ANALYZING TIME WINDOWS AND TIME ALLOCATION TO IN-HOME AND OUT-OF-HOME ACTIVITIES IN WORKERS' ACTIVITY PATTERNS

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Introduction

Analyzing the activity-travel behavior of individuals has become a major concern in activity based travel demand models (Arentze and Timmermans, 2000; Auld and Mohammadain, 2012). The largest population segment in urban areas is out-of-home workers. Transportation professionals have traditionally focused on work-related travel and commute trips to manage peak hour congestion. However, non-work travel demand exhibits greater flexibility and variability across the worker population segments, as well as among non-workers. In developed nations, historically the demand for non-work travel is increasing (Toole-Holt et al., 2005). This paper presents an innovative modeling framework to determine workers' decisions relating to activity participation, with emphasis on non-work trips. All activities taken inside the home are classified together as in-home activities, while those undertaken outside the home are classified as work, school, shopping and services, organizational/hobbies, entertainment, and sports. Since non-work/non-school activities are flexible in time and location in comparison to work and school activities, we kept all the four discretionary categories to capture the variability and determinants related to each. The results of this paper are expected to be incorporated into the Scheduler for Activity, Location and Travel (SALT) for Halifax.

Data and Empirical Analysis

The analysis is based on the STAR (Space-Time Activity Research) travel survey, conducted in Halifax Regional Municipality from 2007 to 2008. Two days or 2880 minutes in the lives of 1,971 Primary Respondents of each households were collected using GPS-assisted prompted recall computer assisted telephone interviews. This translates into 3,919 diary days of information, comprised of 108,529 episodes of time diary information. For each of these minutes the data collector retrieved: (i) what was being done, (ii) what else was being done at the same time, (iii) where it was done, (iv) how long it was done for, (v) who it was done with, and (vi) purpose/for whom it was done. The survey also contains 4,663 diary days of out-of-home activity diary information collected from 4,663 eligible secondary respondents (all other household members aged 5 and older) about the out-of-home activities they engage in for the same two-day reporting period.

The STAR data include socio-demographic information, household size, accommodation type, motor vehicles and modes of transportation, parking availability and type, household energy usage, residential locations, education status, employment statistics (e.g. number of working adults in the household, occupation type, work hours, location, etc.), commitment (family, work, etc.), travel behavior (purpose of trip, duration etc.), spatial information on activities (latitude, longitude, address, municipality information, frequency of visit, etc.), routing information, distance of trip, and trip accompaniment. Full descriptions of the survey design and the socio-demographic characteristics of respondents can be found in Millward and Spinney, 2011.

Hafezi et al. 2017 developed a pattern recognition framework and applied it to the STAR survey data. Using a fine-tuned fuzzy c-mean clustering technique, they obtained twelve unique clusters comprising individuals with homogenous activity patterns. For the empirical studies, we utilized five worker clusters. Table 1 show the activity time-use of all the worker's clusters.

Table 1. Analysis of Cluster Data: Share of activity time-use of all worker clusters

Activity categories	**Descriptions**	**Share of daily activity engagement (%)**				
		#1	#2	#3	#4	#5
In-home (N)	Working at home, eating/meal preparation, indoor or outdoor cleaning, interior or exterior home maintenance, child care or other in-home activities.	12.87	15.54	23.29	17.89	18.21
	Watching TV/listening to radio, reading books/newspapers, etc.	6.17	9.26	11.18	10.53	9.46
	Night sleep	32.26	31.09	34.47	30.95	34.11
Workplace/School (W/S)	Work: Work/job, all other activities at work, work related (conferences, meetings, etc.).	43.47	36.44	24.70	36.29	33.08
	School/college related: Class participation, all other activities at school.	-	0.06	0.13	0.12	0.06
Shopping (P)	Shopping for goods and services, routine shopping.	0.78	1.39	1.73	0.98	1.14
Organizational/ hobbies (G)	Organizational, voluntary, religious activities. Hobbies done mainly for pleasure, cards, board games, all other hobbies activities.	1.14	1.43	1.59	0.72	1.00
Entertainment (E)	Eat meal outside of home, all other entertainment activities.	2.27	3.05	2.01	1.52	1.64
Sports (T)	Walking, jogging, bicycling, all sports related activities.	1.03	1.74	0.91	1.02	1.30
Total (%)		*100.0*	*100.0*	*100.0*	*100.0*	*100.0*

Out-of-Home Entertainment Activity Participation

Table 2 presents the C-MVP parameter estimates for out-of-home entertainment activities for worker clusters. Across the clusters, individuals are more likely to participate in entertainment activities jointly and less likely to participate if the duration of the entertainment activity increases. Work-related variables are also found to significantly affect entertainment activity participation. For instance, hours worked at main job has a significant negative association to entertainment activities. Higher land use mix often brings more alternative entertainment activity destinations within convenient proximity, increasing the probability that they will be visited.

Table 2. Output of C-MVP parameter estimates for out-of-home entertainment activity participation

Entertainment	**Extended**	**8 to 4**	**Shorter**	**7 to 3**	**9 to 5**
	Coeff.	**Coeff.**	**Coeff.**	**Coeff.**	**Coeff.**
Joint (1, if the activity is performed jointly with another individual, 0 otherwise)	1.11*	1.24*	0.95*	1.20*	0.88*
Duration of the activity episode	-0.02*	0.02*	-0.01**	-0.03*	-0.02*
Size of the Household	0.07*	-0.05**	-0.04	0.06	0.15*
Male (1, if the gender of the individual is male, 0 otherwise)	0.04	0.15*	0.13	0.06**	0.71*
Married (1, if the individual is married, 0 otherwise)	0.43**	-0.13	0.14**	0.20	0.30**
Age of the individual	0.07	0.02**	-0.01	-0.03	-0.07**
Driver License (1, if the individual has a valid driver license, 0 otherwise)	0.41*	-0.17		0.46*	
Bus Pass (1, if the individual has a valid Bus pass, 0 otherwise)	-0.29**	0.07		0.09	
Paid worker (1, if the individual is a paid worker, 0 otherwise)	0.51	-0.05**	0.02		
Working Day time (1, if the individual works in the day time, 0 otherwise)	0.37*	-0.12**	-0.29*		-0.44*
Hours worked at main job	-0.06**	-0.06	-0.04**	-0.01*	
More than one job (1, if the individual works in more than one, 0 otherwise)	-0.48**	-0.09	-0.04**	0.06**	0.08
Flexible work Schedule (1, if the individual has a Flexible work Schedule, 0 otherwise)	0.02	0.06*	0.05**	0.01	0.05
Low income level (1, if the individual belongs to low income level, 0 otherwise)	-0.18*	-0.17*	-0.13	0.06**	0.30
Duplex Housing (1, if the individual is living in duplex house, 0 otherwise)	0.52*		0.19*	0.18	
Multiunit Housing (1, if the individual is living in Multiunit house, 0 otherwise)	-0.78	-0.41		-0.18	0.18**
Mean commute time	0.01			0.04	-0.07*

Population density of the home neighbourhood	-0.03*	-0.05	0.05*		-0.05*
Urban Core (1, if the individual is living in urban core, 0 otherwise)	-0.02	0.04**	0.01	0.02**	0.03**
Land use mix in the home neighbourhood		0.03*		0.01	0.04**
Constant	-4.32*	-1.56*	-2.33*	-3.00*	-3.01*

***Represents the significant parameters at 95% confidence level (P-value<0.05)*

**Represents the significant parameters at 98% confidence level (P-value<0.01)*

Conclusions

The aim of this study was to investigate the activity-travel behavior of workers through an innovative cluster-based Multivariate Probit Modeling (C-MVP) framework. Five worker clusters had previously been identified using a daily activity pattern recognition method: Cluster#1: extended work-day workers, Cluster#2: 8 to 4 workers, Cluster#3: shorter work-day workers, Cluster#4: 7 to 3 workers, and Cluster#5: 9 to 5 workers.

This paper uses these identified worker clusters for C-MVP model estimation, assuming a non-zero correlation between the types of activities in which individuals participate in a given day. The explanatory variables include both individual and household characteristics, and characteristics of the neighborhood of residence. Dependent variables are six activity categories: in-home activities, work/school, shopping, organizational/hobbies, entertainment, and sports. Based on the results, we conclude that activity participation of workers is significantly associated with their socio-demographic characteristics, individual characteristics, household structure, accompaniment arrangement, commute time, and neighborhood land use attributes. The model coefficients vary considerably between clusters in magnitude, sign, and significance, showing the value of segmenting the population into homogeneous clusters.

Reference

Arentze, T. A. Timmermans, H. ALBATROSS-A learning based transportation oriented simulation system. *Transportation Research Record: Journal of the Transportation Research Board*, No. 1706, 2000, pp. 136-144.

Auld, J., Mohammadain, A. Activity planning processes in the agent-based dynamic activity planning and travel scheduling (ADAPTS) model. *Transportation Research Part A: Policy and Practice*, 46(8), 2012, pp. 1386–1403.

Toole-Holt, L., S. E. Polzin, and R. M. Pendyala. Two minutes per person per day each year: exploration of growth in travel time expenditures. *Transportation Research Record: Journal of the Transportation Research Board,* No. 1917, 2005, pp. 45–53.

Millward, H., and Spinney, J. Time use, travel behavior, and the rural-urban continuum: results from the Halifax STAR project. *Journal of Transport Geography*, 19(1), 2011, pp. 51–58.