Eur. Transp. Res. Rev. (2016) 8: 26
DOI 10.1007/s12544-016-0213-9

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ORIGINAL PAPER

Variability in daily activity-travel patterns: the case of a one-week travel diary

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Received: 3 June 2015 / Accepted: 18 October 2016 / Published online: 27 October 2016

Abstract
Introduction Understanding temporal rhythms in travel and activity patterns has been recognized as an important issue for the effective management of urban congestion. Research issues related to this topic concern the degree to which travel behaviour varies from one day to another, the differences between weekday and weekend travel, and the determinants of variability. Thanks to a seven-day travel diary collected for 707 individuals in the city of Ghent (Belgium) in 2008, this study goes further by studying this variability according to various time periods within the week and by analysing interpersonal and intrapersonal variations according to the varying attributes of activity-travel patterns.
Methods Different variance indicators and the sequential alignment method are applied for the measurement of variability of travel-activity behaviour. Moreover, the influence of individual characteristics on these variations is examined.
Results The overall picture of a large intrinsic variability in travel behaviour (i.e. trip or home-based tour generation) is confirmed. There is more difference in the number of trips per day for a given individual depending on the various days of week than there is between individuals per se, not including the weekend period, and this aspect is reinforced when considering home-based tours. Unlike the case of trip generation, there is greater difference between persons in their daily time allocation to various activities than between days for a given person in general, either during working days or during the weekend. This is also the case for daily activity sequence. Finally, the influence of socio-demographic characteristics on intrapersonal variability is weak, whether for daily trips, tours, time use or activity sequence.
Conclusions The large level of intrapersonal variability in daily trip numbers already demonstrated in the literature is confirmed. Systematic day-to-day variability is shown to have an extremely low share in intrapersonal variability. The global picture is that intrapersonal variability is large while systematic day-to-day variability is marginal. Moreover, a striking result is that socio-demographic characteristics are mostly unable to explain the level of intrapersonal variability. The results reveal that individual behaviour is neither completely habitual nor completely random. On the one hand, intrapersonal variability is more important than the interpersonal one as regards daily trip numbers for the realization of mobility needs. On the other hand, activity time allocation and sequencing show an inverse trend, which can be linked with the habitual part of behaviour and the social role of the individual (through e.g. work, childcare and other activities).

Keywords Mobility · Activity pattern · Time use · Weekly variability

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1 Introduction

Understanding day-to-day travel demand variability has been recognized as an essential element for urban congestion management. It provides useful information for effectively handling travel demand and responding to the day-to-day variations in travel demand. Empirical studies have shown that travel demand forecasting based on one-day travel behaviour surveys may be biased due to day-to-day variations in trip generation [1, 2]. Moreover, one-day travel surveys cannot obtain an unbiased trip generation rate for different types of activities such as shopping or socio-recreation, which are not realized on a daily basis [3]. The research efforts for understanding day-to-day variations in travel behaviour better, such as intrapersonal variation, has produced substantial results since the 1980s. Past studies have shown that there is significant day-to-day variability in travel/activity behaviour [4–14]. The research issues related to this topic concern the degree to which travel behaviour varies from one day to another, the difference between weekday and weekend, the determinants of the variability, the source (between individuals or within individuals) of variability, etc.

Hanson and Huff [5–7] utilized the 35 consecutive days travel survey data (Uppsala data) to study the day-to-day variability in travel patterns. They found that employed men and non-working women exhibited repetitive travel-activity patterns. They further analysed between-individual and within-individual variability in travel behaviour over a five-week period and found a significant systematic intrapersonal variability. They also concluded that 7-day travel survey data is a good sampling for individuals' long-term travel-activity patterns. Pas and Koppelman [4] applied the Uppsala data to analyse the determinants of day-to-day variability of travel behaviour. They argued that an individual's travel-activity pattern variability is influenced by the variation in their activity needs and by their resources and time constraints. The authors utilized a 5-day travel diary survey data to conduct an empirical analysis of the effect of socio-demographic characteristics on intrapersonal variability in the trip generation rate. They found a large intrapersonal variability in trip generation rates for which there were significant differences between different socio-demographic homogenous groups. Pas and Sundar [2] analysed the day-to-day variability of urban travel behaviour based on 3-day travel survey data. They concluded that there is considerable day-to-day variability in individuals' trip chaining, daily travel time and trip generation rate. Pendyala [3] utilized GPS devices to study travellers' day-to-day variability over a six-day period. The author applied the measurements developed by Pas and Sundar [2] and Pas and Koppelman [4] to quantify the variability of individual travel/activity behaviour. The author found that the degree of intrapersonal variability is influenced by the duration for which travel information is collected. The longer the surveyed period, the greater the level of intrapersonal variability.

Apart from these earlier studies, the Mobidrive six-week travel diary dataset [15] provides a rich source for several studies [9–11, 13]. Schlich and Axhausen [16] utilized the Mobidrive data to study variability in day-to-day travel behaviour. They found that travel behaviour is more stable on weekdays than weekends. They argue that two weeks is a minimum duration in which to measure travel behaviour variability. Schlich et al. [10] studied the temporal and spatial variability of leisure activity. Ettema and van der Lippe [17] utilized the one-week time use survey data in the Netherlands to investigate the influence of role expectations, work status and time pressure on task allocation patterns. The authors proposed a weekly time allocation measure to quantify the rhythms in time allocation in the household. It concluded that the day-to-day variability of travel/activity patterns resulted from the household task allocation process and long-term planning in the household. The authors further suggested household task allocation mechanisms need to be studied to better understand day-to-day travel behaviour variability. Moreover, the authors found spatial factors play a less important role in household task allocation, compared to personal and household characteristics. This conclusion is consistent with the work of Raux et al. [18].

Besides these interesting research results, recent studies in day-to-day variability of travel-activity behaviour found particular interest in spatial and time-geography perspectives. For example, Neutens et al. [14] measured interpersonal and intrapersonal variability in day-specific accessibility, defined as the number of days per week that an individual is "able to visit a government office for at least 20 minutes". The authors found that individual variability of accessibility is mainly attributed to intrapersonal (differences in accessibility per day of the same individual) rather than interpersonal variability (difference in accessibility between individuals). Kang and Scott [19] utilized the Toronto Travel-Activity Panel Survey (TTAPS) [20] to investigate the variation of time allocation in activity over different days of the week. The structural equation model is applied to determine the relationships between activity time allocations and an individual's/household's attributes, work/school constraints, and time allocation of other activities and building environment attributes. The authors found higher car availability contributes to higher time allocation to joint and out-of-home activities of household members. The interpersonal variability of time allocation on weekends is higher than intrapersonal variability. Buliung et al. [12] used the first wave of the TTAPS data set to study spatial variability/repetition in an individual's visited activity destinations over a week. The authors proposed a spatial repetition index that measures the ratio of repetitive activity location choices, to measure the spatial repetition of an activity choice over a period of time. It was found that Sunday has the highest spatial variation in activity destination choices, and Monday and Tuesday have higher spatial variability than Saturday. Stopher and Zhang [21] investigated the repetitiveness of daily travel behaviour based on two Australian panels with recorded GPS data. The authors measured the repetition of different tour types, classified by its tour characteristics, i.e. tour travel time, tour distance, total activity time of tour and total tour duration. They found there is little day-to-day repetition at the level of tour.

Beyond aggregated indicators such as trips, tours or time-budget allocation, the sequence of activities performed in the course of one day is suitable for reflecting the space-time organisation of activities. One critical issue is related to the similarity measures for the daily travel-activity patterns. Wilson [22] first introduced a Sequential Alignment Method (SAM) for activity pattern analysis. The method originated in molecular biology and aims to identify segments of similarity between sequences of DNA or protein. The SAM has recently gained popularity in comparing the similarity between activity patterns [23–28]. Note that beyond the perspective of a day-to-day variability study, the search for repetitive activity-travel behaviour, through attributes of activities and/or trips, is indeed another research issue [7], which is beyond the scope of this study.

As multiday data sets are rare and costly (even if originating in the 1970s, as referred to in the literature), this paper takes the opportunity of a newly available data set, a 7-day travel diary in the city of Ghent (Belgium), to explore again the issue of day-to-day activity-travel behaviour. We are particularly interested in exploring day-to-day variability in travel/activity behaviour in terms of daily trips, tours, time use and activity sequence. Our analysis goes further in that it studies the variability over various time periods within the week and investigates its socio-demographic and spatial determinants on these travel/activity behaviour indicators. Moreover, we investigate to what extent systematic day-to-day variability influences intrapersonal variability.

The questions which guide the analysis are the following:

- What are the relative levels of interpersonal and intrapersonal variability, according to various attributes of activity-travel patterns?
- Which are the days that are most similar during the week from the point of view of activity-travel behaviour?
- Do individual characteristics influence the variability (or stability) observed and to what extent?

The organization of the paper is as follows. Section 2 introduces the 7-day mobility survey data and presents its descriptive statistics. The overall methodology for measuring variability is presented in Section 3. This method is applied to travel indicators (trips and home-based tours), time use over various activities, and daily activity sequence. Section 5 analyses the influence of individual socio-demographic attributes on these variations. Finally, the empirical results are discussed and some conclusions are drawn.

2 The data

The data for the analysis is based on a 7-day mobility survey, conducted in the city of Ghent in 2008 [29]. The objective of the survey was to understand how individuals organize their daily activities and to investigate temporal variations in individual travel-activity patterns. As a 7-day mobility survey is a much more burdensome task compared to a traditional one-day mobility survey, the survey protocol has been carefully designed in order to make it successful. Given the available time and budget constraints, only individuals were surveyed instead of all members of the household.

The surveyed individuals were randomly drawn from the population in the city of Ghent based on the stratification of household size, gender, and age of the head of the household (12 to 75). The survey methodology is based on a paper and web survey followed by phone support. Although this survey cannot collect the activity patterns of all members in the household, it still allows investigation of an individual's daily activity patterns and the determinants of the individual's socio-demographic characteristics. A total of 717 individual 7-day mobility diaries were collected on the basis of 4000 persons contacted at home. The global response rate was around 18 %. The number of respondents is representative for the population of Ghent (251,133 inhabitants in 2008) at 95 % confidence level. The reader is referred to Castaigne et al. [29] for a more detailed description of the survey and descriptive statics of the sample.

The respondents were asked to report their daily trip chaining information, including trip purpose, departure and arrival times at destination, transport modes, as well as socio-economic attributes (gender, age, household income, occupation etc.) and mobility practice (car ownership, season ticket subscription etc.). Twelve trip purposes are distinguished and re-grouped into six categories for our analysis, encoded as 1 home, 2 work or school, 3 shopping (daily and long-term shopping), 4 personal business (bank, doctor etc.), 5 social or recreation (eating, visiting family or friends, walking, riding, leisure, sport, culture, etc.), 6 others (other activities including dropping off/picking up someone else).

The descriptive statistics of the sample are shown in Table 1. It shows that most of the respondents (74.9 %) are the head of the household or their spouse. The average age is 40.1 years. Most respondents live as a couple (79.0 %) with on average 3 people in the household and 1.5 cars. The average employment rate (both full-time and part-time) is 56.3 %. As regards daily trip frequency, the average number of trips per person per day is 3.9, and the average number of trips is higher on weekends (4.2 trips) than on weekdays (3.8 trips).

We further investigate the number of trips per purpose according to the day of week (Table 2). It is found that "home" has the highest frequency (1.45 trips a day on average). The other higher trip frequencies are related to "work" (0.4 trips a day), "drop off / pick up" (0.3 trips a day), "daily shopping" (0.38 trips a day), "visiting family or friends" (0.26 trips) and

Table 1 Summary statistics of individuals' socio-demographic characteristics and number of trips per person per day

Variable	Definition	Mean or percentage
Socio-demographic		
Male		50.3 %
Head or spouse		74.9 %
Age		40.1
Holder of a public transport season ticket		57.8 %
Living together as a couple		79.0 %
Parking available at work place		62.4 %
Presence of children under 12 years in the household		26 %
Number of persons in the household		3.0
Number of cars in the household		1.5
Full time job		43.5 %
Part time job		12.8 %
Driving_license	The individual holds a driving license	80 %
Student	The socio-professional status of the individual is student, schoolboy-girl	16 %
Housewife	The socio-professional status of the individual is housewife/husband, unemployed, disabled	13 %
Pensioner	The socio-professional status of the individual is pensioner	15 %
Worker	The socio-professional status of the individual is worker	56 %
Role in the household and structure		
Child	The role of the individual is child	29 %
Single_with_child	The individual lives alone with the presence of children under 12	1 %
Single_no_child	The individual lives alone without any child under 12	15 %
Couple_with_child_no_worker	The individual lives as a couple with the presence of children under 12 and with no worker in the household	0.1 %
Couple_with_child_one_worker	The individual lives as a couple with the presence of children under 12 and with one worker in the household	2 %
Couple_with_child_two_worker	The individual lives as a couple with the presence of children of age under 12 and with two workers and more in the household	18 %
Couple_no_child_no_worker	The individual lives as a couple without any child under 12 and with no worker in the household	13 %
Couple_no_child_one_worker	The individual lives as a couple without any child under 12 and with one worker in the household	6 %
Couple_no_child_two_worker	The individual lives as a couple without any child under 12 and with two workers and more in the household	16 %
Other Summary statistics		
Density	Population density of statistical zone of residence (persons/km^2)	4376
Average number of trips per day (over 7 days)		3.9
Average number of trips on a weekday		3.8
Average number of trips on a weekend day		4.2
Number of individuals in the sample		717
Population of the city of Ghent in 2008		251,133

"leisure, sport, culture etc." (0.24 trips). When comparing trip purposes between weekdays and weekends, we found Friday and Saturday have the higher daily shopping activity. Saturday also scores higher for "having a meal" trips, "long-term shopping", "visiting family or friends", and "leisure, sport, culture, etc." activities. Overall, the results indicate a day-to-day activity pattern which manifests a weekly rhythm for satisfying the needs and desires for different activities.

3 Methodology for measuring variability

Day-to-day variability in travel-activity patterns is a complex issue with multiple dimensions. Instead of using a multidimensional similarity measurement of individuals' travel-activity patterns [24], this study adopts a cautious approach by considering separately various indicators for analysing the day-to-day variability of travel/activity behaviour. Such

Table 2 Average number of trips per purpose according to the day

Activity purpose	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	Mean
Home	1.46	1.4	1.59	1.54	1.51	1.45	1.18	1.45
Work	0.51	0.52	0.54	0.57	0.51	0.10	0.04	0.40
School	0.15	0.17	0.17	0.17	0.16	0.01	0.01	0.12
Having a meal	0.08	0.07	0.07	0.1	0.1	0.12	0.09	0.09
Daily shopping	0.35	0.34	0.41	0.35	0.46	0.53	0.22	0.38
Long-term shopping	0.13	0.08	0.13	0.1	0.14	0.25	0.05	0.13
Personal business	0.19	0.14	0.18	0.18	0.17	0.09	0.05	0.14
Visiting family or friends	0.21	0.19	0.22	0.2	0.23	0.38	0.38	0.26
Walking, riding, etc.	0.12	0.1	0.1	0.08	0.09	0.18	0.26	0.13
Leisure, sport, culture etc.	0.15	0.18	0.2	0.2	0.22	0.37	0.33	0.24
Drop off / pick up	0.33	0.33	0.38	0.34	0.34	0.22	0.14	0.30
Other	0.18	0.18	0.18	0.24	0.21	0.22	0.15	0.19

analyses allow us to investigate the variability in simpler and more meaningful travel/activity participation indicators and to provide useful information for the stakeholders. The indicators of interest, which are computed at the individual level, are: (1) the number of trips and home-based tours per day; (2) time allocation to various activities per day (i.e. daily time-budget per activity), and (3) activity sequence each day.

Variability in day-to-day behaviour can be attributed either to interpersonal differences or to intrapersonal differences. Basic theoretical results regarding the splitting up of variance may be applied, along with the ideas of Pas [25], who originally developed these measures for analysing day-to-day variability in individuals' travel behaviour.

Consider an indicator of daily activity-travel behaviour, n_{ij} (e.g. the number of trips made by an individual i on day j), then the total variability (total sum of square, TSS) for a set of individuals over a period of time can be defined as

$$TSS = \sum_{i=1}^{I} \sum_{j=1}^{J} \left(n_{ij} - \overline{n}_i \right) \tag{1}$$

where I is the number of people in the sample, and J is the number of days in the observation period. $\overline{n}_i$ is the mean daily travel/activity indicator for individual i over period J (for instance the seven days), $\overline{n}_i = \frac{1}{J} \sum_{j=1}^{J} n_{ij}$. It follows that

$$\begin{aligned} TSS = \sum_{i=1}^{I} \sum_{j=1}^{J} \left(n_{ij} - \overline{n} \right)^2 &= \sum_{i=1}^{I} \sum_{j=1}^{J} \left(n_{ij} - \overline{n}_i \right)^2 \\ &+ \sum_{i=1}^{I} \sum_{j=1}^{J} \left(\overline{n}_i - \overline{n} \right)^2 \\ = \text{WPSS} + \text{BPSS} \end{aligned} \tag{2}$$

with $\overline{n}$ being the mean daily travel/activity indicator for all individuals and the period J (e.g. the average daily number of trips for the whole week across the whole sample),

$$\overline{n} = \frac{1}{IJ} \sum_{i=1}^{I} \sum_{j=1}^{J} n_{ij} \tag{3}$$

The first term on the right-hand side of (2) is related to within-person sum of squares (WPSS) representing *intrapersonal variability*. The second term is related to between-person sum of squares (BPSS), representing *interpersonal variability* (e.g. the variability in the weekly average number of trips across individuals).

When it comes to socio-economic analysis or modelling, the interpersonal variability *BPSS* is generally explained by between-person differences of socio-demographic or place-based attributes.

The intrapersonal variability *WPSS* can be further split up into a systematic day-to-day variability (between-day sum of squares *BDSS*) and a residual variability (within-day sum of squares *WDSS*) as

$$\begin{aligned} \text{WPSS} &= \sum_{i=1}^{I} \sum_{j=1}^{J} \left(n_{ij} - \overline{n}_i \right)^2 \\ &= \sum_{i=1}^{I} \sum_{j=1}^{J} \left[\left(n_{ij} + \left(\overline{n}_j - \overline{n} \right) - \overline{n}_i \right) - \left(\overline{n}_j - \overline{n} \right) \right]^2 \\ &= \text{WDSS} + \text{BDSS} \end{aligned} \tag{4}$$

where $\overline{n}_j = \frac{1}{I} \sum_{i=1}^{I} n_{ij}$ is the mean daily travel/activity indicator for all individuals on day j (e.g. the average number of trips on day j across the whole sample).

$n_{ij}+\left(\overline{n}_j-\overline{n}\right)$ is the travel/activity indicator for person i on day j adjusted for the systematic effect of day j, and

$$\mathrm{WDSS}=\sum_{i=1}^{I}\sum_{j=1}^{J}\left(n_{ij}+\left(\overline{n}_j-\overline{n}\right)-\overline{n}_i\right)^2 \quad (5)$$

$$\mathrm{BDSS}=\sum_{j=1}^{J} I\left(\overline{n}_j-\overline{n}\right)^2 \quad (6)$$

BDSS reflects the systematic influence of days at the level of the overall sample (e.g. Saturday or Sunday when compared to Monday or Wednesday). Since the sample is representative of the overall population, this indicator reflects the overall space-time activity rhythm of the society in question.

Note that all these indicators can be computed over various periods *J*, e.g. Monday to Friday, or Monday to Friday plus Sunday, or again Saturday + Sunday. These variability measurements are used in our empirical study as described in the next section.

4 Variability in various dimensions of activity-travel behaviour in the week

In this section, we apply the variability measurements to the indicators of travel/activity behaviour based on the survey. These indicators are the number of trips and home-based tours per day, individuals' daily activity time use and daily activity sequence.

4.1 Variability in the number of trips and home-based tours per day

The 717 people surveyed all perform at least one outside activity during the week (making at least one return trip home) and on average perform 10.3 return trips home over the seven days with a standard deviation of 3.8. Other activities are practiced at various levels during the whole week, e.g. 57 % for work, 26 % for school, 87 % for shopping and 95 % for social recreation. However, the variability in trip numbers is large when compared with that for the number of trips returning home.

Table 3 shows the inter- and intrapersonal variability in the number of trips per day. One finds again the large level of intrapersonal variability in daily trip numbers observed in the literature, as in Pas [25], with a seven-day data set), and Pas and Sundar ([2], with a three-day data set). However, one can go further by analysing this variability along various time periods within the week.

First, the total variability in daily trip numbers (TSS, divided by the number of days on which this statistic is computed) is roughly the same, whatever the five periods considered (from Monday-Friday to Saturday-Sunday, i.e. five, six and seven days or only the weekend). This indicates that the number and the type of days for which variability is computed have no incidence on TSS level.

The between person variability (BPSS) is in general less than the within person variability (WPSS) except on weekends: the share of BPSS in total variability TSS is minimum (35.8 %) when considering the whole week (Monday to Sunday); it increases to make up 45 % of total variability when considering Monday to Friday period (working days); and it is maximum (60.6 %) when narrowing the period to the weekend (Saturday and Sunday). It is only over the weekend that the between person variability is above the within person variability.

In other words there is greater difference in the number of trips per day for a given individual within the week than between individuals. This difference is maximal over the whole week (Monday to Sunday) while the opposite is the case when focusing on the two weekend days: then the difference between persons is more important.

A further breakdown of within person variability (WPSS) into between-day (systematic day-to-day) and within-day variability shows that the systematic day-to-day variability (BDSS) has an extremely low share of WPSS (about 5 % for the Monday-Sunday period). The intrapersonal variability in trip numbers can hardly be related to the peculiarities of the days in the week (e.g. alternation of days during the working week or during the weekend). This is once more in line with Pas [25] but one can analyse the variations of this share according to the various periods.

First, if one considers the first four lines of the table, which include the working days (Mon-Fri) and Saturday or Sunday, the level of within-day variability (WDSS) remains approximately the same (from about 2.3 to 2.5). However, the share of BDSS changes significantly when Sunday is included (from about 1 % to 5 %), and peaks at 12.5 % when the period is narrowed to

Table 3 Inter- and intrapersonal variability in the number of trips per day

Period	TSS	BPSS	WPSS	BPSS/TSS (%)	BDSS	WDSS	BDSS/WPSS (%)
Mon-Fri	4.16	1.88	2.29	45.1 %	0.03	2.26	1.2 %
Mon-Sat	4.23	1.72	2.52	40.6 %	0.02	2.49	0.9 %
Mon-Fri, Sun	4.15	1.58	2.57	38.0 %	0.15	2.43	5.7 %
Mon-Sun	4.22	1.51	2.71	35.8 %	0.13	2.58	4.7 %
Sat, Sun	4.18	2.53	1.65	60.6 %	0.21	1.44	12.5 %

Remark: BPSS, WPSS, BDSS, WDSS and TSS is divided by 10^3 and by the number of days considered

Saturday-Sunday (BDSS increases while WDSS decreases sharply). As regards variability in trip numbers, this points to the peculiarity of Sunday which definitely appears as a different day from other days of the week, including not only the traditional working days but also Saturday.

Table 4 shows the inter- and intrapersonal variability in number of home-based tours per day. There are some differences when compared with the variability in the number of trips. First, the total variability in the number of daily home-based tours (TSS) is much higher in the weekend period (1.61) than in the four other periods considered. This is explained by both a higher interpersonal (BPSS) and intrapersonal (WPSS) variability in the weekend when compared to other periods over the week. Second, WPSS is at its highest on the weekend for home-based tours while it is the opposite for trips: though out of home activities are organised differently for a given individual between Saturday and Sunday, it may result in less difference in the number of trips. Third, over the various periods the share of intrapersonal variability (100 %-BPSS/TSS) is larger than for the number of trips: there is overall more variability for a given person in the organisation of tours (sequence of activities while not returning home) than in the resulting number of trips.

As regards the breakdown of within person variability (WPSS) into between-day (systematic day-to-day) and within-day variability, we see that the systematic day-to-day variability (BDSS) has an even lower share of WPSS when compared to the number of trips.

To sum up, when compared to the number of trips, the analysis of the various variability indicators in the number of home-based tours confirms the specific behaviour on the weekend and shows an even larger share of intrapersonal variability. The latter is not explained at all by the systematic day-to-day variability.

4.2 Variability in individuals' daily time use

The daily travel/activity indicator under study here is an aggregated indicator of the duration of various activities a on day j for individual i d_{ija}. Only out-of-home activities are distinguished since in-home activities are not available in detail. As mentioned in section 2, twelve original trip purposes are regrouped into six categories for our analysis: 1 home, 2 work or school, 3 shopping, 4 personal business, 5 social or recreation, 6 others. The objective is to understand the level of day-to-day variability in time uses of activities.

Let $\overline{d}_{ia}$ refer to the mean daily duration (in minutes) of activity a (e.g. "2. work") for individual i over period J,

$$\overline{d}_{ia} = \frac{1}{J}\sum_{j=1}^{J} d_{ija} \tag{7}$$

where $\overline{d}_{ja}$ is the mean duration of activity a for all individuals on day j (e.g. the average duration of work activity on Monday across the whole sample),

$$\overline{d}_{ja} = \frac{1}{I}\sum_{i=1}^{I} d_{ija} \tag{8}$$

and $\overline{d}_{a}$ is the mean duration of activity a for all individuals I and period J (e.g. the average duration of work activity per day over the week and across the whole sample),

$$\overline{d}_{a} = \frac{1}{I}\sum_{i=1}^{I} \overline{d}_{ia} \tag{9}$$

Hence we can measure the variability of this time use indicator summed across the K = 6 categories of activities by similar indicators as follows:

$$\mathrm{BPSS} = \sum_{i=1}^{I}\sum_{a=1}^{K} J\left(\overline{d}_{ia} - \overline{d}_{a}\right)^2 \tag{10}$$

$$\mathrm{WPSS} = \sum_{i=1}^{I}\sum_{j=1}^{J}\sum_{a=1}^{K} \left(d_{ija} - \overline{d}_{ia}\right)^2 \tag{11}$$

$$\mathrm{BDSS} = \sum_{j=1}^{J}\sum_{a=1}^{K} I\left(\overline{d}_{ja} - \overline{d}_{a}\right)^2 \tag{12}$$

Note that these indicators are computed on the basis of daily time allocation to various activities, as in a daily "time-budget" approach. For instance, work activity for an individual on one given day ($\overline{d}_{ija}$) organised as one period of work with a duration of 7 h or as two periods of work (separated by trips and other non-work activities) with durations of 4 h and 3 h respectively will count as the same duration of 7 h.

Table 5 shows the various figures of variability for time allocation to the six activities per day. TSS is remarkably

Table 4 Inter and intrapersonal variability in the number of home-based tours per day

Type of day	TSS	BPSS	WPSS	BPSS/TSS(%)	BDSS	WDSS	BDSS/WPSS(%)
Mon-Fri	0.65	0.25	0.40	38.5 %	0.00	0.39	0.9 %
Mon-Sat	0.67	0.23	0.44	34.3 %	0.00	0.44	0.7 %
Mon-Fri, Sun	0.65	0.21	0.44	32.4 %	0.01	0.43	3.0 %
Mon-Sun	0.68	0.21	0.47	30.4 %	0.01	0.46	2.4 %
Sat, Sun	1.61	0.62	0.99	38.5 %	0.01	0.98	0.9 %

Table 5 Inter- and intrapersonal variability in time allocation to activities per day

Period	TSS	BPSS	WPSS	BPSS/TSS(%)	BDSS	WDSS	BDSS/WPSS(%)
Mon-Fri	0.11	0.06	0.04	58.0 %	0.00	0.04	0.6 %
Mon-Sat	0.11	0.05	0.06	44.0 %	0.01	0.05	12.0 %
Mon-Fri, Sun	0.11	0.05	0.06	43.3 %	0.01	0.05	14.6 %
Mon-Sun	0.11	0.04	0.07	35.8 %	0.01	0.06	17.0 %
Sat, Sun	0.07	0.04	0.03	59.2 %	0.00	0.03	1.4 %

Remark: BPSS, WPSS, BDSS, WDSS and TSS is divided by 10^9 and by the number of days considered

stable across the various periods of observation, except for a decrease in variability during the Saturday-Sunday period. Within this variability the share of between-person variability (BPSS) is in the majority only when considering either the working days (Monday-Friday, 58 %) or the weekend (Saturday-Sunday, 59 %). In contrast, the share of BPSS is minimal (36 %) when considering the whole week (Monday-Sunday): the intrapersonal variability in time allocation for the whole week takes the lead. In other words, there is greater difference *between* persons in daily time allocation to various activities than between days for a given person in general, either during the working week or the weekend. However, across the whole week the within person variation is greater, mostly because of the difference in activity participation between the weekend and the other days.

With respect to the breakdown of intrapersonal variability (WPSS), the share of systematic day-to-day variability BDSS is again in the minority (less than 20 %), however, with significant differences when considering various periods in the week. This share is almost null (0.6 %) for working days (Monday-Friday) and about 1 % for the weekend period. This points to the basic (and expected) difference in activity participation between weekends and other days.

This also indicates that within intrapersonal variability, whether for the working days or the weekend period, is not driven by alternation of days but by other kinds of variability.

4.3 Variability in individuals' daily activity sequence

Beyond aggregated trip-based indicators or time-budget allocation, we can address the organisation of activities during the day by means of a person's daily activity sequence, that is to say, the sequence of activities that an individual performs over 24 h. The analysis of its variability allows us to understand to what extent this sequence is different from one day to another. To measure the similarity between two activity sequences, the one-dimensional Sequential Alignment Method (SAM) is used to compute the Levenshtein distance between two sequences of activities by applying a dynamic programming algorithm [23, 24]. The method computes the least number of basic operations (deletion, insertion and substitution), necessary to equalize two sequences. The higher the distance between them is, the more different the two sequences are. For example, consider two activity sequences coded as two strings **f** = "acb" and **g** = "abcd". The SAM method [24] measures the equalisation effort (Levenshtein distance) between **f** and **g** as minimum basic operations to transform the string from **f** to **g**, i.e. 1) "a**c**b" → "a**b**b" (substitution of "c" in **f** for "b"), 2) "ab**b**" → "ab**c**" (substitution of "b" in **f** for "c"), 3) "abc" → "abc**d**" (insertion of "d" in **f**). Hence the Levenshtein distance between **f** and **g** is 3. The SAM uses a comparison table (matrix) to compute the equalization costs. The one-dimensional SAM has been extended to a multidimensional SAM by taking into account the dependencies between different attributes of activity patterns (activity type, location and duration, beginning and ending time, travel mode; see [24]). However, this also makes the calculation of similarity more complex as mentioned by Schlich and Axhausen [26]. The choice of attributes and their scaling, categorizing and weighting still lack theoretical justification. Thus, a one-dimensional alignment method is applied to compare activity type sequences. The reader is referred to Joh et al. [23, 24] for a more detailed description.

Let q_{ij} be the activity sequence on day j performed by individual i. The distance s_{ij} is defined as the sum of Levenshtein distances for individual i, between day j and the other days of the week. We define

$$s_{ij} = \sum_{k=1}^{J} d\left(q_{ij}, q_{ik}\right) \tag{13}$$

where $d(q_{ij}, q_{ik})$ are the Levenshtein distances measured by the one dimensional SAM method [24].

Let $\overline{s}_i$ be the mean Levenshtein distance for individual i from all days j of period J to all other days in the same period J, defined as

$$\overline{s}_i = \frac{1}{J}\sum_{j=1}^{J} s_{ij} = \frac{1}{J}\sum_{j=1}^{J}\sum_{k=1}^{J} d\left(q_{ij}, q_{ik}\right) \tag{14}$$

Similarly, we define $\overline{s}_j$, the mean Levenshtein distance across all the individuals of day j to all other days in period J, as:

$$\overline{s}_j = \frac{1}{I}\sum_{i=1}^{I} s_{ij} = \frac{1}{I}\sum_{i=1}^{I}\sum_{k=1}^{J} d\left(q_{ij}, q_{ik}\right) \tag{15}$$

and $\overline{s}$ is the mean Levenshtein distance across all the individuals and all days of period J, $\overline{s} = \frac{1}{I}\sum_{i}\overline{s}_i$.

Once these Levenshtein distances are computed, the variability can be obtained based on similar variability measures as follows:

$$\mathrm{BPSS} = \sum_{i=1}^{I} J\left(\overline{s}_i - \overline{s}\right)^2 \quad (16)$$

$$\mathrm{WPSS} = \sum_{i=1}^{I}\sum_{j=1}^{J} I\left(s_{ij} - \overline{s}_i\right)^2 \quad (17)$$

$$\mathrm{BDSS} = \sum_{j=1}^{J} I\left(\overline{s}_j - \overline{s}\right)^2 \quad (18)$$

Table 6 shows the inter- and intrapersonal variability of Levenshtein distances for various periods in the week. The total variability (TSS) is minimal in the weekend period (Saturday-Sunday), at a significantly lower level than on other days, and maximal when considering the whole week (Monday-Sunday). This indicates a specificity of Saturday and Sunday in activity sequences when compared with the remainder of the week, as well as a significant degree of homogeneity of these two days as to the nature of their activities when compared with working days.

The main difference with previous indicators is the high level of between-person variability, which is always more than intrapersonal variability (with a share of more than 70 %). This share is maximal during the working days period (Monday to Friday). Thus, the heterogeneity of individuals would explain a large part of the variability in the sequencing of activities.

Furthermore, intrapersonal variability (WPSS) is small and within that the systematic day-to-day variability (BDSS) is even smaller (roughly between 1 % and 9 %).

5 Does socio-demographic status explain intrapersonal variability?

Since we suspect that socio-demographic status might explain the level of intrapersonal variability, linear regression models are employed to investigate the effects of socio-demographic variables on individual intrapersonal day by day variability, i.e. the number of daily trips, number of home-based tours, time use allocation and daily activity sequence. As shown previously, Saturday and Sunday play a specific role in mobility and activity, so this analysis of variability is performed on the Monday-Friday period. Note that linear regression models are estimated based on a stepwise regression method.

Socio-demographic and lifecycle variables are included as explanatory variables for intrapersonal variability analysis. They include gender, age (in categories), socio-professional status, holding of a driving license, and a combination of variables which describe the role of the individual (head, spouse or child) and the household structure (single or couple; with child under 12 or not; zero, one or two workers). Table 1 show the descriptive statistics.

Holding a driving license is retained as a proxy for car availability. Indeed, we know the number of cars available in the household from the survey but not the number of driving licenses within the household. Previous studies indicate that the possession of a driving license influences an individual's travel and activity participation [30].

Moreover, the previous analysis suggests that the intrapersonal variability of individuals' daily travel, time use and activity sequence is likely to depend on individuals' demographic and employment status. Hence, we distinguish four categories: 1. student, schoolboy (−girl); 2. housewife (or husband) unemployed, disabled person; 3. pensioner; 4 worker.

We hypothesize that these four categories of demographic and employment status may interact with other individual attributes such as gender, age, density of residential zone, holding a driving license and the individual role within the household structure. This is why the following regression analyses directly include these interaction effects. The tables in the appendix show the results of these estimations for daily trips (see Table 7), time use (Table 8) and daily activity sequence (Table 9). The results for home-based tours are not shown here since they are very similar to those for trips.

The list of variables that significantly influence the different variations is identical across daily trips, time use and daily activity sequence. Male is systematically significant in interaction with status for all the three variability indicators studied here. Men have lower intrapersonal variability than women in

Table 6 Inter- and intrapersonal variability in individuals' daily activity sequence

Period	TSS	BPSS	WPSS	BPSS/TSS(%)	BDSS	WDSS	BDSS/WPSS(%)
Mon-Fri	0.05	0.04	0.01	78.7 %	0.00	0.01	1.3 %
Mon-Sat	0.07	0.05	0.02	72.5 %	0.00	0.02	8.4 %
Mon-Fri, Sun	0.07	0.05	0.02	73.6 %	0.00	0.02	3.7 %
Mon-Sun	0.10	0.07	0.03	71.3 %	0.00	0.03	4.5 %
Sat, Sun	0.00	0.00	-	100.0 %	-	0.00	NA

Remark: BPSS, WPSS, BDSS, WDSS and TSS is divided by 10^9 and by the number of days considered daily trips, time use and activity sequence. Students have lower intrapersonal variability but only when under age of 25. Older adults (housewife, worker or pensioner), single people and those without children also have lower variability. We note incidentally that "Worker" is not significant.

Overall, the models show that the influence of socio-demographic status on intrapersonal variability is weak. As shown by the sign of the constant which is significant in the three models, there is an overall tendency to an increasing variability. Moreover, the levels of the constants are high, which confirms the low explanation of variability through socio-demographic variables even if the r-squared statistics are reasonable.

6 Discussion

The overall picture of a great intrinsic variability in travel behaviour (i.e. trip or home-based tour generation) is confirmed by our results. There is greater difference in the number of trips per day during the various days of week for a given individual than between individuals and this aspect is reinforced when considering home-based tours. However, our analysis of various periods within the week (Monday to Friday, weekend, and so on) allows us to add richer insights.

The share of intrapersonal variability in trips or tours generation is maximal during the overall week (Monday to Sunday) while this is the opposite when restricted to the two weekend days. In the case of trip generation in the weekend the difference between people becomes more important. As regards activity sequence, the variability is minimal during the weekend period, at a significantly lower level than on other days. This confirms the peculiarity of the two weekend days as to the nature of activities when compared with working days. With respect to travel behaviour (trip generation and cutting out of activities through activity sequence) Sunday definitely stands out as a different day from the other days of the week, i.e. whether the traditional working days or Saturday.

However, beyond this basic difference between Monday-Friday, Saturday and Sunday, the intrapersonal variability of travel behaviour (including activity sequence) is not explained at all by systematic day-to-day variability, i.e. the alternation of days during the working week or during the weekend. This points to a kind of intrinsic, within-person day-to-day variability in travel behaviour, which can hardly be related to the peculiarities of the days of the week but rather to other sources of variability.

When it comes to daily time allocation to activities a slightly different picture emerges. The total variability in time allocation is roughly constant whatever the periods considered within the week, except on weekends (where it decreases). Unlike the case of trip generation, there is greater difference between people in their daily time allocation to various activities than between days for any given person, either during working days or during the weekend. However, there is greater difference in time allocation (i.e. activity participation) between the weekend and the other days for any given individual than between individuals, again reflecting the peculiarity of the weekend.

These results, in contrast to those on trip generation, reflect a difference between the time length which must be allocated to mandatory activities such as work or child care (or other non mandatory activities) and the organisation of this allocation, which can be planned in various ways yielding various numbers of place changes and hence various numbers of trips.

A similar difference in results in relation to previous travel indicators appears with activity sequence since interpersonal variability is always greater than intrapersonal variability. As with activity time allocation there is greater difference within activity sequences between persons than within person days. The heterogeneity of individuals would explain a large part of variability (more than 70 %) in the sequencing of activities.

When trying to find some determinants of intrapersonal variability, other than in the alternation of days, we find that the linkage with socio-demographic characteristics is weak, whether for daily trips, tours, time use or activity sequence. In general men have lower intrapersonal variability than women which would mean for women either more flexibility or more irregular constraints (e.g. linked with maintenance, childcare, shopping). Students under 25 also have lower intrapersonal variability, like other adults living single without children. This obviously points to the gender-based role (male versus female), the age-based role (student versus others) and the impact of the presence of a spouse or children on daily activity organisation in the household. The weakness of this linkage offers a different picture from the previous literature cited in the introduction (Hanson and Huff, 5–7). However, if socio-demographic characteristics only weakly explain intrapersonal variability, what other explanatory factors are left?

The global picture is both that intrapersonal variability is large and that systematic day-to-day variability is marginal. Moreover, a striking result is that socio-demographic characteristics are mostly unable to explain the level of intrapersonal variability.

Hanson and Huff [6] suggested as a working hypothesis that individual behaviour is neither completely habitual (or routine) nor completely random. Our analysis of activity-travel behaviour over a 7-day period shows that intrapersonal variability is greater than the interpersonal one regarding trips or tours (i.e. the carrying out of mobility needs) and this can be linked with the random part of behaviour. In contrast, activity time allocation and sequencing show an intrapersonal variability, which is lower than the interpersonal one and this could be linked with the habitual part of behaviour. One limitation of this analysis, however, is the reference to the day as the basis for computing the activity-travel indicators, while the rhythm of repetition could be every other day or three days, and so on.

7 Conclusion and perspectives

Various travel demand management measures are in play today: they include staggering work hours, incentives to use enhanced bus or light-rail services, "seamless" integration and chaining of various transport modes as alternatives to the car (e.g. bike and public transport), car pooling and car sharing, or even peak (or congestion) pricing. These measures need accurate prediction of their effectiveness in changing behaviour. Obviously, these old and new policy measures will only demonstrate their effectiveness if they match the day-to-day behaviour of the transport users these measures are aimed at.

Unsuspected levels of either flexibility or rigidity in travel behaviour may be revealed in response to travel demand policy measures. This is why the search for regularity, or conversely, for variability in activity-travel behaviour, is of crucial interest for modelling. While several *national* travel surveys already implement multiday travel diary (as in France, the UK, Germany or the Netherlands), our results give a strong case for *local* (city) household travel surveys based on several days of observation (at least seven days) and not only for a single day, as is generally the case nowadays.

Acknowledgments This research has benefited from a grant of ANR (the French Agency for Research, Project EuroCities-DATTA n° ANR-07-BLAN-0032-01). We thank the Groupe de Recherche sur les Transports (FUNDP, Namur) for providing the Belgian Mobility Week database.

Appendix

In the following tables some interaction variables are automatically omitted since they apply to zero or too few individuals (e.g. "pensioner x age 15").

Table 7 Regression analysis for intrapersonal variability (WPSS) of the number of trips per day (Monday-Friday)

Variable	Coef.	Std. Err.	*t*-value	P > |t|
Worker	8.242	12.455	0.66	0.508
Student x male	-41.535	4.698	-8.84	0.000
Housewife x male	-46.284	5.971	-7.75	0.000
Pensioner x male	-46.897	5.053	-9.28	0.000
Worker x male	-44.276	2.520	-17.57	0.000
Student x age < 15	-37.323	11.609	-3.22	0.001
Worker x age < 15	-41.480	28.407	-1.46	0.145
Student x age15_25	-34.137	11.227	-3.04	0.002
Housewife x age15_25	-15.010	14.022	-1.07	0.285
Worker x age15_25	-20.817	14.380	-1.45	0.148
Student x age25_55	-22.243	28.372	-0.78	0.433
Housewife x age25_55	-10.438	13.035	-0.8	0.424
Pensioner x age25_55	21.364	25.613	0.83	0.405
Worker x age25_55	-21.021	14.694	-1.43	0.153
Housewife x age55_65	-0.500	13.696	-0.04	0.971
Pensioner x age55_65	-2.424	5.455	-0.44	0.657
Worker x age55_65	-13.947	14.743	-0.95	0.344
Student x density	0.000	0.001	0.45	0.653
Housewife x density	0.001	0.001	1.02	0.306
Pensioner x density	0.000	0.001	-0.38	0.703
Worker x density	0.000	0.000	-0.13	0.901
Student x driving_license	6.178	6.234	0.99	0.322
Housewife x driving_license	1.946	7.303	0.27	0.790
Pensioner x driving_license	3.473	7.878	0.44	0.659
Worker x driving_license	2.896	5.071	0.57	0.568
Housewife x single_with_child	3.101	18.400	0.17	0.866
Worker x single_with_child	9.701	9.505	1.02	0.308
Housewife x single_no_child	-44.908	8.344	-5.38	0.000
Pensioner x single_no_child	-51.241	11.493	-4.46	0.000
Worker x single_no_child	-15.564	3.560	-4.37	0.000
Student x couple_with_child_one_worker	24.059	27.622	0.87	0.384
Housewife x couple_with_child_one_worker	-10.105	12.124	-0.83	0.405
Worker x couple_with_child_one_worker	-7.098	11.207	-0.63	0.527
Housewife x couple_with_child_two_worker	-10.297	8.826	-1.17	0.244
Worker x couple_with_child_two_worker	-1.866	3.192	-0.58	0.559
Housewife x couple_no_child_no_worker	4.490	10.803	0.42	0.678
Pensioner x couple_no_child_no_worker	3.451	9.561	0.36	0.718
Worker x couple_no_child_no_worker	0.759	12.143	0.06	0.950
Housewife x couple_no_child_one_worker	-6.508	8.348	-0.78	0.436
Pensioner x couple_no_child_one_worker	4.877	11.301	0.43	0.666
Worker x couple_no_child_one_worker	0.690	6.365	0.11	0.914
Constant	90.017	10.186	8.84	0.000
Number of obs	696			
Source	SS	df	MS	
Model	438,582.41	41	10,697.13	
Residual	387,613.80	654	592.68	
Total	826,196.21	695	1188.77	
F(41, 654)	18.05			
Prob > F	0.0000			
R-squared	0.53			
Adj R-squared	0.50			

Table 8 Regression analysis for intrapersonal variability (WPSS) of individuals' daily time use allocation (Monday-Friday)

Variable	Coef.	Std. Err.	*t*-value	P > |t|
Worker	1.739	2.335	0.74	0.457
Student x male	-8.735	0.881	-9.92	0.000
Housewife x male	-8.894	1.120	-7.94	0.000
Pensioner x male	-8.054	0.948	-8.50	0.000
Worker x male	-8.533	0.473	-18.06	0.000
Student x age < 15	-6.358	2.177	-2.92	0.004
Worker x age < 15	-8.047	5.327	-1.51	0.131
Student x age15_25	-5.732	2.105	-2.72	0.007
Housewife x age15_25	-2.302	2.629	-0.88	0.382
Worker x age15_25	-3.630	2.696	-1.35	0.179
Student x age25_55	-2.852	5.320	-0.54	0.592
Housewife x age25_55	-1.415	2.444	-0.58	0.563
Pensioner x age25_55	5.744	4.803	1.20	0.232
Worker x age25_55	-3.817	2.755	-1.39	0.166
Housewife x age55_65	-0.066	2.568	-0.03	0.980
Pensioner x age55_65	-0.483	1.023	-0.47	0.637
Worker x age55_65	-2.731	2.765	-0.99	0.324
Student x density	0.000	0.000	0.49	0.626
Housewife x density	0.000	0.000	0.99	0.321
Pensioner x density	0.000	0.000	-0.45	0.655
Worker x density	0.000	0.000	-0.32	0.751
Student x driving_license	1.218	1.169	1.04	0.298
Housewife x driving_license	0.287	1.369	0.21	0.834
Pensioner x driving_license	0.624	1.477	0.42	0.673
Worker x driving_license	0.666	0.951	0.70	0.484
Housewife x single_with_child	0.316	3.450	0.09	0.927
Worker x single_with_child	1.680	1.782	0.94	0.346
Housewife x single_no_child	-8.952	1.565	-5.72	0.000
Pensioner x single_no_child	-10.409	2.155	-4.83	0.000
Worker x single_no_child	-3.516	0.668	-5.27	0.000
Student x couple_with_child_one_worker	3.586	5.180	0.69	0.489
Housewife x couple_with_child_one_worker	-2.211	2.274	-0.97	0.331
Worker x couple_with_child_one_worker	-1.291	2.102	-0.61	0.539
Housewife x couple_with_child_two_worker	-1.944	1.655	-1.17	0.241
Worker x couple_with_child_two_worker	-0.324	0.598	-0.54	0.588
Housewife x couple_no_child_no_worker	0.544	2.026	0.27	0.788
Pensioner x couple_no_child_no_worker	0.498	1.793	0.28	0.781
Worker x couple_no_child_no_worker	0.366	2.277	0.16	0.873
Housewife x couple_no_child_one_worker	-1.192	1.565	-0.76	0.446
Pensioner x couple_no_child_one_worker	0.774	2.119	0.37	0.715
Worker x couple_no_child_one_worker	0.094	1.194	0.08	0.937
Constant	17.688	1.910	9.26	0.000
Number of obs	696			
Source	SS	df	MS	
Model	16,221.45	41	395.65	
Residual	13,629.85	654	20.84	
Total	29,851.30	695	42.95	
F(41, 654)	18.98			
Prob > F	0.0000			

Table 8 (continued)

Variable	Coef.	Std. Err.	*t*-value	P > |t|
R-squared	0.54			
Adj R-squared	0.51			

Table 9 Regression analysis for intrapersonal variability (WPSS) of individuals' daily activity sequence (Monday-Friday)

Variable	Coef.	Std. Err.	*t*-value	P > |t|
Worker	3.805	5.480	0.69	0.488
Student x male	-18.150	2.067	-8.78	0.000
Housewife x male	-20.002	2.627	-7.61	0.000
Pensioner x male	-20.123	2.223	-9.05	0.000
Worker x male	-19.152	1.109	-17.27	0.000
Student x age < 15	-16.170	5.108	-3.17	0.002
Worker x age < 15	-18.384	12.499	-1.47	0.142
Student x age15_25	-14.751	4.939	-2.99	0.003
Housewife x age15_25	-6.096	6.169	-0.99	0.323
Worker x age15_25	-8.995	6.327	-1.42	0.156
Student x age25_55	-9.668	12.483	-0.77	0.439
Housewife x age25_55	-4.182	5.735	-0.73	0.466
Pensioner x age25_55	9.980	11.269	0.89	0.376
Worker x age25_55	-9.135	6.465	-1.41	0.158
Housewife x age55_65	0.028	6.026	0.00	0.996
Pensioner x age55_65	-1.002	2.400	-0.42	0.677
Worker x age55_65	-6.130	6.486	-0.95	0.345
Student x density	0.000	0.000	0.47	0.639
Housewife x density	0.000	0.000	1.01	0.312
Pensioner x density	0.000	0.000	-0.40	0.689
Worker x density	0.000	0.000	-0.23	0.816
Student x driving_license	2.920	2.743	1.06	0.287
Housewife x driving_license	0.682	3.213	0.21	0.832
Pensioner x driving_license	1.641	3.466	0.47	0.636
Worker x driving_license	1.490	2.231	0.67	0.505
Housewife x single_with_child	1.900	8.096	0.23	0.814
Worker x single_with_child	3.951	4.182	0.94	0.345
Housewife x single_no_child	-20.375	3.671	-5.55	0.000
Pensioner x single_no_child	-22.885	5.057	-4.53	0.000
Worker x single_no_child	-7.609	1.567	-4.86	0.000
Student x couple_with_child_one_worker	10.059	12.153	0.83	0.408
Housewife x couple_with_child_one_worker	-4.454	5.335	-0.83	0.404
Worker x couple_with_child_one_worker	-2.736	4.931	-0.55	0.579
Housewife x couple_with_child_two_worker	-4.501	3.883	-1.16	0.247
Worker x couple_with_child_two_worker	-0.770	1.404	-0.55	0.583
Housewife x couple_no_child_no_worker	1.858	4.753	0.39	0.696
Pensioner x couple_no_child_no_worker	1.559	4.207	0.37	0.711
Worker x couple_no_child_no_worker	0.227	5.343	0.04	0.966
Housewife x couple_no_child_one_worker	-2.887	3.673	-0.79	0.432
Pensioner x couple_no_child_one_worker	2.189	4.972	0.44	0.660
Worker x couple_no_child_one_worker	0.260	2.800	0.09	0.926

Table 9 (continued)

Variable	Coef.	Std. Err.	*t*-value	P > |t|
Constant	40.638	4.482	9.07	0.000
Number of obs	696			
Source	SS	df	MS	
Model	83,361.66	41	2033.21	
Residual	75,034.86	654	114.73	
Total	158,396.52	695	227.91	
F(41, 654)	17.72			
Prob > F	0.0000			
R-squared	0.53			
Adj R-squared	0.50			

References

1. Jones P, Clarke M (1988) The significance and measurement of variability in travel behaviour. Transp 15:65–87
2. Pas EI, Sundar (1995) Intrapersonal variability in daily urban travel behavior: Some additional evidence. Transp 22:135–150
3. Pendyala R (2000) Day-to-day variability in travel using Lexington, KY GPS-based data set. Final report. United States Department of Transportation - Federal Highway Administration.
4. Pas EI, Koppelman FS (1986) An examination of the determinants of day-to-day variability in individuals' urban travel behavior. Transp 13:183–200
5. Hanson S, Huff JO (1982) Assessing day-to-day variability in complex travel patterns. Transp Res Rec 891:18–24
6. Hanson S, Huff JO (1986) Classification issues in the analysis of complex travel behaviour. Transp 13(4):273–291
7. Hanson S, Huff JO (1988) Systematic variability in repetitious travel. Transp 15:111–135
8. Huff JO, Hanson S (1986) Repetition and variability in urban travel. Geogr Anal 18:97–114
9. Lee MS, McNally MG (2003) On the structure of weekly activity/travel patterns. Transp Res part A 37:823–839
10. Schlich R, Schönfelder S, Hanson S, Axhausen KW (2004) Structures of Leisure Travel: Temporal and Spatial Variability. Transp Rev 24(2):219–237
11. Schönfelder S (2006) Urban Rhythms - Modelling the Rhythms of Individual Travel Behavior. Ph.D. Thesis, Swiss Federal Institute of Technology, Zurich, Switzerland.
12. Buliung RN, Roorda MJ, Remmel TK (2008) Exploring spatial variety in patterns of activity-travel behaviour: initial results from the Toronto Travel-Activity Panel Survey (TTAPS). Transp 35(6):697–722
13. Schönfelder S, Axhausen KW (2010) Urban rhythms and travel behaviour: Spatial and temporal phenomena of daily travel. Ashgate Publishing Ltd.
14. Neutens T, Delafontaine M, Scott DM, De Maeyer P (2012) An analysis of day-to-day variations in individual space-time accessibility. J Transp Geogr 23:81–91
15. Axhausen KW, Zimmermann A, Schönfelder S, Rindsfüser G, Haupt T (2002) Observing the rhythms of daily life: a six-week travel diary. Transp 29(2):95–124
16. Schlich R, Axhausen KW (2003) Habitual travel behaviour: evidence from a six-week travel diary. Transp 30(1):13–36
17. Ettema D, van der Lippe T (2009) Weekly rhythms in task and time allocation of households. Transp 36:113–129
18. Raux C, Ma T-Y, Joly I, Kaufmann V, Cornelis E, Ovtracht N (2011) Travel and activity time allocation: An empirical comparison between eight cities in Europe. Transp Policy 18:401–412
19. Kang H, Scott DM (2010) Exploring day-to-day variability in time use for household members. Transp Res Part A 44(8):609–619
20. Roorda MJ, Miller EJ (2004) Toronto activity panel survey—demonstrating the benefits of a multiple instrument panel survey. Paper presented at the 7th international conference on travel methods, Costa Rica
21. Stopher P, Zhang Y (2011) Repetitiveness of Daily Travel. Transp Res Rec 2230:75–84
22. Wilson WC (1998) Activity pattern analysis by means of sequence alignment methods. Environ Planing A 30(6):1017–1038
23. Joh C-H, Arentze TA, Timmermans HJP (2001) A position-sensitive sequence-alignment method illustrated for space-time activity diary data. Environ and Planning A 33:313–338
24. Joh C-H, Arentze T, Hofman F, Timmermans H (2002) Activity pattern similarity: a multidimensional sequence alignment method. Transp Res Part B 36:385–403
25. Pas EI (1987) Intrapersonal variability and model goodness-of-fit. Transp Res 21A(6):431–438
26. Schlich R, Axhausen KW (2004) Analysing interpersonal variability for homogeneous groups of travellers, Arbeitsbericht Verkehrs- und Raumplanung, 296, IVT. ETH Zürich, Zürich
27. Wilson C (2008) Activity patterns in space and time: Calculating representative Hagerstrand trajectories. Transp 35(4):485–499
28. Shimamoto H, Zhang J, Fujiwara A (2009) An effective algorithm to detect the similarities of activity-travel patterns. In: Proceedings of the 12th International Conference of the International Association for Travel Behaviour Research (IATBR. Jaipur, India
29. Castaigne M, Cornelis E, Walle F, Frederix R, Tampere C, Toint P, Viti F (2009) Behaviour and mobility within the week "BMW", Final Report. Brussels: Belgian Science Policy 2009 (Research Programme Science for a Sustainable Development)
30. Bhat CR, Srinivasan S (2005) A Multidimensional Mixed Ordered-Response Model for Analyzing Weekend Activity Participation. Transp Res Part B 39:255–278