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A random utility model for park & carsharing services and the pure preference for electric vehicles

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ABSTRACT

Most of the existing Carsharing business models mainly rely on gasoline vehicles and diesel vehicles, but in recent years there has been a significant increase in hybrid electric vehicles (HEVs) and a resurgence in electric vehicles (EVs). Within this framework, this paper investigates and models the choice to switch from a private car trip to a carsharing service available in peripheral parks as well as the propensity to choose an electric vehicle for such a service. In particular, three issues are addressed: (i) investigating and modelling the propensity to choose carsharing as a transport alternative within a neighbourhood residential carsharing business model; (ii) estimating the effect of also having an EV option available; (iii) measuring the "pure preference", if any, in using electric vehicles over traditional ones, in a context excluding factors that may bias such users preference (e.g. purchase price, energy costs, recharging facilities etc). The analyses are based on a stated preferences survey undertaken on 600 car drivers entering the city centre of Salerno (Southern Italy), and on the estimation of a binomial Logit model with serial correlation. Results allow an interpretation of the main determinants of the short-term choice of carsharing services (i.e. without any car-ownership changes), give general behavioural insights, make it possible to quantify the "pure preference" for EV and the demand elasticity with regard to different pricing strategies of the carsharing services.

1. Introduction and motivations

Carsharing is an increasingly popular solution for personal mobility in many cities worldwide. As highlighted by Shaheen and Cohen (2013), at the end of 2010 carsharing schemes were operating in more than 1100 cities in 26 countries on five continents (Asia, Australia, Europe, North America and South America). Although Europe led carsharing activities for two decades (61% of the world's carsharing membership; Shaheen and Cohen, 2007), as from 2010 North America became the largest carsharing region (48% of worldwide carsharing membership), though Europe continues to account for the majority of worldwide fleets deployed in 2010 (53% in contrast to 32% in North America, Shaheen and Cohen, 2013).

Currently, carsharing is most common in urban areas (Shaheen and Cohen, 2013; Shaheen, 1999; Shaheen et al., 2006, 2010), and several carsharing business models have been successfully developed: neighbourhood residential; business; government and institutional fleets; transit-based; college and university-based; and personal vehicle sharing (Shaheen and Cohen, 2013). Recently, it has also shown interesting potential in some pilot studies regarding suburban areas (de Luca and Di pace, 2015).

The various business models mainly rely on gasoline vehicles and diesel vehicles, but in recent years there has been a significant increase in hybrid electric vehicles (HEVs) and a resurgence[1] in electric vehicles (EVs).

As pointed out by Bakker and Trip (2013) and Shaheen and Chan (2015b), many governments are attempting to implement EV sharing initiatives by providing financial support, whereas major carsharing providers (e.g. Hertz 24/7™, Car2Go, City CarShare, Zipcar, I-GO CarSharing) and global automakers (BMW, Ford, General Motors, Mitsubishi, Toyota, Daimler, Honda and Suzuki) have begun entering in the market to provide a carsharing service with EVs. Indeed, a significant change in carsharing vehicles propulsion has been recently observed in several countries worldwide: EVs in the USA, Japan, France, Italy, Austria, Australia, Denmark, Norway, the UK, the Netherlands, Switzerland and Portugal; HEVs in Canada, Singapore, the USA, Japan, Italy and Switzerland.

In conclusion, as also indicated by Shaheen and Cohen (2013),

[1] Shaheen and Chan (2015b) point out that in the early 2000s 60% of all EV carsharing programmes ceased, while by 2006 the majority of EVs had disappeared in favour of gasoline-electric hybrid vehicles.

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the re-emergence of EVs and the integration of plug-in hybrids into carsharing fleets (e-mobility) will be one of the key trends to emerge in the carsharing business over the next five years. As a matter of fact, E-mobility carsharing solutions would allow the following three objectives to be achieved:

(1) Making carsharing more environmentally friendly, reducing its environmental impact.
E-solutions might respond to the main criticisms that are often levelled against carsharing, such as the risk of an increase in car use (trips by cars supplied by carsharing and kilometres travelled), and the increase in pollution, congestion and all negative externalities related to the use of conventional cars.
(2) Improving the appeal of carsharing and increasing user satisfaction due to its possible symbolic, hedonic and environmental significance.
As reported by Shaheen and Chan (2015b), new e-mobility business models have allowed an increase in carsharing membership and greater flexibility.
(3) Opening up new horizons for EV market penetration.

Since EVs and plug-in hybrid electric vehicles (PHEVs) continue to occupy a niche market, EVs in a carsharing service might be an opportunity for drivers to readily trial new technologies and observe new technologies in use. In particular, embedding e-solutions within carsharing programmes would allow the high capital cost of vehicle batteries to be distributed among several drivers (Shaheen and Chan, 2015b) and reduce the main adoption barriers related to the limited range and to the need to recharge such vehicles (Prem Kumar and Bierlaire, 2012; Wappelhorst et al., 2013; Communauté d'Agglomération de La Rochelle, 2014).

Within the context introduced above, to date few contributions have addressed the potential impacts of EVs in carsharing programmes. As pointed out by Zoepf and Keith (2015) and Shaheen and Chan (2015b), little has been written about the role of vehicle powertrain technologies in the carsharing context and research is still needed to ascertain and quantify e-mobility impacts on vehicle kilometres travelled, household vehicle ownership and modal shift.

Among existing contributions (Nerenberg et al., 1999; Zoepf and Keith, 2015; Firnkorn and Müller, 2015; Wappelhorst et al., 2014; Kim et al., 2015), most consist in descriptive analysis based on real data or stated preference (SP) surveys, and mainly aim to ascertain user satisfaction with e-solutions or the propensity to buy an EV. Only Zoepf and Keith (2015) investigate the choice of powertrain made by carsharing users.

Starting from these considerations, this paper investigates and models the choice to switch from a private car trip to a carsharing service available in peripheral parks as well as the propensity to choose an electric vehicle for such a service. In particular, users may choose whether or not to switch to a car-sharing service which, in turn, may, or may not, contemplate EVs. Therefore, two issues are addressed:

a) the propensity to choose carsharing as a transport alternative within a neighbourhood residential carsharing business model;
b) the effect of also having an electric vehicle option available. Since the respondents faced a binary choice context in which the carsharing service could be supplied by a traditional vehicle or by an electric one, the "pure preference" for an electric solution was directly observed (collected).

In particular, the main determinants are explored, their role is quantified and the "pure preference" for EVs is elicited.

Modelling carsharing behaviour and including EVs is interesting both in methodological and operative terms. First, the carsharing service investigated is a sort of park-and-share service, somewhat overlooked in the literature and in real-world case studies. Thus the proposed models can give interesting insights and/or be transferred to similar case studies. Secondly, the study would allow observation and measurement, using suitable mathematical models, of the "pure preference", if any, of using electric over conventional vehicles without the typical biases that may (positively or negatively) affect EV market behaviour simulation (e.g. price spread, the reliability of battery packs, restricted range, the limited number of charging stations, limited information on the technology and the main features of vehicles on the market). Thirdly, it would help ascertain and quantify whether the use of EVs might be a key factor for carsharing providers, since the availability of an electric vehicle may make the service itself "significantly" more appealing, thus giving useful insights to carsharing operators. Finally, it would indicate whether carsharing could be a niche market for EVs, giving useful insights to automotive manufacturers.

The above issues were addressed through an "ad-hoc" stated preferences survey within a carsharing project in the city of Salerno (Italy), and through specification and calibration of a set of discrete choice models based on the behavioural paradigm of random utility theory. The proposed carsharing service was a one-way service targeting users entering Salerno by car: each user was supposed to leave his/her own car in one of the peripheral parks, pick up the reserved car and continue to travel towards his/her final destination without paying any parking fee and/or without any limitation with respect to restricted traffic zones. Users were intercepted at the main parking lots in central Salerno and were asked whether (and how often) they would choose the carsharing service. Vehicles were assumed always available; electric and traditional technologies were considered and priced at different levels.

The paper is organised as follows. In Section 2 an updated literature review is provided, covering both methods to model carsharing behaviour and scientific contributions investigating perceptions of electric vehicles. In Section 3 the case study, survey and some descriptive results are presented. In Section 4 the modelling framework, estimation results and sensitivity analyses are discussed. Conclusions are drawn in Section 5.

2. Modelling carsharing behaviour: literature review

Carsharing has been investigated since the 1970s, but only in the late 1980s did it begin to be considered a viable solution in urban contexts. In-depth overviews and time-lines of carsharing history may be found in the various contributions produced in the last decade by the Transportation Sustainability Research Centre and its co-director Susan Shaheen.

Studies on carsharing are mainly concentrated in North America, and focus primarily on the feasibility of carsharing programmes and on the impact of carsharing on car ownership and vehicle usage (see de Luca and Di Pace, 2015, for an in-depth synopsis). Most of them rely on RP data and mainly develop descriptive analyses. Interesting overviews are proposed by Steininger et al. (1996), Meijkamp (1998), Katzev (2003), Litman (2000), Haefeli et al. (2006), Shaheen et al. (2006), Barth et al. (2007), Shaheen and Cohen (2007), Shaheen et al. (2009), Shaheen and Cohen, (2013), Shaheen et al. (2015).

With regard to modelling approaches, several models have been proposed to model the usage, the membership behaviour, frequency of usage and other choice dimensions.

With regard to car ownership and vehicle miles travelled daily, the Multinomial Logit model is the most commonly pursued