Development of a multi-class bicyclist route choice model using revealed preference data

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Abstract
Non-motorized travel options have been largely ignored in regional transportation planning studies in the U.S., where decisions on more resource-intensive investments in highway and transit facilities have been of primary concern. Yet, recent policy-maker interest in sustainable transportation systems and healthier lifestyles has shifted some of the decision-making focus to bicycling and walking and the extent to which the urban travel environment supports these alternative modes.

Travel forecasting models, the "workhorse" analytical tool for regional transportation decision making, have been well-developed to reflect the attributes important to predicting traveler responses to changes in the level of service of highway systems and transit systems, but are startlingly unrealistic in their representation of the pedestrian and bicycling environment. Focusing on bicycling, the practice implemented in all known operational travel forecasting models used in North America has been to assume that riders choose the minimum-distance path between origins and destinations using a fixed travel speed, usually without consideration of network attributes. Congestion effects and other travel environment attributes, such as elevation and the presence of dedicated bike lanes, separated bikeways, or bike boulevards, are not considered. Moreover, extant models do not differentiate between classes of bicycle riders, nor do they segment the travel market in ways that could identify the viability of bicycling as a mode alternative, other than applying a maximum trip distance criterion.

Several studies of bicyclists' route choice behavior have been conducted in North America. In most of these studies, participants have been asked to respond to hypothetical choice situations, usually in the form of visually-evoked preferences for different bicycling environments along with information on travel times and distances (Krizek, 2006; Stinson & Bhat, 2003; Hunt & Abraham, 2007). A weakness of these stated choice studies is that it is unclear whether travelers would exhibit the same preferences and sensitivity levels in their actual choices. Further, when asking respondents to state their choice, these studies present path alternatives that reveal only portions of a journey at a time. This approach makes it difficult for respondents to conceptualize how they might make trade-offs between route alternatives which depend on the whole journey, particularly if the context is hypothetical or unfamiliar to the respondent. In other North American studies, bicyclists have been asked to recall paths taken on a previous trip with the aid of a map (Howard & Burns, 2001, Shafizadeh & Niemeier, 1997, Aultman-Hall, Hall & Baetz, 1998). This approach would seem to yield results that are closer to reality; however, it suffers from the usual problems associated with respondent recall of past events. Moreover, it does not account for travel times and speeds accurately. Finally, to our knowledge, the results of these previous research efforts were never integrated into any regional travel forecasting models.

In Portland, Oregon, we have collected detailed survey data revealing the actual paths taken by over 150 bicyclists over the course of several days, using global positioning system (GPS) tracking devices. The data have been mapped to transportation network facilities, creating an enhanced digital bicycle network map files showing facility types, bike lanes and off-road trails. The GPS data reveal not only spatial paths, but also time-of-day readings at each starting and stopping points and elevation changes. Each participant also provided detailed socio-economic, behavior, and attitude data.

In this paper, we will present the results of our development a bicyclist route choice model that can be
applied in a regional travel forecasting framework. The benefits to regional modeling are more accurate estimates of bicyclists' travel paths and costs, which affect upstream destination and mode choices, and enable analysts to answer a more complex set of questions related to urban form and investments in bicycle facilities than existing regional models currently support. To our knowledge this would be the first bicycle route choice model to be developed from revealed preference data that were generated through GPS methods.

Development of appropriate methods for representing bicyclist path choice sets is an important component of the work. Path alternatives may be generated using a network modeling tool that will produce the k minimum paths for each choice situation, where k is the number of alternatives which we judge to be reasonably considered by bicyclists in various trip contexts. Another option is stratified sampling of labeled paths that represent theoretically valid decision criteria, such as paths that represent the minimum distance, maximum use of bike facilities, minimum exposure to traffic congestion, minimum intersection crossings, minimum elevation change, and potentially other criteria. In addition, we will consider branch and bound methods.

The choice context is further complicated by the fact that alternative paths are likely to overlap for some portion of their length, making use of a standard multinomial logit model inappropriate due to the independence of irrelevant alternatives (IIA) property. Accordingly, we will investigate more flexible closed-form discrete choice models, which permit correlated alternatives such as variants of the generalized extreme value (GEV) family, in combination with latent-class models (Greene and Hensher, 2003).

As part of the recruitment process for the GPS survey was self-reporting of historical bicycle usage patterns, resulting in the classification of respondents into utilitarian, recreational and novice riders. We expect the estimation results to either confirm these reported class memberships, or to reveal the relevance of alternative, latent class memberships, which may result in a final latent-class, cross-correlated-choice-set model.

References