LATENT VARIABLES AND ROUTE CHOICE BEHAVIOR

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Abstract:
In recent years, a broad array of disciplines (psychology, economics, marketing, public policy and transportation engineering) have shown a general interest in enhancing discrete choice models by considering, within the framework of the choice process, the influence of latent constructs such as attitudes, preferences, perceptions and knowledge of the choice environment.

In the route choice context, the representation of individual behavior accounts mostly for travel times and costs of alternative routes. Incomplete information about traffic patterns, heterogeneity among drivers in terms of travel time perceptions, and influence of unobservable individual traits motivate the research for improved models, which are able to account for behavioral factors that are likely to affect the choice process.

This paper intends to provide more insight into the analysis of route choice behavior, by considering the influence of latent factors on the choice of a route from a set of available alternatives. First, the measurement of behavioral constructs at the individual level is proposed, by applying exploratory factor analysis to attitudinal indicators collected with a dedicated web-based survey. Then, the generation of alternative routes is considered, by implementing a technique that accounts for behavioral constraints while solving the path enumeration problem. Last, the analysis of route choice behavior is presented, by estimating an innovative model that combines latent variable and discrete choice models.
Data collection focused on individuals who move regularly from home to work in an urban network and agreed to participate in a web-based questionnaire. The first part of the questionnaire consisted of forty-one Likert-type questions, divided into four sections: classification of the respondent, investigation of spatial abilities connected to transportation tasks, exploration of spatial abilities not related to transportation tasks, inquiry of driving attitudes and preferences. The second part of the questionnaire collected routes considered by the respondents to drive from home to the workplace.

Almost 600 observations resulted valid for model estimation purposes, after initial data elaboration cleaned the collected information by eliminating incomplete observations in either of the two parts. Tests of internal consistency and sampling adequacy on the attitudinal survey evaluated the suitability of the dataset to exploratory factor analysis. Most relevantly, the extraction of orthogonal latent factors and the examination of their factor loadings enabled to observe the most significant relationships between indicators and latent variables. Consequently, the exam of these relationships enabled the definition of structural and measurement equations for the latent variable model to be integrated with the discrete choice model.

Path generation concentrated on a path enumeration method based on behavioral constraints, rather than on techniques based on variations to the shortest path search. This paper presents a variation of an existing branch and bound algorithm for constrained path enumeration, in order to account for the theory that travelers develop their network knowledge by following a transition from landmark recognition to path definition and relationship definition within the path area. Specifically, the modification concerns one constraint of the branching rule of the algorithm, which excludes from consideration paths that are highly similar to alternatives in the same area because they share a number of landmarks. This constraint extends the concept of similarity between routes from the physical sharing of a number of links to the physical sharing of a number of anchorpoints through which travelers define their routes.

Choice modeling focused on the estimation of an integrated latent variable and discrete choice model, through an approach that analyzes latent factors able to provide valuable information on aspects of route choice behavior that cannot be inferred only from revealed preferences. The model framework considers observable explanatory variables and latent factors to affect individual preferences toward alternatives, and assumes these preferences as latent variables representing the desirability of alternative choices. Further, the model framework considers the actual chosen routes as manifestations of the latent preferences, and the responses to the survey questions as indicators of the latent factors.

Accordingly, the integrated latent variable and choice model consists of structural and measurement equations. Structural equations relate the observable variables to the latent factors and to the utilities. Measurement equations relate the latent factors to the indicators and the utilities to the latent preferences. The model is estimated through the maximization of a likelihood function that is the integral of the choice model over the distribution of the latent constructs. The choice model portion of the likelihood function is a Path Size Logit model, since this specification allows to account for similarities among alternatives while maintaining the simple Logit structure. The latent variable portion of the likelihood function assumes that latent variables are orthogonal (as observed in the exploratory factor analysis) and indicators are assumed to be independent, conditionally on the observed
variables.

Results confirm the initial hypothesis that considering attitudes and perceptions allows better representation of route choice behavior, as relevant factors such as habit, travel time perception and familiarity with the choice environment are as important as observable variables such as travel time and distance, traditionally considered in any route choice study. From a broader perspective, results suggest the correctness of the suggestion of behavioral researchers to give importance to psychological and cognitive aspects inside the choice processes, and not to consider discrete choice models as black boxes in which the inputs are only the attributes of available alternatives and individual characteristics, and the outputs are the observed choices.

**Keywords:**
Route choice behavior; Attitudes and perceptions; Latent variable models; Discrete choice models; Maximum likelihood estimation.