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Modelling preferences for smart modes and services: A case study in Lisbon

Charisma F. Choudhury [a,*], Lang Yang [b], João de Abreu e Silva [c], Moshe Ben-Akiva [b]

[a] Choice Modelling Centre, Institute for Transport Studies, University of Leeds, 34-40 University Road, LS2 9JT Leeds, United Kingdom
[b] Department of Civil and Environmental Engineering, Massachusetts Institute of Technology, 77 Massachusetts Avenue, MA 02139, USA
[c] CERIS/CESUR, Instituto Superior Técnico, Universidade de Lisboa, Av. Rovisco Pais, 1049-001 Lisboa, Portugal

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ABSTRACT

In this research, we investigate the acceptability of three new and emerging smart mobility options and quantify the associated willingness-to-pay values in the context of Lisbon using a comprehensive stated preferences (SP) survey. The smart mobility options include shared taxi, one-way car rental, and a novel combination of park-and-ride and school bus facilities. While previous surveys on smart mobility options had investigated limited number of alternatives in isolation, the SP survey used in this research presents the smart mobility options alongside the existing options and their traditional variants like congestion pricing and improved public transport systems. Further, the choice of mode, departure time and occupancy are investigated in a multidimensional framework. This resulted a large choice set (with 9 modes, 5 departure times, and 2 occupancy levels leading to 135 alternatives in total) and required a novel survey design.

The main survey administered over the internet and computer aided personal interviews included 2372 valid SP observations from 1248 respondents. Multi-dimensional mixed logit models were used to capture the complex correlations introduced due to the non-traditional survey design. Results indicate a significant preference of one-way car rental and shared taxi for non-commute trips. For commute trips, improved versions of traditional public transport modes are favoured over smart mobility options. These findings, as well as the novel data collection and modelling approach, are expected to provide important information to transportation planners and policy makers working to implement smart mobility options in Lisbon as well as in other cities.

1. Introduction and motivation

The increases in car ownership and usage have resulted in serious traffic congestion problems in many cities worldwide. The problem is often coupled with high dependency on private vehicles and their low occupancy rates leading to a substantial increase in total vehicle miles travelled (VMT). Traditional demand and supply management initiatives focusing primarily on the improvement of public transport and/or road pricing, have already been applied in many cities, but apart from a few cases, have failed to provide sustainable solutions to congestion (e.g. Dudley, 2013; Prud'homme et al., 2012; Carpintero and Gomez-Ibañez, 2011, etc.). Particularly, it has been observed that costly investments to make public transport more

* Corresponding author.
E-mail addresses: cfc@alum.mit.edu (C.F. Choudhury), langyang@alum.mit.edu (L. Yang), jabreu@tecnico.ulisboa.pt (J. de Abreu e Silva), mba@mit.edu (M. Ben-Akiva).

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appealing has resulted in a relatively small proportion of trips diverted from private cars (May and Nash, 1996; Correia and Viegas, 2008). Pricing measures like congestion pricing, for instance, have contributed to reducing congestion by primarily inducing peak-spreading and changes in destinations rather than reducing VMT (Litman, 2011; Barnes et al., 2012; Dudley, 2013). This has motivated transport researchers, planners, and policymakers to concentrate on smart mobility options which can make the best use of technological advancements to provide novel transport solutions within the resource constraints.

The success of these smart modes and services can be ensured by quantifying the sensitivity to different features of these new options prior to their field implementation and predicting the associated willingness-to-pay (WTP). This requires development of rigorous econometric models that investigate the full range of potential choices of the travellers. However, though there have been many studies in recent years evaluating the potential demand and effectiveness of smart mobility options, not many choice models have been developed to quantify the sensitivity to different features of these options.

Choice models of smart travel options have primarily focused on modelling preferences for advanced travel information systems (ATIS)-both for cars and public transport (e.g. see Chorus et al., 2006 for a comprehensive review), shared mobility (e.g. Buliung et al., 2009; Correia and Viegas, 2011), demand responsive services (e.g. Atasoy et al., 2015) and more recently smart/autonomous vehicles (e.g. Shin et al., 2015). The majority of these choice models have relied on the Stated Preference (SP) surveys, particularly the studies which have been conducted in the pre-deployment stage. The scope of these models has however been limited to choices among similar modes (e.g. choice of traditional car vs smart car, car-share vs solo driving, etc.) as opposed to comprehensive choice experiments covering the full range of possible options including multi-modal alternatives. This is primarily due to the complexity associated with the SP survey design in presence of large choice sets. Alternate sources of data include variants of SP survey like 'travel simulator' experiments (e.g. Bogers et al., 2005) and the combination of SP and Revealed Preference (RP) data (e.g. Khattak et al., 1996). These have concentrated on smaller subsets of alternatives at a time rather than the full range of options.

Further, in many cases, the introduction of the smart mobility options affects not only the mode choice but also the choice of departure time, route, destination, activity patterns, etc. Though these potential impacts have been acknowledged in the literature (e.g. Chorus et al., 2006) and modelled in limited scale in the context of congestion pricing (e.g. Vrtic et al., 2007), the multi-dimensionality of the choices are yet to be incorporated in the choice models for smart mobility options.

This motivated this research where we investigate the acceptability and WTP of three smart travel options by extending the state-of-the-art in two directions:

(1) Presenting the smart mobility options alongside existing transport options and traditional measures like congestion pricing and improved public transport.
(2) Explicitly considering the potential multidimensional impacts by joint estimation of the mode, departure time and occupancy choices.

A detailed case study in the context of Lisbon is presented in this regard. The proposed smart options include the following:

- *One-way car rental:* this service involves renting light electric vehicles folded and stacked at parking lots throughout the city (Mitchell et al., 2008). Travellers can check the availability of cars online and walk to a nearby lot, swipe a card to pick up a vehicle, drive it to the lot nearest to the destination, and drop it off there. It may be noted that main novelty of this service is the flexible drop-off point which, unlike conventional car share, can be different than the pick-up point. The foldable and stackable nature of the "CityCar" developed by researchers of MIT Media Lab (Mitchell et al., 2008), which enables the provider to *re-distribute* the cars easily at the end of the day, is expected to substantially contribute to competitive pricing of this service.
- *Shared taxi:* Passengers using smartphone apps to place their taxi reservations have the option to share their ride with other travellers who have similar routes (and benefit from lower fares). The fares are automatically calculated depending on the number of passengers and the time penalty endured for the sake of the other passengers.
- *Novel park and ride with school bus service:* This integrates school bus services with the park-and-ride facilities where children younger than 10 can be dropped off under supervision of qualified tutors. The tutors are reliable people (e.g. school teachers or other parents) and will take care of the children before taking them to their school in school buses.

The expectation is that a combination of these new solutions, combined with the right price signals, could attract a significant proportion of solo drivers to more environmentally friendly and efficient modes. Further details of the smart modes have been presented in Viegas et al. (2008) and Mitchell et al. (2008).

It may be noted that the smart modes and services explored in this study have new operational models and stronger deployment of real-time information and smartphone technologies but are based on existing infrastructure. This makes them easy to implement in many cities.

In the rest of the paper, the methodology is presented first along with an in-depth discussion on the challenges in the survey design and the approaches adopted to tackle the challenges. The details of the survey and the collected data are presented next. This is followed by the details on the model development where the modelling issues related to the unconventional aspects of the survey are highlighted. The results are presented next and the findings and policy implications are discussed in the concluding section.

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