# Exploring Behaviors and Satisfaction of Micro-Electric Vehicle Sharing Service Users: Evidence from a Demonstration Project in Jeju Island, South Korea

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**ACKNOWLEDGMENTS:**

This study has been published in 'Sustainable Citeis and Society', Vol. 79, 2022, https://doi.org/10.1016/j.scs.2022.103673 . The extended abstract is a revised version of the original paper for the presetation for the special issue of "Electrification of transport in cities and regions: deepening spatial disparities or an opportunity for economic growth?" at the 61st ERSA congress, 23-26 August, Pecs, Hungary.

## 1. Introduction

Micro-electric vehicles (micro-EVs), which are a combination of micro-mobility and electric vehicles (EVs), are small EVs having one or two seats. The related terms and regulations for micro-EVs differ from country to country. In this study, if it meets the regulations of a country, it is referred to as a micro-EV.

Micro-EVs are a subset of EVs and have advantages similar to EVs. The advantages are as follows: low maintenance cost, financial incentives, and eco-friendly transportation. In addition, micro-EVs provide convenient movement on narrow roads, convenient parking, and low initial and operating costs due to their much smaller size than general EVs.

In recent years, several studies related to micro-EV car-sharing services have been conducted: the possibility of one-way car-sharing service, micro-EV relocation management for sharing systems, and baseline estimation methodology for key performance indicators in micro-EV sharing services. Furthermore, there are several studies on small EV sharing services, including motivation and travel patterns for free-floating or one-way sharing systems, environmental impact on free-floating systems, private car reduction potential of free-floating car-sharing, and the applicability of mini EVs in car-sharing programs through.

However, there is still limited research on micro-EV use in sharing services, such as how micro-EVs are used and what types of trips are replaced by micro-EV sharing services. Moreover, there is a lack of research on the factors of micro-EVs that can affect the use of micro-EV sharing services. In other words, there is insufficient empirical evidence on how micro-EV, which is attracting attention as future mobility, is used in sharing service systems. Accordingly, the research questions of this study were as follows:

1. What types of trips will micro-EV sharing services be used for, and what types of trips will they replace?
2. What factors affect the use of micro-EV sharing services?

To answer these research questions, we investigated the participants of the SOCAR demonstration project on Juju Island, South Korea. An extensive travel diary survey and micro-EV usage record collection were conducted to investigate trip and usage patterns. In addition, an online survey and in-depth interviews were conducted to obtain more in-depth insights into service satisfaction.

## 2. Description of SOCAR demonstration project

This micro-EV sharing service demonstration project has been conducted jointly by the Ministry of Trade, Industry and Energy of Korea and SOCAR since 2019. The project aims to verify the impact and business feasibility of micro-EV sharing services using micro-EVs, starting from Jeju Island in Korea. Jeju Island is an island with an area of 1849 $km^2$ and a population of about 695,500.

This demonstration project provides a round-trip micro-EV sharing service with 24 micro-EVs at four stations in Ara-dong on Jeju Island. The micro-EVs used in the demonstration project were CEVO-C (12 vehicles) and D2 (12 vehicles). The CEVO-C can travel approximately 60 km with a fully charged battery, whereas the D2 can travel about 90 km. The top speeds of the two micro-EVs are 80 km/h. The demonstration project consists of two types of services: Type 1 is for daily life and can be used from 6 p.m. to 9 a.m. the following day on weekdays and any time on weekends. Type 2 is for business use and can be used from 10 a.m. to 5 p.m. on weekdays, i.e., business hours. Breaks for charging are applied every hour in the middle of the change in service hours for Type 1 and Type 2.

## 3. Data collection

The data used for the analysis were collected using Type 1 and Type 2 testers. In the case of Type 1, participants agreed to participate in four data surveys, whereas Type 2 received consent to participate in only one survey (online survey). For this reason, we collected four data sources from Type 1 testers and collected one data source (online survey) from Type 2. The first was the usage records of the micro-EV sharing service, including driving data (GPS information) and usage logs of the mobile application. The driving data were collected every 40 minutes by default, approximately every 20 seconds when an issue (physical shock, door open, start/off, etc.) was detected on the vehicle, and approximately every two minutes during driving. The usage logs included total reservation time, date, and start and end times. 24 and 69 testers were recruited for Types 1 and 2, respectively.

In addition, through an offline extensive travel diary survey, we collected the testers' main travel activities and their travel modes (including micro-EVs and other transportation modes). Furthermore, the testers' satisfaction levels with diverse components of the micro-EV sharing

service were also collected through an online survey. Finally, we conducted an in-depth interview to qualitatively evaluate the service from 18 out of 24 testers (Type 1).

## 4. Analysis

We employed various measures to investigate users' behaviors and satisfaction using the micro-EV sharing service. The behavior of the micro-EV sharing service users was analyzed by measures representing the users' travel patterns, trip purpose comparing other modes, usage characteristics, travel time, reservation, and spatial distribution of trips. The measures investigating users' travel patterns by trip purpose and comparing other modes were evaluated based on the extensive travel diary survey data. Meanwhile, the users' usage, travel time, and reservation were measured using the driving data and usage logs regarding reservations to use a micro-EV. The micro-EV sharing service user perceptions were analyzed by importance–satisfaction analysis (ISA) and keyword analysis using the qualitative data from the online survey and in-depth interview. For the keyword analysis, categories were first set based on users' responses, describing diverse components of the micro-EV sharing service. Then, by listening to the recorded users' responses, the negative or positive responses of users related to each category were counted.

## 5. Key Findings and Discussion

### *5.1. Short-Distance Trips*

The analytical results for various measures suggest that the micro-EV sharing service tends to be limited as a short-distance travel mode. The average trip distance of the micro-EV sharing service was significantly lower than that of the other modes for all trip purposes except shopping. In addition, the difference in average trip distance between modes according to each trip purpose was large, and the difference in average trip distance between micro-EV sharing services and private car & taxi was significant.

The analysis of the micro-EV sharing service usage record presents another analysis result that can identify the role of the micro-EV sharing service. The estimated travel time based on usage records also suggests that the micro-EV sharing service is used for short-distance trips. With the micro-EV sharing service, the average trip is a short-distance trip of approximately 9 min. In the analysis by user characteristics of the micro-EV sharing service travel pattern, the travel time

slightly increased on weekends. However, it was found to be up to 12 min, indicating that it is mainly used as a mode of the short-distance trip regardless of user characteristics. In addition, the spatial trip distribution of the micro-EV sharing service is very high in areas where the homes, work, and stations and their adjacent areas are located. This result contrasts with the fact that the private car & taxi had an even spatial distribution over a wide area.

However, we confirmed that the trip distribution pattern by trip purpose was very similar between the micro-EV sharing service and other travel modes. Although there may be a difference in the absolute trip frequency, users used the micro-EV sharing service to use existing travel modes. The difference between the modes was only in the average distance. These results indicate that micro-EV sharing services can replace traditional modes in situations requiring short-distance travel to perform certain activities.

*5.2. Physical anxiety*

We suggest that the response to the second research question regarding the factors affecting the role of the micro-EV sharing service is physical anxiety about the micro-EVs. The ISA results for the micro-EV sharing service show that although users consider safety and driving range to be substantial when driving, dissatisfaction with driving safety and battery capacity was high when they used the micro-EV sharing service. In addition, although the importance was relatively low, users' perceptions of the physical factors (Type 1: ride quality, battery capacity, and speed change; Type 2: ride quality, driving safety, and speed change) were unsatisfactory. The analysis results of in-depth interviews show the similar results.

Micro-EV sharing services are expected to be actively used as a new travel method and have been shown to positively affect the modal shift, travel time, and parking. However, physical anxiety can make it difficult to continue driving, affecting negative perceptions of long-distance travel. According to our research, users' perception of long-distance travel (over 10 km) is very negative but very positive for short-distance trips (2 – 3 km). One possible interpretation of this result is that the micro-EV sharing service, with its positive effects of modal shift, shorter travel time, and convenient parking, is a very satisfying mode for short-distance trip, but has negative effects for long-distance travel due to the physical anxiety caused by the vehicle.

*5.3. Policy implications*

In terms of providing a new alternative for various trip types, the micro-EV sharing service is receiving positive responses, such as a replacement effect for existing travel modes and a

reduction in travel time. Hence the future use of the service is expected to be positive. However, the role of the micro-EV sharing service is limited to short-distance trips. This appears to be due to physical anxiety—such as driving anxiety, limited battery capacity, uncomfortable riding, and insufficient in-car space interfering with continuous long-distance travel. For the micro-EV sharing service to be used for long-distance travel, it is necessary to eliminate physical anxiety about the vehicle's body. However, the physical anxiety about the vehicle body is expected to be difficult to improve as it is a chronic limitation due to the small size required for micro-mobility. Therefore, when it is difficult to overcome the physical limitations of the vehicle body, policymakers and service operators can actively utilize the micro-EV sharing service as a short-distance trip model. Although there are physical concerns about micro-EVs due to their smaller size than general EVs, micro-EVs still have strengths compared to general EVs: the convenience of driving on narrow roads, mode of solving FLML problems, convenient parking in tight spaces, and alleviating road congestion. In addition, physical anxiety can be resolved by securing safety through deregulation.

Our findings suggest that the micro-EV sharing service is used for short-distance trips for various purposes. Therefore, the micro-EV sharing service can be actively used for short-distance trips, such as last-mile trips. Therefore, a one-way sharing service using micro-EVs is competitive in the future transportation system. In addition, we suggest that policymakers and service operators invest in fast-charging infrastructure near shopping centers. Our study results show that shopping trips using micro-EV sharing services are very active and offer the highest possibility of replacing existing modes. In addition, providing a charging infrastructure around frequently traveled places positively affects the activation of micro-EVs. Therefore, by investing in fast-charging infrastructure near shopping centers, where micro-EV sharing services are actively used, it will be possible to improve the welfare of passers-by and enhance the modal shift effect.