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Simultaneous modeling of individuals' duration and expenditure decisions in out-of-home leisure activities

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ABSTRACT

In this paper, we propose an activity model under time and budget constraints to simultaneously predict the allocation of time and money to out-of-home leisure activities. The proposed framework considers the activity episode level, given that the activity is scheduled. Thus, the model considers the decision of the quantities for duration and expenditure spent during the activity. We use a flexible utility function and show how the simultaneous equations can be estimated by using structural equations model (SEM) estimation techniques to handle the endogeneity problem of time and expenditure. The estimation results are based on a large national leisure diary data set collected in 2008 in the Netherlands, which provides detailed information about time and money spent as well as timing and location attributes of the activities. The analysis reveals that socio-demographics, travel party, timing and location variables influence the duration and expenditure of activity episodes. It shows that various socio-demographic groups display different preferences in terms of the time and money spent on activities. The results also indicate substitution relationships between spending more time and money for various activity categories. Thus it is concluded that the analysis provides useful results for a better understanding of combined time and money allocation decisions for leisure activities.

1. Introduction

Activity-based models have been developed to better represent the decision mechanisms of individuals and households that underlie their travel demand. Several models are operational for large scale application, such as Tasha (Roorda et al., 2008) and Albatross (Arentze and Timmermans, 2004). A distinctive feature of these models is their consideration of time expenditure on activities and travel for predicting activity-travel patterns in time and space. Time use studies in an activity-travel behavior context (e.g., Kitamura, 1984; Bhat and Misra, 1999) typically examine time allocation to in-home and out-of-home activities for different socio-demographic groups. However, time use for activities is also affected by monetary constraints and vice versa.

The study of monetary constraints on activity participation and time use started in the mid-sixties. Becker (1965) proposed a micro-economic framework addressing the importance of monetary constraints on activity participation. According to his framework, income was added as a constraint. Later, De Serpa (1971) and Evans (1972) proposed improvements and

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modifications of this model. According to these micro-economic theories, utility is a function of time spent on different activities and the consumption of goods during these activities which entails that costs are associated with the activity. Therefore, participation in an activity for a given duration implies a particular cost value. Constraints are derived from time and money budgets to conduct various activities.

These theories have provided the foundation for several recent studies, which aimed at developing a utility-maximizing simultaneous-equations approach, subject to time and money constraints (e.g., Kockelman, 2001; Jara-Diaz et al., 2008; Zhang, 2009; Konduri et al., 2011; Arentze and Timmermans, 2011). Kockelman (2001) modeled household consumption in the context of various discretionary activities across zones as a function of access travel times, and both time budget and income. In her approach, time expenditures are fundamental since the indirect utility is derived from travel times instead of prices. Jara-Diaz et al. (2008) used a Cobb–Douglas specification which is less flexible than Kockelman's approach but allows formulations of the utility function that have closed-form solutions. A further limitation of this approach is that it considers time use and consumption of goods as independent decisions in the sense that the goods consumed are not tied to specific activities. Konduri et al. (2011)'s study, which is based on Jara-Diaz et al. (2008), compared this microeconomic utility-based model with structural equations modeling. Zhang (2009) suggested a utility-maximizing approach in estimating a resource allocation model to describe pedestrian time use and expenditure simultaneously. However, the seemingly unrelated regression analysis used in his study for parameter estimation does not address the issue of endogeneity which occurs due to the correlation of time and money variables. Therefore, estimates may be biased.

Existing frameworks for modeling activity resource allocation, except Zhang (2009), typically consider allocation of budgets at the activity category level, strongly limiting the relevance of these approaches for urban and transportation planning. Activity category refers to the collection of activity episodes over some time unit. Thus these frameworks cannot incorporate conditions and choice facets such as location and timing that may vary across episodes of an activity and hence influence duration and expenditure choices as well. In particular, monetary expenditures are also affected by the location where an activity is conducted. First, by spending more time or money on traveling one can reach a more attractive location where people are likely to spend more time and money. Second, the location may influence time and money spent directly if locations differ in terms of price levels. In addition, timing variables such as start time and day of the week influence activity participation. Not incorporating these effects into models of time use allocations reduce their relevance to transportation planning. To address these issues, Arentze et al. (2010) therefore developed a random utility maximization (RUM) dynamic activity-based framework for simultaneous modeling time and money budget constraints at the activity episode level. In this approach, agents make time and money allocation decisions on a daily basis taking into account day-varying conditions and also the available budgets for a longer time horizon. Due to lack of data, this approach has not been empirically estimated yet.

There are activity-scheduling models (e.g., Habib, 2011; Habib et al., 2012 and Bhat, 2005) which are also based on micro-economic theories of time allocation. However, these studies consider only a single resource, usually, the time budget. Therefore, they cannot handle two resources such as time and money budgets simultaneously. Bhat (2005) proposed an econometric model called the multiple discrete–continuous extreme value (MDCEV) model. This model allows for zero allocation of time to activities and reduces to a logit model under specific assumptions. Thus, it considers activity participation and time allocation choices simultaneously within a given time-budget constraint which makes it a comprehensive model. However, it only considers one resource. Habib (2011) proposed a framework that uses random utility maximization based on discrete continuous modeling for daily activity scheduling within a time-budget constraint. After an activity is conducted, time budget decreases for other activities. Therefore the dynamics of scheduling are modeled by the change in time budget availability in a day and also by the history of activity participation. The model deals with activity scheduling processes and uses the scheduled activity information for empirical estimation. For this model, only time expenditure and activity type are considered. In another study, Habib et al., 2012 proposed random utility maximization based activity-travel scheduling model under time-budget, which are used to investigate the relationship between transportation system performance and daily activity-travel scheduling process. The model can capture the effects of travel time changes on activity type choice, time of day choice and activity duration choice jointly.

In this paper, we propose an activity model under time and budget constraints to simultaneously predict the allocation of time and money to out-of-home leisure activities. The proposed model is derived from well-established utility-based economic theories of resource allocation. The proposed utility function is more flexible than a Cobb–Douglas function and has no closed-form solution. Moreover, the proposed framework considers the activity episode level, given that the activity is scheduled. Thus, the model considers the decision of the quantities of duration and expenditure spent during the activity. We formulate and empirically estimate the proposed model. There is the issue of endogeneity which means that duration and expenditure are correlated. In a consistent estimation of the two functions for duration and expenditure, the resulting error terms should be uncorrelated. To achieve this, a structural equation modeling approach is required. We show how the duration and expenditure equations can be estimated by using structural equations model (SEM) estimation techniques. An important advantage of this new approach is that no closed form of model is required and hence a more flexible utility function can be used. The estimation results presented in this study are based on a large national leisure diary data set (CVTO) collected between 2008 and 2009 in the Netherlands, which provides detailed information about time and money spent as well as timing and location attributes at the activity episode level.