An Analysis of the Long-Term Changes of Cross-Sectional Variations in Japanese Time Use Behavior Using Multilevel Multiple Discrete-Continuous Extreme Value Model

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Extended Abstract

It is expected that activity and travel behavior changes over time. Such behavioral change could occur in both short-term (e.g., hour-to-hour, day-to-day, and week-to-week) and long-term (e.g., year-to-year) contexts. This paper focuses on the long-term changes, which have been extensively examined in western developed countries, but have not been well examined in the Asian context due to the lack of available data. In addition, one of the shortcomings of the existing studies is that they mainly deal with the “average” behaviors, rather than their variations. In our understanding, such shortcoming is mainly caused by the lack of sophisticated methodology. Although such “average” behaviors are certainly one of the most important aspects of behavioral changes to some extent, ignoring the variations would lose a lot of useful information for both behavior analysis and policy analysis. For example, while individual mobility to perform an activity might be improved due to the changes of transportation systems at the “average” level, there would be a possibility to increase the mobility gap between urban and rural areas. Understanding such spatial variations in activity and travel behavior could provide more socially acceptable insights to policy makers, who, for example, attempt to allocate the available budgets to different regions by giving a spatial balance of mobility improvement. Information of variations would be useful not only for such mobility aspects, but also in the discussions related to problem of equity or equality, such as income imbalance and gender inequality. These problems would be most severe in developing nations, but some would be still left in developed countries, e.g., gender disparity problem in Japan. Since time use is one of the very important aspects related to these problems, this study focuses on time use behavior and adopts a national time use data from the “Survey on Time Use and Leisure Activities” conducted by the Ministry of General Affairs in Japan. The adopted time use data were collected at 4 points in time (1986, 1991, 1996 and 2001), respectively. The data include individual time use behavior on a given weekday and a weekend day, as well as individual and household attributes such as household income, residential location, car ownership, member’s occupation and gender, etc.

Here, two types of variations in time use behavior at a point in time (called cross-sectional variations) are distinguished: inter-individual variation and spatial variation at prefecture level. Note that we cannot identify the differences between intra- and inter-individual variations because the adopted data is not a panel data. Therefore, the term “inter-individual variation” is used to represent both intra- and inter-individual variations in this study. On the other hand, spatial variation can be observed when the behavioral differences are caused by the spatial differences related to the place where a decision maker is located. Inter-individual and spatial variations are captured using a multilevel modeling approach. Since some of activities might be not performed on a given day, it becomes necessary to describe whether an activity is performed or not, together with the time allocation in case of
participating in the activity. To accommodate activity participation and time allocation simultaneously, a multiple discrete-continuous extreme value (MDCEV) model, originally proposed by Bhat (2005), is adopted. The MDCEV model is further extended to represent the above-defined variations by integrating with the multilevel modeling approach (called multilevel MDCEV model). Note that the adopted time use data is not a panel data, thus the multilevel MDCEV model is estimated for each time point separately, and we will compare the differences of estimation results at prefecture level (e.g., the differences of car ownership effects between prefectures) across different time points.

In order to estimate the multilevel MDCEV model, we employ a hierarchical Bayesian approach with Markov Chain Monte Carlo (MCMC) method. Such method incorporates prior distribution assumptions and, based upon successive sampling from posterior distributions of the model parameters, yield a chain which is then used for making point and interval estimations. The reasons for employing MCMC method are not only to obtain approximate maximum likelihood estimates, but also to obtain Bayesian Shrinkage Estimator (BSE). BSE is a compromise estimate between the unstable heterogeneous estimates and the untenable homogeneity estimates in order to obtain robust/stable estimates. For example, if the number of samples in a certain prefecture is relatively small and the estimates seem to be unstable, the estimates would shrink to the estimate of national average. BSE can provide the detailed information of variations, i.e., the difference of responses between prefectures can be identified quantitatively.

The multilevel MDCEV model is estimated by incorporating individual/household attributes, such as car ownership, gender and age. These parameters are estimated with the random coefficients of residential location at prefecture level, in order to examine the interactions between these variables and residential locations. For example, if we introduce a random coefficient at prefecture level for gender variable used to describe the work-related time use behavior and observe quite high interaction with residential location, it implies that there are gender differences across prefectures for work-related time use behavior. At the same time, with the estimation results of each time point, we will make discussions on whether the gender differences across prefectures are expanding or not over time. In addition, the above-mentioned BSE can provide further detailed information of these differences, i.e., how much of the differences there are across prefectures.

In this paper, we will give a comprehensive discussion on the long-term changes of: 1) cross-sectional variations (e.g., whether the mobility gap across prefectures is expanding or not over time); 2) the proportion of spatial variation to inter-individual variation; and 3) influential factors related to time use behavior. Even though we apply the multilevel MDCEV model to the analysis of time use behavior, it is expected that this new model could be also applicable to other aspects of activity and travel behavior.

Reference