Investigating suppressed demand effects for increasing car travel costs: A latent variable random effects Poisson (LVREP) approach

Motivation

Recent policy decisions in many developed countries, especially for urban areas, tend to favor car-less and pedestrian-friendly environments to reduce urban traffic and improve overall transport efficiency. The Post-Car World study focuses on intra-household reductions in travel behavior for changes in generalized transport costs, investigating suppressed demand effects from an activity-based perspective. The main research question addressed in this paper is how respondents change their mileage driven, given the increase in car travel cost: When do people start switching from car to other modes for large increases in mobility costs, including car sharing and pooling as potential alternatives (see also Weis, Dobler and Axhausen, 2013)? Results shed new light on the willingness to adapt under changing policy scenarios, presenting a sophisticated and innovative modeling approach in the field of travel behavior to estimate and quantify the price elasticity in the distance traveled by car for heterogeneous user types.

Survey methods

The data was obtained from 228 respondents living in Zurich, Switzerland, who 1) completed the computer-based personal stated adaptation (SA) interviews in the last part of a multi-stage travel survey and 2) traveled by car at least once during the previous one-week reporting period of travel and activity behavior. In addition, data was collected on respondents' mobility tools, personal and household characteristics as well as attitudes towards different mobility-related aspects, such as car-loving and conservative traits, environmental sensitivity and public transport affinity. For each respondent, one day of the one-week travel diary was selected to create the personalized choice sets. Complex schedules were preferred in order to capture a high diversity of potential reactions to changes in travel costs, investigating the changes in the respondents' whole daily schedules in several dimensions (Lee-Gosselin, 1996): Apart from changing travel modes, respondents could skip or add certain activities, change activity durations and activity patterns. When changing activity locations (e.g. to a closer shop or leisure activity), an interactive map presenting all current activity locations was supporting the respondents in their decisions.

Experimental design

The underlying reasoning for the changing cost environments were outlined to the respondents. The basic assumptions are that future policies, such as road tolls and congestion taxes for MIV (motorized individual vehicles; car and motor-bike) are introduced and that fuel prices increase and potentially outreach the pain thresholds of non-adaptive behavior, while MPV (motorized public vehicles; car sharing, taxi and carpooling) and public transport (PT) modes are subsidized by the government, a general tendency that can also be observed in Zurich. The interviewers introduced changes to travel costs by predefined factors, presenting the current situation as well as four adaptation scenarios to the respondents: MIV alternatives experienced the highest increase, with variable travel costs increasing by factors of 1.5 up to 8, while the changes in PT costs ranged between factors of 1.1 and 1.5 of current prices. Travel costs of MPV modes were based on current Swiss market prices and were increased by factors between 1.1 and 1.8.

Modeling framework

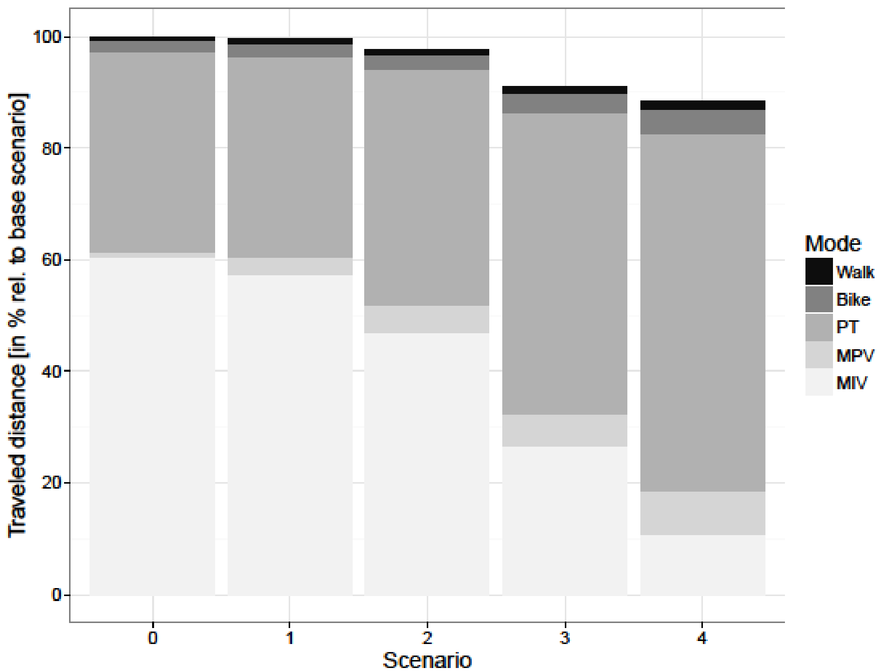
Given the rich data structure, the focus in this paper is on car travel behavior only, using a modeling approach that aims at to account for the nature of the non-negative and highly right-skewed dependent variable, the distance traveled by MIV. Importantly, to account for the excess zeros in the data (i.e. some respondents decided not to use their cars anymore), an exponential family modeling approach (Hausman et al., 1984) was found to fit the data best. Specifically, a latent variable random effects Poisson (LVREP) modeling approach was implemented: The main explanatory variable are the variable car kilometer costs, including interaction terms with socio-economic characteristics and one simultaneously estimated latent variable capturing respondents' environmental sensitivity. To better quantify the adaptation patterns to the increasing costs, a random effects panel data modeling approach was applied to capture unobserved heterogeneity, which for this data set is a major issue given the respondents' extremely heterogeneous daily plans as well as their distinct mode usage and ownership patterns.

Results and main conclusions

The main adaptation was a change in the travel mode, where the strongest adaptation occurred in scenario 3: About 37% of respondents changed modes, while about 18% changed the activity location or skipped some of their daily activities. As shown in Fig. 1, the modal split in traveled distance in the base scenario of about 60% for MIV decreased to 10% in scenario 4, while distance traveled by PT increased by over 30%.

Results of the LVREP model indicate, on average, that if variable MIV travel costs increase by 1%, distance traveled by MIV decreases by 0.5%, lying in the upper range compared to related studies. The quantification of this effect is an indicator to e.g. evaluate potential effects of planned road pricing schemes or fuel tax increases on travel demand. Significant heterogeneity in behavior with respect to socio-demographics and attitudes was found, showing that pro-environmental (the structural model of the latent variable reveals that environmental sensitivity is significantly more pronounced for younger and female respondents owning more than one bike and living in rural areas) and low-income respondents with a higher workload (i.e. regular working hours) exhibit a higher elasticity in the distance traveled by car. This finding is highly policy-relevant, as is shows that mainly "poor working class" respondents would be affected by price changes, while others react much less sensitive.

Figure 1: Modal split in traveled distance.



Literature

Hausman, J. A., B. H. Hall and Z. Griliches (1984) Econometric models for count data with an application to the patents-R&D relationship, *Econometerica*, **52** (4) 909-938.

Lee-Gosselin, M. E. (1996) Scope and potential of interactive stated response data collection methods, *Conference Proceedings*, **10** 115-133, Transportation Research Board, Washington D.C.

Weis, C., C. Dobler and K. W. Axhausen (2013) An interactive stated adaptation survey of activity scheduling decisions, in J. Zmud, M. Lee-Gosselin, M. Munizaga and J. A. Carrasco (eds.) *Transport Survey Methods: Best Practice for Decision Making*, 569-590, Emerald, Bingley.