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Travel using managed lanes: An application of a stated choice model for Houston, Texas

Sunil Patil [a,1], Mark Burris [b,*], W. Douglass Shaw [c]

[a] RAND Europe, Westbrook Center, Milton Road, Cambridge CB4 1YG, UK
[b] Zachry Department of Civil Engineering, Texas A&M University, CE/TTI Building, Room No. 301-B, College Station, TX-77843-3136, USA
[c] Department of Agricultural Economics and Research Fellow, Texas A & M University, Hazard Reduction and Recovery Center, Blocker Building, Room No. 308F, College Station, TX-77843-2124, USA

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ABSTRACT

Managed lane (ML) travel adds flexibility, but also complexity, to travel choices. Stated choice models (SCMs) are often used for modeling complex transportation choices such as these in an effort to predict demand for these travel options. The design methods for SCMs have evolved from simple orthogonal designs to more sophisticated designs such as D-efficient design that can increase efficiency in estimation. We used three different survey design strategies to produce the stated preference portion of surveys, which were used to elicit travel choices for a sample of Houston travelers. Apart from the D-efficient design we also used random and adaptive random designs to generate attribute levels. There were observable differences in choice behavior depending on what design strategy was used. These differences appear to influence estimates of the value of travel time savings (VTTS) obtained from the random parameter logit (RPL) models estimated using these data. This, in turn, would greatly impact the percentage of travelers predicted to use the MLs.

The adaptive random strategy was superior to the other design methods in several categories, and it had similar efficiency to the D-efficient design. However, the mean of VTTS estimate obtained from a D-efficient design was closer to what is typically found in the literature. The difference was considerable and could greatly influence traffic and revenue estimates for the MLs, illustrating the importance of the survey design strategy.

1. Introduction

Houston, Texas is the fourth largest city in the United States with a 2007 US Census population estimate of over 5.7 million people living in the Houston metropolitan area (USCB, 2007). Despite the significant investment in the transportation infrastructure, the Houston metropolitan area remains the seventh most congested area for automobile traffic in the US. The average traffic delay per driver for the year 2005 was about 56 h (Schrank and Lomax, 2007).

In a recent effort to reduce this congestion, the Katy Freeway was expanded. The expansion included the addition of four managed lanes (MLs) in the center of the freeway designed to better manage congestion by using peak-period pricing and preferential treatment for High Occupancy Vehicles (HOVs). The MLs opened to travelers in November 2008, operating as HOV lanes where carpools (2 or more occupants), motorcycles and buses were allowed to travel for free. Single Occupant Vehicles (SOVs) were not allowed on the MLs at that time. Later, in April 2009, the MLs began to allow SOVs on for a toll – operating as High Occupancy Toll (HOT) lanes. Note that HOVs also pay a toll in the off-peak period.

The underlying economic concept associated with MLs is that as congestion increases in general purpose lanes (GPLs), more travelers will be willing to pay to use the MLs to save more travel time. Ideally, to keep the MLs operating at high speeds the toll must increase during periods of peak traffic demand. Priced too high, and travelers will not use the MLs. Priced too low, and the ML itself becomes congested, defeating the purpose of its construction.

This research used the Katy Freeway expansion as an opportunity to study recent advances in stated preference (SP) survey design in estimating the mode choice of travelers where they have managed lane options. This research effort collected data during the period when the managed lanes were operating as HOV lanes and did not allow SOVs. SP surveys can be used to estimate the preferences that travelers have using hypothetical scenarios in which a traveler is asked to choose between various alternatives (travel modes) described using relevant factors (such as toll and travel time). In this

* Corresponding author. Tel.: +1 979 845 9875; fax: +1 979 845 6481.
E-mail addresses: spatil@rand.org (S. Patil), mburris@tamu.edu (M. Burris), wdshaw@tamu.edu (W. Douglass Shaw).
[1] Tel.: +44 1223 353 329

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research, travelers were asked about their potential use of the MLs as a toll-paying SOV prior to that option being available.

One of the limitations of the SP studies is that people may not actually do what they say they will do, and this issue is generally known in the SP literature as potential hypothetical bias (see Little and Berrens, 2004; Murphy et al., 2005 and references within both). However, the SP approach is one of the few ways to estimate reaction to a potential new travel option (such as SOVs being able to use MLs by paying the toll), guiding transportation planning and travel demand management. SP responses can be compared with revealed preferences based on actual decisions, i.e. those corresponding to real world decisions (see Ben-Akiva and Morikawa, 1990; the later studies by Adamowicz et al., 1994; Dosman and Adamowicz, 2006).

In some cases hypothetical bias has led to SP-based probabilities being larger than those corresponding to field or laboratory choices with payments and this has been explored in stated choice models (SCMs) (see Ready et al., 2010). It can also lead to larger implied willingness to pay than the willingness to pay (WTP) based on actual behaviors, and actual payments (e.g. Lusk and Schroeder, 2004). However, a carefully constructed and designed stated choice model can indeed shed light on real-world behaviors and values that individuals have for goods and services (see Louviere et al., 1999). In the context here, MLs can be extremely capital intensive and developing the appropriate toll rate is a key to efficient operation and estimating the costs and benefits of the MLs. Therefore, advanced information regarding travelers' willingness to pay for the MLs based on stated preferences is especially valuable.

Many SCM applications involve purely hypothetical alternatives. However, in this application many of the survey respondents were expected to be familiar with most of the Katy Freeway travel alternatives except for paying a toll to use the MLs as an SOV. This is because at the time the survey was conducted Katy Freeway travelers faced the actual choice of GPLs versus MLs, but the latter were only operating as HOV lanes.

Three versions of the SP survey were based on three different design strategies. The design primarily influences the levels of the attributes that respondents see when they make their choices. The key attributes, travel time and tolls, varied to gauge the sensitivity of travelers to these key attributes of their travel. Analysis of the collected data provides valuable information regarding the traveler's value of travel time savings (VTTS), which can be used for estimating the toll rates for a socially efficient or desirable operation of the MLs on the Katy Freeway. The main objective of the analysis in this paper is to investigate the influence of these three survey design techniques on the estimation of VTTS on Katy Freeway managed lanes.

The remainder of the paper begins with additional background information regarding the Katy Freeway. Next, material related to the survey and data collection (details of the survey and survey designs used) is presented. In Section 3, we discuss the descriptive analysis carried out for samples corresponding to each of the design strategies. Specifically we look at whether the respondents vary their choices in the same fashion across the different designs. In Section 4, we present model estimation results for each design strategy, as the estimated parameters influence the implied VTTS. In the final section, some conclusions based on the estimation results and descriptive analysis are offered and discussed.

2. Survey development and administration

2.1. Study location

Houston is one of the fasted growing cities in the US. The Katy Freeway is a 23 mile stretch of Interstate-10 connecting the cities of Katy (to the west) and Houston. This freeway currently serves more than 219,000 vehicles a day (TxDOT, 2009). Before the expansion in 2008 it had 3 to 4 lanes along with 1 to 2 frontage road lanes in each direction plus one reversible HOT lane in the center. The expansion project began in 2003 and was completed in 2008, with the project costing approximately 2.7 billion dollars (US) (TxDOT, 2009). The expanded facility first opened in October 2008 with a minimum of four continuous through-lanes in each direction and as many as eight lanes at key connecting points, entrance and exit ramp locations. The new expanded facility also has four (two in each direction) MLs. The MLs on the Katy Freeway are separated from the general purpose lanes by flexible "candlestick" barriers. The MLs are free to use for METRO buses at all times of day and also are free to HOV2+ (with 2 or more people in a vehicle) vehicles and motorcycles during the peak traffic periods. From October 2008 until March 2009, SOVs were not permitted on the MLs. Beginning in April 2009, single occupant vehicle drivers willing to pay a toll could also use the MLs. The toll rate was set to vary by time of day ($4, $2, $1 for peak, shoulder and off-peak times, respectively, for the 12 mile stretch), with HOVs and motorcycles paying only during off-peak hours. The toll can only be paid by electronic toll collection (EZTag or TxTag) (HCTRA, 2009).

As mentioned above, we had the advantage over purely hypothetical SCM contexts, of collecting our choice data just at the time when the Katy Freeway MLs opened and most of the travel modes in the survey were available to travelers. The surveys were conducted in the November of 2008 using a sample of travelers who live near, and use the freeway. The survey data were collected via the internet and are described below.

2.2. The internet survey

An internet survey naturally requires that the sample members have at least some temporary, if not permanent access to a computer to take the survey. In the year 2007 about 75% of all US households had an internet broadband connection, which was a large increase of 21% as compared to the previous year (Legatt, 2007). Not every traveler has access to internet, introducing potential sampling bias. However, a recent study focused on this issue of sampling bias in toll road SP studies using data collected from six regions in the USA between 2007 and 2008 (Smith and Spitz, 2010). Smith and Spitz (2010) concluded that "collecting data only from those with Internet access is unlikely to lead to significant coverage error in a travel survey where driving in the study area is required". Further, all survey and sampling approaches have potential biases except in the rare case where 100% of a relevant population is surveyed with perfect completion of all parts of the questionnaire. For example, mail surveys and telephone surveys using landlines often suffer from poor response rates. Telephone surveys have also become increasingly problematic as cellular phones have become the only type of telephone that some homes have. Listings of cell-phone numbers are available but random digit dial approaches for cell phones are met with poor response rates.

In addition, claiming that one has an unbiased sample for any implementation approach requires belief that the sample that self-selects to partially or fully participate is not significantly different than those potential respondents who opt out of the entire survey. Stated choice surveys can involve complex tasks. The more complex the task, the less likely some types of respondents will be to complete the survey, or participate at all. The use of computers is actually quite desirable for implementing the choice survey because the computerized survey can provide visual additions that facilitate communication of key concepts, and because they can control the sequence of presentation, as well as block the respondent from moving on in the survey questionnaire before a question is answered. One way to use the computer is to physically hand a subject a laptop, and stand near them while they do the survey. Another is to post the survey on the internet and broadcast its existence to the relevant target population,