An additive risk-based multistate model for activity chaining behavior analysis

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Abstract
Time-use pattern has been recognized for its correlation with socio-demographic characteristics, spatial settings and institutional contexts. Although the correlation between the duration of single activity participation and explicative covariates has been well studied, the interdependency structure between travel/activities conducted in different episodes of an activity chain is still a relatively unexplored subject.

Previous studies in this direction attempted to identify the interdependency of activity durations conducted in different episodes of the activity chain. Ettema et al. (1995) investigated the effects of temporal constraints on the activity choice, timing and duration, based on the parametric competing risk model. The results suggested that the activity choice, timing and duration are correlated with spatiotemporal constraints under activity chaining process. Bhat (1996) proposed an outcome-specific proportional hazard model to estimate the multiple types of activity duration, which combines activity choice and duration in its specification. Srinivasan and Guo (2007) utilized a mixing distribution for the random error term in a joint hazard-based model to investigate the correlation between durations of adjoined activities. Similarly, Pendyala and Bhat (2004) applied a discrete-continuous simultaneous equation model to investigate the causal structure of activity timing and duration. They found that the activity timing and duration are closely related for non-commuters but weakly related for commuters. Popkowski Leszczyc and Timmermans (2002) utilized conditional and unconditional parametric competing risk models to estimate activity duration and its relationship with socio-demographic covariates. The estimation results showed that the activity duration depends on the type and duration of the activity previously conducted.

Although these studies provided the empirical estimate for the temporal dependency on the activity chaining behavior, most of them are still limited within one or two episodes and lack simultaneous consideration of interdependency structure of activity-specific, timing and temporal constraints on the activity chaining behavior.

This work proposes an additive risk-based (Buckley, 1984) multistate model to investigate traveler's activity chaining behavior. We consider that activity pattern results from a semi-Markov stochastic process, which assumes that the activity-specific transition probability depends on its state type, sojourn times since entering occupied state and related covariates. Conditionally on the sequence of states visited previously, the semi-Markov property admits the estimation of state transition probability separately with cause-specific covariates. The multistate model provides a relevant framework to investigate the activity chaining behavior and related state transition probability estimates. Different from Cox proportional hazard model (Cox, 1972), the additive risk model incorporates the effects of covariates in an additive way, which relaxes the proportionality assumption of Cox proportional risk model and provides a more flexible way to investigate the effect of temporal constraints on the activity chaining behavior.

The proposed additive risk-based multistate model is applied on the Household Travel Survey data collected in Lyon during 2006. For comparative purposes, we provide empirical parameter estimates.
based on the additive risk and the Cox proportional hazard for one-step inter-episode transition hazard estimates. The overall goodness-of-fit statistics, survival function, selected covariates and the parameter estimates will be compared across episodes and activity types. A detailed discussion of the effects of activity-specific covariates on the transition hazard across episodes will be given and compared with existing studies.

Reference