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A decade of dynamics of residential location, car ownership, activity, travel and land use in the Seattle metropolitan region

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ABSTRACT

Using data of attitudes in the Puget Sound region we first identify predispositions in favor of car use (car loving persons and households) and distinguish them from other predispositions favoring other modes (transit and carsharing lovers). Then we explore if like-minded people (homophily) live together and examine heterogeneity within their households. To do this we analyze attitudinal data using multilevel latent class clustering that allows identification of groups of persons and groups of households jointly. Our analysis identifies distinct groups of people with different attitudes towards modes and we do not find strong homophily in attitudes within households. The distinction of attitudes among persons transfers well to the household level giving us the opportunity to identify and test differences among the different attitudinal groups using longitudinal records. We then move to a longitudinal analysis using a small sample of households that participated in more than ten years of the Puget Sound panel survey to explore the sequence of their residential location characteristics, car ownership, and travel. We find in descriptive statistics and in a second application of multilevel cluster models that carpool and transit loyalty persists over time by a portion of car pool and transit lovers. We also find sustained use of cars by car loving households, sustained car use of a neutral in attitudes group, a group of younger households with positive attitudes towards carsharing and sustained car sharing over time, and a possibly disenfranchised older household group lacking access to opportunities. The inclusion in the analysis of the two residential location characteristics (evolution of density and diversity around the household residence) enabled a more complete analysis and a clearer description of household context for both attitudes and behavior.

1. Introduction

The study of attitudes progressed in parallel with the study of travel behavior and the relationship between attitudes and travel has a long history of development with its roots in the policies explored in the 1970s (Hartgen, 1974; Gilbert and Foerster, 1977; Koppelman and Pas, 1980; Koppelman and Lyon, 1981). Early studies showed the attitude-behavior relationship to be circular and without a clear cause-effect with attitudes having multiple identifiable dimensions that are better analyzed using suitable models that can track these relationships (Dobson et al., 1978). Focusing on the task of responding to questionnaires, concerns were also raised with respondent activation and focus in answering attitudinal questions (Benwell and Brög, 1983). In addition, habitual behavior was identified as key in understanding causalities at the household level in which competition for cars in the household fleet and the importance of within household decision roles are important informants of choice (Lanken et al., 1994). Attitudes may also play different roles, due to distinct activation mechanisms, depending on the type of behavior such as planned, habitual, and impulsive

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(Gärling et al., 1998). Over time, however, important lessons were learned about conceptual frameworks that may be more appropriate in identifying paths of influence. This includes the inclusion of residential location choice and neighborhood attributes and their influence on travel behavior (Kitamura et al., 1997; Choo and Mokhtarian, 2004; Cao et al., 2009), activation of attitudes that depends on specific decision making goals/motives (Lindenberg and Steg, 2007), framing of knowledge and decision making that are strongly dependent on context (Steg, 2008; Goulias and Pendyala, 2014), intra-household influences mediated by attitudes (Sidharthan et al., 2011; Seraj et al., 2012), and the need to include gender-roles within households (Yoon et al., 2011). In parallel to a deeper understanding of the role attitudes play in shaping travel behavior we now also have more comprehensive conceptual frameworks that are paying particular attention to decision making hierarchies and interactions in households (Van Acker et al., 2010; Huijts et al., 2012; Arentze and Timmermans, 2013; Burbidge and Goulias, 2013; Maness et al., 2015). We also have an expanded repertoire of estimable choice models that are able to account for attitudes in many different forms (Ben-Akiva et al., 2002; Kamargianni and Polydoropoulou, 2013; Bhat and Dubey, 2014).

Using initial attitudinal data together with longitudinal histories of behavior allows us to test if attitudes measured in the beginning of a panel survey have a long-term influence on residential location, household car ownership and travel behavior. This opens the possibility of not only using attitudes as determinants of travel behavior (as in Wang and Chen (2012) who used mode switching for the commuting trip) in a short horizon but to also use attitudes as predictors of the totality of travel behavior throughout ten years after the respondent provided their answers to attitudinal questionnaires. In McBride et al. (2016) using attitudinal answers by the oldest person in the household we found a strong and durable impact of attitudes on car ownership and car use. Many travel decisions, however, take place through intra-household negotiations and attitudes are formed at the person level. In this paper we expand the analysis to explore the relationships between person-based attitudes and their combination within households and correlate this with the residential location, car ownership, and travel spanning more than 12 years in the life of 230 households in the Puget Sound region. To do this we derive a composite within a household measurement of attitudes using a large sample and estimate more precisely the attitudes that precede the joint sequence of choices in residential location, car ownership and mobility choices. In this way we examine the longitudinal histories of households that belong to different attitudinal groups.

In this paper we first describe the data used. Then we present a multilevel analysis of attitudes (23 attitudinal questions of persons within households) followed by a descriptive presentation of longitudinal behavioral data of the 230 households that participated in all panel waves (also reported in Lee et al. (2016a)). This is followed by a second multilevel analysis of residential location, car ownership, and travel of the 230 households. Behavioral groups thus derived are cross-classified with household-level attitudinal groups at the end of the paper to identify correlation between attitudes and behavior at the household level. As we will see later in this paper initially formed person attitudes have a long lasting impact in household travel behavior and residential location is a key determinant.

2. The Puget Sound Panel data

The Puget Sound Transportation Panel (PSTP) is a “general purpose” urban household panel survey that was created as a tracking device (Murakami and Watterson, 1990). PSTP represents approximately 3.3 million residents (based on data from the US Census of 2000) in Seattle and its surroundings. The survey started in 1989 and ended in 2002 in the four counties (King, Kitsap, Pierce, and Snohomish) of the Puget Sound region in the Northwest corner of the continental US surrounding Seattle. In each wave a household questionnaire and a two-day travel diary are administered on households. In this way, we accumulate households that participated at multiple time points. PSTP takes similar measurements of travel behavior repeatedly on the same observations over time. Each wave of the PSTP includes a two-day travel survey that collects information on household demographics, person social and economic circumstances, and reported travel behavior on two consecutive days for each person 15 years or older. Available data are from ten travel surveys in the years 1989, 1990, 1992, 1993, 1994, 1996, 1997, 1999, 2000, and 2002. More details about this panel can be found in the annotated bibliography in http://www.psrc.org/assets/1488/PSTP_bibliography.pdf.

We use two portions of PSTP. The first portion contains 2472 persons in 1362 households that participated in the 1990 survey of which 1865 persons answered all 23 attitudinal questions about mode perceptions and degree of satisfaction with transportation services. These questions are mostly instrumental and affective by Steg's classification (Steg, 2005). We also include the missing data persons and households because as we will see later they are substantially different from the respondents of the attitudes and display different behaviors. The second portion contains 230 households that participated in all ten waves and we verify if people with positive attitudes for some modes are consistently using these modes over time.

3. Multilevel latent class clustering of attitudes

In the past few years, a unifying framework of multilevel and longitudinal clustering and classification algorithms that merge latent modeling with latent class classification became available (Vermunt and Magidson, 2013). The definition of the multilevel models used here follow (Lukočienė et al., 2010). We use data from answers to 23 attitudinal questions ($i = 1, \dots, 23$) by j individuals ($j = 1, \dots, n_k$). The index k is used for the households and they are 1205. The sum of all n_k is 1865 individuals that provide attitudinal information. Different individuals belong to the same household ($k = 1, \dots, 1205$) and they give us the opportunity to examine how people with possibly different attitudes (heterophily) combine in the same household and if this has any impact on residential location and travel behavior.

In the following equations we use y_{kji} to represent the i response variables ($i = 1, \dots, 23$) of 23 attitudinal responses. The two level classes are at the individual level (denoted by categorical variable x_{kji}) and the household level (denoted by categorical variable w_k). f

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