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Route choice decision under travel time uncertainty

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Abstract

We study route choice behavior when travel time is uncertain. In this case, users choice depends both on expected travel time and travel time variability. We collected survey data in the Paris area and analyzed them using a method based on the ordered probit. This leads to an ordinal as well as to different cardinal measures of risk aversion. Such an approach is consistent with expected and with non-expected utility theory. Econometric estimates suggest that absolute risk aversion is constant and show that risk aversion is larger for transit users, blue collars and for business appointments.

Keywords: Route choice; Travel time; Risk; Expected utility theory; Survey; Ordered probit

1. Introduction

Route choice plays a central role in transportation economics, engineering and operations research. We consider here the simple case of parallel routes. The equilibrium concept, originally introduced by Wardrop (1952) is formally a non-cooperative Cournot (quantity) equilibrium with a *continuum* of players (see discussion in Sheffi, 1984). The (first) Wardrop principle states that each driver selects the shortest travel time route and as a consequence, if the two routes are used at equilibrium, the travel time is necessarily the same on both routes. The second Wardrop

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principle refers to optimal solution. Many authors have questioned this deterministic route choice behavior, i.e. the fact that if the travel times are different on both routes, *all* users select the shortest one. If the users have different values of time and minimize the travel cost c_i^k of alternative i, with $c_i^k = \alpha_k tt_i$ (where α_k denotes the value of time for individual k and tt_i denotes travel time), again all users have the inclination to select the route with the shortest travel time. [1] Note that, at equilibrium, travel time is the same on the two routes, and the model is again questionable since it says nothing about route choice. The assumption underlying deterministic route choice behavior has been challenged by researchers and several variations have been proposed. We will discuss one by one three alternative models, which remove the unrealistic assumption that usually (i.e. when travel times differ) all users select the same route.

Model 1: variety of route choice attributes. Deterministic route choice has been criticized on the ground that a large variety of factors, other than travel time play a role (on this issue, see the seminal paper of Ben-Akiva et al., 1984). If those factors are observable, the above model can easily be extended, since it suffices then to replace the travel time function by a generalized cost function. The cost function of individual k is then $c_i^k = F(X_i, \beta_k)$, where X_i is a vector representing the number of traffic lights, scenery, safety, travel time, etc. and β_k are individual-specific parameters to be estimated. In this case, the travel cost depends on the user preferences (via β_k), so that the choice of two different users facing the same routes may differ.

Model 2: factors unobservable to the modeler but observable to the users. The situation is more complex if factors (other than the travel time) that affect route choice are not observable by the modeler. For example, a user may select a route because he may want to make a stop over. In this case, the travel cost for individual k selecting route i can be written as $c_i^k = \alpha_k tt_i + e_i^k$, where e_i^k is a factor known by user k, but unobservable by the modeler. This additive specification is the most commonly used in the literature. The maximization principle discussed in the deterministic case remains the same from the user perspective. For two routes in parallel, individual k selects route 1 if and only if $c_1^k < c_2^k$. If the factors e_i^k are continuously distributed over the real numbers set ($\mathbb{R}$) in a population, a positive fraction of users will select route 1 and route 2. Since the idiosyncratic terms $\{e_i^k\}$ are not observable by the modeler, the best he could do is to describe the probability P_i^k that an individual randomly selected in the population chooses route i. This probability is given by a discrete choice model (see Anderson et al., 1992 or McFadden, 2001) of the form $P_i = \Pr\{C_i^k < C_j^k\}$, with $C_i^k = \alpha_k tt_i + \varepsilon_i^k$, where ε_i^k is a random variable. For simplicity, we consider that the ε_i^k are drawn from the same distribution for all individuals. This is a probabilistic choice model, even if there is no uncertainty from the individual perspective (see Cascetta, 2001, for a discussion on the use of discrete choice models in route choice).

Model 3: factors unobservable to the users. Attitude towards risk plays a major role in route choice decisions and the user choice behavior under uncertainty is examined in the framework of Model 3. Preliminary work in the mean variance context but without explanatory variables has been carried out by Noland and Small (1995) and Noland et al. (1998). Contrarily to these authors, we do not consider the departure time dimension in our study, but restrict our analysis to route choice. This last case, treated in this paper, corresponds to the situation where some attribute of the route (here the travel time) is not observable by the individuals. The fact that this factor is observable or not by

[1] Any increasing function of travel time would lead to the same discussion. For simplicity, we choose here linearity in travel time.