Towards Comprehensive Modelling Approach and Consistent Behavioural Assumptions for Activity-Based Travel Demand Model: A Random Utility Maximizing Activity Scheduling Model

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1. Introduction

Although activity-based approach to travel demand modelling was introduced three decades ago, the conventional trip-based models are still in use for practical policy investigation in almost everywhere with very few exceptions. The main reason of such failure is the lack of comprehensive modelling framework with consistent behavioural assumptions that can completely replace well-structure trip-based four-stage model. Many issues related to the modeling framework, such as the concept of activity utility, application of so-called rules, modeling time frame (daily versus weekly), and time discretization are still under debate in the research community. The only significant consensus that has been apparently reached so far is the recognition of two general components for an activity-based travel demand model: the activity generation component and the activity scheduling-rescheduling component (Habib and Miller, 2009). There is now significant interest among researchers in capturing the dynamic behavioural process of these two components within comprehensive modelling framework under consistent behavioural assumption, e.g. Random Utility Maximization (RUM). Habib and Miller (2008) presented RUM-based models of activity generation processes. However, to date no such unified econometric model is available for the activity scheduling process. In an effort to address this issue, an econometric model for the activity scheduling process based on RUM is proposed in this paper.

The proposed modeling framework exploits the RUM-based approach to modeling activity scheduling process by considering the dynamics of the time budget constraint over the course of a day. The unique feature of the proposed model is that it does not need to discretize the time. Econometrically the proposed model is a dynamic RUM-based Joint discrete continuous model. For empirical investigation, the proposed framework is applied for weekend activity scheduling using 2002–2003 CHASE (Computerized Household Activity Scheduling Elicitor) survey data collected in Toronto, Canada.

2. RUM-Based Activity Scheduling Model

Let us consider that an individual, i, at a particular point in the day is to choose an activity type and corresponding time expenditure, t_j. In expending time for the chosen activity, however, the individual faces a time budget limitation. This time budget limitation is not constant throughout the day. The day begins with a 24-hour time budget limitation, which is gradually reduced with the number of activities performed over the course of the day. The remaining time budget at any point of scheduling an activity is the left over time after all previously performed activities have been completed. While executing an activity, i.e., defining the duration of a specific activity, the individual trades off between time expenditure to the chosen activity versus total time left over for all other activities to be completed in the balance of the day. As we do not know for certain the causes and factors that influence the individual's tradeoffs in choosing alternative activity types and time expenditures out of a limited time budget, it is reasonable to consider the assumption that the utility associated with activity type and time expenditure includes random elements. Hence, the utility maximizing approach to model activity type choice and time expenditure choice is really a Random Utility Maximizing (RUM) approach. Addressing the facts that the time budget decreases as the day progresses and that the scheduling of any particular activity type is affected by what activities the individual already completed in a given day ensures that the method will capture the true behavioral dynamics of the activity scheduling process. In the context of such a situation the choice of a given activity type at any point in time influences expenditures of the limited amount of time from the left over time budget, and vice versa.

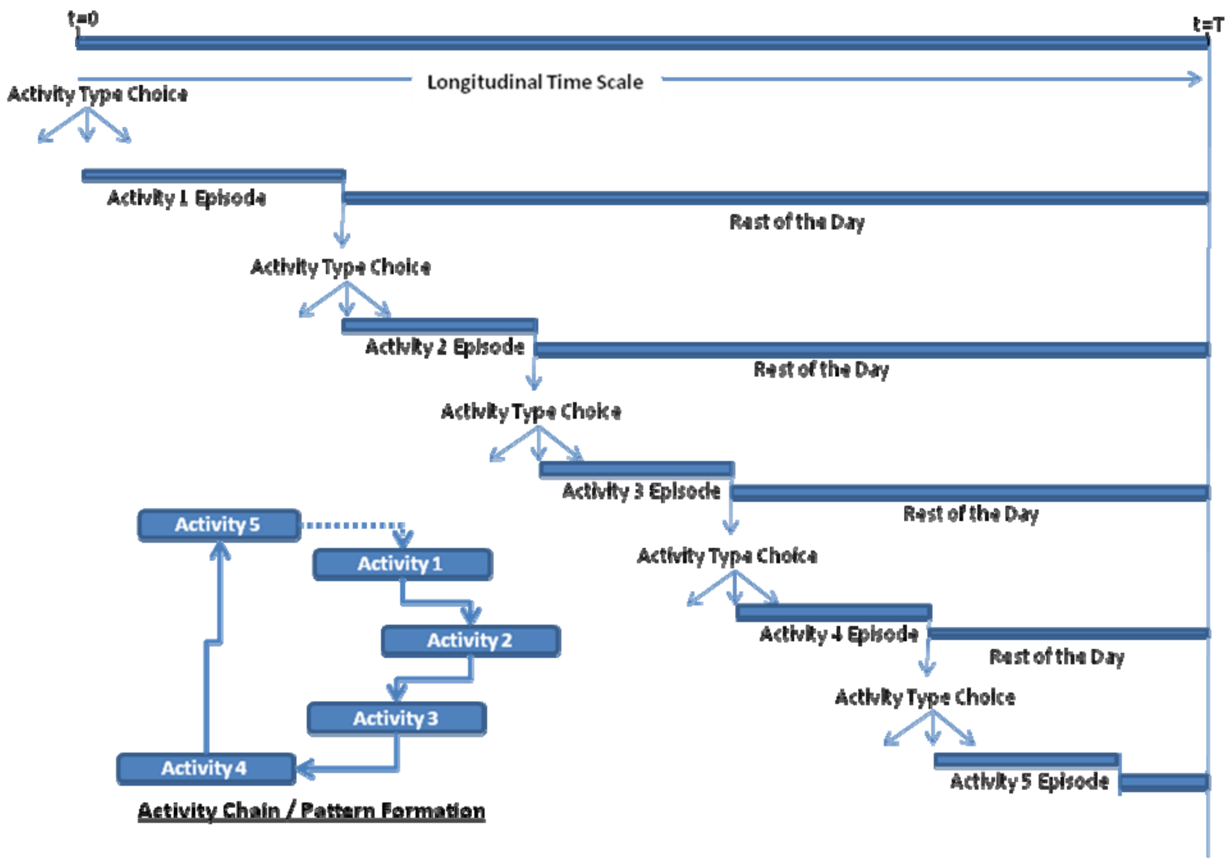

Figure 1: Dynamic Discrete-Continuous Approach to Model Activity Pattern Formation

Figure 1 presents the schematic diagram of such a prototype example of the activity scheduling choice process. This is an example of a single day modeling framework. In the case of a multi-day scheduling process the end of day activity of the previous day is regarded as the first activity of the following day. However, in the case of a single day (a 24-hour time span) model this may or may not be true. In this paper we are presenting a single-day activity scheduling model, where the scheduling process begins at midnight (*t*=0) and continues until the end of the day. For a 24-hr modeling timeframe such temporal referencing is unavoidable, even though it creates left and right censoring issues for the first and last activities. However, beginning at the reference time (*t*=0) different people might perform different numbers and types of activities before the end of the day and thereby may have different types of activity patterns. The proposed approach does not consider different activity patterns as alternatives, rather it models the scheduling process, so that the activity pattern evolves out of the dynamic scheduling process.

3. Econometric Model Formulation

From a modeling point of view the challenge is that the dynamics of activity scheduling and correlation between activity type choice and corresponding time allocation are sufficiently captured in the RUM-based model formulation.

3.1 *Formulation of Utility Function*

let us assume that the utility function of the individual person, *i*, for the *j* alternative activity type choice is:

$$U_j = V_j + \varepsilon_j = \beta_j x_j + \varepsilon_j \quad ; \quad j = 1,2,3,.........A \tag{1}$$

Where V_j is the systematic utility, x_j is a set of explanatory variables, β_j is corresponding parameter vector and ε_j is the random term. Similarly, let us assume that the total direct utility function of the same individual for time expenditure, (t_k) in chosen activity is (Bhat, 2008):

$$U(t_k) = \sum_{k=1}^{2} \frac{\gamma_k}{\alpha_k} \left[\exp(\psi_k z_k + \varepsilon_k^{/})\right] \left\{ \left(\frac{t_k}{\gamma_k} + 1 \right)^{\alpha_k} - 1 \right\} \tag{2}$$

Here k=1 indicates the chosen activity and k=2 indicates the remainder of the amount of time (the composite activity) under the available time budget. The component, $exp(\psi_k z_k + \varepsilon_k^{/})$, is the baseline utility function. In the baseline utility function, z_k indicates a vector of explanatory variables; Ψ_k indicates a vector of coefficient corresponding to z_k; and $\varepsilon^{/}_k$ is the unobserved random error component of the random utility function. Among other components of the utility function, α_k is the satiation parameter and γ_k is the translation parameter. If the total time budget available is given by T, then the time allocation decision becomes an optimization problem under time budget constraints:

$$t_j + t_c = T \tag{3}$$

Here the subscript, $_j$, indicates the time allocated to the current chosen activity while $_c$ indicates the time left over for the composite. By using the Lagrangian function we get:

$$l = \sum_{k=1}^{2} \frac{\gamma_k}{\alpha} \left[\exp(\psi_k z_k + \varepsilon_k^{/})\right] \left\{ \left(\frac{t_k}{\gamma_k} + 1 \right)^{\alpha} - 1 \right\} - \lambda \left[\sum_{k=1}^{2} t_k - T \right] \tag{4}$$

$$\text{Here } k = 1,2 \text{ refer to j and c}$$

Here λ is the Lagrangian multiplier. According to the first-order Kuhn-Tucker optimality condition (Kuhn and Tucker, 1951), the generalized expression can be written as:

$$\left[\exp(\psi z + \varepsilon^{/})\right] \left\{ \left(\frac{t}{\gamma} + 1 \right)^{\alpha - 1} \right\} - \lambda = 0, \; if \; t = t_k, \; k = 1,2 \tag{5}$$

$$\left[\exp(\psi z + \varepsilon^{/})\right] \left\{ \left(\frac{t}{\gamma} + 1 \right)^{\alpha - 1} \right\} - \lambda < 0, \; if \; t < t_k, \; k = 1,2 \tag{6}$$

Considering the composite activity as the reference activity (k=c) for time allocation and given the circumstance that composite activity time allocation is a non-zero value, we can specify λ as a function of the composite activity function:

$$\lambda = \left[\exp(\psi_c z_c + \varepsilon_c^{/})\right]\left\{\left(\frac{t_c}{\gamma_c} + 1\right)^{\alpha - 1}\right\} \qquad (7)$$

Substituting λ in the Kuhn-Tucker optimality conditions we can specify that for a case of $t_j > 0$:

$$\left[\exp(\psi_j z_j + \varepsilon_j^{/})\right]\left\{\left(\frac{t_j}{\gamma_j} + 1\right)^{\alpha - 1}\right\} - \left[\exp(\psi_c z_c + \varepsilon_c^{/})\right]\left\{\left(\frac{t_c}{\gamma_c} + 1\right)^{\alpha - 1}\right\} = 0$$

$$\left[\exp(\psi_j z_j + \varepsilon_j^{/})\right]\left\{\left(\frac{t_j}{\gamma_j} + 1\right)^{\alpha - 1}\right\} = \left[\exp(\psi_c z_c + \varepsilon_c^{/})\right]\left\{\left(\frac{t_c}{\gamma_c} + 1\right)^{\alpha - 1}\right\}$$

Taking the logarithm of both sides:

$$(\psi_j z_j + \varepsilon_j^{/}) + (\alpha - 1)\ln\left(\frac{t_j}{\gamma_j} + 1\right) = (\psi_c z_c + \varepsilon_c^{/}) + (\alpha - 1)\ln\left(\frac{t_c}{\gamma_c} + 1\right)$$

$$\left[\psi_j z_j + (\alpha - 1)\ln\left(\frac{t_j}{\gamma_j} + 1\right)\right] + \varepsilon_j^{/} = \left[\psi_c z_c + (\alpha - 1)\ln\left(\frac{t_c}{\gamma_c} + 1\right)\right] + \varepsilon_c^{/} \qquad (8)$$

$$V_j^{/} + \varepsilon_j^{/} = V_c^{/} + \varepsilon_c^{/}$$

The above condition of equality applies to an expenditure of t_j amount of time on the given activity. Similarly, for the case where $t < t_j$

$$V_j^{/} + \varepsilon_j^{/} < V_c^{/} + \varepsilon_c^{/}$$

Here, the systematic utility component of activity time allocation is

$$V_k^{/} = \left[\psi_k z_k + (\alpha - 1)\ln\left(\frac{t_k}{\gamma_k} + 1\right)\right], \; k = j, c$$

Now to derive the probability function of spending a specific amount of time, (t_2), we can further modify Equation (8) (Bhat, 2008)

$$\begin{aligned} \varepsilon_j^{/} - \varepsilon_c^{/} &= V_c^{/} - V_j^{/} \qquad for \quad t = t_j \\ \varepsilon_j^{/} - \varepsilon_c^{/} &< V_c^{/} - V_j^{/} \qquad for \quad t < t_j \end{aligned} \qquad (9)$$

3.2 Assumption of Error Term Distributions and Deriving Probability Distribution Functions

According to RUM theory, an alternative activity, *j*, will be chosen if the utility of that alternative activity is the maximum of all considered alternatives.

$$U_j > \max_{n = 1,2,3......A,\, n \neq j} U_n$$

$$V_j > \left\{\max_{n = 1,2,3......A,\, n \neq j} U_n\right\} - \varepsilon_j$$

So,

$$\Pr(U_j > \max_{n=1,2,3......A, n \neq j} U_n) = \Pr\left(V_j > \left\{ \max_{n=1,2,3......M, n \neq j} U_n \right\} - \varepsilon_j \right)$$
$$= \Pr\left(V_j > (V_n + \varepsilon_n) - \varepsilon_j\right) \quad (10)$$
$$= \Pr\left(V_n < V_j + (\varepsilon_j - \varepsilon_n)\right)$$

Let us assume that the random variable, ε_j, has the IID Type I Extreme-Value distribution with a mean value of 0 and a scale parameter of 1. Hence, the implied cumulative distribution of the random error term of the chosen alternative, $F(\varepsilon_A)$, can be written as (Ben-Akiva and Lerman, 1985; Lee, 1983; Train, 2003):

$$\Pr(\varepsilon_n < V_j - V_n + \varepsilon_j) = \frac{\exp(V_j)}{\exp(V_j) + \sum_{n \neq j} \exp(V_n)} = \frac{\exp(\beta_j x_j)}{\exp(\beta_j x_j) + \sum_{n \neq j} \exp(\beta_n x_n)}$$
$$\therefore\ F(\varepsilon_j) = \frac{\exp(V_j)}{\exp(V_j) + \sum_{n \neq j} \exp(V_n)} = \frac{\exp(\beta_j x_j)}{\exp(\beta_j x_j) + \sum_{n \neq j} \exp(\beta_n x_n)} \quad (11)$$

For the time allocation model of chosen activity, as shown in Equation (9), let us assume the similar distribution assumption for the random error component, ε'_j, to be an IID Type I Extreme-Value distribution with a mean value of 0 and a scale parameter of σ. Since the time allocation follows the discrete activity type choice, the time allocation is concerned with two alternative options (the chosen activity and the composite activity). According to RUM theory, (considering the time budget constraints and the Kuhn-Tucker optimality condition), the time allocation, t_j, to the chosen activity depends on the condition shown in Equation (9). As mentioned above, the difference between two IID Extreme-Value random terms is logistically distributed. Moreover, the probability distribution function (PDF) and cumulative distribution function (CDF) of ε'_j are given by (Johnson et al., 1995):

$$\Pr\left(\varepsilon'_j = (V'_c - V'_j) + \varepsilon'_c\right) = \frac{1}{\sigma} \exp\left(\frac{-(V'_c - V'_j)}{\sigma} \right) \left[1 + \exp\left(\frac{-(V'_c - V'_j)}{\sigma} \right) \right]^{-2}$$
$$\Pr\left(\varepsilon'_j < (V'_c - V'_j) + \varepsilon'_c\right) = \left[1 + \exp\left(\frac{-(V'_c - V'_j)}{\sigma} \right) \right]^{-1} \quad (12)$$

To ensure model identification, the specification of V'_{ji} and V'_{ci} can be further specified as (Bhat, 2008):

$$V'_j = \left[\psi_j z_j + (\alpha - 1) \ln\left(\frac{t_j}{\gamma_j} + 1 \right) \right]$$
$$and \quad (13)$$
$$V'_c = (\alpha - 1) \ln(t_c)$$

Here V'_{ci} indicates the composite activity for the corresponding chosen activity type under remaining time budget constraints. Now, according to the change of variables theorem, the probability distribution function (PDF) can be determined as follows:

$$\Pr\left(t=t_j\right)=\left(\frac{\delta\left((V_c^{/}-V_j^{/})\right)}{\delta t_j}\right)\frac{1}{\sigma}\exp\left(\frac{-(V_c^{/}-V_j^{/})}{\sigma}\right)\left[1+\exp\left(\frac{-(V_c^{/}-V_j^{/})}{\sigma}\right)\right]^{-2}$$

$$=\left(\frac{1-\alpha}{t_j+\gamma_j}+\frac{1-\alpha}{t_c}\right)\frac{1}{\sigma}\exp\left(\frac{-(V_c^{/}-V_j^{/})}{\sigma}\right)\left[1+\exp\left(\frac{-(V_c^{/}-V_j^{/})}{\sigma}\right)\right]^{-2}$$

where, (14)

$$\left(\frac{\delta\left((V_c^{/}-V_j^{/})\right)}{\delta t_j}\right)=\frac{\delta}{\delta t_j}\left((\alpha-1)\ln(T-t_j)-\psi z-(\alpha-1)\ln\left(t_j/\gamma_j+1\right)\right)$$

$$=\frac{(1-\alpha)}{t_j+\gamma_j}+\frac{(1-\alpha)}{t_c}$$

And

$$\Pr\left(t<t_j\right)=\left[1+\exp\left(\frac{-(V_c^{/}-V_j^{/})}{\sigma}\right)\right]^{-1}$$

$$\therefore\ F(\varepsilon_j^{/})=\left[1+\exp\left(\frac{-(V_c^{/}-V_j^{/})}{\sigma}\right)\right]^{-1} \quad (15)$$

3.3 Joint Probability of Activity Type Choice and Time Allocation

For joint estimation of RUM-based activity type choice and time allocation model, let us consider that the transformed error terms are bivariate normal distributes. As per Lee (1983), the transformed error terms are:

$$\varepsilon_j^{*}=J_1(\varepsilon_j)=\Phi^{-1}[F(\varepsilon_j)]$$
$$\varepsilon_k^{*}=J_2(\varepsilon_j^{/})=\Phi^{-1}[F(\varepsilon_j^{/})] \quad (17)$$

These transformed error terms are correlated with correlation factor ρ_{jt}: BVN[$J_1(\varepsilon_j)$, $J(\varepsilon_j^{/})$, ρ_{jt}]. So,

$$\Pr(Time=t_j\cap Activity\ Type=j)=\Pr(Time=t_j\cap\varepsilon\le J_1(\varepsilon_j))$$

$$=\left(\frac{1-\alpha}{t_j+\gamma_j}+\frac{1-\alpha}{t_c}\right)\frac{1}{\sigma}\exp\left(\frac{-(V_c^{/}-V_j^{/})}{\sigma}\right)\left[1+\exp\left(\frac{-(V_c^{/}-V_j^{/})}{\sigma}\right)\right]^{-2}\Phi\left(\frac{J_1(\varepsilon_j)-\rho_{jt}J_2(\varepsilon_j^{/})]}{\sqrt{1-\rho_{jt}^2}}\right) \quad (18)$$

Based on the above formulation, the likelihood function, L_i, of an individual observation, i,, can be written as:

$$L_i=\prod_{j=1}^{A}\left(\left(\frac{1-\alpha}{t_{ji}+\gamma_{ji}}+\frac{1-\alpha}{t_{ci}}\right)\frac{1}{\sigma}\exp\left(\frac{-(V_{ci}^{/}-V_{ji}^{/})}{\sigma}\right)\left[1+\exp\left(\frac{-(V_{ci}^{/}-V_{ji}^{/})}{\sigma}\right)\right]^{-2}\Phi\left(\frac{J_1(\varepsilon_{ji})-\rho_{jt}J_2(\varepsilon_{ji}^{/})]}{\sqrt{1-\rho_{jt}^2}}\right)\right)^{D_{ji}} \quad (19)$$

D_{ji} is a binary indicator variable for the chosen activity type

Here D_{ji} is a binary indicator variable for the chosen alternative activity. Now if we consider the sequence of activity selection and corresponding time allocation, i.e., the activity scheduling process for 24-hour time period, the joint likelihood function of the complete schedule of an individual, *i*,, becomes:

$$L_{Ti} = \prod_{Z=1}^{S} \left[\prod_{j=1}^{A} \left(\begin{array}{c} \left(\dfrac{1-\alpha}{t_{ji}+\gamma_{ji}} + \dfrac{1-\alpha}{t_{ci}} \right) \dfrac{1}{\sigma} \exp\left(\dfrac{-(V_{ci}^{/} - V_{ji}^{/})}{\sigma} \right) \left[1 + \exp\left(\dfrac{-(V_{ci}^{/} - V_{ji}^{/})}{\sigma} \right) \right]^{-2} \\ \Phi\left(\dfrac{J_1(\varepsilon_{ji}) - \rho_{jt} J_2(\varepsilon_{ji}^{/})]}{\sqrt{1-\rho_{jt}^2}} \right) \end{array} \right)^{D_{ji}} \right]_Z \tag{20}$$

Here S is the total number of activities performed in the 24-hour time period. Now, if we have a sample of observation with sample size, N, the joint likelihood function for the sample, L, becomes:

$$L = \prod_{i=1}^{N} L_{Ti} \tag{21}$$

This expression is a likelihood function of a dynamic RUM discrete-continuous model. It is of a closed form and can be estimated using classical Maximum Likelihood Estimation (MLE) algorithms.

4. Data for Empirical Investigation

CHASE survey data from the first wave of the Toronto Travel-Activity Panel survey (TAPS) are used in this paper for empirical modeling of weekend activity scheduling (Doherty et al, 2004). The CHASE survey was conducted in Toronto in 2002-2003 among 426 individuals in 271 households. After cleaning the dataset for missing information, a total of 423 individuals from 264 households were selected for the sample to estimate the empirical model. In this dataset activities are classified into 9 general types: Basic Needs, Work/School, Household Obligation, Drop/Pick, Shopping, Recreational, Social and Other. Now, if we define the scheduling of an activity type at any point in time as a scheduling cycle, then the observed weekend schedules are composed of a minimum of 3 cycles and a maximum of 30 cycles and the average number of scheduling cycles is 12.

5. Empirical Model of Weekend Activity Scheduling

The modeling begins with activity type choice at the beginning of the day, and the corresponding time expenditures are monitored. At the end of the first activity, the same process of type selection and corresponding time expenditure follows until the end of the day. The process of choosing an activity and consequent time expenditure may be referred as scheduling steps or scheduling cycle. At every scheduling step in the continuous time expenditure model component, we consider the trade-off in time expenditure to the specific chosen activity type, with respect to the leftover time for the composite activity.

The estimated model parameters are presented in Table 1. Several types of variables are considered in the model estimation process. These include socio-economic, residential location, transportation system performance, and activity specific attributes. The complicated structure of the model and the intention of joint estimation of a dynamic 24-hour activity scheduling process posed a significant challenge in parameter estimation for the given sample of data. However, surprisingly, it was found that the estimation process is fairly efficient and a large number of parameters (106 parameters) can be estimated using even a small sample. This is an indication of the behavioural validity of the modeling structure. It proves that the econometric modeling structure fits well with the observed dynamic scheduling formation process.

A series of specifications were tested and, after removing insignificant parameters in different combinations of variable specifications, the final specification (presented in Table 1) was reached. In terms of variables, similar variables entered into the systematic part of the activity type choice utility function and the baseline utility function of the continuous time expenditure model component. In addition to the accommodation of self-selection effects in activity type selection for scheduling and corresponding time expenditure, an unrestricted correlation between unobserved factors influencing activity type choice and time expenditure is accommodated. The goodness-of-fit of the estimated model is calculated using the adjusted rho-square value of 0.1, which is reasonable for such a complicated model structure.

6. Direction for Future Research

Future application of this modeling framework for weekday or complete weekday-weekend scheduling behaviour will be explored. Finally, many variables related to activity location and inter-household interactions are incorporated as exogenous variables in this paper. It is important to incorporate activity location choice within this modeling framework. Similarly, inter-household interactions and travel mode choice (if a trip is necessary in order to arrive at the location of the activity) are also important. It is understood that integration of the activity scheduling model with an activity generation model would resolve issues related to modeling timeframe (typical day versus week-long model). All of these factors pose methodological challenges and hence are taken into account in recommendations for further research.

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Table 1: Estimated Parameters of Weekend Activity Scheduling Model

Activity type Choice Model Component

Variables	Activity Type	Parameter	t-Statistics
Constant			
	Household Obligations	-2.1392	-5.155
	Drop off/Pick up	-3.6148	-22.471
	Shopping	-3.4814	-19.992
	Services	-3.6015	-12.206
	Other	-1.4744	-2.197
Star Time in Hours from Mid Night			
	Work/School	-0.1055	-9.778
	Drop off/Pick up	-0.0238	-1.591
	Services	-0.0414	-1.861
	Recreation/Entertainment	0.068	11.61
	Other	0.0536	4.858
Number of Activities already Performed from beginning of the day			
	Basic Needs	-0.0934	-11.99
	Work/School	0.0838	4.73
	Drop off/Pick up	0.0462	2.127
	Shopping	0.0568	3.708
	Services	0.0554	1.689
	Social	0.0844	5.98
Total Travel Time (Minutes) Required to go the Activity Location from the previous ActivityLocation			
	Basic Needs	-0.0716	-22.228
	Work/School	0.0065	3.557
	Household Obligations	-0.0502	-12.548
	Recreation/Entertainment	-0.0301	-11.021
	Other	-0.0272	-5.435
Household Size: Number of People in the Household			
	Work/School	-0.1001	-2.629
	Household Obligations	-0.09	-2.742
	Shopping	-0.0746	-1.739
	Recreation/Entertainment	-0.1511	-6.723
	Social	-0.2036	-5.246
	Other	-0.1678	-3.678
Logarithm of Age in Years			
	Work/School	-0.4985	-9.374
	Household Obligations	0.242	2.265
	Recreation/Entertainment	-0.583	-19.243
	Social	-0.9811	-13.203
	Other	-0.4025	-2.349

Table 1 (Continue)

Gender: Male		
Work/School	0.3301	3.913
Household Obligations	-0.5607	-7.669
Logarithm of Yearly Income in Canadian Dollars (2002-2003)		
Work/School	0.0276	1.896
Household Obligations	-0.0246	-2.377
Services	-0.0328	-1.422
Social	0.0426	2.152
Other	-0.0458	-2.738
Number of Automobile in Household		
Recreation/Entertainment	0.0943	2.206
Employment Status: Non-Full Time Job		
Household Obligations	0.1645	2.147
Recreation/Entertainment	0.1167	1.867
Social	0.3476	2.899
Number of Children in Household		
Work/School	0.0808	1.501
Household Obligations	0.2999	7.411
Drop off/Pick up	0.3959	8.791
Time Expenditure Model Component		
Constant		
Basic Needs	-1.8765	-5.583
Star Time in Hours from Mid Night		
Work/School	0.0355	1.95
Household Obligations	0.0441	2.965
Drop off/Pick up	0.3274	10.362
Shopping	0.1742	5.58
Services	0.1753	2.251
Recreation/Entertainment	0.3276	22.311
Social	0.2699	9.087
Other	0.1768	9.427
Number of Activities already Performed from beginning of the day		
Basic Needs	0.1509	17.353
Household Obligations	-0.0516	-2.532
Drop off/Pick up	-0.0806	-2.144
Social	-0.0711	-2.209

Table 1 (Continue)

Total Travel Time (Minutes) Required to go the Activity Location from the previous ActivityLocation		
Household Obligations	0.0104	2.492
Drop off/Pick up	0.0513	6.057
Shopping	0.0517	5.217
Services	0.0482	4.001
Recreation/Entertainment	0.0102	4.469
Social	0.012	3.707
Other	0.0194	2.659
Household Size: Number of People in the Household		
Work/School	0.1257	3.056
Household Obligations	-0.4742	-10.303
Drop off/Pick up	-0.2259	-3.044
Recreation/Entertainment	-0.1875	-5.985
Logarithm of Age in Years		
Basic Needs	-0.5918	-6.335
Work/School	-0.8989	-10.003
Drop off/Pick up	-3.7314	-18.392
Shopping	-2.8777	-14.043
Services	-2.2708	-7.123
Recreation/Entertainment	-2.3568	-23.922
Social	-1.7052	-12.407
Other	-2.0626	-14.248
Logarithm of Yearly Income in Canadian Dollars (2002-2003)		
Basic Needs	0.0576	6.154
Work/School	0.0348	1.624
Household Obligations	-0.1508	-11.12
Services	-0.0598	-1.416
Recreation/Entertainment	0.036	2.565
Number of Automobile in Household		
Household Obligations	-0.2229	-2.752
Recreation/Entertainment	0.2225	3.488
Logarithm of Duration (Years) of Living in the City		
Household Obligations	-0.5758	-11.314
Shopping	0.1902	1.67
Recreation/Entertainment	0.1383	2.933
Other	0.2402	2.388

Table 1 (Continue)

Employment Status: Non-Full Time Job		
Work/School	-1.0015	-7.129
Social	-0.7831	-4.078
Other	-0.6725	-3.352
Number of Children in Household		
Household Obligations	0.2439	3.842
Satiation Parameter		
Constant		
Work/School	-0.5267	-7.774
Household Obligations	-0.2286	-8.922
Drop off/Pick up	-0.8955	-18.893
Shopping	-0.7234	-14.907
Services	-0.8185	-4.594
Recreation/Entertainment	-0.696	-14.596
Social	-0.5025	-4.942
Other	-0.3139	-6.312
Star Time in Hours from Mid Night		
Work/School	0.0215	3.983
Services	0.0234	1.84
Recreation/Entertainment	0.0285	10.926
Social	0.0271	4.551
Correlation Coefficient Between Activity Type Choice and Time Expenditure		
Constant	-0.1942	-8.419
Loglikelihood of Full model		-57501.158
Loglikelihood of Constant-Only Model		-63732.032
Adjusted Rho-Square Value		0.1