Assessing Planning Decisions by Activity Type During the Scheduling Process

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ABSTRACT

Existing activity-based models still make assumptions about scheduling decision processes that are not well-informed by empirical evidence. In this paper, a step forward is taken to better understand the activity-scheduling process and to improve activity-based models. In particular, different planning decision mechanisms depending on several activity type classifications are explored.

First, models describing the planning of several aggregate activity types are considered. For these activities, three planning decisions are studied: location, planning time horizon and rescheduling. The “with whom” planning decision is also studied when sub-types of recreational/entertainment activities are investigated in depth.

Significant differences are found in modeling results for each activity type and sub-type and each planning decision. These results confirm the existence of different mechanisms underlying the activity-travel decision process when activity types and sub-types are considered. Important conclusions related to the improvement of microsimulation models are highlighted.

KEYWORDS: Activity-Travel Scheduling, Planning Decision Process, Activity-Based Models

1. INTRODUCTION

Several sequential models that explicitly address the process of scheduling behaviour have been developed. Some of them are SCHEDULER (Gärling *et al*., 1994), AMOS (Pendyala et al., 1995, 1998), SMASH (Ettema *et al*., 1994, 2000), PCATS (Kitamura *et al*., 1996), GISICAS (Kwan, 1997), ALBATROSS (Arentze and Timmermans, 2000), AURORA (Timmermans et al.,2001; Joh et al., 2003, 2004), TASHA (Miller and Roorda, 2003), FAMOS (Pendyala et al., 2005) and FEATHERS (Arentze et al, 2006). Recent advances in household activity models considering the scheduling process can be found in Timmermans and Zhang (2009). Many of the models currently in operation were created using activity pattern data from travel surveys, resulting in a need to make assumptions about the underlying activity scheduling process.

TASHA, for example, makes assumptions for various components of activity scheduling, including the following:

- TASHA assumes a priority-based procedure for generating activities, in which the order of activity types to be inserted into a person's activity schedule is deterministic (work, school, joint social/recreation/personal business, joint shopping, individual social/recreation/personal business, and finally individual shopping). While there is some empirical basis that this is on average the most likely order in which activities are inserted into the activity schedule (Roorda and Miller, 2005), the assumption of determinism is too strong. The degree of preplanning and the likelihood of rescheduling of activities of all types are potentially better represented stochastically.
- Because no data are collected for in-home activities in the underlying travel survey data, TASHA does not attempt to distinguish between in-home activity types, even though there may be significant substitution effects between some types of in-home activities and out-of-home activities that require travel.
- The frequency of joint activities (activities conducted with others) is assumed to be independent of the frequency of individual activities. These activities could well be subject to substitution effects as well.

Similarly, ALBATROSS has a scheduling agent, which can only test the outcome of the scheduling process, and relies on a priori assumptions because process information was not available (Timmermans, 2001).

Currently, data describing specific aspects of the activity scheduling process are available. Following the seminal attempts by Hayes-Roth and Hayes-Roth (1979) using a verbal protocol, Ettema *et al*. (1994) developed Magic, a computer programme for self completion of activity (re-)scheduling tasks. Doherty and Miller (2000) developed CHASE, a computer-aided self-interview of activity scheduling for households, allowing users to record their scheduling decisions over a multi-day period. Other similar software running on the Internet or on handheld computers, were used by Lee *et al*. (2000), Lee and McNally (2001) and Rindsfüser *et al*. (2003). Ruiz (2005) used the Internet as the only tool to collect data on the activity scheduling process. The Toronto Activity Panel Survey (Roorda and Miller, 2004) used several methods to collect activity scheduling data, including CHASE in the first survey wave. Bellemans *et al*. (2008) and Clark and Doherty (in press a) used GPS data to automatically track activity rescheduling decisions. Hato (2010) recently developed a small, portable travel-activity measuring instrument that requires no entry from respondents.

First steps towards a deeper comprehension of the activity scheduling process have been recently taken through empirical analysis of the available data. Ruiz *et al*. (2005), Ruiz and Timmermans (2006) and Auld *et al*. (2008) studied resolution of activity scheduling conflicts. Mohammadian and Doherty (2005), Doherty (2005), Lee and McNally (2006), Mohammadian and Doherty (2006) van Bladel *et al*. (2009) and Akar et al. (2009) analyzed activity scheduling time horizon. Clark and Doherty (in press b) also studied time horizon and the impact of a single decision on the rest of the schedule. Kang et al (2009) studied activity priority during the scheduling process.

Finally, some studies have analyzed several facets of the activity scheduling process, or even global scheduling adjustment (Joh, Polak and Ruiz, 2005; Joh, Doherty and Polak, 2005). In particular, Doherty (2006) found that activity types with similar spatial/temporal/interpersonal flexibility do not share stable attributes (frequency, duration, involved persons, travel time, and location). These results suggest that traditional activity type classifications cannot be used as the only means to explain when and how activity patterns are formed. It is necessary to consider other attributes as well, which may serve to better explain how and why travel behavior is subsequently structured and executed. In the same line, empirical analysis carried out by Doherty and Mohammadian (2007) clearly does not support the assumption that activities are planned in accordance to a fixed hierarchy of activity types. In this study, duration proved to be the most significant activity characteristic when explaining how activity-travel tours are planned. But Clark and Doherty (2008) have recently found that activity type is the most often preplanned activity attribute, followed by location, start time, involved persons, and end time. For trips, the mode type and start time are most often planned first, followed by involved persons and end time. Ruiz and Roorda (2008) studied several decisions during the activity scheduling process including location, time horizon, activity modification and with whom. They found that characteristics of the observed schedule and activities have the greatest influence over scheduling decisions. Several significant correlations among activity scheduling decisions were also identified. Scheduling activity types have recently been modelled together in a study of activity-agenda formation (Habib and Miller, 2009).

The diversity of results obtained so far indicates that there is a need to continue studying the role of activity type classification in the activity scheduling process. In this research we postulate that different types of activities follow different mechanisms underlying the scheduling decision process. The type of activity itself has a significant influence on several characteristics of this process. If this is true, when simulating this process there would be a need to consider different models for each activity type. We expect that in each model, different variables are significant in explaining the same scheduling decision. Our objective is to test this hypothesis using a rich dataset that allows us to study differences even among activity sub-types.

First, multivariate probit models are used to explore scheduling mechanisms underlying activity location choice, preplanning and rescheduling for several aggregate activity types. Then, sub-types of recreational/entertainment activities are analyzed in-depth to detect differences in scheduling decisions. It was possible to include in the latter analysis with whom information (whether or not activities are planned to be carried out with companions), because this planning decision was collected without misunderstanding for recreation/entertainment activities. But it was not feasible to analysis sub-types of other kinds of activities in depth because of sample size restrictions.

We consider that the activity scheduling decision process is defined as “the planning and execution of activity-related decisions over time” (Doherty, 2000). The point of our modelling effort is to show that there are relationships between when an activity is planned, where it is planned, with whom it is planned, and the stability of the scheduled activity. We want to identify whether out of home activities, for example, are planned more in advance, or are harder to reschedule.

Location and with whom are two of the most important elements that are part of the scheduling process, and therefore our joint modelling approach tries to capture this. For location, the relationships between time and space in activity planning are well established (Hagerstrand’s space-time prisms (1970) are the obvious example). Commitments to others (as represented in the “with whom” variable) surely influence the planning horizon and the difficulty of rescheduling. Additionally, planning to carry out an activity with other people requires joint scheduling decisions to make their agendas consistent (Arentze and Timmermans, 2009), which justifies the need to study the with whom scheduling decision.

The paper is organised as follows. After this introduction the characteristics of the dataset used are presented. Then, results from the modelling exercises are analysed. The paper finishes with some conclusions and discussion.

2. DATA

The Travel Activity Panel Survey (TAPS) is an in-depth longitudinal survey of activity and travel scheduling processes, undertaken on an initial random sample of 270 households in Toronto and 250 households in Quebec City, Canada (Doherty *et a*l, 2004; Roorda *et al*, 2005). The TAPS survey consisted of three waves, each of which focussed on different elements of the activity scheduling process. The data used in this study comes from the first wave of Toronto sample. A computerized activity scheduling survey instrument, entitled CHASE© (Computerized Household Activity Schedule Elicitor), which was first developed by Doherty and Miller (2000) were used to collect the data. Each household in the sample was provided, for one week, a notebook computer with the CHASE software, which resembled a computerized day-timer. At the outset of the survey week, the household was interviewed to obtain socio-economic information, the software was customized for the family, and adult household members were asked to enter all activities that were already planned for the week. Each day, respondents were asked to update their activity diary with any new activities that had been planned, any plans for future activities that had changed, and any changes to activities done that day that were not executed as originally planned.

Several variables were collected for each activity that was entered or modified in the schedule. These variables included the activity type, location, start-time, and duration of the activity, the mode(s) of transportation used to get to the activity, the persons that were involved with the respondent on the activity, any children that were under the care of the respondent during the activity, and when the activity was originally planned.

Activity types were collected by means of two classifications. Respondents were first asked to classify their activity in nine categories (aggregate classification), including basic needs, work/school, household obligations, drop-off/pick-up, shopping, services, recreation/entertainment, social, and other. Then, respondents were asked to define in detail the activity using their own words or selecting a pre-determined activity definition (disaggregate classification). Recreation/entertainment activities included: hobbies, exercise or active sports, spectator events/theatre, playing/parks, regular TV programs, unspecific TV, watching video, relaxing/napping/reading, email/internet and other recreation/entertainment.

For each planned activity, respondents were asked *"When did you originally make the decision to add this activity? (i.e. at what point were you relatively sure about when where and with whom this activity would take place)."* The resulting responses were coded into the following general categories (see Clarke and Doherty (2008b) for more detail):

- Spontaneous
- Planned on the same day
- Planned days before
- Planned weeks / months / years ago
- Routine
- Unknown / can't recall / missing

The purpose of this question was to ascertain the types of activities that form the "skeleton" of the schedule, or in other words, the part of the schedule that is routine or planned in advance and which therefore forms the spatio-temporal structure around which other more spontaneously planned activities are scheduled. For the analysis and discussion in this paper, these categories are aggregated into "preplanned activities" (including routine activities and those planned days/weeks/months/years ago), and "spontaneous" activities (including activities recorded as spontaneous and activities planned on the same day). As other dependent variables are binary, we simplified this one to have homogeneous categorizations of dependent variables and to avoid dimensionality problems with the four decision dimensions. (i.e. instead of 16 possible combinations (2x2x2x2) over the 4 binary dimensions, we would be dealing with 48 combinations (2x2x2x6) for each activity type without aggregation). There is a trade-off between the number of dimensions and the number of categories in each dimension, and we have opted to including more scheduling choice dimensions.

The CHASE survey also recorded any activity additions, modifications or deletions that are made to the schedule over the course of the week. Thus, it is possible with this data set to compare the attributes of activities that are executed as originally planned to those that are modified. This can indicate the degree of permanence associated with activities entered into the schedule. After data cleaning, the total number of activity records in the Toronto Wave 1 survey was 40055, including activity additions, modifications and deletions.

As shown in Table 1, basic needs, household obligations and recreation/entertainment activities are more often planned to be carried out at home. The rest of types of activities are more likely to be planned for out-of-home locations.

All types of activities are more frequently executed as planned. Basic needs activities are least likely to be modified or deleted prior to their execution and work/school activities are most likely to be modified or deleted prior to their execution.

Basic needs, work/school and drop-off/pick-up activities are more often preplanned. Household obligations, services and recreation/entertainment activities are almost equally likely to be preplanned or as they are to be spontaneous. Other activity types are most often spontaneously planned.

Recreation/entertainment activities and household obligations are more frequently planned to be carried out alone. As expected, social activities are mostly planned with others. Basic needs activities are as likely to be planned to be performed alone or with others.

TABLE 1 Aggregate classification of activity types and planning decisions

Planning decision	At Home		Out-of-Home		As Planned		Modified/ deleted		Preplanned		Spontaneous		With Others*		Alone*	
Activity	total	%	total	%	total	%	total	%	total	%	total	%	total	%	total	%
Basic Needs	14647	94.2	908	5.8	13692	88	1863	12	10368	66.7	5187	33.3	484	53.3	424	46.7
Work/School	1002	24.8	3034	75.2	3211	79.6	825	20.4	2889	71.6	1147	28.4				
HH Obligations	5281	96.7	182	3.3	4649	85.1	814	14.9	2869	52.5	2594	47.5	56	30.8	126	69.2
Drop-off/Pick-up	129	7.7	1546	92.3	1386	82.7	289	17.3	1073	64.1	602	35.9				
Shopping	6	0.4	1422	99.6	1223	85.6	205	14.4	456	31.9	972	68.1				
Services	68	10.1	602	89.9	559	83.4	111	16.6	373	55.7	297	44.3				
Rec/Entert	6624	84.1	1252	15.9	6698	88	1178	12	3940	88	3936	12	2784	35.3	5092	64.7
Social	914	45.3	1105	54.7	1699	84.7	306	15.3	897	44.7	1108	55.3	1492	74.4	513	25.6
Other	987	75.2	325	24.8	1141	87	171	13	531	40.5	781	59.5				
Total	29658		10376		34258		5762		23396		16624		4816		6155	

(*) Data about the "with whom" planning decision was only available for the following activities: Basic Needs out-of-home, Household Obligations out-of-home, and Recration/Entertainment and Social activities

As shown in Table 2, exercise or active sports, attending events/theater and other recreation/entertainment activities are more frequently planned to be carried out out-of-home. The rest of recreation/entertainment activity sub-types are mostly planned to take place at home.

All sub-types of recreation/entertainment activities are more frequently executed as planned. However, some differences are evident. Activities related to watching regular or unspecific TV programs or video and email/Internet activities are much less often modified or deleted prior to execution than the other sub-types of recreation/entertainment activities.

Hobbies, exercise or active sports and attending events/theatre are typically preplanned. Playing/parks activities are almost equally preplanned or spontaneous. The rest of activity types are mostly spontaneously planned.

Hobbies, exercise or active sports, regular or unspecific TV programs, relaxing, napping, reading, emailing and internet are more frequently planned to be carried out alone. Spectator events, theatre, watching videos, and other recreation/entertainment are more often planned with other(s). Playing/parks activities are almost equally likely to be planned alone or with others.

TABLE 2 Sub-classification of Recreation/Entertainment activities and planning decisions

Planning decision	At Home		Out-of-Home		As Planned		Modified/ deleted		Preplanned		Spontaneous		With Others*		Alone*	
Recreation/ Entertainment	total	%	total	%	total	%	total	%	total	%	total	%	total	%	total	%
Hobbies	160	70.8	66	29.2	184	81.4	42	18.6	128	56.6	98	43.4	64	28.3	162	71.7
Exercise or active sports	157	18.6	689	81.4	685	81.0	161	19.0	514	60.8	332	39.2	295	34.9	551	65.1
Spectator Events/ Theatre	7	4.2	159	95.8	129	77.7	37	22.3	98	59.0	68	41.0	129	77.7	37	22.3
Playing/parks	53	50.0	53	4.4	83	78.3	23	21.7	55	51.9	51	48.1	53	50.0	53	50.0
Regular TV programs	2200	99.0	22	1.8	1912	86.0	310	14.0	1235	55.6	987	44.4	946	42.6	1276	57.4
Unspecific TV	504	98.8	6	0.5	459	90.0	51	10.0	175	34.3	335	65.7	196	38.4	314	61.6
Watching video	245	97.2	7	0.6	237	94.0	15	6.0	102	40.5	150	59.5	166	65.9	86	34.1
Relaxing/napping/ reading	2608	98.0	53	2.0	2221	83.5	440	16.5	1231	46.3	1430	53.7	673	25.3	1988	74.7
Email/internet	728	99.2	6	0.5	648	88.3	86	11.7	303	41.3	431	58.7	59	8.0	675	92.0
Other recreation/ entertainment	101	39.6	154	60.4	224	87.8	31	12.2	154	60.4	101	39.6	151	59.2	104	40.8
Total	6763		1215		6782		1196		3995		3983		2732		5246	

(*) Data about the "with whom" planning decision was only available for the following activities: Basic Needs out-of-home, Household Obligations out-of-home, and Recration/Entertainment and Social activities

3. ANALYSIS AND RESULTS

The objective of this analysis is to develop a set of models, one for each activity type, that describe differences in scheduling decisions. First, for aggregate activity types, three planning decisions are examined including location, time planning horizon and modification or deletion of activities during the scheduling process. Models for all aggregate activity types have been developed, but in this paper only models for basic needs, drop-off/pick-up, recreation/entertainment and social activities are included. These models display the most significant dissimilarities in the scheduling process. Then, the "with whom" planning decision is added in an in-depth analysis to confirm variations in the scheduling process among several sub-types of recreational/entertainment activities including exercise or active sports, regular TV programs, relaxing/napping/reading and email/internet. In the first analysis, the incidence of schedule decisions is described by a 3-binary element schedule decision vector, where the three elements represent whether the activity is carried out at home or out-of-home, spontaneously planned or preplanned, and modified/deleted prior to its execution or executed as planned, respectively. In the second analysis, the incidence of schedule decisions is described by a 4-binary element schedule decision vector, in which the additional element represents whether the activity is carried out alone or with other(s).

Using these characterizations of schedule decisions, we explore how the decisions are affected by a number of factors including characteristics of the household, features of the activities and socio-demographic characteristics of the individual respondent. The focus is on detecting different activity scheduling mechanisms for different activity types. The incidence of scheduling decisions is modeled using a multivariate probit (MVP) model. The MVP is a popular class of models particularly suitable for the analysis of correlated binary data (Greene, 2003). In this class of models, the response is multivariate, correlated and discrete. Generally speaking, the MVP model assumes that given a set of explanatory variables the multivariate response is an indicator of the event that some unobserved latent continuous variable exceeds a threshold, which can be taken to be zero, without loss of generality. The latent continuous variable is assumed to arise from a multivariate normal distribution. The characteristics of this model fit well in this case. MVP models were used by the authors in similar research with different datasets and we obtained coherent results. The appeal of the probit model is that it relaxes the independence of the irrelevant alternatives (IIA) property assumed by the logit model. Model specification and results are discussed in more detail below.

3.1. Multivariate probit model of the incidence of schedule decision

The proposed model concentrates on describing the *incidence* of schedule decisions of different types. Thus, in the first analysis our interest is focused on whether or not the activity is planned to be carried out at home or out-of home, if the activity is preplanned or it is spontaneous, and whether or not the activity is modified or deleted prior to its execution during the scheduling process. In the second analysis we also included whether or not the activity is planned to be carried out with other(s). Each element in the schedule decision vector is recoded as a 0/1 dummy according to whether or not the corresponding schedule decision was made. This recoding of the schedule modification vector results in a dependent variable that has $2^3 = 8$ distinct states in the first analysis, and $2^4 = 16$ distinct states in the second analysis.

We assume that the unobservable propensity of an individual to make each of these scheduling decisions is systematically related to a set of explanatory variables, via a linear model. Corresponding to these underlying unobservables are the actual observations of whether or not decisions are in fact made. Thus we have, for each planned activity in the first analysis:

$$PAH = \beta_1 X + \varepsilon_1 \quad \text{if } ATHOME = 1, \quad PAH = 0 \quad \text{if } ATHOME = 0 \qquad (1)$$

$$PPA = \beta_2 Y + \varepsilon_2 \quad \text{if } PREPLAN = 1, \quad PPA = 0 \quad \text{if } PREPLAN = 0 \qquad (2)$$

$$PAP = \beta_3 Z + \varepsilon_3 \quad \text{if } ASPLANNED = 1, \quad PAP = 0 \quad \text{if } ASPLANNED = 0 \qquad (3)$$

Where:
PAH = unobservable propensity to realize activities at home,
PPA = unobservable propensity to plan activities days/weeks/months in advance or to consider them as routine activities,
PAP = unobservable propensity to realize activities as planned during the scheduling process.

In the second analysis we add:

$PWO = \beta_4 W + \varepsilon_4$ if $WITHOTHE = 1$, $PWO = 0$ if $WITHOTHE = 0$ (4)

Where:

PWO = unobservable propensity to realize activities with other(s),

The quantities *ATHOME*, *PREPLAN*, *ASPLANNED* and *WITHOTHE* are discrete (0,1) variables indicating whether the activity is out-of home/at home, if the activity is spontaneous/preplanned, if the activity is modified or deleted/executed as planned, and the absence/presence of companion(s) during the activity, respectively. The quantities *W*, *X*, *Y* and *Z* are vectors of (potentially identical) exogenous variables and β_i (i=1,…,3) (in the second analysis: β_i (i=1,…,4)) are vectors of estimable parameters associated with the exogenous influences on the incidence of schedule decisions. The correlated error terms ε_i (i=1,…,3) (in the second analysis: ε_i (i=1,…,4)) are assumed to be drawn from a multivariate normal distribution with mean 0 and covariance matrix $\mathbf{\Sigma}$. Since the observed data contain no information regarding the magnitude of the underlying propensities, the diagonal elements of $\mathbf{\Sigma}$ are normalized to unity; the off-diagonal elements of $\mathbf{\Sigma}$ enable the model to accommodate unobserved endogenous effects across the three (four) equations.

These multivariate probit (MVP) systems are simultaneously estimated using weighted least-square with mean and variance correction estimator (WLSMV). The WLSMV is robust against violation of multivariate normality (Greene, 2003)

The model specifications are developed by testing the significance of the available socio-economic variables of the respondents' households, several characteristics of the individuals and a number of attributes of the activities implicated in the scheduling decision process (Table 3). Limdep v.4.0.1 was used to design the MVP models. We selected variables to be included in each model considering their importance outlined in previous research. Then we tested other variables to check their significance. Multicollinearity was easily detected when a new variable entered in the model was found to be statistically significant while one or more other variables already in the model lost their significance. Non-significant variables were not included in the model specification, because they often display non-structured variation, i.e. noise. Their removal will result in a more stable and robust model. Usually the prediction error decreases as well.

Different specifications of the covariance matrix are defined to test the existence of endogeneity among the dependent variables, which are defined in Table 4.

TABLE 3 Sample Mean and Standard Deviations for Explanatory Variables

Variable	Definition	Mean	Std. Dev.
Household characteristics			
H_1nochildteen	Reference category: 1-adult household without children nor teens		
H_1childteen	1 if presence of children or children+teens in 1-adult households, 0 otherwise	0.033	0.178
H_1teen	1 if presence of teens in 1-adult households, 0 otherwise	0.026	0.157
H_2nochildteen	1 if 2-adult household without children nor teens , 0 otherwise	0.347	0.476
H_2childteen	1 if presence of children or children+teens in 2-adult households, 0 otherwise	0.272	0.445
H_2teen	1 if presence of teens in 2-adult households, 0 otherwise	0.087	0.282
H_size	Total number of household members	2.963	1.454
H_kids	Number of kids in household	0.598	1.050
H_teens	Number of teenagers in household	0.188	0.479
H_Adlts	Number of adults in household	2.162	0.963
H_Othrs	Number of other members in household	0.015	0.152
H_Autos	Number of cars in household	1.494	0.602
H_Dsingd	Reference category: single-detached house		
H_Dsemid	1 if semi-detached house, 0 otherwise	0.180	0.384
H_Dtownh	1 if Row house/Town house, 0 otherwise	0.057	0.232
H_Dapardet	1 if Apartment in a detached duplex, 0 otherwise	0.008	0.090
H_Daparbui5	1 if Apartment in a building with FEWER than 5 stories, 0 otherwise	0.051	0.221
H_Daparbui6	1 if Apartment in a building with MORE than 5 stories, 0 otherwise	0.066	0.250
H_Dother	1 if Other single-attached house, 0 otherwise	0.001	0.035
H_OwnRnt	1 if house is owned, 0 otherwise	0.793	0.405
H_ResDur	Residential duration in house (years)	9.715	9.082
H_CitDur	Residential duration in city (years)	18.200	14.965
H_RegDur	Residential duration in region (years)	24.429	16.272
Individual characteristics			
I_Rmalehead	Reference category: male head of household		
I_Rfemhead	1 if female head of household, 0 otherwise	0.480	0.500
I_Rson	1 if son, 0 otherwise	0.043	0.203
I_Rdau	1 if daughter, 0 otherwise	0.064	0.245
I_Roth	1 if other, 0 otherwise	0.014	0.117
I_Gender	1 if male, 0 if female	0.448	0.497
I_Tsingadu	Reference category: Single adult in household		
I_Tadupartn	1 if Adult in partnership in household, 0 otherwise	0.643	0.479
I_Tteen	1 if Teen in household, 0 otherwise	0.032	0.176
I_Taduother	1 if Other adult in household, 0 otherwise	0.017	0.129
I_Taduchild	1 if Adult child in household, 0 otherwise	0.070	0.254
I_Autos	Number of cars	1.557	0.588
I_Age	Age of respondent	43.557	14.272
I_Income	Annual income of respondent	45258.429	36552.300
I_Licens	1 if respondent has driver license, 0 otherwise	0.907	0.291
I_Efulltime	Reference category: Employed Full Time		
I_Eparttime	1 if Employed Part Time, 0 otherwise	0.124	0.329
I_Ehome	1 if Homemaker, 0 otherwise	0.060	0.237
I_Enotemp	1 if Not Employed or Retired, 0 otherwise	0.195	0.396
I_Eworkath	1 if Work at Home, 0 otherwise	0.051	0.221
I_Sfulltime	Reference category: Full Time Student		

Variable	Definition	Mean	Std. Dev.
I_Spartime	1 if Part Time Student, 0 otherwise	0.817	0.386
I_Snotstud	1 if Not a Student, 0 otherwise	0.048	0.213
I_Eelement	Reference category: Elementary studies		
I_Esecond	1 if Secondary studies, 0 otherwise	0.217	0.412
I_Enonuniv	1 if Trades/Non-University certificate or diploma, 0 otherwise	0.207	0.406
I_Edegree	1 if University Certificate/Bachelor’s degree or above/Degree in medicine, dentistry, veterinary/Master’s degree/Doctorate, 0 otherwise	0.542	0.498
I_TranPs	1 if respondent has transit pass, 0 otherwise	0.089	0.285
I_Cnocall	Reference Category: Do not use a cell phone		
I_C1call	1 if respondent use a cell phone less than 1 call per day, 0 otherwise	0.222	0.416
I_C3call	1 if respondent use a cell phone 1 to 3 calls per day, 0 otherwise	0.161	0.367
I_C4call	1 if respondent use a cell phone More than 3 calls per day, 0 otherwise	0.216	0.412
I_Status	1 if married, common law or other couple, 0 otherwise	0.721	0.449
Activity characteristics			
Astart_Am	Reference category: activity to be started in the morning (5 a.m.-11:59 a.m), 0 otherwise		
Astart_Aa	1 if activity to be started in the afternoon (12:00 p.m.-4:59 p.m), 0 otherwise	0.223	0.417
Astart_Ae	1 if activity to be started in the evening (5:00 p.m.-8:59 p.m.), 0 otherwise	0.359	0.480
Astart_An	1 if activity to be started in the night (9:00 p.m.-4:59 a.m.), 0 otherwise	0.238	0.426
Attime	Travel time declared to be expent to arrive where the activity takes place (min.)	24.684	35.256
Atransfer	1 if transfer(s) to be required during the journey, 0 otherwise	0.036	0.187
	Total duration of the planned activity (min.)	96.555	96.147
Aduration	Reference category: planned activity related to Basic Needs		
Abasicneed	1 if planned activity is related to Household Obligations, 0		
Ahouhobl	otherwise	0.017	0.128
	1 if planned activity is related to Recreation/Entertainment , 0		
Arecre	otherwise	0.714	0.451
	1 if planned a Social Activity, 0 otherwise	0.181	0.385
Asocial	Reference category: mode of transport to be Driving		
Amoddriving	1 if respondent not to travel, 0 otherwise	0.680	0.466
Amodnotrav	1 if Transit to be used, 0 otherwise	0.028	0.166
Amodtransit	1 if Non-Motorized mode to be used, 0 otherwise	0.073	0.259
Amodnonmot	Total Number of Activities to be realized that day by		
AtotActDay	respondent	13.306	4.646
	Total time declared by respondent to be spent traveling that		
AtotTTimeDay	day	88.958	69.192
AtotJourDay	Number of journeys to be realized that day by respondent	4.293	2.578
	Total Number of Activities to be realized at home that day by		
AtotActHomDay	respondent	3.569	2.381

TABLE 4 Sample Mean and Standard Deviations for Scheduling Decisions

Variable	Definition	Mean	Std. Dev.
ASPLANNED	1 if planned activity not modified nor deleted prior to its execution, 0 otherwise	0.865	0.342
ATHOME	1 if activity to be taken place at home, 0 otherwise	0.673	0.469
WITHOTHE	1 if activity to be realized with other(s), 0 otherwise	0.502	0.500
PREPLAN	1 if activity is planned day(s)/week(s)/month(s) before the date of its execution or it is a routine activity, 0 otherwise	0.419	0.493

The estimated model parameters, correlation matrix and goodness-of-fit indices are summarized in Tables 5 and 6. The results include for each explanatory variable: coefficient estimates, the ratio of the estimates to their standard errors, and the probability of obtaining a greater F statistic than that observed if the null hypothesis is true. The Est./S.E. column can be used to evaluate significance. If the absolute value of the number in this column is greater than 1.96 the estimate can be interpreted as significant at the 0.05 level. Positive coefficients indicate an increased probability of a particular scheduling decision.

3.2. Analysis for aggregate classification of activity types

Eight models were developed to analyze differences in how respondents make decisions during the activity scheduling process depending on the aggregate classification of activity type. In this paper only four models are presented which include the more statistically significant results obtained for activity types that have large sample sizes. The results are presented in Table 5.

Global differences for each activity type are presented first. A detailed analysis follows, which focuses on those parameters that have different signs between models. Both are directly related to differences about how planning decisions are taken for each activity type. Finally, the modeling approach used allows us to study correlation among planning decisions, and how those correlations differ between activity types.

3.2.1. Estimation results: global differences

Significant differences are found in modeling results for each activity type and each planning decision. The location decision (ATHOME) for basic needs activities is explained in the model by five household characteristics and four features of the observed activities. Respondents in 1 or 2-adult households with children and/or teens are more likely to plan basic needs activities at home than those in 1-adult household without children or teens.

The more teens in the household, the more likely it is that the basic needs activity is planned to be carried out at home. Arguably the presence of teens in the household requires adults to plan more attention to them.

Respondents who live in town houses have a higher tendency to plan basic needs activities at home compared with respondents who live in a single-detached houses.

The longer the respondent has lived in the region the more likely is that basic needs are planned to be carry out at home. This indicates that long-established families, often the elderly, are more home-oriented.

If a basic needs activity does not require travel it is highly likely to be at home, indicating that people tend to report consecutive basic needs activities at home. If it involves a transit trip, it is more likely to be planned at home compared with activities involving a drive trip. But if the respondent plans to use a non-motorized transportation mode, then it is less likely that the basic needs activity will be carried out at home. It may be easier to plan out-of-home basic needs activities when destination can be reach walking or biking.

The larger the number of activities planned per day, the less likely that basic needs activities are planned at home. In this case it is very likely that people are carrying out several activities out-of-home, so basic needs are being fit in as part of a tour of consecutive out-of-home activities.

The location decision model specification is similar for recreation/entertainment activities, for which location is mainly explained by household characteristics and features of the activities. It is interesting that for this model, the later the activity start time, the more likely it is to be planned at home. Shorter duration activities are more likely to be done at home as well. Household structure variables are somewhat mixed, but do indicate that households with children are more likely to stay at home, and that the number of teenagers has a further positive influence on staying home.

The model specifications for drop-off/pick-up and social models are different in the sense that they also include attributes of the individual respondents. These models are based on fewer observations of at-home activities (especially the drop-off/pick-up model) which probably explains the smaller number of statistically significant variables.

TABLE 5 Mulivariate Probit Coefficient Estimates and Correlation Matrix. Aggregate Analysis

Model for Basic Needs

function for ATHOME

Variable	Coeff	b/St.Er.	P[|Z|>z]
Constant	0.6006	7.9690	0
H_1childteen	**0.4038**	**2.6350**	**0,0084**
H_2childteen	0.1699	3.7460	0,0002
H_Teens	0.2735	5.3220	0
H_Dtownh*	0.2430	2.3130	0,0207
H_Regdur	0.0006	4.8360	0
Amodnotrav	1.2529	24.3300	0
Amodtransit	0.7368	4.7660	0
Amodnonmot	-0.5001	-4.9000	0
AtotActHomDay*	-0.0074	-2.0820	0,0374

function for PREPLAN

Variable	Coeff	b/St.Er.	P[|Z|>z]
Constant	-0.1310	-2.1010	0,0357
H_1teen	0.5017	7.7290	0
H_2nochildteen*	-0.0847	-2.4780	0,0132
H_2teen	-0.1828	-5.9880	0
H_Sizae	0.0755	7.7180	0
H_Othrs*	-0.1895	-2.2300	0,0258
I_Eworkath	-0.3822	-5.3780	0
I_Enonuniv	0.3231	5.0760	0
Amodnotrav	0.6163	15.2590	0
Amodtransit	0.5631	5.1860	0
AtotActHomDay	-0.0231	-10.7160	0
AtotJourDay	0.0377	8.3300	0

Model for Drop-off/Pick-up

function for ATHOME

Variable	Coeff	b/St.Er.	P[|Z|>z]
Constant	-1.6307	-6.6570	0
H_TEENS	0.2304	3.4550	0,0005
I_Rdau	0.8648	2.6990	0,0069
I_Spartime*	0.4899	2.0900	0,0366
Amodtransit*	0.6470	2.0770	0,0378
AmotJourDay	-0.0493	-3.2840	0,001

function for PREPLAN

Variable	Coeff	b/St.Er.	P[|Z|>z]
Constant	1.3769	8.0050	0
H_1childteen*	**-0.2794**	**-2.1880**	**0,0287**
H_Adlts*	-0.1167	-2.1730	0,0298
H_Dtownh*	-0.2891	-2.2050	0,0275
H_Daparbui5	-0.8712	-2.9670	0,003
I_Ehome	0.4699	3.3570	0,0008
I_Transps	-0.6705	-3.5310	0,0004
AtotJourDay*	0.0290	2.1990	0,0279
Astart_e	-0.5995	-7.4350	0
Astart_n	-0.7701	-5.2760	0
Aduration	**-0.0025**	**-3.0220**	**0,0025**
AtotActDay	-0.0326	-4.3770	0
Atransfer	0.9709	2.7170	0,0066
Attime	**-0.0064**	**-3.3380**	**0,0008**

Model for Recreation/Entertainment

function for ATHOME

Variable	Coeff	b/St.Er.	P[|Z|>z]
Constant	0.8197	10.9200	0
H_1childteen	**-0.2717**	**-2.8960**	**0,0038**
H_1teen	-0.3203	-4.2160	0
H_2nochildteen*	0.1261	2.4820	0,0131
H_2teen	-0.2036	-3.3890	0,0007
H_Teens	0.1942	4.2850	0
H_Dsemid*	-0.0958	-2.0050	0,045
H_Adlts*	0.0586	2.3380	0,0194
H_Othrs	-0.2901	-2.6350	0,0084
Amodnonmot	-1.5049	-22.9010	0
Atransfer	-0.8617	-2.9650	0,003
Astart_a	0.2338	4.2510	0
Astart_e	0.4269	8.4720	0
Astart_n	1.0930	16.4110	0
Aduration	-0.0020	-9.2780	0

function for PREPLAN

Variable	Coeff	b/St.Er.	P[|Z|>z]
Constant	0.1667	4.0730	0
H_1childteen	**0.2308**	**3.2680**	**0,0011**
H_1teen	0.3168	5.3700	0
H_2childteen	0.0962	2.9790	0,0029
H_Dsemid	-0.1330	-3.4900	0,0005
H_Dapardet	-0.6212	-3.0960	0,002
H_Daparbui5	-0.3773	-5.5620	0
Astart_a	-0.4559	-9.5860	0
Astart_e	-0.2063	-4.8600	0
Astart_n*	-0.0961	-2.1220	0,0338
Atransfer*	0.6672	2.3790	0,0173

Model for Social

function for ATHOME

Variable	Coeff	b/St.Er.	P[|Z|>z]
Constant	-1.5236	-13.9160	0
H_1teen*	-0.7179	-2.2390	0,0252
H_Daparbui6	0.5074	2.9550	0,0031
H_Daparbui6	1.2457	2.8000	0,0051
I_Tadupartn*	0.2626	2.1290	0,0333
Astart_n	0.4938	3.2750	0,0011

function for PREPLAN

Variable	Coeff	b/St.Er.	P[|Z|>z]
Constant	-0.6039	-3.3100	0,0009
I_Edegree	0.5145	2.9670	0,003
I_Esecond*	0.3869	2.1080	0,035
Astart_n*	-0.2676	-2.0900	0,0366
Attime*	**0.0025**	**1.9500**	**0,0511**
Aduration	**0.0014**	**3.9680**	**0,0001**
Amodnonmot*	-0.2478	-2.1490	0,0316

Model for Basic Needs			
	function for ASPLANNED		
Variable	**Coeff**	**b/St.Er.**	**P[|Z|>z]**
Constant	1.2453	13.4440	0
H_1childteen*	0.1949	2.4190	0,0155
H_2childteen	0.1108	2.8380	0,0045
H_2teen	0.1346	2.8900	0,0039
H_Teens	0.1429	4.0310	0,0001
H_Autos*	0.0647	2.1670	0,0302
H_Daparbui5	0.4964	4.5310	0
H_Daparbui6	0.4665	5.0580	0
H_OwnRnt	**0.1601**	**2.8990**	**0,0037**
I_Rdau*	-0.1547	-2.1570	0,031
I_Roth*	0.9052	2.0860	0,037
I_Status	-0.0267	-2.8120	0,0049
I_Eworkath	0.4223	3.4250	0,0006
I_C3call	0.1562	3.7300	0,0002
Astart_a	**-0.3875**	**-7.0270**	**0**
Astart_e	-0.2531	-5.2020	0
Astart_n	**-0.0982**	**-2.6240**	**0,0087**
Atransfer	-0.8905	-3.5860	0,0003
Amodnotrav	-0.2760	-4.8790	0
	Correlation Matrix**		
R(01,02)	**0.0420**	**2.7430**	**0,0061**
R(01,03)***	-0.0010	-0.0520	0,9582
R(02,03)	-0.0874	-4.9550	0
Goodness-of-Fit Indexes			
No Obsev	15555		
L	-13979		
Lo	-19001		
Pseudo R²	0,26430		
AIC	2.25359		
BIC	2.27986		
HQIC	2.26239		

Model for Drop-off/Pick-up			
	function for ASPLANNED		
Variable	**Coeff**	**b/St.Er.**	**P[|Z|>z]**
Constant	1.4618	9.7440	0
H_Dsemid	0.3804	2.8250	0,0047
H_Regdur	-0.0004	-2.7130	0,0067
I_Rdau	-1.3061	-5.2500	0
I_Tadupartn	**-0.4450**	**-3.1770**	**0,0015**
I_Snotstud	-0.5093	-2.6200	0,0088
I_Esecond*	0.2849	2.2990	0,0215
I_Enonuniv	-0.4656	-2.9030	0,0037
Astart_a	**0.3444**	**3.1560**	**0,0016**
Astart_n*	**0.6319**	**2.5000**	**0,0124**
	Correlation Matrix**		
R(01,02)***	**-0.0796**	**-1.7760**	**0,0758**
R(01,03)***	-0.0871	-1.4810	0,1386
R(02,03)*	-0.1196	-2.2370	0,0253
Goodness-of-Fit Indexes			
No Obsev	1439		
L	-1739.382		
Lo	-2286.455		
Pseudo R²	0,23927		
AIC	2.46335		
BIC	2.46446		
HQIC	2.50848		

Model for Recreation/Entertainment			
	function for ASPLANNED		
Variable	**Coeff**	**b/St.Er.**	**P[|Z|>z]**
Constant	1.3152	25.6540	0
H_1childteen*	0.2168	2.3570	0,0184
H_1teen	-0.1851	-2.9170	0,0035
H_Daparbui5	0.2584	2.9350	0,0033
I_Rfemhead	-0.1546	-4.3980	0
Astart_e*	-0.0769	-2.1190	0,0341
Amodnotrav	-0.2383	-4.7220	0
Amodtransit	-0.3185	-2.8080	0,005
Amodnonmot	0.2891	2.8160	0,0049
	Correlation Matrix**		
R(01,02)	**-0.0821**	**-4.7700**	**0**
R(01,03)	0.1132	5.3510	0
R(02,03)	-0.1265	-6.5340	0
Goodness-of-Fit Indexes			
No Obsev	7869		
L	-11461.88		
Lo	-12187.35		
Pseudo R²	0,05953		
AIC	2.92334		
BIC	2.92339		
HQIC	2.26239		

Model for Social			
	function for ASPLANNED		
Variable	**Coeff**	**b/St.Er.**	**P[|Z|>z]**
Constant	1.1248	5.2700	0
H_1teen	-0.4495	-2.5860	0,0097
H_OwnRnt	**-0.4135**	**-2.8230**	**0,0048**
H_Daparbui6	**0.6097**	**2.6340**	**0,0084**
I_Tadupartn*	**0.2591**	**2.0230**	**0,0431**
I_Licens*	0.3929	2.0830	0,0373
Attime	-0.0032	-2.7580	0,0058
	Correlation Matrix**		
R(01,02)*	**-0.1205**	**-2.3460**	**0,019**
R(01,03)***	0.0591	0.7180	0,4726
R(02,03)	-0.1994	-3.3220	0,0009
Goodness-of-Fit Indexes			
No Obsev	969		
L	-1273.8		
Lo	-1364.4		
Pseudo R²	0,06640		
AIC	2.67667		
BIC	2.67667		
HQIC	2.72073		

Highlighted the variables whose parameters have different sign between models

*** X^2 test significant at 0.05 level; all others significant at 0.01 level (except for the correlation matrix coefficients, which are significant over 0.05 level if they are marked with ***)**

(**) 01 = ATHOME, 02 = PREPLAN, 03 = ASPLANNED

It is noted that we did not begin the modeling exercise with very strong a priori expectations about many of the relationships in this set of models, however, none of the implied behavioral relationships appear to be implausible. For the sake of brevity, the results of other models are not described in as much detail.

Similar results are found to explain the planning time horizon (PREPLAN): basic needs and recreation/entertainment activities are mainly explained by household characteristics and features of the activities. In this case, drop-off/pick-up activities are only related to household and individual characteristics. The planning time horizon of social activities is explained by individual characteristics and features of the activities.

Finally, whether or not the planned activity is executed as planned without modification or deletion (ASPLANNED) is mainly explained by household characteristics and features of the activities for recreation/entertainment activities. Individual characteristics are more important to explain this planning decision if it is a drop-off/pick-up activity. Social activities are more explained by household and individual characteristics. Regarding basic needs, a combination of variables are significant in explaining this decision.

Planning of recreation/entertainment activities is mainly related to household and activity variables. Almost no individual variable is significant in this model. As many activities of this type are planned to be carried out with others, it is logical that the type and number of family members are influencing this scheduling decision. Family members are usually the companions in recreation/entertainment activities, or are conditioning where the activity is planned or whether it is modified or not prior to its execution.

Planning of basic needs activities is explained by household and activity variables and to a lesser extent by individual variables. The importance of household characteristics in planning this type of activity is related to the fact that many are planned to be carried out at home, so again the type and number of family members are influencing this scheduling decision.

In contrast, planning of social activities is related to individual and activity variables, and to a lesser extent to household characteristics. This indicates that many social activities are planned to be carried out with non-family members. This explains the lower importance of household characteristics in this scheduling decision. Finally, planning drop-off/pick-up activities depends on a combination of explanatory variables.

3.2.2. Estimation results: differences in parameter signs

Different types of activities are planned in different ways. First, it is clear from Table 5 that different model specifications result for each of the activity types. In each of the models, different variables enter significantly with respect to location, when the activity is planned and whether activities are executed as planned. For the sake of brevity we focus our analysis on those parameters that are significant in corresponding models for different activity types, but exhibit different signs (shaded cells in Table 5). We consider these to be the most important behavioural differences that arise from this analysis.

Planning decisions related to activity location are different for basic needs and recreation/entertainment activities in 1-adults households with children or children+teens. Basic needs related activities are more likely to be planned at home while recreation/entertainment related activities are more likely to be planned out-of-home for these respondents. As explained before, it is very reasonable that the presence of teens obliges adults to pay more attention to them at home, but the teenage years are perhaps the age in which people tend to carry out most of their leisure activities out-of-home, influencing the rest of the family members.

Respondents decide at different times to carry out drop-off/pick-up, recreation/entertainment and social activities. Those living in 1-adult households with children or children+teens are more likely to plan drop-off/pick-up activities on the same day or spontaneously. But recreation/entertainment activities are more likely to be preplanned for such respondents. So planning the latter type of activities requires more coordination among family members than drop-off/pick-up.

High duration drop-off/pick-up activities are more likely to be planned on the same day or spontaneously as well. On the contrary, high duration social activities tend to be preplanned. The longer the trip duration to the drop-off/pick-up activity the more likely it is planned on the same day or spontaneously. However, in similar circumstances social activities are more likely to be preplanned. These results may be explained because social activities require more coordination among participants as well, regardless of the duration of the activity or the associated travel.

Finally, the extent to which activities are executed as planned is different for basic needs, drop-off/pick-up and social activities. Respondents who own their house are more likely to execute basic needs activities as planned. However, home owners tend to modify or delete their drop-off/pick-up activities prior to their execution. Perhaps because planning drop-off/pick-up activities always relies on another person and most of basic needs are carried out alone. Adults in partnership are more likely to modify/delete drop-off/pick-up activities than single adults, quite possibly because the responsibilities can be transferred to the partner. Such respondents, however, present a higher tendency to execute social activities as planned, potentially because the partner can take on other unexpected conflicting obligations that arise.

Basic needs activities starting in the afternoon or at night are more likely to be modified or deleted prior to their execution than the same type of activity starting in the morning. We believe this is because the morning tends to be more routine and future potentially conflicting activities arise at this time of day. On the other hand, drop-off/pick-up activities starting in the afternoon or at night have a higher tendency to be executed as planned than their morning counterparts. Drop-off/pick-up activities at night are planned more spontaneously and this results in less opportunity for modification, whereas drop-off/pick-up in the morning is preplanned and can be affected by later modification.

3.2.3. Estimation results: correlation among planning decisions

There is a significant positive correlation in the error terms between planning basic needs activities at home and planning them in advance or consider them as routine activities. This is very reasonable: most basic needs activities that are planned to be carried out at home are routine (sleeping, having breakfast, etc.). However, the correlation between these two planning decisions is negative for drop-off/pick-up, recreation/entertainment or social activities, indicating that if they are planned to be carried out at home, they are more likely to be spontaneous or planned on the same day. This indicates that the home is available as a venue for such activities without the necessary preplanning associated with accessing other facilities or other people's homes. Error term correlations between location and activity rescheduling are generally less significant. However, there are strong, consistent and sensible negative correlations between preplanning and activity rescheduling. The earlier an activity is planned, the more opportunity there is to reschedule that activity.

3.3. Analysis for disaggregate classification of recreation/entertainment activities

Four models were developed using disaggregate data for the following subtypes of recreation/entertainment activities: exercise or active sports, regular TV programs, relaxing/napping/reading and email/internet. These models are presented in Table 6. In addition to the location, planning horizon and whether activities were executed as planned, "with whom" information was also used as a dependent variable because this data was collected without any misunderstanding for recreation/entertainment activities.

Similar to the previous analysis, global differences for each activity sub-type are presented first. Then, a detailed analysis follows, which focuses on those parameters that have different signs between models. Finally, correlations among planning decisions are presented.

3.3.1. Estimation results: global differences

Again, significant differences in model results are apparent for each activity sub-type and each planning decision. Decisions of whether to engage in relaxing/napping/reading activities with other people (WITHOTHE) are mostly explained by household characteristics. Planning to watch regular TV programs depends on both household and individual characteristics. A combination of household, individual and activity attributes is significant in models for exercise or active sports and email/internet related activities. These differences could be explained considering that planning relaxing/napping/reading activities to be carried out alone or with companions depends to a greater extent on the number and type of members in the household. On the other hand, the rest of the subtypes of recreation/entertainment activities rely more on the individual's preferences, hobbies, etc.

Whether or not the activity is executed as planned depends mainly on household characteristics if the activity is exercise/active sports or email/internet. Other explanatory variables also influence this decision, but are less important. In the case of watching regular TV programs, individual and activity characteristics affect the decision of modifying/deleting the planned activity prior to its execution. Most activities related to watching regular TV programs are planned to be carried out at home. Plausibly other factors related to the activity (timing) or the individual should explain this scheduling decision. For relaxing/napping/reading activities, this planning decision is explained mainly by household and activity characteristics. Again, number and type of family member may influence scheduling decisions related to relaxing/napping/reading activities. As suggested before, the presence of children may alter any planning related specially with at-home activities.

Relatively few variables are statistically significant to explain location decisions and the time horizon of planning. This is probably a result of the smaller sample sizes that are observed when dealing with detailed activity subtypes.

3.3.2. Estimation results: differences in parameter signs

The models in Table 6 show that different sub-types of recreation/entertainment activities are planned in different ways, as indicated by different parameter signs on the same explanatory variable. These differences are indicated with the shaded cells in Table 6.

Decisions of whether activities are done with others are different for relaxing/napping/reading activities and for mail/internet activities. The parameter signs are opposite for the variable indicating a 2-adult household without children/teens. For respondents in such households, relaxing/napping/reading activities are more likely to be planned with others, while mail/internet activities have a higher tendency to be planned alone. Not surprisingly, 2-adult households do not find companionship by spending their time on email or internet, whereas they do for relaxing/napping/reading activities.

Respondents in households with a high number of adults plan with different time horizons relaxing/napping/reading activities and e-mail/internet related activities. The former are more likely to be planned on the same day or spontaneously, but these respondents present a higher tendency to preplan e-mail/internet related activities. The latter finding may be related to the increasing participation in electronic social networks, which frequently requires internet activities to be planned in advance with other network members. However, it is possible that household members are sharing the use of a computer, which would also require preplanning.

Whether activities are executed as planned varies among the four recreation/entertainment sub-types considered. Relaxing/napping/reading activities in the evening are more likely to be executed as planned than those in the morning. But other types of recreation/entertainment activities in the evening present a higher tendency to be modified than those in the morning. This could be explained considering that relaxing/napping/reading activities tend to be planned on the same day or spontaneously as explained previously. So their planning can be adapted to the activities and travels already done earlier in the day, requiring no modification prior to their execution. On the contrary, the rest of the recreation/entertainment activities tend to be preplanned more than relaxing/napping/reading, and it is more likely they have to be modified or deleted before execution because of unexpected changes in earlier activities and travels.

Longer duration relaxing/napping/reading activities are more likely to be modified or deleted prior to their execution. On the other hand, the longer the duration of the exercise or active sports, the more likely it is executed as planned. Again, we have other important finding that confirms the main hypothesis of this study: different activity types present different scheduling processes. Longer duration of activities is usually associated with more flexibility (Auld et al, 2008). But a deeper analysis of subtypes of recreational/entertainment activities show us that long exercise or active sports tend to be executed as planned, because of a commitment to a team or a training schedule.

TABLE 6 Mulivariate Probit Coefficient Estimates and Correlation Matrix. Disaggregate Analysis

Model for Exercise or active sports				Model for Regular TV programs				Model for Relaxing/napping/reading				Model for Email/internet			
function for ATHOME				*function for ATHOME*				*function for ATHOME*				*function for ATHOME*			
Variable	**Coeff**	**b/St.Er.**	**P[|Z|>z]**	**Variable**	**Coeff**	**b/St.Er.**	**P[|Z|>z]**	**Variable**	**Coeff**	**b/St.Er.**	**P[|Z|>z]**	**Variable**	**Coeff**	**b/St.Er.**	**b/St.Er.**
Constant	-1.1267	-4.218	0	Constant	2.6738	16.199	0	Constant	2.8992	7.974	0	Constant	1.7161	1.191	1,191
H_2teen*	-1.0496	-2.398	0,0165	H_Dsemid*	-0.7856	-2.532	0,0113	H_2nochildteen	0.5086	2.325	0,0201	Amodtransit*	1.1546	2.163	2,163
H_Size	-0.2245	-2.604	0,0092	H_Daparbui6	-1.0088	-3.098	0,002	H_Adlts	-0.2646	-3.382	0,0007				
I_Tadupartn	0.9479	3.194	0,0014	I_Rdau*	-0.8422	-1.967	0,0492	I_Tadupartn*	0.4536	2.339	0,0193				
				Amodnonmot	-1.0149	-2.574	0,0101	Aduration*	-0.003	-2.42	0,0155				
								Attime	-0.0917	-3.672	0,0002				
function for PREPLAN				*function for PREPLAN*				*function for PREPLAN*				*function for PREPLAN*			
Variable	**Coeff**	**b/St.Er.**	**P[|Z|>z]**	**Variable**	**Coeff**	**b/St.Er.**	**P[|Z|>z]**	**Variable**	**Coeff**	**b/St.Er.**	**P[|Z|>z]**	**Variable**	**Coeff**	**b/St.Er.**	**P[|Z|>z]**
Constant	1.5973	5.333	0	Constan	0.9585	5.356	0	Constant	0.4388	2.307	0,021	Constant	2.3393	4.604	0
H_2teen	-0.7759	-3.757	0,0002	H_Othrs*	-1.2473	-2.402	0,0163	H_1teen	-0.3295	-3.487	0,0005	**H_ Adlts**	**-0.2694**	**-2.169**	0,0301
I_Rfemhead*	-0.3411	-2.049	0,0405	I_C2call	-0.3332	-2.878	0,004	**H_Adlts***	**0.1152**	**2.162**	0,0306				
I_Age	-0.018	-3.325	0,0009	I_C3call*	-0.2643	-2.05	0,0403	H_Autos*	0.1808	2.304	0,0212				
AtotActDay	0.0696	7.16	0	AtotActDay	0.0301	2.245	0,0248	I_Snotstud*	0.501	2.165	0,0304				
								AtotActDay	0.0423	3.926	0,0001				
								AtotTTimeDay	-0.0914	-4.595	0				
function for ASPLANNED				*function for ASPLANNED*				*function for ASPLANNED*				*function for ASPLANNED*			
Variable	**Coeff**	**b/St.Er.**	**P[|Z|>z]**	**Variable**	**Coeff**	**b/St.Er.**	**P[|Z|>z]**	**Variable**	**Coeff**	**b/St.Er.**	**P[|Z|>z]**	**Variable**	**Coeff**	**b/St.Er.**	**P[|Z|>z]**
Constant	0.7906	3.178	0,0015	Constant	-0.6793	-2.417	0,0156	Constant	0.1513	1.097	0,2727	Constant	-1.2016	-4.557	0
H_1childteen	-1.349	-3.714	0,0002	H_Adlts	0.136	3.375	0,0007	H_1teen	-0.2602	-3.53	0,0004	H_1teen	1.2104	3.5	0,0005
H_2teen	-1.9642	-3.744	0,0002	I_Status	0.0749	3.719	0,0002	H_Dtownh	-0.4788	-2.766	0,0057	H_2teen*	0.5854	2.116	0,0344
H_Teens	1.0851	2.771	0,0056	I_License	0.3478	2.634	0,0084	I_Rson	-0.576	-2.571	0,0101	H_Adlts	0.1851	2.188	0,0287
H_Dsemid	-0.8818	-4.179	0	I_Eworkath	-1.1372	-5.102	0	**Astart_e**	**0.2166**	**2.857**	0,0043	H_Dsemid	-0.7821	-3.487	0,0005
H_Daparbui6	-1.6872	-5.366	0	I_Spartime	0.4333	3.621	0,0003	**Aduration**	**-0.0014**	**-2.92**	0,0035	H_Resdur	0.0333	4.14	0
H_Citdur	-0.0153	-3	0,0027	I_Enonuniv	-0.3452	-2.952	0,0032	**Amodtransit**	**0.7629**	**3.896**	0,0001	I_Rson	-1.1619	-3.867	0,0001
I_Tteen	-1.9582	-4.145	0	I_Edegree*	-0.2114	-2.244	0,0249	**AtotActDay**	**-0.0216**	**-2.656**	0,0079	I_Eparttime	0.9416	4.358	0
I_Status	0.1146	2.601	0,0093	**Astart_e***	**-0.1875**	**-2.444**	0,0145					**Astart_e***	**-0.3267**	**-2.019**	0,0435
I_Transp	-0.7134	-2.719	0,0066	Amodnotrav	-0.459	-4.068	0								
Astart_e	**-0.5091**	**-3.368**	0,0008	**AtotActDay***	**0.0209**	**2.23**	0,0258								
Aduration*	**0.0042**	**2.151**	0,0315	AtotTTimeDay*	-0.0014	-2.103	0,0355								
Amodtransit	**-0.4385**	**-2.725**	0,0064												

Model for Exercise or active sports				Model for Regular TV programs				Model for Relaxing/napping/reading				Model for Email/internet			
function for WITHOTHE				*function for WITHOTHE*				*function for WITHOTHE*				*function for WITHOTHE*			
Variable	**Coeff**	**b/St.Er.**	**P[|Z|>z]**	**Variable**	**Coeff**	**b/St.Er.**	**P[|Z|>z]**	**Variable**	**Coeff**	**b/St.Er.**	**P[|Z|>z]**	**Variable**	**Coeff**	**b/St.Er.**	**P[|Z|>z]**
Constant	-0.0314	-0.113	0,9097	Constant	-0.8059	-3.289	0,001	Constant	-0.4291	-3.016	0,0026	Constant	-1.7694	-9.152	0
H_1childteen*	0.9854	2.171	0,0299	H_2childteen	0.8568	8.846	0	H_1childteen	1.1481	4.491	0	**H_2nochildteen**	**-0.8029**	**-3.708**	0,0002
H_2childteen	0.3655	2.305	0,0212	H_2teen	0.5399	4.567	0	**H_2nochildteen**	**0.5514**	**4.296**	0	I_Tadupartn	0.9065	4.91	0
H_Autos	-0.3856	-3.026	0,0025	H_Adlts	0.1238	3.621	0,0003	H_2childteen	1.4775	7.993	0	I_Esecond*	0.4663	2.291	0,0219
I_Tteen	1.4541	3.335	0,0009	H_Othrs	1.6524	2.59	0,0096	H_2teen	0.8895	4.545	0				
I_Status	-0.1474	-3.03	0,0024	I_Rfemhead	0.2395	2.92	0,0035	H_Size	-0.2166	-4.481	0				
I_Enonuniv	0.4281	2.62	0,0088	I_Rson	-0.8678	-3.265	0,0011	H_Kids*	0.1422	2.046	0,0408				
Astart_a	0.6371	3.46	0,0005	I_Age	-0.0092	-2.569	0,0102	H_Dtownh*	-0.4325	-2.387	0,017				
Astart_e	0.5336	3.218	0,0013	I_License*	0.2979	2.055	0,0398	I_Ehome	0.5082	3.556	0,0004				
Astart_n	2.0996	2.991	0,0028	I_Eworkath	0.5627	2.763	0,0057	Amodnotrav	-0.2829	-3.235	0,0012				
				I_Edegree	0.2715	3.199	0,0014								
Correlation Matrix**				**Correlation Matrix****				**Correlation Matrix****				**Correlation Matrix****			
R(01,02)*	-0.2668	-2.421	0,0155	R(01,02)***	-0.2746	-1.812	0,07	R(01,02)*	-0.3515	-4.387	0	R(01,02)***	-0.4447	-0.918	0,3587
R(01,03)***	0.0384	0.48	0,631	R(01,03)***	0.0242	0.573	0,5664	R(01,03)***	0.0653	1.619	0,1054	R(01,03)***	-0.0647	-0.741	0,459
R(02,03)***	-0.058	-0.575	0,565	R(02,03)	0.1367	2.669	0,0076	R(02,03)***	-0.0443	-0.906	0,3648	R(02,03)***	0.0381	0.349	0,7271
R(01,04)***	0.0613	0.616	0,5379	R(01,04)***	-0.026	-0.492	0,6226	R(01,04)***	0.0416	0.878	0,3801	R(01,04)***	0.0565	0.391	0,6959
R(02,04)	0.302	3.568	0,0004	R(02,04)***	-0.0377	-0.509	0,611	R(02,04)***	-0.0825	-1.346	0,1784	R(02,04)***	0.02	0.123	0,9019
R(03,04)***	-0.0895	-0.879	0,3793	R(03,04)***	-0.0366	-0.678	0,4978	R(03,04)	-0.1638	-3.673	0,0002	R(03,04)***	-0.0652	-0.678	0,4975
Goodness-of-Fit Indexes				**Goodness-of-Fit Indexes**				**Goodness-of-Fit Indexes**				**Goodness-of-Fit Indexes**			
No Obsev	443			No Obsev	1222			No Obsev	1423			No Obsev	432		
L	-802.6817			L	-2037.465			L	-2419.887			L	-504.1722		
Lo	-1205.176			Lo	-2470.181			Lo	-3005.137			Lo	-622.6329		
Pseudo R^2	0,33397			Pseudo R^2	0,17518			Pseudo R^2	0,19475			Pseudo R^2	0,19026		
AIC	3.7954			AIC	3.39847			AIC	3.45311			AIC	2.46376		
BIC	4.14654			BIC	3.5615			BIC	3.58989			BIC	2.72745		
HQIC	3.93389			HQIC	3.45983			HQIC	3.5042			HQIC	2.56787		

Highlighted the variables whose parameters have different sign between models

*** X^2 test significant at 0.05 level; all others significant at 0.01 level (except for the correlation matrix coefficients, which are significant over 0.05 level if they are marked with ***)**

(**) 01 = ATHOME, 02 = PREPLAN, 03 = ASPLANNED

If transit is planned to be used to go to a relaxing/napping/reading activities, there is a higher tendency to execute them as planned compared with driving a car. But if transit is planned to be used to go to an exercise or active sports activity, it is more likely that the activity is modified or deleted prior to execution. We have again that different activities (relaxing/napping/reading and exercise or active sports activity) in a similar context (planning to use transit) are scheduled in a different way. Although we have to consider here more information to explain the way they are scheduled: planning to use transit introduces a certain degree of flexibility, while planning long activities increases rigidity. This confirms results from Doherty (2006) and Doherty and Mohammadian (2007).

Respondents with a greater number of activities per day have a higher tendency to modify or delete relaxing/napping/reading activities prior to their execution. However, if we consider watching regular TV programs in the same context, respondents are more likely to execute them as planned. In general, the more activities planned, the more likely it is that they are modified or deleted prior to their execution (Ruiz et al, 2005). But if one considers planning of watching regular TV programs, as this is usually spontaneously done, there is less chance to be modified or deleted.

4. CONCLUSIONS AND DISCUSSION

The results presented in this paper support the hypothesis that scheduling decisions per activity type follow different mechanisms. There does not seem to be a single set of variables that consistently explains scheduling behaviour across activity types either at the aggregate level or at the disaggregate level. Using a rich dataset the following activity planning decisions were studied: location, time horizon and the execution of activities as planned. This analysis was carried out separately by activity types. In general, basic needs activities are mainly influenced by household characteristics. On the other hand, recreation/entertainment and drop off/pick up activities are more related to individual and activity characteristics. A combination of factors influences social activities. Many different types of activities with similar household, individual or activity characteristics are planned in different ways.

To confirm the previous findings, additional analysis was conducted using only recreation/entertainment activity sub-types, and adds the “with whom” planning decision, which distinguishes whether activities are done alone or with others. Overall, relaxing/napping/reading activities and doing exercise or active sports depend largely on household characteristics. But watching regular TV programs is explained mainly by individual characteristics. Email/internet related activities are influenced by a combination of household, individual and activity characteristics. In this later case we also have found that many different sub-types of activities with similar household, individual or activity characteristics are planned in different ways.

These findings provide indications of how to improve the current generation of activity-travel scheduling models.

- It is clear that a wide variety of detailed household, individual and activity attributes should be brought to bear when generating activity attributes, such as location, and whether activities are done alone. Activity scheduling models that rely on limited contextual information will miss many of these relationships.

- Many activity types and sub-types can be conducted either at-home or out-of-home and it is possible to relate these substitutions to explanatory variables. Activity scheduling models that do not specify the nature of at-home activities miss out on these substitution effects.
- Activities conducted alone and joint activities of the same activity type are not planned independently, as is assumed in some activity scheduling models. Reflecting interdependencies in the generation of such related activities would be beneficial.
- Activity scheduling models that insert activities deterministically in order of aggregate activity type could be improved by reflecting the scheduling process more stochastically. This analysis has shown that every activity type has a stochastic propensity to be preplanned, and thus has some probability to be included in the skeleton schedule and some probability to be inserted spontaneously into a highly-specified schedule just prior to execution. Ignoring this stochasticity may lead to inaccuracies in the activity patterns that emerge from the scheduling process.
- The incidence of scheduling modifications can be at least partially explained by explanatory variables. Direct simulation of the incidence of activity modifications/deletions in the process of scheduling would not be consistent with the philosophy of most activity scheduling models (TASHA for example uses a process of activity insertion that assumes deterministic rules for activity modification/deletion for specific types of scheduling conflict). However, some validation could be done using the models developed here to assess the quality of these rules, and whether some degree of stochasticity might be warranted.
- There is clear heterogeneity in the decision processes for different activity types and subtypes. Thus it seems prudent to represent a greater disaggregation of activity types than is present in the current generation of activity scheduling models, in order to capture this heterogeneity.
- There are significant correlations between the outcomes of planning decisions regarding activity location, planning time horizon, the incidence of activity modifications, and with whom. Activity scheduling models that treat these decisions as independent could more accurately reflect the correlations found in this analysis.

Further research would include:

- Further analysis exploring differences among groups of activities defined not only by type but also by other characteristics, as suggested elsewhere in the literature.
- Using random parameter probit (RPP) specification to test for preference heterogeneity in dichotomous choice responses.
- Development and testing of a system of activity planning that is suitable to be incorporated within an operational activity scheduling microsimulation model such as TASHA. Such development could involve the direct incorporation of probit models similar to those developed in this paper, or could involve simpler refinements to the existing rule base to incorporate some of the insights attained in this exercise.

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