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by

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ABSTRACT

An application of activity-based approach to urban travel demand is presented. A day-schedule framework is developed both for workers and non-workers and their travel behaviour is extensively compared. The methodology is applied to two European data sets: the Belgium National Travel Survey and the travel diary survey conducted in two cities of Germany: Halle/Saale and Karlsruhe. A detailed empirical analysis gives insights about the transferability of complex activity based models from a country to another. In the paper both spatial and temporal aspects of mobility are presented: number of tour per day, number of stops per tour, tour and stop activities, interaction between stop making, mode choice, in network time of day for different patterns, distance from stop to stop and activity duration.
Two mode choice models for the main activity are estimated both for workers and non-workers. Given the fact that the German survey is a multi-day travel diary a mixed logit formulation has been applied, which allows efficient estimation when there are repeated choices by the same individual. Results show that coefficients in logit with repeated observations are very similar to those estimated in standard logit model, but standard error is much smaller for workers and slightly smaller for non-workers. This observation confirms the fact that workers' behaviour is homogeneous across weekdays and that non-workers travel behaviour vary a lot across different days. The estimated standard deviations of time are highly significant both for workers and non-workers, indicating that time do indeed vary in the population.
These results are encouraging us to pursue the transferability of activity based model to national travel survey data and to apply mixed logit formulation to model most of the components of the activity-travel framework.

Keywords: transferability of activity-based approach, mixed logit, repeated observations.

1. Introduction

Activity-based analyses attempt to obtain a better understanding of the behavioural basis for individual, decisions regarding the use of time and resources, and for participations in activities in certain places at given times. They aim to recognize the complex interactions between activities and travel behaviour, leading to a more realistic representation of travel demand. Travel behaviour is becoming more and more complex; individuals manage to accomplish to all their needs by chaining work, leisure and maintenance activities constrained by time, space and budget resources. Interaction across household components and differences across days of week for the same individual cannot longer be modelled by the classic four-stage method. Our knowledge in terms of analytical methods and our informatics tools can now support this complex way to study travel behaviour: the activity-based models.
This paper contains several types of results. We first present a descriptive activity-based analysis of the Belgium Travel Survey data collected in 1999 and of German data collected in two urban areas: Halle/Saale and Karlsruhe in autumn 1999. For this purpose we first provide a methodological overview of our approach (Section 2). We then develop a general framework for workers (Section 2.1) and non-workers (Section 2.2), which aims to represent the daily activities performed by the individuals. We then compare the travel behaviour in Belgium and in Germany (Section 3) to examine to what extent the developed framework can be validated and transferred from a country to another (Section 4). We finally estimate a mode-choice model for workers and non-workers using mixed logit formulation and in particular we analyse the individual behaviour across different days of the week (Section 5).

2. The structure of an activity-based approach

2.1. The activity framework

An activity program is defined in this conceptual framework as an agenda of activities (that have been decided upon and will be participated in over a particular time period) along with their attributes (frequency, duration, location of activity performance, mode of transportation to this location and time-window for participation). This broad view of an activity program is adopted because the attributes mentioned above are intricately linked, and it is therefore not advisable to study any one element (or group of elements) in isolation from the others. Its practical representation allows the specification of simultaneous decision-making, in which there is a strong relationship between travel pattern and activity participation.
We first develop a comprehensive representation of daily activities and patterns for individuals, both for workers (that is individuals reporting a work activity on the survey day) and non-workers (the others). The main difference between these two categories is that the main activity is identified as work for the first, while we identify the main activity on the basis of its duration for the second. All daily schedules are subsequently represented in relation with this main activity. The travel pattern is then subdivided in tours; a tour being a

circuit that begins at home and ends at home, or begins at work and ends at work. This representation thus rests on the fixity of the home and of the work activity locations. Within a tour, the individual can stop one or more times to perform additional secondary activities. These activities are defined, in home or outside, by their duration, location and purpose.

2.2. The activity schedule for workers

Let us first consider the workers that is individual who commute, in the sense that they go to and return from work. The morning and the evening legs of this commuting pattern are grouped into a single work commute pattern, since the travel mode for both these legs will often be the same; they are referred to as the morning commute and evening commute. All activities that take place before the morning commute will be referred to as morning activities, and the associated displacements grouped into one or more morning tours. Similarly, all activities taking place after the return from work to home (the evening commute) will be referred to as evening activities and the associated displacements grouped into one or more evening tours. Additionally, all activities taking place outside the work location will be called midday activities and the associated displacements, whose origin and destination are at work, are grouped into one or more midday tours.
Within each of the morning, midday and evening tours there might be several activity stops. A main activity is additionally identified (as that of maximum duration) for the morning, midday and evening patterns, other activities being accounted as stops.
We define four different (sub-)patterns in the representation of daily activities for workers:

1. The **morning pattern** represents the activities and travel undertaken before leaving home to work in the morning.
2. The **(work) commuting pattern** represents the activities and travel performed during the morning and evening legs of the commuting pattern.
3. The **midday pattern** includes all activities and travel undertaken from work, typically during the midday break.
4. Finally the **evening pattern** comprises the activities and travel of individuals after their return home from work.

We consider household and individual socio-demographics as exogenous determinants of activities and travel pattern during the day. Conditional on socio-demographics; individuals make medium-term decisions (in combination with other individuals in their household) regarding their employment (whether to be employed, hours of work, start time at work in the morning and end time of work in the evening, location of work, place, etc), residence (type of residence, location) and car ownership.

2.3. The activity schedule for non-workers

In the activity-based research literature, the examination and analysis of workers activity travel patterns has been extensive (*18*) and (*8*). The primary motivation for the focus on worker activity choices is the significant effect of commuting pattern on peak traffic congestion especially in the morning and pollutant emissions. In contrast, the activity travel

behaviour of non-workers has been comparatively little studied. However it clearly provides important input for transportation planning as will be confirmed by our analysis. A large proportion of non-workers include children or retired individuals who may have special mobility and accessibility problems. Another important non-working group comprises people whose main activity is at home, while exhibiting high levels of mobility. They have rather flexible schedule due to the absence of time constraints (unlike commuting trips for workers). Moreover the underlying factors influencing the travel-related decisions of non-workers are likely to be quite different from those of workers.

For non-workers, we replace the concept of work by that of principal activity of the day, which is the activity of maximal duration during the day. The remaining activities and displacements can then be organized in relation to this main activity in a manner similar to that used for organizing workers' days around their work activities.

We distinguish three different (sub)-patterns in the representation of daily activities for non-workers:

1. The **morning pattern** represents the activities and travel undertaken before leaving home to perform the main activity of the day;
2. The **principal activity pattern** represents the activities and travel performed within the tour comprising the principal activity of the day. This principal activity pattern is itself decomposed in a principal activity access pattern (the activities and displacements within the principal activity tour but before the principal activity itself), the principal activity proper, and the principal egress pattern (the activities and displacements within the principal activity tour but after the principal activity itself).
3. The (afternoon and) **evening pattern** comprises the activities and travel of individuals after their return home from their principal activity.

Note that the morning and evening patterns of non-workers contain a main activity (not to be confused with the principal activity, which can be viewed as the main activity of the tour containing the principal activity).

The complete daily activity pattern is characterized by a number of different attributes for each component of the representation adopted. These attributes may be classified according to their associated level of representation, that is, whether they are associated with a pattern, a tour, or a stop

Pattern level attributes include the number of tours within the pattern and the home stay duration that precedes it. Tour level attributes include travel mode, number of stops, home stay duration before the tour, work stay duration for work pattern, and sequence of tours in the pattern. Stop level attributes include activity type, travel time to stop from previous stop, location of stop, activity duration, and sequence of stop in the tour.

3. The survey

3.1. The Belgian National Travel Survey: MOBEL

The Belgium National Mobility Survey took place in 1999 and 2000. It aimed at understand the mobility patterns of Belgian households during a complete year. Data on socio-

demographic characteristics of the household and each individual in the household was collected, as well as a one-day travel diary to be filled out by all members of the household of 5 years of age and more. Each trip undertaken by an individual on a reference day is described by: its start time, end time, destination, activity purpose, travel mode, distance and travel time. The data collected can be grouped into three broad categories.

1. The background information on the household (the household file) comprising a description of the household's structure (relationships of the household members to each other); data on household location (placement of the household home versus the transport system); data on household history (duration of residence at the same address, same city), data on the household resources and their use (income, car, bicycle, motorcycle, …).
2. The background information on personal resources (the person file) containing information on each person (year of birth, gender, education level, job description (type, number of working hours), capabilities and driving licences.
3. Each trip performed during the reference day is also described, including details of the associated activity (the trip file).

The survey also contains a detailed description of the households' vehicles, which will not be used in our analysis.

This survey contains enough data to allow us to apply our framework for modelling of activity scheduling. The record of the activities was reconstructed from the trip data and includes for each activity, its nature (or purpose), duration, start time, end time, location, distance, and travel mode. In order to study entire "sequences" of activities and travel, the data set was subjected to a series of cleaning and screening procedures. We selected only those individuals who reported activities outside of their home and the associated trips. The original data sets contained information on 7037 individuals of which 5351 (76.04%) were kept in a first analysis. In order to compare travel behaviour in urban areas we excluded data from rural regions; at the end the analysis was based on 3900 individuals (1657 workers and 2243 non-workers).

3.2. Two urban surveys in Germany: *Mobidrive*

The survey is a continuous six-week travel diary data set of long-term individual travel behaviour, which is part of the German research project *Mobidrive*. The survey was conducted in the cities of Halle/Saale and Karlsruhe in autumn 1999. A total of 317 persons over 6 years in 139 households participated in the main phase of the survey, after testing the survey instruments in a pilot with a smaller sample in spring 1999 (44 persons). The paper-based travel diary instrument was supplemented by further survey elements covering the socio-economic characteristics of the households and their members, the details of the households' car fleet and transit season tickets owned and personal values as well as attitudes towards the different modes of transport. (*26*)

The details of the number of households, of persons surveyed, and of reported trips are in Table 1.

The German survey design is quite different from the Belgian case because of its multi-day structure. It contains nevertheless, all the data necessary to construct the activity chains (for more details on framework and definitions see (*13*) for both workers and non-workers. The main hypothesis in our analysis is that each day observation is independent from the others and can be taken into account as a single record for our schema. In synthesis, for the German case, we have got a greater number of reported trips and a smaller number of household and individual characteristics than in Belgium. The common element into two surveys is that information has been collected both on weekdays and on weekends.

4. Framework analysis

4.1. Tour analysis

The number of daily tours is reported in Table 2 for workers and in Table 3 for non-workers. We observe that the average number of tours along the day is higher in Germany than in Belgium especially for workers (1.73 against 1.53), the difference is smaller for non-workers (1.65 against 1.54). Although the mobility of workers is larger in Germany, the non-workers contribution is not negligible.
In the morning the average number of tour is exactly the same for workers and a bit higher for non-workers (see Table 4 and Table 5). German workers tend to go out for lunch even less than Belgians, the percentages are much more comparable within Europe (less than 10 % in both European cases), than across European and American data (between 65.0 % and 74.0 %). In the evening both workers and non-workers are much more mobile in Germany. Also in this case we can assume that there are not more than two tours in each pattern, which again is consistent to what Bhat found in the American cases analysed in his research (*8*).
Before looking at tour purposes we note that the German survey didn't present exactly the same number and labels of activity purposes. For example the purpose "eat out", which was found very important in the Belgian case for midday pattern (25 %) is lacking. Also, since the two purposes "family related" and "recreational" are not explicitly mentioned, we have added the first to the personal business category and the second to the group "Leisure/sports/culture". The main difference we note in comparing the percentages in Table 6 and in Table 7 is that in Germany picking up/dropping off someone is much less frequent than in Belgium; the negative trend is found across the different periods of day and both for workers and non-workers. The main reasons to start a tour are leisure/sport/culture activities, for which we have twice the percentages in Germany compared to Belgium. Shopping seems more important for workers, while for non-workers shopping rates are not very different across the German and Belgian cases. Personal business and family related account for the same percentages in the morning in the two countries, but are much more relevant in Belgium in the evening.

4.2. Stop analysis

This section analyses the number of stops and their purposes, which occur in each pattern for both workers and non-workers in Belgium and in Germany. In comparing black and blue values in Table 8 and in Table 9, we note that German workers stop less during the morning commute, a similar trend is found during the evening commute and in the evening pattern. Looking at purposes of stopping during the two commute-legs we found that German stop much less for picking-up/dropping off than Belgians; shopping is again much more relevant for Germans especially in the morning (32 % against 18 %), as well as personal business and leisure activities.
For non-workers (Table 10) we found that the percentage of German non-stopping or stopping at least once is less during the principal activity pattern and that they stop at least once more often than Belgians in the morning and evening pattern. The main reasons (Table 11) why non-workers seem to stop during the principal pattern seems to be related to personal business or leisure and other recreational activities.

4.3. Interaction in stop making across different times of day

We now consider the possible substitution between stops across different times of day and different activities. To do so it is necessary to analyse the interaction between the stops occurrence, timing and purpose.
Table 12 shows, for workers in Belgium and in Germany, the relation between the occurrence of stops across the different patterns of the day. The results show that there is little interaction between stops made in the midday pattern and during the evening commute (as the relative percentage of workers making a stop during one of these periods is relatively independent of the occurrence of a stop in the other period. However, there is a positive interaction (significant in Belgium) between the evening commute and the evening patterns, as workers who stop in one of these periods are more likely to stop in the other. These observations seem to indicate that the substitution effects between stops across different times of day are very small.
The behaviour of non-workers is more flexible, as it is shown by Table 13. The amount of possible substitution between the morning and the evening patterns seems to remain small in Belgium but significant in Germany. It appears that there is more room for substitution between stops occurring during the principal activity pattern and the evening one in Belgium than in Germany. Shopping is the main reason to stop during the morning and the evening patterns, which, combined with the observation that shopping is also the most frequent principal activity, makes this purpose central in the day of non-workers.

4.4. Mode choice

So far the activity pattern analysis seems to give similar results for the German and Belgian cases, the latest were already consistent with what found by Bhat (Bhat and Singh, 2000) in two American cases. This seems to confirm that the activity based approach and the framework proposed is transferable quite easily from a country to another on the regards of pattern, tour and stop elements of the activity travel behaviour. Table 14 and Table 15 show

the modal split for both countries during the different periods of day for workers and non-workers. Here the behaviour is very different between the two countries. We find a smaller use of car (both as driver and passenger) in Germany. About 30% of workers used car as driver against the 45% of the same category found in Belgium during the commute pattern and in the evening pattern. Non-workers show a similar behaviour for all three periods of day (above 30% in Germany against 46% in Belgium). German use more the Public transport services to commute 27.5% (against Belgian public transport users, who are only 13%). Walk (15.6 in Germany against 7.8 in Belgium) and bike (18.7 in Germany against 8.4 in Belgium) are also more used in Germany.
We also found a clear positive interaction between the use of cars and the number of stops for the commute tour for workers and the principal tour for non-workers. It is difficult to explain this difference just looking at data and statistical results. An explanation could be found looking at the location of housing, working places or shopping and leisure activities; the quality of the public transport service can also play an important role in mode choice.

4.5. In-network time of day

We are also interested in trying to understand the transportation network load as a function of the activity patterns for workers and non-workers. In order to provide a measure of this load, we consider in this paragraph the in-network time which we define as the time of day at which each respondent is in the middle of the first part of its travel within the morning, work (or principal), midday (if applicable) and evening patterns. This definition is justified by the relatively high number of patterns, which contains only one stop.
Figures 1, 2, 3 and 4 report in-network time of day in function of the number of daily tours for the morning and evening commute in both countries and Figures 5 and 6 provide the same information for the principal patter for non-workers.
Workers commute in the morning at the expected peak hours, from 7:00 to 9:00, and come back home from work without any evident peak from 15:00 to 19:00. Evening patterns typically start around 17:00 and end late at night.
It seems that there is no particular relationship between number of tours and in-network time. This analysis confirms the intuition that workers are constrained by the time of their arrival at work, while the organisation of the day for non-workers is less constrained, allowing for later departure.

4.6. Distance and duration activity

When we presented the first results of our Belgian analysis to public authorities, one of their questions was: where are the stops located? Are they close to home zone or are they closer to the work location?
The answer to this question is on the tables 16 for workers and 17 for non-workers. It appears that commuters stop closer to home especially in the evening and that for other purpose patterns they stop closer to the activity locations. A similar trend is found for non-workers, distances covered by non-workers are similar or larger than those found for workers. The

main difference with German data is that distances from home to work or activity locations are smaller.
Concerning activity durations, we note that they are very close within the two sets of urban data, and that in general morning activities take less time than evening activities.

5. Mode choice: A mixed-logit application

5.1. Model specification

Mixed logit models are a generalisation of standard logit that do not exhibit "independence from irrelevant alternatives" property and explicitly account for correlations in unobserved utility over repeated choices by each costumer (*25*). Mixed logit also allows efficient estimation when there are repeated choices by the same individual, as occurs in Mobidrive survey.
Each individual faces a choice among the alternatives in set J. The number of choice situations can vary over people, and the choice set can vary over people and choice situations. The utility of an alternative is specified as:

$$U_{njt} = \beta_n^{'} x_{njt} + \varepsilon_{njt} \qquad (1)$$

where x_{njt} is a vector of observed variables (which vary over alternatives and individuals), β_n is a vector of unobserved coefficients and varies in the population with density $f\left(\beta_n \mid \theta^*\right)$ (representing the individual's tastes) where θ^* are the (true) parameters of this distribution, and ε_{njt} is an unobserved random term that is distributed IID extreme value independent β_n and x_{njt}. The probability that person *n* chooses alternative *i* in period *t* is standard logit:

$$L_{nit}(\beta) = \frac{e^{\beta_n^{'} x_{nit}}}{\sum_j e^{\beta_n^{'} x_{nit}}} \qquad (2)$$

The unconditional probability is the integral of the conditional probability over all possible values of β_n, which depends on the parameters of the distribution of β_n:

$$Q_{nit}(\theta^*) = \int L_{nit}(\beta_n) f(\beta_n \mid \theta^*)\, d\beta_n \qquad (3)$$

For maximum likelihood estimation we need the probability of each sampled person's sequence of observed choices. Let i(n,t) denote the alternative that person n chose in period t; the probability of person n's observed sequence of choices is the product of standard logits:

$$S_n(\beta_n) = \prod_t L_{ni(n,t)t}(\beta_n) \quad (4)$$

The unconditional probability for the sequence of choices is :

$$P_n(\theta^*) = \int S_n(\beta_n) f(\beta_n \mid \theta^*) d\beta_n \quad (5)$$

The coefficient vector β_n is the parameters associated with person n, representing that person's tastes. These tastes vary over people; the density of this distribution has parameters θ^* representing, for example, the mean and the covariance of β_n. The goal is to estimate θ^* that is the population parameters that describe the distribution of individual parameters.

5.2. Model estimation

Using data from the city of Karlsruhe (Germany), we estimate the evening-commute mode choice model (Table 18) and the principal pattern mode choice model for non-workers (Table 19). The number of workers' observations is 1554 and the average number of observations for each of them is 16.8; non-workers are 1734 units and gave in average 12.3 responses. The respondents face a choice among 5 alternatives: car driver, car passenger, public transport, walk and bike.
We first specify all coefficients to be fixed (logit model on the first column of results), then we estimate a similar model taking into account the correlation across the observations (logit on panel data in the second column). We finally allow some of the coefficients to be independently normally distributed (mixed logit).

In the evening-commute choice model the alternative specific constants are estimated taking as base the alternative car driver, all four coefficients are positive except car passenger which is negative but not significant. The alternative specific constants for public transport, walk and bike are positive and significant, but their values are not very different from each other.
Looking at coefficients' estimation we observe that time is highly significant for workers even in the model with repeated observations. Household variables are positive and significant in the logit model, Income and number of working people in the household become not significant in the other two models; the number of cars and the number of working people stay significant in the mixed logit model with repeated observations.
Working schedule variables (arrival at work before 9:00 and departure from work between 16:00 and 17:00) are negative for the utility of the alternatives car driver and car passenger, again the significance of the variables drops from the logit model to the logit model on panel data.
The coefficients in logit with repeated observations are very similar to those estimated in standard logit model, but standard deviation is much smaller (about 1/4). In the mixed logit the mean coefficients are consistently larger than the fixed coefficients. This result reflects the fact that the mixed logit decomposes the unobserved portion of utility and normalises parameters on the basis of part of the unobserved portion. The parameters rise by a factor of

two in the workers model, which implies that the random parameters constitute a large share of the variance in unobserved utility.
In the mixed logit the estimated standard deviations of time are highly significant, indicating that time do indeed vary in the population. Also the likelihood ratio test index rise (although there is one more degree of freedom) from allowing parameters to vary, indicating that the explanatory power of the mixed logit is considerably greater than with standard logit.

For principal pattern mode choice model we kept a similar structure. Alternative specific constants are all negative except walk; public transport is the most negative. This result confirms what found in empirical analysis on four European data sets, non-workers tend to use more the private vehicle that workers. Time is much less significant and scheduling variables were not significant. They have been replaced by some individual variables: age and number of stops in the principal activity pattern. Older people tend to use public transport and the fact to stop on the way of the principal activity is positive for the utility of car driver. Households' variables are significant in all three models. The number of cars in the household increases the probability of travelling by car (as driver or passenger) as well as the number of household members.
For non-workers the standard deviation of the logit model on panel data is half of the standard deviation of the simple logit model. This result compared with what found for workers, confirms the fact that workers' behaviour is homogeneous across weekdays and that non-workers travel behaviour vary a lot across different days.
Cost coefficient hasn't been estimated because at the time I estimated the models this information was not available; it implies that I couldn't estimate the VOT (Value of Time) and see the difference between the three model formulations.
From a practical point of view the application of mixed-logit structure to activity-based models increases the number of alternative structures and utility function specification. Here mixed-logit models are used to take into account repeated observations and to have a better estimation of time over the population. This represents the minimally complex model to capture and represent travel behaviour. More practice in this kind of application will help to develop rules to guide the search among complex alternative structures in order and to save computational time to obtain the "best" model.

6. Conclusions

I have applied the activity pattern analysis of Bhat et al. (2000) to the framework of the working population within the Belgian national travel survey (urban regions only) and the Mobidrive data from two cities in Germany, and found that the overall activity patterns are very coherent between the American, Belgian and German cases. On the regards of pattern alternative structure the only significant difference is that European workers seem to travel less during their midday break. This break is essentially devoted to eating and there is, in Belgium, less shopping or leisure activity associated than in the USA. The main differences between the two data sets are in mode sharing and distances from home to activity locations. Here it is clear that land use policy and transport network play an important role; unfortunately we haven't the elements to investigate those aspects of travel behaviour.

Furthermore, I have extended this type of analysis to cover the case of non-workers. This extension is based on the definition of a principal activity of the day, around which the remaining activities and displacements of non-workers are organised. This analysis reveals, in particular, the central role of shopping and the limited use of public transport for this category of the population.
As a final observation, I have shown that, for both workers and non-workers a positive interaction exists between the occurrence of various stops during the day, which might indicate that the amount of substitution possible between these stops is limited.
Since our experience of applying/extending this analysis to the European population appears to be successful, I'm currently pursuing this line of work for other European countries: UK and France using their national travel surveys. Comparisons between them and the USA will the subject of a forthcoming paper.

I have also applied the mixed logit formulation to estimate the mode choice model for the evening commute and principal activity pattern for non-workers. This flexible tool allowed me to measure the differences between workers and non-workers. The significant correlation across different days of week reveals how important is to collect multy-day surveys to study travel behaviour.

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LIST OF FIGURES

In network time of day workers

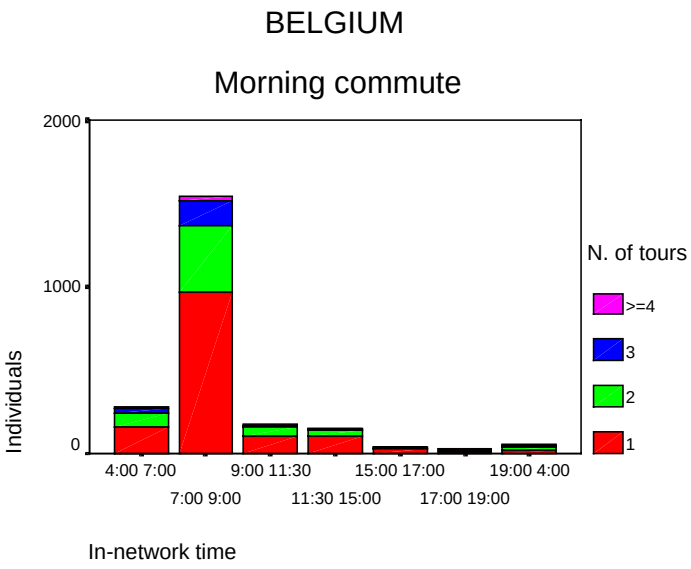

FIGURE 1

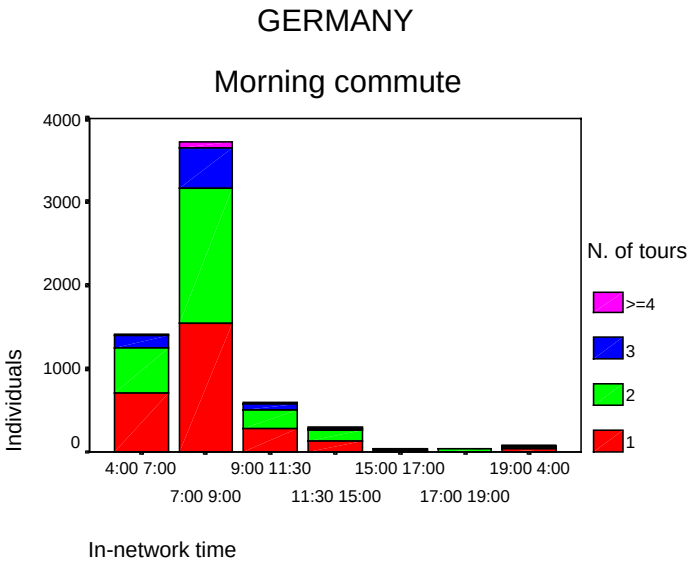

FIGURE 2

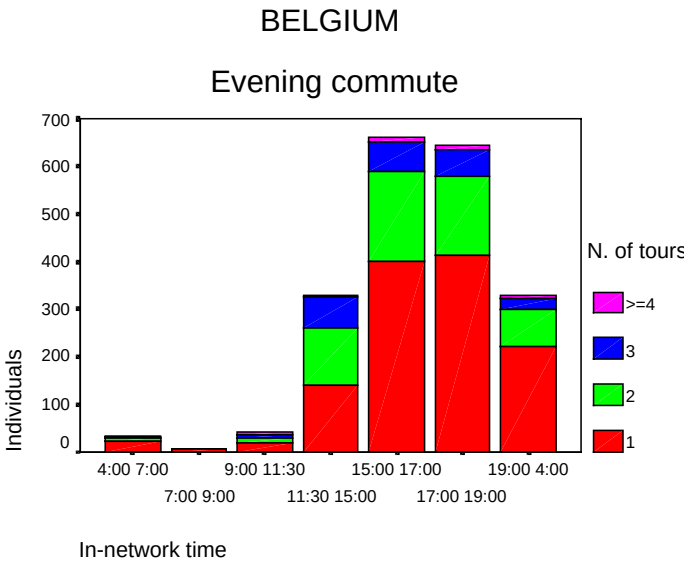

FIGURE 3

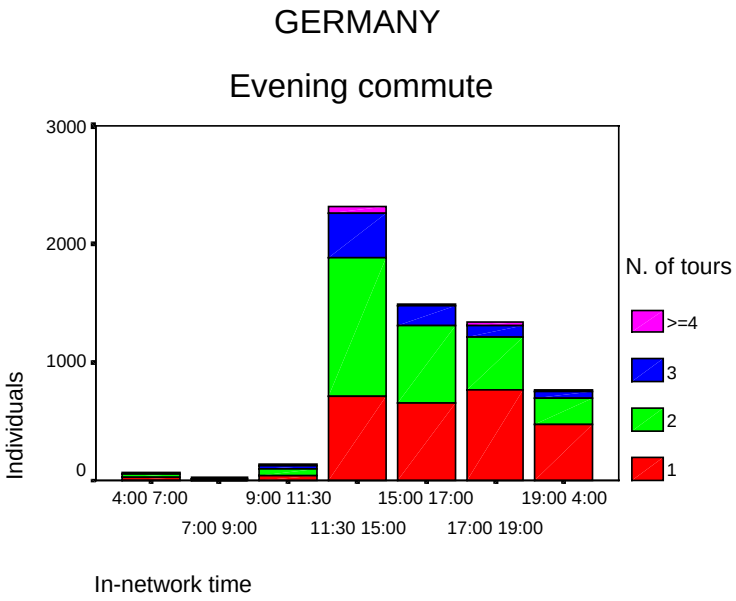

FIGURE 4

In network time of day
non-workers

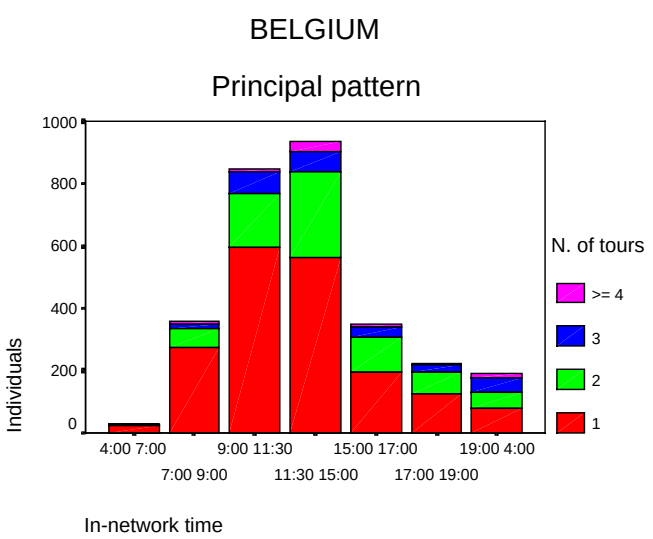

FIGURE 5

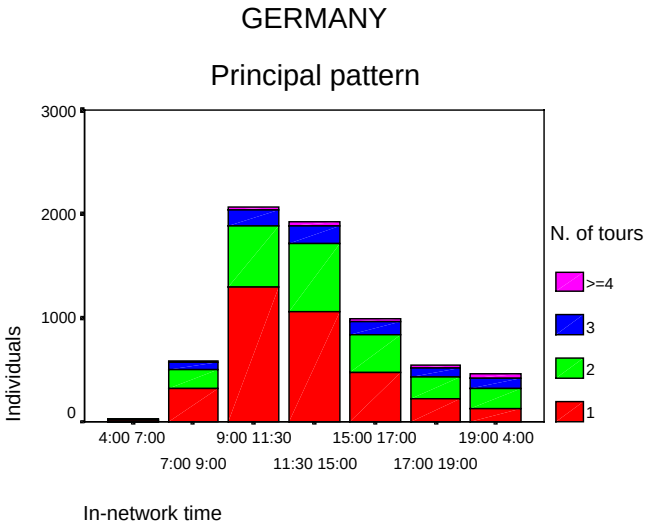

FIGURE 6

LIST OF TABLES

TABLE 1 Number of households, persons and trips in the German survey

City	Households	Persons	Trips
Karlshruhe	94	202	31.281
Halle/Saale	68	159	20.992
Total (German case)	162	361	52.273

TABLE 2 Number of Tours for workers

	Morning pattern	Midday pattern	Evening pattern	For the day
Mean	0.043	0.096	0.25	1.39
	0.037	0.058	0.43	1.52
Sum	71	159	429	3517
	239	371	2717	10986

TABLE 3 Number of Tours for non-workers

	Morning pattern	Evening pattern	For the day
Mean	0.31	0.18	1.49
	0.35	0.26	1.61
Sum	707	399	3462
	2346	1739	10987

TABLE 4 Distribution of Number of Tours for workers

No of Tours	Percentage of each number of tours in:							
	Morning Pattern		Midday Pattern		Evening pattern		For the day	
	BELGIUM	GERMANY	BELGIUM	GERMANY	BELGIUM	GERMANY	BELGIUM	GERMANY
0	96.2	96.6	91.0	94.6	78.8	66.1	-	-
1	3.4	3.1	8.3	4.9	17.1	26.1	61.3	44.3
2	0.3	0.3	0.6	0.4	3.5	6.9	27.1	41.2
>=3	0.1	0.0	0.0	0.0	0.6	0.9	12.6	14.5

TABLE 5 Distribution of Number of Tours for non-workers

No of Tours	Percentage of each number of tours in:					
	Morning pattern	Morning pattern	Evening pattern	Evening pattern	For the day	For the day
	BELGIUM	GERMANY	BELGIUM	GERMANY	BELGIUM	GERMANY
0	76.9	72.7	85.9	79.2	-	-
1	16.5	20.9	11.3	16.6	64.1	53.0
2	5.1	5.0	2.1	3.3	23.3	33.0
>=3	1.5	1.3	0.6	0.9	12.6	14.0

TABLE 6 Distribution of main activity natures for workers

Activity type	Percentage of each activity type during:					
	Morning pattern		Midday pattern		Evening pattern	
	BELGIUM	GERMANY	BELGIUM	GERMANY	BELGIUM	GERMANY
Go home	-	-	54.3	74.2	-	-
Pick-up/drop off	35.3	11.6	1.4	1.5	12.8	5.0
Work related	12.3	2.3	5.4	3.2	0.7	1.6
Eat-out	-	//	31.8	//	5.2	//
Shopping	27.2	38.1 + 6.0	4.4	5.0 + 1.5	17.3	19.0 + 7.4
Personal business	13.1	26.5	1.1	5.3	9.5	14.2
Family related	3.6	//	-	//	20.5	//
Recreational	1.1	//	0.8	//	3.7	//
Leisure/sport/culture	7.3	14.9	0.7	5.0	29.9	52.1
Others	-	0.5	-	2.6	0.4	0.8

TABLE 7 Distribution of main activity natures for non-workers

Activity type	Percentage of each activity type during:					
	Morning pattern		Principal activity pattern		Evening pattern	
	BELGIUM	GERMANY	BELGIUM	GERMANY	BELGIUM	GERMANY
Pick-up/drop off	19.9	7.5	9.1	3.3	27.2	3.0
Work related	0.7	2.5	2.3	4.6	0.2	9.1
Eat-out	0.4	//	4.3	//	5.1	//
Shopping	45.8	36.4 + 9.6	29.6	17.4 + 7.7	28.2	20.2 + 8.4
Personal business	12.1	20.3	9.4	13.3	10.6	17.6
Family related	9.4	//	21.3	//	12.1	//
Recreational	2.7	//	7.8	//	6.2	//
Leisure/sport/culture	8.8	22.6	15.7	52.3	9.8	39.6
Others	0.2	1.0	0.4	1.5	0.7	2.0

TABLE 8 Distribution of Number of Stops for workers

No of Stops	Percentage of each number of stops in:									
	Morning pattern		Morning Commute		Midday Pattern		Evening commute		Evening Pattern	
	BELGIUM	GERMANY	BELGIUM	GERMANY	BELGIUM	GERMANY	BELGIUM	GERMANY	BELGIUM	GERMANY
0	96.2	96.6	73.9	91.4	91.0	94.8	68.3	78.6	78.8	66.1
1	1.5	3.1	20.5	3.5	7.5	4.5	17.4	14.2	12.9	20.5
2	1.1	0.3	5.6	3.0	0.8	0.4	10.2	4.6	4.8	9.2
3	1.1	0.0	0	1.0	0.7	0.3	3.2	1.4	2.3	2.6
4	0	0	0	0.6	0	0	0.4	0.7	0.4	1.1
>=5	0	0	0	0.5	0	0	0.5	0.5	0.8	0.5

TABLE 9 Distribution of Number of Stops for non-workers

No of Stops	Percentage of each number of stops in:					
	Morning pattern		Main pattern		Evening pattern	
	BELGIUM	GERMANY	BELGIUM	GERMANY	BELGIUM	GERMANY
0	76.4	72.7	54.7	72.8	85.9	79.2
1	12.4	20.9	21.0	13.8	7.4	14.6
2	6.3	5.0	11.1	6.9	3.2	2.9
3	2.5	1.2	6.2	3.2	1.8	2.1
4	1.2	0.1	3.1	1.6	0.8	0.5
>=5	1.1	0	3.9	1.7	0.8	0.6

TABLE 10 Distribution of Activity type of Stops

Activity type	Percentage of stops for each activity type during:			
	Morning commute		Evening commute	
	BELGIUM	GERMANY	BELGIUM	GERMANY
Pick-up/drop off	62.4	15.2	30.3	6.3
Work related	6.5	9.2	9.9	14.4
Eat-out	0.2	//	4.7	//
Shopping	17.7	27.9 + 5.1	26.3	23.3 + 7.7
Personal business	6.2	30.8	7.2	22.6
Family related	3.0	//	12.9	//
Recreational	3.5	//	1.5	//
Leisure/sport/culture	0.1	11.0	6.5	24.8
Others	0.5	0.7	0.6	1.0

11 Distribution of Activity type of Stops

Activity type	Percentage of stops for each activity type during the main activity pattern:	
	BELGIUM	GERMANY
Pick-up/drop off	9.1	10.3
Work related	2.3	5.2
Eat-out	4.3	//
Shopping	29.6	20.4 + 7.6
Personal business	9.4	24.1
Family related	21.3	//
Recreational	7.8	//
Leisure/sport/culture	15.7	31.8
Others	0.4	1.0

TABLE 12 Interaction in stop-making across different times of day

Control variable		Percentage of individuals making a stop during:					
		Midday pattern		Evening commute		Evening pattern	
		BELGIUM	GERMANY	BELGIUM	GERMANY	BELGIUM	GERMANY
Made a midday stop?	Yes	-	-	26.1	19.3	31.7	31.0
	No	-	-	25.0	21.5	20.5	34.1
Made an evening commute	Yes	6.3	4.7	-	-	26.2	28.3
stop?	No	6.1	5.4	-	-	19.5	25.5
Made a evening pattern stop?	Yes	9.0	4.8	31.0	17.8	-	-
	No	5.2	5.5	23.4	13.2	-	-

TABLE 13 Interaction in stop-making across different times of day

Control variable		Percentage of individuals making a stop during:					
		Morning pattern		Principal activity pattern		Evening pattern	
		BELGIUM	GERMANY	BELGIUM	GERMANY	BELGIUM	GERMANY
Made a morning pattern	Yes	-	-	39.8	24.4	16.2	12.3
stop?	No	-	-	46.9	28.0	13.5	23.7
Made a principal activity	Yes	20.3	24.4	-	-	13.1	19.8
stop?	No	25.4	28.0	-	-	15.0	20.8
Made a evening pattern	Yes	26.5	16.1	42.0	26.1	-	-
stop?	No	22.5	29.9	45.8	27.3	-	-

TABLE 14 Distribution of MODE choice for workers

Main mode	Percentage of each mode in:									
	Before work pattern		Morning Commute		Midday pattern		Evening commute		Post-home arrival pattern	
	BELGIUM	GERMANY	BELGIUM	GERMANY	BELGIUM	GERMANY	BELGIUM	GERMANY	BELGIUM	GERMANY
Walk	11.3	28.4	7.8	15.6	28.0	30.5	9.0	15.8	15.6	24.1
Bike	-	15.3	8.4	18.7	16.2	33.1	8.3	18.9	7.0	15.5
Motorcycle	-	0.5	1.7	1.5	1.5	0	1.8	1.5	1.0	1.7
Train	9.3	0	4.6	1.3	-	3.5	4.3	1.2	0.2	0
Bus	0.5	0.5	6.5	4.3	3.4	0.3	7.0	3.4	0.4	0.8
Tram/metro	-	2.3	2.9	21.9	1.5	7.6	2.6	21.0	0.4	9.1
Taxi	0.7	0.0	0.1	0	-	0	0.1	0	-	0
Car driver	71.9	48.8	47.7	31.4	33.8	22.0	46.1	31.7	47.6	30.5
Car pas.	6.3	4.2	19.3	5.1	15.6	2.9	19.8	6.4	27.6	18.3
Other	-	0	1.0	0.1	-	0	1.0	0.1	0.1	0

TABLE 15 Distribution MODE choice for NON-workers

Main mode	Percentage of each mode in:					
	Before Max Activity		Max Activity		Post Max Activity	
	BELGIUM	GERMANY	BELGIUM	GERMANY	BELGIUM	GERMANY
Walk	25.3	34.5	19.7	24.0	28.3	33.2
Bike	11.6	16.0	5.8	9.7	6.5	11.1
Motorcycle	0.2	0.8	0.4	0.7	1.3	0.6
Train	0.4	0	0.3	0.6	0.6	0.6
Bus	1.1	0.5	2.6	0.9	1.0	0.9
Tram/metro	0.4	7.8	0.5	9.7	0.1	6.2
Taxi	0.5	0	-	0	-	0
Car driver	44.6	30.0	44.7	33.4	45.3	35.1
Car passenger	16.1	10.2	24.7	21.0	16.4	12.3
Other	0.1	0.1	1.0	0	0.5	0

TABLE 16 Distance home-activities and main activity duration for workers

	Morning pattern		Morning commute		Evening commute		Evening pattern	
	BELGIUM	GERMANY	BELGIUM	GERMANY	BELGIUM	GERMANY	BELGIUM	GERMANY
Main activity distance from home (km)	7.71	4.18	15.84	8.93	16.84	10.31	8.34	6.35
First stop distance from home (km)	6.41	2.97	7.09	4.78	12.25	7.11	6.11	6.72
Activity duration (min.)	32.78	37.42	-	-	426.42	406.82	88.11	89.67

TABLE 17 Distance home-activities and main activity duration for non-workers

	Morning pattern		Principal pattern		Evening pattern	
	BELGIUM	GERMANY	BELGIUM	GERMANY	BELGIUM	GERMANY
Main activity distance from home (km)	6.86	4.71	19.59	13.38	10.57	6.15
First stop distance from home (km)	5.52	5.94	12.44	6.83	5.62	5.76
Activity duration (min.)	38.53	42.58	148.55	132.66	48.25	46.41

TABLE18 Evening-commute mode choice model

Number of observations = 1554			
Average number of observations per individual = 16.8			
Variables	**Logit**	**Logit on panel data**	**Mixed-Logit**
Alternative specific constants (ASC)			
Car driver (as base)	-	-	-
Car passenger			
m	-0.4615	-0.4606	-0.9544
	(-1.7971)	(-0.5517)	(-1.2299)
Public transport			
m	1.2443	1.2454	2.2986
	(5.0499)	(1.5575)	(2.8109)
Walk			
m	1.6035	1.6045	2.087
	(6.2989)	(1.9272)	(1.5976)
Bike			
m	1.7266	1.7280	2.9222
	(7.2129)	(2.2589)	(3.5406)
Household variables			
Income/number of working people (car driver)			
m	0.1475	0.1475	0.3491
	(2.051)	(0.5456)	(1.1963)
Number of vehicles (car driver)			
m	1.5318	1.5327	1.3445
	(10.8601)	(2.9815)	(2.3757)
Number of household members (car passenger)			
m	0.4793	0.4794	0.9159
	(4.3216)	(1.5387)	(3.3060)
Work schedule variables			
Arrival at work before 9:00 (car driver and car pass)			
m	-0.3701	-0.3715	-0.1808
	(-2.4106)	(-1.0148)	(-0.4151)
Departure from work between 16:00 and 17:00 (car driver and car pass)			
m	-0.4799	-0.4796	-0.8104
	(-2.6515)	(-1.0937)	(-1.8828)
Level of service variables			
Time			
m	-0.0499	-0.0499	-0.24055
	(-11.9483)	(-4.1213)	(-4.4538)
s			0.3441
			(4.2129)
Log-likelihood	- 1823.71	- 1823.71	- 1437.25

TABLE 19 Principal pattern mode choice model

Number of observations = 1734			
Average number of observations per individual = 12.3			
Variables	**Logit**	**Logit on panel data**	**Mixed-Logit**
Alternative specific constants (ASC)			
Car driver (as base)	-	-	-
Car passenger			
m	-0.5554	-1.4884	-1.4099
	(-3.8588)	(-3.2933)	(-3.1294)
Public transport			
m	-0.6126	0.1067	0.2909
	(-2.8419)	(0.2799)	(0.7193)
Walk			
m	0.5451	0.6174	1.3383
	(2.7117)	(1.3572)	(2.9333)
Bike			
m	-0.1017	-0.0320	0.3604
	(-0.6439)	(-0.0687)	(0.7337)
Household variables			
Number of vehicles (car driver and passenger)			
m	0.6609	0.6572	0.5982
	(7.5359)	(2.4893)	(2.2116)
Number of household members (car passenger)			
m	0.3127	0.4345	0.3535
	(4.4270)	(4.1949)	(3.1707)
Individual variables			
Age (in PT)			
m	0.0137	0.1247	0.6190
	(3.9657)	(0.6039)	(1.9489)
s			2.2339
			(3.9629)
Number of stops (car driver) (principal activity)			
m	0.0474	0.0842	0.4632
	(1.0882)	(1.0042)	(2.1574)
s			1.1962
			(2.9868)
Level of service variables			
Time			
m	-0.0312	-0.0316	-0.0950
	(-4.9710)	(-3.4775)	(6.9216)
s			0.0471
			(8.8014)
Log-likelihood	- 2306.85	- 2300.87	-2141.02