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Modeling free-floating car-sharing use in Switzerland: A spatial regression and conditional logit approach

Henrik Becker *, Francesco Ciari, Kay W. Axhausen

ETH Zurich, Institute for Transport Planning and Systems, Stefano-Franscini-Platz 5, 8093 Zurich, Switzerland

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ABSTRACT

Free-floating car-sharing has been one of the latest innovations in the car-sharing market. It allows its customers to locate available vehicles via a smartphone app and reserve them for a short time prior to their rental. Because it is available for point-to-point trips, free-floating car-sharing is not only an alternative to private cars, but also to public transportation. Using spatial regression and conditional logit analysis of original transaction data of a free-floating car-sharing scheme in Switzerland, this research shows that free-floating car-sharing is mainly used for discretionary trips, for which only substantially inferior public transportation alternatives are available. In contrast to station-based car-sharing, it does not rely on high-quality local public transportation access, but bridges gaps in the existing public transportation network.

1. Introduction

Free-floating car-sharing has been one of the latest innovations in the car-sharing market. It allows customers to locate available vehicles via a smartphone app and reserve them for a short time prior to their rental (typically 15 min). At the end, customers may leave the vehicle at an eligible on-street parking space within a pre-defined (typically city-wide) service area. It therefore offers flexible one-way trips and has been able to attract new customer groups for car-sharing (Shaheen et al., 2015). Moreover, because it is available for point-to-point trips, free-floating car-sharing is attractive not only as an alternative to private cars, but also to active modes and public transportation. However, little is known about the actual use cases of free-floating car-sharing so far.

Although there is substantial growth of free-floating car-sharing around the globe, a number of cities have already seen a cessation of operations of such schemes allegedly due to a lack of profitability (BBC, 2014; Smiley, 2016). It appears that even after several years on the market, only little is known about which factors govern free-floating car-sharing demand (Kortum et al., 2016).

This research uses transaction data of a free-floating car-sharing operator to better understand the market niche of free-floating car-sharing. It does so by studying the effect of neighborhood characteristics on free-floating car-sharing demand in a spatial regression approach and by studying the effect of trip attributes in a mode choice model. The analysis is conducted for the city of Basel, where at the time of this research, a car-sharing operator provides 120 free-floating vehicles. Although the city's agglomeration extends into Germany and France, the main service area only spans the city of Basel as well as a number of adjacent municipalities in Switzerland. In addition, there is an outpost of the service area at the tri-national

* Corresponding author.
E-mail address: henrik.becker@ivt.baug.ethz.ch (H. Becker).

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airport, which is located in France. Within the service area, car-sharing customers may use any free or residential on-street parking as well as dedicated parking spaces at the main train station and the airport. In total, the on-street parking spaces available for the car-sharing scheme correspond to about 82% of the total number of on-street parking spaces in the city.

2. Background

Apart from a few experimental set-ups, car-sharing has for a long time been offered as station-based service only. In this setting, customers can reserve a vehicle, take it from a fixed parking space and use it for the reserved period of time. Most of such schemes are operated as return-trip schemes meaning that at the end of the rental, the vehicle needs to be brought back to the point of departure.

Station-based round-trip car-sharing schemes are already quite well understood. For example, it has consistently been found that round-trip car-sharing is most likely to be adopted in dense urban areas, which are well connected by public transportation (Litman, 2000). It was also found, that younger, highly educated and car-free households are most likely to become car-sharing members (Burkhardt and Millard-Ball, 2006; Becker et al., 2017c). Moreover, there is agreement that car-sharing facilitates a car-free lifestyle by providing a vehicle in situations, in which it is actually needed (Shaheen and Cohen, 2013). This way, it helps to reduce car-ownership and vehicle miles travelled (Martin et al., 2010; Martin and Shaheen, 2011).

Whilst most of the empirical research on round-trip car-sharing was based on member surveys, a few studies used geo-information to complement insights from those surveys. For example, Celsor and Millard-Ball (2007) studied the socio-demographic composition of census blocks adjacent to car-sharing stations. Their results suggest that neighborhood characteristics are even more important to car-sharing success than individual members' demographics. In particular, they suggest that part of the local car-sharing demand can be predicted by the average household vehicle ownership as well as the mode share of walk among commuters in a given area. The findings were extended by Stillwater et al. (2009) showing that also characteristics of the built environment, particularly street width and public transportation service levels significantly affect local demand for station-based car-sharing. Including land-use variables in their model, Kang et al. (2016) point out that car-sharing is used more intensively in business districts and areas with a high density of car-sharing stations. However, they also find that in Seoul, station-based round-trip car-sharing is most successful in areas featuring higher vehicle ownership rates and less rail accessibility indicating substantial differences in car-sharing adoption and use between Asia and the North America.

Using transaction data and the monthly usage and availability as dependent variables, de Lorimier and El-Geneidy (2013) confirm that the number of vehicles parked at a given car-sharing station and the number of car-sharing members living in the vicinity have a strong positive effect on use. However, they also find large seasonal variation in car-sharing use.

In a different approach, Leclerc et al. (2013) also used vehicle tracking to better understand usage of station-based round-trip car-sharing schemes. In particular, they have found that car-sharing tours contain more trips than tours made with private cars. Moreover, the stops are shorter indicating a more efficient use of the vehicle.

A step towards opening car-sharing up to new markets was the introduction of station-based one-way car-sharing, where the return-trip requirement is relaxed and customers may end their trip at any car-sharing station. However, for such schemes, imbalances in the spatio-temporal demand distribution require substantial efforts of vehicle relocations or user incentives (Jorge et al., 2015b). As an alternative, the one-way option can be reduced to trips between selected station and a point of interest with high demand (Jorge et al., 2015a).

An even more flexible form is free-floating car-sharing. It operates without fixed car-sharing stations and return trip requirements. Due to such structural differences to station-based return-trip services, it was found to attract different customer groups and to also have a different impact on travel behavior (Le Vine et al., 2014; Becker et al., 2017a; Le Vine and Polak, 2017). Therefore, knowledge about the drivers of station-based car-sharing demand as outlined above may not be applicable to free-floating car-sharing.

This notion is supported by early agent-based simulations showing substantial differences in the demand patterns of the two systems (Ciari et al., 2014). In addition, agent-based simulations were further used to study e.g. the effect of different pricing schemes and parking prices on free-floating car-sharing demand (Ciari et al., 2015; Balac et al., 2017). However, so far, the results of these and other agent-based approaches to model car-sharing (Heilig et al., 2017) are limited by the lack of dedicated mode choice models covering any form of car-sharing.

In a first approach to better understand free-floating car-sharing adoption using empirical data, Kortum and Machemehl (2012) analyzed transaction data of a free-floating car-sharing scheme in Austin, TX. By combining the transaction data with spatial information on the rental start points, they found that free-floating car-sharing is particularly often used in neighborhoods with a high population density, a high share of younger (aged between 20 and 40 years) and male inhabitants as well as smaller household sizes. Using a similar approach for Berlin and Munich, Schmöller et al. (2015) were able to confirm that free-floating car-sharing is most heavily used in areas with young residents living in smaller households. In addition, higher residential rents and a high density of businesses (including offices, shops, restaurants and bars) were found to have a positive effect on car-sharing utilization. They also found high short-term variations in demand, which may partly be explained by weather effects. However, by using simple linear regression models to study the effect of neighborhood characteristics, both approaches neglect spatial autocorrelation, which may lead to bias in the respective results.