Generating purpose-dependent production factors through Monte Carlo sampling techniques.

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Problem and research question

Determining the demand for a transportation network has been a classical topic for researchers and practitioners in the past decades. The most classical methodology to generate this demand is the *four step model*. This model is based on aggregate demographic data and provides an origin-destination (OD) matrix, which is a good approximation of the demand of commuters for a specific network. Since its demand is based only on spatial-demographic information, this model is useful for planning and forecasting applications, on the basis of statistical trends for a specific area. This representation of the demand is normally *macroscopic,* since the demand is represented at an aggregated level. One of the main limitations of this approach, is that demographic variables are normally assumed *static,* which means that they are not suited to capture *within-day* traffic dynamics (congestion dynamics, spillback,…).

An alternative approach may be to use *Activity Based Models* and, specifically*, Activity-Based demand generation models* (Bowman et al., 1999; Hensher and Research, 2001)*,* to represent the demand. In this case a synthetic population is generated by census data, generating A*ctivity Plans*, which describe the entire daily activity pattern for each user on the network. The advantage is twofold. First, since the *Activity Plan* includes departing/arrival times at the destination, it is a *dynamic* information, which is a desirable property for the demand model. Furthermore, this plan includes different activities, which allow the model to consider other purposes rather than the basic home-work commuting. While the relevance of the trip chain has been already investigated in literature (Ettema and Timmermans, 2003), assessing its potential contribution to represent the demand is still missing in macroscopic models.

If research on *Activity-Based* models is attracting more and more interests, this branch of the research mainly focuses on the *single-user* point of view. Rather than producing an OD matrix, A*ctivity Plans* are generally used as input for *microscopic agent-based DTA.* In these models, like Albatross (Arentze and Timmermans, 2004) and MATSim (Feil et al., 2009), each user is modelled as a single user, maximizing his own utility, which, according to economic theory (Winston, 1982) is function (at least) of the departing time, the number of scheduled activities, the duration of the activities and the travel time.

We believe that a correlation between an aggregated representation of the demand and its behavioral component is needed in order to reduce the uncertainty in transport models. Specifically, this work investigates the possibility of using a Monte Carlo approach for generating activity based demand flows. The classic emission flow for each traffic zone is in our approach assumed to be a convolution of different activity patterns. Some of them are defined as *rigid*, like the "work" activity, and they are more difficult to be modified or rescheduled, while others are more *flexible.* It should be pointed out that the proposed formulation could be used to estimate the trip distribution instead of the generated flows. However, this one is highly correlated with congestion and travel time. As a consequence, it can be estimated within the proposed framework only if a (Dynamic) Traffic Assigment model is explicitly considered in the Monte Carlo framework.

Methodology, research strategy

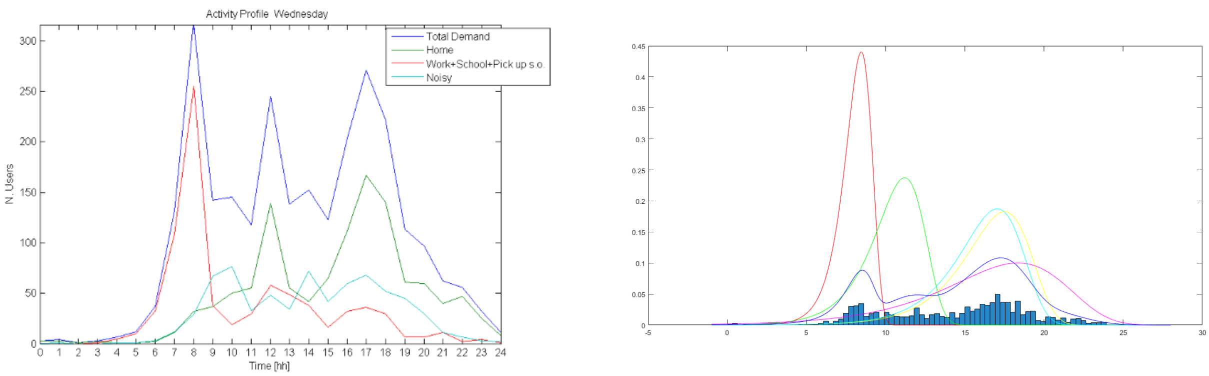
The goal is to exploit the Travel Diary in order to reproduce *aggregate Activity Patterns*, rather than *disaggregate* Activity Plans. We first focus on identifying *Demand Activity Patterns*, according to the definition of *rigid* and *flexible* demand patterns. The database has been collected in the BMW Project (Behaviour and Mobility within the Week, Viti et al., 2010), which was carried on by KU Leuven and the University of Namur. 500 participants provided information for six weeks, including purpose of their trips, departure times and locations. As first step, we identify at least three groups of activities (*Activity Components*):

I. *Within-Day-Systematic Activities (DSA):* These are *rigid* activities, in which arrival and/or departing time is not flexible (i.e. going to work, returning home)
II. *Within-Week-Systematic Activities (WSA):* These are *flexible* activities, which are not systematic within the day, but recur every week (i.e. swimming pool, weekly shopping).
III. *Not-Systematic Activities (NSA):* These *flexible* activities represent extraordinary events with respect to the usual user activity scheduling (i.e. visiting the doctor is an example).

All the activities are classified according to the above three groups through a cluster analysis. The authors identify that the demand can be represented through four/five distinct *Activity Demand Components*. Under these assumptions, the *Home-Work Activity Pattern,* composed only by the rigid components, represents a relevant share of the total demand (12%). If we consider all the *point-to-point* movements - which means not more than two trips during the day – the percentage rises up to 35%. These percentages, which are similar to other reported in literature (Ben-Akiva and Bowman, 1998), show how considering trip chains and daily patterns is fundamental to capture the total demand, as non-work related trips are the largest majority in a day.

In order to estimate aggregate Activity Patterns, a Markov Chain Monte Carlo Model (MCMC) is adopted in this study. In order to estimate the production for each traffic zone, we assume that the departure time from a certain origin for a specific purpose follows a certain (known) distribution, whom parameters are calibrated through the MCMC model. Because of this assumption, the algorithm requires a slight number of information, which are used to compute the likelihood with regard to the number of generated trips.

Major findings



(a) (b)

Figure 1: (a) Real Demand and (b) estimate generated demand for the BMW dataset;

Using dynamic or even static Origin-Destination matrices, and without information at user level, the model can be used to identify activity patterns and calibrate purpose-dependent demand factors. Figure 1 shows preliminary results of the application of the proposed methodology on the BMW database. Although these are still preliminary results, the proposed methodology showed its capability of identifying the hidden activity patterns for the regional network of Ghent. The three more evident peaks, work, home in the afternoon and home in the evening, are properly recreated in the model, while clearly the "nosy" component, representing those activities for which less observation exist. One of the main reason is that, working on the generation flow, the MCMC can simulate all the traffic zones at the same time, meaning that scalability is not an issue for the proposed model.

Keywords

OD matrix, Activity based, Demand, Markov Chain Monte Carlo, Estimation.

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