



Will commute drivers switch to park-and-ride under the influence of multimodal traveler information? A stated preference investigation

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ABSTRACT

The knowledge about en-trip mode switching behavior with presence of multimodal traveler information is very limited so far. This study investigated the impacts on commute drivers' en-trip mode switch decisions of smartphone multimodal traveler information systems (SMTIS) which integrate dynamic information of auto-drive and subway park-and-ride (P&R). This is based on data collected from a stated preference survey in Shanghai, China. A panel mixed probit model which accounts for potential correlations of observations among a same driver and heterogeneity in preferences for travel time savings and comfort level of subway car was developed. The panel model has a much better goodness of fit than a model without consideration of panel effect and heterogeneity. The results show that SMTIS have significant impacts on commuter drivers' decision about switching from auto drive to P&R; the impacts depend on personal attributes including gender, age, education level, income, and P&R use experience; the sensitivity to time savings in the case non-incident induced delays, and the sensitivity to comfort level of subway, both vary significantly among the driver sample.

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1. Introduction

With the fast developing information and communication technologies and the increasing popularity of Smartphone, it has been a trend to deploy Smartphone based multimodal traveler information systems (SMTIS) (e.g. Brazil & Caulfield, 2013; Chorus, Molin, Wee, Arentze, & Timmermans, 2006; Frei & Gan, 2015; Gan 2015; Götzenbrucker & Köhl, 2012; Kenyon & Lyons, 2003; Minea, Badescu, & Dumitrescu, 2011; Natvig & Vennesland, 2010; Natvig & Westerheim, 2007; Zhang et al., 2011). Such systems can disseminate, during the whole trip, real time information concerning traffic congestion on selected routes, public transit arrival and departure time, route planning and navigation, and emissions information of alternate modes. It is expected SMTIS can encourage car drivers to use greener travel modes such as bus, rail transit, park and ride (P&R), thus facilitating more efficient infrastructure utilization and the enhancement of city mobility/sustainability (e.g. Brazil & Caulfield, 2013; Chorus et al., 2007; Gan, 2015; Kramers, 2012). This is particularly true in China. Chinese government has recently released the national 'Internet + Transportation' Strategic Guideline. In line with this national

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guideline, local governments in many big cities are planning to develop mobile internet based multimodal traveler information systems. This naturally motivates the study of travelers' behavior in response to real-time multimodal information, since a profound understanding of traveler behavior is a prerequisite for better design and wiser investment of SMTIS.

Only a small bulk of publications explored travelers' mode choice behavior under multi-modal information so far. Kenyon and Lyons (2003), through questionnaire surveys, found multi-modal information has effects on overcoming habitual and psychological barriers to consideration of alternative modes. Abdel-Aty and Abdalla (2006) investigated travelers' mode/route choice behaviors under multi-modal information using stated preference data in a 'bus/car' context. Bachok, Yue, Zito, Australasia (REAAA) Conference, and Korea (2009) evaluated a hypothetical rail-bus information integration strategy and estimated a multinomial logit model to predict feeder bus marked shares. Brazil and Caulfield (2013) investigated the impacts of 'Smartphone delivered alternate modes emissions information' on mode choice behavior in a 'car/bus' context, and developed a logit model. Chorus et al. (2007) estimated discrete choice models to describe drivers' mode choice decisions using stated preference data in a 'car/train' context. Most of these studies did not explicitly address SMTIS. A recent review of SMTIS related studies by Gan (2015) and Frei and Gan (2015) showed that so far only a very small number of publications have addressed behavioral aspects of multimodal traveler information systems and establish behavioral models, and most of them only explored pre-trip mode choice decision and did not include P&R. Gan (2015) using stated preference data of Shanghai drivers, estimated a logit model to describe commute drivers' en-trip mode switch behavior with presence of Smartphone multimodal information about car driving and subway P&R. Frei and Gan (2015), extending the work by Gan (2015), addressed the issue of heterogeneity in sensitivity to traffic delay by a mixed logit model.

Regarding P&R studies, existing publications addressed such topics as the optimal P&R facility location problem (e.g. Kepaptsoglou, Karlaftis, & Zongzhi, 2010; Khakbaz, Nookabadi, & Shetab-Bushehri, 2013), equilibrium model of user P&R point choice behavior (e.g. Olsen, 2013; Palma & Nesterov, 2006), the relation of private car utilization patterns and P&R facility space number and density of a city (e.g. Moenaddini, Asadi-Shekari, & Shah, 2014), empirical study of P&R facility utilization patterns (e.g. Hamid, 2009), survey of P&R motivations and air quality norms in Europe (Dijk, de Haes, & Montalvo, 2013), the influence of P&R facility on vehicle kilometer traveled (e.g. Duncan & Cook, 2014; Meek, Ison, & Enoch, 2011; Mingardo, 2013; Parkhurst, 1995; Parkhurst, 2000), analysis of stated intention of travelers' park and cycle ride (P + CR) use (e.g. Ando, Yamazaki, Haraand, & Izuhara, 2012), empirical analysis of P&R facility choice behavior (e.g. Clayton, Ben-Elia, Parkhurst, & Ricci, 2014), and attitudinal survey of P&R and non-P&R users (e.g. Kwon & Kwon, 2001). However, these studies did not address the mode choice decision behavior in the context of dynamic traffic information.

The above literature review shows that so far the link between P&R facility, en-trip mode switching behavior, and multimodal information has been rarely addressed. It is therefore of much interest to investigate travelers' en-trip mode switch decisions under SMTIS that incorporate auto and P&R options.

Given the above context, this study, in contrast to earlier studies by other scholars, investigates commute drivers' en-trip mode switch behavior with the presence of SMTIS which enables a direct comparison of level-of-service attributes among 'auto drive' and 'P&R' options. This study is conducted in the context of Shanghai, China, through a stated preference (SP) survey of Shanghai drivers. It addressed a realistic two-alternative situation for commute trips: "auto only" and subway "park-and-ride" (i.e. auto access + rail transit). This study extended the work of Gan (2015) through conducting an in-depth study on heterogeneity in travel time and subway crowdedness sensitivities among driver population, and addressing potential correlations among observations of the same individual. These extensions reach a better understanding of the commute drivers' mode switch behavior under SMTIS, and help to improve the explanatory power of the developed mode switch model and obtain more useful insights for SMTIS deployments.

The rest of this paper is organized as follows. First, this paper describes the survey method for collecting data on en-route mode switch behavior under SMTIS. Then, it presents the modeling approach to quantify the SMTIS impacts. Next, it discusses model estimation results. Finally, it gives concluding remarks.

2. Data

A stated preference experiment was designed to collect behavioral data on travelers' response to smartphone multimodal information since currently no real SMTIS applications including P&R exist in China. The experiment was designed on the basis of a realistic 'auto-driving' vs 'subway park & ride' commute trip scenario as depicted by Fig. 1. Respondents were asked to assume that their home and workplace are respectively on the west and the east of Huangpu River. The auto-driving option is a roadway route mainly comprised of an expressway. The P&R option requires a driver to drive to a P&R facility and transfer to subway.

Travel mode attributes values under normal conditions are presented in Fig. 1. The auto-driving option takes 38 min. The P&R option takes 45 min and its cost is 14 Yuan (a 10-Yuan parking fare plus a 4-Yuan subway fare) (1 Yuan \approx 0.16 Dollars).

For the SP experiment, experimental factors include auto delay, reason of delay, P&R cost, and level-of-comfort of subway car. Auto delay has three levels: 15 min, 25 min, and 35 min. Reason of delay has two types: incident-induced and not incident-induced. P&R cost has three levels: 14 Yuan (i.e. no discount), 10 Yuan (about a 30% off discount) and 7 Yuan (a 50% off discount). Level-of-comfort of subway car has two levels: 'with seat and not crowded' and 'without seat and crowded'. Orthogonal design was applied to generate nine travel scenarios (see Table 1) which are in accordance with nine SMTIS messages. In the survey experimenters asked respondents to imagine that as they left from their residence parking lot,

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