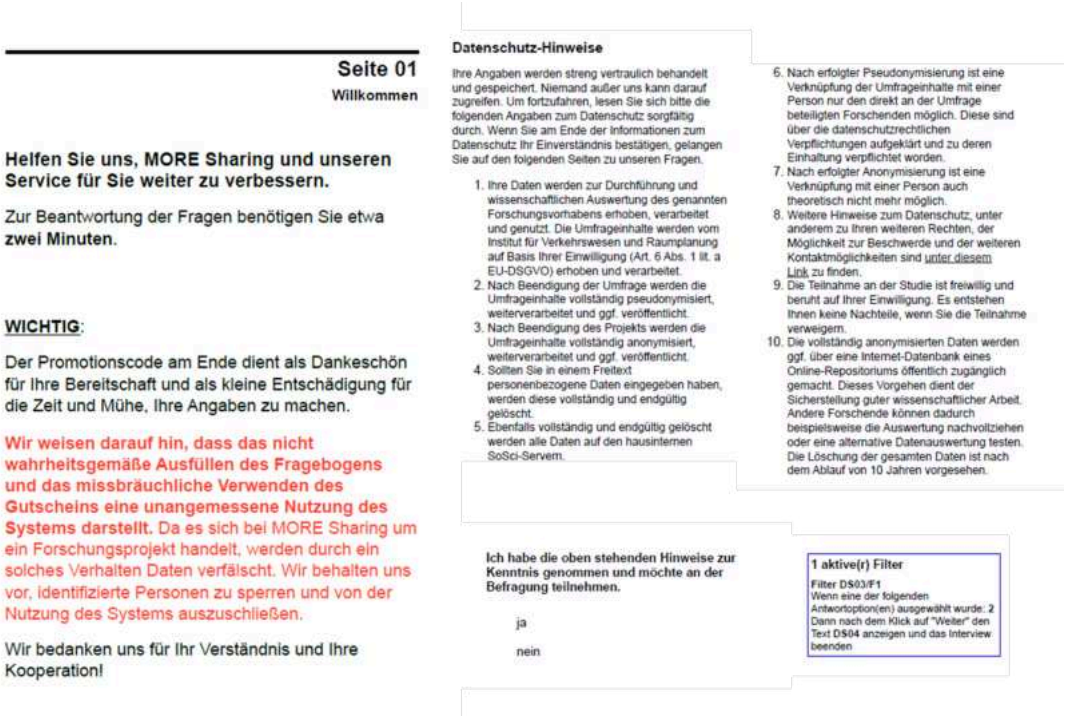
11 Appendices

11.1 Appendix 1. Post-trip MORE Sharing Survey in German



Seite 01

Willkommen

Helfen Sie uns, MORE Sharing und unseren Service für Sie weiter zu verbessern.

Zur Beantwortung der Fragen benötigen Sie etwa **zwei Minuten.**

WICHTIG:

Der Promotionscode am Ende dient als Dankeschön für Ihre Bereitschaft und als kleine Entschädigung für die Zeit und Mühe, Ihre Angaben zu machen.

Wir weisen darauf hin, dass das nicht wahrheitsgemäße Ausfüllen des Fragebogens und das missbräuchliche Verwenden des Gutscheins eine unangemessene Nutzung des Systems darstellt. Da es sich bei MORE Sharing um ein Forschungsprojekt handelt, werden durch ein solches Verhalten Daten verfälscht. Wir behalten uns vor, identifizierte Personen zu sperren und von der Nutzung des Systems auszuschließen.

Wir bedanken uns für Ihr Verständnis und Ihre Kooperation!

Datenschutz-Hinweise

Ihre Angaben werden streng vertraulich behandelt und gespeichert. Niemand außer uns kann darauf zugreifen. Um fortzufahren, lesen Sie sich bitte die folgenden Angaben zum Datenschutz sorgfältig durch. Wenn Sie am Ende der Informationen zum Datenschutz Ihr Einverständnis bestätigen, gelangen Sie auf den folgenden Seiten zu unseren Fragen.

1. Ihre Daten werden zur Durchführung und wissenschaftlichen Auswertung des genannten Forschungsvorhabens erhoben, verarbeitet und genutzt. Die Umfrageinhalte werden vom Institut für Verkehrswesen und Raumplanung auf Basis Ihrer Einwilligung (Art. 6 Abs. 1 lit. a EU-DSGVO) erhoben und verarbeitet.
2. Nach Beendigung der Umfrage werden die Umfrageinhalte vollständig pseudonymisiert, weiterverarbeitet und ggf. veröffentlicht.
3. Nach Beendigung des Projekts werden die Umfrageinhalte vollständig anonymisiert, weiterverarbeitet und ggf. veröffentlicht.
4. Sollten Sie in einem Freitext personenbezogene Daten eingegeben haben, werden diese vollständig und endgültig gelöscht.
5. Ebenfalls vollständig und endgültig gelöscht werden alle Daten auf den hausinternen SoSci-Servern.
6. Nach erfolgter Pseudonymisierung ist eine Verknüpfung der Umfrageinhalte mit einer Person nur den direkt an der Umfrage beteiligten Forschenden möglich. Diese sind über die datenschutzrechtlichen Verpflichtungen aufgeklärt und zu deren Einhaltung verpflichtet worden.
7. Nach erfolgter Anonymisierung ist eine Verknüpfung mit einer Person auch theoretisch nicht mehr möglich.
8. Weitere Hinweise zum Datenschutz, unter anderem zu Ihren weiteren Rechten, der Möglichkeit zur Beschwerde und der weiteren Kontaktmöglichkeiten sind unter diesem Link zu finden.
9. Die Teilnahme an der Studie ist freiwillig und beruht auf Ihrer Einwilligung. Es entstehen Ihnen keine Nachteile, wenn Sie die Teilnahme verweigern.
10. Die vollständig anonymisierten Daten werden ggf. über eine Internet-Datenbank eines Online-Repositoriums öffentlich zugänglich gemacht. Dieses Vorgehen dient der Sicherstellung guter wissenschaftlicher Arbeit. Andere Forschende können dadurch beispielsweise die Auswertung nachvollziehen oder eine alternative Datenauswertung testen. Die Löschung der gesamten Daten ist nach dem Ablauf von 10 Jahren vorgesehen.

Ich habe die oben stehenden Hinweise zur Kenntnis genommen und möchte an der Befragung teilnehmen.

ja

nein

1 aktive(r) Filter

Filter DS03/F1
Wenn eine der folgenden Antwortoption(en) ausgewählt wurde: **2**
Dann nach dem Klick auf "Weiter" den Text **DS04** anzeigen und das Interview beenden

Seite 02
Evaluation



Welches MORE Sharing Verkehrsmittel haben Sie für Ihre letzte Fahrt benutzt?

- City Bike
- E-Bike
- E-Cargo Bike
- E-Roller
- E-Scooter

- Ich weiß es nicht mehr

Bitte geben Sie den Tag und die Uhrzeit an, wann Sie Ihre letzte Fahrt begonnen haben.
Schätzen Sie die Angaben, so gut Sie können.

Start-Datum: _____

Start-Uhrzeit: h:mm

Bitte machen Sie folgende Angaben zu Ihrer letzten Fahrt.
Schätzen Sie die Angaben, so gut Sie können.

Dauer der Gesamtmiete (inkl. Reservieren & Parken): _____ min

davon reine Fahrtzeit: _____ min

zurückgelegte Strecke: _____ km

Wie zufrieden sind Sie mit Ihrer letzten Fahrt?

sehr unzufrieden — sehr zufrieden

Gab es bei Ihrer letzten Fahrt Probleme, die Sie in dieser Befragung berichten wollen?
Falls ja, werden Ihnen auf der nächsten Seite konkrete Fragen dazu gestellt.

- nein
- ja

1 aktive(r) Filter
Filter PB13/F1
Wenn eine der folgenden Antwortoption(en) ausgewählt wurde: **2**
Dann Seite(n) Probleme des Fragebogens anzeigen (sonst ausblenden)

Seite 03
Probleme

Probleme bei der letzten Fahrzeugmiete

Im folgenden Abschnitt geht es nun um mögliche Probleme bei Ihrer letzten Miete bei MORE Sharing.

Hierfür werden Ihnen einzelne Schritte aufgelistet, bei denen Schwierigkeiten auftreten könnten.

Hatten Sie Probleme, das Fahrzeug, das Sie zunächst in der Realität gesehen und ausgesucht haben, daraufhin in der App zu finden?
Wenn ja, welche?

- nein
- ja

Welche Probleme sind aufgetreten?

- trifft auf meine letzte Fahrt nicht zu

Hatten Sie Probleme, das Fahrzeug, das Sie zunächst in der App gesehen und ausgesucht haben, daraufhin tatsächlich zu finden?
Wenn ja, welche?

- nein
- ja

Welche Probleme sind aufgetreten?

- trifft auf meine letzte Fahrt nicht zu

Hatten Sie Probleme beim Buchen/Reservieren des Fahrzeugs?
Wenn ja, welche?

- nein
- ja

Welche Probleme sind aufgetreten?

Hatten Sie Probleme beim Entsperren des Fahrzeugs?
Wenn ja, welche?

- nein
- ja

Welche Probleme sind aufgetreten?

Hatten Sie Probleme bei der Nutzung des Fahrzeugs?
Wenn ja, welche?

- nein
- ja

Welche Probleme sind aufgetreten?

Hatten Sie Probleme beim Parken des Fahrzeugs?
Wenn ja, welche?

- nein
- ja

Welche Probleme sind aufgetreten?

Hatten Sie Probleme mit dem Beenden der Fahrzeugmiete?
Wenn ja, welche?

- nein
- ja

Welche Probleme sind aufgetreten?

Gab es Probleme bei der Sauberkeit des Fahrzeugs?
Wenn ja, welche?

- nein
- ja

Welche Probleme sind aufgetreten?

Gab es Probleme mit dem technischen Zustand des Fahrzeugs?
Wenn ja, welche?

- nein
- ja

Welche Probleme sind aufgetreten?

Gab es noch weitere Probleme bei Ihrer letzten Fahrzeugmiete?
Bitte beschreiben Sie uns kurz das Problem, wenn sie neben den oben genannten noch andere Schwierigkeiten hatten.

Seite 04
Trip Wahl

Hätten Sie diese Fahrt auch unternommen, wenn es MORE Sharing nicht geben würde?

- ja
- nein

1 aktive(r) Filter
Filter MS16/F1
Wenn eine der folgenden Antwortoption(en) ausgewählt wurde: **1**
Dann Frage/Text **MS22** später im Fragebogen anzeigen (sonst ausblenden)

Würden Sie sich in Zukunft bei der gleichen oder einer ähnlichen Fahrt wieder für MORE Sharing entscheiden?

- ja, mit dem gleichen Verkehrsmittel
- ja, aber ich würde ein anderes Verkehrsmittel wählen
- nein

- Ich bin mir unsicher / Ich weiß es nicht

1 aktive(r) Filter
Filter SH03/F1
Wenn eine der folgenden Antwortoption(en) ausgewählt wurde: **2**
Dann Frage/Text **MS25** später im Fragebogen anzeigen (sonst ausblenden)

Seite 05
Filter

Wenn es MORE Sharing nicht geben würde:
Welches Verkehrsmittel hätten Sie für diesen Weg am liebsten genutzt?

- PKW
- zu Fuß
- eigenes Fahrrad
- ÖPNV
- Sonstiges

Wenn Sie sich bei diesem oder einem ähnlichen Weg für ein anderes Verkehrsmittel entschieden hätten:
Welches MORE Sharing Verkehrsmittel hätten Sie am liebsten benutzt (sofern verfügbar)?

- City Bike
- E-Bike
- E-Cargo Bike
- E-Roller
- E-Scooter

Seite 06
Freitext

Gibt es noch weitere Erfahrungen oder Kommentare, die Sie uns zu Ihrer letzten Fahrt mit MORE Sharing mitteilen möchten?
Bitte teilen Sie uns Ihre Beobachtungen mit.
Konkrete Beschreibungen von technischen Problemen senden Sie bitte zusätzlich auch an die Serviceadresse moresharing@evhcle.com">moresharing@evhcle.com (idealerweise mit Screenshots).

Seite 07
Infos

Details zu Ihrer letzten Fahrt

In diesem Abschnitt würden wir gerne noch ein paar allgemeine Informationen zu Ihrer letzten Fahrt mit MORE Sharing erfahren.

Bitte wählen Sie den Zweck Ihrer Fahrt aus.

Mehrfachauswahl möglich. Bitte wählen Sie alle zutreffenden Zwecke für Ihre Fahrt aus, wenn Sie diese für mehr als einen Zweck genutzt haben.

- Fahrt zur Arbeit / Ausbildung
- dienstliche Erledigung / Besorgung
- private Erledigung / Besorgung
- Einkauf
- Freizeitaktivität
- Erreichen des ÖPNV
- Weg nach Hause
- Spaßfahrt
- jemanden absetzen / abholen
- Sonstiges

Wieso haben Sie sich bei diesem Weg für MORE Sharing entschieden?

Mehrfachauswahl möglich

- Verfügbarkeit in der Umgebung
- Erreichbarkeit des Ziels
- Fahrspaß mit Sharing-Verkehrsmitteln
- Gesundheit und Fitness
- Wetterbedingungen
- Umweltschutzgründe
- Kostenersparnis
- Zeitersparnis
- Komfort
- Sonstiges

- Kann ich nicht sagen

Mussten Sie bei dieser Fahrt pünktlich am Ziel sein bzw. hatten Sie Zeitdruck?



nein, überhaupt nicht | nein, kaum | teils, teils | ja, ein wenig | ja, sehr

Haben Sie während Ihrer MORE Sharing-Fahrt einen Helm getragen?

- ja
- nein

Mussten Sie während Ihrer Reise Personen oder schwere Gegenstände transportieren?

- ja, Personen
- ja, schwere Gegenstände oder Gepäck
- nein

Wichtiger Hinweis

Die Fahrzeuge von MORE Sharing dürfen generell nur von einer Person genutzt werden!

Ausnahmen gelten lediglich für den E-**Roller**, auf dem eine zweite Person mitgenommen werden kann, und das **Lastenrad**, in dem ausschließlich Kleinkinder vorne sitzen dürfen.

Im Lastenrad gilt dabei ein maximales Zuladungsgewicht von 100kg.

Generell sind die Vorschriften der StVO zu beachten und Mitfahrende durch Tragen eines Helmes (und im Lastenrad durch Anschnallen) zu sichern.

Details hierzu sind in den AGB von MORE Sharing zu finden.

Seite 08
Missings

text('DS16')

Leider haben Sie zu wenig Angaben gemacht, um einen persönlichen Gutschein-Code zu erhalten.

Wir bedanken uns dennoch für Ihre Teilnahme und hoffen, Sie auch in Zukunft bei MORE Sharing begrüßen zu dürfen.

Seite 09
Code

Vielen Dank!

Wir danken Ihnen herzlich, dass Sie sich die Zeit genommen haben, unsere Fragen zu beantworten.

Ihr persönlicher Gutscheincode lautet

UmqwbJxy

Bitte fügen Sie diesen Aktionscode im Menü der MORE Sharing App unter "Profil" → "Gutscheine" → "+" ein.

Letzte Seite

Vielen Dank für Ihre Teilnahme!

Wir möchten uns ganz herzlich für Ihre Mithilfe bedanken.

Ihre Antworten wurden gespeichert, Sie können das Browser-Fenster nun schließen.

Prof. Dr. Anja Katharina Huemer & M.Sc. Maryna Pobudzei – Institut für Verkehrswesen und Raumplanung, 2023

11.2 Appendix 2. MORE Sharing Registration Survey in German



Seite 01
DS

Hinweis

Diese Umfrage soll lediglich einmal im Rahmen der Erstregistrierung bei MORE Sharing ausgefüllt werden. Der Gutscheincode am Ende dient als Dankeschön und kleine Entschädigung.

Leider gibt es vereinzelt Fälle, in denen die Befragung mehrmals ausgefüllt wird, um das Mobilitätsbudget künstlich zu erhöhen. Wir weisen daher darauf hin, dass das missbräuchliche mehrmalige Ausfüllen und Verwenden des Gutscheins eine unangemessene Nutzung des Systems darstellt. Da es sich bei MORE Sharing um ein Forschungsprojekt handelt, werden hierdurch Daten verfälscht. Wir behalten uns vor, identifizierte Personen zu sperren und von der Nutzung des Systems auszuschließen.

Wir bedanken uns für Ihr Verständnis und Ihre Kooperation!

Vielen Dank für Ihr Interesse an MORE Sharing der Universität der Bundeswehr München

Die Beantwortung des Fragebogens dauert etwa zehn Minuten. Wenn Sie einen gewissen Anteil an Fragen beantwortet haben, erhalten Sie am Ende als Dank für Ihre Zeit und Mühe einen **50-Euro-Gutschein**, den Sie zur Deckung der Kosten für **MORE Sharing** verwenden können. Ihre Teilnahme hilft uns, die Mobilitätsbedürfnisse auf dem Campus besser zu verstehen und Verbesserungen am Verkehrssystem vorzunehmen.

Datenschutz-Hinweise

Ihre Angaben werden streng vertraulich behandelt und gespeichert. Niemand außer uns kann darauf zugreifen. Um fortzufahren, lesen Sie sich bitte die folgenden Angaben zum Datenschutz sorgfältig durch. Wenn Sie am Ende der Informationen zum Datenschutz Ihr Einverständnis bestätigen, gelangen Sie auf den folgenden Seiten zu unseren Fragen.

1. Ihre Daten werden zur Durchführung und wissenschaftlichen Auswertung des genannten Forschungsvorhabens erhoben, verarbeitet und genutzt. Die Umfrageinhalte werden vom Institut für Verkehrswesen und Raumplanung auf Basis Ihrer Einwilligung (Art. 6 Abs. 1 lit. a EU-DSGVO) erhoben und verarbeitet.
2. Nach erfolgter Pseudonymisierung ist eine Verknüpfung der Umfrageinhalte mit einer Person nur den direkt an der Umfrage beteiligten Forschenden möglich. Diese sind über die datenschutzrechtlichen Verpflichtungen aufgeklärt und zu deren Einhaltung verpflichtet worden.
3. Nach Beendigung der Umfrage werden die Umfrageinhalte vollständig pseudonymisiert, weiterverarbeitet und ggf. veröffentlicht.
4. Nach Beendigung des Projekts werden die Umfrageinhalte vollständig anonymisiert, weiterverarbeitet und ggf. veröffentlicht.
5. Sollten Sie in einem Freitext personenbezogene Daten eingegeben haben, werden diese vollständig und endgültig gelöscht.
6. Ebenfalls vollständig und endgültig gelöscht werden alle Daten auf den hausinternen SoSci-Servern.
7. Nach erfolgter Anonymisierung ist eine Verknüpfung mit einer Person auch theoretisch nicht mehr möglich.
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10. Die vollständig anonymisierten Daten werden ggf. über eine Internet-Datenbank eines Online-Repositoriums öffentlich zugänglich gemacht. Dieses Vorgehen dient der Sicherstellung guter wissenschaftlicher Arbeit. Andere Forschende können dadurch beispielsweise die Auswertung nachvollziehen oder eine alternative Datenauswertung testen. Die Löschung der gesamten Daten ist nach dem Ablauf von 10 Jahren vorgesehen.

Ich habe die oben stehenden Hinweise zur Kenntnis genommen und möchte an der Befragung teilnehmen.

- ja
- nein

1 aktive(r) Filter

Filter DS03/F1
Wenn eine der folgenden Antwortoption(en) ausgewählt wurde: **2**
Dann nach dem Klick auf "Weiter" den Text **DS04** anzeigen und das Interview beenden

Seite 02
DE

Vielen Dank für Ihre Bereitschaft, an unserer Befragung teilzunehmen!

Zunächst haben wir ein paar Fragen zu Ihrer Person.

Bitte geben Sie ihr Geburtsjahr im Format JJJJ an.
z. B. 1968

Ich bin im Jahr [ ] geboren.

Bitte geben Sie Ihr Geschlecht an.

- männlich
- weiblich
- divers
- Möchte ich nicht sagen

Was ist Ihr höchster Bildungsabschluss?

- Volksschule / Hauptschule / Mittelschule
- Mittlerer Schulabschluss / Mittlere Reife (bis 10. Klasse)
- Abgeschlossene Berufsausbildung
- Abitur / Fachhochschulreife
- Bachelor
- Master / Staatsexamen / Diplom
- Akademischer Grad (Promotion / Habilitation)

Besitzen Sie die folgenden Führerscheine?
Bitte kreuzen Sie die Führerscheinklassen an, die Sie haben.

- A (Kraftrad, Trike und Quad)
- B (Pkw)
- M (Kleinkrafträder)
- Ich habe keinen Führerschein

Bitte geben Sie Ihren Familienstand an.

- ledig
- verheiratet oder eingetragene Lebenspartnerschaft
- verwitwet oder eingetragene/r Lebenspartner/in verstorben
- geschieden oder eigetragene Lebenspartnerschaft aufgehoben

Wie viele Personen leben in Ihrem Haushalt?

- alleinstehender Erwachsener, kein Kind
- alleinstehender Erwachsener, mit Kind
- mehrere Erwachsene, kein Kind
- mehrere Erwachsene, mit Kind(ern)

Wie hoch ist Ihr persönliches monatliches Netto-Einkommen?
Gemeint ist das Einkommen nach Abzug der Steuern und Sozialversicherungsbeiträge.

- Unter 500€
- 500 bis 1.000€
- 1.000 bis 2.000€
- 2.000 bis 3.000€
- 3.000 bis 4.000€
- 4.000 bis 5.000€
- 5.000€ und mehr
- Keine Angabe

Bitte geben Sie Ihre Postleitzahl an.
Die Angabe wird benötigt, um Ihr Mobilitätsverhalten in die bestehende Infrastruktur einordnen zu können.

Seite 03
CM

Wie gehören Sie aktuell der UniBwM an?

- Studierende
- Beschäftigte in Technik und Verwaltung
- Wissenschaftliche Mitarbeitende
- Professorin oder Professor
- Andere

Wie groß ist die Entfernung zwischen Ihrem aktuellen Wohnort und dem UniBw-Campus?
Falls Sie auf dem UniBw-Campus untergebracht sind, beziehen Sie sich bitte auf die Entfernung zwischen dem UniBw-Campus und Ihrem sonstigen Wohnort. Bitte runden Sie dabei auf ganze Zahlen auf.

[ ] km

Welche(s) Verkehrsmittel nutzten Sie bisher (also vor ihrer Registrierung für MORE Sharing) üblicherweise auf dem Weg zum Campus?
Bitte geben Sie alle Verkehrsmittel an, die Sie auf Ihrem regelmäßigen Weg zum Campus bisher benutzt haben. Mehrere Angaben sind möglich.

- ausschließlich zu Fuß
- Fahrrad (auch E-Bike, Pedelec, Lastenrad)
- PKW (auch E-Auto, Hybrid)
- Bus (Regional)
- Regionalzug
- U-Bahn / S-Bahn
- Kraftrad (Motorrad, Moped, Mofa, Roller)
- E-Scooter / Tretroller
- Fernzug
- Fernbus
- Sonstige [bitte nennen]

Wie beurteilen Sie die grundsätzliche Erreichbarkeit des Campus mit folgenden Verkehrsmitteln?

	sehr schlecht	schlecht	mittel	gut	sehr gut	Kann ich nicht beurteilen
Motorisierter Individualverkehr (PKW, Krafträder, E-Scooter)	○	○	○	○	○	○
Fahrrad (auch E-Bike, Pedelec, Lastenrad)	○	○	○	○	○	○
ÖPNV	○	○	○	○	○	○

Seite 04
AM

Vielen Dank für Ihre bisherigen Angaben.
Als Nächstes stellen wir Ihnen ein paar Fragen zu Ihrem generellen Mobilitätsverhalten.

Wie häufig nutzen Sie in der Regel die folgenden Verkehrsmittel?

	(fast) nie	seltener als monatlich	1-3 Tage pro Monat	1-3 Tage pro Woche	(fast täglic	Habe ich nicht zur Verfügung
PKW (auch E-Auto, Hybrid)	○	○	○	○	○	○
Fahrrad (auch E-Bike, Pedelec, Lastenrad)	○	○	○	○	○	○
Kraftrad (Motorrad, Moped, Mofa, Roller)	○	○	○	○	○	○
E-Scooter / Tretroller	○	○	○	○	○	○
ÖPNV	○	○	○	○	○	○

Besitzen Sie einen eigenen PKW?

- ○ ja, steht mir immer zur Nutzung zur Verfügung
- ○ ja, steht mir nach Absprache zur Nutzung zur Verfügung
- ○ nein

Bitte geben Sie Ihre jährliche Fahrleistung (beruflich und privat) mit dem PKW an.

- ○ Unter 12.000 km
- ○ 12.000 bis 20.000 km
- ○ 20.000 bis 30.000 km
- ○ Mehr als 30.000 km

- ○ Ich weiß nicht
- ○ Ich fahre keinen PKW

Bitte kreuzen Sie die Mobilitäts-Abos an, die Sie aktuell besitzen.
Mehrfachauswahl möglich

- ☐ Deutschland-Ticket
- ☐ Job-Ticket
- ☐ Monatskarte für den ÖPNV
- ☐ BahnCard
- ☐ CarSharing-Mitgliedschaft
- ☐ BikeSharing-Mitgliedschaft
- ☐ E-Scooter-Mitgliedschaft
- ☐ andere, und zwar

Welche Fahrkarte verwenden Sie am häufigsten, wenn Sie den ÖPNV in München nutzen?

- ○ Einzelfahrschein, Kurzstreckenticket oder Tageskarte
- ○ Streifenkarte
- ○ Wochen- oder Monatskarte ohne Abo
- ○ Monats- oder Jahreskarte im Abo
- ○ Semesterticket, Job-Ticket

- ○ Ich fahre in München nie mit dem ÖPNV

Seite 05
AM2

Erhalten Sie aktuell eine (anteilige) Kostenerstattung für den ÖPNV von Ihrem Arbeitgeber?
Damit ist der Arbeitgeberzuschuss zu den Kosten für Fahrten im ÖPNV zwischen Wohnung und Dienst- bzw. Ausbildungsstelle gemeint.

- ○ ja
- ○ nein

Bund und Länder haben sich im Rahmen des Entlastungspakets in der Energiekrise darauf geeinigt, 2023 ein Deutschlandticket für 49 Euro im Monat einzuführen.

Nach aktuellem Stand soll das deutschlandweit gültige 49-Euro-Ticket zum 1. Mai 2023 starten. Das Angebot soll in allen Verkehrsmitteln des ÖPNV gelten, also u.a. in den Regionalbahnen und Regionalexpress-Zügen, in S- und U-Bahnen, Straßenbahnen, Linienbussen und mancherorts auch auf Fähren.

Das 49€-Ticket soll es einem monatlich kündbaren Abo geben und bereits bestehende Abos werden automatisch angepasst.

Wie wahrscheinlich ist es, dass Sie das 49-Euro-Ticket erwerben werden?

- ○ sehr wahrscheinlich
- ○ wahrscheinlich
- ○ mittel
- ○ unwahrscheinlich
- ○ sehr unwahrscheinlich

- ○ Ich weiß es nicht / Ich bin mir unsicher

Seite 06
SH1

Im folgenden Abschnitt geht es um Sharing-Angebote.

Mit welchen Sharing-Angeboten haben Sie bereits Erfahrung?

- ☐ (E-)Car-Sharing
- ☐ (E-)Bike-Sharing
- ☐ (E-)Motorroller-Sharing
- ☐ E-Scooter-Sharing

- ☐ Ich habe bisher noch kein Sharing-Angebot genutzt

Seite 07
SH2

Wie häufig nutzen Sie aktuell die folgenden Sharing-Angebote?

	(fast) nie	seltener als monatlich	1-3 Tage pro Monat	1-3 Tage pro Woche	(fast) täglich
(E-)Car-Sharing (z.B. StattAuto, Flinkster, DriveNow, Car2Go, FREE NOW, SIXT, Miles)	○	○	○	○	○
(E-)Bike-Sharing (z.B. MVG Rad, Call a Bike)	○	○	○	○	○
(E-)Motorroller-Sharing (z.B. emmy, TIER)	○	○	○	○	○
E-Scooter-Sharing (z.B. TIER, Lime, Bird, Voi)	○	○	○	○	○

Seite 08
SH3

Bitte beurteilen Sie, inwieweit Sie den folgenden Aussagen persönlich zustimmen.

	stimme überhaupt nicht zu	stimme nicht zu	neutral	stimme zu	stimme völlig zu
Ich bin sehr interessiert an der Einführung neuer Verkehrsmittel.	○	○	○	○	○
Ich gehöre immer zu den Ersten, die neue Verkehrsmittel nutzen.	○	○	○	○	○
Ich glaube, dass neue Verkehrsmittel in der Zukunft allmählich zunehmen werden.	○	○	○	○	○
Neue Verkehrsmittel werden bequemer sein als herkömmliche Verkehrsmittel.	○	○	○	○	○
Wenn ich eine kurze Strecke zurücklege, gehe ich meistens zu Fuß.	○	○	○	○	○
Gehen ist gut für meine Gesundheit.	○	○	○	○	○

Seite 09
MS1

Im folgenden Abschnitt geht es nun konkret um das Sharing-Angebot auf und um den Campus der UniBwM.

Was glauben Sie: Verbessert MORE Sharing die allgemeine Mobilitätssituation auf dem und um den Campus?

trifft überhaupt nicht zu	trifft eher nicht zu	teils teils	trifft eher zu	trifft völlig zu
○	○	○	○	○

Was glauben Sie: Wie häufig werden Sie MORE Sharing nutzen?

(fast) nie	seltener als monatlich	1-3 Tage pro Monat	1-3 Tage pro Woche	(fast) täglich
○	○	○	○	○

Seite 10
MS2

Aus welchen Gründen wollen Sie MORE Sharing nicht nutzen?
Mehrfachauswahl möglich

- ☐ Ich habe hygienische Bedenken
- ☐ Ich habe Sicherheitsbedenken
- ☐ Ich habe körperliche oder gesundheitliche Gründe
- ☐ Die Mitnahme von Gepäck ist mir zu unkomfortabel
- ☐ Die Nutzung ist mir zu umständlich
- ☐ Die Verfügbarkeit der Fahrzeuge ist mir zu ungewiss
- ☐ Ich mag es generell nicht, Fahrzeuge zu teilen
- ☐ Ich habe keinen Bedarf
- ☐ Andere Gründe

Aus welchen Gründen wollen Sie MORE Sharing nutzen?

Mehrfachauswahl möglich

- ☐ Neugier / Ausprobieren
- ☐ Bequemlichkeit
- ☐ Geld sparen
- ☐ Zeit sparen
- ☐ Umweltschutz
- ☐ Gesundheit und Fitness
- ☐ Andere ____

Wo werden Sie MORE Sharing voraussichtlich nutzen?

Bitte geben Sie an, wie sich Ihre Fahrten mit MORE Sharing vermutlich aufteilen werden. Indem Sie den Schieberegler nach links oder rechts bewegen, können Sie den geschätzten Anteil angeben.

	0%	100%
auf dem Campus	———	
außerhalb des Campus	———	

Was denken Sie: Zu welchen Zwecken werden Sie MORE Sharing nutzen?

Mehrfachauswahl möglich

- ☐ Fahrt zur Arbeit / Ausbildung
- ☐ dienstliche Erledigung / Besorgung
- ☐ private Erledigung / Besorgung
- ☐ Einkauf
- ☐ Fahrt zur Freizeitaktivität
- ☐ Erreichen / Ergänzen des ÖPNV
- ☐ Weg nach Hause
- ☐ Spaßfahrt
- ☐ jemanden absetzen / abholen
- ☐ Sonstiges ____

Wichtiger Hinweis

Die Fahrzeuge von MORE Sharing dürfen generell nur von einer Person genutzt werden!

Ausnahmen gelten lediglich für den **E-Roller**, auf dem eine zweite Person mitgenommen werden kann, und das **Lastenrad**, in dem ausschließlich Kleinkinder vorne sitzen dürfen.

Im Lastenrad gilt dabei ein maximales Zuladungsgewicht von 100kg.

Generell sind die Vorschriften der StVO zu beachten und Mitfahrende durch Tragen eines Helmes (und im Lastenrad durch Anschnallen) zu sichern.

Details hierzu sind in den AGB von MORE Sharing zu finden.

Seite 11

M$3

Die folgenden Verkehrsmittel stehen Ihnen im Rahmen von MORE Sharing zur Verfügung.



Bitte geben Sie an, welche Optionen des MORE Sharing-Angebots Sie für die folgenden Wege nutzen würden.

Mehrfachauswahl möglich

Fahrt zur Arbeit / Ausbildung

City Bike	E-Bike	E-Cargo Bike	E-Roller	E-Scooter	Nichts davon
☐	☐	☐	☐	☐	☐

dienstliche Erledigung / Besorgung

City Bike	E-Bike	E-Cargo Bike	E-Roller	E-Scooter	Nichts davon
☐	☐	☐	☐	☐	☐

private Erledigung / Besorgung

City Bike	E-Bike	E-Cargo Bike	E-Roller	E-Scooter	Nichts davon
☐	☐	☐	☐	☐	☐

Einkauf

City Bike	E-Bike	E-Cargo Bike	E-Roller	E-Scooter	Nichts davon
☐	☐	☐	☐	☐	☐

Fahrt zur Freizeitaktivität

City Bike	E-Bike	E-Cargo Bike	E-Roller	E-Scooter	Nichts davon
☐	☐	☐	☐	☐	☐

Erreichen / Ergänzen des ÖPNV

City Bike	E-Bike	E-Cargo Bike	E-Roller	E-Scooter	Nichts davon
☐	☐	☐	☐	☐	☐

Weg nach Hause

City Bike	E-Bike	E-Cargo Bike	E-Roller	E-Scooter	Nichts davon
☐	☐	☐	☐	☐	☐

Spaßfahrt

City Bike	E-Bike	E-Cargo Bike	E-Roller	E-Scooter	Nichts davon
☐	☐	☐	☐	☐	☐

jemanden absetzen / abholen

City Bike	E-Bike	E-Cargo Bike	E-Roller	E-Scooter	Nichts davon
☐	☐	☐	☐	☐	☐

Seite 12

NOk1

Herzlichen Dank für Ihre Angaben bis hierhin!

Im folgenden Abschnitt stellen wir Ihnen zum Abschluss noch ein paar Fragen zu Ihren Einstellungen bezüglich Autofahren und Umweltschutz.

Bitte antworten Sie spontan auf alle Fragen, es gibt keine richtigen oder falschen Antworten.

Bitte beurteilen Sie, inwieweit Sie den folgenden Aussagen persönlich zustimmen.

Der ansteigende Autoverkehr ist ein großes Problem für den Umweltschutz.

stimme überhaupt nicht zu	stimme nicht zu	neutral	stimme zu	stimme völlig zu
○	○	○	○	○

Der Anteil des Autoverkehrs an der Umweltzerstörung wird von den Medien unnötig hochgespielt.

stimme überhaupt nicht zu	stimme nicht zu	neutral	stimme zu	stimme völlig zu
○	○	○	○	○

Ich mache mir Sorgen, wenn ich an die Umweltzerstörung durch das Autofahren denke.

stimme überhaupt nicht zu	stimme nicht zu	neutral	stimme zu	stimme völlig zu
○	○	○	○	○

Ich fühle mich aus Umweltschutzgründen verpflichtet, in meiner Freizeit möglichst selten mit dem Auto unterwegs zu sein.

stimme überhaupt nicht zu	stimme nicht zu	neutral	stimme zu	stimme völlig zu
○	○	○	○	○

Ich fühle mich aus Umweltschutzgründen verpflichtet, für Fahrten in die Innenstadt das Fahrrad oder die Straßenbahn zu benutzen.

stimme überhaupt nicht zu	stimme nicht zu	neutral	stimme zu	stimme völlig zu
○	○	○	○	○

Ich fühle mich dafür verantwortlich, dass ich die Lebensqualität meiner Wohnumgebung nicht durch meine Pkw-Nutzung verschlechtere.

stimme überhaupt nicht zu	stimme nicht zu	neutral	stimme zu	stimme völlig zu
○	○	○	○	○

Ich fühle mich bei der alltäglichen Wahl meines Verkehrsmittels für den Erhalt der Umwelt verantwortlich.

stimme überhaupt nicht zu	stimme nicht zu	neutral	stimme zu	stimme völlig zu
○	○	○	○	○

Seite 13

NOk2

Bitte beurteilen Sie, inwieweit Sie den folgenden Aussagen persönlich zustimmen.

Ohne das Mitwirken der einzelnen Bürger sind die verkehrsbedingten Umweltprobleme nicht zu lösen.

stimme überhaupt nicht zu	stimme nicht zu	neutral	stimme zu	stimmt völlig zu
○	○	○	○	○

Dem Einzelnen kommt eine große Bedeutung bei der Lösung der verkehrsbedingten Umweltprobleme zu.

stimme überhaupt nicht zu	stimme nicht zu	neutral	stimme zu	stimmt völlig zu
○	○	○	○	○

Ich kann durch eine umweltschonende Verkehrsmittelwahl einen Beitrag zum Umweltschutz leisten.

stimme überhaupt nicht zu	stimme nicht zu	neutral	stimme zu	stimme völlig zu
○	○	○	○	○

Ich glaube, dass ich durch die Nutzung öffentlicher Verkehrsmittel einen Beitrag zum Umweltschutz leisten kann.

stimme überhaupt nicht zu	stimme nicht zu	neutral	stimme zu	stimme völlig zu
○	○	○	○	○

Seite 14

BS

Bitte wählen Sie aus, welche Aussage aktuell am ehesten auf Sie zutrifft.

- ○ Ich bin mit meiner derzeitigen PKW-Nutzung zufrieden und sehe keinen Grund, diese zu reduzieren.
- ○ Ich würde gern meine PKW-Nutzung reduzieren, weiß aber noch nicht wie.
- ○ Ich denke derzeit darüber nach, meine PKW-Nutzung reduzieren und andere Verkehrsmittel für die Wege zu nutzen. Ich bin mir aber nicht sicher, wie ich die PKW-Fahrten ersetzen kann.
- ○ Mein Ziel ist es, meine PKW-Nutzung zu reduzieren. Ich weiß, welche Fahrten ich durch andere Vekehrsmittel ersetzen kann. Das Vorhaben habe ich aber noch nicht in die Praxis umgesetzt.
- ○ Ich versuche schon jetzt, meine PKW-Nutzung zu reduzieren und ersetze so viele Fahrten wie möglich durch andere Verkehrsmittel. Das Vorhaben möchte ich fortführen.
- ○ Ich nutze keinen PKW.

Seite 15

CO

Vielen Dank!

Wir danken Ihnen herzlich, dass Sie sich die Zeit genommen haben, unsere Fragen zu beantworten.

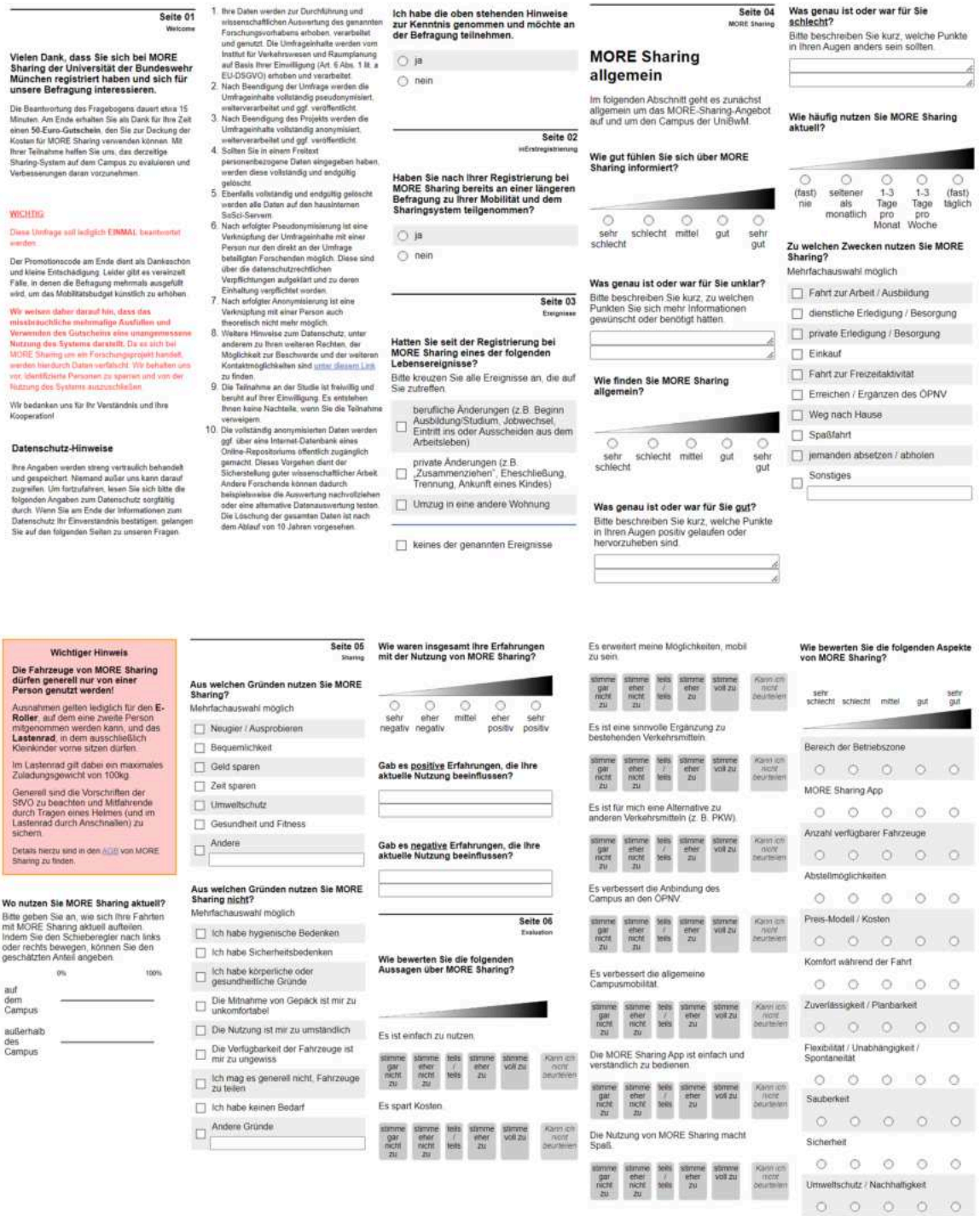
Wir freuen uns, Sie bei MORE Sharing begrüßen zu dürfen und wünschen Ihnen viel Spaß und jederzeit gute Fahrt!

Ihr persönlicher Gutscheincode lautet

SZusLKwW

Bitte fügen Sie diesen Code im Menü der MORE Sharing App unter "Profil" → "Gutscheine" → "+" ein.

11.3 Appendix 3. MORE Sharing User Experience Survey in German



Seite 01
Welcome

Vielen Dank, dass Sie sich bei MORE Sharing der Universität der Bundeswehr München registriert haben und sich für unsere Befragung interessieren.

Die Beantwortung des Fragebogens dauert etwa 15 Minuten. Am Ende erhalten Sie als Dank für Ihre Zeit einen 50-Euro-Gutschein, den Sie zur Deckung der Kosten für MORE Sharing verwenden können. Mit Ihrer Teilnahme helfen Sie uns, das derzeitige Sharing-System auf dem Campus zu evaluieren und Verbesserungen daran vorzunehmen.

WICHTIG:

Diese Umfrage soll lediglich EINMAL beantwortet werden.

Der Promotionscode am Ende dient als Dankeschön und kleine Entschädigung. Leider gibt es vereinzelt Fälle, in denen die Befragung mehrmals ausgefüllt wird, um das Mobilitätsbudget künstlich zu erhöhen.

Wir weisen daher darauf hin, dass das missbräuchliche mehrmalige Ausfüllen und Verwenden des Gutscheins eine unangemessene Nutzung des Systems darstellt. Da es sich bei MORE Sharing um ein Forschungsprojekt handelt, werden hierdurch Daten verfälscht. Wir behalten uns vor, identifizierte Personen zu sperren und von der Nutzung des Systems auszuschließen.

Wir bedanken uns für Ihr Verständnis und Ihre Kooperation!

Datenschutz-Hinweise

Ihre Angaben werden streng vertraulich behandelt und gespeichert. Niemand außer uns kann darauf zugreifen. Um fortzufahren, lesen Sie sich bitte die folgenden Angaben zum Datenschutz sorgfältig durch. Wenn Sie am Ende der Informationen zum Datenschutz Ihr Einverständnis bestätigen, gelangen Sie auf den folgenden Seiten zu unseren Fragen.

1. Ihre Daten werden zur Durchführung und wissenschaftlichen Auswertung des genannten Forschungsvorhabens erhoben, verarbeitet und genutzt. Die Umfrageinhalte werden vom Institut für Verkehrswesen und Raumplanung auf Basis Ihrer Einwilligung (Art. 6 Abs. 1 lit. a EU-DSGVO) erhoben und verarbeitet.
2. Nach Beendigung der Umfrage werden die Umfrageinhalte vollständig pseudonymisiert, weiterverarbeitet und ggf. veröffentlicht.
3. Nach Beendigung des Projekts werden die Umfrageinhalte vollständig anonymisiert, weiterverarbeitet und ggf. veröffentlicht.
4. Sollten Sie in einem Freitext personenbezogene Daten eingegeben haben, werden diese vollständig und endgültig gelöscht.
5. Ebenfalls vollständig und endgültig gelöscht werden alle Daten auf den hausinternen SoSci-Servern.
6. Nach erfolgter Pseudonymisierung ist eine Verknüpfung der Umfrageinhalte mit einer Person nur den direkt an der Umfrage beteiligten Forschenden möglich. Diese sind über die datenschutzrechtlichen Verpflichtungen aufgeklärt und zu deren Einhaltung verpflichtet worden.
7. Nach erfolgter Anonymisierung ist eine Verknüpfung mit einer Person auch theoretisch nicht mehr möglich.
8. Weitere Hinweise zum Datenschutz, unter anderem zu Ihren weiteren Rechten, der Möglichkeit zur Beschwerde und der weiteren Kontaktmöglichkeiten sind unter diesem Link zu finden.
9. Die Teilnahme an der Studie ist freiwillig und beruht auf Ihrer Einwilligung. Es entstehen Ihnen keine Nachteile, wenn Sie die Teilnahme verweigern.
10. Die vollständig anonymisierten Daten werden ggf. über eine Internet-Datenbank eines Online-Repositoriums öffentlich zugänglich gemacht. Dieses Vorgehen dient der Sicherstellung guter wissenschaftlicher Arbeit. Andere Forschende können dadurch beispielsweise die Auswertung nachvollziehen oder eine alternative Datenauswertung testen. Die Löschung der gesamten Daten ist nach dem Ablauf von 10 Jahren vorgesehen.

Ich habe die oben stehenden Hinweise zur Kenntnis genommen und möchte an der Befragung teilnehmen.

○ ja
○ nein

Seite 02
inEinstregistrierung

Haben Sie nach Ihrer Registrierung bei MORE Sharing bereits an einer längeren Befragung zu Ihrer Mobilität und dem Sharingsystem teilgenommen?

○ ja
○ nein

Seite 03
Ereignisse

Hatten Sie seit der Registrierung bei MORE Sharing eines der folgenden Lebensereignisse?

Bitte kreuzen Sie alle Ereignisse an, die auf Sie zutreffen.

☐ berufliche Änderungen (z.B. Beginn Ausbildung/Studium, Jobwechsel, Eintritt ins oder Ausscheiden aus dem Arbeitsleben)
☐ private Änderungen (z.B. „Zusammenziehen", Eheschließung, Trennung, Ankunft eines Kindes)
☐ Umzug in eine andere Wohnung
☐ keines der genannten Ereignisse

Seite 04
MORE Sharing

MORE Sharing allgemein

Im folgenden Abschnitt geht es zunächst allgemein um das MORE-Sharing-Angebot auf und um den Campus der UniBwM.

Wie gut fühlen Sie sich über MORE Sharing informiert?

○ sehr schlecht ○ schlecht ○ mittel ○ gut ○ sehr gut

Was genau ist oder war für Sie unklar?

Bitte beschreiben Sie kurz, zu welchen Punkten Sie sich mehr Informationen gewünscht oder benötigt hatten.

Wie finden Sie MORE Sharing allgemein?

○ sehr schlecht ○ schlecht ○ mittel ○ gut ○ sehr gut

Was genau ist oder war für Sie gut?

Bitte beschreiben Sie kurz, welche Punkte in Ihren Augen positiv gelaufen oder hervorzuheben sind.

Was genau ist oder war für Sie schlecht?

Bitte beschreiben Sie kurz, welche Punkte in Ihren Augen anders sein sollten.

Wie häufig nutzen Sie MORE Sharing aktuell?

○ (fast) nie ○ seltener als monatlich ○ 1-3 Tage pro Monat ○ 1-3 Tage pro Woche ○ (fast) täglich

Zu welchen Zwecken nutzen Sie MORE Sharing?

Mehrfachauswahl möglich

☐ Fahrt zur Arbeit / Ausbildung
☐ dienstliche Erledigung / Besorgung
☐ private Erledigung / Besorgung
☐ Einkauf
☐ Fahrt zur Freizeitaktivität
☐ Erreichen / Ergänzen des ÖPNV
☐ Weg nach Hause
☐ Spaßfahrt
☐ jemanden absetzen / abholen
☐ Sonstiges

Wichtiger Hinweis

Die Fahrzeuge von MORE Sharing dürfen generell nur von einer Person genutzt werden!

Ausnahmen gelten lediglich für den **E-Roller**, auf dem eine zweite Person mitgenommen werden kann, und das **Lastenrad**, in dem ausschließlich Kleinkinder vorne sitzen dürfen.

Im Lastenrad gilt dabei ein maximales Zuladungsgewicht von 100kg.

Generell sind die Vorschriften der StVO zu beachten und Mitfahrende durch Tragen eines Helmes (und im Lastenrad durch Anschnallen) zu sichern.

Details hierzu sind in den AGB von MORE Sharing zu finden.

Wo nutzen Sie MORE Sharing aktuell?

Bitte geben Sie an, wie sich Ihre Fahrten mit MORE Sharing aktuell aufteilen. Indem Sie den Schieberegler nach links oder rechts bewegen, können Sie den geschätzten Anteil angeben.

0% 100%

auf dem Campus

außerhalb des Campus

Seite 05
Sharing

Aus welchen Gründen nutzen Sie MORE Sharing?

Mehrfachauswahl möglich

☐ Neugier / Ausprobieren
☐ Bequemlichkeit
☐ Geld sparen
☐ Zeit sparen
☐ Umweltschutz
☐ Gesundheit und Fitness
☐ Andere

Aus welchen Gründen nutzen Sie MORE Sharing nicht?

Mehrfachauswahl möglich

☐ Ich habe hygienische Bedenken
☐ Ich habe Sicherheitsbedenken
☐ Ich habe körperliche oder gesundheitliche Gründe
☐ Die Mitnahme von Gepäck ist mir zu unkomfortabel
☐ Die Nutzung ist mir zu umständlich
☐ Die Verfügbarkeit der Fahrzeuge ist mir zu ungewiss
☐ Ich mag es generell nicht, Fahrzeuge zu teilen
☐ Ich habe keinen Bedarf
☐ Andere Gründe

Wie waren insgesamt Ihre Erfahrungen mit der Nutzung von MORE Sharing?

○ sehr negativ ○ eher negativ ○ mittel ○ eher positiv ○ sehr positiv

Gab es positive Erfahrungen, die Ihre aktuelle Nutzung beeinflussen?

Gab es negative Erfahrungen, die Ihre aktuelle Nutzung beeinflussen?

Seite 06
Evaluation

Wie bewerten Sie die folgenden Aussagen über MORE Sharing?

Es ist einfach zu nutzen.

Es spart Kosten.

Es erweitert meine Möglichkeiten, mobil zu sein.

Es ist eine sinnvolle Ergänzung zu bestehenden Verkehrsmitteln.

Es ist für mich eine Alternative zu anderen Verkehrsmitteln (z. B. PKW).

Es verbessert die Anbindung des Campus an den ÖPNV.

Es verbessert die allgemeine Campusmobilität.

Die MORE Sharing App ist einfach und verständlich zu bedienen.

Die Nutzung von MORE Sharing macht Spaß.

stimme gar nicht zu | stimme eher nicht zu | teils / teils | stimme eher zu | stimme voll zu | Kann ich nicht beurteilen

Wie bewerten Sie die folgenden Aspekte von MORE Sharing?

sehr schlecht | schlecht | mittel | gut | sehr gut

Bereich der Betriebszone
MORE Sharing App
Anzahl verfügbarer Fahrzeuge
Abstellmöglichkeiten
Preis-Modell / Kosten
Komfort während der Fahrt
Zuverlässigkeit / Planbarkeit
Flexibilität / Unabhängigkeit / Spontaneität
Sauberkeit
Sicherheit
Umweltschutz / Nachhaltigkeit

Wie wahrscheinlich ist es, dass Sie MORE Sharing in Zukunft nutzen werden?

- sehr wahrscheinlich
- wahrscheinlich
- mittel
- unwahrscheinlich
- sehr unwahrscheinlich

Seite 07
Erwartungen

Was schätzen Sie, im Vergleich zu Ihrer aktuellen Nutzung von MORE Sharing, wie oft werden Sie MORE Sharing in ungefähr drei Monaten nutzen?

sehr viel seltener | seltener | genauso wie jetzt | häufiger | sehr viel häufiger

Was schätzen Sie, im Vergleich zu Ihrer aktuellen Nutzung von MORE Sharing, wie oft werden Sie MORE Sharing in etwa einem Jahr nutzen?

sehr viel seltener | seltener | genauso wie jetzt | häufiger | sehr viel häufiger

Wie häufig nutzen Sie aktuell die folgenden anderen Sharing-Angebote?

(E-)Car-Sharing
(z.B. StattAuto, Flinkster, DriveNow, Car2Go, FREE NOW, SIXT, Miles)

(fast) nie | seltener als monatlich | 1-3 Tage pro Monat | 1-3 Tage pro Woche | (fast) täglich | nicht registriert

(E-)Bike-Sharing
(z.B. MVG Rad, Call a Bike)

(fast) nie | seltener als monatlich | 1-3 Tage pro Monat | 1-3 Tage pro Woche | (fast) täglich | nicht registriert

(E-)Motorroller-Sharing
(z.B. emmy, TIER)

(fast) nie | seltener als monatlich | 1-3 Tage pro Monat | 1-3 Tage pro Woche | (fast) täglich | nicht registriert

E-Scooter-Sharing
(z.B. TIER, Lime, Bird, Voi)

(fast) nie | seltener als monatlich | 1-3 Tage pro Monat | 1-3 Tage pro Woche | (fast) täglich | nicht registriert

Wie häufig nutzen Sie das Angebot anderer Sharing-Anbieter seit der Registrierung bei MORE Sharing?

sehr viel seltener | seltener | genauso wie vorher | häufiger | sehr viel häufiger

Seite 08
Fahrzeuge

Fahrzeuge bei MORE Sharing

In diesem Abschnitt haben wir Fragen zu den einzelnen Fahrzeugen, die Sie im Rahmen von MORE Sharing nutzen können.

Die folgenden Verkehrsmittel stehen Ihnen dabei zur Verfügung:

Wie häufig nutzen Sie die einzelnen Fahrzeuge von MORE Sharing?

(fast) nie | seltener als monatlich | 1-3 Tage im Monat | 1-3 Tage pro Woche | (fast) täglich

City Bike
E-Bike
E-Cargo Bike
E-Roller
E-Scooter

Welche Fahrzeuge haben Sie zum ersten Mal ausprobiert, weil sie im Angebot von MORE Sharing enthalten sind?
Mehrfachauswahl möglich

- City Bike
- E-Bike
- E-Cargo Bike
- E-Roller
- E-Scooter

Ich habe keines neu ausprobiert

Wie finden Sie den Mix an Fahrzeugen im bestehenden Angebot von MORE Sharing?

sehr schlecht | schlecht | mittel | gut | sehr gut

Falls Sie den Fahrzeugmix als (eher) schlecht bewerten: Bitte nennen Sie uns Ihre Gründe und Wünsche.

Welches MORE Sharing Fahrzeug nutzen Sie am liebsten?
Bitte sortieren Sie die Fahrzeuge in einer Rangfolge. Platz 1 entspricht dabei Ihrem absoluten Lieblingsfahrzeug, Platz 6 dem am wenigsten gern benutzten Fahrzeug.

City Bike	1
E-Bike	2
E-Cargo Bike mit zwei Rädern	3
E-Cargo Bike mit drei Rädern	4
E-Roller	5
E-Scooter	6

Bitte bewerten Sie jedes Fahrzeug im Angebot von MORE Sharing insgesamt.

sehr schlecht | schlecht | mittel | gut | sehr gut | kann ich nicht beurteilen

City Bike
E-Bike
E-Cargo Bike
E-Roller
E-Scooter

Bitte wählen Sie für die folgenden Szenarien aus, für welches MORE Sharing Fahrzeug Sie sich am ehesten entscheiden würden.
Ziehen Sie hierfür das jeweilige Fahrzeug von der Auswahl in die Lücke. Sie können bei jedem Szenario ein beliebiges Fahrzeug wählen. Jedes Fahrzeug kann auch mehrmals eingesetzt werden.

City Bike | E-Bike | E-Cargo Bike | E-Roller | E-Scooter | kein MORE Sharing Fahrzeug

Wenn in meiner Nähe **alle MORE Sharing Fahrzeuge verfügbar** sind, nehme ich am ehesten ____.

Wenn das **Wetter schlecht** ist, nehme ich am ehesten ____.

Wenn ich **nicht zu spät kommen** darf, nehme ich am liebsten ____.

Wenn ich **größere Distanzen zurücklegen** muss, nehme ich am ehesten ____.

Wenn ich **etwas transportieren oder einkaufen** muss, nehme ich am ehesten ____.

Wenn ich **zur Arbeit / Ausbildung fahre**, nehme ich am ehesten ____.

Wenn ich **dienstlich etwas erledigen/besorgen** muss, nehme ich am ehesten ____.

Wenn ich auf dem **Weg zu einer Freizeitaktivität** bin, nehme ich am ehesten ____.

Wenn ich den **ÖPNV erreichen** will, nehme ich am ehesten ____.

Wenn ich **nach Hause fahren** möchte, nehme ich am ehesten ____.

Wenn ich **nur zum Spaß** fahren möchte, nehme ich am ehesten ____.

Seite 09
City Bike

City Bike

In diesem Abschnitt geht es um die Nutzung eines City Bikes.



Für welche(n) Zweck(e) nutzen Sie ein City Bike?
Mehrfachauswahl möglich

- Fahrt zur Arbeit / Ausbildung
- dienstliche Erledigung / Besorgung
- Einkauf
- Fahrt zur Freizeitaktivität
- Erreichen / Ergänzen des ÖPNV
- Weg nach Hause
- Spaßfahrt
- jemanden absetzen / abholen
- Sonstige

Ich nutze nie ein City-Bike

Bitte bewerten Sie das City Bike hinsichtlich der folgenden Aspekte.

sehr schlecht | schlecht | mittel | gut | sehr gut | kann ich nicht beurteilen

Komfort während der Fahrt
Wendigkeit
Zuverlässigkeit / Planbarkeit
Transport von Dingen
Flexibilität / Unabhängigkeit / Spontaneität
Verfügbarkeit
Sauberkeit
Sicherheit
Umweltschutz / Nachhaltigkeit

Aus welchen weiteren Gründen nutzen Sie ein City Bike?

Aus welchen Gründen nutzen Sie das City Bike nicht ?

Sind bei der Nutzung eines City Bikes Probleme aufgetreten?
Falls ja, beschreiben Sie bitte, welche Schwierigkeiten Sie hatten.

Tragen Sie bei der Nutzung eines City Bikes in der Regel einen Helm?

- ja
- nein

Same for e-bike, e-moped, e-scooter

Seite 11
Cargo Bike

E-Cargo Bike

In diesem Abschnitt geht es um die Nutzung eines E-Cargo Bikes.



Für welche(n) Zweck(e) nutzen Sie ein E-Cargo Bike?
Mehrfachauswahl möglich

- ☐ Fahrt zur Arbeit / Ausbildung
- ☐ dienstliche Erledigung / Besorgung
- ☐ Einkauf
- ☐ Fahrt zur Freizeitaktivität
- ☐ Erreichen / Ergänzen des ÖPNV
- ☐ Weg nach Hause
- ☐ Spaßfahrt
- ☐ jemanden absetzen / abholen
- ☐ Sonstige

☐ Ich nutze nie ein E-Cargo Bike

Bitte bewerten Sie das E-Cargo-Bike hinsichtlich der folgenden Aspekte.

Komfort während der Fahrt
Wendigkeit
Zuverlässigkeit / Planbarkeit
Transport von Dingen
Flexibilität / Unabhängigkeit / Spontaneität
Verfügbarkeit
Sauberkeit
Sicherheit
Umweltschutz / Nachhaltigkeit

sehr schlecht | schlecht | mittel | gut | sehr gut | kann ich nicht beurteilen

Welches E-Cargo Bike nutzen Sie lieber?



○ ○ ○ Ich habe keine Präferenz

Aus welchen weiteren Gründen nutzen Sie ein E-Cargo Bike?

Aus welchen weiteren Gründen nutzen Sie das E-Cargo Bike nicht?

Sind bei der Nutzung eines E-Cargo-Bikes Probleme aufgetreten?
Falls ja, beschreiben Sie bitte, welche Schwierigkeiten Sie hatten.

Tragen Sie bei der Nutzung eines E-Cargo Bikes in der Regel einen Helm?

○ ja
○ nein

Seite 16
App

MORE Sharing

In diesem Abschnitt geht es konkret um die Benutzerfreundlichkeit des Sharing-Systems.

Bitte geben Sie an, inwieweit Sie den folgenden Aussagen zustimmen.

Die Möglichkeiten/Fähigkeiten des MORE-Sharing-Systems entsprechen meinen Anforderungen.
stimme gar nicht zu ○○○○○○○ stimme voll zu

Die Verwendung des MORE-Sharing-Systems ist eine frustrierende Erfahrung.
stimme gar nicht zu ○○○○○○○ stimme voll zu

Insgesamt ist das MORE-Sharing-System einfach zu bedienen.
stimme gar nicht zu ○○○○○○○ stimme voll zu

Ich muss zu viel Zeit damit verbringen, Schwierigkeiten mit dem MORE-Sharing-System zu überwinden.
stimme gar nicht zu ○○○○○○○ stimme voll zu

Bitte geben Sie an, ob die folgenden Schwierigkeiten mit der MORE Sharing App bei Ihnen aufgetreten sind.
Kreuzen Sie hierfür die zutreffenden Punkte an, bei denen Sie Probleme hatten. Mehrfachauswahl ist möglich.

- ☐ Zahlungsmethode hinzufügen
- ☐ Fehlermeldung: Mobilfunkempfang zu schlecht
- ☐ Problem beim Entsperren des Fahrzeugs
- ☐ Problem beim Verriegeln des Fahrzeugs
- ☐ App mit Handy nicht kompatibel
- ☐ Sonstige Probleme

☐ Ich hatte keins der genannten Probleme

Wie hilfreich fanden Sie die Fragen und Antworten im FAQ-Bereich?

○ gar nicht hilfreich ○ nicht hilfreich ○ mittel ○ hilfreich ○ sehr hilfreich

Seite 17
Campus

Schließlich haben wir noch ein paar Fragen zu Ihrer derzeitigen Campus-Mobilität.

Welche(s) Verkehrsmittel nutzen Sie üblicherweise auf dem Weg zum Campus?
Bitte geben Sie alle Verkehrsmittel an, die Sie auf Ihrem regelmäßigen Weg normalerweise benutzen. Mehrere Angaben sind möglich.

- ☐ ausschließlich zu Fuß
- ☐ Fahrrad (auch E-Bike, Pedelec, Lastenrad)
- ☐ PKW (auch E-Auto, Hybrid)
- ☐ Bus (Regional)
- ☐ Regionalzug
- ☐ U-Bahn / S-Bahn
- ☐ Kraftrad (Motorrad, Moped, Mofa, Roller)
- ☐ E-Scooter / Tretroller
- ☐ Fernzug
- ☐ Fernbus
- ☐ MORE Sharing
  Welche(s) MORE-Fahrzeug(e)?
- ☐ Sonstige

Welche(s) Verkehrsmittel nutzen Sie üblicherweise für Wege auf dem Campus?
Mehrere Angaben sind möglich.

- ☐ ausschließlich zu Fuß
- ☐ Fahrrad (auch E-Bike, Pedelec, Lastenrad)
- ☐ PKW (auch E-Auto, Hybrid)
- ☐ Kraftrad (Motorrad, Moped, Mofa, Roller)
- ☐ E-Scooter / Tretroller
- ☐ MORE Sharing
  Welche(s) MORE-Fahrzeug(e)?
- ☐ Sonstige

Bitte beurteilen Sie, inwieweit Sie der folgenden Aussage persönlich zustimmen.

Das MORE Sharing Angebot verbessert in meinen Augen die allgemeine Mobilitätssituation auf dem und um den Campus.
stimme überhaupt nicht zu | stimme nicht zu | neutral | stimme zu | stimme völlig zu
○ ○ ○ ○ ○

Wie beurteilen Sie die grundsätzliche Erreichbarkeit des Campus mit folgenden Verkehrsmitteln?

Motorisierter Individualverkehr (PKW, Krafträder, E-Scooter)
Fahrrad (auch E-Bike, Pedelec, Lastenrad)
ÖPNV
MORE Sharing

sehr schlecht | schlecht | mittel | gut | sehr gut | kann ich nicht beurteilen

Seite 18
Demographie

Zum Schluss haben wir noch ein paar Fragen zu Ihrer Person.

Bitte geben Sie Ihr Geburtsjahr im Format JJJJ an.
z. B. 1968

Ich bin im Jahr ____ geboren.

Bitte geben Sie Ihr Geschlecht an.

- ○ männlich
- ○ weiblich
- ○ divers

○ Möchte ich nicht sagen

Was ist Ihr höchster Bildungsabschluss?

- ○ Volksschule / Hauptschule / Mittelschule
- ○ Mittlerer Schulabschluss / Mittlere Reife (bis 10. Klasse)
- ○ Abgeschlossene Berufsausbildung
- ○ Abitur / Fachhochschulreife
- ○ Bachelor
- ○ Master / Staatsexamen / Diplom
- ○ Akademischer Grad (Promotion / Habilitation)

Besitzen Sie die folgenden Führerscheine?
Bitte kreuzen Sie die Führerscheinklassen an, die Sie haben.

- ☐ A (Kraftrad, Trike und Quad)
- ☐ B (Pkw)
- ☐ M (Kleinkrafträder)

☐ Ich habe keinen Führerschein

Bitte geben Sie Ihren Familienstand an.

- ○ ledig
- ○ verheiratet oder eingetragene Lebenspartnerschaft
- ○ verwitwet oder eingetragene/r Lebenspartner/in verstorben
- ○ geschieden oder eingetragene Lebenspartnerschaft aufgehoben

Wie viele Personen leben in Ihrem Haushalt?

- ○ alleinstehender Erwachsener, kein Kind
- ○ alleinstehender Erwachsener, mit Kind
- ○ mehrere Erwachsene, kein Kind
- ○ mehrere Erwachsene, mit Kind(ern)

Wie hoch ist Ihr persönliches monatliches Netto-Einkommen?

Gemeint ist das Einkommen nach Abzug der Steuern und Sozialversicherungsbeiträge.

- ○ Unter 500€
- ○ 500 bis 1.000€
- ○ 1.000 bis 2.000€
- ○ 2.000 bis 3.000€
- ○ 3.000 bis 4.000€
- ○ 4.000 bis 5.000€
- ○ 5.000€ und mehr

- ○ Keine Angabe

Bitte geben Sie Ihre Postleitzahl an.

Die Angabe wird benötigt, um Ihr Mobilitätsverhalten in die bestehende Infrastruktur einordnen zu können.

Seite 19

FollowUp

Haben Sie noch weitere Anmerkungen zu MORE Sharing?

Geben Sie gerne Ihre offenen Wünsche, Vorschläge oder Anregungen für die zukünftige Gestaltung von MORE Sharing an.

Seite 20

Missings

Leider haben Sie zu wenig Angaben gemacht, um einen persönlichen Gutschein-Code zu erhalten.

Wir bedanken uns dennoch für Ihre Teilnahme und hoffen, Sie auch in Zukunft bei MORE Sharing begrüßen zu dürfen.

Seite 21

Gutschein

Vielen Dank!

Wir danken Ihnen herzlich, dass Sie sich die Zeit genommen haben, unsere Fragen zu beantworten.

Ihr persönlicher Gutscheincode lautet

204asQfs

Bitte fügen Sie diesen Code im Menü der MORE Sharing App unter "Profil" → "Gutscheine" → "+" ein.

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List of Abbreviations

AM Ante Meridiem (midnight to 11:59 noon)

GBFS General Bikeshare Feed Specification

GBC Gradient Boosting Classifier

GBRTs Gradient Boosted Regression Trees

GPS Global Positioning System

IoT Internet of Things

Km Kilometer

Km/h Kilometers per hour

MaaS Mobility as a Service

MDS Mobility Data Specification

Min Minutes

MNL Multinomial Logit Model

NBR Negative Binomial Regression

NN Neural Networks

NNC Neural Network Classifier

PM Post Meridiem (12 noon to 11:59 midnight)

RF Random Forest Model

RFC Random Forest Classifier