Structural equations modelling of travel behaviour dynamics using a pseudo panel approach

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Introduction

The objective of the work, which is embedded in a current research project, is to test hypotheses on how individuals’ travel behaviour reacts to changes in generalized costs (the weighted sum of factors such as travel times and monetary costs) of participating in activities. Travel is regarded as a demand derived from activity participation (Jones, 1977). As such, individuals can adapt their travel behaviour on several levels:

- the decision to leave home, i.e. to participate in out-of-home activities;
- the number and duration of out-of-home activities;
- the combination of out-of-home activities and trips into trip chains, or tours (successions of trips starting and ending at home);
- the scheduling of activities (departure time choice);
- the choice of locations for carrying out the activities (destination choice);
- the choice of an origin-destination connection (mode and route choice).

Given the large number of existing studies dealing with the latter two dimensions (which effectively constitute the second to fourth steps in the classic model), the analysis focuses on the upper levels, i.e. on the demand generation side. Here, the hypotheses to be tested are that, as a reaction to a reduction in generalized costs of travel:

- the share of days with out-of-home activities will increase;
- the number and duration of out-of-home activities will increase;
- the demand for transport services (distances traveled and trip durations) will increase;
- the number of trips per tour will decrease, as the return to the home location becomes cheaper (in terms of generalized costs).

The observed effects are expected to be non-linear and exhibit hysteresis, i.e. there will be a time lag between the cause (i.e. primarily the changes in generalized costs) and the effects (i.e. the adaptation of traffic demand schemes). The applied modelling framework is able to capture such lagged effects.
The work draws on a number of existing data sources and yields information about long-term trends in transport demand as a function of structural changes of the population, welfare and generalized costs of activity participation. The following working steps will be described in the paper:

- processing and enrichment of the available data;
- confirmatory analysis of the hypotheses using the existing data (modelling of long-term travel behaviour dynamics).

Data processing

The aforementioned analyses are based on harmonized data from the Swiss Microcensus (National Household Travel Survey) surveys, which has been carried out approximately every 5 years from 1970 through 2005. The data were enriched with information from network models (i.e., travel times and distances) and municipality databases (population and accessibility data). For the estimation, several different approaches for modelling generalized costs were formulated: price indices for individual travel (Abay, 2000), adjusted car costs (Frei, 2005), improved estimates of public transport fares and regional variations of fuel costs (Carle, 2006), accessibility data for the Swiss municipalities (Tschopp et al., 2005).

The enriched Microcensus data were used to compile so-called pseudo panel datasets (Deaton, 1985; Pelzer et al., 2005), i.e. the individuals from the surveys were aggregated into cohorts with an assumed fixed membership over time. These data can be used in the absence of “real” panel data to simulate the following up of virtual persons (created by the aggregation into cohorts; Mason and Wolfinger, 2004) over long time periods and test for generation membership effects. Examples for the application of the method in the transport planning field are Bush (2003), a study aiming to forecast future travel demand of older adults; Dargay (2002, 2007) and Huang (2007), where the substantial influence of cohort effects on household car ownership is modelled.

As much variance as possible was maintained when creating the pseudo panel datasets, meaning that the analysis units were chosen on as disaggregate a level as possible. As a compromise between sufficient cohort size and level of detail, a cohort subdivision according to the 3 following criteria was chosen:

- year of birth (in 10 year bands),
- gender,
First results

The first models that were estimated using the resulting pseudo panel dataset test the hypotheses separately, i.e. using univariate regression models. Special focus was laid on the panel effects on the one hand, and the impact of the various survey instruments used for the Microcensus surveys on the other hand. Controlling for these effects, the impact of generalized costs on travel behaviour is being modelled.

Figure 1 provides an example of the first modelling results. For the univariate regression model of the number of trips (one of the relevant mobility indicators mentioned above), the estimated cohort (generation) and age (life cycle) effect - accounting for all other effects - are displayed. Both effects exhibit the expected trends: mobility is higher for younger cohorts (as depicted by the different lines), and for each cohort, decreases with increasing age.

Furthermore, the first results appear to confirm the hypothesis that decreases in generalized costs (modelled in a first approach by increases in accessibility) do have an effect on individuals’ trip generation.
Outlook

The univariate models form the basis for the formulation of structural equations models (Bollen, 1989), which will test all the hypotheses simultaneously for all relevant dimensions. These models are expected to provide the elasticities for the individual relevant dimensions of travel demand, which are corrected for the influence of all other variables. The structural equations framework (see Golob, 1988, 2003; Pendyala, 2003 for transport planning applications) allows the simultaneous consideration of dependencies over time (panel effects; Yaffee, 2003), between the individual indicators (numbers of trips and tours, trip durations and distances etc.; also called endogenous variables), and the effects of spatial, sociodemographic and cost characteristics (exogenous variables). Further examples for the application of the methodology can be found in Simma and Axhausen (2004), as well as de Abreu e Silva et al. (2006).

References


