Transportation Research Part A 65 (2014) 56–67

Contents lists available at ScienceDirect

Transportation Research Part A

journal homepage: www.elsevier.com/locate/tra

Modeling the behavioral determinants of travel behavior: An application of latent transition analysis

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ARTICLE INFO

Article history:
Received 17 April 2012
Received in revised form 17 November 2013
Accepted 15 April 2014
Available online 13 May 2014

Keywords:
Travel behavior
Multi-modality
Latent class transition analysis

ABSTRACT

This paper applies the relatively new method of latent class transition analysis to explore the notion that qualitative differences in travel behavior patterns are substantively meaningful and therefore relevant from explanatory point of view. For example, because the bicycle may function as an important access and egress mode, a car user who also (occasionally) uses the bicycle may be more likely to switch to a public transit profile than someone who only uses the car. Data from the Dutch mobility panel are used to inductively reveal travel behavior patterns and model transitions in these patterns over time. Additionally, the effects of seven exogenous variables, including two important life events (i.e. moving house and changing jobs), on cluster membership and the transition probabilities are assessed. The results show that multiple-mode users compared to single-mode users are more likely to switch from one behavioral profile to another. In addition, age, the residential environment, moving house and changing jobs have strong influences on the transition probabilities between the revealed behavioral patterns over time.

1. Introduction

A fruitful way to improve the predictive power of travel behavior models and to increase our general understanding of travel behavior lies in the use of panel data (repeated measures from the same individuals). Whereas cross-sectional data can only reveal inter-individual differences at one moment in time, panel data can reveal intra-individual changes over time. In effect, panel data are generally better suited to understand and predict (changes in) travel behavior.

In the transport domain (at least) two approaches to handling panel data can be discerned. Within the first, the variables under investigation are directly related over time. Typically, this involves the specification of a structural equation model with lagged stability relationships (between the same variables over time) and cross-lagged relationships (between different variables over time), see e.g. Golob and Meurs (1987); Golob (1990a). An overview of such studies can be found in a review paper of Golob (2003). While focused on different substantive questions, a general conclusion of this line of research is that past travel behavior is highly predictive of future travel behavior. Hence, travel behavior is found to be strongly inert.

The second and less adopted approach is based on the idea that, at each point in time, a finite set of clusters underlies the associations between the variables of interest and that change over time can be captured by modeling people's transitions between these clusters. Hence, in contrast to the first approach, no direct (lagged) relationships are estimated between the variables over time. Instead, (any) effects over time are assumed to be mediated by the relationship between the latent cluster variables, which are defined by the (same set of) observed variables at each point in time.

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http://dx.doi.org/10.1016/j.tra.2014.04.010
0965-8564/

In several papers Ma and Goulias (Ma and Goulias, 1997; Goulias, 1999) applied this approach to data from the Puget Sound transportation panel. Using cluster analysis in combination with a mixed Markov latent class analysis, Goulias (1999) identified various activity and travel behavior clusters and examined the cross-sectional and over-time relationships between them. The notion that travel behavior is strongly inert was confirmed by this line of research, as many people were observed to remain in their initial cluster. However, a substantial proportion was also observed to transition between (very) different activity/travel patterns over time, indicating that, from one year to the next, many people renegotiated their activity/travel patterns.

While this second approach to handling panel data can be extended in many interesting ways, these have, as far as the author is aware, not been explored in any follow-up study. Focusing on travel behavior, this paper aims to further explore the potential of this alternative approach and thereby illustrate its value to practitioners and researchers alike. Its specific contributions are threefold.

The first and main contribution of the present research lies in the recognition that qualitative differences between travel behavior patterns are substantively meaningful and therefore relevant from explanatory point of view. For example, it may be expected that a car user who also (occasionally) uses the bicycle is more likely to switch to a public transit profile than someone who only uses the car (because the bicycle may function as an important access and egress mode). Hence, being member of a particular travel behavior cluster not only increases the probability of remaining in the same cluster, but may also be associated with particular probabilities of moving to another cluster (different from other clusters). Several other mechanisms (discussed in the next section) may be identified why the probabilities of remaining in the same cluster or transitioning to another over time may be differently affected by initial cluster membership.

As a second contribution, this study explores the effects of several exogenous variables and events on both initial cluster membership and the transition probabilities. More specifically, this study will examine the role of several personal characteristics (gender, age, education level, employment status) and whether a person lives in an environment which is conducive of a car-, cycling- and/or public transport or not. These variables may be expected to influence the probabilities of belonging to a particular cluster (at one point in time) as well as the probabilities of remaining in the same cluster or transitioning to another cluster over time. The effects of two life events, namely moving house or changing jobs, will also be assessed. Such events represent possible 'windows of opportunity' to change one's travel routines (Bamberg, 2006) and may therefore also be assumed to influence the transition probabilities.

The third and final contribution of the present research is that it introduces latent class transition analysis to inductively reveal travel behavior patterns and model transitions in these patterns over time (Collins and Lanza, 2009). Cluster research in the transport domain generally relies on the ad-hoc and deterministic classification method of cluster analysis to identify homogenous clusters. Latent class analysis, on the other hand, is a model-based clustering technique which probabilistically assigns individuals to classes/clusters. This reduces misclassification biases. Additional benefits over cluster analysis are that statistical criteria can be used to judge the optimal number of classes and that variables of mixed-scale type can be accommodated (there is also no need to standardize variables) (Magidson and Vermunt, 2002). Finally, a major advantage in the context of the present research is that a latent class model can easily be extended to a panel data context, resulting in a latent class transition model (Collins and Lanza, 2009).

The data used for the analyses are derived from the Dutch mobility panel, a 10-wave survey among Dutch households conducted over a 5-year period (from March 1984 to March 1989). The structure and aim of this panel are described in Golob et al. (1985) and Meurs and Van Wissen (1987). While the Dutch mobility panel has been used to answer an extensive range of research questions (for an overview see Van Wissen and Meurs (1989)), none of the reported studies attempted to reveal latent travel behavior clusters or transitions in these clusters over time. The data are nonetheless well-suited for this purpose.

2. Theoretical background and expectations

Various mechanisms may be identified why membership of initial travel patterns will differently influence membership of future travel patterns. As mentioned in the introduction, some modes may complement each other in specific ways. Hence, since the bicycle may function as an important access and egress mode, it may be expected that a car user who also (occasionally) uses the bicycle may be more likely to switch to a public transit profile than someone who only uses the car.

A second mechanism relates to the notion that travelers who use only a single mode develop different expectations and attitudes toward various modes than multi-modal travelers (Diana and Mokhtarian, 2009). For example, it has been shown that car users generally have biased views toward possible public transit alternatives, overestimating their travel times and costs (Pedersen et al., 2011). Car users, who also use public transport, will not be affected by such biases. Hence, given that multi-modal travelers generally have more realistic perceptions on the available options and their attributes than single-mode travelers, they may also be expected to adjust their behavioral patterns more readily.

A third possible mechanism relates to the notion that multi-modality in itself can be regarded as a reflection of a trait representing the degree to which an individual deliberately chooses a mode (dependent on the context) as opposed to an individual who habitually (i.e. without deliberation) chooses a single particular mode (irrespective of the context). Hence, a person who uses multiple modes can be regarded as a deliberate choice traveler, whereas a person who exclusively uses a single mode is more likely to be a habitual traveler. Previous research, in this respect, has indeed shown that travelers can into be identified along, what can be termed, a rational-habitual dimension (Van Exel et al., 2011).