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Towards a Post-Processor-Based HOT-Lane Mode Shift Model

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Introduction

Traditional four-step travel demand models have generally incorporated some level of tolling analysis capability but often have inherent drawbacks. One of these drawbacks is an inability to fully model dynamic pricing. Existing methods to model pricing can be categorized into several basic groups, characterized by the step of the model they utilize including: mode choice, trip assignment and diversion models[1]; post-processor models; sketch planning methods which are quick-response tools for project evaluation[2]; and activity-based models, which can incorporate tolls in such areas as auto ownership, residential and employment locations, and land use patterns[3]. These methods are not exclusive, meaning that multiple methods can be employed in the same model.

Especially in the context of project development, completely revising an existing model set to incorporate congestion pricing can be a large undertaking, requiring significant calendar time and resources. As a possible alternative, subsidiary (generally, post-processor-based) analyses can be an effective way to explore sensitivity to pricing without requiring the same level of resources to implement. This paper discusses such an approach and a proof-of-concept in the form of its application to a recent study in the greater Washington, D.C. metropolitan area.

Approach

The latest market research techniques offer the ability to generate highly-customized survey instruments, including customized questions that result from prior answers. This capability enables the development of choice experiments to test responses to hypothetical scenarios that are tailored to the actual experiences of the respondent. This capability can also address a key problem in some past stated preference experiments in that the scenarios presented can be within a realm of realism so that the respondent "buys in" to the scenario and therefore answers the presented questions in a realistic fashion.

For a proposed HOV to HOT lane conversion, there are several angles of exploration that are of interest to decision-makers. These include: impact on mode choice, impact on carpooling and

[1] Spear, Bruce D. (2005). A Summary of the Current State of the Practice in Modeling Road Pricing. Presented at the Expert Forum on Road Pricing and Travel Demand Modeling. November 14-15, 2005.

[2] Kriger, David (2005). Traffic and Revenue Forecasting for Roads and Highways: Concerns, Methods and a Checklist for Practitioners. Presented at the Expert Forum on Road Pricing and Travel Demand Modeling. November 14-15, 2005.

[3] Evans, J., K. Bhatt, and K. Turnbull (2003). TCRP Report 95, Chapter 14, Road Value Pricing.

transit usage specifically, and level of interest in paying for access to the lane. Market research coupled with special-purpose model estimation can greatly help inform these explorations over what is available solely relying on existing tools. For example, with such a resulting model, it is possible to forecast mode choice or choice to pay for time savings at different price points for selected market segments using a post-processor-based tool.

Proof of Concept

Cambridge Systematics, in association with Southeastern Institute of Research, had an opportunity to explore a proof of this concept during its recent work in support of the "I-95/I-395 HOV/HOT-Lane Transit/TDM Study" for the Virginia Department of Rail and Public Transportation. As part of the project, a comprehensive market research study was conducted among commuters in the corridor. The proposed HOT lanes in this corridor would be free for vehicles with three or more occupants, but a congestion pricing toll would be charged to lower occupancy vehicles.

A postcard mailing to 75,000 households was conducted to recruit respondents to an Internet-based survey. In addition, special targeted lists were used to provide an oversample of shared-ride and transit populations. A total of 3,288 completed interviews were obtained. The result was a rich dataset including, in addition to the choice experiment, information about current commute patterns and transportation attitudes and preferences.

The choice experiments were asked to each respondent. Three experiments were performed with each current shared-ride or transit user respondent and four were performed with each respondent using a single occupant vehicle. Each respondent was shown an amount of time savings, varying from 5 to 20 percent of their total reported travel time, and a randomly generated cost of $0.08/minute to $0.50/minute (shown to the respondent as a total cost, e.g., $4.50). For existing transit and shared ride users, the amount of time savings shown was capped so as not to be unrealistic, since these riders both currently and in the future would not be charged to ride in the HOT lanes, and therefore their time savings would come from a decreased wait/meet-up time at the start of their trip. Respondents were asked that given they could use the features of the HOT lanes to achieve the indicated minutes saved for the total cost shown, to choose their likely mode of travel.

The choice options for current drive-alone (DA) respondents were: DA in the HOT lanes and pay the toll; switch to an HOV mode to use the HOT lanes for free; carpool with one other person and split the HOT lane toll; not change their behavior (continue to DA in the free lanes); or something else. Nondrive-alone (Non-DA) respondents had the choices of driving alone and paying the HOT lane toll, driving alone in the free lanes, not changing their current mode, or something else. If a current DA respondent said they would switch to an HOV mode, they were then asked to choose from the following list: carpool, become a slug driver, become a slug passenger, vanpool, ride the bus, ride a train, or other.

Choice Experiment Analysis

A total of 9,858 choice records, 3,835 of which were currently DA respondents, and 6,023 currently Non-DA respondents were available to analyze. As a proof-of-concept the focus was on performing disaggregate analysis on the universe of respondents (i.e., both DA and non-DA respondents). Figures 1 and 2 explore the propensity of all respondents to choose to pay for time savings, i.e., pay the toll to drive alone in the HOT lanes, regardless of their current mode of travel. These figures detail the cumulative percentages, and so are not normalized for each set of "Pay"/"Not Pay" bars. The "Not Pay" option includes all other mode choices, such as driving in the free lanes, transit, HOV 3+, etc. If a respondent currently uses a qualifying shared ride mode, a "not pay" choice would be to continue to use their current mode.

To analyze the data, the price per minute of time savings was calculated by dividing the total price shown to the respondent by the total time savings shown. This was done to normalize the data in respect to travel time. Figure 1 shows the percentage of respondents who chose to pay the toll over all free modes at various levels of the price per minute of time savings in the proof of concept. The ratio of "Pay"/"Not Pay" varied from a high of 1 versus 6 for the lowest price per minute category to a ratio of 1 versus 10 for the middle category to a much lower ratio of 1 versus almost 20 for the highest price per minute category. Such a presentation was useful in highlighting relative degrees of potential adoption of HOT lane usage among the sampled population.

The data collected from this technique support the estimation of a binary choice model to illuminate the probability that a driver will choose to pay the toll to drive alone given a price per minute saved of time savings. Such a model permits what-if analyses that would not otherwise be possible using the existing traditional forecasting tools. In the proof of concept, there was a decrease in willingness to pay with the increased price per minute of time savings, as shown in Figure 2. The details of the binary choice model estimated in the example can be found in the Table 1.

Figure 1. Percentage Choosing to Pay Based on the Price per Minute of Time Savings

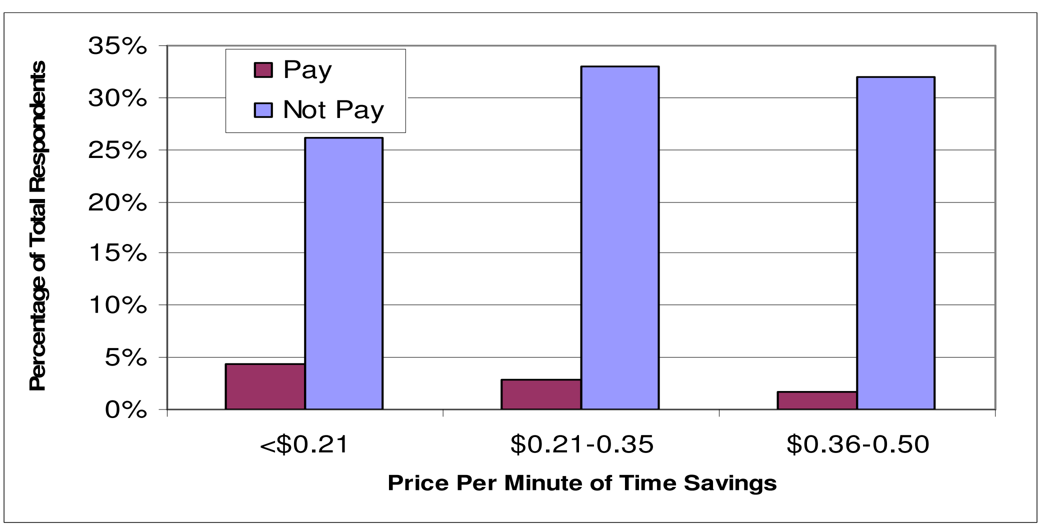

Figure 2. Probability of Paying Based on the Price per Minute of Time Savings

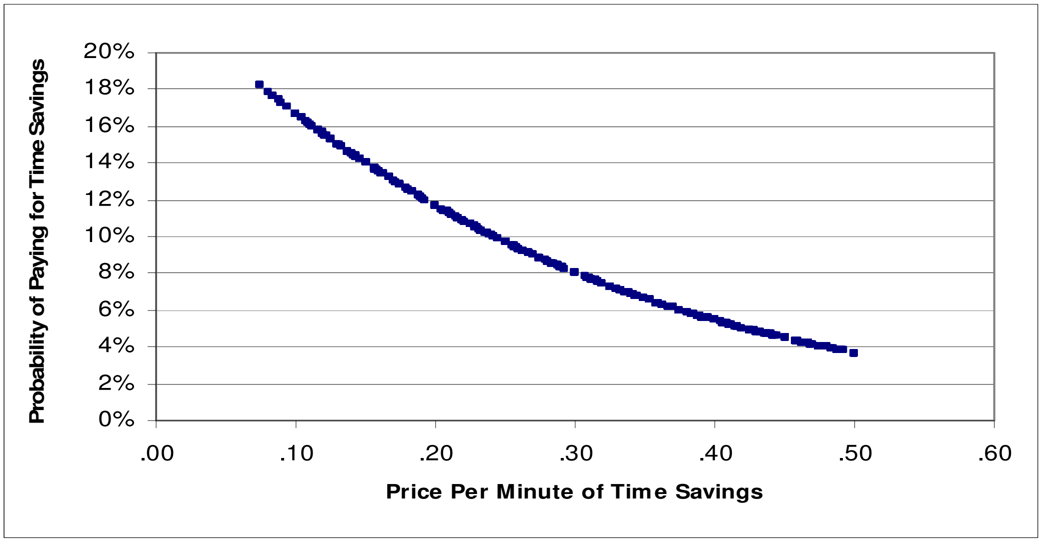

Table 1. Probability of Paying at Price per Minute of Time Savings – Binomial Logit Choice Model

Parameter	Estimate	Standard Error	T-Stat	Chi-Square
Intercept	-1.1921	0.0819	-14.56	211.7225
Benefit	-4.1519	0.3013	-13.78	189.9337

Implications and Further Work

The proof-of-concept suggests that the post-processor methodology could be quite useful to expanding on analyses that are otherwise possible with existing traditional travel demand forecasting tools. The methodology does not require a time-consuming and costly revision of the existing model system to implement. It permits mode split outputs from the traditional four-step travel demand model to be further analyzed to identify potential shifts to the added choices made available by the HOT lane. In the proof-of-concept, it permits the post-processor mode-shift tolling model to be used to determine the percentage shifting to pay to drive alone or with one other person in the toll lanes.

The model presented as a proof-of-concept represents a first-level of exploration with the specific collected dataset and with the technique in general. Further work includes exploring the use of alternative model specifications (beyond binary choice) and the use of a variety of segmentation slices to identify differences in the choice behavior in various populations (e.g., household income level or respondent gender). Difference in reported existing trip characteristics could also be tested as factors in the choice to pay to use HOT lanes within the post-processor framework.

The calibration and use of similar models in different geographic areas could lead to better understanding of the potential transferability of findings from one metropolitan area to another. Current experience with actual pricing response remains limited to a few areas and results, particularly in terms of impact to transit or carpooling behavior. These post-processor pricing models could potentially be a great asset to the practice of toll modeling, particularly in exploring mode switches, without requiring as major an investment as a complete overhaul of model sets.

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