Spatial Choice Modelling Issues

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1 Introduction

Destination choice models are arguably less well developed than many other components of travel demand model systems (notably mode and route choice), for both trip-based and activity-based model systems (Wang and Miller, 2014). Major issues in destination choice modelling include: choice set definition, model specification, dynamics, aggregation, and model accuracy.

This paper explores these and related issues in destination choice modelling. It presents a critical literature review of the current state of practice/art in destination choice modelling and establishes a taxonomy of modelling issues, methods and options. It pays particular attention to the issue of spatial precision, in terms of both the levels of precision needed for various planning and modelling purposes and the precision levels which are likely to be achievable within practical models. Opportunities for improved destination choice modelling within activity/agent-based microsimulation modelling frameworks are discussed. The paper concludes with a recommended list of research topics for improving destination choice modelling.

2 Choice Set Definition

Perhaps the most challenging issue in any spatial choice model is the definition of appropriate choice sets for the problem at hand. In logit model applications randomly drawn choice sets are routinely used in model estimation, but choice set definition in forecasting application remains problematic. Randomly drawn choice sets naively drawn will generally produce exceptionally poor results, while use of the universal choice set of all destinations is computationally burdensome and behaviourally unrealistic. In activity-based applications, time-space prisms can be used to restrict the choice set to destinations that can be feasibly accessed between various "fixed points" within the trip-maker's activity pattern, but these choice sets often are also large except in the case of very tight time-space constraints.

One theoretically attractive approach is to assume that each person has an "awareness set" of locations of which he/she is aware. Time-space constraints can then be applied to this awareness set to generate a "feasible" set of locations for a given activity episode. Approaches for modelling the awareness set include various rule-based approaches and latent choice set models, but challenges exist in developing operationally practical implementations of such models.

3 Model Specification

Utility/"impedance" functions characterizing the attractiveness of spatial alternatives are often relatively simplistic in nature, typically consisting of simple accessibility terms (perhaps at most the "logsum" of a logit mode choice model) and simple "size" variables (number of employees, floorspace, etc.) characterizing the "attractiveness" of the competing destinations. Such simplified utility functions often are a result of a lack of detailed data characterizing alternative locations, but also arguably reflect a lack of strong behavioural theory to guide model specifications (Timmermans, 2003).

The linkage between location choice and other components of activity/travel choice (start time, travel model, episode duration) is also generally not well understood. In order to calculate time-space prisms travel mode should be known, but many model systems assume that location is determined prior to mode choice. Locations for some activities (e.g., visit family doctor) are pre-determined by longer-term processes, in which case the choice is when to visit this location, not what location to visit for this purpose. On the other hand other locations for a given activity episode may be very dynamically/impulsively chosen to exploit an opportunity within the daily activity schedule.

4 Dynamics

As noted in the previous paragraph, consider dynamics exist within the activity scheduling process in terms of when activity episodes of various types are scheduled. The timing of such decisions clearly will affect the gaps within the schedule and locations that are feasible for these episodes.

Dynamics also enter into the formation of the trip-maker's awareness set, since this presumably evolves over time based on the trip-maker's previous choices and learning experience. While one in principle can specify models of learning, habit formation, etc., how such models might be applied in practical forecasting applications is generally unclear, especially given that such forecasts inevitably are made for arbitrary points in time and without the ability to model a detailed history of agents' learning and preference formation (at least not without modelling every day in the life of these agents!).

5 Aggregation Issues

The inevitably aggregate nature of activity type specification is rarely discussed in the context of destination choice modelling, but it may well represent a limiting constraint on the level of model detail and predictive accuracy that one can expect of these models. That is, we inevitably aggregate the myriad of human activities into a relatively small number of activity types for modelling (shopping, personal business, recreation, etc.). Wang and Miller (2014), for example, exploit a relatively detailed survey to define six types of shopping, which is far more than the typical case. Even in this model, however, it is clear that considerable aggregation over store type, products sold and attributes such as "price", "quality", etc. (which we generally believe should influence store choice) occurs. Further, even if greater homogeneity in activity types could be achieved in estimation with detailed datasets, practical questions exist with respect to our ability to forecast future activity locations and their attributes at such a level of detail.

6 Model Accuracy

Remarkably little attention seems to have been given in either theory or practice to the accuracy of trip distribution / destination choice models. For conventional trip-based, four-step trip distribution models, model estimation generally involves matching trip-length frequency distributions, with the models being subsequently calibrated to fit observed screenline counts. Hutchison and Smith (1979), however, demonstrated that such models routinely generate significant errors at the traffic zone origin-destination (O-D) level – the level of spatial detail required for operational mode and route choice modelling. Disaggregate, logit-based destination choice models are often touted as being superior to doubly-constrained gravity/entropy models, but little empirical evidence of this is generally provided -- and with differences in performances generally being due to differences in aggregation level and functional specification, since the two model formulations are mathematically effectively the same, as are their parameter estimation methods (Anas, 1983). Both Elgar, et al. (2009) and Wang and Miller (2012) have found significant prediction errors at the traffic zone level of unconstrained, disaggregate location choice models, despite considerable care in choice set formulation and utility function specification. If operational models are not able to generate destination choices at reasonable levels of accuracy and spatial precision, surely the reliability of the entire activity/travel model system is questionable. This concern can only be accentuated by current trends to highly spatially disaggregated (small grid and parcel level) microsimulation models.

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