Exploring the Consumer Market of Microtransit Services in the Sacramento Area, California

May 2022

A Research Report from the National Center for Sustainable Transportation

Yan Xing, University of California, Davis

Susan Pike, University of California, Davis

Elham Pourrahmani, University of California, Davis

Susan Handy, University of California, Davis

Yunshi Wang, University of California, Davis

National Center for Sustainable Transportation

ITS UCDAVIS INSTITUTE of TRANSPORTATION STUDIES

TECHNICAL REPORT DOCUMENTATION PAGE

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
NCST-UCD-RR-22-16	N/A	N/A

4. Title and Subtitle	5. Report Date
Exploring the Consumer Market of Microtransit Services in the Sacramento Area, California	May 2022
	6. Performing Organization Code N/A
7. Author(s) Yan Xing, Ph.D., https://orcid.org/0000-0003-1173-1872 Susan Pike, Ph.D., https://orcid.org/0000-0001-6558-3479 Elham Pourrahmani, Ph.D., https://orcid.org/0000-0003-0155-813X Susan Handy, Ph.D., https://orcid.org/0000-0002-4141-1290 Yunshi Wang, Ph.D., https://orcid.org/0000-0001-5224-3408	**8. Performing Organization Report No.** UCD-ITS-RR-22-09
9. Performing Organization Name and Address University of California, Davis Institute of Transportation Studies 1605 Tilia Street, Suite 100 Davis, CA 95616	**10. Work Unit No.** N/A **11. Contract or Grant No.** Caltrans 65A0686 Task Order 052 USDOT Grant 69A3551747114
12. Sponsoring Agency Name and Address U.S. Department of Transportation Office of the Assistant Secretary for Research and Technology 1200 New Jersey Avenue, SE, Washington, DC 20590 California Department of Transportation Division of Research, Innovation and System Information, MS-83 1727 30th Street, Sacramento, CA 95816	**13. Type of Report and Period Covered** Final Research Report (January 2021 – December 2021) **14. Sponsoring Agency Code** USDOT OST-R

15. Supplementary Notes

DOI: https://doi.org/10.7922/G2HX1B0S
Dataset DOI: https://doi.org/10.25338/B8VK84

16. Abstract

Microtransit is an emerging, technology-enabled, on-demand transportation mode whereby small shuttles provide shared rides through flexible routing and scheduling in response to customers' requests for rides. Given its potential to address the equity and accessibility needs of the public, public transportation agencies are experimenting with this service to fill gaps in traditional transportation in the US. However, why some people are interested in microtransit while others are not remains an open question. For people who have never used it, what factors could work as facilitators or barriers in their willingness to adopt microtransit? Who are the early adopters of microtransit? Guided by the theory of planned behavior, this study aims to fill the gap in knowledge by conducting a large-scale survey of microtransit adopters and users of other means of transportation in the Sacramento area of California in 2021. This study focuses on the microtransit service SmaRT Ride (SR), operated by the Sacramento Regional Transit District (SacRT). Focus groups and interviews were conducted before the large-scale online survey to gather preliminary information, help develop survey questions, and improve understanding of research findings, given the novelty of microtransit. Discrete choice models, including binary logit and ordered logit models and latent class analysis, were employed to explore barriers to and facilitators of SR adoption, willingness to use it, and underlying subgroups of early adopters. Important findings include that people who like fixed-route transit are less likely to adopt microtransit. Social support plays an important role in explaining the willingness to use microtransit. The analysis reveals three salient classes of microtransit users: travel time savers with environmental awareness, riders with a neutral mindset, and pro-SR and travel cost savers.

17. Key Words	18. Distribution Statement
Microtransit, theory of planned behavior, focus group, discrete modeling, latent class	No restrictions.

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	68	N/A

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

About the National Center for Sustainable Transportation

The National Center for Sustainable Transportation is a consortium of leading universities committed to advancing an environmentally sustainable transportation system through cutting-edge research, direct policy engagement, and education of our future leaders. Consortium members include: University of California, Davis; University of California, Riverside; University of Southern California; California State University, Long Beach; Georgia Institute of Technology; and University of Vermont. More information can be found at: ncst.ucdavis.edu.

Disclaimer

Acknowledgments

This study was funded, partially or entirely, by a grant from the National Center for Sustainable Transportation (NCST), supported by the U.S. Department of Transportation (USDOT) and the California Department of Transportation (Caltrans) through the University Transportation Centers program. The authors would like to thank the NCST, the USDOT, and Caltrans for their support of university-based research in transportation, and especially for the funding provided in support of this project. The authors would also like to give deepest thank you to Stuart Mori from Caltrans for his great help in keeping things on track. They also would like to acknowledge with heartfelt gratitude the support from James Drake, Dan Thao, Jessica Gonzalez, and other members from SacRT for helping survey design, circulation, and data collection.

NCST

Exploring the Consumer Market of Microtransit Services in the Sacramento Area, California

A National Center for Sustainable Transportation Research Report

May 2022

Yan Xing, Institute of Transportation Studies, University of California, Davis

Susan Pike, Institute of Transportation Studies, University of California, Davis

Elham Pourrahmani, Institute of Transportation Studies, University of California, Davis

Susan Handy, Institute of Transportation Studies, University of California, Davis

Yunshi Wang, Institute of Transportation Studies, University of California, Davis

NCST

[page intentionally left blank]

TABLE OF CONTENTS

List of Tables

List of Figures

Glossary

Acronym	Definition
AIC	Akaike information criterion
BIC	Bayesian information criterion
CSUS	California State University, Sacramento
DRRP	demand responsive ride pooling
DRT	demand responsive transit
EL (as in EL model and null/EL)	equally likely
LCA	latent class analysis
MS (as in MS model)	market share
SacRT	Sacramento Regional Transit District
SR	SMaRT Ride
TPB	theory of planned behavior

Exploring the Consumer Market of Microtransit Services in the Sacramento Area, California

EXECUTIVE SUMMARY

Microtransit is an emerging, technology-enabled, on-demand transportation mode whereby small shuttles provide shared rides through flexible routing and scheduling in response to customers' requests for rides. It can complement and enhance transit systems on the one hand and balance ridership efficiency and convenience on the other hand. Given its potential benefits, public transportation agencies are experimenting with this service to fill gaps in traditional transit service in the US. However, why some people are interested in microtransit while others are not remains an open question. For people who have never used it, what factors could work as facilitators or barriers in their willingness to adopt microtransit? Who are these early adopters of microtransit? Previous literature has explored a limited set of factors that influence microtransit ridership, such as availability and accessibility, wait time, design of app routing algorithms, and booking system. However, empirical evidence on the factors influencing microtransit use is still lacking. Guided by the theory of planned behavior (TPB), this study aims to fill the gap by conducting a large-scale survey of microtransit adopters and users of other means of transportation users in the Sacramento area of California in 2021.

The microtransit service our research focuses on is SmaRT Ride (SR) which is operated by the Sacramento Regional Transit District (SacRT). SR services started in Citrus Heights, California in 2018 and then expanded to 8 additional areas in the Sacramento area due to its success in Citrus Heights. With the help of SacRT, focus groups and interviews were conducted before the large-scale survey to gather preliminary information, help develop survey questions, and improve understanding of research findings, given the novelty of microtransit. Based on the feedback of the focus groups and interviews, an online survey was developed and participants recruited through various promotion methods, including sending a message through the SR app when riders enter the app and pushing it through various social media such as Facebook, Twitter, and the Nextdoor Neighborhood platform. Incentives for participation were provided. The respondents had a chance to win a $100, $50, or $10 gift card if complete the survey. To attract more interest, during the middle of the survey period, we added another incentive policy that the first 50 individuals to complete the survey would receive a $10 gift card. A sample size of 997 was achieved and a majority (78.9%) of them were SR users.

To address the research questions, discrete choice models—including binary logit and ordered logit models, and latent class analysis—were employed to explore barriers, facilitators to SR use adoption, and underlying subgroups of early SR adopters. The results show that age and education are negatively associated with choice of SR. Physical conditions that limit driving encourage choice of SR, but affect toward fixed-route transit negatively correlated with the use of SR. The attitude of liking SR strongly encourages the use of it, so does the perception that SR services save time. For people who are aware of SR but have never ridden it, the willingness to adopt SR is negatively influenced by education level. Inability to drive discourages the

willingness to use SR, which may pertain to their limited knowledge about SR due to the lack of any riding experiences. On the other hand, because SR does not provide door-to-door services in most of its service zones, groups of people with physical conditions that limit driving are less likely to use it because they cannot summon it as an on-demand paratransit. Similarly, inability to take fixed-route transit is also negatively associated with willingness to adopt SR, implying common features between SR and other transit services. This may be the case especially because SR cannot currently pick up passengers at their doorsteps and picks them up, like buses, at fixed-locations. The affect toward SR facilitates the increase of the level of willingness to SR adoption. The novelty and time reliability of SR encourage people to adopt it significantly. S*ocial support* effects adoption. Individuals who feel that people they know would support SR are more willing to adopt SR.

An extension of latent class analysis reveals three classes of early microtransit adopters in the SR customer market: (i) *travel time savers with environmental awareness,* characterized as favoring driving, valuing travel time, liking bicycling, and having a pro-environmental attitude; (ii) *riders with a neutral mindset,* who have a neutral attitude toward almost all manifest variables we tested, including various attitudes, beliefs, subjective norms, and behavior control factors; and (iii) *pro-SR and travel cost savers,* who are attracted by the novelty, time- and money-saving of SR services and perceive the use of SR supported by their family, friends, and society. The inclusion of covariates such as socio-demographics and environmental context enables further refinement of the three classes of SR users. The first class are users who are younger, of white race, more educated, more likely to be employed and telecommute frequently, and live in areas of high population and low employment density. The second class are likely to be older users, of non-white race, and low education level, living in areas with a high job density and low population density. Users in the third class are likely to be middle-aged SR users with medium education levels. They are less likely than the first class of SR users, but more likely than the second class, to be of white race, employed, and telecommute. They may live in areas of medium population density and medium employment density.

This study contributes to the literature by examining the impacts of a wide spectrum of potential factors on microtransit use and adoption using original survey data. Though this study is limited by its cross-sectional design and ignoring of endogeneity between the variables, the degree of effects of endogeneity may be minimized considering that the SR pilot program has been operating less than 3 years. The study provides insights that can guide the development of more complex models or longitudinal studies in the future and it provides new and important insights into understanding the SR customer market. The results will help transportation planners better understand important factors as facilitators or barriers to adoption and use of microtransit and thereby help them make well-informed decisions to encourage microtransit use.

1 Introduction

Public transit plays an important role in transportation systems by providing basic and essential mobility services to people, especially those without access to a car or who are unable to drive. Moreover, it allows two or more passengers (family members, friends, or strangers) with a similar travel schedule and itinerary to share a ride. This sharing may help reduce traffic congestion, energy consumption, air pollution, and carbon emissions (Furuhataa et al., 2013). Given its benefits to accessibility, equity, and environment as a whole, public transit has been focused on and advocated by policy makers globally for decades. However, barriers such as unpredictable wait and travel times, inconvenient transfers, and set schedules of the service (un-responsive to variations in passenger demand) discourage people from adoption.

Microtransit has the potential to fill gaps in public transit by overcoming the barriers to its adoption mentioned above. Microtransit is an on-demand and technology-enabled transit that resembles ridehailing services provided by transportation network companies (TNCs) but is much more affordable. Microtransit, also known as demand responsive transit (DRT) in some studies, is defined as an alternative transit service that incorporates flexible routing and/or flexible scheduling to meet customers' demand through the use of information and communication technology (ICT) (Shaheen et al. 2015; Shaheen & Cohen, 2019). Microtransit usually operates with a variety of small-scale vehicles, including SUVs (sport utility vehicles), vans, minibuses, and shuttle buses to deliver passengers. Microtransit can also improve passengers' experiences by providing on-demand scheduling and more flexible routes and extend the efficiency and accessibility of the transit service. Moreover, previous studies suggested that this service is believed to help leverage vehicle electrification and automation to help create livable urban communities (Shaheen & Cohen, 2019). Some studies found that microtransit may lead to the decline of driving (S. Shaheen, A. Stocker, J. Lazarus, & A. Bhattacharyya, 2016). Another study suggested that both the number of vehicles on the road and energy consumption would be greatly decreased if on-demand transit substituted for all the taxis in Shanghai, China (Liu, Zhang, & Yang, 2019). However, a report from CityLab stated that microtransit may also bring new transit competition to replace buses and threaten city traffic by increasing congestion and pollution (Jaffe, 2015). Despite its controversial effect on transport, microtransit, as one of smart mobility modes, provides solutions to enhance public transportation by improving mobility and accessibility. Therefore, although the state of the practice of microtransit is still in an early phase, growing interest in it has been shown and pilot programs are emerging in the US, as in Grand Rapids, MI; King County, WA; Albany, NY; Los Angeles and Sacramento, CA; and Eugene, OR (American Public Transportation Association, 2020). Among the public agencies, the Sacramento Regional Transit District (SacRT) is the largest microtransit provider in the US. SacRT launched its first microtransit model, SmaRT Ride (SR), in Citrus Heights, California in February 2018 and then expanded to eight additional areas in the Sacramento area due to its success in Citrus Heights (American Public Transportation Association, 2020) (Figure 1). SR allows passengers to book a ride through an app, online, or by phone. The fare is the same as that of a traditional bus service in the area, $2.50, and gives a 50% discount to seniors, persons with disabilities, and students (SacRT, 2020).

However, since this service at its very early stage, it remains unclear what factors are the facilitators of and barriers to its adoption and use . Specifically, why are some people not interested in microtransit? Who are the early adopters of microtransit? In spite of the importance of addressing these questions, only a few previous studies focus on them due to the limited market commercialization of this new service model. To fill the gap, this study explores factors that may inhibit versus encourage the adoption of microtransit. The study used focus groups and a large-scale online survey with both adopters and other transit riders in the Sacramento area of California. By contributing to an improved understanding of factors influencing the decision to use microtransit, the study provides an empirical basis for policy makers to promote microtransit.

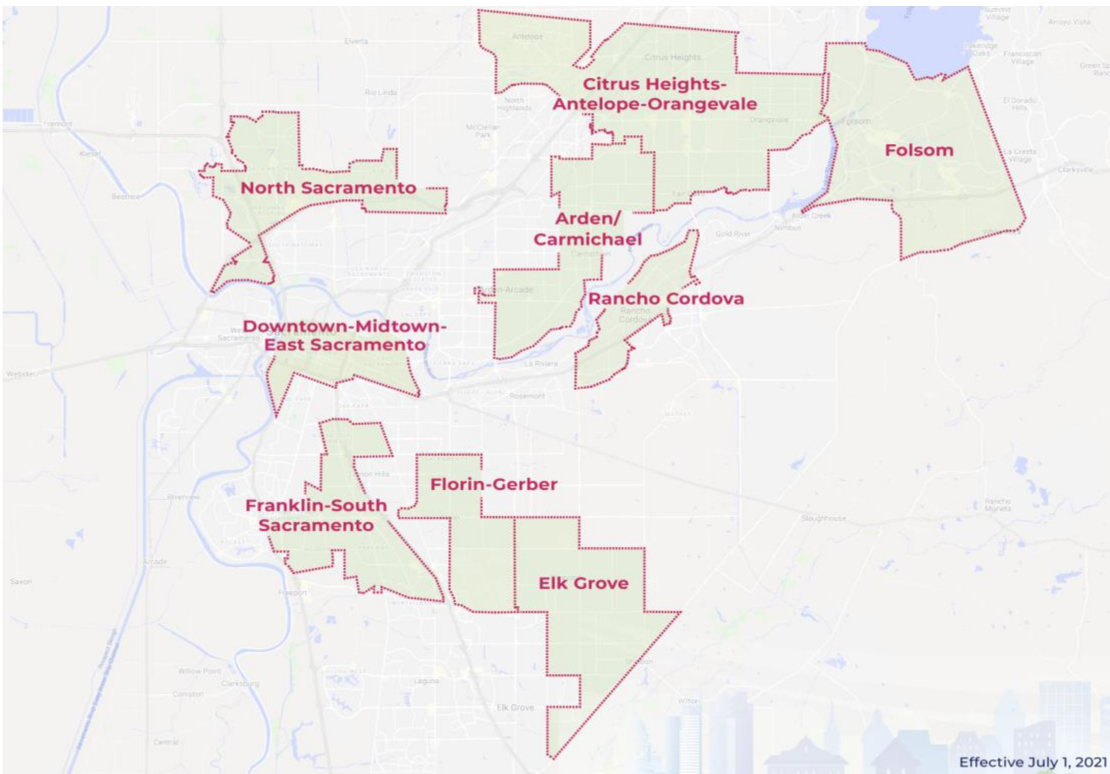


Figure 1. SmaRT Ride service zones in the Sacramento area of California (Source: SacRT)

This report is organized as follows. Section 2 describes the conceptual basis of this report and provides a literature review of previous studies on microtransit. Section 3 covers methodology, including the research design, survey sampling, administration method, survey questions and derived variables, and an overview of riders' most recent SR trips. Section 4 describes the results of the interviews and focus groups. Section 5 covers in detail the results of the survey, describing the model structures, factors associated with microtransit adoption, and latent classes of microtransit users. Section 6, the discussion and conclusions, describes the limits of the models and recommended topics for future research. Conclusions are drawn from the main results and, finally, policy implications are put forward.

2 Conceptual Basis and Literature Review

This study is based on a conceptual model derived from the theory of planned behavior (TPB), first introduced by Icek Ajzen (I. Ajzen, 1991). The literature review covers existing research on factors that may influence microtransit use.

2.1 Conceptual basis

The conceptual framework derived from TPB distinguishes between attitude, subjective norms, and perceived behavioral control in explaining microtransit adoption behavior (Figure 2). TPB theory is a widely used theoretical framework for explaining behavioral intentions. It assumes that an individual's behavioral intention and the consequences of a practiced behavior are influenced by three categories of factors:

1. his/her *attitude*, which includes an individual's overall evaluation of the behavior (e.g., the affect toward the behavior) and beliefs pertaining to the probable consequences of the practiced behavior,
2. subjective norms/normative beliefs (an individual's beliefs about whether other people think he/she should engage in the behavior), and
3. control beliefs (perceived barriers or facilitators to the behavior) (I. Ajzen, 1991).

Following the theory of planned behavior, three corresponding sets of factors are hypothesized to directly affect the intention to adopt microtransit. Authors on TPB (Icek Ajzen, Albarracin, & Hornik, 2007) have further suggested that inclusion of additional predictors and background variables within the context of the TPB may help improve its predictive power. Therefore, we added more attitudinal and background variables to enhance the understanding of microtransit adoption.

One limit of TPB is that it fails to capture the influence of past experiences with the behavior and does not include real limitations on the ability to perform the behavior, such as lack of resources. To solve this problem, we designed screening questions to categorize the respondents into groups of people who had never heard of microtransit, who had heard of it of but never used it, and who had used it before taking the survey. To reduce the barrier from a lack of knowledge of microtransit, a detailed introduction of microtransit was provided to people who had never used it. The questions pertaining to behavioral intentions were asked under the assumption that microtransit services were available at the needed time and location. Further, individual health and socio-demographics were included to provide more information of an individual's ability to use microtransit.

We note that reciprocal relationships (illustrated by two-headed-arrows in Figure 2) may exist across the three sets of main factors that drive microtransit adoption. For example, an individual's attitude may contribute to the formation of subjective norms in a community; on the other hand, it may also be influenced by the perceived subjective norms over time. Similarly, supportive subjective norms may lead to residents' advocacy for investment in microtransit to help increase self-efficacy in riding it, while higher levels of self-efficacy, in turn, may help strengthen a supportive environment. The two-headed-arrows in Figure 2 illustrate the possible interactions of the categories of variables. However, these bi-directional relationships between the variables were not examined in this study. Since SR service has been operating for less than 3 years, the degree of the reciprocal effects may be minimal. However, considering them may be useful in developing more complex models and longitudinal studies in the future.

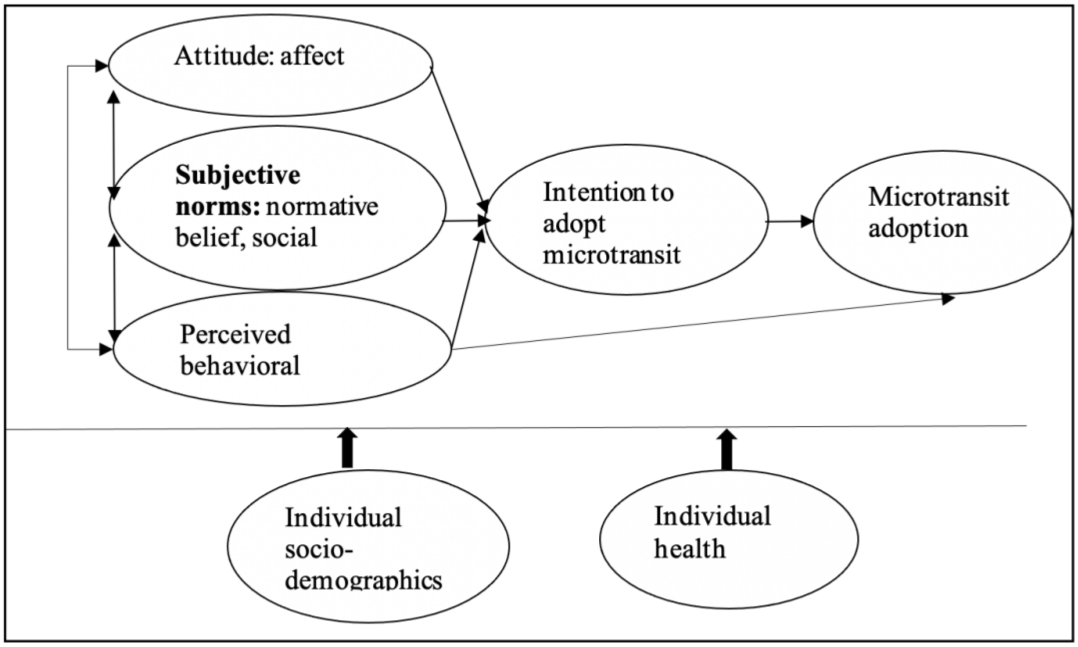


Figure 2. Hypothesized Conceptual Model

2.2 Literature Review on Studies of Microtransit

This literature review provides an overview of studies focusing on technology-supported microtransit, rather than general DRT services. DRT is defined by the Federal Transit Administration (FTA) as "a transit mode comprised of passenger cars, vans or small buses operating in response to calls from passengers or their agents to the transit operator, who then dispatches a vehicle to pick up the passengers and transport them to their destinations." (Ellis & Mccollom, 2009). DRT includes traditional modes of transportation such as Americans with Disabilities Act (ADA) paratransit services and recent technology-supported modes, such as microtransit and automated shuttles.

A concise summary of the literature review is presented in Table 1.

Previous research provides evidence of the importance of individual ***attitude*** and ***perceived behavioral control*** on microtransit choice. Influences of individual attitude on microtransit adoption has not been largely explored. One study provides a hint that individual habits, which may be affected by attitude, inhibit the intention to adopt microtransit (Franco, Johnston, & McCormick, 2020). Most studies show the influence of perceived behavioral control—such as availability of service, ease of use of microtransit app, accessibility of pickup/drop off locations—on microtransit adoption. The control factors examined in these studies include availability of service area and schedule, wait time, ease of use of microtransit software/app, accessibility of pickup /drop-off locations, ease of use of payment method, vehicle equipment, and cost. For example, a study examined *lack of spatial coverage* (e.g., medical and health centers as well as grocery stores were not covered by the service). D*ifficulty in use* works as a potential barrier in the path of adopting microtransit (Miah et al., 2020). *Availability and accessibility* of microtransit are found to be the main influences on the willingness to use it (Rudloff & Straub, 2021). Miah et al. also indicate that the *operating schedule* of Via, a leading microtransit provider, does not match with riders' needs *and restricted service hours* may discourage ridership (Miah et al., 2020). Shorter *wait time* was identified as an essential factor to improve passengers' satisfaction and facilitate microtransit adoption (Avermann & Schlüter, 2019; Haugland, Ho, & Laporte, 2007). Herminghaus (2019) found that long wait times reduce the use of microtransit. Microtransit apps, booking systems, and payment method are also found to be associated with microtransit use. One study suggests that improved routing algorithms that could result in shorter wait times and higher location accuracy can increase ridership significantly (Ma, Chow, Klein, & Ma, 2020). Sufficient and effective software handling scheduling and requests influence the willingness to use microtransit (Herminghaus, 2019). Another study showed that the following factors were vital in encouraging people to ride microtransit: improved apps, such as those providing accurate pick-up locations; booking systems, such as those compatible with a screen reader; and payment methods integrating Apple Pay and Google Pay (Patel, Etminani-Ghasrodashti, Kermanshachi, Rosenberger, & Weinreich, 2021). Location accuracy is a contributing factor to increase demand (Haugland et al., 2007). Some studies showed that accessibility of pick-up/drop-off locations—including ease of entry and walking access—and location accuracy impact microtransit ridership (Avermann & Schlüter, 2019; Haglund, Mladenović, Kujala, Weckström, & Saramäki, 2019; Miah et al., 2020). Miah et al. indicate that some people may face challenges with using the smartphone and credit card payment system (Miah et al., 2020). Moreover, improved vehicle equipment facilitates the ridership of people with disabilities (Patel et al., 2021). Cost is also found to negatively influence the willingness to ride microtransit (Herminghaus, 2019).

Previous studies also suggest important impacts of individual health and socio-demographics on adoption of microtransit. For example, physical disability is associated positively with microtransit use (Wang, Quddus, Enoch, Ryley, & Davison, 2015). However, another study shows that riders who are not disabled, without an assistive device, and older adults (age>54) who have frequent healthcare and discretionary trips are more willing to adopt microtransit service (Miah et al., 2020). One study indicates that people with disabilities face challenges with using the smartphone and credit card payment system (Miah et al., 2020). Female gender did not correlate with the use of DRT services (Avermann & Schlüter, 2019). People with no car were slightly more interested in using a microtransit shuttle service (Brown, Grossman, & Noble, 2021). One study indicates that riders are overwhelmingly younger, upper income, highly educated, and vehicle owners (Susan Shaheen, Adam Stocker, Jessica Lazarus, & Abhinav Bhattacharyya, 2016). Another study (Macfarlane, Hunter, Martinez, & Smith, 2021) found that younger individuals in larger households are more willing to use the service. People who are travelling for work are likely to travel more frequently by microtransit (Wang et al., 2015), whereas another study shows that most riders use the service for various trip purposes (e.g., social and business trips) (Haglund et al., 2019).

Previous studies provide insights in factors associated with microtransit adoption and use. It is notable that different studies come up with seemingly contradictory results, e.g., one study found that older adults are more willing to adopt microtransit, whereas another study found that younger people are. These differences in findings may be due to differences in the areas studied, or some services are meant to serve different types of riders. For example, one pilot focuses on providing services for the disabled and remote rural areas (Wang et al. 2015); another was designed for specific employees (Franco et al. 2019). Most importantly, sociodemographics are more closely associated with access to technology rather than with area of service, i.e., the service cannot serve people who live in the area but have no bank account or are unable to access booking or payment online. Additionally, given the significant influence of attitude toward a transportation mode on the intention to use it, it is helpful to explore more attitudinal elements to understand people's motivations for using microtransit. Further, influence of social support, i.e., support from family or friends, on using microtransit has not been explored in previous studies. Therefore, we consider a wide spectrum of potential factors that could influence microtransit adoption, including attitude that consists of more beliefs, subjective norms, and perceived behavior control, as well as features of microtransit.

Table 1. Summary of literature review

Reference	Setting	Method	Purpose	Important factors or variables
Wang, C. et al. (2015).	-CallConnect DRT in England, -Flexible service, integrated with fixed route bus -Have home pickups for disabled and remote rural areas -Book by phone, SMS and online	-Customer Survey (N=432) plus census data, -Ordered Logit Model	Estimating travel frequency	Service area, Trip purpose, Booking method, Satisfaction of the service, Sociodemographic
Avermann and Schluter, 2019	-EcoBus DRT in Germany -On demand without fixed routes, timetables or stops -Door to door with pickup time window -Book online, by app or phone	-Customer paper-based survey during pilot run from riders inside the bus (N=212) -Ordered Logit Model	Estimating overall satisfaction	Type of ticket, Number of riders on the bus, Waiting time, Satisfaction with the entry possibilities of the bus and bus equipment, Reason for travelling, Sociodemographic
Herminghaus, S. (2019).	-Hypothetical demand responsive ride pooling (DRRP) -Minibuses with limited capacity -Door to door with pickup time window	Statistical and analytical models	Identify the environment quantities where DRRP is deployed, and predict performance	Travel distance, Travel frequency, Area density, Demand temporal variation, Wait time, Fleet size, Vehicle capacity, Road network parameters (e.g., signal density), Detour
Haglund et al., 2019	-Kutsuplus DRT in Finland -Vehicles with 9 seats and no standing -Door to door with earliest pickup time window -Operating on fixed bus stops and smaller number of virtual stops in low density areas	Routing and pricing models and demand data analysis (82,290 journeys)	Evaluation of service accounting for operating area, timing, and pricing scheme	Pricing type, Time of the day/year operation, Vehicle occupancy, Age of riders, Travel time, Wait time

Reference	Setting	Method	Purpose	Important factors or variables
Franco et al. (2019)	Two mobility services in UK: - SeverNet BUZ: fixed schedule bus for employees and occasional users, booked by employer or using an app - My First Mile: on-demand feeder for the bus routes and a door-to-door service	Agent based simulation and travel demand model	Predicting the demand and quantifying the benefits	Travel distance, Travel time, Trip frequency, Time of the day, Willingness to pay
Kang and Hamidi, 2019	-GoLink DRT in Dallas Texas -Mostly used as a feeder to fixed-route transit -Booking by app, phone or walk-in	Analyzing data from various sources (trip data, American Community Survey, employer-household dynamics data)	Examining the service as a feeder to public transit in low-density areas	Land use, Connection modes (car, bike, walk, bus, DRT), Wait time, Travel time, Walk distance, Time of the day operation, Sociodemographic
Ma et al., 2020	-Kussbus DRT in Luxembourg -Book by app -Pickup/drop off within walking distance of the desired points at a given time window	Matching, and pricing model and trip data analysis	Evaluating the service performance under various pricing policies	Ridership, Profit, Cost, Travel Time, Access time, Wait time, Capacity, Socioeconomic
Mavrouli, 2020	-Hypothetical DRT in Greater Columbus Area, Ohio -Employer-sponsored service for commute travel -Pickup employees at a stop close to their house	Web-based stated preference survey (N=952), descriptive statistics and mixed logit model	Estimating the probability of using the service	Commute patterns, Attitudes and level of satisfaction with various travel modes and facilities (e.g., travel time, cost, distance, accessibility, availability, flexibility, comfort, wait time, walk time)
Backman et al. 2020	DRT Trial in outer suburban areas in Logan, Utah	Online survey (N=400) and content analysis	Exploring how people are using the DRT service and its impacts	Accessibility, Travel pattern, Alternative modes, Sociodemographic

Reference	Setting	Method	Purpose	Important factors or variables
Macfarlane et al., 2021	-DRT in the southern part of Salt Lake county--mainly low-density suburban area -Stops are either at the vicinity of origin and destinations or at the public transit stations -Booking by app or phone call	Intercept survey of riders before and immediately after the service is launched (N=130), descriptive analysis	Investigation of factors affecting willingness to use	Frequency and purpose of use, Access mode, Awareness, Sociodemographic
Brown et al., 2021	-On-demand Shuttle Via2G for Google employees in Menlo Park, CA	Pre pilot survey (N= 2,306) and pilot trip data, descriptive analysis	Exploring the service operation and users	Travel frequency for various modes, Trip characteristics (walk time/distance, wait time, travel time/distance, sociodemographic), Travel demand pattern, Cancelations
Yoon et al., 2021	Fixed route transit, flexible-route transit (fixed and flexible stops), and on-demand transit	Simulation	Analyze and compare the three transit services	Route length, Service area, Arrival rate, Walk speed, Vehicle capacity, Fleet size and Number of stops
Truden et al., 2021	DRT small buses as a feeder to fixed transit lines in rural areas	Simulation	Evaluation of system performance in terms of customer satisfaction and trust	Fleet size, Vehicle capacity, Time windows, In-vehicle travel time, Service operation time, Wait times

3 Methodology

The study employs a cross-sectional research design to determine the relative influence of attitude and socio-demographics on microtransit use. The unit of analysis for the study is the individual. The area of focus is the behavior of transit users in the Sacramento area.

3.1 Survey sampling and administration

Qualitative methods, including interviews, focus groups, and participant-observer techniques, are useful tools for understanding complexities of travel behaviors (Clifton & Handy, 2003). Due to the novelty of microtransit, we employed focus groups and interviews to gather preliminary information, maximize our understanding of research questions, and identify important themes among SR adopters that could serve as the basis for the design of the subsequent survey questionnaire. In addition to recruiting microtransit adopters, other transit riders who have never taken a ride in SR were chosen as the comparison population to explore barriers to adoption. Meanwhile, we interviewed stakeholders including a board member, a planner, an operation supervisor, and two operators (drivers) who are representatives of SacRT to collect a diversity of experiences, opinions, and views from the provider perspectives. One purpose of including the interviews with stakeholders is to provide a context to better understand the findings from the focus groups and the study overall. We also aim to explore more details concerning the daily operation of microtransit from SacRT to identify discrepancies between the perceptions of microtransit from consumers and providers. Note that all the focus groups and interviews were conducted online due to the COVID-19 pandemic. Different from traditional in-person focus groups, in which all participants are present in one room, they participated in an online conference through Zoom. Although the online method excludes people who are unable access internet or use the online conference platforms and limits observations and responses to body language, it may encourage people to participate because of its convenience and making travel unnecessary.

In June 2021, SacRT helped us circulate an invitation message to SR adopters through LeanPlum, a mobile platform provided by Via (software provider). Specifically, the center pop-up message of LeanPlum was sent to SR adopters who were 18 years old or older when they first used the app. Meanwhile, other transit users who have not ridden in a SR were reached through the full riders' email list, i.e., anyone that signed up to receive emails from SacRT. A $25 gift card was offered to each participant as an incentive for participation. Based on the time of volunteers' responses and riding experiences, we chose 32 candidates for 4 focus groups:

- frequent SR users (use it weekly),
- infrequent SR users (use it less than once a week),
- transit riders who have not heard of SR, and
- transit riders who have heard of SR but not ridden in it.

Although schedule options either on a weekday or weekend were provided and both confirmation and reminder emails were sent to the volunteers before the appointed time for the focus groups, only 14 participants attended: 4 frequent SR users (4 infrequent users, 5 other transit riders who have heard of SR but not ridden in it, and 1 transit rider who has not heard of it) joined the 5 focus groups at the appointed times. The respondents participated in the focus groups using Zoom and the average discussion time was about one hour. Later, we interviewed the board member from SacRT about motivations to initiate this service, their goals, and near- and long-term plans. The operation supervisor and operators were interviewed to collect information about the daily operations of the SR service.

After further revision of the survey questionnaire based on the feedback from the focus groups and interviews, in August 2021, with the help from SacRT, we published our survey through Qualtrics, a web-based survey tool. Survey promotion methods included sending a center pop-up message through the SR app when riders enter the app; pushing it through social media such as Facebook, Twitter, and Nextdoor Neighborhood platform; emailing the survey information (brief introduction, the links, and the QR code) to all riders who have registered in SacRT; placing the survey information on SacRT website; and providing information about it in SacRT's September riders' newsletter (print, email, and online). Although materials such as rack cards and notices as promotion materials to be put in buses and SmaRT Ride shuttles were prepared, this on-vehicle recruitment method was not executed due to a time conflict with campaigns of SacRT starting in August 2021. Although our online survey recruitment method was wide-reaching at a low cost, it may have failed to capture underserved population who are unable to access the internet or use digital technology.

As an enticement for participation, respondents could choose to be entered into a drawing for one $100, four $50, and 25 $10 prizes. At the end of September, we later added another incentive of $10 for the first 50 respondents, which dramatically increased the survey response rate. About two months after the survey was published, we achieved a sample size of 997, 79.5% of whom used SR and 19.5% who had never used it. Although we designed the survey to be relevant to all individuals, it is possible that individuals who do not use SR were less inclined to complete the survey, resulting in more SR users captured in our data. To check the representativeness of the SR users in the sample, we compared the percentage of all the SR-riding respondents (over the duration of the survey) that were from a given service zone to the percentage of all SR boardings per day that occurred in that service zone. Note that SR boardings/day, which may not reflect the population of SR users in each service zone, was used instead due to the lack of the total numbers of SR population in each service zone. Figure 3 shows that we may have had an overrepresentation of SR users in Franklin, Rancho Cordova, and Folsom service zones, but an underrepresentation of SR users in Citrus Heights and Natomas service zones. However, because the focus of our study is on explaining SR use as a function of other variables rather than describing a simple univariate distribution of SR use, these differences may not materially affect the results (Babbie, 2009).

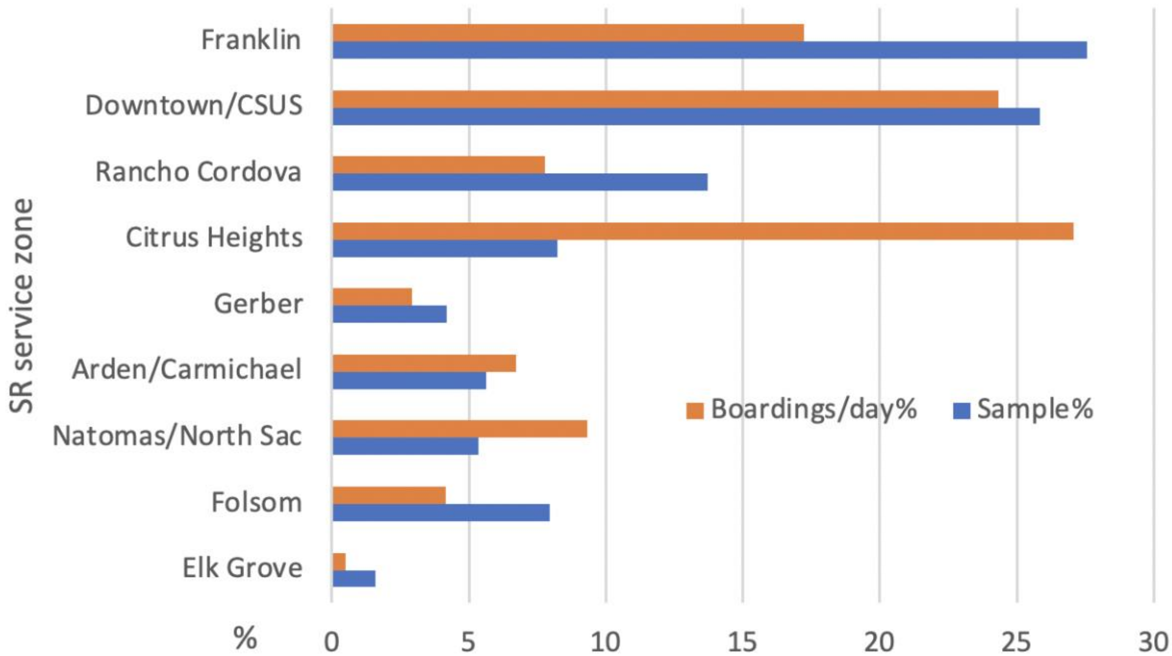


Figure 3. Comparison of percent of sample SR users and boardings/day across the SR service zones (N=693). (Source: Boardings/day were collected by SacRT as of December 2021.)

A further comparison of some sample socio-demographics with the corresponding census data of population by city shows that the overrepresented service zones—Rancho Cordova, Franklin, Folsom, and Elk Grove—have relatively younger populations and higher median household income levels (Table 2 and Figure 4). Additionally, in the sample, the percent of the sample of SR users who are seniors (65-years-old or older) is smaller than the percent of the population in each city that are seniors. In the service zones with lower percentages of white people, these people represented a higher percentage of the sample than of the population. All the above findings may imply overrepresentation of people who are younger, white, and have higher incomes. This overrepresentation may be due to the limit of our survey recruitment method, which may have failed to capture underserved populations in the service zones.

Table 2. Comparison of census population and SR users' socio-demographics in the sample by city

	Age 65+		Female		White only		Bachelor's degree or higher**	
	Census	Sample	Census	Sample	Census	Sample	Census	Sample
Elk Grove	12.3%	0%	51.9%	44.4%	43.1%	55.6%	36.7%	12.5%
Folsom	12.7%	5.1%	49.1%	55.0%	66.8%	66.7%	50.2%	40.6%
Natomas/North (Sacramento)*	13.3%	0%	50.9%	59.3%	43.5%	48.1%	34.3%	36.4%
Arden/ Carmichael	16.5%	3.4%	52.5%	57.1%	58.2%	71.4%	37.2%	45.8%
Gerber	19.8%	0%	49.3%	37.5%	21.1%	65.2%	10.4%	35.0%
Citrus Heights	16.8%	9.1%	51.4%	50.0%	79.0%	77.3%	21.6%	51.4%
Rancho Cordova	11.5%	1.6%	51.0%	49.2%	58.2%	65.1%	27.4%	49.0%
Downtown/CSUS (Sacramento)*	13.3%	5.5%	50.9%	40.8%	43.5%	60.4%	34.3%	46.4%
Franklin	10.1%	3.6%	51.5%	41.7%	48.2%	58.3%	6.1%	32.2%

*Individual census data of North Sacramento and downtown/California State University, Sacramento (CSUS) is lacking, and the census data of Sacramento City was used instead.
**% of persons age 25 years+, 2016-2020
Source: 1) U.S. Census Bureau QuickFacts: Sacramento city, California; Franklin CDP, California; Elk Grove city, California; Rancho Cordova city, California; Folsom city, California; Citrus Heights City, California; Arden-Arcade, California.
2) Gerber, California (CA 96035) profile: population, maps, real estate, averages, homes, statistics, relocation, travel, jobs, hospitals, schools, crime, moving, houses, news, sex offenders (city-data.com).

Figure 4 also shows that almost 80% SR users have an annual household income level less than $100,000 in all the service zones. In the zones with higher median household income level such as Elk Grove and Folsom, SR users tend to have household income levels lower than the local median, while in the areas like Gerber and Arden where residents have a lower median household income level, SR users tend to have higher household income levels than the local median.

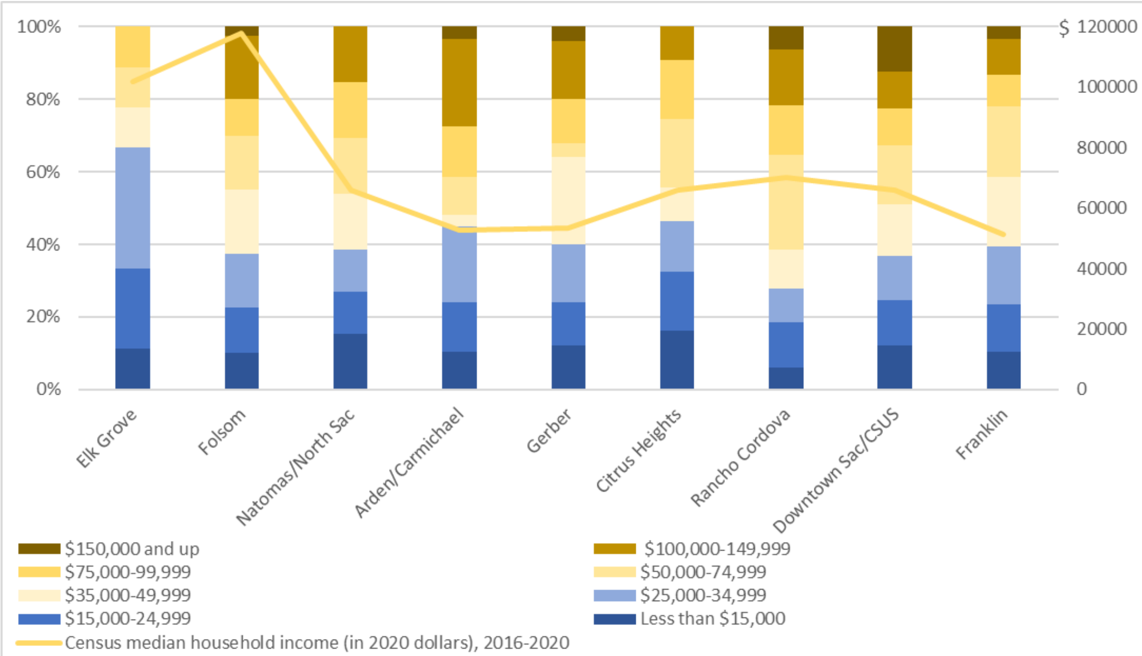


Figure 4. Comparison of annual household income level of SR users in the sample and median household income in the 2020 census by city. Note that individual census data of North Sacramento and downtown/CSUS is lacking, and the census data of Sacramento City was used instead in the figure.

3.2 Data cleaning

As the initial step, survey data was processed by editing, fixing, and improving its quality by the following procedure to prepare data for further analysis. We cleaned the data through several phases and achieved a sample size of 997. Note that this sample still includes observations with missing data because we try to keep as many answers as possible for each respondent. The various analyses in this report are based on several subsets of this data. The data cleaning process is described below:

3.2.1 Remove incomplete records

Some respondents failed to answer all survey questions. About 3% (total of 36) of the respondents left more than 70% of the survey questions unanswered during the process. These 36 records were removed from the final dataset due to lack of sufficient information.

3.2.2 Remove speeders

Speeders are respondents who rush through the survey questions and reduce their effort in answering questions by taking mental shortcuts. Their responses may bias the overall results. Thus, we identified the speeders who completed the survey in less than 5 minutes while the average estimated time needed for completion is about 15-20 minutes in our survey. The very low response duration time indicates that the respondent was not attentive and did not think enough before selecting the options. We removed them from the dataset, leaving a sample size of 997 for analysis. Next, we looked for respondents who straight-lined, in other word, selected the same option (neutral/unapplicable) on every Likert question with probably little or no thought. In our dataset, we did not find any of these types of respondents.

3.2.3 Fix structural errors

Structural errors refer to misspellings, incorrect, or improper responses. The questions with text entry are subjected to structural errors, such as zip code, address, auto ownership, and household size. These were explored in the survey and resolved.

3.2.4 Fix invalid records

This step is mainly conducted through cross-field validation, meaning that certain conditions must hold consistently across multiple fields. For example, an individual cannot be both full-time employed and unemployed. These are identified across several fields of variables and corrected.

3.3 Survey questions

Following the conceptual model, the main questions for both focus group participants and the large-scale survey were categorized into 6 groups as follows. The variables measuring SR behaviors and the explanatory variables were derived from these survey questions accordingly. The variables in the first 5 groups that entered the inferential analysis are documented. Then the overview of the most recent SR trip is introduced based on the responses of the survey questions in the 6th group.

3.3.1 Socio-demographics and individual health

These questions were about an individual's socio-demographics, such as age, gender, education level, race, household size and individual's physical conditions that limit his/her ability to walk, bike, drive, and taking transit.

3.3.2 Attitude

These questions about attitude include affect toward SR as well as other transportation modes such as driving, ridehailing, and transit. We also measured other opinions, beliefs, and thoughts about travel time and travel cost, which pertain to an individual's perceptions of likely consequences of using SR. Moreover, attitude toward specific attributes of SR—including its environmental impact, novelty, accessibility, wait times, and travel time reliability—were also assessed.

3.3.3 Subjective norm

A question about normative belief was designed to identify people who consider the impact of mode choice on environment and energy. The respondents were also asked whether people they know will be/are supportive of SR to measure social support, which pertains to whether they believe they are expected by their friends, family, and society to use microtransit.

3.3.4 Perceived behavioral control

We asked about several potential facilitators or barriers to using SR associated with individual control belief, such as the perception of ease of use of the app, mental effort to interact with SR, availability of service areas and schedule, travel cost, and total travel time.

3.3.5 SR behavior

The respondents reported whether they had heard of SR. For the respondents who had heard of it, they further reported whether they had used it before taking the survey. SR behavior questions also include the respondents' intention to use SR (for non-users) and intention of continuous use (for users) in the future . Additionally, how SR users' choices of transportation changed because of SR were collected to examine the probable modal shift due to the use of SR. SR users were also asked about the influence of the COVID pandemic on the use of SR.

Specifically, the respondents were asked to recall their most recent SR trip and to report trip attributes such as trip purpose, access walk, egress walk, wait time, in vehicle travel time, etc. Questions also related to perceptions of vehicles' exterior and interior characteristics, such as how easy to get on and off, especially using wheelchair, cleanliness, comfort, temperature, and noise levels. The questions also asked about the drivers' manner toward riders and driving skills.

3.4 Variables measuring behaviors and explanatory variables

The variables measuring microtransit use vary in the models according to the different research questions in this report. A survey question asking whether an individual had heard about SR before taking this survey was designed to screen out people who had never heard of any information about SR. People who had heard of it were further asked, before taking the survey, whether they had ever used SR. Then detailed information about SR was introduced to people who had heard of it, but not used it before. To explore why some people use SR but others do not, even though they have heard of it, a dichotomous dependent variable was defined as having used SR in the past and never use SR for people who had heard of it before taking the survey. We then focus on people who had heard of it but never used it and examined their willingness to use it in the future. For this model, the dependent variable is created from respondents' likelihood to use SR in the future in one of 5 categories: 1 = Definitely not; 2= Probably not; 3=Might or might not; 4=Probably yes; 5=Definitely yes.

The explanatory variables fall into four categories suggested by our conceptual model: individual socio-demographics and health variables, attitude, subjective norms, and perceived control factors (Table 3). The wordings of the corresponding survey questions are indicated in the table.

Table 3. Description of Variables in Model

Variable name	Percent / Mean (s.d.)	Description
Dependent Variable		
SR use	80.5%	1=I have used SmaRT Ride in the past; 0= I have never used SmaRT Ride.
Will use SR	3.18 (0.86)	Will you use SmaRT Ride in the future? 1 = Definitely not; 2= Probably not; 3=Might or might not; 4=Probably yes; 5=Definitely yes.
Explanatory Variables		
Socio-Demographics and health		
Age	38.64 (15.13)	Age in years
Female	49.1%	1=Female. 0=Male
Education Level	3.37 (0.95)	The highest level of education. 1= Less than grade/high school; 2= High school diploma or equivalent, 3= Some college or trade/technical/vocational training, 4= Bachelor's degree(s), 5= Graduate degree(s), e.g., MS, PhD, MBA or professional degree(s), e.g., JD, MD, DDS
White	59.9%	1=white, not of Hispanic origin, 0=all other races.
Household Size	3.25 (1.95)	The number of persons living in the household.
Have Kids	22.6%	1=Household with children under 6; 0=Household without children under 6.
Have seniors	15.2%	1=Household with seniors at 65 or older; 0=Household without seniors at 65 or older.
Income	5.50 (2.60)	The annual household income level. 1= Less than $10,000; 2= $10,000-14,999; 3=15,000-24,999; 4=$25,000-34,999; 5=$35,000-49,999; 6=$50,000-74,999; 7=$75,000-99,999; 8=$100,000-124,999; 9=$125,000-149,999; 10= $150,000-174,999; 11=11 $175,000-199,999; 12=$.200,000 and up
Car Ownership	79.4%	Car ownership. 0=Have no cars, 1=Have a car
Employed	85.9%	1=Full time/part time employment/Intern/ Self-employment; 0=Unemployed / Retired / Unable work.
Telecommute Frequency	1.99 (1.68)	0=Rarely or never; 1=1 day/week; 2=2 days/week; …; 5=5 days or more/week.
Bank Account	93.4%	Do you have a bank account? 1=Yes; 0=No.
Driver License	86.3%	Do you have a Driver's license? 1=Yes; 0=No.
Limit Walk	22.8%	Do you have any physical conditions that limit your ability to walk? 1=Yes; 0=No.
Limit Bike	21.2%	Do you have any physical conditions that limit your ability to bike? 1=Yes; 0=No.
Limit Drive	24.5%	Do you have any physical conditions that limit your ability to drive? 1=Yes; 0=No.
Limit Transit	19.8%	Do you have any physical conditions that limit your ability to use fixed-route public transit? 1=Yes; 0=No.

Variable name	Percent / Mean (s.d.)	Description
Attitude		
Like SR	3.91 (0.93)	Agreement that “I like SmaRT Ride services” on a 5-point scale*.
Travel Waste Time	2.86 (1.14)	Agreement that “Travel time is wasted time” on a 5-point scale*.
Travel Cost	3.41 (1.13)	Agreement that “The cost of travel affects the choices I make about my daily travel” on a 5-point scale*.
Like Driving	3.30 (1.18)	Agreement that “I like driving” on a 5-point scale*
Like Ridehailing	3.26 (1.10)	Agreement that “I like ride-hailing services (e.g., Uber/Lyft)” on a 5-point scale*
Like Transit	3.68 (0.96)	Agreement that “I like taking buses, light rail, or trains” on a 5-point scale*
Like Biking	3.30 (1.19)	Agreement that “I like riding a bike” on a 5-point scale*
Like Walking	3.63 (1.07)	Agreement that “I like walking” on a 5-point scale*
Save Money	3.78 (0.99)	Agreement that “Using SR saves/will save me money” on a 6-point scale**
Save Time	3.69 (1.08)	Agreement that “Using SR saves/will save me time” on a 6-point scale**
Good Environment	3.97 (0.94)	Agreement that “SmaRT Ride services are good for environment” on a 6-point scale**.
Novelty	3.85 (0.95)	Agreement that “I am attracted to the novelty of SR” on a 6-point scale**
Accessibility	3.26 (0.98)	Response to “Would/Does the factor, access time or distance to pick-up locations/ from drop-off locations to destinations, discourage or encourage your willingness to use SmaRT Ride services? / Does the factor, access time or distance to pick-up locations/ from drop-off locations to destinations, discourage or encourage your use of SmaRT Ride?” on a 5-point scale***
Wait Time	3.03 (1.04)	Response to “Would the factor, wait times, discourage or encourage your willingness to use SmaRT Ride services? /Does the factor, wait times, discourage or encourage your use of SmaRT Ride?” on a 5-point scale***
Time Reliability		Response to “Would the factor, travel time reliability, discourage or encourage your willingness to use SmaRT Ride services? /Does the factor, travel time reliability, discourage or encourage your use of SmaRT Ride?” on a 5-point scale***
Share Vehicle		Response to “Would the factor, Sharing a shuttle with strangers, discourage or encourage your willingness to use SmaRT Ride services? /Does the factor, travel time reliability, discourage or encourage your use of SmaRT Ride?” on a 5-point scale***
Subjective Norms		
Environmental Concern	3.50 (1.06)	Agreement that “Environmental and energy concerns affect my choice of travel mode” on a 5-point scale*
Social Support	3.85 (0.92)	Agreement that “People I know are/will be supportive of it (SR)” on a 6-point scale**

Variable name	Percent / Mean (s.d.)	Description
Perceived Behavior Control Factors		
Easy App	3.93 (0.98)	Average agreement that “It was easy/will be easy for me to learn how to use the app to request a ride” on a 6-point scale**
Mental Effort	2.98 (1.16)	Average agreement that “Interacting with this service requires will require a lot of mental effort” on a 6-point scale**
Schedule Meet	3.65 (1.02)	Agreement that “SmaRT Ride service operates at the times I need to get places” on a 6-point scale**
Service Area Meet	3.65 (1.05)	Agreement that “SmaRT Ride service goes to most of the places I need to go” on a 6-point scale**

Note: *1=Strongly disagree, 2=Disagree, 3=Neutral, 4=Agree, 5=Strongly agree.
**1=Strongly disagree, 2=Disagree, 3=Neutral, 4=Agree, 5=Strongly agree, 6= Unapplicable or not sure. The response 6 was treated as system missing in the analysis.
***1= Strongly discourage, 2=Somewhat discourage, 3= Neither discourage nor encourage, 4=Somewhat encourage, 5=Strongly encourage.

3.4.1 Socio-demographics and health variables

Individual socio-demographic variables are age, gender, educational background, race, household size, household with children under 6, household income level, vehicle ownership, employment status, days telecommuting per week, having bank account, and having a driver’s license. Individuals’ physical conditions that limit their ability to walk, bike, drive, and use fixed-route transit were measured by a dichotomous response. Some of these variables were collected in the original questionnaire, such as income, bank account, and driver license. Some were generated by calculations, e.g., age and household size. The age of an individual was calculated based on the corresponding response to the original survey question that asks in which year the respondent was born. The size of a household was generated by adding the number of family members in each age group, under 6, 6-15, 15-64, and 65 years old and older. The other variables—including female, education level, white race, etc.—were recoded from the original responses of the corresponding questions.

3.4.2 Attitude

Attitude factors were measured in a number of ways. First, the attitude toward SR was measured in this study as agreement that “I like SmaRT Ride services” on a 5-point Likert-type scale from “strongly disagree” to “strongly agree.” Attitudes toward travel time and cost are reflected by measuring the levels of agreement with the statement “The cost of travel affects the choices I make about my daily travel” on a 5-point scale respectively. Respondents also expressed their attitudes toward driving, ridehailing, taking fixed-route transit, biking, and walking on 5-point scales. These variables were derived from the responses to the original survey questions accordingly. Figure 5 displays the response distribution to the attitude question. Accordingly, more than 50% of the sample care about the travel cost and its environmental impacts. More than 60% expressed interested in public transit and SmaRT ride services, while about 50% of individuals like some sort of active mode (walk or bike).

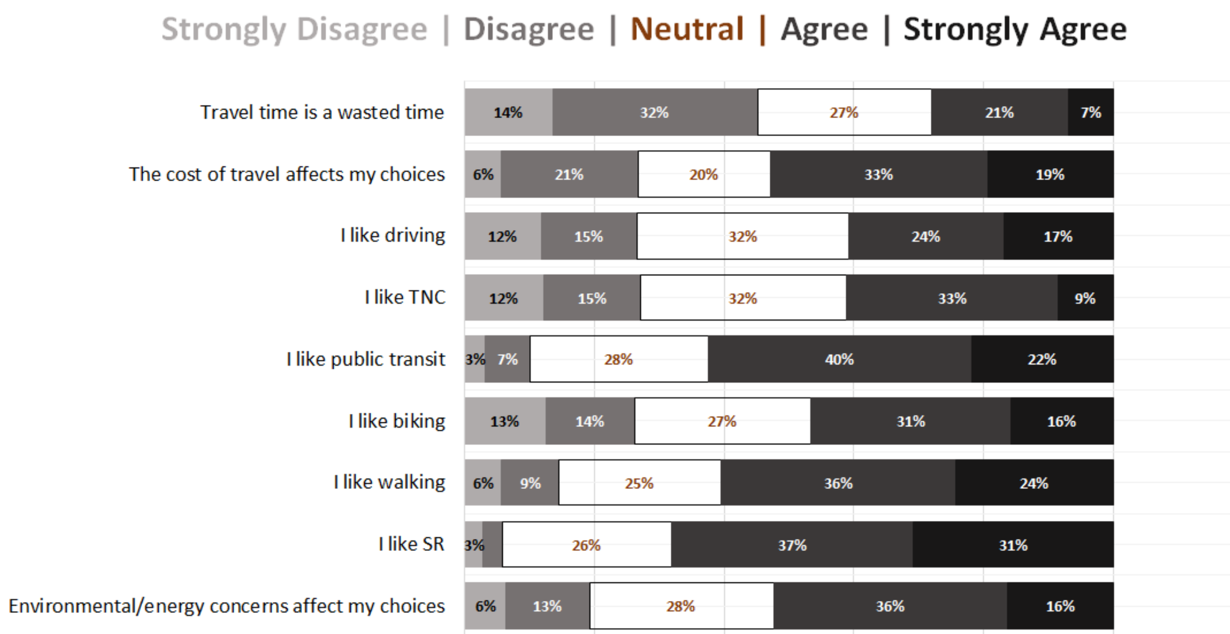


Figure 5. Attitudes toward travel and travel choices (N=639)

The attitude toward SR attributes includes the belief that SR is good for the environment and an interest in the novelty of SR. Similar to the variable "social support", these attitudinal variables were graded on a 5-point Likert scale with an additional option, "unapplicable or not sure" , which was treated as a missing data point in the analysis, for those who had not used SR. Attitude toward other important attributes of SR such as accessibility, wait times, travel time reliability, and sharing a vehicle with strangers were also included in the analysis. Considering that people who had not used SR may not have knowledge or perceptions of these factors due to the lack of riding experiences, the measures of these aspects were designed as self-reported levels of encouragement or discouragement to use SR. Figure 6 shows that waiting time and access to pickup/drop offs generate the most discouragement and encouragement to use the service, respectively.

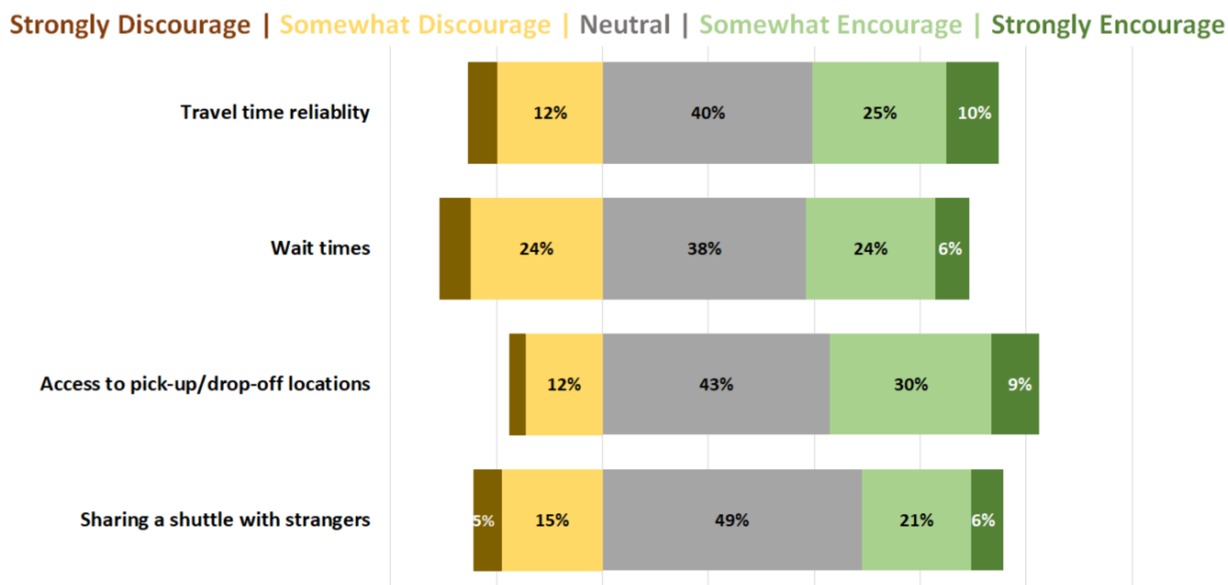


Figure 6. Encouragement and discouragement factors about using SmaRT Ride (N=639)

3.4.3 Subjective norms

The importance of environmental benefits when choosing modes was measured by the levels of agreement from "strongly disagree" to "strongly agree" on a 5-point scale. Another important subjective norm, social support—which indicates whether individuals perceive they are supported by their friends, their family, and other people in their communities to use SR—was also measured. The level of social support is reflected by the agreement level on the statement that "People I know are/will be supportive of it (SR)" on a 5 Likert scale with an additional option "unapplicable or not sure" for those who had not used SR because they may neglect the attitudes of other people toward SR due to a lack of attention. Then we treated this option as missing data in our analysis.

3.4.4 Perceived behavior control factors

Perceived behavioral control factors refer to individual's beliefs about factors that may facilitate or hinder their use of SR. Based on the literature and feedback from the focus groups, the control factors we measured were the belief of ease of use of SR app, mental effort required to interact with SR, and the schedule and service area availability.

3.5 Overview of SR Users' Most Recent Trips

The overview of SR services in the Sacramento area was based on SR users reports of their most recent SR trip on the survey. The data shows the socio-demographical characteristics of SR users, booking and payment methods, their overall evaluation of SR services, the accessibility of SR service measured by the reported time to get to the pick-up location and from drop-off to destination. The wait times and customers' willingness to pay for this specific trip are also presented to give an overview of SR services in this area.

3.5.1 Socio-demographical characteristics

The average age of SR users who participated in the study is 35 years old. Fewer female users than male users participated in the survey. Most of respondents, accounting for 81.7% of the total, have cars. Of the SR user respondents, about 71% have an annual household income less than $50,000 and 56% have an education level less than bachelor's degree.

Table 4. Socio-demographics of SR users

Socio-demographics	**%/Mean (s.d.)**	**N**
Age	34.95 (13.07)	583
Female	45.2	602
Education		611
High school diploma or equivalent	10.8	
Some college or Trade/technical/vocational training	45.7	
Bachelor's degree(s)	29.5	
Graduate degree(s), e.g., MS, PhD, MBA or professional degree(s), e.g., JD, MD, DDS	9.0	
Income level		605
Less than $10,000	3.8	
$10,000-14,999	8.1	
$15,000-24,999	13.2	
$25,000-34,999	14.9	
$35,000-49,999	14.4	
$50,000-74,999	16.4	
$75,000-99,999	10.4	
$100,000-124,999	8.1	
$125,000-149,999	4.3	
$150,000-174,999	2.0	
$175,000-199,999	1.5	
Car ownership	81.7	596

3.5.2 Booking and payment technology adoption

Booking and payment methods were repeatedly discussed in the literature as important factors in facilitating access to the service, particularly for disabled and older population who represent an important potential demand for the service. Figure 7 and Figure **8** show the trend in booking type and payment method for the users' most recent trip, according to age group. While the older aged subgroup is larger than other aged subgroups among disabled individuals, the rate of using the app for both booking and payment is lower for those having disability in general. People with disabilities are more frequently using other methods, e.g., asking someone to help, rather than the app on a smartphone, computer, or phone call for booking and payment.

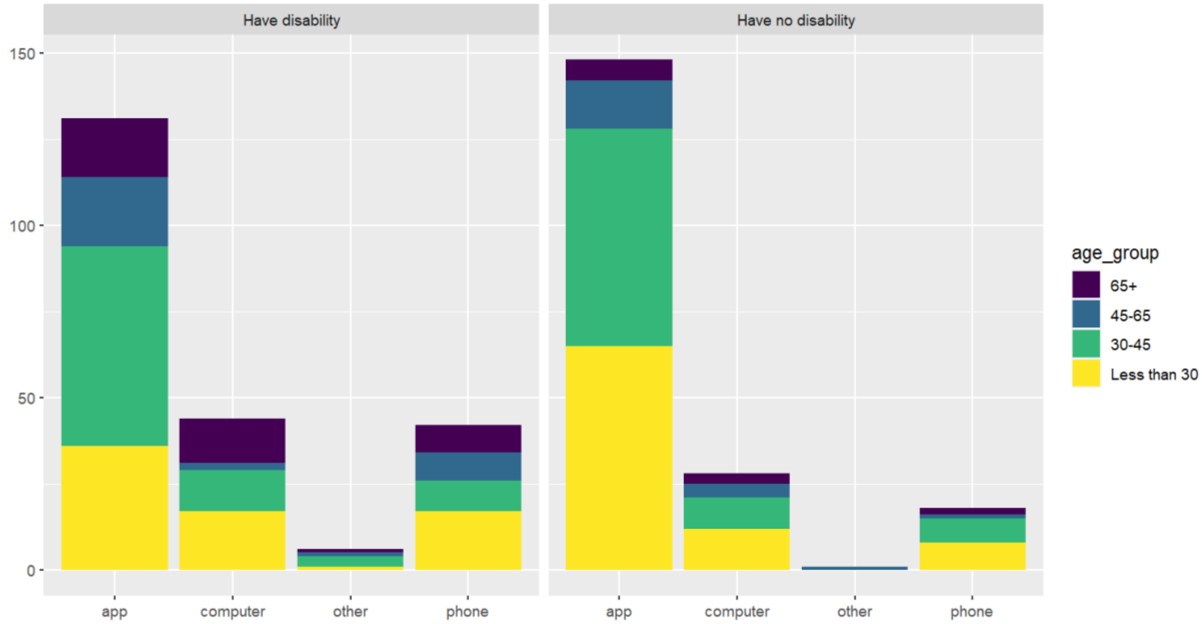


Figure 7. Booking method for the most recent trip those with and without disability, according to age groups (N=321). These data were derived from the following survey questions about the most recent SR trip, "How did you book it?", "Do you have any physical conditions that limit your ability to walk, bike, drive, or use public transit? ", and "What year were you born? – Year."

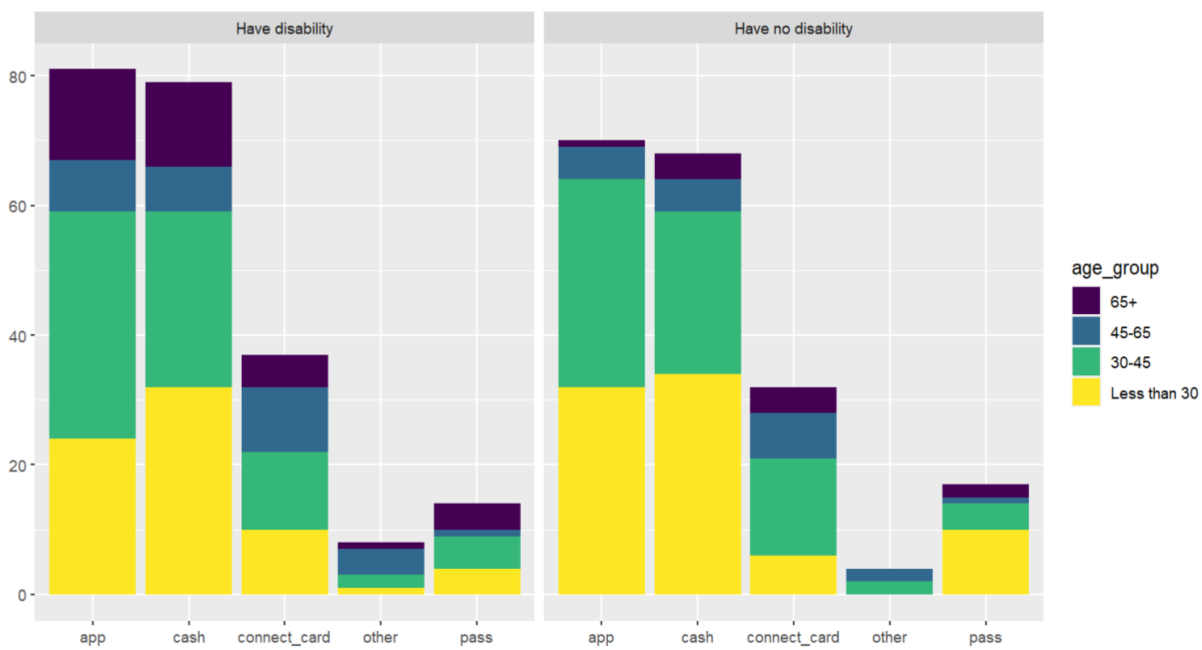


Figure 8. Payment method for the most recent trip by disability and age groups (N=321). These data were derived from the following survey questions about the most recent SR trip, "How did you pay the fare for this most recent trip?", "Do you have any physical conditions that limit your ability to walk, bike, drive, or use public transit? ", and "What year were you born? – Year."

3.5.3 Overall evaluation of SR boarding and on-board experience

Respondents overwhelmingly have a positive evaluation of both interior and exterior characteristics of shuttle vehicles, such as: how easy is it to get on and off, especially using a wheelchair, as well as cleanliness, comfort, temperature, and noise levels. It also includes drivers' attitude and driving skills. Almost 80% of SR users agree or strongly agree that they felt safe riding in the shuttle. They also strongly agreed that SR shuttles were clean and sanitized. However, a relatively higher percent (about 10%) of users reported the shuttle may not be friendly to the disabled and real-time information was lacking during the trip.

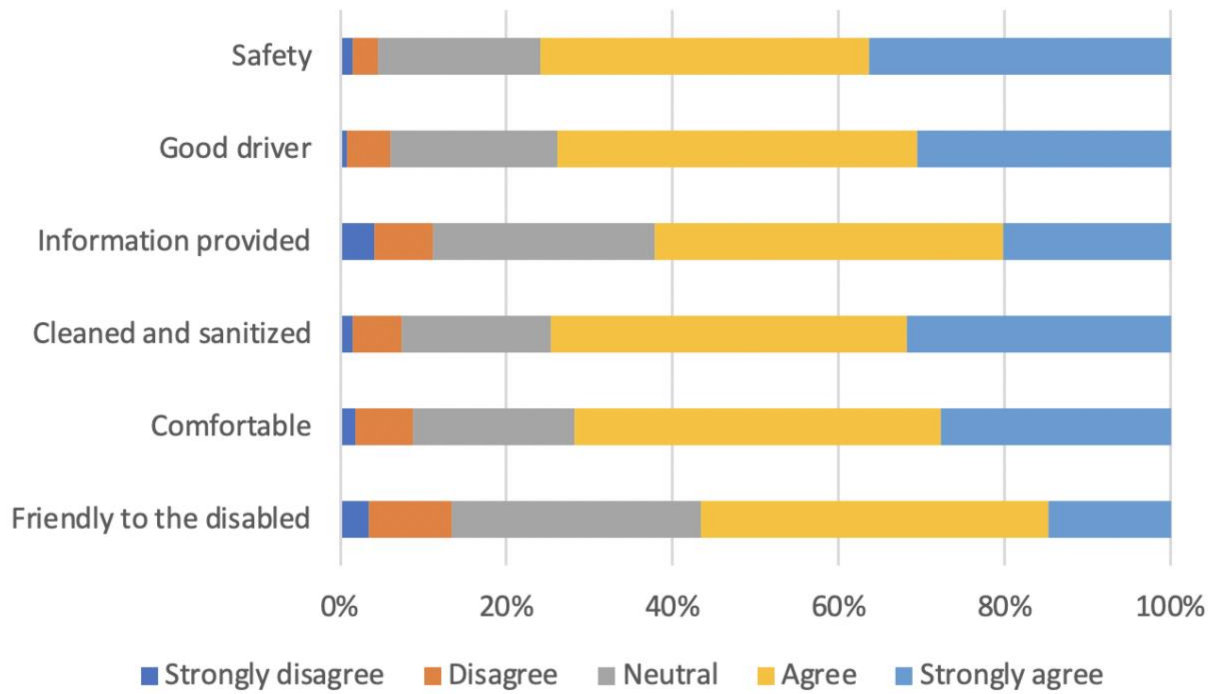


Figure 9. Overall evaluation of SR services (N=642). These data were derived from the survey questions that "For the most recent trip you traveled with SmaRT Ride, please tell us how you felt about the shuttle interior on that trip. Do you agree or disagree with the following statements? - I felt safe riding in the shuttle; The driver was nice and interactive; Information was provided during the trip, e.g., actual delays and arrival time; The shuttle had been cleaned and sanitized; I felt comfortable riding in the shuttle; and It was easy for people with disabilities to get on and off."

3.5.4 Accessibility

The survey questions "How long did it take you to get to the pick-up location?" (access time) and "How long did it take you to get from the drop-off location to your final destination? (in minutes)" (egress time) were designed to measure the accessibility of SR services. To get to the pick-up locations, respondents might use transportation modes other than walking. Therefore, we use access time rather than access walking time in this analysis. Additionally, the egress time may be overestimated because some people used SR to connect to another transportation mode before arriving at their final destinations. To adjust for this possible overestimation, we asked the following question and only used egress times from those respondents who chose (a): Was you last SR ride a one-way/round trip (a) to the destination by SR only; (b) to connect to another means of transportation such as a car, Uber/Lyft, etc.; or (c) to connect to public transit such a bus, light rail, or train; or other.

The average time to get from the origin to the pick-up location is 17.56 (s.d.=13.11) minutes and from the drop-off location to the destination, 19.45 (s.d.=13.59) minutes. The data shows that about 25% of SR users reported that it took them less than 5 minutes to reach the pick-up locations. It is known that curb-to-curb (door-to-door) services are provided in the zone of Citrus Heights only, while 8% of the respondents reported they used SR in this zone. Therefore, in corner-to-corner service zones, about 17% of people have an access time of less than 5 minutes. Additionally, fewer than 40% of respondents reported that the time from the origin to the pick-up location was less than 10 minutes. About 80% of respondents arrived at the pick-up location within 30 minutes. The average time from drop-off location to destination was longer than from origin to pick-up location for people who used SR only and did not connect SR to another means of transportation for their last SR trip: Figure 10 shows 30% of them arrived at their destinations within 6 minutes of the drop-off location and about 80% arrived within 25 minutes.

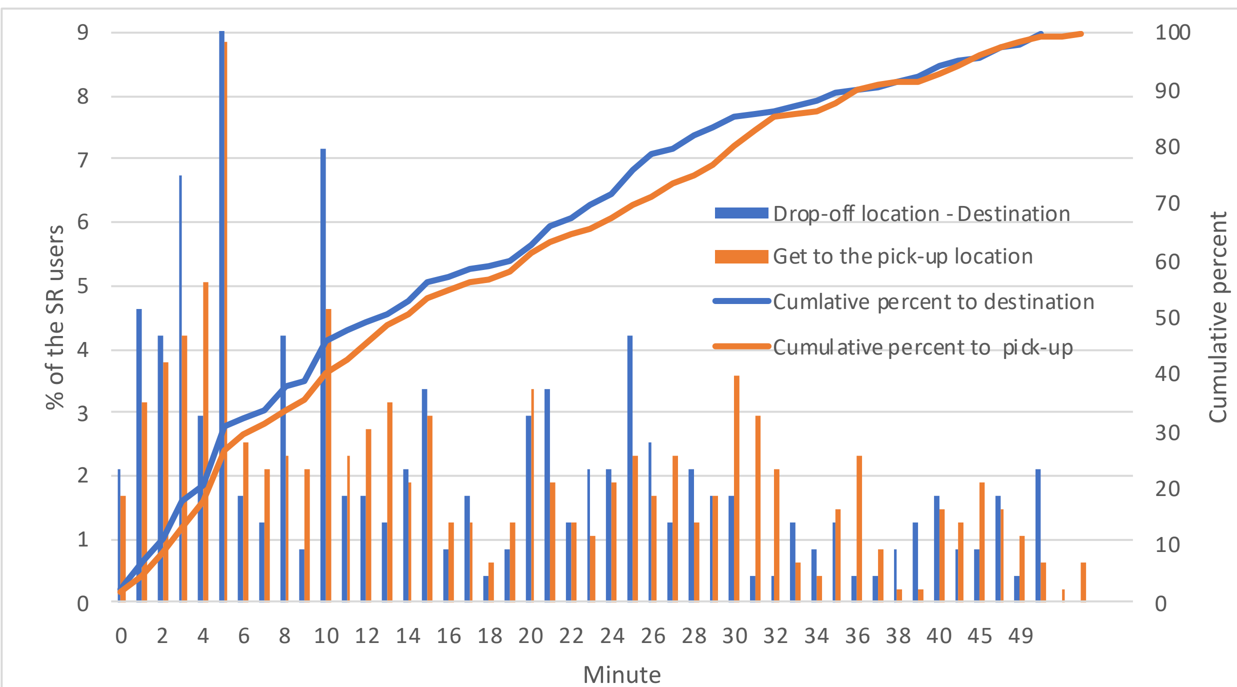


Figure 10. Access (N=475) and egress times for SR services (N=237). These data were derived from the survey questions "How long did it take you to get to the pick-up location?" and "How long did it take you to get from the drop-off location to your final destination? (In minutes)"

3.5.5 Wait times

Both the expected wait time and actual wait time were reported by SR users for their most recent trip. Figure 11 shows the calculated differences between these times. They are a little bit left skewed, indicating a large share of users had shorter wait times than they expected. The mean of the actual wait time is 16.77 minutes (s.d.=11.66) and that of the expected wait time is 19.17 minutes (s.d.=11.31).

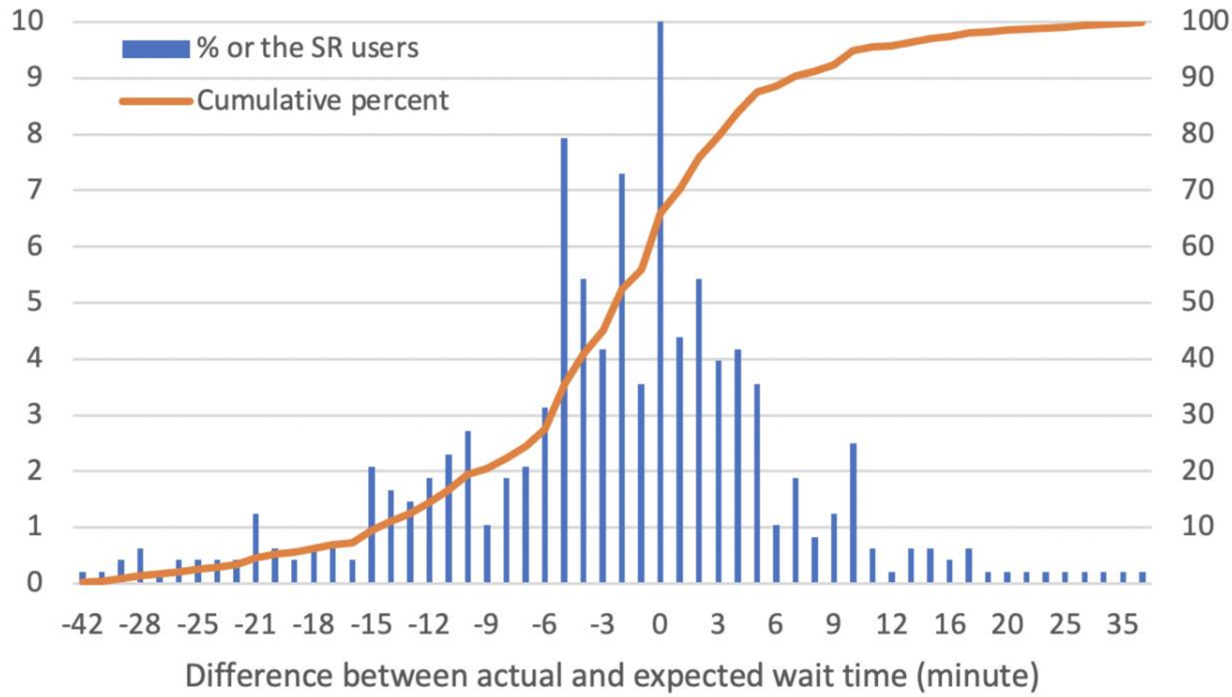


Figure 11. Difference between actual and expected wait times (N=479). These data were derived from the survey questions that for the most recent SR trip, “What was your expected waiting time?” and “What was your actual waiting time?”

3.5.6 Willingness to pay

For the most recent SR trip, we asked respondents at what price they would consider this service to be so expensive that they would NOT consider using the SmaRT Ride service; at what price they would consider this service starting to get expensive, but they would still consider using it; and at what price they would consider this service to be a good value for the cost. The slider question type, which enables respondents to drag a bar to indicate their preferred prices within the range of $0 to $10 was used to capture the wiliness to pay. The data shows that, on average, SR users consider $5.03 (s.d.=2.28) to be the price at which they would stop using it. This service would start to get expensive at the price of $4.23 (sd=2.00), and they would consider it to be a good value at $3.14 (s.d.=1.68). Figure 12 provides more detailed information about the willingness to pay. For example, it shows that only about 22% of users would tolerate the price of $5 or more, approximately 60% of users think $4.20 is the price where the service would start to be expensive, and 45% of them think a price higher than $3.10 would still to be a good value for the service.

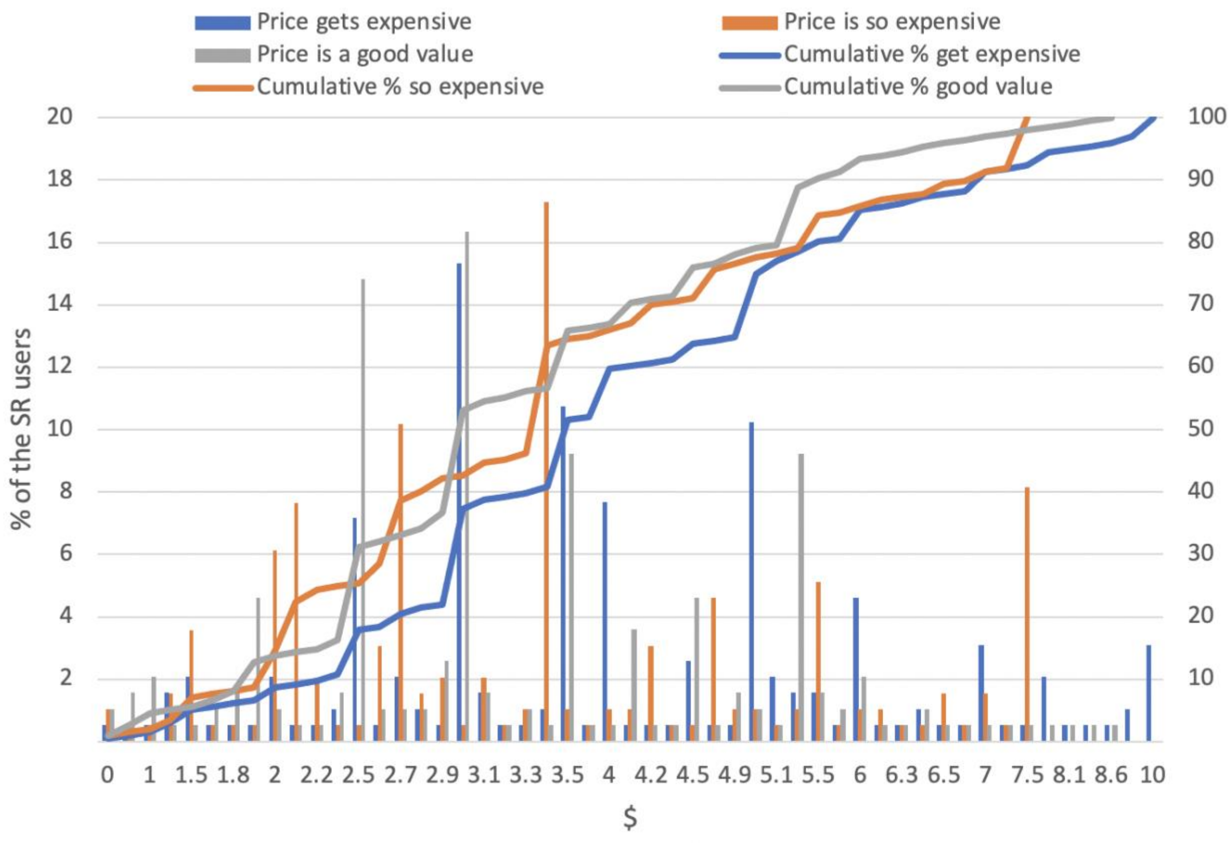


Figure 12. The willingness to pay for SR services (N=197). The data was derived from the survey questions "At what price would you consider this service to be so expensive for this trip that you would NOT consider taking the SmaRT Ride service?", "At what price would you consider this service starting to get expensive for this trip, but you would still consider using the SmaRT Ride service?", and "At what price would you consider this service to be a bargain or a great buy for the money for this trip?"

3.5.7 Modal shift due to SR use and pandemic impact on SR ride

Macfarlane et al. (Macfarlane et al., 2021) indicate that the microtransit service is most competitive to transportation network company (TNC) services as well as fixed route transit. Then what transportation mode is most affected by SR services in the Sacramento area? To examine the modal shift due to the use of SR, a survey question was designed to ask SR users about how their choices of transportation modes changed because of SR. Figure 13 shows that SR substantially substitutes for *bicycling* and *paratransit* trips, with the highest shares of completely replaced trips, followed by walking, solo driving, and ride hailing. The figure also indicates synergistic effects between SR and other transportation modes, e.g., a great deal more walking was reported due to using SR. SR was shown, for some riders, to be a feeder to transit systems, including bus and light rail: about 4% of both bus and light rail users reported they had a great deal more transit trips because of SR use. However, a higher percent of transit users reported that their transit trips had been completely replaced by SR or were a great deal less because of using SR.

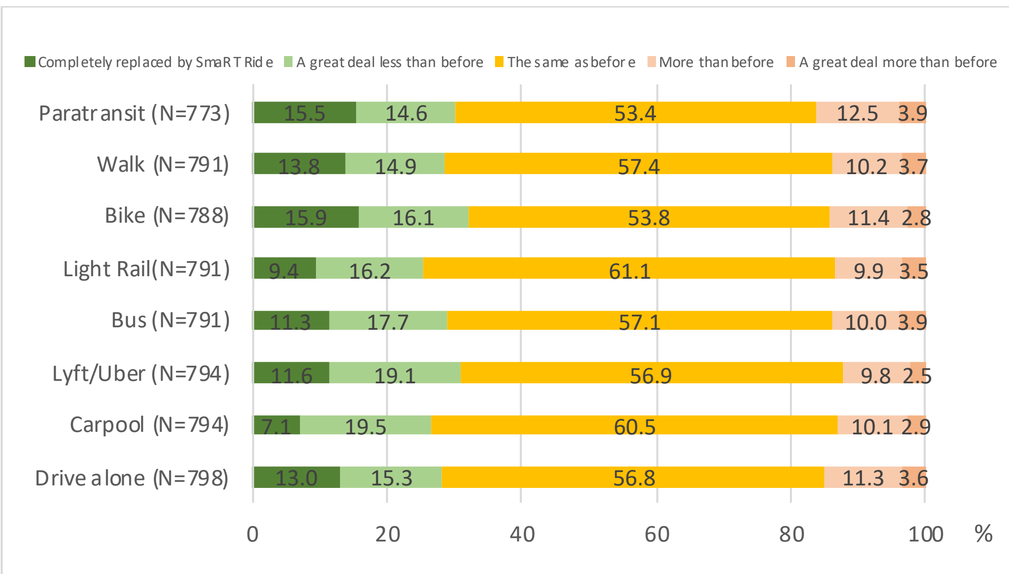


Figure 13. Modal shift due to SR use. The data was derived from the survey question "How have your choices of transportation means changed because of SmaRT Ride? (Multiple choice)"

In addition to being asked about potential modal shifts, SR users were asked about their alternative travel mode choice if SR were not available for their most recent trip. The most common alternative travel mode was driving alone, followed by driving with others and taking a bus. Contrary to several studies in the literature where microtransit was reported as being the most competitive to the TNC, here TNC is ranked as the fourth most frequent alternative (Figure 14). Further, the data also shows that about 5.3% of SR riders reported that they would not have made this trip if SR had not been available, implying trips potentially induced by SR.

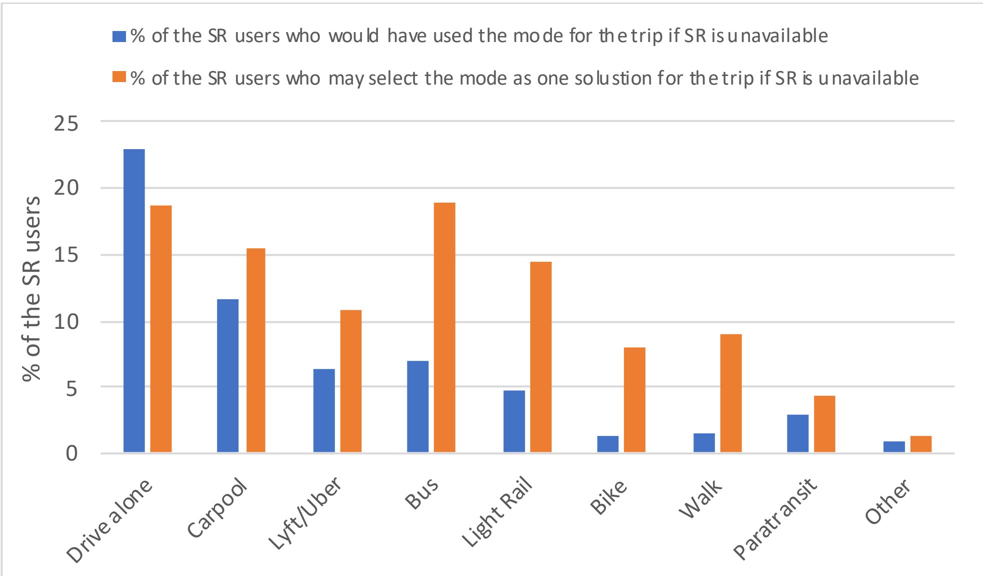


Figure 14. Alternative mode choice for the most recent SmaRT trip (N=563). The data was derived from the survey question "For the most recent trip you traveled with SmaRT Ride, if SmaRT Ride had not been available, what transportation mode would you have used for this trip?"

The impact of the COVID-19 pandemic on SR use was measured by responses to the question "Have you changed your SMarT Ride use since the [onset of the pandemic (April 2020)?" The data shows more than 50% of SR user respondents use SR less than before or even stopped using it. However, about 30% of the users still use it the same as before and more than 15% of users use it more than before.

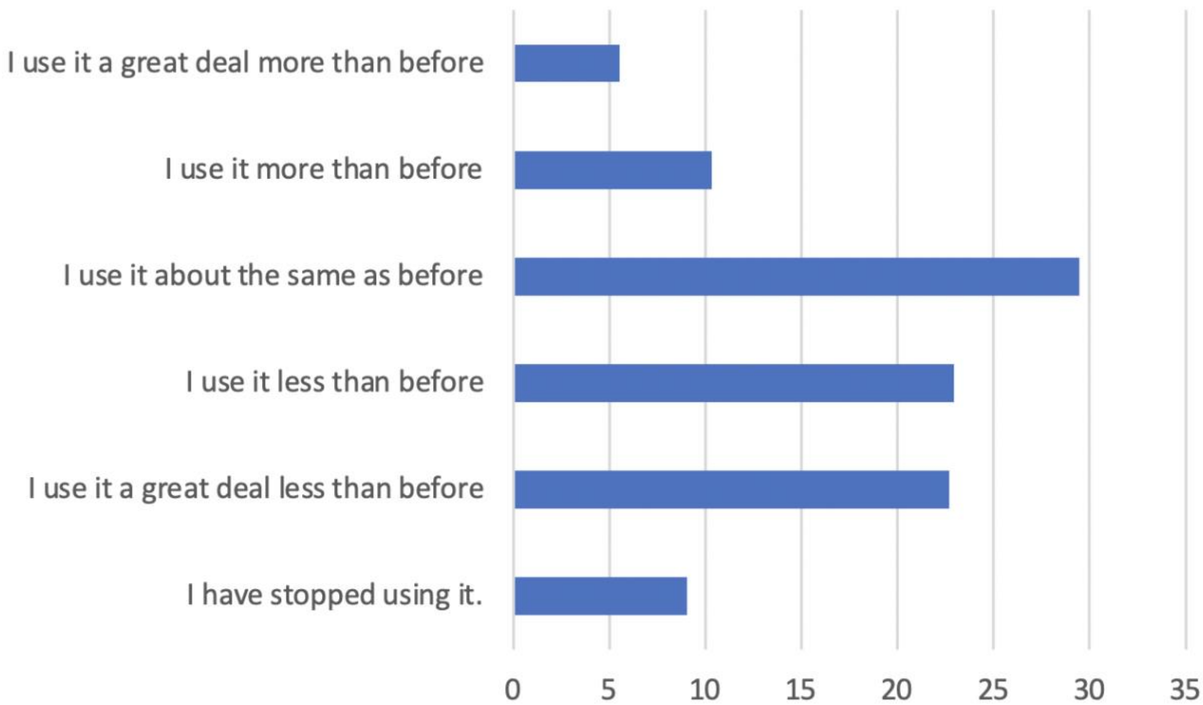


Figure 15. Pandemic impact on SR use (N=397). The data was derived from the survey question "Please recall your SmaRT Ride use before the COVID-19 pandemic (before April 2020). How have you changed your SmaRT Ride use since then?"

4 Interviews and Focus Groups

We conducted interviews with board members, planners, supervisors, and SR operators aiming to capture background information on SR services. Specifically, the questions for the this group regarded motivations to initiate the service, their goals, and short- and long-term plans. The operation supervisor and operators were interviewed to collect information about the daily operations of the SR service. Meanwhile, focus groups were conducted, focusing on both SR users and non-users. Following the conceptual model, the questions for SR users and non-users in the focus groups were categorized into five areas: (a) socio-demographics and individual health; (b) attitude; (c) subjective norms; (d) perceived behavioral control; and (e) SR behavior. (These are detailed in sections 3.3 Survey questions and 3.4 Variables measuring behaviors and explanatory variables.)

4.1 Findings from the Interviews and Focus Groups

We analyzed the transcripts of the focus groups and interviews, collecting the concepts, categories, and themes that arose during the interactive process. We described the background information derived from the interviews with the board member and planner. Then guided by the conceptual model, important factors were identified and categorized to form a more detailed framework that helped further design the large-scale questionnaire. From these factors, we captured the key facilitators and barriers to the adoption and use of microtransit for existing and potential adopters by analyzing feedback from the focus groups. The opinions and the details of daily operation from perspectives of the supervisor and operator helped us understand the behind-the-scenes aspects of microtransit service from the supply side.

4.1.1 Background information from the interviews

In the interviews with the board member and planner, we learned that the motivation to start this pilot program was the need for it. The board member commented that “Being from a suburb of Sacramento, transportation has been frustrating” and “Some bus stops can be more than a mile [away from home].” With the support of Sacramento Transportation Authority (STA), they decided to do a microtransit pilot project that started in Citrus Heights. Like a business, when SacRT is promoting its product, SR, the most important step is product positioning, i.e., where this service fits in the transit system. The planner we interviewed stated, “(SR) is feeding the system rather than competing with the system.” This is also the principle they followed to expand new service zones. Basically, from the operator side, SR is expected to solve first- and last- mile problems and serve low-density (low-demand) areas where fixed-route transit is inefficient and/or insufficient. For example, the planner stated, “[The] North Sacramento zone was designed originally to cover an area that didn't really have much fixed route service” and “Gerber and South Sacramento SmaRT Ride service zones were designed specifically to replace fixed route service (which wasn't very well used and wasn't very productive).”

Additionally, flaws in the SR app and system design were confirmed by both the operator and the supervisor based on their experiences of daily operation.

One operator commented,

> "So I am thinking the app is supposed to line you up with the address where the passenger is. [It] would have the passenger go across the street … That is what I was told, and it always do [did] that."

The operator indicated a system design flaw for picking up or dropping off passengers, e.g., a user was picked up once on a corner where vehicles made left turns (or where there were left-turn lanes):

> "[It was] not safe; people behind me made left turns. [I] tried to move a little bit to make sure cars behind me were clear."

The supervisor commented on the Via app problems such as directing drivers to wrong locations, malfunctions resulting in the loss of information, inefficient design for the pick-up of passengers, and no texting in the app.

> "The operator issues…[are] usually basically [caused by] the GPS, for some reason in certain areas and it pins the ride at a certain spot… You have to go like half a mile around the block on the other side of the building or other side of the wall, or the other side of the street to pick up certain passengers…"

> "Sometimes the system just automatically loses that information, so the driver doesn't know when to take lunch … or when to end the shift… Especially the newer operators, so they worked like [an] extra two hours before they call[ed] us …., you have officially violated federal law by working over two hours and it happens, sometimes actually more often than not."

> "And there's another passenger who booked a ride, which is on their tablets and there's the second passenger they need to pick up. They both are standing right there, … but the system will not direct the driver to pick them up, the system wants them to pick up this one passenger, … and then come back for the other passenger."

> "We don't have the ability to message operators, like text message on the ride… This would help customer service and passengers a whole lot if they could text [each other] information and add it to that SR app."

4.1.2 Facilitators and barriers to the use and adoption of SR from the focus groups

The discussions with SR adopters and riders of other forms of transit in the focus groups reveal the potential importance of the factors of attitude, subjective norms, and perceived behavior control in the adoption of SR.

4.1.2.1 Attitude

Affect. The attitudinal element, the affect toward transportation mode, was identified as an essential factor that influence both the adoption and use of SR.

Two transit riders **who like walking and bus services** said they would not use SR:

> "I wouldn't use it for almost everything [anything], you know, I'm a runner and I'm a walker, so I do all that kind of stuff [i.e. , running and walking] now but it's nothing for me to get on the [SR] bus."
>
> "**I like bus services**."

However, people's attitude of **disliking or limiting driving** encourage microtransit adoption.

> "…since I don't drive, it [SR] would be used for every single thing."

Some SR adopters talked about their affect toward it, one of them said,

> "I was tired of dealing with having a car and I haven't had one, for SR has really like facilitated me being able to take that break from doing that, which I feel kind of spoiled…I **appreciate it**."

Attitude towards an SR attribute: uncertain travel time. SR adopters and non-users pointed out the disadvantage of uncertain travel time and that it inhibited them from using SR, especially when they have planned trips or an appointment.

> "There's a potential for SMarT Ride to cancel your trip at any point in time between when you book it, and when you expect it to be there… I was **definitely** going to be able **to catch a train or bus** instead of taking a chance and waiting and not getting an SR."
>
> "… basically a time where I **trust my own two feet more than I trust it [SR]**…"

Wait time. Long wait time was frequently reported by SR adopters. Most cancelled trips were cancelled due to long wait time. Long wait times usually occur during peak hours. These cancellations would have the greatest consequences for riders waiting in an unsafe area and/or with no alternative ride available, with physical disabilities, or with many things to carry.

> "Once I went to a market in midtown within the boundary with SR. [The] return trip had an hour wait time. After 30 minutes, the ride [was] **cancelled and no other ride is available**. Then I took a TNC. This happened several other times—then I had to walk long and high with a cane and shopping stuff. Another time the ride was expected to [have a] 25 min wait time and it turn[ed out] to have [a] **58 minute wait time**."
>
> "**Long wait time**, not always easy to get a return trip or available back up option, peak times make it worse (3-3:30 PM). In some regions, several construction workers rely on SR and add to the queue."

> "… **long delays and wait times**. Having many things to carry, it is a problem. If you wait in an unsafe area, this is a problem."

Sharing with strangers. Most SR adopters also take buses, so they are accustomed to sharing rides with strangers. Only one adopter showed a negative attitude toward sharing rides with strangers. Some adopters think SR passengers are more friendly and "normal" than those using other transit modes because SR drivers have already checked the information about passengers before they take a ride.

> "[SR] drivers **question** their **safety more** than bus [drivers]. They [bus drivers] do not get enough info about who they pick up."

4.1.2.2 Subjective Norm

Normative belief. Normative belief about what a person should do is important to choosing to adopt SR. One respondent who preferred the bus stated that he would not use SR due to his belief that bus services contribute to solving climate problems.

> "Using the bus as often as possible seems like the best way that I can **contribute to preventing a climate catastrophe**…"

Social support. The support of family, colleagues, friends, or community members etc. may encourage an individual to make the decision to try using microtransit. One potential SR adopter said,

> "My low vision it's very low. I get words mixed a lot and **somebody else** with … sight impaired will **have the same experiences** [of using SR], I can do that for sure."

The influence of social support is especially obvious among SR adopters. Many of them agreed that "**I know a few people using it**" and "**other people from my building also use it**." One frequent user was supported in using microtransit by his/her employer.

> "I pay with [a] connect card like through the website, but … my card is linked to my employer, **providing a little subsidy** and I just paid like the small difference "

4.1.2.3 Perceived Behavior Control: Control Belief

Knowledge. Obtaining knowledge about a transportation mode is an essential prerequisite for choosing it. An individual must have detailed information about SR, such as how to contact it, what its schedule is, where to go to pick it up, and how to pay for it. Gaps in any of this information can result in a decision not to use it. Two transit riders expressed their confusion pertaining to SR services:

> "I'm visually impaired I'm almost blind… I've gone to the website to look up a smart RT. It's very confusing. I can't figure [it] out… I got a little **scared of using it**. Do I call from this location? Which locations? Can I call it? How long will it take? How long do I have to wait at this location? The

other thing is, I couldn't figure out how much it costs … I just couldn't [get it] after reading the website. I couldn't figure [it] out."

"It is very difficult. It's very unfriendly. It doesn't explain it well…. it's not inviting. It's very important for people to kind of **understand what it is you're providing and make it enticing**.

"[I was] thinking SmaRT [Ride] was SacRT, because the words look so similar."

Service area and schedule unavailability. The unavailability of service in areas and at certain times is a major inhibitor to adoption and use of SR. Many adopters expressed their demands for extending service areas and schedules:

"I'd like the expansion to midtown, weekends are nice, but I prefer **more coverage and drivers** during weekdays."

4.1.2.4 Perceived Behavior Control: Ease of Use

Technology ease of use. The feedback from the adopters shows that although it is very convenient to use the app, the real-time technology has some flaws, such as inaccuracies in navigation, GPS tracking problems, freezing, location mismatching, setting issues, and failing to provide the correct vehicle information to users, which frustrate both SR drivers and users.

"Based on map, the driver could not come and pick me up due to the boundaries… the app for[the] driver is **not very accurate in navigation**."

"In general drivers are great and helpful, but one issue is that rarely where **they expect** me to be picked up is **different from** where I **expected** to pick up from App."

"It was horrible with the tracking. It would say it was coming in an hour and you couldn't really tell where it was and then now it's like you can look at it and be like, I better walk a little faster, …Two times at least I can think of within the last year… The poor person driving me was **led to a dead end and into different areas**, … It's frustrating for them [drivers]."

"Sometimes the directions at the end would get weird and they [drivers)] would kind of say the **App was freezing** on them—the directions were freezing"

"…but the map location accuracy needs to be improved, it must be more user friendly, it automatically selects destination when you open the app and you **need to manually change it**. It can be confusing."

"In TNC, some drivers use a separate App for routing. [The] app gives me name and number of the vehicle, but this does not match with the shuttle. We have rider number, but **it does not show it** to us. [The] supervisors have it."

Accessibility to pickup/drop-off locations. The question regarding this was designed to examine the ease of reaching pickup or drop-off locations for SR users. Some of them mentioned that it is a door-to-door service in their living areas, e.g., "It was **just like a private car**. It would drop me off right in my house, so it was always amazing." Others need to walk to an assigned corner or pickup location, but most of them complained about the inaccuracy of the app in navigation, which led to inconvenience and compromised safety at the pickup or drop off locations.

Payment method. Most participants have encountered problems with their payment methods. Various fare payment methods are available, e.g., cash, Connect Card, Zip app, or RT pass. Two adopters mentioned sometimes the Connect Card reader does not work correctly.

> "[I use] Connect Card to pay. Once it happened the machine was not **working**, but they offered a free ride."

Convenience and flexibility, money saving, time saving, novelty. These behavior control elements are facilitators for using SR services and were mentioned most often by the adopters in the focus groups.

> "…I'm very grateful for it [SR]. It seemed like no one was using it, and how can that be? It was so **convenient**."

> " ... For me **flexibility** was huge… The app has the feature to track [the movement of the shuttle], it was really important and helpful"

> "It is **money saver**. I get somewhere with SmaRT and return by bus and it only cost $1.25. Before, I had to buy a DayPass and it was more expensive. It is such an unbelievable bargain."

> "It has been a money saver. I used to rely heavily on Lyft before. It is convenient as it is almost door-to-door for pick up and very short distant from the drop offs. [It is] **time saving** compared to [the] bus, which must stop at all stops."

> "I really appreciate it. SR is kind of stepping up to do a little bit more **technology-savvy,** you know, stuff."

4.2 Conclusions

The findings of interviews and focus groups demonstrate meaningful effects of attitude and subjective norms on acceptance of microtransit for transit riders who have not ridden in microtransit. As suggested by the results, *affect* towards other transportation modes works as a key factor for the decision to adopt microtransit. People who like walking or riding a bus tend to have no interest in or intention to use microtransit. *Normative belief*, e.g., beliefs about environmental concerns, strongly affect the acceptance of microtransit. Having someone familiar to share experiences on microtransit, i.e., getting *social support* from other people, presents a positive influence on the intention to use microtransit.

Subjective behavior control plays a critical role in microtransit adoption. *Lacking knowledge* of microtransit such as its specific name, how to request a ride, where to go to get it, inhibits people from using it. Undoubtedly, *unavailability of service area and schedule* are salient barriers to microtransit adoption, evidenced by the statements of most riders of other forms of transit.

For existing microtransit adopters, attitude, subjective norm, perceived behavior control, and individual socio-demographics and attributes of the service play important roles in strengthening or discouraging their use of microtransit. *Negative affect* toward driving was identified as a critical factor influencing the use of microtransit. Disliking or limiting driving makes people more likely to use microtransit, which is a convenient alternative to driving a car. Additionally, affect toward microtransit can be formed through experiences of using microtransit, which in turn, encourages an individual to use microtransit more. *Knowledge* of microtransit is the perquisite condition for people to use it. It is notable that Uber/Lyft is one of the daily transportation choices for most microtransit adopters, which enable them to acquire the knowledge of microtransit easily. One subjective norm factor***,*** *social support* from family, friends, etc. was shown commonly among the adopters, suggesting its important role in microtransit use. The support includes knowing people who are microtransit adopters, being accompanied with someone on SR trips, or being supported by employers. The use of microtransit is limited or encouraged greatly by the *availability of service area and schedule, wait time, and security*. C*onvenience, money savings, time savings, and novelty* of microtransit encourage people to use it. Perceived difficulties in using the microtransit app frustrates and discourages the use of microtransit. Although in some areas, door-to-door microtransit services are provided, this feature of convenient *accessibility to pick-up or drop-off locations* was not present for many users, due to inaccuracies in the app in identifying locations. One attribute of the microtransit vehicle, loud noise, may discourage people from use. The users commonly think SR *drivers* are friendly and professional and the *fare* is a bargain, which positively influence their choice of microtransit.

These findings helped to provide an in-depth understanding of factors that influence microtransit adoption and use. The topics covered and the ways they were discussed seemed to support our theoretical framework. However, the findings are limited by the small sample. The key use of the focus groups was to inform the large-scale survey and generate explanations for the following inferential studies.

5 Microtransit Study

Discrete choice models, a binary logit and ordered logit model, and latent class analysis were employed to explore barriers and facilitators to SR adoption and characteristics of early SR adopters. Given the cross-sectional design for this study, multicollinearity (high correlations among two or more independent variables) that could lead to instability of coefficients and unexplainable results may be a significant concern. We therefore checked all the explanatory variables which would be examined in the models by looking at the correlation matrix of all these variables. This assessment showed that all the bivariate correlations across the explanatory variables are less than 0.5. Tabachnick, Fidell, & Ullman (2007) pointed out that the independent variables with a bivariate correlation should not be more than 0.70, which suggests an acceptable level of multicollinearity for this study.

Because we have missing data for many socio-demographical and attitudinal questions, to avoid a significant decrease in the sample size due to the missing data of explanatory variables, we entered the explanatory variables into the models in turn by sets defined in the conceptual model. The order of the variables sets for entering the model is according to the order of the sets shown in Table 3, i.e., individual socio-demographics and health variables, attitude, subjective norms, and then perceived behavior control factors. Further, in each step, only variables that showed significance in the model were kept.

5.1 Why do some people ride in SmaRT Ride but others do not?

Even though some people had been aware of SR, they had not used it. We therefore focus on exploring probable barriers that may inhibit them from using SR and facilitators that may encourage their use. A binary logit model was employed to examine the influence of individual socio-demographics, attitude, subjective norms, and behavior control factors on choice of using SR, based on the conceptual model and the literature. One major concern with this model is that using only an online survey recruitment method may lead to a biased sample in which underserved populations are lacking. However, the findings still shed light on explanations of why some individuals are less likely to use SR though they are aware of and have access to it.

5.1.1 Model approach

The model uses a dichotomous dependent variable, SR Use. This variable presents two discrete alternatives (or outcomes), namely, 1 = I have used SmaRT Ride in the past and 0 = I have never used SmaRT Ride. A binary discrete logit model was chosen to examine the relative importance and significance of individual socio-demographics, attitude, subjective norms, and behavior control factors on choice of SR use.

Supposing there are two choices, *i* and its complement *j*. An individual *n* chooses the alternative that maximizes his/her utility. If we assume the probability of individual *n* choosing alternative *i* is $P_n(i)$ and alternative j is $P_n(j)$, the binary logit model can be written as,

$$\frac{P_n(i)}{P_n(j)} = \frac{P_n(i)}{1-P_n(i)} = \frac{\exp(\beta' x_{in})}{\exp(\beta' x_{jn})} = \exp[\beta'(x_{in} - x_{jn})] = \exp(\beta' x_n),$$

where $x_n = x_{in} - x_{jn}$, x is a vector of explanatory variables, β' is the vector of coefficients.

Further the concept of "odds," the ratio of the probability of choosing alternative *i* and its complement, i.e., the probability of choosing alternative *j*, is applied and then we take the logarithms of the odds (i.e., logit). The formula above is then expressed as:

$$\text{logit} = \ln\frac{P_n(i)}{1-P_n(i)} = \beta' x_n.$$

The method of maximum likelihood is used to estimate the parameters. A positive coefficient indicates that an increase of the corresponding explanatory variable leads to an increase of the odds; a negative sign means the opposite. The exponentiated coefficient, the odds ratio (OR), of an explanatory variable, denotes the amount of change in the ratio of the probability of choosing one alternative to the probability of choosing the reference alternative when the given explanatory variable undergoes one unit change. Note that if an OR is less than 1, it indicates the reference alternative is more likely to be chosen, given an increase of the corresponding explanatory variable.

5.1.2 Model interpretation

The results of the final best-fitting model for SR adoption are shown in Table 5. Of all respondents, 84.9% (N=378) reported that they had used SR before taking the survey. The model goodness of fit was measured under the guidance of measuring methods for discrete choice models suggested by Mokhtarian (2016). Three important measures of goodness of fit are reported in Table 5. The McFadden ρ^2 (Pseudo R^2) measures are based on the Equally-Likely (null/EL) model (i.e., containing no explanatory variables) and the Market Share (MS) model (i.e., containing constant terms only). These measures for this model are 0.642 and 0.415, respectively. They indicate that about 70% and 50% of the information contained in the data has been explained by this model relative to the EL model and the MS model, respectively. This is considered a good fit, as suggested by the interpretation that a value of the MS-based ρ^2 greater than 0.3 is considered a decent model fit for a discrete model (Hensher, Rose, Rose, & Greene, 2005). Another measure of model goodness of fit is the adjusted ρ^2 ($\bar{\rho}^2$), which corrects for the number of estimated parameters and simulates analogously to the adjusted R-square of linear regression models. This value was 0.366, also indicating a good explanatory power of the model.

Table 5. Binary logit SR model

Variable	Coefficient	Significance	OR
Constant	1.797		6.032
Socio-demographics			
Age	-0.069	***	0.934
Education Level	-0.626	**	0.535
Have Kids	1.362	***	3.904
Limit Drive	1.381	**	3.979
Attitude			
Like SR	0.733	**	2.081
Like Transit	-0.576	**	0.562
Travel Cost	0.471	**	1.601
Save Time	0.546	**	1.726
N			378
LL(null)			-262.010
LL(MS)			-160.303
LL ($\hat{\beta}$)			-93.707
McFadden Pseudo- R^2 EL base			0.642
McFadden Pseudo- R^2 MS base			0.415
Adjusted Pseudo- R^2			0.366

*10% significance level, ** 5% significance level, *** 1% significance level

Influences of socio-demographics on SR adoption are shown in the model results. Elder *age* and higher *education level* are negatively associated with SR use: one year older and one level higher of education may result in the likelihoods of using SR being, respectively, 6.6% and 46.5% lower compared to that of not using it; whereas *families with children under 6-year-old* are more likely to be in the groups of SR users. Individual health also correlates with SR use. Physical conditions that *limit one's ability to drive* are strongly associated with an increased likelihood of SR use, other things being equal.

Accounting for socio-demographics and individual health conditions, attitude also affects SR use versus non-use. Affect toward SR plays an important role in explaining SR choice. People who have a higher level of agreement with the statement "I like SmaRT Ride services" are more likely to use SR. Note that the cross-sectional model does not reveal the underlying causality between affect toward SR and the use of it. It is also possible that the more an individual uses it, the more likely she/he likes it due to good riding experiences. Additionally, people who reported higher level of affect toward fixed-route transit are less likely to be SR users, which may imply a potential substitutive relationship between SR and fixed-route transit. A higher level of agreement that "The cost of travel affects the choices I make about my daily travel" may increase the likelihood of using SR by 60.1% compared to that of not using it, indirectly reflecting the influence of the low travel cost of SR compared to other motorized transportation modes such as driving and ride hailing. The perceived time saving by SR shows its significance in explaining SR choice behavior. A higher level of agreement that "Using this service saves/will save me time" is positively associated with SR use.

5.2 Who will be more likely to ride in SmaRT Ride?

To find ways that may lead to promotions to raise SR adoption, next we focus on people who had never used SR. The primary interest of this section is to identify factors, by employing an ordinal logistic regression model, that may influence people's willingness to use SR services.

5.2.1 Model approach

A survey question, "Will you use SmaRT Ride in the future?" was treated as the dependent variable to explore factors associated with the willingness to use SR for non-SR-riders. The responses to this question fall into five categories, 1 = Definitely not; 2= Probably not; 3=Might or might not; 4=Probably yes; 5=Definitely yes (Table 6). Because the responses present an ordinal scale whereas the distance between the scales is unknown, the ordinal logistic regression model was chosen to model the relationship between the ordinal response of willingness to use SR and potential explanatory variables.

Table 6. Five categories of willingness to use SR

Category	Number	Percent (%)
1 Definitely not	7	5.8%
2 Probably not	11	9.2%
3 Might or might not	43	35.8%
4 Probably yes	37	30.8%
5 Definitely yes	22	18.3%
Total	120	100%

The cumulative logit method, which applies the log to the ratio of a cumulative probability to its complement, was employed for ordinal logistic regression. If the underlying response variable y, which represents the observing Y, takes ordinal values from 1 to J and j ∈[1, J], and x is a vector of explanatory variables, then the function form of ordinal logistic regression models is as follows,

$$\text{logit} = \ln\frac{\Pr(y \le j)}{1-\Pr(y \le j)} = \alpha_j - \beta' x,$$

where $\alpha_1 < \alpha_2 <..< \alpha_j <..< \alpha_{J-1}$ are J-1 unknown parameters (cut points or thresholds); and β' is the vector of coefficients.

The ratio of probability of observing Y of an individual n in the *j*th or lower categories to the probability of Y falling in its complement can be achieved by exponentiating the logit.

$$\frac{\Pr(y_n \le j)}{1-\Pr(y_n \le j)} = \frac{\Pr(y_n \le j)}{\Pr(y_n > j)} = e^{\alpha_j - \beta' x_n}$$

This expression can also be expressed as the ratio of the probability of observing Y in the categories higher than the *j*th to the probability of observing Y falling in its complement,

$$\frac{\Pr\,(y_n > j)}{\Pr\,(y_n \leq j)} = e^{-\alpha_j + \beta' x_n}$$

Specifically, this study employed the cumulative logit that the outcome is observing "Y greater than j" versus its complement, thus a positive coefficient indicates that one unit increase in an explanatory variable increases the ratio of the probability of falling in the categories higher than a cut point to that of falling in its complement; a negative sign means the opposite. The proportional odds ratio (OR), the exponentiated coefficient, measures the magnitude of the ratio. Ordinal logistic regression models assume that each explanatory variable exerts the same impacts on each cumulative logit, so they are also known as proportional odds models.

5.2.2 Model interpretation

Table 7 presents the outputs of the best-fitting ordinal logistic model. Similar goodness of fit measures of the binary logit model introduced before were used. An analogue to the OLS-R^2, the McFadden pseudo-R^2 of this model is 0.216, which is still acceptable for discrete logit models. Although the sample size of 120 is a big concern, given the fact that this pilot study focuses on a new service model that many people may not be familiar with and thus not interested in, it still satisfies the rule of thumb suggested by Pearmain et al. (1991) that sample sizes over 100 for discrete choice designs are able to provide a basis for modeling preference data. A test of the proportional odds assumption was applied and the p value of 0.275 indicates this assumption is met for this model, implying that the impacts estimated of each explanatory variable, i.e., the estimate of the coefficients, are the same across the five response levels.

The model results show that *education* level negatively correlates to SR adoption, a higher level of education may result in a 29% decrease of the likelihood of presenting a higher willingness level to use SR. Individual health factors influence SR adoption greatly. *Inability to drive* due to any physical conditions is a significant barrier to SR adoption, which may be related to unawareness of the feasibility of using SR for people who had never used it before. Additionally, *inability to take fixed-route transit* due to any physical conditions is also negatively associated with SR adoption, which may be due to common barriers of transit services.

The attitude of *liking SR* exerts strong positive influence on the willingness to use SR. The higher level an individual's agreement with "I like SmaRT Ride services" is, the more likely that individual is to be in a category of greater willingness to use SR. Unsurprisingly, the *affect toward driving* discourages SR adoption, indicating a potential substitutive relationship between driving and SR use. A stronger agreement with "Travel time is wasted time" is negatively associated with a higher level of willingness to use SR, which may indirectly reflect the perception of longer travel time by SR relative to driving or ridehailing. Positive attitude toward two SR attributes, *novelty* and *time reliability*, are found to encourage SR adoption significantly.

The effect of *social support* is shown. The perception that other people an individual knows will support SR significantly increases the likelihood of that individual's willingness to use SR.

Table 7. Ordered logit model of willingness to use SR

Variable Name	Parameter		
	Coefficient	Significance	OR
Thresholds			
Threshold 1	-1.404		
Threshold 2	0.169		
Threshold 3	2.841	**	
Threshold 4	4.925	***	
Socio-Demographics			
Education Level	-0.337	*	0.714
Limit Drive	-1.552	**	0.212
Limit Transit	-1.270	***	0.281
Attitude			
Like SR	0686	**	1.986
Like Drive	-0.430	**	0.651
Travel Waste Time	-0.504	**	0.604
Novelty	0.417	**	1.517
Time Reliability	0.348	*	1.417
Subjective Norms			
Social Support	0.624	**	1.867
Valid N		120	
LL(C)		-170.469	
LL ($\hat{\beta}$)		-133.641	
McFadden Pseudo- R^2		0.216	
Adjusted Pseudo- R^2		0.163	

Note: *10% significance level, ** 5% significance level, *** 1% significance level.
LL(C) indicates the log-likelihood of a model in which all the slope, i.e., coefficients, parameters are set to zero.

5.3 Who are early adopters of SmaRT Ride?

SR in the Sacramento area, akin to other on-demand ride-share microtransit services elsewhere, provides dynamic-route rides to passengers within the service boundaries. Although SR ridership is trending up,[1] the market of SR—pilot program—is still at its early stage. Given the novelty of this service model and limited previous research on its market, it remains unclear who earlier adopters of microtransit are. However, planners and providers will need to identify who SR users are and what they are interested in, to meet customers' needs and provide good services effectively. In the previous section, we explored significant factors that may discriminate SR users from users of other transportation modes. In this section, we focus on SR

[1] ZEVs, Service Expansions Power SacRT's Microtransit - New Mobility - Metro Magazine (metro-magazine.com)

users and perform a latent class analysis to discover subgroups of users that may be distinguished by socio-demographics, attitude, behavior control beliefs, and environmental context. This study aims to provide an improved understanding of microtransit users that will help policy makers, planners, and providers in their efforts to encourage SR adoption and sustainable use in the long run.

5.3.1 Model approach

To explore various subgroups within SR users, we used latent class analysis (LCA), a statistical technique for identifying underlying (latent) membership within a population using categorical observed variables (manifest). LCA estimates a probability of being in each underlying subgroup for each individual by using maximum likelihood method. Next, the highest probability determines which class an individual belongs to, i.e., each observation is probabilistically grouped into an underlying class. An important assumption of this method is that all observed manifest variables are statistically independent. In this study, we employed an extension to the basic latent class model, which allows the inclusion of covariates and enables a simultaneous estimation of latent class and regression model (Linzer & Lewis, 2011). Specifically, the observed manifest variables—including attitude, subjective norms, and perceived behavior control factors—from the explanatory variables in Table 3 enter the membership model. This approach is an extension of that described by Swait (1994), whereby attitudes are most often used to identify latent classes. All the socio-demographics in Table 3 are also tested as covariates in the model to predict latent class membership. Additionally, the SR users who responded to our survey reported the service zones that they used most often. Based on specific service zones, the associated zone characteristics, e.g., the percent of minority (non-white) and population density, were also included to test impacts of environmental context on explaining class membership.

Table 8. The environmental context that tested in the model as covariates

	Minority	Population / Square Mile	Jobs / Square Mile	Boardings / day
Citrus Heights	34%	5655	1000	157
Franklin	86%	7557	1629	100
Gerber-Florin	83%	5260	1510	17
Rancho Cordova	51%	6246	2174	45
Downtown/CSUS	39%	6792	16234	141
Natomas/North Sac	71%	4781	2146	54
Arden/Carmichael	30%	4860	1453	39
Folsom	38%	2728	1341	24
Elk Grove	65%	1784	200	3
Total	52%	4699	2041	580

Source: Data collected by SacRT in 2021

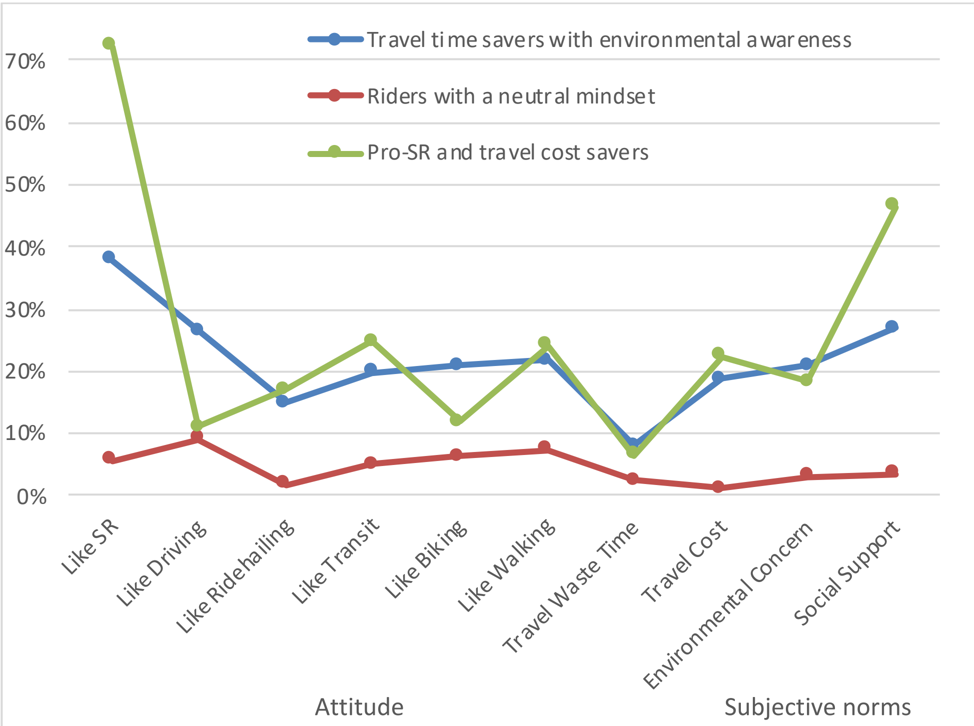
The number of classes is decided by using the two most widely accepted parsimony measures, Bayesian information criterion (BIC) and Akaike information criterion (AIC). The two goodness of fit criteria indicate how well the model fits. The number of classes that fits best, which present the smallest BIC and AIC, to the observed data was considered for this model. Meanwhile, we also checked the probabilities of group membership to make sure a highest probability of class membership is smaller than 0.7 (Nagin, 2009). Most importantly, the number of classes was determined based on the consideration of interpretability of the model results. Table 9 shows the comparison of the criteria by the number of classes. The BIC of the class membership model with 3 classes has the minimum value, but the AIC criterion is greater than that of the model with 4 classes. However, the BIC is considered to be more appropriate for latent class models due to its relative simplicity (Forster, 2000). Therefore, the model with 3 latent classes was chosen for this study.

Table 9. Comparison of BIC and AIC by the number of classes

Measure / Number of classes	2	3	4
AIC	21155.85	20772.08	20511.23
BIC	21877.42	21870.12	21985.75

5.3.2 Model interpretation

The final latent class model contains 373 valid cases and identifies three latent classes within the SR users. The three classes differ on the probabilities of the highest scores for the manifest variables, including attitude and subjective norms (Figure 16, top) and control factors and attitude towards SR attributes (Figure 16, bottom). According to the various probabilities of the 3 classes summarized in Figure 16 for the manifest variables, Class 1 is characterized by higher probabilities of the highest scores of the agreement with the statement that “I like driving”, “I like riding a bike”, and “Travel time is wasted time”. This class also shows a higher probability of the highest score on the agreement that “Environmental and energy concerns affect my choice of travel mode”. Moreover, the probability of people who strongly agree with the statement that “Interacting with this service requires/will require a lot of mental effort” in class 1 is higher. Therefore, we labeled this group as ***travel time savers with environmental awareness***. Class 2 presents relatively neutral mindset toward all the attitude and subjective norms. Neither pros and cons are shown for any control factors of SR such as the SR app, mental effort needed to interact with SR, accessibility to SR, and wait times, thus this class is identified as ***riders with a neutral mindset***. Conversely, class 3 indicates a strong affect toward SR. This class also shows higher probabilities of containing people who have the highest scores on liking transit and walking and agreement with the statement “The cost of travel affects the choices I make about my daily travel.” A very high probability of people who have the belief that “People I know are/will be supportive of it (SR)” presents in this class. This class also highly values all the attributes of SR, including of the belief that the novelty of SR is attractive, SR saves time and money, SR services are good for environment and are available and accessible. Obviously, class 3 embodies ***pro-SR and travel cost savers***. The three class are predicted to account for 43.7%, 31.9%, and 24.4% of the total sample respectively.



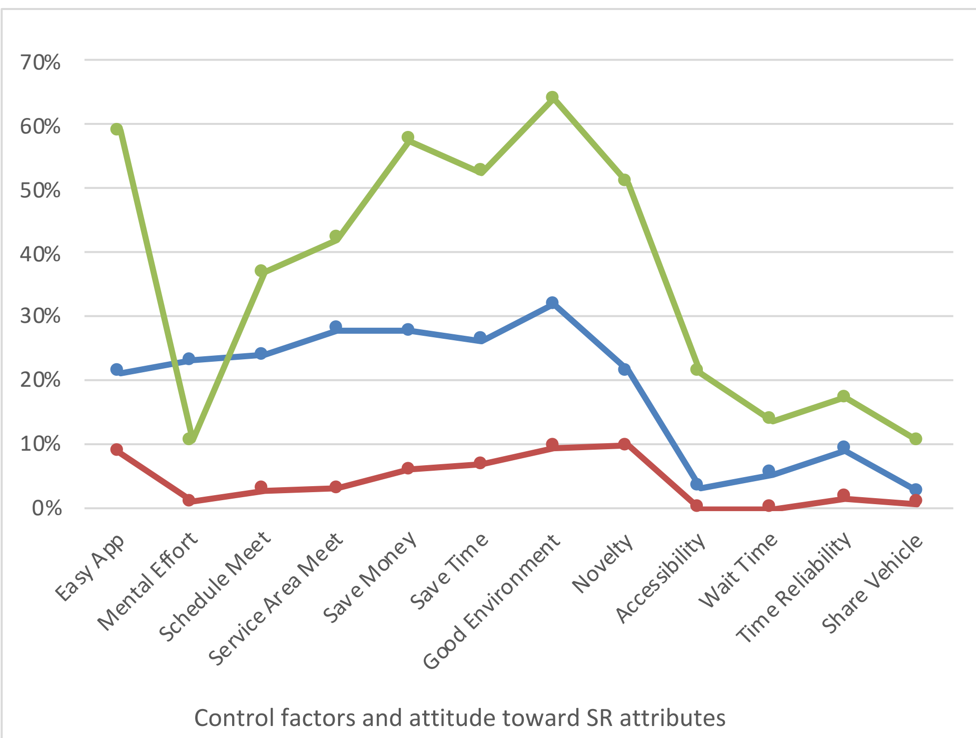


Figure 16. Probability of the highest score of manifest variables by class

Further, the model simultaneously estimates the influences of the covariates including socio-demographics and environmental context on class membership prediction. Table 10 shows the estimates of the LCA model with the covariates. The coefficient indicates the significance and magnitude of the impact of the corresponding covariate on the log-ratio probability that an individual is in a certain class with respect to a reference class. A positive sign denotes that an additional unit increase of a covariate may increase the likelihood of being in a certain class compared to the base class. A negative sign means the opposite.

The results show that socio-demographics explain class membership. People with older age are more likely to fall in the class 2, i.e., people with a neutral mindset, while younger SR users are more probably in class 1, travel time savers with environmental awareness. People with white race are more likely to be in the class of travel time saver with environmental awareness and non-white incline to fall in the class of riders with a neutral mindset toward SR. SR users who work and telecommute more frequently are identified to be more likely in the class of travel time savers with environmental awareness, but the opposite group of SR users who do not work fall in the class of riders with a neutral mindset toward SR. Moreover, the environmental context factors test the influences of characteristics of local environment on class membership estimation. SR users living in a population dense area are predicted to be in the class of travel time savers with environmental awareness, whereas the class of riders with a neutral mindset toward SR may be more likely to live in areas in proximity to employment. Note that although the covariates age, telecommute frequency, and jobs/square mile do not show statistically significant influences on the likelihood of being in class 2 with respect to class 1. The influences of these covariates are consistent with the results of the log-ratio comparisons between the other two classes. The insignificance may result from the relatively small sample size, given a large number of parameters to be estimated.

Table 10. Estimates of LCA model with covariates

Class name	C2 vs. C1 ln (p2i/p1i)*		C3 vs. C1 ln (p3i/p1i)		C2 vs. C3 ln (p2i/p3i)	
	Coefficient	Significance	Coefficient	Significance	Coefficient	Significance
(Intercept)	-0.01829	***	-0.00856	***	-0.01166	***
Age	0.00743		0.02183	**	0.02182	**
White Race	-0.01472	***	-0.02644	***	-0.01443	***
Education Level	-0.19767	***	-0.04756	***	-0.11489	***
Employed	-0.02263	***	-0.02900	***	-0.01971	***
Telecommute Frequency	-0.03674		-0.33981	***	-0.11139	**
Population / Square Mile	0.00003		-0.00013	*	-0.00011	*
Jobs/ Square Mile	0.00001		0.00006	**	0.00005	**

* ln (p_{ai}/p_{bi}) is the log-ratio probability that the individual i is in the class a with respect to the base class b.

6 Discussion and Conclusions

This study provides a comprehensive analysis of various factors that may influence a person's likelihood to adopt and use microtransit, including attitude, subjective norms, and perceived behavior control, as well other background factors. The analysis is based on a firsthand survey conducted in the Sacramento area of California. The results shed light on understanding what are barriers and facilitators that may influence people's choice of microtransit. They also help indicate strategies to get potential customers. More important, the results demonstrate the subgroups sharing common characteristics within microtransit adopters, which fills the gap of the previous literature on microtransit and improves the understanding of microtransit users. This study shows the importance of attitude, subjective norms, and behavior control factors on microtransit adoption and use. The attitude of liking SR plays a key role in explaining SR use and adoption. Social support from people familiar shows its significant impact on microtransit adoption. Control factors reflecting attributes of SR services also prove to be significantly associated with microtransit use and adoption.

6.1 Summary of the Findings

This study aims to address several research questions and the findings provide insights into explaining the customer market of microtransit in the Sacramento area. The model results confirm many of the findings of previous studies, but also identify new factors that help address the behavior of microtransit use and adoption, and customer type as well. For instance, the negative association between microtransit use and the affect toward fixed-route transit was shown. Social support—i.e., the support of microtransit by family, friends, neighbors, and community members is proven to play an important role in explaining the willingness to adopt microtransit. Finally, three classes of microtransit users are distinguished. To sum up, the key findings are described below.

6.1.1 Factors influencing choice of microtransit

The following summarizes the factors that significantly differ between users and non-users of SR.

Younger age and *lower education level* are associated more with microtransit users than with non-users. *Families with young children* are more likely to use microtransit. Some of these associations are consistent with those found in other studies, e.g., microtransit users are more likely to be younger people (Susan Shaheen et al., 2016) and in larger households (e.g., Macfarlane et al. 2021). However, one previous study found that microtransit users are highly educated (Susan Shaheen et al., 2016). Individual health also influences SR use. Physical conditions that limit driving significantly encourage the choice of microtransit, which is possibly due to the substitutive role SR plays with driving. A good explanation is from one interviewer who commented that "…since I don't drive, it [SR] would be used." Moreover, *the affect toward fixed-route transit* shows an unexpected negative effect on microtransit use in this study. A preference for taking fixed-route transit is negatively associated with using microtransit, which means a fixed-route transit rider is not necessarily a microtransit user, and vice versa. This finding is further supported by the people in the focus groups who prefer buses and stated that they like fixed-route transit due to its travel time certainty and reliability and they believed bus services are one of the best ways to solve climate problems. Undoubtedly, the *affect toward microtransit* strongly encourage people to use it. People who value the cost of travel are more likely to use microtransit due to the relatively low fare of SR. The perception that SR services *save time* is positively associated with SR use. Yoon et al (2021) indicated that because on-demand microtransit system can reduce access and egress walks, it can provide the shortest average weighted travel time compared to other transit (Yoon, Chow, & Rath, 2021). This finding may reflect that this advantage of SR is more likely to be perceived among SR users than non-SR-users.

6.1.2 Factors influencing the willingness of microtransit adoption

Less educated individuals may have higher level of willingness to adopt microtransit in this study, though this differs from the finding that microtransit users are more likely to be high educated (Susan Shaheen et al., 2016). *Inability to drive* was associated with a greater likelihood of using SR in the (binary logit) model based on a sample of the population who had heard of SR and had either used it or not used it. In contrast, *inability to drive* was associated with a lower willingness to try SR in the (ordered logit) model based on a sample of the population who had heard of SR but not yet used it. It makes sense that the binary model shows that the *inability to drive* encourages people to use SR, which is designed to provide mobility for these people. However, counter-intuitively, the ordered logit model shows that *inability to drive* discourages the willingness to adopt SR in people who had never used it. This reduced willingness is probably due to their lack of knowledge or information about the service, which may bring to the foreground their concerns about SR.

Inability to take fixed-route transit due to any physical conditions is also negatively associated with SR adoption. This negative association may be related to a common limitation shared by SR and fixed-route services, namely that neither pick-up passengers at their doorsteps but rather at fixed-locations.

The *attitude of liking SR* significantly encourages the willingness to use it, but the *affect toward driving* decreases the likelihood of SR adoption. People who value travel time are less likely to use SR, resulting from the comparatively longer and uncertain travel time by SR with respect to driving. The effect of *social support* is shown. The perception that friends, family members, and acquaintances will be supportive of SR facilitates its adoption. People who are attracted by the *novelty* of SR and value the *time reliability* of SR services are also more likely to adopt the service.

6.1.3 Who are early microtransit adopters

Early microtransit adopters in the Sacramento area are categorized into 3 latent classes based on statistical analysis. SR users in the first class present characteristics of favoring driving, valuing travel time, liking bicycling, and having pro-environmental attitude, thus are labeled *travel time saver with environmental awareness*. Class 2 members have a neutral attitude toward almost all manifest variables we tested including various attitude, beliefs, subjective norms, and behavior control factors. SR users in this class did not provide strong evaluations of SR services such as the SR app, accessibility, and wait times, probably due to their infrequent use of it. We thus name this class as *people with a neutral mindset*. By contrast, users in class 3 demonstrate their enthusiasm for SR. They focus on travel cost, which may motivate their use of SR and lead to the affect toward transit. They may be attracted by the novelty and time and money saving of SR services and perceive the use of SR supported by their family, friends, and society. Therefore, this class denotes *pro-SR and travel cost savers.* The first class is predicted to have a relatively larger market share of 43.7%, followed by the second and third class with shares of 31.9% and 24.4% of the SR customer market respectively.

We further explore these 3 classes based on the findings from the extended LCA model with covariates. The first class, *travel time savers with environmental awareness*, are SR users who are younger, white, more educated, more likely to be employed and telecommute frequently, and live in areas of high population and low employment density. The second class, *people with a neutral mindset*, are likely to be older SR users, non-white, and low education level, living in areas of the high job density and low population density. The third class, *pro-SR and travel cost savers,* are middle aged SR users with medium education levels, more likely than the second class but less likely than the first class to be white, employed, and telecommute. They may live in areas of medium population density and medium employment density.

6.2 Policy Implications

The findings of this study together suggest that a multifaceted approach is needed to encourage microtransit acceptance and use. Most notably, the feedback from the interviews in the focus groups suggest the importance of programs that increase people’s awareness and knowledge of microtransit, including its complementary role to transit, through advertisement and social or community media channels. Given the strong and direct effect of attitude on SR adoption and use shown in this empirical study, therefore, strategies urging or encouraging people to alter their attitude may have a fast and strong effect on increasing SR ridership, provided that microtransit services are available to begin with. Positive attitude toward microtransit could be encouraged through promotional or educational programs, such as establishing a positive social image of microtransit as a greener alternative to driving, and providing discount or fare free days, which may have some lasting effect on microtransit use. Although the effectiveness of accessibility is not suggested by this study, the overall perception of saving time and the novelty and time reliability of SR is found to encourage its adoption and use. Therefore, it is critical to improve the quality of microtransit services to increase the customer satisfaction level on these attributes. However, users in the focus groups pointed out that the inaccuracy of GPS tracking technology led to long and uncertain travel time, indicating that improvement of the microtransit app to provide precise real-time information and thus reduce stress of both drivers and passengers is urgently necessary to increase the quality of the service. The software provider, Via, RT supervisors and operators, and representatives of microtransit adopters may work together to upgrade the app to meet demand and evolving expectations of both operators and riders. Moreover, the effect of social support is shown in this empirical study, implying that a microtransit-oriented community culture helps increase the willingness to adopt it. Social support can be created through promotional community events, publicizing high-profile role models of microtransit users, or even financial incentives to raise public interest and encourage more people to use microtransit. The revealed 3 subgroups of microtransit customers enables providers to divide the customer market and target the most easily identifiable class, e.g., pro-SR and travel-cost savers, to apply these promotional programs to get the best effect. In other words, microtransit providers may succeed more in promoting microtransit in areas that have high population and job density.

However, promoting microtransit ridership should be put under the broad vision of SacRT, which aims to provide microtransit as a complement to the transit system by solving first- and last-mile problems and serving low density areas that may be inefficiently and insufficiently covered by fixed-route transit. Given the high productivity, low cost, environmental benefits, and relative time reliability of fixed-route transit, it would not be replaceable by microtransit. This lack of replacement by microtransit is supported by our finding that people who like taking buses, light rail, or trains are less likely to use SR. Fixed-route transit would ideally continue playing a major role and microtransit would complement and increase the effectiveness of the current transit system. However, our survey data shows that more fixed-route transit trips had been substituted rather than boosted by SR (Figure 13). Macfarlane et al. (2021) also found that microtransit service is most competitive with TNC services and fixed route transit. How to enable synergies between microtransit and fixed-route transit is therefore a conundrum confronted by many providers. Tentative strategies may focus on guiding microtransit adopters to use it, rather than TNC services, as a feeder to connect to fixed-route transit. First, it is possible to boost the ridership of both of microtransit and fixed-route transit by providing a discount or even charging nothing for a ride connecting them. Similarly, a higher price could be charged for SR rides that do not serve as a feeder to fixed-route transit. The current SR fare, $2.50, which is the same as that for fixed-route transit services, may be viewed as a disincentive to fixed-route transit users. Our study shows users in the Sacramento area would consider an average price of $ 3.14 to be a good value for microtransit services (Figure 12). Second, the effectiveness of some policies needs to be carefully examined, e.g., a promotion providing free SR rides to groups of five or more people. Some such policies may attract commuters away from fixed-route transit during rush hours. Therefore, saving and shifting this policy to off peak hours may better serve the goal of increasing SR use without harming the ridership of fixed-route transit.

Although this research provides new and potentially important insights into factors influencing microtransit adoption and use, it still points to additional research needs. It is unclear how to evaluate the performance of microtransit and what criteria should be used for evaluation by public transit agencies. A deeper examination into how underserved subpopulations—who may face barriers to mobility due to income, race, disability, primary language other than English, etc.—use and interact with microtransit is needed. A holistic cost-benefit analysis of microtransit is necessary and should include a measurement of how much it provides access to jobs and services, especially in underserved communities. This is especially important given the lower productivity of microtransit compared to fixed-route transit. Moreover, the environmental impact of microtransit has not been explored. Future studies should fill these gaps.

7 References

Ajzen, I. (1991). The Theory of Planned Behavior. *Organizational Behavior and Human Decision Processes, 50*(2), 179-211.

Ajzen, I., Albarracin, D., & Hornik, R. (2007). *Prediction and change of health behavior: Applying the reasoned action approach*: Psychology Press.

American Public Transportation Association. (2020). Microtransit. Retrieved from https://www.apta.com/research-technical-resources/mobility-innovation-hub/microtransit/

Avermann, N., & Schlüter, J. (2019). Determinants of customer satisfaction with a true door-to-door DRT service in rural Germany. *Research in Transportation Business & Management, 32*, 100420.

Babbie, E. (Ed.) (2009). *The Practice of Social Research* (12 ed.). Belmont, California: Wadsworth: Cengage Learning.

Brown, A., Grossman, A., & Noble, L. (2021). Via2G Microtransit Pilot Evaluation.

Clifton, K. J., & Handy, S. L. (2003). *Qualitative methods in travel behaviour research*: Emerald Group Publishing Limited.

Ellis, E., & Mccollom, B. (2009). *Guidebook for Rural Demand-Response Transportation: Measuring, Assessing, and Improving Performance*. *The National Academies Press*. https://doi.org/10.17226/14330.

Forster, M. R. (2000). Key concepts in model selection: Performance and generalizability. *Journal of Mathematical Psychology, 44*(1), 205-231.

Franco, P., Johnston, R., & McCormick, E. (2020). Demand responsive transport: Generation of activity patterns from mobile phone network data to support the operation of new mobility services. *Transportation Research Part A: Policy and Practice, 131*, 244-266.

Furuhataa, M., Dessoukyb, M., Ordóñezc, F., Brunetd, M.-E., Wangb, X., & Koeniga, S. (2013). Ridesharing: The state-of-the-art and future directions. *Transportation Research Part B, 57*, 28-46.

Haglund, N., Mladenović, M. N., Kujala, R., Weckström, C., & Saramäki, J. (2019). Where did Kutsuplus drive us? Ex post evaluation of on-demand micro-transit pilot in the Helsinki capital region. *Research in Transportation Business & Management, 32*, 100390.

Haugland, D., Ho, S. C., & Laporte, G. (2007). Designing Delivery Districts for the Vehicle Routing Problem with Stochastic Demands. *European Journal of Operational Research, 180*(3), 997-1010.

Hensher, D. A., Rose, J. M., Rose, J. M., & Greene, W. H. (2005). *Applied choice analysis: a primer*: Cambridge University Press.

Herminghaus, S. (2019). Mean field theory of demand responsive ride pooling systems. *Transportation Research Part A: Policy and Practice, 119*, 15-28.

Linzer, D. A., & Lewis, J. (2011). poLCA: polytomous variable latent class analysis version 1. 4. *J Stat Softw, 42*, 1-29.

Liu, K., Zhang, J., & Yang, Q. (2019). Bus Pooling: A Large-Scale Bus Ridesharing Service. *IEEE Access, 7*, 74248-74262.

Ma, T.-Y., Chow, J. Y., Klein, S., & Ma, Z. (2020). A user-operator assignment game with heterogeneous user groups for empirical evaluation of a microtransit service in Luxembourg. *Transportmetrica A: Transport Science, 17*(4), 946-973.

Macfarlane, G. S., Hunter, C., Martinez, A., & Smith, E. (2021). Rider Perceptions of an On-Demand Microtransit Service in Salt Lake County, Utah. *Smart Cities, 4*(2), 717-727.

Miah, M. M., Naz, F., Hyun, K. K., Mattingly, S. P., Cronley, C., & Fields, N. (2020). Barriers and opportunities for paratransit users to adopt on-demand micro transit. *Research in Transportation Economics, 84*, 101001.

Mokhtarian, P. L. (2016). Discrete choice models' ρ2: A reintroduction to an old friend. *Journal of Choice Modelling, 21*, 60-65.

Nagin, D. (2009). *Group-based modeling of development*: Harvard University Press.

Patel, R. K., Etminani-Ghasrodashti, R., Kermanshachi, S., Rosenberger, J. M., & Weinreich, D. (2021). *Exploring Preferences towards Integrating the Autonomous Vehicles with the Current Microtransit Services: A Disability Focus Group Study.* Paper presented at the International Conference on Transportation and Development 2021.

Pearmain D, Swanson J, Kroes E, Bradley M. Stated preference techniques: a guide to practice. 2nd ed. Steer Davies Gleave and Hague Consulting Group. 1991.

Rudloff, C., & Straub, M. (2021). Preprint: Mobility surveys beyond stated preference: Introducing MyTrips, an SP-off-RP survey tool, and results of two case studies. *ScienceOpen Preprints*.

SacRT. (2020). *SacRT launched six additional SmaRT Ride service areas Monday, January 6, 2020*. Retrieved from https://www.sacrt.com/apps/smart-ride/:

Shaheen, S.; Chan, N.; Bansal, A.; Cohen, A. Shared Mobility a Sustainablity and Technology Workshop: Definition, Industry Development and Early Understanding; University of California Berkeley Transportation Sustainability Research Center: Berkeley, CA, USA, 2015; p. 30. Available online: http://innovativemobility.org/wp-content/uploads/2015/11/SharedMobility_WhitePaper_FINAL.pdf (accessed on 15 September 2019).

Shaheen, S., & Cohen, A. (2019). Shared ride services in North America: definitions, impacts, and the future of pooling. *Transport Reviews, 39*, 427–442.

Shaheen, S., Stocker, A., Lazarus, J., & Bhattacharyya, A. (2016). *RideKC: Bridj pilot evaluation: Impact, operational, and institutional analysis*. Transportation Sustainability Research Center (TSRC), UC Berkeley.

Shaheen, S., Stocker, A., Lazarus, J., & Bhattacharyya, A. (2016). RideKC: Bridj Pilot evaluation: impact, operational, and institutional analysis. *Transportation Sustainability Research Center (TSRC), UC Berkeley*.

Swait, J. (1994). A structural equation model of latent segmentation and product choice for cross-sectional revealed preference choice data. *Journal of Retailing and Consumer Services, 1*(2), 77-89.

Tabachnick, B. G., Fidell, L. S., & Ullman, J. B. (2007). *Using multivariate statistics* (Vol. 5): Pearson Boston, MA.

Wang, C., Quddus, M., Enoch, M., Ryley, T., & Davison, L. (2015). Exploring the propensity to travel by demand responsive transport in the rural area of Lincolnshire in England. *Case Studies on Transport Policy, 3*(2), 129-136.

Yoon, G., Chow, J. Y., & Rath, S. (2021). A simulation sandbox to compare fixed-route, flexible-route transit, and on-demand microtransit system designs. *arXiv preprint arXiv:2109.14138*.

8 Data Summary

Products of Research

Data used for this study was collected from a large survey. The survey questions were categorized into six groups as follows. Data includes variables measuring SR behaviors and the explanatory variables derived from the survey questions. These data were entered into models as dependent and independent variables to estimate the outputs.

Socio-demographics and individual health

These questions were about an individual's socio-demographics such as age, gender, education level, race, household size, and individual's physical conditions that limit the ability to walk, bike, drive, and take transit.

Attitude

The questions about attitude include affect toward SR as well as other transportation modes such as driving, ridehailing, and transit. We also measured other opinions, beliefs, and thoughts about travel time and travel cost, which pertaining to an individual's perceived likely consequences of using SR.

Subjective norm

A question about normative belief was designed to identify people who consider the impact of mode choice on environment and energy. The respondents were also asked whether people they know will be or are supportive of SR. This question served to measure social support, which pertains to whether respondents are expected by their friends, their family, and society in general to use microtransit.

Perceived behavioral control

We asked about several potential facilitators or barriers to using SR associated with individual control belief, such as the perception of ease of use of the app, mental effort to interact with SR, availability of the service in areas and at certain times, travel cost, total travel time, environmental impact, novelty, accessibility, wait times, and travel time reliability of SR.

SR behavior

The respondents reported whether they had heard of SR. For the respondents who had heard of it, they further reported whether they had used it before taking the survey. SR behavior questions also include the respondents' intention (for non-SR respondents)/future (for SR users) use of SR. Additionally, how SR users' choices of transportation changed because of SR were collected to examine the probable modal shift due to the use of SR. The influence of the COVID pandemic on the use of SR was also reported by the respondents.

Specifically, the respondents were asked to recall their most recent SR trip and to report exterior and interior shuttle characteristics, such as cleanliness, comfort, temperature, noise levels, and how easy it was to get on and off the vehicle, especially using a wheelchair. The survey also asked about drivers' attitude and driving skills.

Data Format and Content

The data is in the format of a SPSS file. The file contains 997 cases collected from a large survey being published online from August 23 through November 2, 2021. Another word file provides a dictionary to describe the meaning of each variable and its corresponding scales.

Data Access and Sharing

The data is available through the Dryad data repository. The general public can access the dataset at https://doi.org/10.25338/B8VK84.

Reuse and Redistribution

There are no restrictions for reuse of the data. They are published on Dryad and only require attribution. Suggested citation:

> Xing, Yan (2022), Dataset of microtransit consumer market in the Sacramento Area, California, Dryad, Dataset, https://doi.org/10.25338/B8VK84