THE VALIDITY OF ASSUMING ONLY ONE ACTIVITY PER OUT-OF-HOME LOCATION IN ACTIVITY-BASED DEMAND MODELS CONSTRUCTED FROM TRIP-BASED SURVEY DATA

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ABSTRACT

Over the last decade, several efforts have been made to develop operational models of full-day activity-travel patterns. Given the lack of local activity-based surveys, most activity-travel demand models are developed using conventional travel diaries, using trip-based survey data as a proxy for out-of-home activity data. In particular, this assumes that the traveller only takes part in one activity per non-home destination; but this assumption has not been questioned in the literature. The analysis reported in this paper uses data from the 2000 UK National Time Use Survey (TUS) to evaluate the validity of this assumption. Respondents in the TUS record their 'primary' activities for each 10 minute interval over a 24 hour period of time, with no limit on the number of successive primary activities that can be recorded at the same location, without an intervening travel activity. In addition, respondents are asked to record any secondary activities, that take place in parallel with the primary activity(ies).

The analysis finds that there is an average of 1.26 primary activities per (non-home) stop, and 0.34 secondary activities – making an average of 1.6 activities per stop. The paper then focuses on cases where there are multiple primary activities at the same stop. It defines one 'main' activity at each location, to mirror the reporting of the 'main' trip purpose in a travel diary. Since we do not know on what basis a respondent selects their 'main' trip purpose where there are multiple primary activities at one stop, we explore four alternative definitions: (i) the activity with the longest duration, (ii) the first activity carried out at each location, (iii) a hierarchical selection, based on some notion of activity importance, and (iv) a random selection of 'main' activity. 'Primary' activity combinations at non-home destinations are examined, using these four definitions, as well as the percentage of time allocated to main and non-main activities at different types of locations.

The paper compares the main trip purpose distribution frequencies resulting from the application of each definition, to see whether one most closely approximates the trip purpose frequencies in the 2002- 6 British National Travel Survey (NTS); results were inconclusive.

The paper concludes by discussing some analytical and policy implications of the non-reporting in a conventional travel diary of multiple activities at non-home locations. In particular, reported reductions in annual trip rates over time in the NTS gives the impression of reduced out-of-home activity participation, whereas this may reflect increased multi-activity participation at out-of-home locations.

Keywords: Out-of-home activities, Trip purposes, Secondary activities, Time use survey, Travel diaries

1. INTRODUCTION

Given the lack of local activity-based surveys, most activity-travel demand models are developed using data from conventional travel diaries (Miller and Roorda, 2003). In a travel diary, respondents are asked to record, for each non-home location visited, the main purpose of the trip to that location, along with information on arrival and departure times, mode of travel, etc. This information is then transformed into a non-home activity record, by treating the trip purpose as the activity, and calculating activity duration by subtracting the location arrival from the location departure time. Conventional travel diaries only allow for the possibility of one main trip purpose (or primary activity) at each destination, and usually only provide a limited range of purpose categories.

Conversely, traditional time use surveys provide a much richer recording of the activities carried out at each location (both in the home and non-home), in terms of the number of activity categories, and the possibility of recording several sequential primary activities at the same location. Some surveys also allow for the recording of secondary activities, carried out in parallel with the primary activity(ies). In other respects, time use survey data is cruder than travel diary data, often using time bands to record activity duration rather than precise clock times, and in the detail in which activity locations are recorded (Kitamura et al., 1997) – but these restrictions are not directly relevant to the issues addressed in this paper.

Thus, when using travel diary survey data to represent out-of home activities (e.g. Munizaga; 2009), it is assumed that the traveller only takes part in one activity per non-home location. This assumption has been made in models of full-day out-of-home activity-travel patterns (Kitamura et al. 1998; Bowman and Ben Akiva, 2001; Jonnalagadda et al., 2001; Bhat, et al, 2004; Pendyala, et al, 2004; Arentze and Timmermans, 2005), and has not been previously questioned in the literature.

This paper addresses two critical issues in the recording and analysis of out-of-home activities, focussing on weekday activity-travel patterns. Firstly, it examines the validity of assuming only one activity per non-home destination in activity-based demand modelling, by analysing the type and frequency of primary activities that individuals take part in at out-of-

home locations by using time use survey data; results show that a significant number of individuals engage in more than one primary activity while at an out-of-home location.

Where there are multiple primary activities at the same non-home location, the question arises as to which one of these a respondent would have recorded as their main trip purpose in a conventional travel diary. It is hypothesised that this selection might be based on one of four criteria: longest duration, first activity, relative importance, or a random selection. Where there are multiple primary activities during one stop, the conditional probabilities of 'primary' activity combinations are examined, as is the duration of the 'main' primary activity at different kinds of location. The paper also looks at the nature and extent of non-home 'secondary' activities that are carried out in parallel with the primary activities at each stop.

The frequency distribution of 'main' activities that is generated under each of these four assumptions is then compared to the distribution of trip purposes from a travel diary survey, to establish which heuristic best replicates the observed trip purpose distribution. Finally, the paper concludes by discussing some analytical and policy implications of assuming only one activity per non-home location.

2. DATA AND DEFINITIONS

The analysis reported here uses individual data records for Mondays to Fridays from two national surveys. The main analysis of the nature and frequency of non-home activities draws on the 2000 UK Time Use Survey (TUS), while the comparison with trip purpose data uses the 2002-6 Great Britain National Travel Survey (NTS). These data sets differ slightly time (2000 vs. 2002-2006), but the differences are not thought to have a major effect on the comparisons. Only adult individuals residing in Great Britain have been analysed in TUS (i.e. excluding Northern Ireland participants), to ensure compatibility with NTS.

2.1 Time Use Survey data

The TUS records the various activities that the UK population takes part in over a 24 hour period, on a weekday and a weekend day (UK 2000 Time Use Survey Technical Report, 2003). The TUS sample was selected using a cluster design. The survey comprised only private households and the members living in those households. Each household completed an interviewer-administered questionnaire which requested summary information on all the individual household members, plus supplementary information about the household. Each household member over the age of eight years was asked to complete an individual questionnaire. Spatial information regarding the geographical location of activities is not provided in TUS data.

Data has been extracted for individuals aged 16 and over (adult individuals) for Great Britain only (England, Wales, and Scotland) on weekdays; this gives a sample size of 6,172 adult diary days. Individuals record the activities they engaged in, together with the location type of these activities (e.g. home, workplace) and whether they were accompanied, for each 10

minute interval over a 24 hour period of time; there is no limit on the number of successive activities that can be recorded at the same location. Individuals are also asked to report whether they were engaged in more than one activity at the same time and record one as the 'primary' and the other as the 'secondary' activity. For example, someone might be watching television (primary activity) and drinking tea or supervising children (secondary activity) at the same time; respondents decide which activity is designated as primary. No secondary activity can be recorded during the time spent at work or school, or asleep.

2.2 National Travel Survey data

The National Travel Survey (NTS) is a continuous survey recording the personal travel of residents in Great Britain, with field work being implemented throughout the year. It also includes details of individuals' characteristics (such as age, working status and driving licence ownership) and household characteristics (such as income levels and car availability). The NTS is based on a stratified two-stage random probability sample of private households in Great Britain. It uses two data collection methods: face to face interviewing using computer assisted personal interviewing (CAPI) and self-completion of a 7 day travel record. Detailed geographical information of home locations and trip destinations is not provided in the NTS available data.

The NTS collects a one week travel diary from all members of participating households. Individuals are asked to record only walk trips of one mile or more on the first six days, but on the final travel day (day seven) details of all walks of at least 50 yards are recorded; very short walks (of less than 50 yards) are always excluded in NTS. Since some walk-based tours will be missed by the restriction on minimum trip lengths on days one to six, the analysis reported in this paper is for adult individuals who record at least one out-of-home activity on 7th day of travel, when this is on a weekday. The resulting sample contains 43,753 adult individual diary days.

2.3 Comparison between NTS and TUS

Figure 1 shows the adult population distribution by gender in the NTS and TUS samples; this shows that the proportion of males is slightly higher in NTS in comparison with TUS.
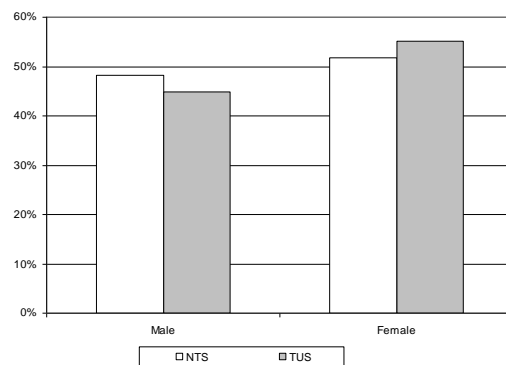

Figure (1). Population distribution by gender in NTS and TUS

Table 1 shows the population distribution by age group for adult males and females in NTS and TUS. As it can be seen, the proportion of adult aged less than 40 is higher in TUS (44%) in comparison with NTS (38%). No adjustments have been made for this in the analysis that follows.

Table (1). Comparison between NTS and TUS data by age group for males and females

Age group	Male		Female	
	NTS	TUS	NTS	TUS
16-19	6%	7%	5%	6%
20-29	13%	16%	14%	17%
30-39	19%	21%	20%	22%
40-49	19%	19%	19%	20%
50-59	18%	17%	17%	16%
60-69	14%	11%	13%	10%
70 plus	12%	9%	12%	9%

2.4 Activity definitions

Table 2 shows the seven categories of out-of-home activities that have been used in this analysis, and how they relate to the classification of activities recorded in the UK Time Use Survey and the GB National Travel Survey. As can be seen, some categories are similar between these two surveys, while others differ.

Table (2). Activity categories used in the analysis and their relation to definitions used in TUS and NTS

Activity category	Definition in TUS	Definition in NTS
Personal care	Eat/drink, Medical care, Other personal care	Personal business eat/drink, Personal business medical
Employment	Work, In course of work, Volunteer work & meetings	Work, In course of work
Study	Education	Education
Shopping and services	Shopping for food and clothing, Window shopping or other shopping as leisure, Commercial and administrative services	Food shopping, Non-food shopping, Personal business other
Entertainment	Hobbies & games, Mass media	Entertainment, Public social activities
Social life	Socialising with household members, Visiting and receiving visitors, Telephone conversation, Other social life	Visit friends/relative, Other social
Sports & outdoor activities	Outdoor sports & activities	Outdoor sports & activities

3. EMPIRICAL RESULTS

3.1 Primary activity participation by type of out-of-home location

The frequency of participation in the seven out-of-home activity categories, by type of location, (six categories) is shown in Table 3, based on the UK Time Use Survey data. Employment, shopping and services, social life and personal care are the most frequent primary activities that individuals engage in, each recording over 2,800 occurrences in the data.

Table (3). Observed frequency of primary activities at each type of location on weekdays

	Employment	Study	Shopping and services	Entertainment	Social life	Sports & outdoor activities	Personal care	**Total**
Working place or school	4,852	515	106	220	274	4	967	6,938
Other people's home	460	0	273	309	1,314	4	798	3,158
Restaurant, café or pub	6	0	34	58	504	3	625	1,230
Sports facility	15	0	27	9	61	429	59	600
Arts or cultural centre	4	0	5	1	114	0	8	132
Other specified location (not travelling)	328	0	3,313	189	557	50	370	4,807
Total	*5,665*	*515*	*3,758*	*786*	*2,824*	*490*	*2,827*	*16,865*

Figure 2 shows the frequency distribution of the seven types of primary activities at non-home stops, both for all primary activities (using data from Table 3) and also situations where only one primary activity is recorded. In both cases, the most common activity categories are Employment and Shopping/services, but they are relatively more dominant at single-activity stops, whereas Social Life and Personal care become relatively more common at multi-activity stops.
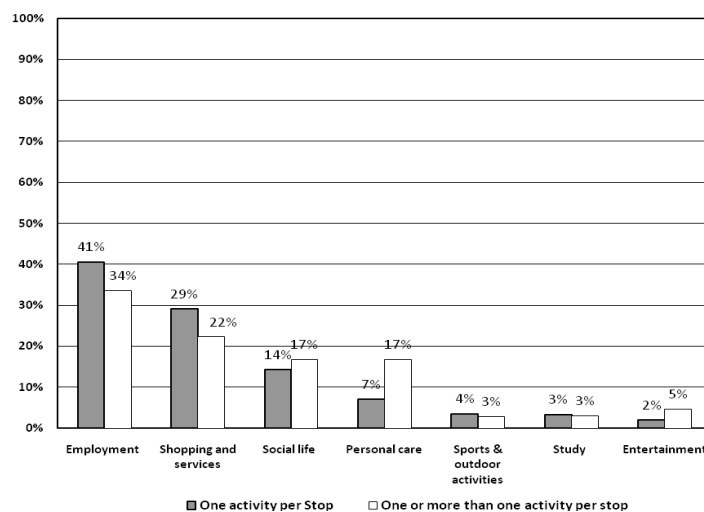

Figure (2). Frequency distribution of primary activities at non-home stops

3.2 The number of activities per stop[1]

Conventional travel diaries only allow for the possibility of one main trip purpose (or primary activity) at each stop. The time use survey places no such restriction on data recording, so it is possible to examine how often respondents engage in multiple primary activities during one stop at a location. This shows that many individuals engage in more than one activity per non-home stop. As can be seen in Figure 3, in 20% of locations individuals take part in more than one primary activity without intermediate travel. The mean number of activities per location for the total sample is 1.26 – suggesting that activity-based models derived from travel diaries underestimate non-home primary activity participation by over 25%.
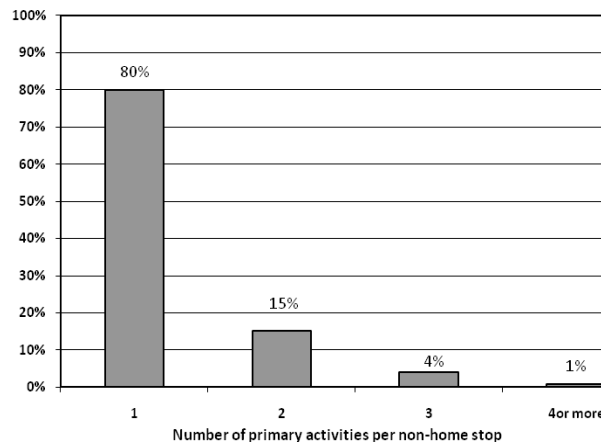

Figure (3). Distribution of number of primary activities per non-home stop

Figure 4 shows the distribution of the number of primary activities per out-of-home stop on occasions when people participate in more than one primary activity. In 76% of these cases there are only two primary activities, but in 4% of cases there are four or more.
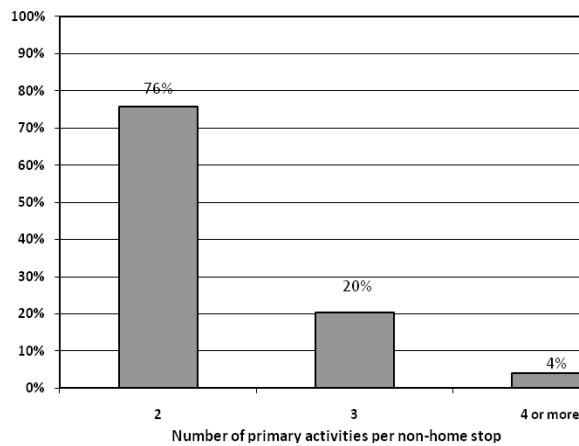

Figure (4). Number of primary activities per non-home stop, where there are two or more such activities

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[1] This number is not absolute and will clearly vary according to the coarseness of the data recording and analysis; were more than seven discrete activity categories used, then the number of primary activities per stop would be expected to increase.

3.3 Engagement in secondary activities

Some individuals record 'secondary' activities in the TUS time use diaries, in parallel with their primary activities. The frequency of participation in these 'secondary' activities, by type of location (six categories) is shown in Table 4. Social, and employment, are the most frequent secondary activities that individuals engage in, each with over 1,000 occurrences in the data. Note that the most common location for secondary activities is 'other people's home'.

Table (4). Observed frequency of 'secondary' activities at each type of location

	Employment	Study	Shopping and services	Entertainment	Social life	Sports & outdoor activities	Personal care	**Total**
Working place or school	911	11	10	50	120	0	21	1,123
Other people's home	13	3	28	116	1,072	0	83	1,315
Restaurant, café or pub	80	0	16	55	364	1	126	642
Sports facility	14	0	13	36	95	3	31	192
Arts or cultural centre	2	0	4	1	18	0	8	33
Other specified location (not travelling)	181	1	185	184	495	9	141	1,196
Total	*1,201*	*15*	*256*	*442*	*2,164*	*13*	*410*	*4,501*

Figure 5 shows the frequency distribution of 'secondary' activities. As can be seen, in 31% of stops individuals engage in 'secondary' activity/ies in parallel with their primary activity/ies.
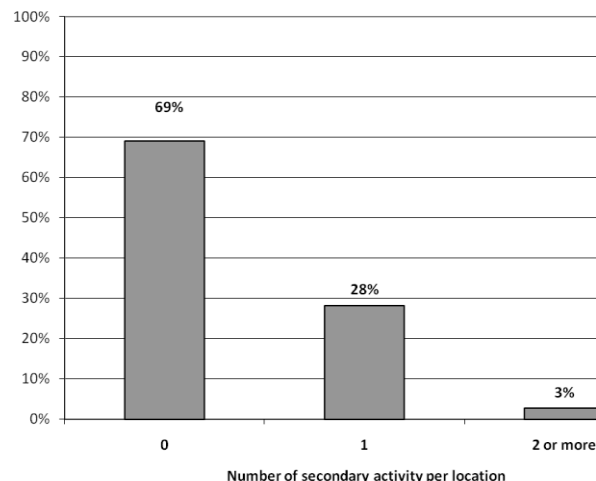

Figure (5). Distribution of frequency of number of secondary activities per non-home stop

The duration and frequency of secondary activities are shown in Table 5. Across the whole sample, individuals engage in an average of 0.34 secondary activities in parallel with their primary activity, for 17% of the total time spent at that stop. The average duration of secondary activities per non-home stop is 15 minutes, but there is a marked difference

between cases where there are single and multiple primary activities at a stop. In stops with more than one primary activity, the time spent on secondary activities increases to 26% of the total amount of time spent at that stop, and the average duration for the secondary activity increases to 39 minutes. The average frequency of secondary activities also increases sharply to 0.9, compared to only 0.2 where there is only one primary activity.

Table (5). Frequency and duration (min) of secondary activities per non-home stops

Number of primary activities per location	Duration of secondary activity (min)	Frequency of secondary activity	% of total allocated time at each out-of-home stop that individuals engaged in two parallel activities (simultaneously in primary activity and secondary activity)
one primary activity per location	9	0.20	15%
More than one primary activity at location	39	0.90	26%
All	15	0.34	17%

The distribution of the total number of primary and secondary activities per non-home stop is shown in Figure 6. Here we can see that at 35% of non-home stops, individuals take part in more than one activity, and the average number of activities per stop (primary and secondary) is 1.60 (i.e. 1.26 + 0.34). This aspect of behaviour is completely omitted from analysis and modelling using travel diary data.
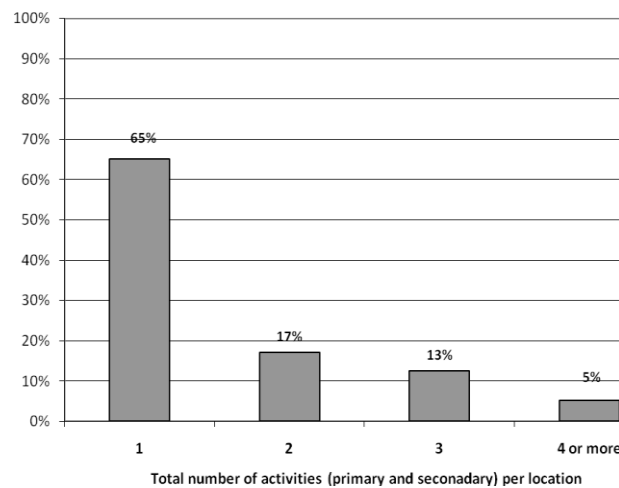

Figure (6). Distribution of total number of activities (primary and secondary) per out--home stop

3.4 Defining the 'main' trip purpose

We have noted that travel diary surveys only record one 'main' trip purpose per stop, and that in around 20% of stops people take part in multiple primary activities. So, on such occasions on what basis would people select a 'main' trip purpose for trip diary recording purposes? This has not previously been investigated, and we postulate four possible

decision rules for selecting a 'main' trip purpose from a set of multiple 'primary' activities at a stop, as follows.

Alternative 1: The activity with the longest duration

At each recorded non-home stop, the activity with the longest duration is defined as the 'main' trip purpose. In rare cases where two or more activities are recorded as being of equal duration, then the first activity undertaken by an individual at that location is taken to be the main trip purpose. All the other primary activities carried out during that stop are categorised as non-main activities.

Alternative 2: The first activity carried out at each location

This is the simplest assumption to operationalise, and is unambiguous: regardless of activity duration, it is the first recorded primary activity at a stop which is assumed to be the 'main' trip purpose.

Alternative 3: Selection based on a prioritisation scheme

This selection criterion is based on the notion of relative activity importance. This can be derived empirically by defining the proportion of occurrences of each activity category at the six location types, and converting this into a ranking. Table 6 shows the rankings of six activity categories at each location (here place of work and school have been combined into one activity category). For each type of location, the activity ranked '1' is selected as the 'main' trip purpose.

Table (6). Hierarchy for selecting activities at each type of location

	Employment /Study	Shopping and services	Entertainment	Social life	Sports & outdoor activities	Personal care
Working place or school	**1**	5	4	3	6	2
Other people's home	3	5	4	**1**	6	2
Restaurant, café or pub	5	4	3	2	6	**1**
Sports facility	5	4	6	2	**1**	3
Arts or cultural centre	4	3	5	**1**	6	2
Other specified location (not travelling)	4	**1**	5	2	6	3

Alternative 4: A random selection of the 'main' trip purpose

All activities at a stop have an equal chance of being selected. If there is n number of activities at each location, then the chance of being defined as the main trip purpose for each of the activities is 1/n. An equal interval is allocated to all activities at each location. So, the allocated interval for the ith activity is [(i-1)/n , i/n]. A random number between 0 and 1 is generated. If this number falls within the allocated interval for activity i, then this activity will be selected as the main trip purpose for that stop.

3.5 Characteristics of the 'main' trip purpose at each stop, under different definitional assumptions

Figure 7 shows the percentage distribution of main trip purposes under these four definitional rules. As can be seen here (and from Tables 12 to 15), there are quite marked differences for Personal Care and Employment, but not for the other trip purposes. When we compare the chosen purposes across the four definitions, we find that at 66% of stops the same activity is selected as the 'main' trip purpose using both the 'first activity' and 'hierarchical selection' and 62% when using 'longest duration' rule. In the case of the 'hierarchical selection and the 'longest duration' rules, the match rises to 74% of trip purposes.
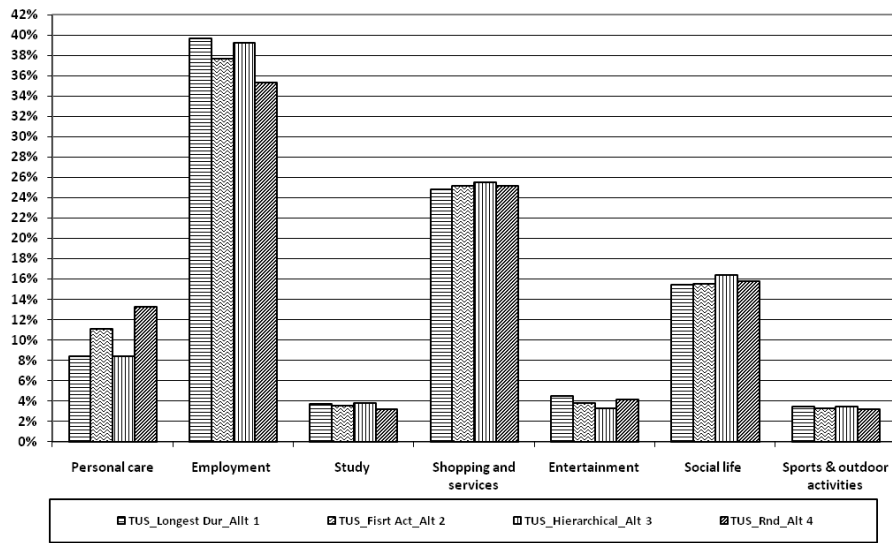

Figure (7). Frequency distribution of main trip purposes in TUS under the defined rules

The percentage of the total amount of time spent at each stop on the 'main' trip purpose, in cases where there are multiple primary activities, is shown in Figure 8. This varies considerably across the four definitions of 'main' trip purpose, from only 49% using the 'random' rule up to 80% using the 'longest duration' rule. So, a significant proportion of the time spent at each non-home stop is allocated to the other, non-main primary activity(ies).
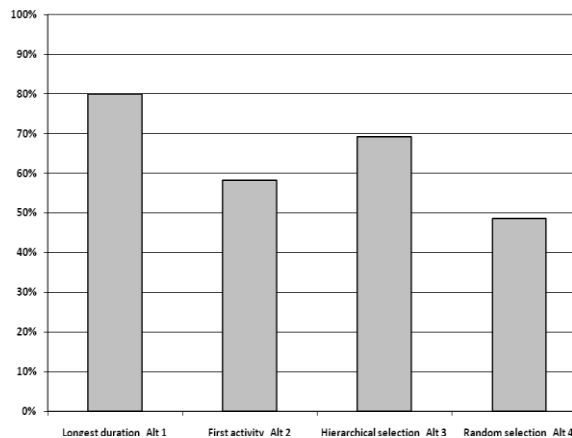

Figure (8). % of time at each stop allocated to the 'main' trip purpose, where there are multiple primary activities

Figure 9 looks in more detail at the percentage of total time allocated to the 'main' trip purpose according to the type of location. As can be seen, at work and school locations only about 10% of the time spent there is allocated to non-main primary activities, for both the 'hierarchical' and 'longest duration' definitions of main trip purpose; this rises to 48% under the random rule. The amount of time spent on non-main primary activities increases in locations such as Restaurant and café, Sports facility and other's people home, for all definitions.
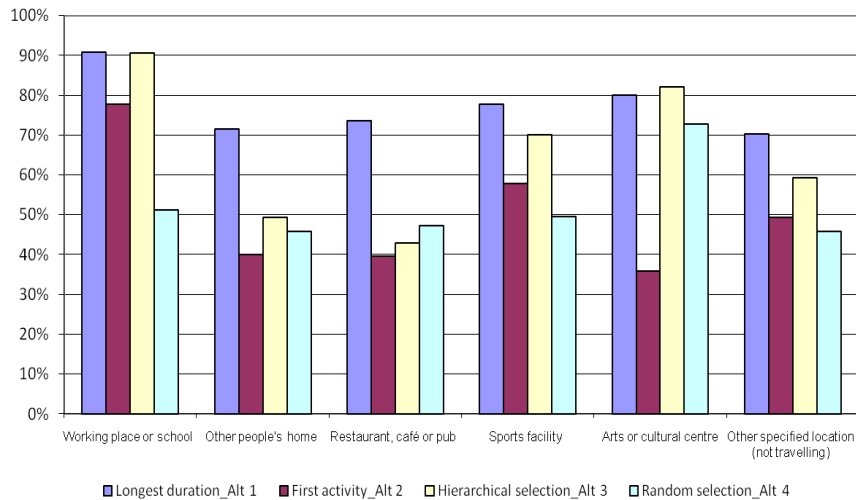

Figure (9). % of time at each location type allocated to the 'main' activity, where there are multiple activities

3.6 Association of 'main' trip purpose with other primary activity types

'Primary' activity combinations are examined at stops with multiple activities by estimating the conditional probability of taking part in one or more non-main primary activities, given participation in a specified main trip purpose. Tables 7 to 10 show the results for each of the four definitional rules for main trip purpose, in turn.

Several points can be noted, and (unless otherwise indicated) apply to all four definitional rules:

- Except under the 'hierarchical' rule, 'Personal care' is associated with each main trip purpose on 50% of occasions or more, being highest for 'Employment' and 'Study' (at around 80%). In addition……..
- Where 'Employment' is the main trip purpose, it is weakly associated with 'Entertainment' and 'Social life' (at around 20% each).
- 'Study' as a main trip purpose is associated with 'Social life' (at 30% to 39%).
- 'Shopping and services' as the main trip purpose is associated with 'Social life' (at between 34% and 39%).
- 'Entertainment' as the main trip purpose is strongly associated with 'Social life' (between 45% and 57%), and this is reciprocated (at between 21% to 43%).
- 'Sports and outdoor activities' as the main trip purpose is mainly associated with 'Social life' (at between 28% to 41%).

Table (7). Likelihood of association of non-main primary activities with 'main' trip purpose, using the 'longest duration' rule

Non-main activity *Main trip purpose*	Personal care	Employment	Study	Shopping and services	Entertainment	Social life	Sports & outdoor activities
Personal care		0.7%	0.4%	31.6%	24.6%	56.6%	2.9%
Employment	81.5%		0.5%	5.2%	20.2%	19.1%	0.3%
Study	79.3%	2.1%		2.1%	11.0%	38.6%	0.7%
Shopping and services	50.6%	0.0%	0.4%		13.9%	39.4%	0.8%
Entertainment	63.4%	0.5%	0.2%	27.5%		51.6%	0.5%
Social life	75.8%	0.0%	0.2%	16.4%	23.7%		0.9%
Sports & outdoor activities	63.3%	0.0%	0.0%	11.1%	3.3%	41.1%	

Table (8). Likelihood of association of non-main primary activities with 'main' trip purpose using the 'first activity' rule

Non-main activity *Main trip purpose*	Personal care	Employment	Study	Shopping and services	Entertainment	Social life	Sports & outdoor activities
Personal care		21.5%	1.5%	16.0%	26.2%	53.0%	1.8%
Employment	81.1%		0.5%	3.8%	18.9%	19.1%	0.1%
Study	82.0%	3.3%		1.6%	10.7%	30.3%	0.8%
Shopping and services	50.3%	5.1%	0.3%		22.3%	34.1%	2.0%
Entertainment	54.9%	7.3%	0.8%	19.9%		44.7%	0.8%
Social life	64.7%	3.4%	2.6%	21.9%	41.1%		4.1%
Sports & outdoor activities	70.0%	0.0%	0.0%	10.0%	3.3%	28.3%	

Table (9). Likelihood of association of non-main primary activities with 'main' trip purpose using the 'hierarchical selection' rule

Non-main activity *Main trip purpose*	Personal care	Employment	Study	Shopping and services	Entertainment	Social life	Sports & outdoor activities
Personal care		0.0%	0.0%	24.7%	45.1%	42.6%	2.7%
Employment	81.7%		0.4%	5.1%	20.4%	19.2%	0.3%
Study	79.9%	0.0%		2.8%	12.5%	38.9%	0.7%
Shopping and services	46.0%	0.0%	0.0%		19.8%	36.9%	1.7%
Entertainment	48.2%	0.0%	0.0%	16.4%		57.3%	0.9%
Social life	73.6%	0.0%	0.0%	16.7%	43.4%		1.5%
Sports & outdoor activities	62.0%	0.0%	0.0%	10.1%	3.8%	40.5%	

Table (10). Likelihood of association of non-main primary activities with 'main' trip purpose, using the 'random' selection rule

Non-main activity *Main trip purpose*	Personal care	Employment	Study	Shopping and services	Entertainment	Social life	Sports & outdoor activities
Personal care		40.4%	5.2%	15.0%	21.2%	36.9%	3.1%
Employment	81.6%		0.4%	3.0%	17.9%	16.2%	0.2%
Study	75.0%	6.9%		2.8%	8.3%	31.9%	1.4%
Shopping and services	50.9%	6.3%	0.4%		27.7%	34.0%	2.1%
Entertainment	55.0%	22.1%	1.5%	17.4%		45.9%	1.2%
Social life	60.3%	13.9%	4.2%	17.5%	28.3%		2.7%
Sports & outdoor activities	61.2%	2.0%	0.0%	8.2%	4.1%	38.8%	

3.7 The 'lost' primary activities

As previously noted, travel diary surveys only record one activity (i.e. trip purpose) per destination, although we have shown that, on average, there are 1.26 primary activities per non-home location. This section addresses the question: are there systematic biases in the kinds of non-main primary activities that are under represented where only one activity is recorded per location? This is examined for each of the four selection rules analysed above.

Figure 10 shows how the primary activity episodes that would not be recorded in a travel diary are distributed across the seven categories of activity, and how this distribution differs when applying each of the four main activity selection rules. As can be seen, in each case Personal Care represents between 37% and 40% of all the 'lost' primary activities, followed by Social Life (20% - 22%), and then (in three of the four cases) Entertainment (14% - 16%). Note that between 10% and 16% of these 'lost' activities are for Employment, and around 10% for Shopping and Services.
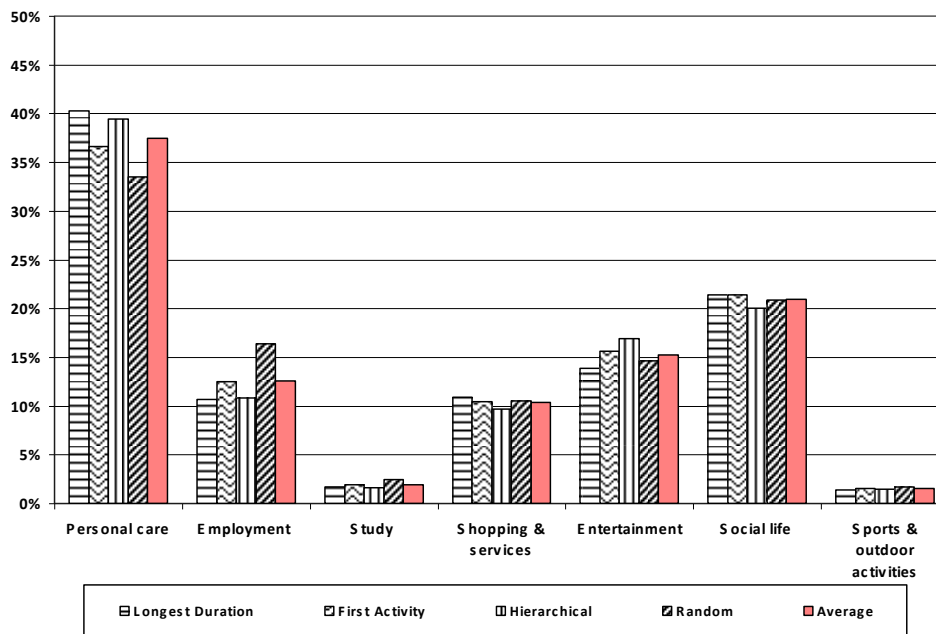

Figure (10). Distribution of non-main primary activity episodes by type of activity

Another way of looking at the effects of only recording one activity per location in a travel diary is to examine what proportion of each category of activity is 'lost' when this kind of data is used for activity analysis. This is reported in Table 11, which shows the non-main primary activity episodes (i.e. those which are missing from travel diaries) as a proportion of <u>all</u> the main activity episodes reported in the time use survey, for each category of activity. As can be seen, this percentage 'loss' varies according to which decision rule is used to determine the 'main' activity, but on average around 12% - 14% of all Employment, Shopping/Services and Sports and Outdoor activities go unrecorded, rising to 32% for Social Life, 41% for Entertainment and over half (57%) for Personal Care activities. This rank ordering is not substantially affected by which decision rule is used.. Thus, Table 11 gives an indication of the degree of underestimation of the different types of activity episodes incorporated into activity based models which are constructed from trip based survey data.

Table (11). Non-main activities as a percentage of all primary activities, for each activity category

Type of Activity Applied Rule	Personal care	Employment	Study	Shopping & services	Entertainment	Social life	Sports & outdoor activities
Longest Duration	63%	10%	14%	13%	36%	33%	12%
First Activity	54%	12%	16%	13%	43%	33%	14%
Hierarchical	62%	10%	13%	12%	48%	30%	13%
Random	47%	16%	21%	13%	39%	32%	16%
Average	57%	12%	16%	13%	41%	32%	14%

3.8 Which rule provides the best mapping between primary activities and trip purpose? A comparison of out-of-home activity distributions in TUS and NTS

Finally, we compare the main primary activity distribution frequencies resulting from applying each of the four definitional rules to the time use data, with the trip purpose distributions from the travel diary data, to see whether one of the former most closely approximates the trip purpose frequencies the National Travel Survey. Comparisons are shown in Figure 11.
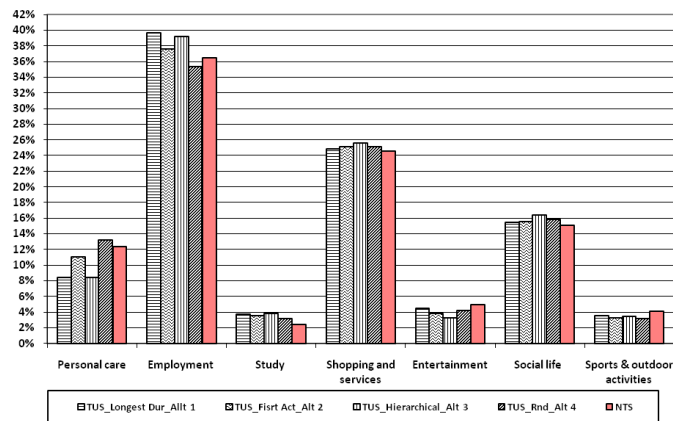

Figure (11). Frequency distribution of main trip purposes in TUS, using four alternative definitions and NTS

Tables 12 to 15 test whether each of the four definitional rules result in a distribution of main trip purpose frequencies that is not statistically significantly different from that generated from NTS data. The tables show Chi square and p values. The null hypothesis is that the distribution of out-of-home activities in NTS does not differ from defined alternatives in TUS at significance level of 0.001.

Table (12). Comparison of proportion of different type of out-of-home activities between NTS and TUS Longest Duration

Type of activity	TUS_Longest Dur	NTS	TUS_Longest Dur	NTS	Chi square value	p-value
Personal care	1,146	8,854	8%	12%		
Employment	5,410	26,070	40%	37%		
Study	506	1,707	4%	2%		
Shopping and services	3,388	17,516	25%	25%		
Entertainment	613	3,539	4%	5%	332.87	0.000*
Social life	2,109	10,769	15%	15%		
Sports & outdoor activities	476	2,939	3%	4%		
Total	**13,648**	**71,394**	**100%**	**100%**		

*The Null Hypothesis that the two distributions are the same is rejected at a significance level of 0.001.

Table (13). Comparison of proportion of different type of out-of-home activities between NTS and TUS First Activity

Type of activity	TUS_First Act	NTS	TUS_First Act	NTS	Chi square value	p-value
Personal care	1,486	8,854	11%	12%		
Employment	5,047	26,070	38%	37%		
Study	477	1,707	4%	2%		
Shopping and services	3,374	17,516	25%	25%		
Entertainment	511	3,539	4%	5%	161.10	0.000*
Social life	2,079	10,769	15%	15%		
Sports & outdoor activities	442	2,939	3%	4%		
Total	**13,416**	**71,394**	**100%**	**100%**		

* The Null Hypothesis that the two distributions are the same is rejected at a significance level of 0.001.

Table (14). Comparison of proportion of different type of out-of-home activities between NTS and TUS Hierarchical

Type of activity	TUS_Hierarchical	NTS	TUS_Hierarchical	NTS	Chi square value	p-value
Personal care	1,124	8,854	8%	12%		
Employment	5,238	26,070	39%	37%		
Study	505	1,707	4%	2%		
Shopping and services	3,412	17,516	26%	25%		
Entertainment	438	3,539	3%	5%	416.77	0.000*
Social life	2,185	10,769	16%	15%		
Sports & outdoor activities	459	2,939	3%	4%		
Total	**13,361**	**71,394**	**100%**	**100%**		

* The Null Hypothesis that the two distributions are the same is rejected at a significance level of 0.001.

Table (15). Comparison of proportion of different type of out-of-home activities between NTS and TUS Random

Type of activity	TUS_Rnd	NTS	TUS_Rnd	NTS	Chi square value	p-value
Personal care	1,802	8,854	13%	12%		
Employment	4,815	26,070	35%	37%		
Study	433	1,707	3%	2%		
Shopping and services	3,422	17,516	25%	25%		
Entertainment	569	3,539	4%	5%	99.27	0.000*
Social life	2,150	10,769	16%	15%		
Sports & outdoor activities	435	2,939	3%	4%		
Total	**13,626**	**71,394**	**100%**	**100%**		

* The Null Hypothesis that the two distributions are the same is rejected at a significance level of 0.001.

In each case the hypothesis is rejected, indicating that all four rules result in a distribution of simulated 'main' trip purposes which differ from that found in the NTS travel diary survey. Interestingly, it is the random rule which produces the lowest Chi Square value, showing that it has the greatest similarity with the NTS data for weekdays.

4. SUMMARY AND DISCUSSION

The assumption, embedded in activity/travel models derived from travel diary data, that travellers engage in only one activity at each non-home stop, has not previously been questioned in the literature. Results of the analysis presented in this paper show that some individuals engage in more than one primary activity while at a non-home stop. On average, individuals take part in more than one primary activity at 20% of stops, and the mean number of primary activities per stop for the total adult sample on weekdays is 1.26, when using seven activity/trip purpose categories. This indicates that an activity-based analysis of out-of-home activity participation using travel diaries typically underestimates overall activity frequency by around 25%, and the analysis reported here has shown that this under-representation varies by type of activity. The percentages would be greater were more activity categories used.

The analysis has been extended to look also at secondary activity participation, which occurs when respondents participate in parallel activities while taking part in primary out-of-home activities. Here we find that, on average, there are recorded secondary activities at around one-third of stops, which rises to 90% at stops with multiple primary activities. Taking into account both primary and secondary activities, more than one activity is recorded at a non-home stop on 35% of occasions, and the average number of recorded activities (primary plus secondary) per non-home stop (using a seven category classification) is 1.60.

Since trip diaries only allow for the recording of one main trip purpose per out-of-home stop, the question arises as to how respondents who take part in multiple activities at a stop

decide which one to record as their main trip purpose. This paper examined four potential definitional rules for selecting a 'main' trip purpose from a set of multiple 'primary' activities at one stop, and showed that in some cases selecting different rules can make a marked difference to the reported distribution of trip purposes and average activity durations.

When we examined primary activity combinations at stops with multiple primary activities, we observed a tendency to combine personal care, shopping and services, and social life activities (as non-main activity) with the main activity under all four definitional rules. The amount of time spent on the main trip purposes at each non-home stop under the four rules varies between 49% and 80% of the total amount of time spent at that stop.

We then compared the simulated main trip purpose distribution frequencies derived from each definitional rule with the observed trip purpose frequencies in the Great Britain National Travel Survey (NTS). In each case the Null Hypothesis was rejected, indicating that none of the four definitional rules was able to replicate the NTS distribution of trip purposes using the time use survey data. This suggests that more work, probably including qualitative research with respondents, would need to be done to establish the appropriate decision rule. There may well be important conceptual definitional issues here too: should we expect a respondent to use the same category for 'trip purpose' as they would if considering what they did as a 'primary activity'? For example, travelling to a local office to take part in a video conference might well be classified as a 'work-related' trip purpose, but as an activity it might be recorded as 'media related'.

Considering the analytical implications of what we have found regarding the incidence of multi-activity stops, the results of this study show that there is a general underestimation of out-of-home activity participation using travel diary data. This might help to account for a trend of declining annual trip rates observed in the British National Travel Survey over a number of years: down from 1086 in 1995/97 to 1026 in 2004 (see Figure 12). With an increase in major purpose-built shopping and entertainment centres, and increasing pressures on people's time, it may be that there has been an increase in multi-activity participation at out-of-home stops – so that activity participation rates have been maintained while trip rates have fallen.
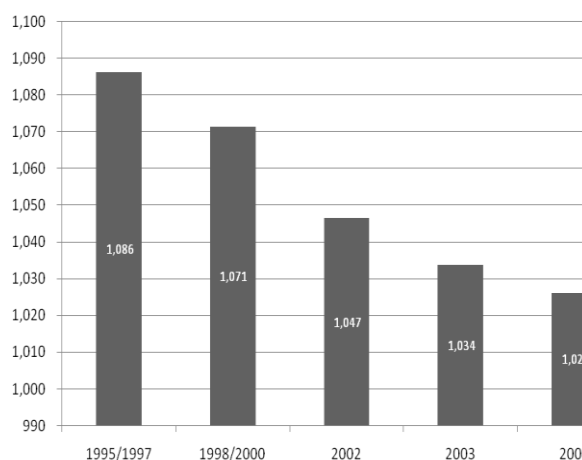

Figure (12). Trips per person per year in Great Britain (DfT, 2008)

Unfortunately, the Time Use Survey does not provide information on geographical location or land use type, so it is not possible to determine the kinds of locations where multiple activities take place (e.g. major shopping/service centres).   But, if there has been a concentration of activities at fewer sites, this raises the possibility of introducing planning policies to further encourage mixed use developments in order to increase opportunities for the 'densification' of activity participation at fewer stops.   Provided such locations are not remotely located, this would help to reduce total travel – particularly by car - and increase the efficiency of the travel that is undertaken (i.e. by resulting in more activities per km travelled).

While this paper has opened up a new area for investigation, there is much research that remains to be done. This analysis could be repeated, using the same data sets, for weekend travel, and it would be interesting to explore variations in the incidence of multi-activity stops by type of person, car availability, area of the country, etc. It would also be very valuable to repeat the analysis using other national or local time use and travel diary data sets; and to explore how respondents select a 'main trip purpose' category where they take part in multiple activities during one stop, and whether referring to 'purpose' rather 'activity' has an effect on the way in which a particular event is classified. Were comparable historical time use data available, it would also be interesting to see whether the incidence of multiple activities at stops has increased over time.

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