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Promoting carsharing attractiveness and efficiency: An exploratory analysis

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ABSTRACT

Carsharing has grown significantly over recent years. Understanding factors related to the usage and turnover rate of shared cars will help promote the growth of carsharing programs. This study sets station-based shared car booking requests and turnover rates as learning objectives, by which generalized additive mixed models are employed to examine various effects. The results are: (1) stations with more parking spaces, longer business hours and fewer nearby stations are likely to receive more booking requests and have a higher turnover rate; (2) an area with a higher population density, a higher percentage of adults, a higher percentage of males, a greater road density, or more mixed land use is associated with more car usage and a higher turnover rate; (3) stations nearby transit hubs, colleges, and shopping centers attract more shared car users; (4) shared cars are often oversupplied at transit hubs; (5) both transit proximity and housing price present high degrees of nonlinearity in relation to shared car usage and turnover rates. Findings provide evidence for optimizing the usage and efficiency of carsharing programs: carsharing companies should identify underserved areas to initiate new businesses; carsharing seems more competitive in a distance to a bus stop between 1.2 km and 2.4 km, and carsharing is more effectively served in areas with constraints in accessing metro services; carsharing should be optimally discouraged at transit hubs to avoid the oversupply of shared cars; local authorities should develop a location-based and geographically differentiated quota in managing carsharing programs.

1. Introduction

Due to the great potential of reducing car ownership, greenhouse gas emissions, traffic congestion, and parking lands, carsharing has become a very promising and rewarding urban travel option in recent years. Simultaneously, electrical cars are favored by the public and expanded at an unprecedented rate (Bardhi and Eckhardt, 2012; Fellows and Pitfield, 2000; Katzev, 2003), and being widely integrated as an indispensable element of many recently launched carsharing programs. The carsharing market has grown considerably over recent years throughout the world (Shaheen et al., 2009). For example, car2go's service had grown by 30% during 2017 (Drive, 2017). The measurements to evaluate the success of a carsharing company may include, but not be limited to, the number of customers, average rental duration, turnover rate of shared cars, and the number of newly established programs in other cities.

Compared to conventional car rentals, carsharing can be operated for customers' round trips or one-way trips, where in the latter parking shared cars may be stationed-based or free-floating (Shaheen et al., 2016). The round-trip type requires users to return cars to

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their original stations; the one-way type allows users to pick up cars at one station and return cars at any station; the free-floating type allows users to borrow or return a car at any on-street parking space within the designated scope of a city. Also, with the help of information and communication technologies, most carsharing services allow users to reserve cars via a smartphone app. Such convenience greatly adds flexibility to users and enriches the further growth of carsharing programs (Nourinejad and Roorda, 2015).

As carsharing provides economic and environmental benefits to our society, many government agencies strive to promote such programs, in order to cultivate the market and accelerate the growth (Cohen and Shaheen, 2018; Shaheen and Cohen, 2012). At the early stage, the development of carsharing programs greatly depends on the governmental support; with revenue increments, some carsharing programs successfully establish business models and become large taxpayers (Cohen and Shaheen, 2018). According to a recent report published by the Transportation Sustainability Research Center at the University of California, by October 2016, carsharing has been operated in 46 countries and 6 continents, accounting for an estimated 15 million members sharing over 157,000 vehicles. Asian countries have the largest carsharing markets, accounting for 58% of carsharing memberships and 43% of miles traveled (Shaheen et al., 2018). EVCARD, the biggest carsharing program in China, started its operation from 2013, now serves more than 1.2 million users with a fleet of over 16,000 electrical cars in 39 cities by 2017 (Daily, 2017).

Carsharing companies face many challenges when expanding their businesses. One urgent challenge is the station location choice. Certainly, carsharing companies want shared cars to be conveniently accessible to users and be efficiently used. Alternatively saying, those companies expect to achieve an equilibrium of shared cars (Kim, 2015; Kortum et al., 2016). Currently, the number of shared cars and the number of stations steadily increase with the number of registered members. Carsharing companies want their members to receive qualified services. Expanding the business is recognized as an indispensable part to maintain their competitiveness in the carsharing market. Taking Shanghai as an example, the municipality generally encourages the development of carsharing programs because carsharing is treated as an effective way to curb car growth. However, to avoid the brutal growth of shared cars, the city transportation department tried to prevent the quick expansion by allocating restrictive quotas. There are disagreements between multiple relevant governmental agencies, which reflects the lack of evidence in designing policy tools to manage shared cars. With an accurate prediction, along with a solid understanding of the trend, those governmental agencies can better evaluate how many shared cars should be allowed in the city. As a result, the government can act a more supportive role rather than present a self-contradictory role to manage carsharing and can also develop preventive strategies to avoid various market or government failures, such as avoiding the oversupply of shared cars in some local regions.

Examining factors related to the usage and turnover rate of shared cars can potentially help carsharing companies identify proper locations for stations and maximize their revenues. However, existing studies are far from adequate because the carsharing industry is immature and the data opened for deepening our understanding is rather limited. This study uses one-year shared-car transaction data obtained from a station-based one-way carsharing program and tries to answer the following research questions. First, what are spatial and temporal factors related to the use of shared cars? Second, what factors are correlated with the station-level turnover rate of shared cars? Third, what is the relationship between transit and carsharing? This study employs the generalized additive mixed modeling (GAMM) approach. Both spatial and temporal autocorrelations of shared-car usage between consecutive time intervals and approximate stations are adjusted. In addition, this GAMM approach is advanced in capturing nonlinear effects of various explanatory factors. The fixed effects are made of socio-demographics, travel-related features, station attributes, transit proximity, land use characteristics and time-varying variables. Findings from the car usage model help carsharing companies to gain insights into how to refine their business models to attract more customers, which ultimately convert to more profits. Findings from the turnover rate serve to adjust the locations of existing stations, which help improve the operational efficiency of the system and increase the accessibility of stations to customers.

2. Literature review

Possibly due to carsharing is a relatively new field, data are not well documented or opened to the public. Car usage or the number of booking requests is examined in the prior studies (Celsor and Millard-Ball, 2007; Jorge and Correia, 2013), whereas turnover rate has rarely been studied. Shaheen et al. developed the STEPS (Spatial, Temporal, Economic, Physiological, and Social) framework to analyze factors related to shared mobility (Shaheen et al., 2017). As synthesized by STEPS, fixed effects examined in the prior studies can be categorized as socio-demographic characteristics, travel-related features, station attributes, land use features, road facilities, transit proximity, and time-varying variables, as shown in Table 1.

2.1. Socio-demographic factors

Among various socio-demographic characteristics, population density, the percentage of young people, the density of members suggest positive relationships with shared car usage (Awasthi et al., 2007; Becker et al., 2017; Celsor and Millard-Ball, 2007; Costain et al., 2012; De Lorimier and El-Geneidy, 2013; Heilig et al., 2017; Kortum et al., 2016; Schmöller et al., 2015). In contrast, household size and the number of cars per household suggest negative relationships with shared car usage (Celsor and Millard-Ball, 2007; Heilig et al., 2017; Kortum et al., 2016; Schmöller et al., 2015). Job density shows different effects in the prior studies. In neighborhoods with a high job density, carsharing is greater in weekday daytime but less for weekday nighttime and weekends (Kim, 2015). The effects of income on carsharing is controversial (Celsor and Millard-Ball, 2007; Kim, 2015). Some studies have shown that low-income people are more likely to use shared cars (Costain et al., 2012; De Lorimier and El-Geneidy, 2013), while others studies suggest that middle-income people are primary users of carsharing services (Cervero et al., 2007).