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Modelling the attraction of travel to shopping destinations in large-scale modelling

Ida Kristoffersson[a,*], Andrew Daly[b,c,d], Staffan Algers[e]

[a] VTI Swedish Road and Transport Research Institute, Box 55685, SE-10215 Stockholm, Sweden
[b] ITS, University of Leeds, Leeds, UK
[c] RAND Europe, Cambridge, UK
[d] CTS, Stockholm, Sweden
[e] KTH Royal Institute of Technology, Stockholm,Sweden

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ABSTRACT

Development of major shopping centres continues even though online shopping is increasing. This has implications for mode and destination choice for shopping travel and therefore also for sustainability, which need to be considered in planning policy. In this paper, we estimate models for shopping travel using an unusually rich data set of shopping attractions. We find that shopping travel is best represented in three separate models: consumables in short and long activity segments and durables. In all of these models, we show that representing nearby attractions outside the destination zone adds to the measured attraction. For long activity consumables and for durables, the addition of secondary attractions within 2 km of the main destination gives the best models. For short activity consumables, both 2 km and 5 km add to the model, but 5 km is slightly better. Furthermore, we find significant within-zone correlation in the consumables models but are unable to find significant between-zone correlation, indicating that zone boundaries have some behavioural meaning for shopping travellers, but larger areas are not viewed in this way. Shopping attractions with a specifically Swedish impact, Systembolaget (official alcohol outlet in Sweden) and IKEA, proved to be important in all the models. These attractors work better as part of the size than as part of the utility, indicating that they appear to be separate attractors of trips, rather than as adding to the utility of other attractors. The models are also applied in two policy scenario analyses in which the impacts of new IKEA establishments and availability of Systembolaget in all zones on destination and mode choice are assessed.

1. Introduction

The rapid development of on-line shopping has taken attention from the continuing importance of 'physical' shopping and travel to shops and shopping centres. But development in shopping facilities continues apace: the recent opening on the London 2012 Olympic site of Stratford Shopping City in east London (175,000 sq. m., completing the largest shopping centre in the EU) is evidence of the importance attached by retailers to 'footfall': attracting shoppers in person to their sites. Shopping centres aim at extending the conventional shopping trip with possibilities to combine it with visits to restaurants and cinemas and meetings with friends. In Sweden also, large shopping malls have been established, like Mall of Scandinavia in Stockholm which opened in 2015 (101,000 sq. m.). IKEA is another example of an important shopping attractor, which not only attracts shoppers itself, but also attracts other shops (and their customers) to nearby locations.

The large volume of trips attracted to shops and shopping facilities means that transport planners need to understand the impact that these trips may have on congestion, emissions and energy consumption. Particularly the balance between central and peripheral locations and their very different impacts on travel mode choice mean that planners need to understand how planning decisions taken by developers and governments will influence shopper behaviour and hence the transport consequences of these decisions. A good understanding of how people travel for shopping is essential for these policy decisions.

The most recent Swedish study (Algers and Jonsson, 2013) has developed models for shopping using a richer source of shopping supply than had previously been available. A nationwide retail database was made available by the retail research institute HUI Research. The purpose of the model development was to achieve a better understanding of how supply affects shopping behaviour. These models offered improved insight into shopper behaviour, but were limited to model

* Corresponding author.
E-mail addresses: ida.kristoffersson@vti.se (I. Kristoffersson), andrew@alogit.com (A. Daly), algers@kth.se (S. Algers).

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formulations including only information on attractions in the specific destination zone, without providing a broader context of the neighbouring areas, which might offer increased utility for secondary shopping. Important interaction phenomena are therefore largely neglected.

The present study aims to improve the modelling of shopping behaviour in the context of large-scale travel demand modelling. In particular, models are developed that improve the representation of shopping attraction. Here, we benefit from the unusually rich HUI data set which represents shopping attractions in a number of dimensions, such as numbers of shops, floor space and retail employment. Additionally, we have identified the location of specific shops that have been shown to influence traveller behaviour, such as IKEA and Systembolaget (official alcohol outlets). This has allowed us to develop separate and richly detailed models for both consumables and durables shopping. A particular interest of the present study is the extent to which shopping travel behaviour is influenced by the presence of multiple attractions at the same site or nearby. We explore this issue based on the model specifications reported in Algers and Jonsson (2013) with several extensions. The first is not to sample destination alternatives but to use the full set of destinations to avoid possible bias; the second is to segment the model for consumables shopping into two separate models based on the activity time at the shopping destination. Further extensions concern the addition to the utility of a specific zone offered by the availability of shopping attractions in nearby zones; this may relate to measured or unmeasured variables. The differences between the previous models and our new models are discussed in more detail in the sections on model specification and results.

The following section of the paper reviews the literature on shopping models. Section 3 then describes the choice modelling framework. Results are presented in Section 4 and Section 5 concludes.

2. Literature review

In this literature review, we briefly summarise the history of models of shopping travel, starting with the first basic models and continuing with models of increased complexity that have been developed over the years.

The first models of shopping travel were of the gravity model type, which is the most widely used type of spatial interaction model (Haynes and Fotheringham, 1984). Gravity models assume that the probability to choose a destination for shopping decreases with the distance to the destination and increases with the size (attraction) of the shopping centre. The most famous model of this type is the so-called Huff-model (Huff, 1963). Several models of the gravity type have been developed following upon the Huff-model (Gonzalez-Benito, 2005; Simmonds and Feldman, 2011). They differ mainly in the specification of the attraction and the distance decay function.

Criticism of spatial interaction models – that they were not based on standard economic theory – encouraged the development of another type of model, discrete choice models, and also their application to shopping trips (McFadden, 1974; Ben-Akiva and Lerman, 1985). Discrete choice models consist of a deterministic part (the observed part of the utility function) and a stochastic error term. Assuming that the error terms are IID extreme value distributed led to a discrete choice model with a closed form – the multinomial logit model (MNL). The MNL model has been applied in several studies to explain and predict shopping behaviour, see e.g. Oppewal et al. (1997). The results of these studies suggest that travel distance, shopping centre characteristics (also called shopping centre image), and parking facilities are the main variables explaining choice of shopping destination (Arentze and Timmermans, 2001).

The MNL model is convenient, but has some severe drawbacks. First, it relies on the principle of independence of irrelevant alternatives (the IIA-property), meaning that the alternatives that the user chooses between must be independent. Second, in MNL models, users are treated as homogenous with common parameter values estimated for the entire population and thus ignoring heterogeneity among consumers. Third, conventional MNL models (as well as gravity models) are designed to handle single-purpose and single-stop trips. In the following paragraphs, we describe how these deficiencies of the MNL model have been tackled in the research literature by the development of more complex models.

It is likely that some shopping destination alternatives appear more similar to the user than others. This means that the IIA property does not hold. One way to solve this problem is to group similar alternatives in nests and estimate a nested logit model. Evidence exists that a specific store in a shopping centre is often the reason for choosing that centre (Ahn and Ghosh, 1989), which implies that all shopping centres where this store is present are more attractive to the consumer than the other centres. Suárez et al. (2004) estimate a nested logit model with choice of hypermarket on the upper level and choice of shopping centre on the lower level. Their results show that all shopping centres do not compete with each other to the same extent; the opening of a new shopping centre will have greatest effect on other shopping centres containing the same hypermarket. The IIA property can also be relaxed by using a mother-logit model in which the utility of one alternative depends on the attribute of other alternatives. The mother-logit model has been applied to shopping destination choice in Timmermans et al. (1992).

An alternative to the nested logit model is the competing destinations model (Fotheringham 1988), which is one of the key models in the field of transport geography. The major advantage of the competing destinations model, compared to the nested logit model, is that the competing destinations model can account for spatial structure effects, i.e. competition and agglomeration effects. Agglomeration effects occur when shops located near each other increase the probability of choosing the destination where these shops are located. Conversely, competition effects occur when shops located near each other decrease the probability of choosing that destination. Furthermore, in the competing destinations model, no a priori tree structure needs to be defined, which is useful since space is a continuous variable and the boundaries for destinations that appear more similar are often fuzzy. Scott and He (2012) take another approach to deal with destination choice set specification: they use detailed GIS data to generate constrained shopping destination choice sets depending on user specific time budget, travel times and spatial distribution of shops. However, even though it is theoretically clear that more advanced models are superior to the MNL model, Borgers and Timmermans (1987) show that the MNL model can reproduce simulated data with reasonable accuracy.

Suárez et al. (2004) tackle the second question concerning preference heterogeneity. They estimate a random effects model in which the parameters are randomly distributed in the population and find that a segment of their consumers is less sensitive to travel time than the others. Preference heterogeneity has been accounted for also by other means than using a random effects model, i.e. by demand segmentation (Gupta and Chintagunta, 1994), introducing a variable for revealed shopping behaviour of the consumer (Guadagni and Little, 1983) and fixed effects models that assign a fixed parameter to the utility function of each consumer (Chamberlain, 1979).

The third drawback of the conventional MNL model – that it cannot handle multi-purpose and multi-stop trips – has been dealt with using either advanced discrete choice models or activity-based models. Activity-based models aim at predicting the daily schedule of a user including the performed activities, their destinations, transportation mode, time of day and travelled route, taking into account also constraints at the household level regarding e.g. access to a car. An activity-based model that has been specifically applied in shopping behaviour research is Albatross (Arentze and Timmermans, 2004). Rasouli and Timmermans (2013) provide an uncertainty analysis of shopping forecasts using the Albatross model. Furthermore, Bhat (1996) uses an activity-based framework to model multi-stop trips (stop for shopping on the way home from work). Discrete choice models have been used to