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Assessing the viability of enabling a round-trip carsharing system to accept one-way trips: Application to Logan Airport in Boston

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ABSTRACT

Although one-way carsharing is suitable for more trip purposes than round-trip carsharing, many companies in the world operate only in the round-trip market. In this paper, we develop a method that optimizes the design of a one-way carsharing service between selected origin–destination pairs of an existing round-trip carsharing system. The goal is to supplement the established round-trip services with new one-way services and increase profitability. We develop an integer programming model to select the set of new one-way services and apply it to the case study of Boston, USA, considering only trips with one endpoint at a station in the round-trip *Zipcar* service network and the other endpoint at Logan Airport. The airport was chosen as a necessary endpoint for a one-way service because it is a very significant trip generator for which the round-trip carsharing is not suitable. Results show that these supplemental one-way services could be profitable. Enabling relocation operations between the existing round-trip stations and the Airport greatly improves the demand effectively satisfied, leads to an acceptable airport station size (in terms of the number of parking spots required), and is profitable; however, these benefits come with the need to manage relocation operations.

1. Introduction

Two main urban transportation modes have been used in the past few decades: private vehicle and public transportation. When the use of private vehicles started to become common, greater accessibility and flexibility in industrialized countries was achieved; however, several externalities resulted, including loss of time, pollution, congestion, and unrecoverable costs associated with the vehicle itself (Mitchell et al., 2010). Traditional public transportation modes like bus and rail may help solve these issues. However, public transportation has drawbacks, such as poor service coverage, schedule inflexibility and lack of personalization due to high investment costs.

Therefore, there is the need to find alternatives that are both sustainable and also guarantee that people have transport that enables them to carry out their activities. One of those alternatives is carsharing services. Carsharing systems involve a

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small to medium fleet of vehicles available at several stations to be used by a relatively large group of members (Shaheen et al., 1999). It appeared in 1948, in Europe, with a cooperative known as *Sefage*, which initiated services in Zurich, Switzerland. Later, in the 1980s, it came to the US within the *Mobility Enterprise* program (Shaheen et al., 1999). Currently, one of the world's largest carsharing companies is *Zipcar*, which was founded in January 2000. It has more than 850,000 members and about 10,000 vehicles spread across the USA, Canada, UK, Spain, and Austria (Zipcar(a), 2014). In March 2014, *Zipcar* started to offer one-way trips in Boston, USA (ZipcarOneWay, 2014).

Some studies (Litman, 2000; Schuster et al., 2005) have shown that carsharing has a positive impact on urban mobility, through a more efficient use of automobiles, mainly by reducing the time that each car is waiting to be used. The use of carsharing systems has also quite often allowed car ownership rates to decline (Schure et al., 2012; Klincevicius et al., 2014) and thus lowered car usage (Celsor and Millard-Ball, 2007; Martin and Shaheen, 2011; Sioui et al., 2013). Furthermore, some recent studies concluded that carsharing systems should have positive environmental effects by allowing the reduction of greenhouse gas emissions (Martin and Shaheen, 2011; Firnkorn and Müller, 2011).

Considering the operating model, carsharing systems can be classified into: round-trip systems, in which users have to return a car to the station where it was picked up; and one-way systems, in which users may pick up a car from one station and return it to another (Shaheen et al., 2006). Recently, a particular case of one-way carsharing appeared in which the vehicles are scattered around parking spots within a city, the so-called free-floating carsharing (Ciari et al., 2014; Schmoller et al., 2014). From the user perspective, round-trip services may not be attractive if a trip requires spending a long time parked at a location other than the vehicle's home location. Hence, this type of carsharing is mostly used for short trips when vehicles are parked for a short duration (Balac and Ciari, 2014; Barth and Shaheen, 2002; Costain et al., 2012), typically for leisure, shopping and sporadic trips; whereas one-way carsharing can be used for all other trip purposes, even commuting (Balac and Ciari, 2014; Ciari et al., 2014). Therefore, one-way carsharing systems are suitable for more trip purposes than round-trip services. Schmoller et al. (2014) concluded this through a study on two German cities, Munich and Berlin. In the one-way systems that are implemented in these cities, the highest number of bookings occurs on Fridays and Saturdays, which indicates that the system is used for shopping and social-recreational activities. However, during the week, peaks of demand correspond to the typical rush hours, that is, commuter traffic. This was also concluded by Balac and Ciari (2014), who found that peaks of demand for one-way carsharing occur in the morning rush hour, around noon, and in the afternoon rush hour, while for round-trip carsharing peaks of demand happen outside rush hours. Balac and Ciari (2014) did, however, conclude that the introduction of one-way carsharing does not cause a significant decline in round-trip carsharing demand, showing that the services are complementary.

Despite being an advantage for users, one-way carsharing operators often face the complexity of managing fleet imbalances since incoming and outgoing trips are rarely balanced at each station at any given time and clients may not find vehicles or parking spots available when they need them. Moreover, one-way carsharing may compete with public transportation, walking and cycling as well as with the car, as concluded by Ciari et al. (2014); this might be less beneficial than round-trip carsharing in terms of transportation sustainability. Balac and Ciari (2014) showed that car and walking are the modes more likely to be replaced by one-way carsharing. With respect to the car, this replacement is good and more sustainable. But the replacement of walking is harmful because it might lead to more car usage.

We can therefore conclude that a combination of round-trip and one-way carsharing could be better for the operator and the clients, considering that the decision to offer one-way trips is limited to special services, at least for a transition period. A carsharing system that operates as a one-way system can easily be used for round-trips; however, the opposite is rarely possible because the daily management of the system would have to be changed. The hypothesis discussed in this paper is that one-way carsharing services can sometimes be beneficial for both the users, who do not need to pay for the time the vehicle is parked, and the operator, which will be able to expand its market. When carsharing is operated only as a round-trip service, clients will choose other transportation modes for long-stay durations at the destination. One such mode is the taxi, which has door-to-door capability and only charges for the effective distance of the trip. Therefore, allowing a one-way service for some trips could be particularly interesting in cities where carsharing prices are significantly lower than the cost of a taxi or a private vehicle (if parking charges are included). Alfian et al. (2014) studied this possibility using a simulation tool to test several types of carsharing services, specifically those that offer both round-trip and one-way. They concluded that those services need to be cheaper than the taxi price for intermediate length trips. The goal of our work is to develop a methodology for testing if a round-trip carsharing system can provide a one-way service for very specific OD pairs, for which the round-trip service is usually not appropriate because it involves vehicles being parked for a long time. Despite the introduction of this new one-way service, round-trip service is the core business of the company. We consider the introduction of this service to be a strategic planning level problem.

A mathematical programming model is proposed that maximizes the expected daily profit from accepting or rejecting one-way trips between a specific high demand generator site in a city and the existing round-trip stations. We think that for these types of trips, it is easy for users to find alternative transportation modes if one-way carsharing is not available when needed. The availability of one-way carsharing service, however, does provide users with a less expensive option when compared to using a private vehicle or taxi.

The model is applied to the case study of trips between the round-trip carsharing stations in Boston's *Zipcar* network and Logan International Airport. It is relevant to note that Boston is a city where carsharing costs significantly less than other transportation modes, such as private cars and taxis, especially for longer trips.

Therefore, the main contributions of this paper are: