Learning Demands for Ride-pooling Services: A Case Study in Berlin

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Abstract— **We design a survey-and-scenario-based method for investigating the demand of real people for ride-pooling services in Berlin. We deploy it among public transport users to study where, why, how, and when they would use ride-pooling. In particular, we learn about their socio-demographic features, trip purposes, and deciding factors, as well as their preferences for service waiting times and fares. Our results inform service operators about dispatching decisions, allow for encoding user behavior in utility functions for reasoning, and enable the design of fair pricing schemes to improve service accessibility.**

I. Introduction

Microtransit refers to a form of on-demand transportation service that uses vans or minibusses to provide point-to-point rides for passengers. Unlike traditional fixed-route buses, micro-transit services are more flexible in their schedules, as they can adapt dynamically to the specific needs of passengers. This flexibility is made possible through the use of technology and algorithms that optimize the schedules by matching passengers traveling in similar directions [1]. Normally, passengers request rides through a mobile app or a centralized booking unit, and the system responds by dispatching the closest available vehicle. Microtransit can adapt its service schedule based on the current demand of passenger requests. Compared to fixed-route public transit vehicles, the smaller scale of microtransit allows for a more personalized experience, with fewer passengers on board and potentially shorter travel times [2]. Microtransit is commonly perceived as a component of transit systems, aiming to extend transit access to hubs or complement less frequent conventional bus routes in scarcely populated regions. Contrasting shared ride-hailing, microtransit typically employs larger vehicles and is often managed or coordinated by public transportation operators [2]. A study carried out in the United States identifies three distinct categories of microtransit services. The first category is the ”First-mile/Last-mile” (FMLM) service, designed to cater to the transportation needs of passengers when traveling to and from fixed-route transit stops or stations. The second category is the ”Transit Coverage Gap” (TCG) service, which utilizes microtransit to bridge existing gaps in transit coverage. The third category involves microtransit as a ”Fixed-route Replacement” (FRR) service, intended to mitigate the negative effects of mobility on the community, resulting from reductions or discontinuation of fixed-route services [3].

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II. Microtransit in Berlin

In Germany, the advancement of ride-pooling services is driven by its potential to act as a feeder for public transportation networks in urban and peri-urban agglomerations. It has been in existence for several decades as a form of on-demand transport option [4]. The growth of Microtransit in Germany has been relatively slow in the last years [5]. However, the amendment to the Passenger Transport Act in 2021 provided a legal basis for the facilitation of the extension of ride-pooling. For this reason, in the future, it is expected that the adoption of ride-pooling services will increase throughout Germany. Berlin, the capital city of Germany, offers a multifaceted demographic landscape that however creates a challenge for the adoption of ride-pooling because, with a population exceeding 3.76 million, Berlin has a diverse range of residents from various ethnicities and nationalities. The robust economic foundation of Berlin and the relatively affordable cost of living in Berlin attract individuals from diverse socio-economic backgrounds, further diversifying commuter preferences for transportation demands. The Berlin transportation system, comprising an extensive network of buses, trams, trains, and subways, serves as the backbone transport line for inhabitants. The Berliner Verkehrsbetriebe (BVG) serves as the primary public transportation operator in Berlin. This organization manages the U-Bahn (subway), tram, bus, and ferry networks, excluding the S-Bahn urban rail system. Their microtransit service, known as BVG Muva, was introduced in October 2022. The service of BVG Muva was however operated since 2018, but under the name BerlKönig, within the vicinity of Lichtenberg, confining its operational scope to this particular region until today. Nowadays, BVG Muva is a collaboration between BVG and ViaVan, a company that develops technology platforms for on-demand shared rides. Their service is intended to be integrated into the existing public transportation network. For this purpose, BVG Muva has extended its services to the districts Marzahn-Hellersdorf, Treptow-Köpenick, and Friedrichshain-Kreuzberg. This integration requires understanding the demand for microtransit services in the different parts of Berlin. Therefore, we study the following questions:

1) What demand for microtransit services exists in the different parts of Berlin?
2) What are the key purposes and factors for using microtransit services in Berlin?
3) What are the preferences for integrating microtransit services as part of journeys in Berlin?

III. Outline

We next summarize several state-of-the-art related works in the area of microtransit services (Section IV). We then describe our survey (Section V). It has three integrated sections. With it, we aim to learn the demographic features of the Berlin population and their microtransit experiences. We also run a discrete-choice experiment, which consists of common scenarios, to learn the preferences of people about how they would use the microtransit service. Thus, in this paper, we give socio-demographic results (Section VI) and results about the trip reasons and deciding factors of commuters (Section VII), as well as their waiting time and fare preferences (Section VIII). Then, we discuss the lessons learned (Section IX) and the limitations of our approach (Section X), motivating several future directions (Section XI). Finally, we conclude with a summary (Section XII).

IV. Related works

Several studies have been conducted around the world, to explore the user demographics, user perceptions, behavioural patterns, financial viability, and other facets of on-demand microtransit services.

A. User profiles, preferences, and purposes of use

A study conducted in Utah, USA with the participation of 130 transit riders in a newly launched microtransit service area has revealed that younger passengers express a more than expected willingness to use microtransit, middle-aged passengers a less than expected willingness, and older passengers neutral or no expressed opinion [6]. Other work has found that transit users had a higher preference for using this service over using other modes, particularly revealing that men, younger riders, highly educated, and transit riders are more likely to be interested in microtransit services [2]. Also, it has been concluded that individuals with lower household incomes who use public transit would be more inclined to consider ride-pooling alternatives, whereas users of ride-sourcing services from higher socioeconomic backgrounds would be less likely to contemplate transitioning to a shared-ride service [7].

B. Factors influencing the demand for microtransit

Several studies highlight various factors that shape the demand for microtransit services. One such study has highlighted that the interest in these services among public transportation users is dependent upon two principal factors: their willingness to pay for personalized service, as well as the fare difference in comparison to conventional public transportation choices [8]. Consistent with this, another work has shown that two primary determinants for travelers, when considering the choice between microtransit services versus solo ride-sourced trips, are travel time and trip cost [9]. Also, another paper has reported findings, according to which the value of time (VOT) for riders is a key system parameter for microtransit services, and minimizing access time while prioritizing punctuality holds the potential to attract commuters as a first-mile/last-mile connector to fixed-route public transit [2].

V. Methodology

The common analyses conducted for Germany as a whole may not fully apply to Berlin due to its unique transport dynamics, emphasizing the need for specific investigations. To address the diverse needs of Berlin commuters effectively, it is essential to gather primary data directly from them, ensuring that the services developed are aligned with their preferences and requirements. Previous studies have indicated that microtransit services are more likely to be utilized by public transport users [2], prompting this study to focus primarily on acquiring data from this user group. Furthermore, as commuting represents the largest share of passenger mobility in Berlin [10], any improvements in microtransit services for commuting could have a substantial impact on revenue and sustainability, making this line of research a crucial area of investigation. As a response, we give a unique approach to examining the potential impact of first-mile and last-mile factors on the demand for microtransit services among public transport users, a perspective that has not yet been explored within the context of Berlin. By addressing these gaps and building upon previous research, we aim to contribute to the advancement and effectiveness of microtransit services in Berlin and potentially offer insights that could apply to other urban and peri-urban settings. To democratize the public choice for microtransit services in Berlin, we designed a survey to acquire primary data from commuters, regarding their interest in using microtransit services. The survey defined first what a microtransit service is and, after that, it contained three sections, namely Demographics, Microtransit, and Scenarios: see Figure 1.

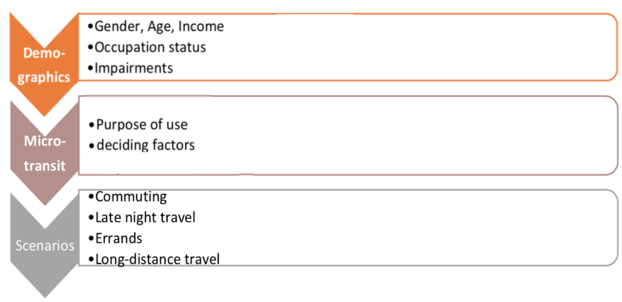

Fig. 1. The section structure of the survey.

The survey was distributed online from July to August 2023 among public transport users, who normally have a higher interest in using microtransit. The survey questionnaire was prepared both in English and German to reach a wider audience. To expand the reach even further, private messages were sent to Berlin residents via social media platforms, applying location-based filters. Participation was entirely voluntary and not incentivized via monetary means. The sample size was 1 000 responses ($N = 1000$) from among the public transport users in the BVG Facebook group "Weil wir dich lieben". Basically, we tried to find out how BVG commuters feel about BVG deploying more microtransit services. All respondents were presented with an identical set of questions.

VI. DEMOGRAPHICS

We start with the socio-demographic data of the respondents in the survey. This includes their age group, gender, occupation, and whether they have some sort of mobility impairment, causing difficulties in reaching the service points. The socio-demographic characteristics of the respondents were compared with Statista data about the population of Berlin. We show the results in Figure 2.

Attribute	Sample	Population (Berlin)
Gender		
Male	61%	49.5%
Female	36%	50.5%
Non - Binary	3%	n/a
Age category		
0 - 18	0.0%	16.7%
18 - 29	51%	14.5%*
30 - 39	41%	15.8%*
40 - 49	6%	14.7%*
50 - 59	2%	12.5%*
> 60	0%	25.7%
Occupation		
Employed full-time	66%	59.2%**
Employed part-time	4%	n/a
Student + employed	9%	5.5%**
Student	19%	
Unemployed	2%	10.6%
Retired	0%	19.2%

Fig. 2. The socio-demographic features of the respondents in comparison with those of the population of Berlin.

In the sample, 61% are male respondents, slightly exceeding the Berlin population distribution of 49.5%. Female respondents account for 36%, closely aligned with the Berlin population at 50.5%. Non-binary respondents make up 3%, but the corresponding Berlin population data is not available. Furthermore, in the sample, the 18-29 age group is over-represented, constituting 51%, whereas, in the Berlin population, it's 14.5%. Those aged 30-39 are also over-represented with 41%, compared to 15.8% in the Berlin population. Not least, in the sample, full-time employees are at 66%, in contrast to the Berlin population at 59.2%, whereas part-time employees are 4%. A significant 28% of the respondents are students, differing from the Berlin student population of 5.5%. Other occupation categories also show disparities between the sample and Berlin populations.

Regarding mobility impairment, in responding to the question, "Do you experience difficulty with mobility due to a physical or health condition?", 3.4% of all respondents indicated that they face challenges with mobility. We also asked participants to submit the name of the district in which they live, not the address as this is private. Thus, we could build a spatial distribution of the demand for microtransit. This is useful for operators to decide where to locate and dispatch their services. Interestingly, Lichtenberg, Charlottenburg-Wilmersdorf, and Mitte take the top three places for candidates of microtransit service: see Figure 3. Hence, BVG Muva might want to strengthen its service there.

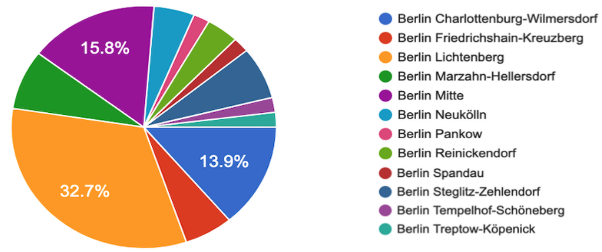

Fig. 3. The demand distributions for using microtransit in Berlin.

VII. PURPOSES AND FACTORS

We move on by reporting our findings regarding the potential purpose of using microtransit, and key factors that might influence the personal decisions of users for whether or not to use microtransit services.

A. *Service purpose of use*

Answering the question "If you are considering using microtransit, what specific purpose of use do you have in mind?", the participants in the survey have checked different purposes of their prospective microtransit trips. Multiple selection was allowed in the answers list, resulting in a sum beyond 100%. We report the results in Figure 4.

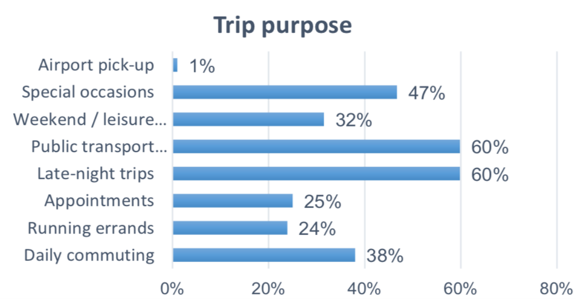

Fig. 4. The trip purposes for using microtransit in Berlin.

The distribution of purposes among respondents offers valuable insights into the varied roles of microtransits within our daily travel behavior. With 38% of responses indicating daily commuting, microtransit proves its significance as a reliable means for regular travel needs. Furthermore, 24% of the selections highlight its convenience for running errands, while 25% for appointments, showcasing its role in facilitating scheduled activities. An intriguing finding emerges as 60% of respondents turn to microtransit for late-night trips, highlighting its contribution to late-night mobility. Similarly, the same percentage of respondents opt for using microtransit during public transport disruptions, emphasizing its value in addressing unforeseen situations such as schedule interruptions of trams, buses, or trains due to fallen trees, road construction, etc. It is noteworthy that, by effectively accommodating passengers during interruptions in fixed routes, microtransit can potentially play a crucial role in keeping passengers within the public transport network.

B. Deciding factors

The responses to the question "Which of the below factors would you consider most important when deciding whether to use microtransit services?" revealed a range of factors seemingly playing a key role among respondents when deciding whether or not to use the service. They were allowed to select multiple options, hence the values summing up to more than 100%. The results are reported in Figure 5.

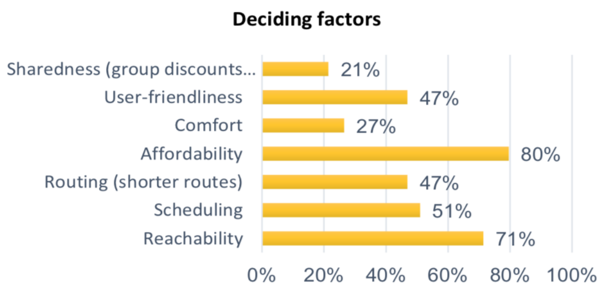

Fig. 5. The deciding factors for using microtransit in Berlin.

"Affordability" was the most selected factor among respondents, with 80% choosing it, making it a key driver for choosing microtransit services. "Reachability" emerged as the next prominent factor, with 71% of respondents considering it crucial. "Scheduling" was marked important by 51% of respondents. "Routing", particularly prioritizing shorter routes, was deemed significant by 47% of respondents. "Comfort" was a consideration for 27% of respondents. Similarly, "User-friendliness" was regarded as important by 47% of respondents. Lastly, the aspect of "Sharedness", which includes elements like group discounts, resonated with 21% of the respondents. These diverse responses reflect the range of considerations individuals take into account when deciding whether or not to use microtransit services.

VIII. Learning Preferences

With the last section of our survey, we aimed to study the preferences of users in various scenarios. For this purpose, we used a discrete-choice experiment. This is a research method commonly used in social sciences, economics, and market research to understand how individuals make choices among a set of alternatives. It is often employed to study consumer preferences, decision-making processes, and the trade-offs individuals are willing to make when faced with different options. Several studies, both on a global scale and within the German context, have employed similar experiments to capture user preferences related to microtransit services. Examples include the works [2] and [11]. Extending their methodology, a discrete-choice experiment was integrated into the survey for this research. Participants were presented with four hypothetical mobility scenarios tailored to capture their preferences in various contexts. These scenarios were strategically designed to mimic real-world decision-making scenarios, each accompanied by a brief description and a set of travel options.

To reach their destination, respondents were provided with three travel options: fixed-route transit, microtransit, and ride-hailing. These reflect the idea that microtransit often occupies a middle ground between individual ride-hailing and mass transit, as cited in [4]. The experiment incorporated several assumptions and features, as outlined next:

- All scenarios assumed equal journey distances, with microtransit journeys having no detours. This is motivated by the fact that users normally are willing to pay more only if the service saves them travel time.
- Another assumption made was that respondents possessed a public transport pass (e.g. ticket, subscription, etc.), negating the need for additional payments when using public transport as part of their journey and, thus, modeling only the marginal increase associated with microtransit they are willing to pay.
- Each scenario employed time values and fares derived from popular mobility apps, journey planners (such as Google Maps), public transport sources (like BVG Fahrinfo), and microtransit apps (such as BVG Muva). This ensured consistent spatial and temporal conditions across all options.
- Minimal gaps were intentionally employed between attribute levels in each scenario option, aiming to capture the threshold points where choices shift.
- In addition to the three predefined options, respondents were given the flexibility to respond "None of the options works for me", aiming to avoid imposing a forced choice.

The scenario presentation was designed to resemble the interface of an app-based journey planner, aiming to create a familiar and relatable experience for respondents. The travel options were framed using four distinct attributes, each featuring varying attribute levels. The attributes employed, along with their respective levels, are depicted in Figure 6. The results from the experiment are presented in Figure 7.

Scenario 1 depicts a regular commute, with 58.1% of respondents choosing public transport and 27.9% opting for microtransit. The preference for microtransit, despite slightly longer waiting times, could be attributed to its ability to reduce walking time by 3 minutes at a minimal price difference. In the responses, walking and cycling options were mentioned under the category 'other'.

In scenario 2, focused on late-night travel, a majority of 58.1% favored microtransit. This preference can be linked to the higher waiting and walking times set in public transport options, compared to microtransit. Additionally, 7% of respondents chose ride-hailing, suggesting a greater willingness to pay for enhanced late-night service.

In scenario 3, reflecting post-errand travel, 46.5% opted for public transport and 34.9% for microtransit. The slight reduction in walking time offered by microtransit for a price increase of 1.20 € indicates that people are willing to pay for convenience after shopping. The 9.3% of respondents selecting ride-hailing underscores further the value placed on reduced walking time.

		Attributes			
		Waiting time	Walking time	Travel time	Fare
Scenario 1 (Commuting)	Option 1	3 min	7 min	2 min	~0 €
	Option 2	4 min	3 min	2 min	1.00 €
	Option 3	5 min	-	2 min	6.00 €
Scenario 2 (Late night travel)	Option 1	20 min	6 min	2 min	~0 €
	Option 2	8 min	2 min	2 min	2.20 €
	Option 3	6 min	-	2 min	7.00 €
Scenario 3 (Errands)	Option 1	3 min	2 + 6 min	2 min	~0 €
	Option 2	3 min	2 + 2 min	2 min	1.20 €
	Option 3	4 min	-	2 min	6.00 €
Scenario 4 (Leaving for vacation)	Option 1	10 min	7 min	2 min	~0 €
	Option 2	5 min	3 min	2 min	2.00 €
	Option 3	5 min	-	2 min	6.50 €

Fig. 6. The attributes and attribute levels across the four scenarios in the discrete-choice experiment.

In scenario 4, tailored for long-distance travel, 47.6% chose public transport and 40.5% opted for microtransit. Despite a minimal reduction in arrival time, the preference for microtransit could stem from its convenience in handling luggage. This is supported by the 11.9% willing to pay for ride-hailing, which is the highest ride-hailing portion within all four scenarios.

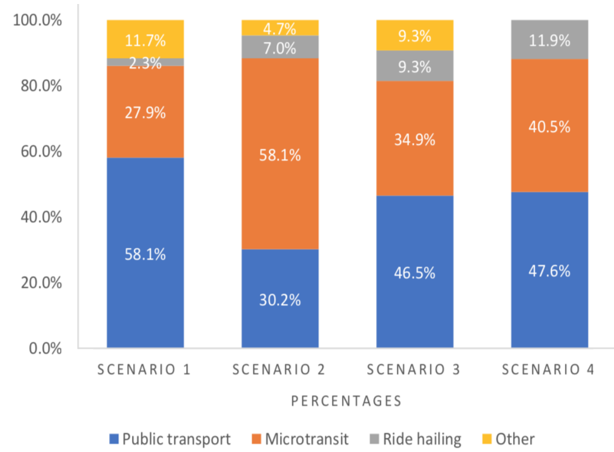

Fig. 7. The results from the discrete-choice experiment.

Apart from the above observations, the results from the discrete-choice experiment can be leveraged to derive a utility function. For example, the observed choices can be used to estimate the underlying utilities that individuals associate with the different attribute levels. Even more specifically, by using statistical models like multinomial logit or mixed logit models, we can estimate the coefficient for each attribute level, which will indicate how much utility respondents derive from that level. These coefficients could then be used to construct a utility function that quantifies how individuals value each attribute when making choices. This utility function can be valuable for predicting preferences and making policy recommendations in various contexts, such as transportation planning or product design.

Furthermore, the results from the discrete-choice experiment can inform designing a pricing scheme for passengers, accounting for their income and poverty levels even without retrieving this concrete information from them. For example, the occupation of respondents can serve as a predictor for these levels, as retirees, unemployed, and students have normally lower income (say we place them in “income and poverty” level one) than part-time employees (say we place them in “income and poverty” level two) and these often have lower income than full-time employees (say we place them in “income and poverty” level three). Thus, a pricing scheme, according to which everyone would pay equally for equal services, but would also use subsidies to achieve low service prices to individuals from level one, average service prices to individuals from level two, and high service prices to individuals from level three, is more likely to be perceived as fair by users as it would promote service usability and equitability.

IX. Lessons Learned

To enhance service attractiveness, operators could prioritize minimizing waiting times and walking distances, consequently reducing overall travel times for passengers. Implementing dynamic pricing mechanisms based on various criteria, such as time-based factors, could effectively cater to passengers with diverse willingness-to-pay preferences, thereby maximizing service utilization. Improving the user experience and multi-language support in booking apps can contribute to a seamless and accessible service for a broader user audience. Furthermore, during periods of low-frequency fixed-route services, when longer waiting and travel times are prominent, microtransit services might inadvertently compete with established modes. Exploring strategies to harmonize microtransit and fixed-route services during off-peak hours can help optimize resource allocation and mitigate potential competition. This aligns with the goal of operators to ensure both convenience and efficiency in urban and sub-urban mobility for passengers.

X. LIMITATIONS

This study comes with several limitations that should be kept in mind when interpreting the findings. For example, the absence of private car users, as well as individuals below 18 and above 60, could lead to biases in the results. Also, the over-representation of full-time employees and students in the sample, compared to the broader population, might skew certain trends. Not least, in the discrete-choice experiment, while real-world attributes and levels were employed, their universal applicability across diverse geographies and scenarios might be uncertain, potentially affecting the applicability of the results to other settings. Finally, these limitations underscore the need for caution when generalizing the findings beyond the specific context of this study.

XI. FUTURE WORK

This study opens up several avenues for further research that could deepen our insights into microtransit demand and its integration into urban and sub-urban transport systems. Exploring the predictors identified here could provide a more detailed understanding of how commuting frequency, and distance impact microtransit demand. Additionally, extending the discrete-choice experiment to encompass more diverse combinations of scenarios could yield a more accurate representation of commuter preferences in Berlin. The derivation of precise utility functions and pricing schemes from the outcomes of the discrete-choice experiment would motivate designing a mathematical approach that includes these functions and schemes in the modeling and decision-making of algorithms that optimize the schedules of micro-transit vehicles. Furthermore, probing into the relationship between socio-demographic factors and service preferences could uncover valuable patterns in microtransit adoption, that could contribute to a comprehensive understanding of demand dynamics.

XII. CONCLUSIONS

This study offers valuable insights into the predictors of demand for microtransit services among commuters in Berlin. The identified predictors, including demand frequency and trip purposes, shed light on the factors influencing the inclination to utilize microtransit. The findings from the discrete-choice experiment underline further the dynamic nature of demand, revealing time-sensitive preferences and varying scenarios that impact mode selection. Notably, concerns about waiting and walking times emerged as crucial considerations. Finally, these results collectively emphasize the measures necessary to establish microtransit as a dependable and cost-effective transportation solution that caters to the diverse needs of commuters.

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