A Simple Method for Handling Tours with Multiple Destinations in Large Scale Transport Demand Models

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1 Introduction

A new model system for travel demand is currently being developed in Norway. Estimation and implementation is a joint effort between the Institute of Transport Economics and Molde Research. The "short distance" model that includes trips up to 100 kilometres (one way) is implemented as 5 regional models. The largest region has 4200 zones and the smallest region has 2000 zones. These models have sub-models for 5 travel purposes and 5 modes of travel are included in each sub-model.

Large scale transport demand models (i.e. models with several thousand zones) that include trip generation, trip distribution and mode choice usually take tours as the unit that travellers decide on. In order to simplify estimation and implementation of these models it is frequently assumed that we deal with tours that have only one destination, purpose and mode of travel. The data used to estimate such models usually comes from travel surveys. In travel surveys a fairly high share of the tours has more than one destination and multiple purposes may also be involved in a tour. Travel surveys also show that different trips included in a tour may use different modes of travel. In order to avoid dropping too many tours from the estimation, some rules are often applied to define a main destination, purpose and mode for tours with multiple destinations. This permits tours that satisfy the rules to be treated as tours with one purpose, destination and mode of travel. Only tours that that are to complex to yield some simple rules are dropped. This is also the approach used in the estimation of sub-models for mode/destination choice in the regional models being developed in Norway.

Trip matrices produced by models that use tours with one destination are symmetric around the diagonal. A consequence of the simplifications made in estimation and implementation is that the number of trips that the models produce will deviate more or less from the “true” number of trips. The extent and structure of deviation depend on how trip generation is modelled. For example, in a recent Norwegian travel survey, the tours with one destination makes up only 51 per cent of the total number of trips. If we by some rules also manage to include all tours with two destinations in the model estimation and treat these tours as tours with one destination, we will still only have about 2/3 of the trips observed in the travel survey if we use a tour generation model based on these tours. Even if we use the total number of tours in the travel survey as a basis for estimation of a tour generation model, we will underestimate the total number of trips by the order of ¼ if we assume that all tours only have one destination.

To avoid that implemented models produce too few trips, a simple ad hoc solution may be multiply the trip matrices produced by a model by a factor that corrects for the bias with respect to the total number of trips. For example if we know that the method used to generate tours only produces 2/3 of the actual number of trips we may multiply the trip matrices for different modes by 1.5. This may still leave us with an unknown bias when it comes to the structure of the matrices and possibly also the number of trips by mode. An alternative may of handling the relationships between tours and trips would be to explicitly model trip chains. This is possible, but is too complex and time consuming to implement in large scale models.

2 The approach to trips with multiple destinations

This paper reports on a new method that has been developed and applied in the new system of models developed in Norway. It is based on the idea that the basic unit of interest is the number of places visited for different purposes. The number of tours and trips are a consequence of how these visits are arranged in time and space.

The method uses the following building blocks:

- A “trip generation” model that produces the number of visits made with different purposes (5) (Larsen 2003). This is a somewhat unconventional model in the sense that the unit is “visit” rather then trip or tour. It combines a Poisson model for the total number of visits with a logit model that gives the distribution on different purposes.
- Mode/destination choice models (5 purposes) for home based tours with on destination. These have been estimated as structured logit-models. For each origin these models give us probability distributions over destinations for each purpose and mode.

- A matrix of "transition probabilities" that gives the probability that a visit with purpose "i" will be followed by a visit with purpose "j" in a tour with multiple destinations and the probability that an outbound tour from home for a specific purpose is directly followed by a homebound trip.

In principle this allows for Markov-chains in tours, but in order to reduce the running time of the models we make the simplifying assumption that all tours with more than one destination only have two destinations. Another simplifying assumption is that "between purposes" trips only depend on the probability distributions over destinations for the outbound and homebound trips and not on the time and cost of the actual "between purposes" trip itself. From a behavioural point of view this is clearly an inaccurate assumption, but was necessary for computational reasons.

The method allows us to construct a trip matrix that is the sum of 3 matrices:

1. A matrix that contains the outbound and homebound trips of tours with one destination (and purpose). This matrix is symmetric around the diagonal.
2. A matrix that contains the outbound and homebound trips of tours with two destinations.
3. A "between purposes" matrix that contains the intermediate leg of tours with two destinations.

This is done in a consistent manner that maintains the total number of visits for each purpose that is produced by the "trip generation" model. Due to the simplifying assumption of using a maximum of two visits in a tour, the method will have an upward bias in the total number of trips. Based on the data from the national travel survey in Norway it seems that the bias will be of the order of 5 per cent. This upward bias may compensate somewhat for the fact that most travel surveys have an underreporting of trips, but the estimate of the bias can also be used for a simple adjustment of the matrices.

Although this method increases the running time of the models it can be programmed fairly efficiently. Due to the fact that time and cost of the "between purpose" trips themselves do not enter the picture, the calculation of vectors for matrix 2 and the full matrix 3 can be handled within the main loop over origins that calculates the probability vectors that are used to construct matrix 1. Still a further simplification must be used because the models have very extensive segmentation and each segment represent in itself a separate model. In order to avoid construction of matrices 2 and 3 for each segment we therefore use probability vectors that are a weighted average of the vectors for each segment.

The method used essentially it means that we solve a system of 5 linear equations in 5 unknowns to find a vector of outbound trips by purpose. Having found this vector it is straight forward to calculate the number of direct return trips by purpose, the vectors of outbound and homebound trips for multipurpose tours and the 5 by 5 matrix of “between-purpose” trips. The vectors for outbound and homebound trips are multiplied by the probability distributions over destinations to give the number of trips from the origin to all destinations and vice versa.

For each origin the “between purposes” trips forms a full matrix. This matrix is calculated by P^T*VV*P where P is the nx5 matrix of probability distributions over destinations (n is the number of zones) and VV is the 5x5 matrix of between purpose trips. The total “between purpose” matrix is the sum of the matrices for each origin zone.

At present we have still not tested in a full implementation how much the total the running times of the models will increase due to the inclusion of multipurpose trips with this method.

The paper gives a simple example of application of the method based on data from the Norwegian travel survey that is the main data source for model estimation.

References

Larsen Odd I, “Estimating independent and simultaneous trip frequency models for all travel purposes with combined Logit/Poisson,” presented at European Transport Conference, Strasbourg, October 2003.