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# Travel Demand Modeling Needs for Road Pricing: Challenges and Opportunities

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## Introduction

Whereas once the talk of economists and forward thinking planners, the idea of road pricing as a potential solution to urban congestion rather than, or in addition to, infrastructure expansion is being discussed more and more by elected officials and other decision makers. The challenge on the transportation planning community is to provide analysis that gives these decision makers reliable information from which to make their decisions. We are accustomed to using travel demand modeling tools to support similar decisions; however, most existing models cannot provide reliable answers to the questions we want answered. This paper addresses some of the issues that have arisen, and discusses how the latest modeling tools may help answer these questions, where they may not be up to the task, and where additional research or new techniques are needed.

The following issues involving the use of travel models are critical in producing accurate demand forecasts for road pricing scenarios:

- Shifts in travelers' times of day due to variable pricing
- Distribution shifts, or, how much will price change peoples' live/work/activity decisions?
- The effects of bottlenecks and over-saturation of highway networks
- Aggregation error
- Quality and applicability of stated preference data
- The lack of a body of revealed preference research on a range of existing toll and priced facilities
- Uncertainty of travel times from day to day

The extent to which newer modeling techniques can address these issues is discussed in the remainder of this paper.

## Issues

### *Time of day shifts*

One of the main benefits of pricing that varies by time of day is the potential to shift demand from more congested to less congested times of day. It is well known that conventional four-step models are not capable of estimating shifts in time of day; when considered at all, time of day is almost always considered through the use of fixed factors. Higher tolls in peak periods will have no effect on overall modeled demand – just trip distribution, mode choice, and routing (if the analyst chooses to use these submodels).

Modern activity based models include time of day choice models at the tour level (departure from and arrival to home) and trip level for intermediate stops. All of these models use as variables some form of travel impedance that varies by time of day. This allows the model to take into account, for example, that if peak travel time increases relative to off-peak travel time, then travelers may choose to shift to off-peak periods.

There are two main reasons why even these more advanced models may be unable to accurately estimate the effects of tolls that vary by time of day on time of travel choices. First, some models include only travel time, not cost, as he impedance measure. This simply reflects the fact that most urban travel models are estimated using only revealed preference data, and there is no time-varying road pricing in most urban areas. Second, it is difficult to estimate the effects of congestion on time of day choices because of inverse cause and effect relationships. Travelers desire to travel during periods of decreased congestion, and therefore decreased demand, but congestion is the result of the desire to travel. There is a correlation between high demand and high travel times, contrary to the desire to travel during periods of lower travel time.

Another point worth noting is that good data on travel time variations for short periods is elusive. However, some variable pricing schemes adjust prices based on intervals as short as three minutes. Models are generally unable to produce reliable travel demand estimates, and therefore travel time estimates, for such short periods.

### *Distribution shifts*

Road pricing can affect a number of travel related decisions, including route, mode, destination, time of day, whether to perform an activity, and whether to travel or to stay put in order to perform an activity. Longer term decisions that also affect shorter term travel decisions may also be affected; these may include auto ownership, workplace location, and residential location.

In conventional four-step models, price usually enters into only the route and mode choice decisions. It may also enter into the destination choice decision, if mode choice model accessibilities are used as inputs, and perhaps the longer term decisions if such models as land use models are used and incorporate accessibility variables that consider price. As discussed above, time of day choices are not considered, nor are those about whether to perform an activity or to make a trip, which are generally part of the trip generation component.

In activity based models, accessibility variables (i.e. logsums) are generally "fed" from subsequent to previous model components. To the extent that price is considered in these lower level choices, it is considered in other choices.

### *Effects of bottlenecks and over-saturation of highway networks*

Despite the disaggregate manner in which travel is treated in their application, all of the activity based models currently used or under development by U.S. agencies continue to use the same aggregate highway assignment methods, usually static user equilibrium, as are used in conventional four-step models. While disaggregate traffic microsimulation has become more commonplace in recent years, application at a regional level has not yet proven reliable enough for its use to become widespread.

Issues with the use of static user equilibrium assignment regarding the way link travel times are estimated are well known. First, the relationships between link volume, capacity, and travel time are oversimplified, reflecting a lack of network data attributes in most models; relevant attributes are often limited to link length, free flow speed, and hourly capacity. Information such as signal timing and phasing, merging and weaving considerations, on-street parking, and adequacy of turn lanes are usually not explicitly included. Second, link travel times are based only on the characteristics of that link, not on other links. In reality, interactions between links occur with regard to queuing, merging/weaving, intersection capacities, and opposing left turns. (Some areas use node based capacities, but these are only a partial solution, and most such applications have been in smaller urban areas less likely to be considering congestion pricing.)

Some possible ways to address this issue are evident, even while planners wait for regional level traffic simulation to become a viable option for large areas. One possible method would be microsimulation on a subregional level where pricing is being considered—say at the corridor level. A feedback process between the demand model and the traffic microsimulation could be implemented to ensure that the more accurate travel time information from the traffic microsimulation is considered in the demand estimation, including time of day choice.

One of the main reasons why traffic microsimulation has not been implemented at the regional level has the large amount of detailed traffic operations data required for traffic microsimulation. Large urban areas have thousands of intersections, and detailed signal timing and geometric data may be difficult or impossible to obtain and maintain. One possible area of further research would be to obtain such data for a small number, say 50, of key intersections in a region and to synthesize data for remaining intersections. The intersections for which detailed data are obtained could include the most congested and/or complex from a traffic operations standpoint. This has the potential to greatly improve the accuracy of travel time estimates.

### *Aggregation error*

A major motivation in the implementation of modern activity based models is their use of microsimulation of individuals and their travel and activity patterns, with aggregate information being generated through summation of individual results. Aggregation error in conventional trip based models is prevalent through the use of inadequate market segmentation, made necessary by the realities of computation requirements. This greatly affects road pricing analysis, where the same value of time is assumed for different market segments, which at best separate commercial from personal travel, which may be segmented by income level. It is well known that values of travel time can vary significantly among individuals within the same demographic segment.

The microsimulation of individuals in modern activity based models provides an opportunity to incorporate values of time into travel choice models in a much more meaningful way. Rather than just assuming a value of time for an individual based on some market segmentation variable such as income, a distribution of time values could be assumed, and the value for the individual simulated in the same was as other travel choices. The main issue is that research is needed into the best distributions to use and the variables on which they should be based.

### *Quality and applicability of stated preference data*

Stated preference (SP) data has a mixed reputation at best in the transportation planning field. There is no doubt that SP data has been misused, either through poor choice experiment design, misapplication, or through erroneously treating the data as if it were revealed preference data. Naturally, the poor quality results of models that contain these errors have tainted the entire practice of using stated preference data. Because of this, and the fact that for many years the types of analyses for which travel models were used could be done using revealed preference (RP) data, SP data has not been used in the development of most regional travel models.

Models developed from RP data can only be considered valid over the range of experience of the population surveyed, at the time of the survey. In many areas, there is no experience with tolling whatsoever, or, toll values are being considered that are higher than those that exist. Therefore, RP data for travelers experiencing these toll values would not be available.

It would benefit the analysis of road pricing (and other transportation planning issues) for the correct practices on conducting SP experiments and the use of SP data in model development to become well known. A guidance document or documents would seem well worth preparing. The best way to use SP data is in connection with data from RP surveys, which can be used to scale the results of the SP data.

### *Need for large scale revealed preference research on a range of existing toll and priced facilities*

There is a frustrating lack of revealed preference research that shows the actual response of travelers to pricing. There is some good work that was done in conjunction with the HOT lanes in southern California, but aside from that there is little real data to draw from. Although the research would be expensive, considering the focus that is being put on pricing solutions at the national level, it would be reasonable for federal participation in a national research program aimed at identifying revealed preferences related to pricing. This research should address:

- A variety of conditions: urban/rural; radial/circumferential; many alternatives/few alternatives; roads/bridges/tunnels.
- A variety of pricing levels

- Survey people that choose to use the toll facility, and those that do not.
- Address issues such as actual travel time savings, perceived travel time savings, impact of electronic tolling on perception of price, quality of ride, and reliability.

### *Uncertainty of travel times from day to day*

Both conventional and advanced travel models rely on average travel times, which are a function of roadway characteristics and congestion. However, route choices often depend on factors other than the expected travel time. One of these factors is the reliability of travel time from one day to another. Reliability is one of the reasons travelers may be willing to pay a toll to use a particular route.

Incorporating reliability into route choice (traffic assignment) models would require the procedures to be fundamentally changed. (This may be desirable for other reasons as well, as discussed above.) While it may be difficult to incorporate reliability into aggregate assignment methods, disaggregate methods, including traffic microsimulation, may lend themselves to it. To reduce simulation error to an acceptable level, microsimulation models must be run several times and the results combined. Running traffic microsimulation a number of times may provide insight into variations in travel times. It would be important to validate such information through observed data collected over many days.

## Conclusion

No model will ever be perfect, but decision makers are forcing our community to investigate new techniques, and they deserve to have the most reliable answers that we can give them. At the very least, we need to be honest with our customers about the reliability of the answers we are providing now, making sure that we indicate areas where the answers could be very different if different techniques or assumptions were used. At the very least, we need to provide the benefit of our judgment, and the potential limitations of that judgment to these customers that depend on us. Situations will arise where new techniques can be developed, and these will advance the state of the art. With respect to the need for revealed preference data, this can be addressed through a significant, although not impossible federal research program. Such data could be used around the country to the benefit of pricing projects.