Impact of Road Pricing in Round-Trip and Free-Floating Carsharing Operations

Carsharing is a car rental system in which members have access to a fleet of cars on a time basis.
Up to today several different carsharing services have been developed by private companies, two of the most renowned are round-trip and free-floating: the first one is characterized by a more rigid structure because of its station-based nature while the second tends to be more flexible since a customer can pick up and drop off the car in any public parking inside a wide area.
Carsharing has the potential to satisfy individual transport demand in a more sustainable and socially beneficial way (International Transport Forum, 2017) [1]than the private car by reducing traffic and parking congestion and increasing cohesion amongst sharers [2].
According to previous studies there is evidence that different carsharing systems attract different types of users depending on both demand and supply factors [3].
The round-trip system has been analyzed focusing on the relationship between supply and demand factors considering stations accessibility, booking times and comfort regarding the vehicle type the main variables affecting this mutual dependency. Results show that there is a potential market for expanding carsharing [4].
The typical profile member of a round-trip carsharing service is drafted through a survey using a stated preferences methodology; the average member tends to be in his 30th, to work in a professional field and to live alone or with one or more unrelated adults [5]. Furthermore, authors show how most of the current choice model analyses have been done comparing private modes and carsharing services considering the car availability as an exogenous attribute [6].
Free-floating has been analyzed collecting data from different carsharing services in different cities to gain a deeper knowledge of how vehicles are used and their spatial movements. This is considered to be one of the first steps made to understand how this kind of service is used by customers [7].
By an empirical analysis of free-floating usage using booking data, it has emerged that most of the service spatial demand is concentrated within a few areas including shopping, tertiary and residential zones[8]. Furthermore, the service is used by customers whose living location is poorly served by public transport [9].
Previous studies showed that car availability is an important predictor for carsharing membership choice [1011]. Moreover, being a member is the first step users have to take to use a carsharing service and also, to the best of authors' knowledge, there isn't yet a valid model generally representing carsharing membership [12].
This article is a natural follow up of a previous study which investigated how supply attributes are connected to membership choice considering this choice dependent from the supply system characteristics. In this study a random utility function was used for both services adopting a synthetic population from Berlin [13].
Through a sensitivity analysis for both round-trip and free-floating services, this study shows how membership is sensible to supply attributes (i.e. parking availability, parking price, distance from the city center and users' trip chain in relation with location of activities) and how much these impact the choice.
Furthermore, car ownership is also considered as an attribute and its endogenization is implemented in order to capture its influence on membership choice.
Results show how attributes respond differently depending on the type of carsharing service: on one hand, a typical free-floating member tends to always have a car available, lives mostly in areas where parking availability is low and not for free, he/she also tends to live close to the city center and his/her typical daily trip is a point to point with travel time of at least 15 minutes. Results show that he/she uses the service as a substitution of the privately-owned car, for a point to point trip or for his daily trip chain. On the other hand, the typical round-trip member, having a more complex activity chain with more than one destination, is more willing to use the service. In this case the car is not always available, he/she does not live in suburban areas and he/she also has the payment parking in his neighborhood. Finally, the round-trip member seems to be apt to do more planned trips than free-floating users.
Starting from the aforementioned results, this paper investigates on how different road-pricing strategies can affect a free-floating and a round-trip carsharing service. The impact of carsharing on the modal split on a typical day in Berlin is around 3,4% (LSECities, 2015)[14], this value could change (e.g. because of companies' strategies and/or sustainable development policies) but, at the best of authors' knowledge, no survey has been done in order to catch the modal choice, in a case where carsharing is available, in case of tolling policies. For this, importing the membership data obtained in the previous study and focusing on the network of Berlin and its synthetic population, the authors aim to

simulate a road congestion pricing in an agent-based modeling framework in order to capture the user behavior during an ordinary day.
Getting into the details, this study analyzes two distinct phases in the mode choice process: the choice between free-floating and other modes and the choice between round-trip and other modes.
The metrics used in this study are the modal split, the number of drivers accessing the city center, the number of kilometers driven inside the tolling area and the amount of money flowing in the carsharing system.
By managing different road pricing policies, the expected output is an increment in carsharing modal split to the detriment of the system cost (e.g. congestion and pollution in the city center) and guidelines on how some policies impacts one service than the other considering the different nature of them.
For what it concerns the remaining metrics, the paper focuses mainly on the environmental aspects of what a tolling policy can bring and how it can affect people entering the central area of the city, since a reduction of the kilometers driven can be easily translated in an accessibility issue from a traveler point of view.
Finally, the amount of money flowing in the carsharing system it is going to be used as a key performance index for an artificial carsharing company who wants to offer its service; that is going to be employed to possibly advise which kind of service (i.e. free-floating and round-trip) tends to be more advantageous, that is to say which type of service will produce an higher revenue per vehicle.

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