



Modeling household activity travel behavior: Examples of state of the art modeling approaches and research agenda

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ABSTRACT

Even though the importance of representing group decision-making mechanisms of household behavior has been recognized since the 1980s in the context of the activity-based approach, studies about group behavior in transportation are relatively new and consequently limited, compared with the research about individual decisions. In line with the special issue “Modeling Intra-Household Interactions and Group Decision-Making” published in the Journal of Transportation in 2005, and motivated by the recent progress of group behavior research in transportation, this special issue presents examples of state-of-the-art modeling approaches to household activity travel decisions. We hope it will stimulate more intensive discussion about future research directions from both methodological and practical perspectives. Five papers are selected to cover diverse methodologies, including group decision theory, utility theory, latent class modeling, rule-based modeling, and micro-simulation approaches. The topics cover household task and time allocation, car ownership, vehicle transaction, mode choice, activity generation, and activity scheduling behavior.

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1. Introduction

Members in a household physically share various household resources (e.g., income, living space, car, etc.) and play different roles in the household. As a result, household members interact for long periods of time in various contexts. Such intra-household interaction can be usually observed in several ways. First, joint trip-making and activity participation by two or more household members clearly involve a group decision-making process. Second, in some other cases, even though household members do not join the same trip or activity, their decisions are influenced by other household members. Shopping is such an example. Since shopping is usually a household task, for instance, when a housewife goes to a supermarket to buy foods for dinner, she usually has to take into account other household members' tastes. Similarly, car allocation among household members needs a joint decision. Time allocation is another type of resource allocation within the household, which involves more or less group decisions, depending on the type of activities.

In addition to such daily activity travel behavior, one can also observe similar group decision-making phenomena in the context of long-term decisions (e.g., job choice, residential choice, choice of children's school, and car ownership behavior) and some non-daily behavior like tourism behavior. Thus, group decisions can be observed with respect to various aspects of household travel behavior. Nevertheless, models based on individual decision-making processes have dominated transportation research. Considering that the household is the basic unit of analysis in transportation, household behavior modeling

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from the viewpoint of group decisions is important for researchers and policy makers alike. Logically representing intra-household interaction is motivated by the need to bring more consistency in addressing the interdependencies that characterize travel behavior.

Even though the importance of representing group decision-making mechanisms of household behavior has been recognized by some researchers since the 1980s in the context of the activity-based approach, compared with the research about individual decisions, studies about group behavior in transportation are relatively new and consequently limited in number. Fortunately, these days, one can find an increasing number of studies focusing on group behavior. For example, several relevant papers were presented at the 11th International Conference on Travel Behavior, held in Kyoto in 2006. These papers present several types of promising methodologies related to both modeling and survey approaches. Recent reviews can be found in the selected papers for this special issue as well as in the review papers by Timmermans (2008), Zhang and Fujiwara (2008), and Zhang and Daly (2008).

2. A brief review of the selected papers

This special issue is in line with the special issue “Modeling Intra-Household Interactions and Group Decision-Making” published in the Journal of Transportation in 2005 (Bhat and Pendyala, 2005), where the selected papers represent “a great leap forward in understanding and modeling intra-household interactions and group decision-making in a rigorous activity-based behavioral context”, primarily focusing on the utility-based modeling approach. Different from that special issue, the papers selected for this special issue adopt diverse methodologies, including group decision theory, utility theory, latent class modeling, rule-based modeling, and micro-simulation approaches, and the topics cover household task and time allocation, car ownership, vehicle transaction, mode choice, activity generation, and activity scheduling behavior. A brief review of the papers is given below.

- (1) Kato, H. and Matsumoto, M. (2008): Intra-household interaction in a nuclear family: A utility-maximizing approach.
- (2) Wang, D. and Li, J. (2008): A model of household time allocation taking into consideration of hiring domestic helpers.
- (3) Roorda, M.J., Carrasco, J.A. and Miller, E.J. (2008): An integrated model of vehicle transactions, activity scheduling and mode choice.
- (4) Zhang, J., Kuwano, M., Lee, B. and Fujiwara, A. (2008): Modeling household discrete choice behavior incorporating heterogeneous group decision-making mechanisms.
- (5) Arentze, T.A. and Timmermans, H.J.P. (2008): A need-based model of multi-day, multi-person activity generation.

The first three papers attempt to improve existing methodologies, while the other two papers deal with some new modeling approaches.

First, Kato and Matsumoto (2008) propose a Tobit-type joint time allocation model in the context of a nuclear family with a *child* (a representative child). The model adopts a special case of the multi-linear and iso-elastic household utility, i.e., the additive type of household utility (Zhang et al., 2002; Zhang and Fujiwara, 2006). It refines the aforementioned studies in three ways. First, a child is explicitly introduced into the model. Even though the multi-linear and iso-elastic models can be theoretically used to represent the influence of children, this has not been empirically examined. Second, the newly developed model incorporates not only the constraint of available time, but also that of monetary budget. Third, the new model explicitly represents the occurrence of activity (i.e., whether an activity is performed or not) by using a non-linear Tobit-type modeling approach. In addition, comparisons of model estimation results between a mega city and a local city in Japan reveals that the size of a city could lead to different time allocation behaviors in the sense of both time use patterns and influential factors.

Second, Wang and Li (2008) present a model of household time allocation with the consideration of hiring *domestic helpers*. Although the modeling methodology adopted here is similar to the above-described paper, it is unique in the sense that it deals with the influence of domestic helpers on household time allocation behavior. The influence of cost of hiring the helpers on time allocation is incorporated with the help of all household members' incomes. Time of hiring the helpers is reflected into the model conditional on the constraint of total maintenance time required by the household. Such modeling approach reflects the fact that domestic helpers impose a continuing influence on the household across a given period of time. Even though hiring domestic helpers is a common practice in some limited Asian countries and regions such as Singapore, Hong Kong and the mainland of China, it could also have its specific policy implications with the increase of women (especially the married women) participating in the labor market in the context of other countries and regions. The paper provides a logical and operational method to represent the influence of some specific persons on household time allocation behavior. These persons could include not only the domestic helpers, but also the extended family members such as parents of household heads.

Third, Roorda et al. (2008) propose an integrated model of vehicle transactions, activity scheduling and mode choice with the help of the concept of *stress*, which is expected to “occur when one’s current state deviates from some alternative desired/expected/optimal state” (Miller, 2005). The importance of introducing the stress can be justified by the existence of irreversibility and uncertainty, especially in long-term decision, where transaction costs might be significant. The stress could come from both a household member him/herself under study and other member(s). The stress from other member(s) reflects the level of conflicts among the household members. The authors operationalize the concept of the stress, as a measure of potential improvement in behavioral change, based on the utility loss due to the unavailability of household

vehicles and the occurrence of conflicts over the use of household vehicles. In the integrated model, the stress is used as feedback into the model of vehicle transactions and type choice. Furthermore, the integrated model explicitly represents intra-household interaction in joint activity participation, vehicle allocation, and ridesharing, chauffeuring and conflict resolution.

Fourth, Zhang et al. (2008) develop a new type of household discrete choice model with *heterogeneous group decision-making mechanisms* by integrating group decision theory and latent class modeling approach. Concretely speaking, the authors first present a general modeling approach, which could theoretically incorporate various types of household decision-making mechanisms (mainly represented by the multi-linear and iso-elastic utilities, or their special cases) at the same time within the same modeling framework. Here, the latent class corresponds to a choice probability with particular household utility and the model is estimated based on the EM (Expectation–Maximization) algorithm. In theory, the proposed model can be used to represent any discrete type of household decision, irrespectively of whether the members involved in joint decision are known a priori or not. It can be also used to deal with any group with a pre-specified number of members.

Fifth and lastly, Arentze and Timmermans (2008) describe the household behavior based on the concept of *need* in the context of multi-day, multi-person activity participation. The need of household or its member is the source of motivations to perform various activities and the change of need consequently generates the utility. The authors introduce the concept of *potential* to illustrate how and how much an activity could satisfy certain need of a household and/or its member(s). Intra-household interaction is represented in several ways. First, it is proposed to use a weight that a household assigns to the household needs relative to the weight that a household member assigns to his/her personal needs. Accordingly, altruism-selfishness is implicitly incorporated. Then, an exchange procedure is further proposed to reflect the fact that the household members “use joint decision rules first to make their agendas consistent and next to see whether personal re-allocations could improve the group result.” The joint decision rules are introduced to properly evaluate the influence of disagreement between household members on the selection of household activities and the allocation to members. Since the need may vary over time, a dynamic micro-simulation approach is proposed.

3. New challenges

The selected papers for this special issue provide an additional set of promising state-of-art methodologies to represent household behavior modeling. However, studies are further required to model more interactions or interdependencies that characterize activity travel behavior across episodes and space, over time and among decision makers from context to context, given a set of dynamic constraints. Such modeling requirements come from the need to bring more behavioral consistency in predicting travelers’ responses under policy interventions, especially focusing on the context and situation effects, and temporal (e.g., week-to-week and day-to-day) effects. In addition, current model developments and empirical analyses mainly focus on decision outcomes, rather than the processes. Thus, future studies should pay more attention to exploring group decision-making processes that are closely linked with policy instruments. In line with such consideration, stated choice experiments could be a promising way to, for example, represent inter-personal negotiation.

The relative influence of household members should be further modeled as it seems to depend on contextual and situational variables. In addition, it seems relevant to estimate models with attribute-specific weights. It is necessary to clarify that to what extent households have developed a typical, habitual pattern that allocates tasks across household members, as well as the conditions under which households fall back to secondary or tertiary learned patterns that together make up a repertoire of interrelated household and individual-specific activity travel patterns. One of the issues in household activity travel patterns is the issue of uncertainty in making it on time to pick up the children, arriving on time for a joint activity etc. One of the coping strategies to deal with uncertainty in such situations is to rely on other household members and members of the social network. An interesting research question is to what extent this reliance on other household members occurs and to what extent the notion of permanent rescheduling behavior enabled by modern communication technology has intensified such reliance and reduced flexibility margins in activity travel scheduling behavior? A second one concerns the substitution of household members and members of the social network. This would bring in a broader scope, and also requires an investigation how to deal with decision-making in social networks. For these purposes, more theories are required, some of which could be drawn on from other research fields. Game theory could serve as a powerful tool, but needs to be examined based on more empirical studies.

Methodological breakthroughs are expected to deal with the complexity resulting from the consideration of the above-mentioned consistency, balancing between policy requirements and operational applicability. In this sense, comprehensive activity-based models should take a more fundamental look at household decision-making and incorporate more interdependencies between the choice facets of different household members across different days/weeks/months.

Finally, it is expected that more innovative models would be developed in the near future, but better understanding of group decision-making mechanisms requires more observation surveys with high quality, focusing on both decision outcomes and processes.

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