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## Travel pattern transitions: Applying latent transition analysis within the mobility biographies framework

M.C. de Haas<sup>a,\*</sup>, C.E. Scheepers<sup>a</sup>, L.W.J. Harms<sup>a</sup>, M. Kroesen<sup>b</sup><sup>a</sup> *KiM Netherlands Institute for Transport Policy Analysis, PO Box 20901, 2500 EX The Hague, The Netherlands*<sup>b</sup> *Delft University of Technology, PO Box 5015, 2600 GA Delft, The Netherlands*

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### ABSTRACT

This paper applies the relatively new method of latent transition analysis within the mobility biographies framework to assess how life events influence changes in travel behaviour. Using transition analysis, it is assessed how people switch between different travel patterns over time. Data from the first three waves of the Netherlands Mobility Panel (MPN) are used to reveal different travel patterns and analyse transitions between these patterns over time. Six different meaningful travel patterns are revealed. Four exogenous variables and six life events within the household, employment and residential biography are included to assess their effects on people's transitions between the travel patterns over time. For all life events significant effects are found, indicating that there might indeed be 'windows of opportunity' to change travel behaviour when a life event occurs. The results show that, on average, people who only use a single mode are less likely to change their travel pattern compared to multimodal travellers. In addition, the effects of life events and exogenous variables depend on the initial travel pattern. In general, single-mode travellers are less affected by life events than multimodal travellers. This indicates that it is important to include past travel behaviour within mobility biographies studies.

### 1. Introduction

Travel behaviour can generally be described as inert or habitual behaviour; it does not change very often (Chorus and Dellaert, 2010; Gärling and Axhausen, 2003). It is therefore interesting to gain more insight into when travel behaviour does change. Since a lot of travel behaviour studies are based on cross-sectional data, any events leading up to changes cannot be modelled. A relatively new approach to study travel behaviour change is the mobility biographies approach. Mobility biographies studies take a life-course approach and assume there are certain key events (life events) in an individual's life course that trigger change in travel behaviour (Lanzendorf, 2003). Mobility biographies studies are often based on longitudinal data to analyse individual changes over time.

These life events have been described as 'windows of opportunity' to change everyday routines (Schäfer et al., 2012). Multiple studies have shown that people are indeed more susceptible to interventions after life events such as a residential move or changing jobs (Anable, March 2013; Thøgersen, 2012; Verplanken and Roy, 2016). Recent overviews of mobility biographies studies are provided by Müggenburg et al. (2015) and Schoenduwe et al. (2015). Knowledge about these windows of opportunity could benefit transport policy that is aimed at changing travel behaviour or realizing a modal shift.

Most mobility biographies studies are, however, of a very explorative nature and do not consider the events and their effects in a

\* Corresponding author.

E-mail addresses: [Mathijs.de.Haas@minienm.nl](mailto:Mathijs.de.Haas@minienm.nl) (M.C. de Haas), [Eline.Scheepers@gmail.com](mailto:Eline.Scheepers@gmail.com) (C.E. Scheepers), [Lucas.Harms@minienm.nl](mailto:Lucas.Harms@minienm.nl) (L.W.J. Harms), [M.Kroesen@tudelft.nl](mailto:M.Kroesen@tudelft.nl) (M. Kroesen).

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broader theoretical framework (Müggenburg et al., 2015). A number of theoretical frameworks have been proposed over the years (Clark et al., 2014; Lanzendorf, 2003; Müggenburg et al., 2015; Scheiner, 2007). All frameworks are comparable in the fact that they distinguish different domains of life events that might have an influence on an individual's travel behaviour. Scheiner (2007) distinguishes three domains of life events that interact with the mobility biography; events in the household biography, the employment biography and the residential biography. Besides effects on the mobility biography, Scheiner (2007) argues that there are interrelations between the domains of life events. An important extension to this, as well as the other frameworks is given by Clark et al. (2014) who proposes that the deliberation of travel behaviour that takes place after certain life events is influenced by mediating factors, such as an individual's personal history (e.g. initial travel behaviour) and intrinsic motivations (e.g. economic reasons). Most mobility biographies studies, however, only assess the direct effects of life events on travel behaviour and often do not consider the interaction with past travel behaviour. Some mobility biographies studies do include past travel behaviour (see e.g. Prillwitz et al. (2006), Scheiner and Holz-Rau (2013) and Yamamoto (2008)), but they often do not consider interactions between past travel behaviour and the effects of life events (with the exception of Kroesen (2014)). To date, there is therefore limited empirical support for the mediating factors (in terms of initial travel behaviour) as proposed by Clark et al. (2014).

This paper aims to apply the relatively new latent class transition analysis within the mobility biographies framework to reveal different travel patterns and assess the influence of life events on changes in travel behaviour. This is done by extending the latent class model to a latent transition model. While traditional clustering techniques deterministically assign people to clusters, latent class analysis takes measurement error into account by probabilistically assigning people to clusters. Latent class- and transition analysis have already successfully been used to identify different types of multimodal travellers (Molin et al., 2016) and to assess the influence of several exogenous variables on changes in travel behaviour (Kroesen, 2014).

The first contribution of this study is that it applies a latent clustering- and transition analysis within the mobility biographies framework. This paper considers travel patterns, defined by self-reported trip rates, instead of the use or ownership of a single mode. Most mobility biographies studies only consider a single mode (see e.g. Clark et al. (2014) and Oakil et al. (2011)) or multiple modes in different models (see e.g. Beige and Axhausen (2012) and Scheiner and Holz-Rau (2013)). Only a limited number of studies consider multimodal travel patterns, see e.g. Kroesen (2014) and Scheiner et al. (2016). Considering multimodal travel patterns within the mobility biographies framework offers a holistic view of travel behaviour and the effects of life events. This also offers the possibility to assess how the use of different travel modes influences the probabilities that one will change its travel pattern, even without the occurrence of a life event. It can, for instance, be expected that people who use different modes, are more prone to change their behaviour since they are already familiar with multiple modes. Diana (2010) showed that multimodal travellers show a stronger propensity to use other modes, something that was also concluded by Kroesen (2014).

The second contribution is the fact that the influences of both life events and other exogenous variables on changes in travel patterns as a whole are assessed. Besides six life events (change in the number of adults in the household, changing jobs, stop working, moving house, birth of a child and start or changing education), nine exogenous variables are included in the analyses (gender, age, educational level, household composition, income, working hours per week, level of urbanization, distance to a train station and number of reported weekend days). While most mobility biographies studies include one or more exogenous variables, they do not consider the effects of these variables on changes in the travel pattern as a whole, but rather on a single mode, as explained in the previous paragraph. Besides having an influence on initial travel behaviour, it could be argued that several personal- and household characteristics have an influence on changes in travel behaviour. For instance, people with a low income may have fewer financial possibilities to change their travel behaviour and might show more inert behaviour compared to people with a higher income. The same holds for people living in rural areas where public transport is often less of an option than for people living in densely populated areas where there is often a better public transport network. Therefore, people in densely populated areas might show more changes in their travel behaviour. It can therefore be expected that these exogenous variables not only have an influence on an individual's initial travel pattern, but also on the transition probabilities.

The third contribution of this paper is that it considers the initial travel pattern of people when analysing changes in travel patterns and especially the interaction between past travel behaviour and life events. It has been argued that past behaviour is an important predictor of future behaviour (Ouellette and Wood, 1998). Although initial travel behaviour is sometimes included in mobility biographies studies, interactions between past travel behaviour and life events are often not. This paper explicitly considers interactions between life events and initial travel behaviour to assess whether effects of life events are different, depending on one's past travel behaviour.

## 2. Model conceptualization

Latent class- and transition analysis will be used to reveal different travel patterns and assess how transitions between these classes are influenced by the occurrence of different life events. Fig. 1 shows the conceptual model for the latent transition analysis.

At each point in time, a latent class model is specified to cluster respondents based on their similarities with respect to the included indicators. Latent class analysis is built on the assumption that the associations between the indicators are explained by an underlying latent variable (McCutcheon, 1987). The latent variable is not directly measured, but it is inferred from observed indicators. In this study, trip rates of different modes (car, bike, public transport and walking) are used as indicators. As a result, the latent categorical variable represents an individual's travel pattern.

After defining the different travel patterns, transitions between these patterns are assessed by extending the latent class model to a latent transition model. A latent transition model can be described as repeated latent cluster analyses over-time where the same travel

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