Activity-based Travel Behavior Analysis Using the Disaggregate Logit Model

非集計ロジットモデルによる活動ベースの交通行動分析

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1. Introduction

During the last 25 years a large amount of research has been done to incorporate the insights gained on activity-based travel theory into urban travel forecasting models. Some of the most advanced operational model systems capture the interrelated personal decisions regarding the travel from home to one or more activity locations and to home back again. A tour can be defined as a sequence of trip segments that start at home and end at home, as depicted in Figure 1. Tour-based systems were first developed in the late 1970s and 1980s in the Netherlands, and were applied extensively there and elsewhere.

This research presents the tour-based model concept, which explicitly models an individual's choice of an entire day's schedule, as briefly described by Bowman (1995, 1998). The research analyzes the travel behavior of workers and non-workers considering non-working activity, either Maintenance or Discretionary activity (MD). Hear, maintenance activities include business of household or individual (for example, pick up or drop off a child), and discretionary activities include those engaged in for pleasure, recreation or refreshment. The significant distinction is that non-workers can freely travel every time without the constraint of fixed activity, while workers have a fixed and subsistence activity such as Work on Tour (WT) or Work at Home (WH). They may not perform maintenance or discretionary activities very often.

The objectives of the research are to describe individual choice of doing maintenance and discretionary activity, staying at home or just carrying out work activity for both of workers and non-workers, and how the constraint of subsistence activities influences maintenance and discretionary activities for workers.

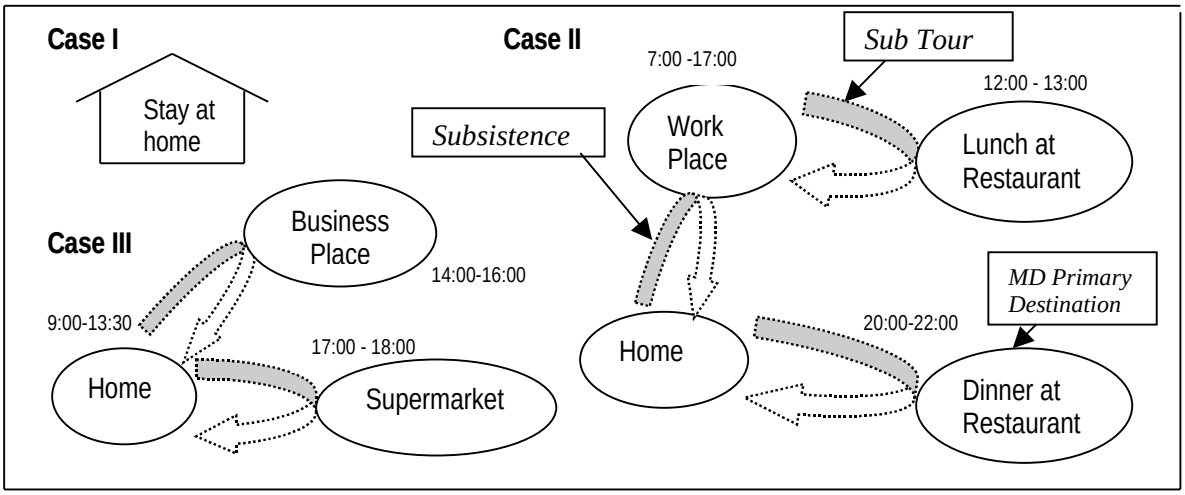

Figure 1. Tour Concept for Workers

2. Model System and Data

Figure 2 shows a hierarchical structure of the daily activity travel model comprising of a series of the disaggregate nested logit models. Lower level choices are conditional on decision at a higher level, and a higher-level decision is informed from a lower level through the expected maximum utility (Logsum) variable. The model system is designed as a series of disaggregate nested logit models assuming a hierarchy of model components based on the demonstration project for travel model improvement in Portland, Oregon (TMIP (1997), Bowman et. al. (1998)).

For each hierarchical structure of workers and non-workers, three types of a sub-model comprise the system: (1) daily activity pattern, (2) time of day, and (3) mode. The daily activity pattern model includes decision of whether to make home-based trips for maintenance and discretionary activity (MD on Tour=MDT), or stay at home (MD at Home=MDH, or No MD=NMD). The time of day model includes decision of choosing time to travel, which is broken down into 4 time periods, either in AM peak, Midday, PM peak, or in the evening. Further, those 4 time periods are combined into 5 alternatives, Time 1, Time 2, Time 3, Time 4, and Time 5. The mode choice model includes decision of choosing mode from 5 available alternatives, either drive alone (DA), drive with passenger (DP), car passenger (CP), two-wheels vehicle (TWV), or walk (W). The mode choice model is conditioned by choice of time, and the time of day choice model is conditioned by choice of daily activity pattern.

The probability of a particular daily travel pattern *p*(daily travel) is therefore expressed in the model as the product of marginal probability and conditional probability (Bowman, 1995, 1998).

p(daily travel) = *p*(pattern) *p*(time|pattern) *p*(mode|time),

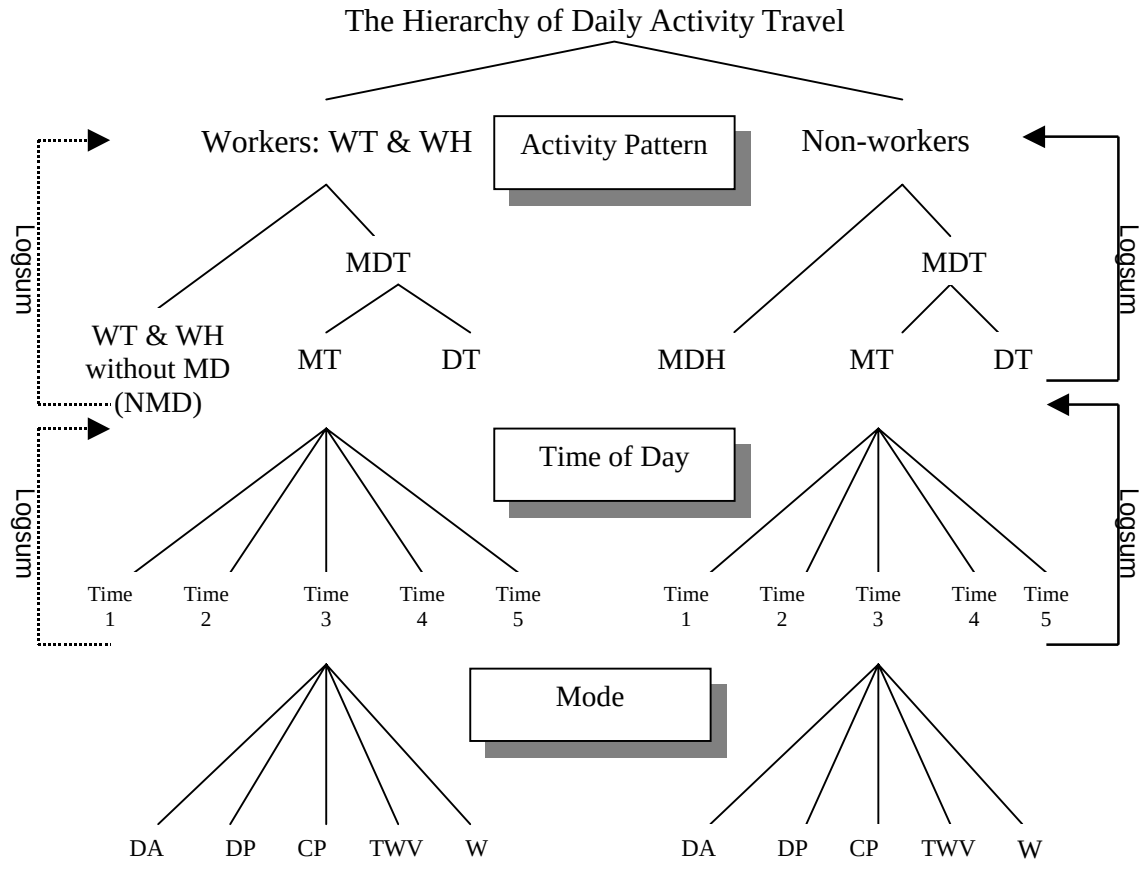

Fig. 2. Daily Activity Travel Hierarchy

where *p*(pattern) is the probability of choosing activity pattern, while *p*(time|pattern) is the conditional probability of choosing time given choice of pattern, and *p*(mode|time) is the conditional probability of mode given time.

Survey of daily travel behavior was performed in November 1999 in the Nagaoka Metropolitan Area, involving 4,944 households and more than 16,000 individuals. Samples of only a householder (one person household) were removed from the data set. Samples of household members with two or more persons (a householder and spouse, and a householder with family) were used in the analysis, which consist of 9,222 individuals.

3. Estimation Results

3.1 Model fitness

Table 1, Table 2 and Table 3 show estimated results of workers and non-workers models of choosing mode, time of day or activity pattern for maintenance and discretionary trips. The log-likelihood ratio ρ^2 results in the range between 0.101 and 0.375 for the entire models, indicating that fitness of some models is not so good and satisfactory. The hit ratios are not uniform, that is some are high and some are very low.

3.2 Mode choice

Table 1 shows the model of mode choice for workers and non-workers. Both for the workers and non-workers models, *car competition in household* is applied only to car-chosen alternatives: drive alone, drive with passenger, or car passenger, excluding two-wheels vehicle and walking. It indicates the ratio of number of adults in household divided by number of cars in household. The result yields a positive sign for those three modes, which means that as *car competition in household* becomes bigger, people tend to use more car-related modes including car passengers.

For the workers model, *drive to work place* yields a positive sign. It indicates the tendency that workers who drive to work place would also choose car mode for MD activity. Variable of *travel to work place* (not staying at home for work) yields a negative sign. It indicates that they would not choose drive alone for primary MD destination. Workers of *return home after 5 PM* may not choose car passenger for MD activity, but they prefer to use other modes. A destination land use variable, *JR station as destination zone* presents a positive sign; it means that they choose car passenger to go to a city center zone around the JR station for maintenance and discretionary activities. *People of age 50 to 70* tend to choose two-wheels vehicle and walking for primary MD destination. *People who have more than two cars in household* tend to choose drive alone, and they might not choose driving with passenger.

For the non-workers model, some of choice tendency are almost similar to the workers model. People who make *secondary tour* result in a positive sign, indicating that they choose drive alone or drive with passenger. *Female with two or more adults in household* and *single person with no spouse (live without spouse)* will choose car passenger, two-wheels vehicle or walking, and they may not choose drive with passenger because of its negative sign. *JR station as destination zone* results in a negative sign for drive alone and two-wheels vehicle, meaning that they would not choose those modes to go to city a center zone for primary MD activity.

3.3 Time of day choice

Table 2 represents the model of time of day. It shows a slight difference between the workers and non-workers models. The non-workers model gets feedback from the mode choice model through a logsum variable, while the workers model not. Parameter of *mode choice logsum* yields a small value, indicating decision of mode choice influences very

Table 1. Mode Choice

		WORKERS			NON-WORKERS		
No	Choice	Variables	Coef.	T-Stat	Variables	Coef.	T-Stat
1	DA	Female, 2+adults in HH	-0.798	-3.887	Constant	-2.347	-8.728
		Car competition in HH	3.183	8.150	Car competition in household	4.957	15.998
		DA cost (円)	-0.004	-1.797	DA cost (円)	-0.020	-10.385
		Drive to work place	2.0887	4.188	Male, less than 4 person in HH	0.704	2.507
		No intermediate stop	-0.5109	-2.324	Male, 2+workers in HH	0.668	2.170
		Travel to work place	-0.7970	-2.379	JR station as destination zone	-0.441	-3.023
		2+cars in household	0.2697	1.189	Secondary tour	0.902	5.072
		Male, less than 4 person in HH	0.4139	2.492			
2	DP	Drive to work place	2.293	5.545	Secondary tour	1.013	4.821
		Secondary tour	0.353	1.775	Car competition in household	4.644	12.836
		Car competition in HH	2.719	6.018	DP cost (円)	-0.020	-10.586
		DP cost (円)	-0.004	-1.840	Female, kids under 12 in HH	1.125	4.657
		Male, 1+workers in HH	0.832	3.434	Live without spouse	-1.515	-1.959
		Leave home during midday	-0.524	-2.694	Age 55-70	-0.347	-1.855
		2+cars in household	-0.409	-1.523	Female, 2+workers in HH	-1.184	-3.188
		Female, 4+person in HH	0.473	1.791	Female, 2+adults in HH	-1.042	-3.261
		No intermediate stop	-1.335	-5.399			
3	CP	Car competition in HH	0.859	2.257	Constant	-4.543	-10.312
		CP cost (円)	-0.004	-1.618	Car competition in HH	1.693	3.986
		JR station as dest. zone	0.390	1.966	CP cost (円)	-0.022	-10.094
		Female, no kids in HH	0.766	3.248	Female, 2+adults in HH	3.200	7.783
		Leave home during midday	-0.659	-2.783	Female, 1+workers in HH	-1.020	-4.641
		Drive to work place	1.383	2.406	Residential area as dest. zone	0.445	2.403
		Return home after 5 PM from WP	-0.760	-1.624	2+cars in HH	0.457	1.930
		No intermediate stop	-1.248	-4.819			
4	TWV	Constant	1.784	2.113	Constant	-1.161	-3.664
		TWV cost (円)	-0.004	-2.634	TWV cost (円)	-0.016	-11.219
		Female, 2+adults in HH	-1.148	-1.418	Female, 2+adults in HH	0.850	2.621
		Age 50-70	0.640	2.758	JR station as destination zone	-0.275	-2.079
		Male, 1+workers in HH	-2.114	-2.642	Fewer cars than adult in HH	0.515	2.918
		Female, no kids in HH	-0.398	-1.332	Female, husband worker	0.548	3.274
					Live without spouse	1.167	2.896
					Female, less than 4 person in HH	-0.265	-1.433
					No kids in HH	-0.292	-1.611
5	W	Constant	0.429	1.143	W cost (円)	-0.003	-11.274
		W cost (円)	-0.001	-2.727	Live without spouse	1.083	2.941
		Female, 4+person in household	0.401	1.628	Male, only adults in HH	-1.071	-3.693
		Age 50-70	0.433	2.202	Male, 4+person in HH	-0.823	-2.780
		No. of obs: 1181			No. of obs: 1654		
		Rho-squared:0.259			Rho-squared:0.219		
		DA Hit Ratio: 0.871			DA Hit Ratio: 0.607		
		DP Hit Ratio: 0.239			DP Hit Ratio: 0.209		
		CP Hit Ratio: 0.200			CP Hit Ratio: 0.302		
		TWV Hit Ratio: 0.246			TWV Hit Ratio: 0.201		
		W Hit Ratio: 0.325			W Hit Ratio: 0.696		

slightly on the choice of time of day. For the workers model, workers who *return home after 5 PM* result in a significant value, and they tend to perform MD activity during time 5 or in the evening. *Secondary tour* variable results in a big value for non-workers, and they tend to choose time 1 or in the morning. *Maintenance tour or Discretionary tour* variables are applied to all alternatives in order to give feedback of logsum into the activity pattern choice model.

3.4 Activity pattern choice

Table 3 presents the models of activity pattern choice for workers and non-workers. Workers who *drive to work place* tend to choose DT or NMD rather than MT, because of a negative sign. Workers who *work at home* tend to choose MT and DT. *Male worker with less than four people in household* and *male worker with more than two adults in household* tend to choose MT or NMD rather than DT.

Time choice logsum for the non-workers model results in a very big value, indicating

Table 2. Time of Day

		WORKER			NON-WORKER		
No	Choice	Variables	Coef	T-Stat	Variables	Coef.	T-Stat
					Mode Choice Logsum	0.047	1.078
1	Time 1	Constant	0.455	2.811	Secondary tour	1.298	7.249
		Age under 50	-0.441	-2.703	Female, husband worker	-0.346	-2.396
		Residential area as dest. zone	0.206	1.304	Grandfather/grand mother age over 70	0.518	4.025
		Return home after 5 PM from WP	1.920	3.902	Male, 4+person in HH	0.853	3.716
		No stop to/from Work Place	-0.608	-1.972	Discretionary Tour	-0.268	-1.901
		WH with Discretionary on Tour	0.340	1.996			
2	Time 2	Constant	0.327	1.619	Male, 4+person in household	0.701	2.675
		Secondary tour	-1.966	-7.949	No intermediate stop	-0.871	-5.918
		Male, only adults in household	0.364	2.256	Female, no kids in HH	-0.381	-2.426
		Male, 4+person in household	0.660	3.777	Origin zone dummy	0.462	2.610
		WH with Maintenance on Tour	0.596	3.366	Residential area as dest. zone	0.404	2.343
					Discretionary Tour	0.530	3.142
3	Time 3	Constant	0.669	3.119	Secondary tour	0.719	4.096
		Secondary tour	-0.764	-3.705	Female, 1+workers in HH	-0.305	-2.494
		Male, 1+workers in household	-0.254	-1.123	Maintenance Tour	1.348	8.883
		Female, less than 4 person in HH	0.320	1.370			
		No stop to/from Work Place	0.409	1.147			
4	Time 4	Constant	-0.215	-1.798	Female, less than 4 person in HH	0.220	1.246
		Return home after 5 pm from WP	-1.240	3.534	Male, wife non-worker	-0.344	-2.077
		Female, less than 4 person in HH	-0.536	-2.282	Age under 50	-0.393	-2.346
		Female, no kids in household	1.138	1.264	Children over 12 in HH	-0.356	-1.517
		JR station as destination zone	-0.417	-1.047	Female, 2+adults in HH	-0.366	-1.878
		No cars in household	0.481	2.415	Maintenance Tour	1.226	6.684
		Female, 2+workers in HH	-0.267	3.119			
		WT with Maintenance on Tour	-0.845	-3.705			
5	Time 5	Return home after 5 pm from WP	3.285	7.293	Male, 2+adults in HH, 1+nonworkers	-1.398	-6.631
		Male, 2+adults in HH, 1+nonworkers	-0.492	-2.404	Female, kids under 12 in HH	-0.736	-3.437
		No cars in household	-0.726	-1.353	Secondary Tour	0.506	2.102
					Female, less than 4 person in HH	-1.126	-7.236
					Maintenance Tour	1.114	6.229
		No. of obs: 1181			No. of obs: 1654		
		Rho-squared:0.134			Rho-squared:0.101		
		Time 1 Hit Ratio 0.343			Time 1 Hit Ratio: 0.409		
		Time 2 Hit Ratio: 0.671			Time 2 Hit Ratio: 0.351		
		Time 3 Hit Ratio: 0.291			Time 3 Hit Ratio: 0.489		
		Time 4 Hit Ratio: 0.223			Time 4 Hit Ratio: 0.191		
		Time 5 Hit Ratio: 0.481			Time 5 Hit Ratio: 0.224		

Table 3. Activity Pattern

		WORKER			NON-WORKER		
No	Choice	Variables	Coef.	T-Stat	Variables	Coef.	T-Stat
1	MT	Female, kids under 12 in HH	0.771	5.025	Time Choice Logsum	0.984	20.665
		Drive to work place	-0.822	-5.768	Female, kids under 12 in HH	0.863	6.364
		Return home after 5 PM	-2.304	-15.648	Female, less than 4 person in HH	-0.268	-3.770
		Male, 2+workers in household	-0.120	-1.156	Female, 2+non-workers in HH	-0.497	-5.938
		Working at home	0.279	3.027	Age under 50	0.125	1.558
2	DT	Male, less than 4 person in HH	-1.781	-17.469	Time Choice Logsum	0.984	20.665
		Working at home	0.897	9.947	Male, less than 4 person in HH	0.302	1.465
		Male, 2+adults in HH, 1+nonworkers	-1.664	-15.617	Male, only adults in HH	-0.270	-1.232
		Female, husband worker	-1.390	-10.106	Male, 2+non-workers in HH	-0.450	-3.346
3	NMD/	Female, husband worker	0.838	7.611	Live without spouse	1.864	11.723
	MDH	Grandfather/grand mother age over 70 in HH	0.522	6.227	Female, kids under 12 HH	1.417	9.787
		Stop to/from home	0.624	4.226			
		No. of obs :.5662			No. of obs : 3478		
		Rho-squared: 0.375			Rho-squared: 0.103		
		MT Hit Ratio : 0.357			MT Hit Ratio: 0.155		
		DT Hit Ratio : 0.114			DT Hit Ratio : 0.475		
		NMD Hit Ratio : 0.874			MDH Hit Ratio: 0.720		

decision of time influences significantly the choice of MT and DT. Non-workers of *female with kids under 12 in household* tend to choose MT and MDH rather than DT.

4. Conclusions

For the workers model of maintenance and discretionary activity, activity pattern, time of day and mode models were estimated without logsum variables, because parameters of logsum did not fit the acceptable range between 0 and 1, and their estimation had very large standard errors. Working conditions influence mode, time of day and activity pattern choice in performing maintenance and discretionary activity, but without any feedback interaction. Workers who drive to work place would choose drive alone or drive with passenger, and they tend to perform discretionary activity or working tour only rather than maintenance activity. Workers who return home after 5 PM from work place would carry out MD activities in the evening.

For the non-workers model, activity pattern, time of day and mode choice were estimated as a sequential nested logit model system. Parameter of mode choice logsum is very small, 0.048; therefore mode choice slightly influences time choice decision. Time choice logsum computed for activity pattern model has a significant value, 0.98, meaning that the decision of activity pattern is considerably influenced by time of day choice.

References.

Bowman, J.L. (1995). Activity based travel demand model system with daily activity schedules, Master of Science, MIT.

Bowman, J.L. (1998). The day activity schedule approach to travel demand analysis, Ph. D Dissertation, MIT.

Bowman, John L., Mark A. Bradley, Yoram Shiftan, T. Keith Lawton and Moshe E. Ben-Akiva (1998). Demonstration of an activity based model system for Portland, Conference on Transport Research, July 12-17, 1998, Antwerp, Belgium.

TMIP (1997). A System of Activity-Based Models for Portland, Oregon, A Demonstration Project for FHWA Travel Model Improvement Program (TMIP), December 1997.