MODELING OUT-OF-HOME RECREATIONAL ACTIVITY DURATION USING HAZARD-BASED DURATION MODELS WITH LATENT HETEROGENEITY

Farhana Ferdous
Graduate student, Dept. of Geography and Earth Sciences
McMaster University, 1280 Main Street W, Hamilton, ON
Phone: 905-5259140 Ext. 26949, Email: ferdouf@mcmaster.ca

Abstract
This paper presents econometric models of recreational activity duration that individuals pursue throughout the week. It examines both semi-parametric and parametric hazard-based duration model with different assumptions on the baseline distributions. It also tests latent heterogeneity into the model in terms of frailty. Among all the models Weibull parametric model with Gamma heterogeneity performs better. The study uses a dataset of 941 individuals from General Social Survey 1998. It reveals that work duration, in-home activity duration, sequence of recreational activity, home ownership, companionship with children, work end time etc. have significant impact on the duration of daily out-of-home recreational activity. This research would have implications on advancement of activity-based travel modeling and help in making informed decisions.

1. Introduction

Since travel is a derived demand, activity-based modeling is increasingly popular for analyzing individual travel behavior. Such modeling techniques generally address the issues of frequency of different types of activities; activities conducted by whom, with whom, at what time, for how long, at what location and by what

mode etc. (Roorda, 2005). This paper attempts to model duration of activities, more specifically duration of out-of-home recreational activities, which is very important in this modern age of living, and has significant impact on the transportation system mostly ignored in traditional travel behavior analysis. It applies hazard-based duration modeling techniques in order to ascertain factors affecting time allocation of recreational activities. Both semi-parametric and parametric hazard models are examined for the study. For parametric models, accelerated failure time assumption was made and various distributions for the baseline hazard were tested. It also examined latent heterogeneity in the parametric models.

The following sections of the paper are organized as follows: the next section briefly discusses previous modeling efforts on recreational activities. Section 3 presents basic principles of the models applied for the study. Section 4 states data preparation and Section 5 describes the variables used for the paper. Finally, section 6 explains the results of the models with a subsequent conclusion.

2. Modeling recreational activities

There are very few studies focusing on recreational activities in the literature. Some studies have addressed the issue of inter urban travel to perform recreational activities (see Train, 1998; Moray *et al.*, 1991; Yai *et al.*, 1995; Kozak and Rimmington, 2000; Kemperman *et al.*, 2002). Recreational activity is one of the important activities, as this type of activity may have a significant impact on travel demand analysis. It is one of the major activities during weekends and holidays and requires considerable amount of transport facilities and vehicular support.

Out-of-home recreational activity episodes can be characterized in different dimensions. "They can be analyzed by determining the total number of recreational activities, the type of recreational activities, the location of participation, time-of-day of participation and chaining of recreational episodes with other recreational and non-recreational episodes etc." (Bhat and Lockwood, 2005). In a recent study, Bhat and Lockwood (2005) have employed a mixed multinomial logit model for examining the out-of-home recreational episode participation of individuals over the weekend. In this study, they focused on the determinants of participation in physically active

versus physically passive pursuits and travel versus activity episodes (Bhat and Lockwood, 2005). Again, in another study Bhat and Gossen (2004) formulated a mixed multinomial logit for the type of recreational activity episodes pursued during the weekends. The choice included in-home, out-of-home, and pure recreational episodes (Bhat and Gossen, 2004). Based on the literature reviewed appears to be no study has been done directly to model the duration of recreational activities. To this extent this paper is unique in modeling duration of recreational activities by using hazard-based duration modeling techniques. In the following section, the model structure is briefly discussed.

3. Model structure

This paper applied hazard-based duration models for the purpose of analyzing duration of recreational activities. Two types of models were tested: semi-parametric and parametric models. Notable difference between these two models rests on the assumption for the baseline hazard. For the semi-parametric models, there is no need to make any assumption for the baseline hazard. It assumes proportionality where covariates have multiplicative effects. It is the partial log-likelihood method put forwarded by Cox (1972), which makes it possible to estimate parameters without specifying a baseline hazard. On the other hand, parametric models assume a distribution for the baseline hazard and utilize full information maximum likelihood estimation method. There are wide varieties of distributions that can be employed in the parametric models including exponential, Weibull, log-logistic, log-normal, gamma, generalized F, Gompertz, Makeham etc. (see Lancaster, 1990; Kalbfleisch and Prentice, 2002). However, some researchers doubt on using parametric models unless supported by adequate theoretical/empirical evidence since it might inconsistently estimate the baseline hazard if the assumed parametric form is incorrect (Meyer, 1990). For this reason, this paper employed both semi-parametric and parametric models in order to analyze duration of recreational activities.

It is also argued that there might be a heterogeneity problem within the sample of study in the hazard-based duration models. Such heterogeneity might arise from the unobserved factors, for example, due to omitted covariates and/or motivations, tastes, preferences of

the individuals (Bhat, 1996). Accordingly, It is very important to have control for latent (unobserved) heterogeneity otherwise it may lead to severe bias in the nature of duration dependence and the estimates of the covariate effects (Bhat, 1996, Heckman and Singer 1984). Since the sample used for this study was drawn from the entire Ontario province (from cosmopolitan Toronto to rural North), we suspect the presence of heterogeneity in the sample. Hence this paper tested latent heterogeneity in the estimated models. In the following section preparation of data for the study is discussed.

4. Data preparation

The whole study was conducted based on a secondary data set derived from General Social Survey 1998 (GSS, 98) on time use. The dataset used for the study contained almost 2402 respondents. These 2402 individuals performed 47,834 in-home and out of home activities on the interviewed day. In other words, the total activity episodes of the data are 47,834. This study filtered the sample in several steps to produce an appropriate dataset for the analysis. First, individuals who are 15 years or older and do not attend school are considered for the analysis. The reason for eliminating school going persons is, they have a different dimension of lifestyle and their daily routine is more or less regulated by mandatory activities (Scott and Kanaroglou, 2002). Second, only the out-of-home activities were selected from the data set. Third, activity episodes that are conducted specifically for recreational purposes were selected. The study considers activities as recreational if those are specified by the broad category "Entertainment (attending)" and "Sports and Hobbies" in the GSS survey. The final derived dataset consists of 1570 out-of-home recreational activities, performed by 941 individuals. Percentage of this type of activity compared to all other out-of-home activities including work related activities is 9.35%. On the other hand, out-of-home recreational activities compared to only non-work other out-of-home activities is 40.17%.

5. Variable selection

The dependent variable, recreational activity duration, ranged from five minutes to eight hundred and ten minutes with a standard deviation of 105.95 minutes. The mean duration was found as 114.83

minutes. A histogram indicating the frequency distribution of out-of-home duration has been presented in the Figure1. This variable was log transformed for the parametric estimation. However, the original duration is used for the semi-parametric models. The models are estimated by using the statistical software LIMDEP, version 8.0 (Greene, 2002).

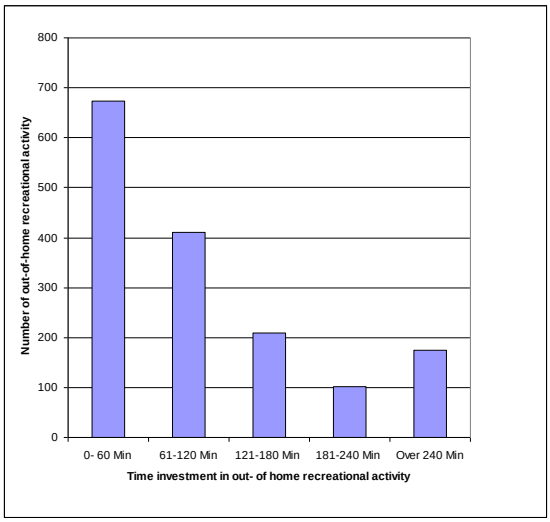

Figure 1: Frequency Distribution of Out-of-home Recreational Activity Duration

A number of explanatory variables were tested to find out the factors that affect out-of-home recreational activity duration for Ontario residents (Variable definitions are provided in table1). The variables were created aiming to address a number of issues:

- To identify the relationship between age and the recreational activity duration.
- Differences of activity duration on weekends versus weekdays
- Is there any effect of companionship on recreational activity duration?
- Number of the recreational activities conducted on the target day
- Does the work duration; other non-work out-of-home activity duration and in-home maintenance activity duration affect the out-of-home recreational activity duration?

At the beginning of the work, the study tried to explore the relationship between age and the recreational activity duration. Past evidence shows that older people have less out-of-home activity duration (Srinivasan and Bhat, 2005). So a variable describing the age of the respondent was considered. Another variable was taken that explains the ownership of the dwelling. The *a priori* assumption was that he who owns a house devotes more time himself in in-home maintenance activities compared to out-of-home recreational activities (similar to Srinivasan and Bhat, 2005).

Table1: Variable definitions

Variables	Definition
Socio Demographic Characteristics	
AGEC	Age of the respondent
DDOWN	1 if individual own a home, 0 otherwise
Episodic Specific (Recreational activity)	
WEEKDAY	1 if the day is weekday, 0 otherwise
SALONE	1 if individual does the activity alone
SCHLDHSD	1 if individual does the recreational activity with children, 0 otherwise
OCCREC	Sequence proxy of the recreational activity
TRECACT1	1 if individual does more than one out-of-home recreational activity in a given day, 0 otherwise
Characteristics of other activities (including work)	
TOUTACT1	1 if individual does more than eight out-of-home activity (including work) on that day
WKDUR8	1 if individual has work duration less than eight hours, 0 otherwise
DAYWORK2	1 if individual departs from work before 4 pm
DUONWO2	1 if individual has total out-of-home activity duration other than recreational more than 2 hours, 0 otherwise
MNTAC120	1 if individual has in-home maintenance activity duration more than 2 hours, 0 otherwise

To understand the episodic nature a variable was created named as WEEKDAY that translates the fact whether the interview day was weekday or weekend. It was assumed that recreational activity duration in weekdays will be less than the weekends as people remain busier with work related and other mandatory activities in weekdays compared to weekends. So a dummy variable was created where the value '1' stands for the activity in weekdays or '0' otherwise. Additionally, an effort was given to determine the effect of companionship on the recreational activity duration. Accordingly, two variables, SALONE and SCHILHSD were created. These two variables describe whether the activity was performed alone or with children respectively.

To test the impact of the sequence of the recreational activities in the duration of the activity, a new variable called OCCREC was constructed. The variable describes the position of the recreational activity in the activity agenda for a particular person in a given day. It was obtained by dividing the serial number of the recreational activity by the total number of the activity conducted by the person in that day. The value of the variable is presented in the scale of '0' to '1'. It was hypothesized that if the recreational activity is carried out in a late sequence (i.e. in the later part of the day), the usual duration would be longer.

In addition, another variable was tested to see the impact of multiple recreational activities in a given day entitled as TRECACT1. The variable is used as dummy, where the value '1' stands for more than one activity on that day and '0' otherwise. Again, an attempt has been made to find out the relationship between total number of out-of-home activity (including the work activity) and the duration recreational activity. The variable TOUTACT1 is used for the purpose to see how people react to recreational activity if he/she has more than more than eight out-of-home activities. This is a dummy variable where '1' means that the person conducts more than eight activities and '0' otherwise. Selection of number of activities in this case was not completely *ad-hoc*. The average number of out-of-home activity (including work) is 6.5 for the sample used in this study ranging from a minimum of 0 to a maximum of 28. So this dummy represents an individual that performs more than average out-of-home activities in a given day. It is assumed that persons having more than

eight out-of-home activities will have less time allocation for recreational activities.

To test the impact of work duration characteristics of work activities on duration of recreational activities several variables were created. A dummy variable WKDUR8 is used to see the impact of the work duration ('1' representing work duration less than eight hours for a person, '0' otherwise). It was hypothesized that a person having less than eight hours work duration (regular working hours) might be able to allocate more recreational duration in his/her activity agenda. On the other hand, end time of the last work episode in a day was also assessed and presented with a variable named as DAYWORK2. It was assumed that if the last work episode ends at or before 4.00 pm then the person has more scope for longer out-of-home recreational activity. So the variable DAYWORK2 represents the binary value of '1', means if the latest work episode ends at or before 4.00 pm it attains the value as '1'and '0' otherwise. Again, the test was also carried out to observe if the duration of out-of-home non-work activities affect the out-of-home recreation activity duration. Accordingly, an explanatory variable, DUONWO2 was constructed where the variable represents '1' for duration of out-of-home non-work activity duration is more than two hours '0' otherwise.

Finally, in-home maintenance activity duration was assessed and another dummy variable (MNTAC120) was constructed. The dummy with the value '1' means person engage himself in-home maintenance activity more than two hours and '0' otherwise. *The a priori* is that he who devotes himself more than two hours in in-home maintenance activity has lesser tendency to have longer recreational activity duration.

6. Model results

The model results are presented in this section. As discussed earlier, out-of-home recreation activity duration was modeled using both semi-parametric and parametric hazard modeling techniques. To model the duration three different distributions for the hazard function were used. The distributions this study tested were Weibull, log-logistic and exponential. While exponential distribution exhibits no-ageing property (due to lack of memory property), Weibull and log-logistic models show duration dependency. That is why these two

later types of distribution assumptions were tested. Again a Weibull model only represents monotonically increasing (or decreasing) duration dependency. So a log-logistic distribution is utilized that permits non-monotonic hazard forms. In the semi-parametric models, no assumption is made on the baseline hazard.

Model results shows that the semi-parametric model (that Cox proportional model) has the lowest goodness-of-fit statistics (Rho-square value of 0.019037). This fit statistic is calculated by one minus ratio of log-likelihood at the full model and null model (1-L/L0). On the other hand, all parametric models show better goodness-of-fit statistics. Among the paramatric models, the Weibull model has the highest Rho-square values. In addition, mostly all variables are significant in the Weibull model in comparison to all other parametric models as well as the Cox model. Hence, Weibull model specification is selected as a final candidate model. Results of all parametric models and the Cox model are tabulated in Table 2.

As mentioned the study also investigated latent heterogeneity in the model. Latent heterogeneity arises from unobserved differences found among the individuals in a sample. So the unobserved heterogeneity, for example differences in tastes, preferences, motivation across the respondents was modeled to avoid the inconsistent estimates and inappropriate standard errors. For the heterogeneity, a positive distribution (gamma) was assumed for the distribution of the latent heterogeneity term in the parametric models. These types of models are called "Frailty" Models. The study found that the Weibull model with gamma heterogeneity exhibits the highest Rho-square value (0.110755) compared to all parametric models without heterogeneity (see Table 2). Also the heterogeneity term (Theta) is found significant in the log-likelihood ratio test. Almost all variables are found statistically significant at least at the 95% confidence level. The results of the final model are presented in the Table 3. In the following section, the effects of different variables on duration are briefly discussed.

The explanatory variables used in the final model can be categorized into three segments. The first category included the variables describing the socio-demographic status, whereas the second category explains episodic characteristics of the recreational

activities and the last category includes the variables that indicate the characteristics of all other activities including work.

Table 2: Results of Parametric and Semi Parametric Models

Explanatory Variables	**Weibull** Coef. (*t* stat.)	**Log-logistic** Coef. (*t* stat.)	**Exponential** Coef. (*t* stat.)	**Cox** Coef. (*t* stat.)
Socio Demographic Characteristics				
AGE	-0.002	-0.001	-0.002	0.003
	(-2.18)	(-0.47)	(-0.91)	(1.90)
DDOWN	-0.075	-0.058	-0.069	0.094
	(-1.99)	(-1.320	(-0.96)	(1.74)
Episodic Specific (Recreational activity)				
WEEKDAY	-0.115	-0.121	-0.117	0.154
	(-2.76)	(-2.66)	(-1.52)	(2.72)
SALONE	-0.457	-0.501	-0.469	0.566
	(-9.11)	(-7.96)	(-4.80)	(7.36)
SCHLHSD	-0.096	-0.046	-0.085	0.112
	(-1.73)	(-0.70)	(-0.79)	(1.42)
OCCREC	0.758	0.681	0.744	-0.966
	(9.40)	(7.16)	(4.80)	(-7.94)
TRECACT1	-0.317	-0.366	-0.329	0.419
	(-8.30)	(-8.12)	(-4.44)	(7.55)
Characteristics of other activities (including work)				
TOUTACT1	-0.373	-0.394	-0.379	0.486
	(-8.42)	(-7.63)	(-4.45)	(7.45)
WKDUR8	0.212	0.191	0.206	-0.271
	(2.75)	(2.21)	(1.40)	(-2.61)
DAYWORK1	0.290	0.245	0.279	-0.374
	(4.35)	(3.31)	(2.20)	(-4.15)
DUONWO2	-0.049	-0.100	-0.065	0.063
	(-1.21)	(-2.12)	(-0.83)	(1.07)
MNTAC120	-0.347	-0.333	-0.344	0.446
	(-8.30)	(-6.84)	(-4.28)	(7.40)
CONSTANT	4.653	4.374	4.574	
	(45.22)	(37.47)	(23.43)	
Ancillary parameters				
Sigma	0.717	0.477	1	
log likelihood	-1921	-1967	-2047	-9853
Rho square	0.108	0.084	0.065	0.019

In total, twelve exogenous variables are retained in the final model. The first independent variable AGEC showed a negative association with the recreational activity duration, which means that elderly people have shorter leisure duration than the young people. The results comply with the assumptions and the past evidences (such as Bhat and Gossen, 2004). The coefficient of the second variable DDOWN indicates that a person who owns a house is less likely to participate in out-of-home recreational activity and eventually has shorter recreational duration. It can be explained such that owner of a house might need to engage home repair and maintenance work in their spare times, so they can allocate lesser time for out-of-home recreational activities.

While looking into the episodic characteristics the variable WEEKDAY shows that our-of-home recreational activity duration at weekdays is comparatively for lesser time. All the tested models confirm this previously established expectation with 95% confidence level. In the final model, the variable has a negative parametric value of 0.13. To test the effect of companionship two variables SALONE and SCHLDHSD were included in the model. The results indicate that in both cases the duration is shorter. So it can be concluded that usually people spent less time in out-of home recreational activity when he/she is alone. Besides, it also says that recreational activity duration with children does not take longer time.

The variable representing the sequence of the recreational activity in the daily activity agenda (OCCREC) is also found to be statistically significant. It shows that if the leisure is performed at the later part of activity agenda then it has longer duration, which complies with the previous assumption made. I think this finding is reasonable since the activities done in the later part of agenda usually carried out at late afternoon or evenings which is in other way more convenient and relaxed time for non-mandatory activities such as visiting friends and family, eating out in social settings, and going to the movies. The negative effect is also found in the case where there is more than one recreational activity performed in a given day. In other words, the model suggests that if a person performs more than one out-of-home recreational activities in a day then the recreational activities on average have a shorter duration. Again, it can be said from the results that he/she who has more than eight out-of-home

activities in a day has relatively shorter out-of-home recreational activity duration. This result is also quite expected since the more you have out-of home activities the less you have time to allocate for recreational activities.

Table 3: Results of Weibull Model with Gamma Heterogeneity

Explanatory Variables	**Coefficient**	***t*-statistics**
Socio Demographic Characteristics		
AGEC	-0.002	-1.62
DDOWN	-0.069	-1.70
Episodic Specific (Recreational activity)		
WEEKDAY	-0.131	-3.02
SALONE	-0.486	-8.65
SCHLDHSD	-0.091	-1.52
OCCREC	0.736	8.47
TRECACT1	-0.326	-7.92
Characteristics of other activities (including work)		
TOUTACT1	-0.378	-7.97
WKDUR8	0.203	2.52
DAYWORK2	0.273	3.93
DUONWO2	-0.073	-1.64
MNTAC120	-0.338	-7.54
Constant	4.606	42.23
Ancillary parameters		
Sigma	0.648	25.91
Theta	0.171	2.74
log likelihood	-1915	
Rho square	**0.110755**	

It was also found that duration of work and work end time has significant impact on that of recreational activities. The final model shows that a person who has work duration of less than eight hours is more likely to have longer duration of recreational activities. Similarly, if the last work activity episode ends before 4:00 pm duration of out-of-home recreational activity is higher. In other

words, if the latest end time of the work is 4.00 pm then there is good probability of having longer duration for leisure activity. The *t*-statistics for the variable is 3.929.

Furthermore, the paper also examined the effect of out-of-home non-work activity duration (other than recreational) on the duration of recreational activity. It was seen from the final results that the dummy variable DUONWO2 (representing individuals having more than two hours of other non-work out-of-home activities) has a negative sign. It means that those people who spent more than two hours in a given day for out-of home non-work activity spends less time for recreation. The result is quite expected meaning that the more time someone spent on other out-of-home non-work activities yields less time available for recreation. In the same way, the dummy variable representing individuals who spent two hours of in-home maintenance work has negative coefficient with high statistical significance. That is, those who are intensively involved with the in-home maintenance work allot less time for out-of-home recreational activities.

7. Conclusion

The paper presents hazard-based duration models for out-of-home recreational activity duration. The novelty of the study is that it attempts to model duration of recreational activity, which is mostly missing in existing literature. It examined both semi-parametric and parametric hazard models. In addition, it incorporates latent heterogeneity into the models. The Weibull model with gamma heterogeneity shows the best fit with significant heterogeneity component. Mostly the estimated parameters are significant at the 95% confidence level. The empirical analysis of this paper is entirely based on the secondary dataset of GSS-98 for Ontario residents. Following are the specific results of the final model for this sample data:

- The elderly people are less likely to participate in out-of-home recreational activity hence has shorter duration compared to the young ones.
- The homeowners spent less time in out-of-home leisure activity than those who do not own a home.

- Duration of out-of-home recreational activity is less if the person is alone. Presence of children is also another constraint for longer out-of-home recreational activity duration.
- Out-of-home recreational activity duration is higher if it is performed at the later sequence of the activity agenda.
- Multiple recreational activities reduce duration of the recreational activities on a given day.
- Total out-of-home activity other than the recreational activities has negative effect on the out-of-home recreational activity duration.
- Work duration has a significant effect on recreational activity duration. If it is less than eight hours, then duration of recreational activity is longer.
- End time of the latest work activity episode also has an effect on out-of-home recreational activity duration. It is found from the model that if the work ends at or before 4.00 pm, then the person has longer out-of-home recreational activity duration.
- Again, if the total duration of other non-work out-of-home activity is less than two hours, it ultimately provides the scope for longer out-of-home recreational activity duration.
- Finally, in-home maintenance activity duration more than two hours a day restricts the person from longer out-of -home recreational duration.

The above results may have an implication on the travel demand management and travel behavior analysis and for informed policy making.

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