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Experimental tour-based travel demand models

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Abstract

In this paper some experimental sequential models for the simulation of trip-chains are presented; the models have been calibrated on the basis of a survey made in a medium-sized town.

This work is part of a research, effected by the Department of Regional Planning of the University of Calabria, to forecast travel demand and to analyze travel behavior of the transport system users (Festa et al., 2000).

The travel choices of individuals have been reproduced simulating the decisional process in sequential steps, by models based on the random utility theory.

The tour generation models, proposed by Festa et al. (2001), have been once again calibrated introducing a new set of variables in the systematic utility function of the alternatives of choice.

Some models for the travel type choice simulation are also presented; the models have a *Binomial Logit* functional structure, with *trip-tour* and *trip-chain* as choice alternatives.

Keywords: Utility theory; Transport demand; Trip chain; Modal split

1. Sequential models for travel demand estimation

In literature, various model structures, finalized to estimate the travel demand, are reported. Considering the complexity of the phenomenon and the variety of the adopted formulations, it is difficult to make a rigorous classification. However, there are two main approaches: a *global approach*, which reproduces the phenomenon by a single model, and a *sequential approach* which, by a system of sub-models, replicates the decisional process in successive stages which represent the corresponding dimensions of choice.

The sequential models differ for the elementary unit that represents the travel demand. This unit, in order of complexity, can be identified with the single movement from an origin to a destination (*trip*), the sequence of trips based at home (*tour*), or the daily/weekly travel program (*pattern*).

The trip-based models are built on the hypothesis that the choices related to the various

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movements are not mutual conditioned. A similar travel demand model system was developed for the MTC (Metropolitan Transportation Commission), in the metropolitan planning organization for the San Francisco area (Ben-Akiva and Lerman, 1985). An analogous formulation has been proposed in the Transport Project of the Italian National Research Council, to forecast the travel demand in medium-sized Italian towns (Cascetta, 1990).

The tour-based models, unlike the previous ones, take account of the time and space constraints among the trips of the same tour. The tours are generally characterized through the *Primary Destination*, defined as the destination in which the most important activity is made. Recently, various behavioral travel demand model systems, based on the random utility theory, have been developed; these models differ each other for the definition of the dimensions of choice. The better-structured models simulate, in various stages, the tour generation and frequency, the space distribution (primary and secondary destination), the tour type and the mode choice (Cascetta, 1998). Other formulations represent more dimensions of choice through a single aggregate sub-model, like the destination and mode choice (Bowman and Ben-Akiva, 2000).

The daily or weekly travel pattern demand models take account of the interactions among the tours made during the reference period; therefore, they have a more complex formulation. Some authors propose regressive models, in which the travel program depends on the activity program; the explicative variables, both of the travel behavior and activities participation, are assumed as endogenous variables, and are expressed in function of the individual and household socio-economic characteristics (Lu and Pas, 1999; Golob, 2000).

2. Specification, calibration and validation of the demand models

In literature, different functional structures are specified, which are used in the demand models, as the simplest regressive type formulations, or more complex expressions that include circular relations among the explanatory variables. Moreover, the demand models can be distinguished in descriptive and behavioral models; the latter models differ by the former for the specific hypotheses on the user's choice behavior.

The simplest descriptive models consist in the direct estimation of the average number of trips $m^i[osh]$ made by the generic category of users i to leave from the origin zone o, for the purpose s, at the time h.

The most used formulations of the behavioral models present a *Binomial* or *Multinomial Logit* structure, on the basis of the number of available choice alternatives.

The Logit models, which are *random utility* models, are based on the hypothesis of the *rational behavior* of user, as much as he chooses the alternative that maximizes his own utility. Given the *choice set* I^i, which includes all the alternatives available for the user i, to every alternative $j \in I^i$ the user associates a measure of the expected utility U^i_j, that is a function of measurable attributes X^i_j peculiar both of the alternative and of the decision maker (Cascetta, 1998). The utility U^i_j is not known with certainty, but it can be considered a random variable, equal to the sum of two terms: a first one represents the average of the U^i_j, calculated for the users with the same choice set I^i and defined *systematic utility* (V^i_j); a second term represents the difference between the U^i_j and its average value V^i_j, defined as the unknown measurement error (ε^i_j). The Logit model is based on the hypothesis that the residual errors ε^i_j are independently and identically distributed like Gumbel variables with null average and a ϑ parameter; therefore the probability of choosing the alternative j, in the choice set I^i, with m available alternatives, is calculated as

$$p^i_j = \frac{e^{V^i_j/\vartheta}}{\sum_{k=1}^{m} e^{V^i_k/\vartheta}}. \tag{1}$$

For sake of simplicity, the systematic utility V^i_j is often obtained like a linear function of the X^i_j attributes vector, through the coefficients vector β. Given the r attributes, the systematic utility of the alternative j can therefore be expressed as