Daily and Weekly Time Allocation to Travel and Activity in some European Cities

Charles Raux[a*], Tai-Yu Ma[a], Iragaël Joly[b], Eric Cornelis[c]

[a] Laboratoire d'Economie des Transports (CNRS, Université de Lyon, ENTPE)

[b] Laboratoire d'Economie Appliquée de Grenoble (INRA, Grenoble-INP)

[c] Groupe de Recherche sur les Transports (FUNDP, Namur)

[*] corresponding author: email: charles.raux@let.ish-lyon.cnrs.fr,
address: LET, ISH, 14 av. Berthelot, 69363 Lyon Cedex 07, France.
Phone: +33 472726454, Fax: +33 472726448

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Abstract

The paper discusses the relative effects of socio-demographic, spatial context, transport availability and city-specific variables on time allocation to travel and various out-of-home activities. The discussion is based on results obtained from econometric analyses of, on the one hand, travel surveys in eight European cities over three countries: France (Lyon, Grenoble, Strasbourg and Rennes), Switzerland (Geneva, Bern and Zurich) and Belgium (Brussels); on the other hand a one week survey in Ghent (Belgium). The results from these different sources converge to underline that socio-demographic characteristics (and especially gender and marital status) play by far the major role in time allocation to travel and various activities. This is the case in all urban areas surveyed, despite restricted to the European cultural area, considering whether isolated weekdays or a whole week.

Keywords: travel, activity, time allocation, Europe, duration model

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1 Introduction

Recurring issues in the studies of activity and travel behaviour are about the way individuals allocate resources (and especially time) to various activities. Individual's daily time allocation results from a complex interaction between socio-demographic characteristics, social rhythms, urban forms and transport settings.

An important reference is of course the seminal work by Gary Becker (1965) about the allocation of time. Becker pointed at the importance of non-working time when analysing economic welfare, his theory being based on the assumption that households are producers – when they input goods and time for producing commodities – as well as consumers. The issues of allocation of time within family, e.g. for childrearing, and of division of labour between household and market tasks are also at stake in the *Treatise on the Family* (1991).

Empirical studies on activity and travel behaviour looked at from the point of view of time allocation (or "budget") are numerous.

Pas and Koppelman (1986), using a five-day record of travel, show the importance of household role related variables (such as gender related effect of children) in the day-to-day behaviour. Ettema and van der Lippe (2009) analyze a one-week time use survey held over couples in The Netherlands and conclude that spatial factors play a limited role in task allocation, compared to personal and household characteristics (presence of young children, work status, age, gender). Kitamura et al. (1992) compared time use based on the national time use surveys of Netherlands in 1985 and California in 1988. Levinson (1999) analyzed and compared regional time use in the United States. Eurostat (2003) compared mean national time use of twelve European countries. Timmermans et al. (2002, 2003) have exploited a comparative study of time use pattern across cities in The Netherlands, UK, USA, Canada and Japan based on travel survey data. They found that the household type, based on predefined socio-demographic groups, and day-of-week effect are highly correlated to the time allocation pattern across different cities. The spatial and transportation settings, however, provide less significant effects on time allocation pattern.

Our work is based on two sources of activity-travel survey data. The first one gathers household activity-travel surveys performed in eight European cities over three countries: France (Lyon, Grenoble, Strasbourg and Rennes), Switzerland (Geneva, Bern and Zurich) and Belgium (Brussels). These data were collected in different periods (1997-2006) through a 24 hours travel diary in all these cities, which provide detailed information on individual's daily time use pattern and related socio-demographic characteristics. The second source of data is a new 7-day data set collected in the city of Ghent (Belgium) in 2008, in the framework of a research project devoted to the exploration of variability in day-to-day activity-travel behaviour (Belgian Mobility Week).

The main issue which guides our analysis is the relative role of individual socioeconomic and demographic factors, spatial context and transport supply, or city/country specificity, in travel and various activity time allocation.

Unlike previous literature, rather than using predefined socio-demographic groups we analyze the effects of age, gender, work status, presence of children and so on directly at the individual level. A lot of checking and harmonization have been carried out in order to make these different sources of data as comparable as possible despite differences of data collection methods and survey questionnaires between countries.

To examine the relative effects of these covariates on the time allocation, the Cox proportional hazard mixture model is applied. Our results show that socio-demographic (and especially gender and household type) and city-specific characteristics play a major role, while spatial context and transport supply have almost no significant impact on travel time budget and out-of-home activity time budgets.

The organization of the paper is as follows. The description of the data set of these cities and further processing to make them comparable on a common basis are presented in section 2. In section 3, the Cox proportional hazard mixture model is introduced. The results of analysis are presented in section 4. Finally, we discuss these results and draw some conclusions.

2 The data

The first source of data has been collected through household travel surveys for eight cities across three countries in Europe. It includes Lyon (2006), Grenoble (2002), Rennes (2001) and Strasbourg (1997) in France, Geneva, Bern and Zurich in Switzerland (2000) and Brussels (1999) in Belgium. These cities were selected partly because of the availability of the surveys and their relative contemporaneousness (see Table 1 and Table 2). Moreover, while involving different countries these surveys implement a similar methodology regarding the reporting of travel and activity by the respondents (despite the important and difficult work of harmonisation required for comparison, see below).

As the datasets across these countries differ in terms of survey items and level of details, some common reclassification in terms of travel purposes (activity types), transport modes and socio-demographic characteristics need to be pre-proceeded. As mentioned by Timmermans et al. (2002), international comparative studies usually suffer from similar reclassification problems of dataset in terms of common dependent variables (activity purposes) or explanatory variables (transport mode). Researchers try to make these datasets comparable as possible and avoid utilizing some subjective variables.

To this end, the out-of-home activity types are grouped as 1 work/training, 2 school, 3 shopping/personal business, 4 social-recreation, 5 accompanying. The initial trip purposes can be found in Appendix A. While the identification of “work” or “school” does not raise much difficulty, the difference between shopping/personal business and social-recreation should be regarded cautiously: declaration of the person interviewed, coding by the interviewer and pre-coding nomenclature, which may differ and be interpreted differently across countries and linguistic areas, interact in the elaboration of the “purpose” of the activity.

The transport modes are reclassified as 1 walk, 2 bicycle, 3 public transport, 4 car, 5 other. Note that in case of a multimodal trip, one main mode is assigned the total travel time for the entire trip according to the following priority: public transport > car > bicycle > walk. Note also that only weekdays (from Monday to Friday) are available in the surveys and thus included in the analysis. This absence of Saturday and Sunday in the surveys is of course a limit regarding shopping and leisure trips. However, the second set of data do not suffer from this limitation (see below).

Table 1: Characteristics of the eight surveys

	France	Switzerland	Belgium
Title of survey	Enquêtes-Ménages-Déplacements (household travel survey)	Microrecensement 2000 (microcensus)	Belgian mobility survey (MOBEL)
Study year	1997 (Strasbourg) 2001 (Rennes) 2002 (Grenoble) 2006 (Lyon)	2000	1998-1999
Methodology of investigation	Home-based interview	Computer assisted telephone interview (CATI)	Postal survey with additional follow-up telephone contact if necessary
Respondents	All individuals of age over 5 in the household	one individual of the household of age over 6 if the household size is less than four persons, otherwise two individuals are studied	All individuals of age over 6 in the household
Day when trips are conducted	All trips conducted the weekday before the day of interview	All trips conducted the day or two days before the day of survey*	All trips conducted the day before the day of survey*
Period of study	One reference day over several months out of the year (October to May)	One reference day over the entire year	One reference day over several months out of the year (October to May)

Source: Joly et al. (2007); MOBEL (2009); Office fédéral de la statistique (2001)
* only weekdays have been considered for this study

Table 2: Surface, population and sample per city in the eight surveys

City	Surface of survey area (km²)	Number of zones / municipalities	Average zone surface (km²)	Population	Number of individual in analysis
Grenoble	310	36	8.6	386 886	5864
Rennes	609	46	13.2	358 561	8242
Strasbourg	305	32	9.5	449 036	4111
Lyon	490	76	6.4	1 226 052	11703
Brussels	557	33	16.9	1 309 478	1196
Geneva	228	42	5.4	410 261	2071
Bern	422	36	11.7	333 334	1458
Zurich	906	99	9.2	983 937	2215

The travel time of one trip is calculated as the duration between its arrival time at final destination and departure time. Similarly, the activity duration is approximated as the duration between the departure time of next trip and the arrival time of previous trip.

The explanatory variables in travel/activity time budgets analysis include socio-demographic characteristics (gender, age, household type, presence of children and work status). Note that the age variable is reclassified in five segments to include non-linear effects on travel behaviour. Note also that work status doesn't distinguish whether the individual works full time or part time, or works at home for some or all of the time. Unfortunately these potential very important distinctions are not available and this is an obvious limitation. Income is as well not included in this data because of the high level of non-response in the surveys (especially in France) and also because of complications in comparing income data between different countries.

When it comes to spatial characteristics, municipality-based population residential density is used as an indicator of proximity to facilities, such as shops or other urban amenities, and hence of distance needed to reach these amenities. These data are summed up in the first part of Table 3.

Regarding transport supply, the two basic modes have been considered, private car (and of course car ownership by the household) and public transport.

As an indirect indicator of potential speed of driving and access to urban amenities, we use the distance of the individual home to the nearest high speed road infrastructure, here a "divided highway"[1]. As regards the quality of public transport supply it stands basically in the frequency of service, reliability and speed. These three characteristics are generally simultaneously improved with rail modes (tramway or light rail, metro or regional train): moreover the presence of such kind of service discriminates locations inside the urban areas, contrary to bus services which are generally available over the whole area. Thus public transport supply is reflected by the distance to the nearest stop of a rail mode as defined above.

The distances are calculated as Euclidean distance between the centre of the zone[2] where the individual resides and the stations/interchanges of rail/road network. Based on these common definitions these distances have been computed by the different research teams in their countries. Overall the data from different cities have been provided by the different teams and processed centrally by the LET team. A summary of characteristics of transport supply is given in the second part of Table 3.

The second source of data is a seven-day travel diary collected in the city of Ghent in Belgium (Castaigne et al, 2008). The surveyed individuals are randomly drawn from the population in the city of Ghent based on the stratification of household size, gender and age of household head (12 to 75). The survey methodology is based on paper and web survey followed by phone support. The collected information contains continuous trip chain information over a week (trip purposes of twelve categories, approximate address of destination, departure and arrival time of trip, travel cost, used modes and travel time) and its potential influence factors (socio-demographic characteristics and mobility practices). The survey was conducted from September to November 2008 and 717 individual 7-day mobility diaries were collected (starting from any day within a week). Basic socio-demographic characteristics of the sample are shown in Table 4. Note that opposite to previous data income is here available and has been coded into three classes.

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[1] Divided highway is defined as a road or highway in which the two directions of traffic are separated by a central barrier or strip of land without direct access (neither stops, nor traffic lights).

[2] using the finest zoning available: the location of household is only available on a zone basis.

Table 3: Descriptive statistics of individual's characteristics for the eight surveys

Covariates	Definition	Grenoble	Rennes	Strasbourg	Lyon	Brussels	Geneva	Bern	Zurich
Socio-demographic characteristics									
Male	Gender (1 if male, 0 female) (% of 1)	49.3	46.5	47.5	48.7	48.2	45.7	43.4	48.1
Age<15	1 if the age of the individual is under 15 (% of 1)	13.5	15.5	14.8	15.7	13.0	9.1	6.7	9.6
Age15_25	1 if the age of the individual is within $[15, 25)$ (% of 1)	21.2	19.8	17.9	12.8	12.3	9.0	8.1	9.5
Age25_55	1 if the age of the individual is within $[25, 55)$ (% of 1)	45.0	47.6	48.3	45.3	51.3	50.4	46.0	45.3
Age55_65	1 if the age of the individual is within $[55, 65)$ (% of 1)	9.6	8.3	9.4	11.8	9.5	14.7	15.1	15.1
Age≥65	1 if the age of the individual is 65 or over (% of 1)	10.8	9.0	9.7	14.4	13.9	16.8	24.2	20.5
Couple	1 if couple (% of 1)	75.0	75.6	78.6	78.6	23.9	62.9	61.7	64.8
Children_12	1 if children under 12 are present in the household (% of 1)	26.1	36.2	36.2	35.7	33.2	23.1	16.2	20.6
Work_status	Employment status (1 have a job) (% of 1)	43.0	59.8	46.1	46.6	50.1	57.1	56.8	57.1
Spatial and transport availability characteristics									
Dist_interchange	Distance to the nearest interchange of divided highway (km) (mean)	1.6	2.0	2.0	1.9	2.6	2.0	2.0	2.2
Dist_PT	Distance to the nearest station of metro or tramway (km) (mean)	1.6	2.4	1.6	1.5	0.4	1.0	0.4	0.5
Car_ownership	1 if car is available in the household (% of 1)	86.5	90.2	84.8	88.1	83.6	79.9	70.8	76.9
Density	Population density of municipality of residence (persons/km^2) (mean)	1248.0	588.8	1472.2	2502.1	2350.9	1799.4	789.9	1086.0

Table 4: Descriptive statistics of individuals' characteristics for the one-week Ghent survey

Variable	Definition	mean
Gender	Gender (1 if male, 0 female)	0.49
Age < 15	1 if the age of the individual is less than 15 years, 0 otherwise	0.05
Age 15-25	1 if the age of the individual is within $[15, 25)$ years	0.17
Age 25-55	1 if the age of the individual is within $[25, 55)$ years	0.54
Age 55-65	1 if the age of the individual is within $[55, 65)$ years	0.14
Age 65	1 if the age of the individual is over 65 years	0.10
H_type	Household type (1 if couple, 0 if single)	0.79
Hhead_spouse	1 if the individual is the head or spouse of the household	0.71
Work_status	1 if the individual has a job (fulltime/part-time)	0.55
Children_12	1 if presence of children of under 12 years in the household	0.26
D_license	1 if the individual holds a driving license	0.80
Hhincom_low	1 if the net household income is less than 2000 euro per month	0.16
Hhincom_median	1 if the net household income is between 2000 and 4000 euro per month	0.35
Hhincom_high	1 if the net household income is more than 4000 euro per month	0.11

3 The model

The main objective of this study is to assess the effects of explanatory variables on the duration of trips and activities across these European cities. Our application questions the determinants of individual's daily travel time budget and trip duration to various activities. To this end, we consider the methods deriving from survival analysis, which in general aims to investigate failure time distributions and assess the effects of influence factors.

In order to examine the relative effects of these covariates on time allocation, the Cox proportional hazard model (called Cox PH model hereafter) is applied. The advantage of the Cox PH model is that it needs not to specify the baseline hazard function and can incorporate the covariates of interest. We present here a short introduction of applied methods for this purpose. Detailed descriptions of applied methods and related applications can be found in Kalbfleisch and Prentice (2002).

Let *T* be a nonnegative continuous random variable representing the failure time of a process or the duration of the process. The survival function $S(t)$ is defined as the complement of the cumulative probability distribution function:

$$S(t) = \int_t^\infty f(u)du \qquad (1)$$

where $f(t)$ is the density function of failure time *T*. We are particularly interested in the estimation of hazard function $\lambda(t)$, defined as:

$$\lambda(t) = \lim_{h \to 0} \frac{P(t \le T < t + h | T \ge t)}{h} \qquad (2)$$

The hazard function represents the instantaneous rate of failure of the process at time *t* given that the process has lasted until time *t*. Based on the above hazard function, the density function can be written as:

$$f(t) = \lambda(t)S(t) \qquad (3)$$

For the above hazard function specification, parametric, non-parametric or semi-parametric methods may be applied. The parametric model specification tries to fit the duration data to some usual parametric probability distribution, such as exponential, Weibull, or gamma distribution. Previous empirical studies have shown that the profile of travel/activity duration hazard is generally irregular and with multiple spikes (Ma et al., 2009). As we are interested in investigating the effects of covariates on duration data, semi-parametric models (also called Cox models) are preferred. Cox PH model is estimated using the partial likelihood framework suggested by Cox (1972), which does not need the specification of the baseline hazard function $\lambda_0(t)$. One avoids then the risk of a misspecified baseline hazard function. The quality of the estimation of the covariates coefficients is considered to be more robust than the fully-parametric approach (Oakes, 1977).

The Cox PH model is specified as:

$$\lambda(t|\mathbf{X}) = \lambda_0(t)exp(\mathbf{X}'\boldsymbol{\beta}) \qquad (4)$$

where $\lambda_0(t)$ denotes the baseline hazard function for failure time *t*, **X** and $\boldsymbol{\beta}$ the column vectors of covariates and regression coefficients, respectively .

The above model specification assumes that the effects of covariates on duration hazard are multiplicative. Hence each individual hazard is proportional with respect to the baseline hazard. Separation of the time effect and the covariate effect leads to the proportional hazard assumption with respect to each covariate by keeping the values of other covariates constant. The relative risk between individual *i* and *j* is the ratio of hazards:

$$\frac{\lambda_i(t)}{\lambda_j(t)} = \frac{\lambda_0(t)\cdot\exp\{X_i\beta\}}{\lambda_0(t)\cdot\exp\{X_j\beta\}} = \exp\{(X_i - X_j)\beta\} \qquad (5)$$

Hence, the hazards of two individuals are proportional with respect to their related covariate values.

However, ignoring the sample selection issue (i.e. engaging or not in an out-of-home activity) will lead to biased parameters (Bhat, 1996). The model needs to take into account whether the event of interest occurs (i.e. "incidence") and given that it occurs its duration (i.e. "latency"). This problem is similar to those dealt with in clinical trials with "mixture cure models". Following Corbière and Joly (2007), let U be the indicator denoting an individual is susceptible ($U = 1$) or non-susceptible ($U = 0$) to engage in the activity and T is a non-negative random variable denoting the failure time, defined only when $U = 1$. The mixture cure model is given by

$$S(t|x,z) = \pi(z)S(t|U=1,x) + 1 - \pi(z) \qquad (6)$$

where $S(t|x,z)$ is the unconditional survival function of T for the entire population, $\pi(z) = P(U=1|z)$ is the probability to engage in the activity given the covariate vector z, $S(t|U=1,x) = P(T > t|U=1,x)$ is the survival function for "engaged" individuals given the covariate vector *x*. π(t) is modelled using a binary logit model.

Simultaneous estimation of the individual probability of engagement in out-of-home activity (with a logit model) and the duration of activity for those engaged (with a Cox PH model) relies on the SAS macro for semiparametric mixture model proposed by Corbière and Joly. The reader is referred to this paper for detailed description of the estimation procedure and the SAS macro, which performs simultaneous maximisation of both the likelihood of the logit model and the Cox's partial-likelihood of the duration PH model, using EM algorithm.

When interpreting the results of Cox PH models, it should be noted that a *positive* regression coefficient means a greater risk of stopping travel/activity, i.e. a *shorter* travel/activity time budget, while a *negative* regression coefficient means a *longer* travel/activity time budget.

4 Results

In this section, we analyse successively the two sources of data, that is to say firstly the comparison of the eight one-day surveys and secondly the one-week survey in Ghent.

4.1 Daily time allocation to travel and main out-of-home activities in the eight surveys

We present here the duration analysis with respect to individual's travel time budget and activity time budgets per day. The travel time budget is defined as the summation of durations of trips conducted in 24 hours. Similarly, the activity time budget is calculated by the summation of durations of activities of the same type conducted during the 24 hours period.

The socio-demographic, spatial and transport availability covariates are included in the duration model (Table 5). City fixed effects are added and specified as dummy variables to investigate their effects on duration data. Moreover, the survey methodology is expected to influence the measurements. Grossly speaking, there is one common methodology in each of the three countries, i.e. common to the four French cities on the one hand, and for the three Swiss cities on the other hand. For Belgium we have only the Brussels city, so this methodology effect is confounded with the city-effect. By analyzing either the French cities or the Swiss cities on a whole we can detect such methodology effect. It should be noted that this includes not only the survey methodology effect but also other effects specific to the country such as those relating to way-of-life, culture and so on.

4.1.1 Daily travel time budget

The Cox PH mixture model estimation results of daily travel time budget are shown in Table 5 (1st column for logit model and 2nd column for Cox PH model).

Engagement in out-of-home activities (i.e. non zero travel time budget) is higher for male, for adults between 15 and 65 when compared with adults over 65 (and lower for youngsters under 15), very high for workers, and lower for those living in couple or when children under 12 are present in the household. Socio-demographic factors have expected effects. Engagement in out-of-home activities is also higher when car is available in the household. Regarding cities, only in Rennes a significant lower propensity to engage in out-of-home activity appears.

Regarding travel time budget socio-demographic factors have also expected effects (see Mokhtarian and Chen (2004) and Joly (2006) for reviews of studies on daily travel time): males have a longer travel time budget compared with females, younger people (under 15) have a shorter travel time budget when compared with adults over 65, while other between 15 and 65 have a longer travel time budget. The presence of children under 12 or living in couple induces a shorter travel time budget.

As for the impact of spatial context and transport mode availability, it is interesting to note that there is no effect of car ownership, density and distance to public transport on travel time budget. Only a greater distance to major highway has a slight effect of increasing travel time budget (the hazard is reduced by less than 2%).

The results of daily activity time budgets model for each of activity purposes are also shown in Table 5. We fit a Cox PH mixture model for each of activity purposes. School activity (and therefore accompanying activity) time budget is excluded from the analysis since the duration of this activity is largely determined by exogenous societal rhythms. The estimation results are discussed below for each of activity purposes.

4.1.2 Daily work/training (out-of-home) time budget

Regarding engagement in work activity, it should be noted that only individuals with full or part-time working status (whether they work at home or not) are included in this model. Thus given the various days of the week when the survey occurs, these people may or may not engage in out-of-home work activity. The probability is higher for males and for individuals between 15 and 65 when compared with those over 65, and lower when being in couple or when young children are present in the household. These socio-demographic effects are as expected, whereas there is neither significant effect of spatial and transport characteristics nor of city.

Table 5: Cox PH mixture models for daily travel and activity time budgets for the eight surveys

	Travel time budget		Work time budget		Shopping / Personal business time budget		Social-Recreation time budget	
Model	Logit	Cox PH	Logit	Cox PH	Logit	Cox PH	Logit	Cox PH
Intercept	4.925***		2.055		8.254***		7.192***	
Socio-demographic characteristics								
Gender	0.239**	-0.105***	1.523***	-0.374***	-0.571***	0.022	0.357	-0.041**
Age<15	-1.027***	0.442***	n.a.	n.a.	-6.513***	0.099**	-2.233*	0.110***
Age15_25	4.580***	-0.319***	2.049***	-0.446***	-4.450***	0.0125	1.157	0.075**
Age25_55	2.344***	-0.283***	6.897***	-0.496***	-2.338***	-0.122***	-0.773	0.091***
Age55_65	1.183***	-0.162***	4.107***	-0.478***	-1.265**	-0.138***	-0.391	0.021
Age≥65	ref.	ref.	ref.	ref.	ref.	ref.	ref.	ref.
Couple	-0.985***	0.039***	-1.556**	0.060***	-0.601***	-0.077***	-1.768***	0.150***
Children_12	-0.688***	0.042***	-1.814***	0.080***	-0.334***	0.063***	-2.385***	0.141***
Work_status	6.425***	0.005	n.a.	n.a.	-0.395***	0.220***	1.150***	0.247***
Spatial and transport availability characteristics								
Car_ownership	1.212***	-0.019	0.409	-0.170***	0.0057	-0.0315	2.134***	0.001
Density	-0.047*	-0.003*	0.077	0.002	-0.020**	0.006*	-0.075*	-0.010
Dist_PT	-0.030	-0.004	0.003	0.025***	-0.089***	0.0072	-0.228***	-0.015**
Dist_interchange	0.084	-0.014***	0.130	-0.0003	-0.006	0.0004	0.456***	0.004
City-specific variables								
Grenoble	0.272	-0.020	4.640	-0.139**	0.180	0.143***	3.595***	0.178***
Rennes	-1.277***	0.143***	-0.541	-0.188***	0.340**	0.179***	1.091*	0.161***
Strasbourg	-0.228	-0.030	3.707	-0.148**	0.366**	0.236***	2.010***	0.109*
Lyon	0.047	-0.08***	3.178	-0.199***	-0.397**	0.096*	1.015*	0.152***
Geneva	0.345	-0.109***	1.496	-0.283***	0.038	0.133***	5.717	0.108*
Bern	-0.064	-0.073*	0.499	-0.453***	0.859***	0.237***	4.992	0.0826
Zurich	0.794	-0.177***	0.911	-0.526***	0.651***	0.230***	6.267	0.109*
Brussels	ref.	ref.	ref.	ref.	ref.	ref.	ref.	ref.
Models fit statistics								
Sample size	36860	30267	15651	11400	36860	12652	36860	12050
Log-likelihood	-15129.10	-280987.44	-8758,36	-94805,26	-21507.19	-106754.36	-22639.84	-100969.37
Total log-likelihood	-296116.54		-103563,62		-128261.55		-123609.21	
Likelihood ratio (df)	6426.98*** (19)		1355,62*** (17)		4608.95*** (19)		1745.04*** (19)	

Remarks: 1) levels of significance are: * 0.1, ** 0.05, *** 0.01; 2) "ref." means reference covariates; 3) all parameter estimates are obtained at 1.0E-5 convergence criterion of log-likelihood value; 4) Sample size: for each of the four models the first number refers to the overall sample size, the second to sample with strictly positive time budget.

When it comes to work daily time budget, here again socio-demographic factors have expected effects: male people have longer work time budget as well as the central age categories (over 15 and under 65). Being in couple or the presence of children under 12 induce shorter work time budget.

Car ownership is associated with longer work daily duration, while it is the opposite for the distance to public transport. Density and distance to major highway have no significant effect.

4.1.3 Daily shopping or personal business time budget

As for engagement in shopping or personal business out-of-home activities, the logit model indicates a lower engagement for males, and youngsters and adults when compared with people over 65, and also a negative effect of being in couple, having young children at home or being a worker. While distance to public transport has also a negative effect as expected, density has too, which is somewhat unexpected.

Regarding shopping and personal business time budget, the results indicate that couples have a slightly higher activity time budget, but the presence of children under 12 has inverse effect. People over 25 and under 65 have longer activity time budget. Also, workers spend less time on shopping or personal business activity, probably due to less available time for their personal use.

Spatial and transport availability characteristics play no significant role for shopping and personal business activity time budget. City-specific effects indicate that in all French and Swiss cities (but at a lesser degree in Lyon) people spend less time on shopping and personal business when compared with Brussels.

4.1.4 Daily social or recreation time budget

Regarding engagement in social and recreation activities, being in couple or having young children at home has a negative effect while being a worker has a positive effect. Car ownership and proximity to the high speed road network has also a positive effect, while it is negative for proximity to public transport. Only in the two cities of Grenoble and Strasbourg is found a significant and positive effect on activity engagement. This can be related with some immeasurable specificities of lifestyle in these two cities.

As for time budget devoted to social or recreation activity men have slightly longer activity time budget, while being in couple and the presence of children of age under 12 have inverse effect. Older people (over 65) have longer activity time budget, and, here again, workers have lower social-recreation time budget probably due to less available personal time.

Regarding spatial and transport availability characteristics, only distance to public transport plays a significant role: it induces slightly more time spent in social and recreation activity. For city-specific effects, in all French and Swiss cities (but with lower significance in this last case) people spend less time on social and recreation activity when compared with Brussels.

4.2 Weekly behaviour in the Ghent survey

The sample includes 717 individuals, of which 51% are female, 79% are living in couple, 71% are head or spouse in the household, 55% are working and 26% have at least a child under 12 years living in the household (see Table 4).

Regarding time budgets, travel time and other activities such as “at home”, work, shopping or personal business, and social or leisure activity are successively analysed with the Cox PH mixture model. School is not considered because of its peculiarity (it is mandatory for youngsters and its duration is given by institutional arrangements). Moreover, for travel and “at home” the logit model is irrelevant since everybody in the sample has a strictly positive time budget for these two activities: everybody spends some time at home and performs at least one out-of-home activity during the week.

Gender is definitely a significant variable, since male individuals have a longer travel time budget, a shorter time spent at home, a longer time at work and a shorter time on shopping or personal business. However, gender is not significant regarding social or leisure activities.

Age is significant for young between 15 and 25 spending less time at home, and for categories between 15 and 65 engaging more than others in work activity and spending more time on it. Also for those engaging in social or leisure activity, those between 25 and 55 show a lower duration of activity.

Household type, i.e. living in couple, induces less engagement in work. The only other activity where it is significant is for engagement in social or leisure activities where those living in couple spend less time than those living single.

Those who are head or spouse in the household, when engaging in shopping or personal business, have longer duration in this kind of activity.

Those having a job ("work status") spend more time travelling during the week and, as expected, less time at home. When they engage in shopping or personal business, they have shorter duration in this kind of activity than non workers.

Unexpectedly the presence of young children ("Children_12") has no significant effect on these various activity durations.

Finally income is significant only at the higher level, entailing a longer time spent on travel during the week and a higher engagement in work activity. However, when engaged in work activity, there is no significant effect of income on the duration of the activity.

Table 6: Cox PH mixture models for weekly travel and activity time budgets for the Ghent survey

Time budget	Travel	Home	Work		Shopping / personal business		Social / leisure	
	Cox	Cox	Logit	Cox	Logit	Cox	Logit	Cox
Intercept			-4.02***		6.399		6.3372	
Gender	-0.203***	0.129*	0.098	-0.406***	-0.926	0.232***	0.577	-0.055
Age < 15	0.295	0.47*	na		-0.453	0.929***	0.076	0.289
Age 15-25	0.035	0.485**	4.017***	-2.365***	0.23	0.327	0.3541	0.046
Age 25-55	0.038	0.107	6.997***	-2.441***	1.196	0.21	-1.2554	0.381**
Age 55-65	0.041	0.083	2.672***	-1.925***	-0.831	-0.033	-2.0649	0.104
Age >65	ref	ref	ref	ref	ref	ref	ref	ref
H_type	0.112	-0.005	-0.81**	0.192	0.997	-0.011	0.445	0.234**
Hhead_spouse	0.014	-0.245*	1.079	0.223	2.159	-0.357**	1.7792	0.184
Work_status	-0.421***	1.494***	na		0.156	0.278***	-0.8376	-0.143
Children_12	-0.022	0.127	0.153	0.166	-1.326	0.003	-0.6857	0.116
D_license	0.019	-0.087	1.711***	-0.037	0.811	0.104	3.1422	0.008
Hhincom_low	ref	ref	ref	ref	ref	ref	ref	ref
Hhincom_median	0.019	-0.095	0.424	-0.041	-2.056	0.047	-1.3194	-0.006
Hhincom_high	-0.274**	-0.038	2.209**	-0.099	-2.528	-0.001	-1.3862	0.015
Sample size	696	696	661	388	696	632	696	653
Log-likelihood	-3837.61	-3708.91	-160.15	-1910.39	- 6.52	-3414.44	-3.44	-3570.17
Total log-likelihood			-2070.54		-3420.96		-3573.61	
Likelihood ratio test	<0.0001	<0.0001	<0.0001		<0.0001		<0.0001	

* 0.1; ** 0.05; *** 0.01
(1) "ref" means reference covariate.
(2) all parameter estimates are obtained at 1.0E_5 convergence criterion of log-likelihood value.
(3) sample size: for each of the four models the first number refers to the overall sample size, the second to sample with strictly positive time budget.

5 Discussion and conclusion

When comparing the eight cities, the impact of spatial context and transport supply on daily travel time budget is limited: car ownership is linked to a higher probability to travel and travel time budget is slightly positively influenced by the distance to a high-speed road network. Regarding work time budget the main effect of transport is channelled through car ownership. The most prominent role in time allocation is played by socio-demographic factors whether for travel or various out-of-home activities. In parallel, city (or country) specific effects play a noticeable role in activity time budgets, especially for work and shopping or personal business activity, and to a lesser extent for travel time budget. This may reflect spatial characteristics not yet considered in the data or cultural and lifestyle differences specific to each city.

These results are somewhat in line with previous work on this topic (Timmermans et al, 2002). Given our efforts to check and harmonize these sources and build a common methodology, jointly with an individual-based analysis, our conclusions strengthen the case: they confirm the minor impact of spatial context and transport supply on travel and activity time allocation, when compared with socio-demographic and city (and sometimes country or cultural area) specific characteristics.

Regarding the one-week activity-travel diary in Ghent, the picture is the one of relative specialisation as shown by the influence of gender on longer time spent on travel and at work, contrasting with shorter time spent at home or on shopping. However, having a job also induces the same kind of behaviour, adding to the gender effect. A sign of this specialisation is also given by the fact that living in couple involves less work engagement. The activity of the household as a “producer”, with its time inputs, is also shown by the positive link between income and work engagement.

One noticeable difference between the two sources of data is that the presence of young children does not influence significantly time allocation in the second source. One possible explanation would be that the care of young children is discriminating the behaviours of adults on one given weekday (Monday to Friday), while this would not be the case when considering the whole weekly time budget.

Overall the convergence of results regarding the effects of gender and marital status on time allocation is somewhat striking. This is the case in all urban areas surveyed, despite restricted to the European cultural area, considering whether isolated weekdays or a whole week.

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Reference

Becker, G.S. (1965) A Theory of the Allocation of Time. *The Economic Journal*, vol. 75, No 299 (Sep. 1965), pp. 493-517.

Becker, G.S. (1991) *A Treatise on the Family*. Harvard University Press.

Bhat, C. (1996) A generalized multiple durations proportional hazard model with an application to activity behavior during the evening work-to-home commute. *Transportation Research B* 30(6), 465-480

Castaigne, M., Cornelis, E., Toint, P., Descamps, J., Pauly, X, Walle, F. (2008). Activity report intended for the intermediate evaluation – Document G – Contract number SD/TM/03A BMW (Behaviour and mobility within the week).

Corbière, F., Joly, P. (2007) A SAS macro for parametric and semiparametric mixture cure models. *Computer Methods and Programs in Biomedicine* 85, 173-180.

Cox, D.R. (1972) Regression Models and Life Tables. *Journal of the Royal Statistical Society B*, 34,187-200.

Ettema, D., van der Lippe, T., 2009. Weekly rhythms in task and time allocation of households. Transportation (2009) 36:113-129.

Eurostat (2003) *Time use at different stages of life - Results from 13 European countries*, Rapport de recherche, Publication Officielle de la Communauté Europeenne, Luxembourg, 77 p.

Joly, I. (2006) Stability of regularity of the daily travel time in Lyon? Application of a duration model. *International Journal of Transport Economics*, XXXIII, vol. 3, 369-400.

Joly, I., Kaufmann, V, Littlejohn, K. (2007) *La croissance des budgets-temps de transport en question: nouvelles approches*. Rapport final de recherche, Programme Français de Recherche et d'Innovation dans les Transports Terrestres (PREDIT), Groupe Opérationnel n°1, « Mobilité, territoires et développement durable » (2005-2006).

Kalbfleisch, J.D., Prentice, R.L. (2002) *The Statistical Analysis of Failure Time Data*. New York: John Wiley & Sons. Inc. 2nd Edition.

Kitamura, R., Robinson, J., Golob, T.F., Bradley, M., Leonard, J., van der Hoorn, T. (1992) *A comparative analysis of time use data in the Netherlands and California*. Report UCD-ITS-RR-92-9, Institute of Transportation Studies, University of California

Levinson, D.M. (1999) Space, money, life-stage, and the allocation of time. *Transportation* 26(2), 141-171.

Ma, T.Y., Raux, C., Cornelis, E., Joly, I. (2009) Multi-state non-homogeneous semi-markov model of daily activity type, timing and duration sequence. *Transportation Research Record*, no. 2134, 123-134.

MOBEL, Belgian Mobility Survey Web Site. http://www.mobel.be/ (30 Dec. 09)

Mokhtarian P.L., Chen, C. (2004) TTB or not TTB, that is the question: A review and analysis of the empirical literature on travel time (and money) budgets. *Transportation Research Part A*, 38, 643-675.

Oakes, D. (1977) The asymptotic information in censored survival data. *Biometrika* 64, 441-448.

Office fédéral de la statistique (2001) *La mobilité en Suisse, Résultats du micro-recensement 2000 sur le comportement de la population en matière de transports.* Berne et Neuchâtel.

Pas, E.I., Koppelman, F.S. (1986). An examination of the determinants of day-to-day variability in individuals' urban travel behavior. Transportation 13, 183–200.

Timmermans H., van der Waerden P., Alves M., Polak J., Ellis S., Harvey A.S., Kurose S., Zandee R. (2002) Time allocation in urban and transport settings: an international, inter-urban perspective. *Transport Policy*, 9(2),79-93.

Timmermans H., van der Waerden P., Alves M., Polak J., Ellis S., Harvey A.S., Kurose S., Zandee R. (2003) Spatial context and the complexity of daily travel patterns: an international comparison. *Journal of Transport Geography*, 11, 37-46.

Appendixes

Appendix A. Classification of initial trip purposes for the eight cities

	Grenoble, Rennes, Strasbourg, Lyon	Brussels	Geneva, Bern, Zurich
Work	usual work non usual work	work, visit for work	work, training,
School	nursery school, primary school, second school, university	school	school
Shopping/personal business	daily/weekly purchase, looking for a job, administration, health, purchase of equipment, clothing or leisure	daily/weekly purchase, shopping, personal business	daily purchase, shopping, personal business, service
Social-recreation	walk, sports, culture and associative activities, out-of-home eating, visit to the family or to friends	walk, sports, culture and leisure activities, out-of-home eating, visit to the family or to friends	leisure
Accompany	accompany	deposit or seek someone	accompany