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Modelling activity-travel behaviour dynamics with panel data: The state-of-the-art

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The field of travel behaviour dynamics represented a vibrant research area in the 1980s and the 1990s (Golob & Meurs, 1987; Golob, Kitamura, & Long, 1997; Kitamura, 1990), but has since, probably due to lack of mobility panel data, received relatively little attention by transportation researchers. Nevertheless, through the use of panel data (repeated measures of the same individuals) many new insights may be gained with respect to travel behaviour, insights that are fundamentally different from those that can possibly be gained from cross-sectional data.

In essence, whereas cross-sectional data only allow researchers to study differences between individuals at one point in time, panel data enable researchers to study changes 'within' individuals over time. In effect, panel data are generally better suited to perform causal analysis, assess the influences of certain events on (changes in) travel behaviour or reveal transition processes in travel behaviour. Due to these benefits they are generally better able than cross-sectional data to improve our understanding of travel behaviour.

Another relevant feature of panel data is that they allow the relaxation of an implicit, but very important assumption which underlies research based on cross-sectional data, namely that an estimated relationship between an independent and dependent variable (based on differences between subjects) holds for any specific subject of the sample/population. Obviously, this assumption does not need to hold true as has been shown empirically by several studies outside the transport domain (Borsboom et al., 2003). The increased use of panel data within the transport domain allows transportation researchers to systematically explore this assumption and its implications in relation to various types of models (e.g. for a discussion with respect to hybrid choice models see Chorus, & Kroesen, 2014).

Fortunately, it can be observed that interest in modelling panel data in the transport domain is slowly returning, which can attributed to three relatively independent causes, namely: (1) the introduction of new conceptual frameworks, e.g. the mobility biographies approach; (2) the increased availability of new mobility panel data, such as the recently instituted Dutch mobility panel; and (3) the increased availability of novel statistical methods like transition analysis and latent transition analysis / Markov models.

The objective of this special issue is to integrate these developments and thereby contribute to reinvigorating the field of activity-travel behaviour dynamics. To achieve this, an overview will be provided of the state-of-the-art in research in this field. In total, seven empirical studies are presented. All contributions were part on an invitational workshop on activity-travel behaviour dynamics, which was hosted by Delft University of Technology in July 2015. Together, the

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studies encompass the various contemporary lines of research in the field of activity-travel dynamics.

The first two papers can be subsumed under the heading of the 'mobility biography approach'. The basic tenet of this approach is that travel behaviour is assumed to be relatively stable, e.g. due to the existence of travel habits, but that key life events - originating from various other biographies (e.g. the employment or housing biography) - can act as triggers of behavioural change (Lanzendorf, 2003; Scheiner, 2007). Recent reviews of the achievements of the mobility biography approach indicate that an eclectic body of knowledge has been developing with empirical studies using a variety of quantitative and qualitative methods and data sources (Müggenburg et al., 2015; Schoenduwe et al., 2015). All in all, the approach seems to offer a promising framework to understand travel behaviour change over the life course.

The first paper by Scheiner (2016) proceeds from the idea that key life events likely interact with gender in determining changes in people's activity and behavioural patterns. As such, it capitalizes on an important research gap within the mobility biography literature, in which typically only main (generic) effects of life events are considered. To assess the expectation that life events affect the activity patterns of men and women differently, Scheiner (2016) uses data from the German Mobility Panel (GMP) (1994 to 2014) to estimate a series of regression models with time use changes for employed work, out-of-home leisure, escort, and time spent at home, as dependent variables. The results indeed show the gendered effects of various key events on changes in time use. An important overall finding is that key events in partnership and the family affect women's time use more than men's, while for labour market events it is mostly the other way round.

The second paper by Oakil, Manting and Nijland (Oakil et al., 2016) focusses on the effects on the level of car ownership of a very specific life event, namely the entry into parenthood (the birth of a first child). The innovation of this paper lies in the unique dataset that is used for the analysis. Oakil et al. (2016) were able to combine population register data of Statistics Netherlands, which contain data on the whole population of the Netherlands (including income, household composition, employment status, and residential location) with vehicle registration data, which contain all registered cars in the Netherlands, for two years (2011 and 2013), thereby obtaining a unique panel dataset. The multinomial logistic regression reveals that couples are more likely to enter car ownership and less likely to exit car ownership when they enter into parenthood, which implies that the delay of entry into parenthood might lead to later entry into car ownership. This finding provides a compelling explanation for the observed downward trend in car ownership among young people.

The third paper by Van der Coevering, Maat, Kroesen and Van Wee (Van der Coevering et al., 2016) addresses a longstanding debate in transportation/planning research about the causal direction between the built environment and travel behaviour and attitudes. Theoretically, effects in both directions may be expected. To date, however, most empirical studies have applied cross-sectional designs to investigate these reciprocal relationships. The study by Van der Coevering (2016) represents one of the first attempts to employ a longitudinal design. The study is based on a two-wave panel of over 1,300 Dutch individuals. The dataset covers a relatively long time period (7 years) and includes an extensive range of variables, relating to travel behaviour, mode-related attitudes and characteristics of the built environment. Because of the long time frame, the panel is uniquely suited to study the bidirectional influences between the built environment and travel behaviour/attitudes. The findings of the estimated structural equation model indicate that (over time) the residential built environment has a small but significant influence on car use as well as travel attitudes, suggesting that people tend to adjust their attitudes to their built environment. Overall, the paper provides an important substantive contribution to the literature on residential self-selection (Cao et al. 2009).

The fourth paper by Olde Kalter and Geurs (Olde Kalter and Geurs, 2016) is one of the first studies to use data from the recently instituted Mobility Panel Netherlands (MPN). This panel comprises over 2,000 Dutch households who (each year) complete a 3-day travel diary and an extensive survey regarding various (travel-related) topics. The paper of Olde Kalter and Geurs (2016) uses data of the first two waves of the MPN (2013 and 2014) to address the question how relations inside households affect mode choice, specifically the decision to use the car (or not) for home-based tours. To model this dichotomous outcome, while taking into account the three-level hierarchy in the units of observation (households, individuals and tours), a multilevel binary logit model is estimated. The findings indicate that variability between households and individuals accounts for more than one third of the total variation in the mode choice of home-based tours. In addition, the findings show that interactions between household members, resulting in joint (or not) activity patterns, have significantly different outcomes in terms of car use. Overall, the paper illustrates that intra-household interactions and group decision making, aspects which are often neglected in individual mode choice analysis, have important implications for mode choice behaviour.

The fifth paper by Chatterjee, Clark and Bartle (Chatterjee et al., 2016) applies a relatively uncommon but straightforward methodology to analyse panel data, namely transition analysis. This method proceeds from the identification of several distinct discrete states, in this case various commute mode choice patterns (e.g. car alone, partial car, no car alone) and then attempts to model and explain the transitions between these states over time using a set of explanatory variables. The analysis is based on the North Bristol Commuter Panel, in which over 1200 British commuters participated. Weekly commuting data were collected on five occasions at three month intervals between July 2014 and July 2015. The results indicate that changes in commute mode choices are influenced by (amongst others) employment characteristics, access to mobility resources and life circumstances. An examination of the complete trajectories for those panel participants who responded to all five waves revealed that very few commuters switch between extreme commuting groups (car alone commuting to no car alone commuting or vice versa). On the other hand, there are more cases of sustained switches between intermediate groups (e.g. car alone commuting to partial car alone commuting). This finding suggests that strong travel habits are more prevalent among unimodal travellers compared to multimodal travellers, which is intuitively plausible.

The sixth paper by McBride, Lee, Lundberg, Davis, and Goulias (McBride et al., 2016) extends the approach of Chatterjee et al. (2016) by assuming that the states are not directly observable, but can be represented as latent categories, which are measurable via multiple observed indicators. Extending this model to multiple points in time and assuming heterogeneity in the transition patterns, yields the so-called mixture latent class Markov model. Based on data from 230 households of the Puget Sound Transportation Panel, McBride et al. (2016) estimate such a model using variables related to car ownership and (shared) car use as indicators of the latent states. Four states are revealed with reflect various levels of car mobility groups (from low to high). From a behavioural point of view, an interesting finding is that significant lagged and lead variables of behavioural change are found, which implies that households not only adapt to internal and external changes to their environment but they also anticipate changes and go through a "preparation" stage (e.g., adding another car in their fleet in expectation of adding another employed person). Overall, the findings illustrate how new behavioural insights can be gained from complex dynamic models, including repeated observation and a wide range of relevant explanatory variables (socio-demographics, attitudes, and land use characteristics).

The seventh and final paper is by Kroesen and Cranenburgh (Kroesen and Cranenburgh, 2016) and also uses the mixture latent class Markov model. In this application the indicators of the latent states represent the use of different modes, namely car as driver, car as passenger, public transport and bicycle. Using data from German mobility panel (1999-2009) five travel patterns are revealed which differ in the degree of mono-/multimodality. Similar to the study of Chatterjee et

al. (2016) it is found that monomodal travellers have a higher probability to remain in their respective pattern than multimodal travellers. The analysis also reveals the existence of three underling/generic mobility styles, namely habitual travellers, car (in)dependent choice travellers and car users with an alternative mode preference. In line with the expectation that the mobility styles reflect more deeply-rooted individual traits, it is found that the mobility styles are less strongly correlated with socio-demographic background variables than the travel behaviour patterns. Overall, in a similar fashion as the study of McBride et al. (2016), the study illustrates how complex dynamic models can yield novel behavioural insights.

While the papers collected in this special issue represent an eclectic set of studies, their communality lies in the fact that each seeks to improve our understanding of travel behaviour dynamics using panel data. With new mobility panel data being gathered and new theories and methods being developed, we believe there are exciting times ahead for the field of activity-travel behaviour dynamics.

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