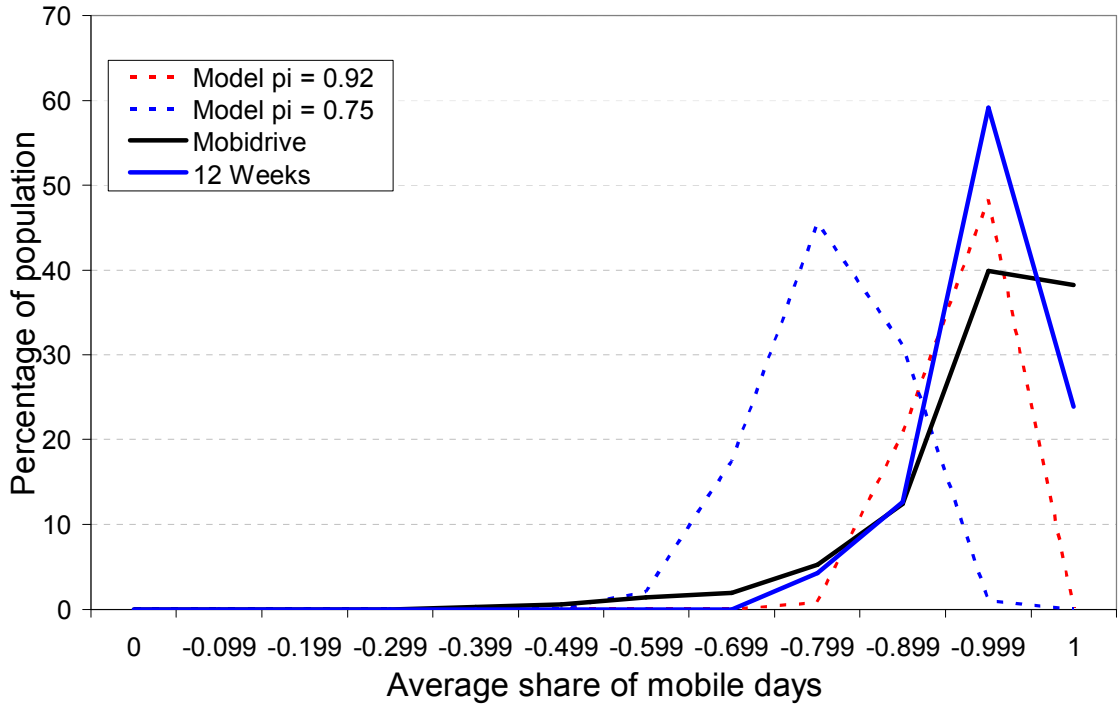

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Immobility: A microdata analysis

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Arbeitsbericht Verkehrs- und Raumplanung 166 **Juli 2003**

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Immobilität: Eine disaggregierte Analyse

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Kurzfassung

Der Anteil der Immobilen, d.h. derjenigen die an einem Befragungstag das Haus nicht verlassen, ist sowohl ein Ergebnis, wie ein Qualitätsindikator einer Verkehrsbefragung. Dieser Aufsatz stellt eine Ergebnisse vor, die die Abhängigkeit der Immobilität von den soziodemographischen darstellen. Deazu werden sowohl Querschnitts- wie Längsschnittdaten verwendet.

Die Ergebnisse zeigen, dass die Immobilität für jeden einzelnen Tag ein Zufallsprozess ist. Generell ist aber zu sagen, dass die teilweise sehr hohen Werte, die in der Literatur berichtet werden (20-25%) zu hoch sein dürften, da sie weder mit einer Längsschnittsbetrachtung konsistent sind, noch mit einer Abschätzung der wahrscheinlichen Ober- und Untergrenzen für dieses Verhalten.

Schlagworte

Verkehrsverhalten, Immobil, Antwortverhalten, Wegetagebuch, disaggregierte Modelle

Zitierungsvorschlag

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Working paper

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Abstract

This paper reports the results of a disaggregate analysis of immobility, i.e. the report of not having left the house on any one day in a survey period. The cross-sectional and the panel results indicate that immobility is a random process, which cannot be properly predicted on socio-demographic variables alone.

The results also indicate that the high estimates common in the literature (20-25% on any one day) are too high to be consistent with a longitudinal view of human travel behaviour and too high considering what is known about behaviour from other sources.

Keywords

Travel behaviour, immobile, response behaviour, travel diary, disaggregate analysis

Preferred citation style

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1 Motivation

Persons, who have been approached for a survey, say a travel diary, have a range of alternatives for their response:

- to refuse consistently
- to refuse initially, but to participate partially/fully in a later initial refuser – survey [1]
- to refuse initially, but to participate partially or fully later, still to the original instrument
- to participate partially, i.e. omitting certain objects/items on purpose
- to participate fully, while maybe omitting some objects/items by chance, forgetfulness or lack of understanding; each of these response is due the designer of the surveys and not principally due to the respondent.

A travel diary surveys consists of a group of related survey instruments, including in the main:

- a household survey addressing the description of the household and its resources
- person survey(s) covering the socio-demographic and mobility-related characteristics of each household member, plus their work and school locations
- vehicle survey(s) describing the vehicles of the household and their usage
- and finally, diaries for each household member requesting a report of the activities/movements of that person for a specified period.

The response burden implied in the first three surveys is mainly determined by the survey designer and the number and difficulty of the items requested, in particular as the number of vehicles and persons to be described does not vary greatly. This is not true for the diaries, as the respondent has to decide, how many activities or movements (objects), he or she wants to report. The number and complexity of the items requested for each object should have an influence on this decision (see for example Axhausen, Köll, Bader and Herry, 1997). The complexity is defined by both the number of items and, in particular, the requested format of the

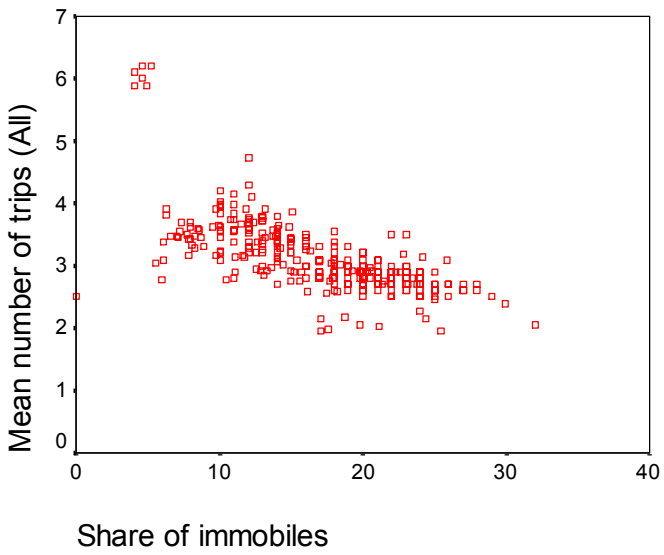
[1] The alternative term "non-response-survey" is confusing and therefore not used here.

report (tours, trips, stages or activities), here then also the definition of activity and the thereby implied number of activities and, in turn, trips (Axhausen, 2003). A respondent, who reports to have been immobile on the reporting day, is a problem for the survey analyst. Has this person indeed not left the house, has the person forgotten the trips actually undertaken or is the person using this report as a way to reduce his or her response burden ?

The problem is actually more general, as the analyst has always to consider the question, whether the respondent has omitted objects (tours, trip/activities) or whether the respondent has aggregated activities into larger groups, thereby omitting trips. Examples are the tour to the restaurant for lunch during a working day, the drop-off activity during the morning commute or the shopping tour, actually involving a range of stops/activities during the 90-120 minutes of its duration; strictly speaking each a trip/activity in its own right. If these decisions are taken at random by the respondents and are unrelated to the number of objects they would have to report, then modelling results are unbiased (see Polak and Han, 2003), although the constants will always be biased downwards; as one has to assume that no - few - respondents invent and report additional, not actually performed trips/activities.

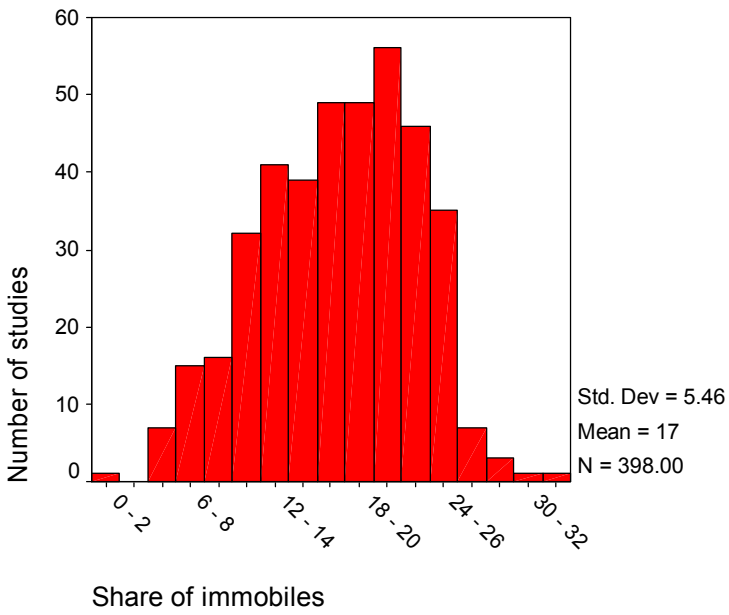
The share of immobiles has a special importance in this context, as it has an immediate and strong impact on the mean number of reported objects (trips/activities) (See Figure 1). A number of recent multiday surveys, mostly involving the payment of an incentive has raised the issue, what a reasonable share of immobiles should be: 7-10% or 15-20% person-days ? The German Panel (7 day diary) reports about 8% (Chlond, Lipps, Manz and Zumkeller 1999), the 6-week Mobidrive - survey 6% (Axhausen, Zimmermann, Schönfelder, Rindsfüser und Haupt, 2002), a 12-week diary in Zürich 5% (Schlich, Kluge, Lehmann and Axhausen, 2002). Finally a sample of GPS-tracked cars in a small Swedish town was not driven in the study area for 23% of the 50'000 observed days, which includes stays out-of-town or days when the car owner only used other modes. See Figure 2 for the distribution of reported levels of immobility in a sample of about 400 surveys.

Figure 1 Average number of reported trips versus share of immobiles



Source: Axhausen, Madre, Erl and Brög (Forthcoming)

Figure 2 Reported shares of immobiles in an international cross section of travel diaries



Source: Axhausen, Madre, Erl and Brög (Forthcoming)

The purpose of this paper is to identify the main factors of immobility related to the scope of the survey (what population is excluded?), to the characteristics of the individual surveyed, to the context (characteristics of the household, place of residence, etc.) and of the period during which he or she declares to have stayed at home. Indeed, making no trip has not the same meaning during single day and during a longer period (i.e. one or several weeks), which surveys conducted during a long enough period (e.g. Mobi*drive*) allow to analyse. The proportion of immobiles is obviously lower as the period gets longer: for instance, in the 7 days diary of the National Personal Transport Survey (NPTS) conducted in France in 1981-82, there were 17% of immobiles among the population aged 6 or more on any single day, while this proportion is only 1.6% during the whole week described [2]. Thus, cross-sectional and longitudinal data will be studied. Finally, we will consider if the results of these analyses allow to distinguish "true immobility" from "soft refusal of the survey".

2 SCOPE OF THE SURVEY AND REASONS GIVEN FOR IMMOBILITY

Travel diary survey exclude normally as a matter of policy a number of groups, because their sampling or interviewing is difficult:

- persons in common accommodation, such as hotels, hostels etc;
- persons living in communal quarters, military barracks, student dormitories, retirement homes etc.;
- young children (generally under 6 years old) and sometimes elderly; children <6 years old, for whom a diary was filled in the French NPTS of 1981-82, are quite immobile (26% of them don't move on an average week day);
- persons staying in hospitals and similar institutions;
- persons living in prisons or other closed and semi-closed institutions.

It is unclear at this point, what impact these omissions have on the estimate of the share of immobile travellers in an area. The balance will depend on the relative share of persons in the last two categories in comparison with the first two categories. Still, it is important to realise

[2] if we skip 155 diaries out of 3026, corresponding to missing age, with 55% of empty diaries).

that the numbers derived from a travel diary exclude certain - by definition - immobile people systematically: people staying in hospitals and people living in closed institutions [3].

When no trip has been described, asking a "why?" question avoids certainly the ommission of trips and is not a burden, since only those who have no trip to describe are concerned. What items would be the best in order to avoid ommissions?

According to the items proposed in the 1993-94 French NPTS (Table 1), the main reason explaining the level of immobility is "didn't need to move" (about 3 cases out of 4). In the population of ordinary households, which excludes the categories listed above:

- about 1% suffer a permanent incapacity, which is a reason of immobility;
- about 1.6% a temporary incapacity (sick, pregnant, etc.);
- about 1% need to stay at home (caring for someone sick, having work to do);
- about 1% of people don't move because of bad weather (snow, may be rain, but not fog, according to the logit analysis described below);
- and some other, mainly anecdotic, reasons (mostly related to car availability).

Except for permanent incapacity, the proportion of each reason is lower in the Paris region where there is less immobility (Table 2). In this metropolitan region, the proportion of persons who stay at home has dropped under 10% in the 90's. Considering a longer reference period, among the 5% of individuals who did move neither the day before the interview neither during the last week-end, 1% suffer a permanent disability and 1% a temporary one (French NPTS 1993-94).

[3] See http://www.kcl.ac.uk/depsta/rel/icps/worldbrief/highest_prison_po pulation_rates.html for details on prison population. The US rate of 0.7% nationally is noticeable.

Table 1 France 1993-94: Reasons for not leaving the house

	Week day	Saturday	Sunday
Made mechanised trips	70.4	64.1	54.2
Only walk	13.5	14.0	14.1
Temporary physical incapacity	1.6	1.6	1.6
Permanent physical incapacity	1.0	0.9	0.9
Needed to stay home	0.7	1.0	1.2
Didn't need to move	11.8	16.6	25.2
No car in the household		0.2	0.2
Car broken down		0.1	0.1
Nobody to drive		0.0	0.0
Bad weather		0.5	1.3
Other reasons	1.0	0.9	1.2
Total	100.0	100.0	100.0

Source: French National Personal Transportation Survey 1993-94.

Table 2 Paris 1977-1998: Reasons for not leaving the house

Share [%]	1977	1984	1992	1998
Mobile persons	88.2	88.9	93.4	94.0
Didn’t leave the house (1)	10.3	4.7	2.7	2.7
Permanent physical handicap	0.9	-	0.7	0.8
Temporary physical handicap	0.2	0.2	1.0	0.9
No car	0.4	-	0.1	0.1
Not in region		0.1	0.6	0.1
Bad weather		0.0	0.1	0.2
Non response		6.1	0.4	1.2
Total	100.0	100.0	100.0	100.0

Source: French National Personal Transportation Survey 1993-94.

For an estimate of an upper or lower bound of the proportion of immobiles, one would need to know, how many persons living at residential addresses are not able to leave the house. Gant

(2002) cites UK evidence for this share: 8% of the disabled population is housebound according to an official national survey. The definition of disability used covers 11% of the UK population, which would result in estimate of 1% of the residential population being homebound. Adding another 1% for people with long-term illnesses plus the low estimate of 6% immobiles found in the long-duration surveys, we would obtain a lower bound of 8% for the share of immobiles.

Assuming conservatively that in addition to the homebound the 40% of UK disabled using wheel chairs and walking aids leave the house only every second day, one would obtain a share of 3% [4].

Again adding 2% for long-term illness and a high estimate of 10% from the long-duration surveys, one obtains an upper bound of 15%. Similar shares can be deduced from other international statistics on disability (see www.loegd.nrw.de/ for Nordrhein-Westfalen, ABS (2001) for Australia, McNeill (2001) for the USA, Madre and Bussière (1996) for France, or CBS (2001) for Israel). The range of 8-15% suggested by these rough estimates is well below the majority of the studies under review. If true, it would indicate a substantial share of hidden non-response, which would need to be corrected for to obtain correct estimates of trip making or activity participation.

3 A CROSSSECTIONAL MODELLING APPROACH

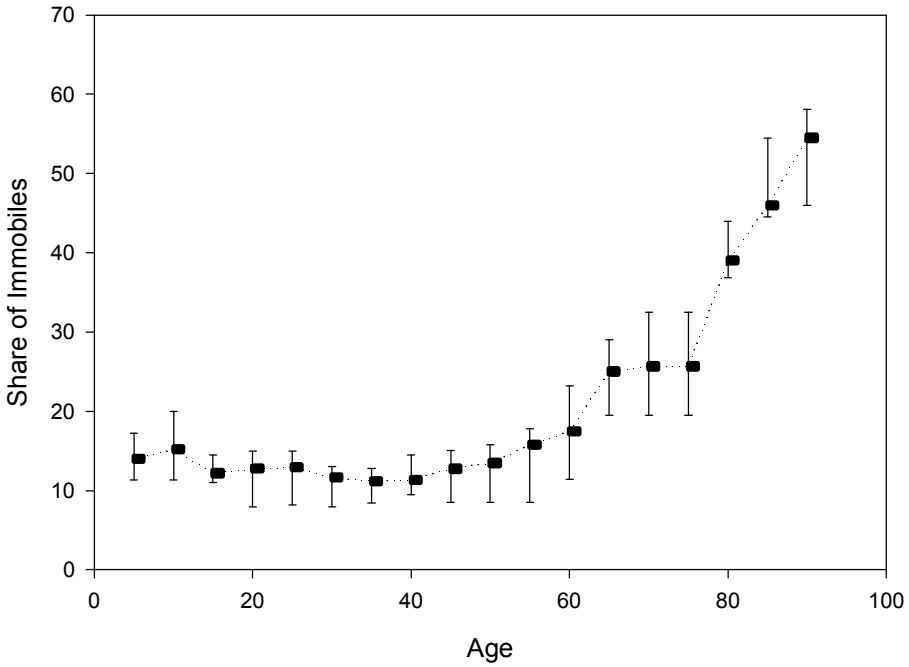
This analysis is based on the description of daily mobility in the 1993-94 French NPTS. It consists in an interview on the trips made the day before (a week day) and during the last week-end, with a question on reasons for immobility (see section 2 above). First, we will give a descriptive analysis and then we will consider what contribution a logit model can give to the detection of soft refusals.

3.1 Descriptive analysis

The main determinants of immobility on a week day are:

- old age, with additional effects of retirement and disabilities (see Figure 3 with results from various surveys); very young children are also quite immobile as mentioned above; along the week, the profile is more contrasted for young people than for elderly; for the Metropolitan area of Paris, where 4 surveys conducted in 1977, 1984, 1992 and 1998 allow to build an age-cohort model, a generation effect of nearly 10 points has been shown;

Figure 3 Share of immobiles by age for selected surveys (Box-Plot – 1.-3. Quartile)



Source: Axhausen, Madre, Erl and Brög (Forthcoming) Based on 25 selected surveys from around the world

- living in a low density area: rural (with an additional effect for farmers) or small towns when considering the size of urban areas, far outer suburbs when considering concentric zones; the share of immobiles could be above 30% in rural areas far from big conurbations, while it has fallen under 10% in the Metropolitan Area of Paris); thus we have to be careful for comparisons: between urban and national data, between subsequent surveys for the same metropolitan area when the survey area has been extended to outer suburbs, where the share of immobility is higher;

[4] Hird (No date) reports a 4% share of persons, who do not leave the house during the seven day reporting period of the UK National Travel Survey. This includes persons, who a permanently housebound, as well as people who are temporarily ill or handicapped.

- working at home or being unemployed, but also having a non- fixed work location (being self employed has almost no additional influence).

Minor but significant factors of immobility are:

- no car in the household or never driving (surprisingly enough, occasional driving seems to have more influence);
- living at home (working or having holidays at home) in summer (July or August);
- snow, and slightly rain, but not fog (confirming that bad weather is seldom a reason for immobility);
- an annual income below about 35'000 Euros.

When controlling for the factors above, the level of instruction and part time work have no influence. It is the same for the audio-visual equipment of the household (number of TV sets, video-recorder, computer) except for TV by cable; leisure at home does not seem to be a substitute for activities out of home..

Extending the analysis from a week day to the week-end, the explanatory power of the model is lower for Saturday than for a week day and lower for Sunday than for Saturday, mainly because variables related to work have less influence (unemployment and "work at home" are still significant with a lower value). Moreover, income has almost no influence on Sunday. The only factors which seem stronger during week-ends are related to car availability: no car in the household, never drive. Reintroducing the audio-visual equipment, which is not significant on week days, does not improve the model (still no substitution between leisure equipment and trip making during the week-end like during the rest of the week), just less immobility for households without a TV set.

More important for our purpose is the day when the interview on trips made during the last week-end is conducted. In case of memory effects, immobility would be increasing from those conducted on Tuesday to those on Saturday, which does not seem to be the case. Only interviews conducted on Thursday show significantly less mobile persons during the week-end, and it is the same for data collected on Friday about those who did not move on the last Sunday.

3.2 A difficult reconstitution of immobility by the model

The overall quality of a simple logit model is satisfactory: 85% of observations are correctly reconstituted for a week day, 80% for Saturday and 70% for Sunday (Table 3). It is as expected, since the reconstitution for two modalities is more difficult when their proportion is nearer to 50%, and we have seen that the proportion of immobiles is higher on Sunday than on a week day. 98% of mobiles are correctly given by the model, but only 20% of immobiles on a week day and 10% on Sunday, which is a very low proportion. Moreover, this proportion decreases quite rapidly as poorly significant factors are withdrawn from the model.

Table 3 Reconstitution of Immobiles by Logit Models (Shares in %)

	Week day	Saturday	Sunday
Simple logit model with a 0.5 threshold:			
Sensitivity = n11/(n11 + n10)	20.3	15.4	10.5
Specificity = n00/(n01+ n00)	98.1	98.0	97.5
False positive rate =n01/(n11 + n01)	31.5	31.2	34.3
False negative rate =n10/(n10 + n00)	14.2	20.0	29.6
Correct = (n00 + n11)/(n00 + n01 + n10 + n11)	85.0	79.5	70.2
Weighting immobiles by 10 and mobiles by 1: equivalent to the logit with a threshold of about 0.9			
Sensitivity = n11/(n11 + n10)	86.4	75.8	66.8
Specificity = n00/(n01+ n00)	51.2	50.8	50.1
False positive rate =n01/(n11 + n01)	73.5	69.2	62.0
False negative rate =n10/(n10 + n00)	5.1	12.1	23.3
Correct = (n00 + n11)/(n00 + n01 + n10 + n11)	57.1	56.4	55.4
Multinomial logit (0, 1 to 3, 4-5, >=6 trips):			
Sensitivity = n11/(n11 + n10)	31.8	21.8	21.3
Specificity = n00/(n01+ n00)	51.6	70.5	72.9
False positive rate =n01/(n11 + n01)	88.2	82.4	73.5
False negative rate =n10/(n10 + n00)	21.2	24.3	33.1
Correct = (n00 + n11)/(n00 + n01 + n10 + n11)	48.2	59.5	56.7

In order to improve the reconstitution of immobiles, we have tested two solutions:

- to give a weight of 10 to immobiles and only 1 to mobiles,
- to chose a probability threshold different than 0.5, since the overall percentage of correct reconstitution does not vary so much according to this threshold: for a week day, it is greater than 84.5% for a threshold between 0.28 and 0.6.

In fact, the results obtained by over-weighting are equivalent to those obtained with a threshold of about 0.9. 86% of immobiles are correctly modelled on a week day, 76% on Saturday and 66% on Sunday; but only half of mobiles are left correct and the overall proportion of correct is below 60%. A compromise would be the probability for which the proportion of correct is about the same for mobiles and for immobiles: it is around 0.8 for a week day or Saturday with 70% observations correctly reconstituted, and only 60% on Sunday for a probability of 0.7.

Introducing the number of trips made by mobile persons does not seem to bring useful information into the model. A multinomial logit with four alternatives (no trip, 1 to 3 trips, 4 or 5 trips, 6 trips or more) does not give better results for immobility: 21 to 32% correctly modelled, for an overall rate of correct between 48% and 60%.

Up to now, we have modelled each day separately. As many surveys describe the mobility on several days for the same person, let us now consider whether a longitudinal approach would bring more useful information.

4 A LONGITUDINAL APPROACH

Three recent surveys have tracked persons or households over multiple weeks: 6 weeks of German households in Mobidrive survey (Axhausen, Zimmermann, Schönfelder, Rindsfüser and Haupt; 2002); 12 weeks of individuals in a Swiss leisure activity survey (Schlich, Kluge, Lehmann and Axhausen, 2002) and a variable number of weeks in a Swedish Rattfart GPS-based observational study (www.rattfart.com). Before a formal analysis of this data, it is worthwhile to look at the variation in mobility from day to day.

The levels of mobility vary considerably from day-to-day, especially due to the effects of Saturday and Sunday, but a larger longer drop is only visible in the Swedish data, which span both the Christmas/New Year and the Easter period (Figure 4 to Figure 6).

The distributions of the mean mobility rates for the respondents are highly skewed, as shown in Figure 7 by the difference between the median and mean of distributions. The frequency distributions the average rates over 6, 12, or a variable number of weeks not smaller then seven (Rattfart) confirms this.

Figure 4 Mobidrive: Share of mobiles by day of reporting period

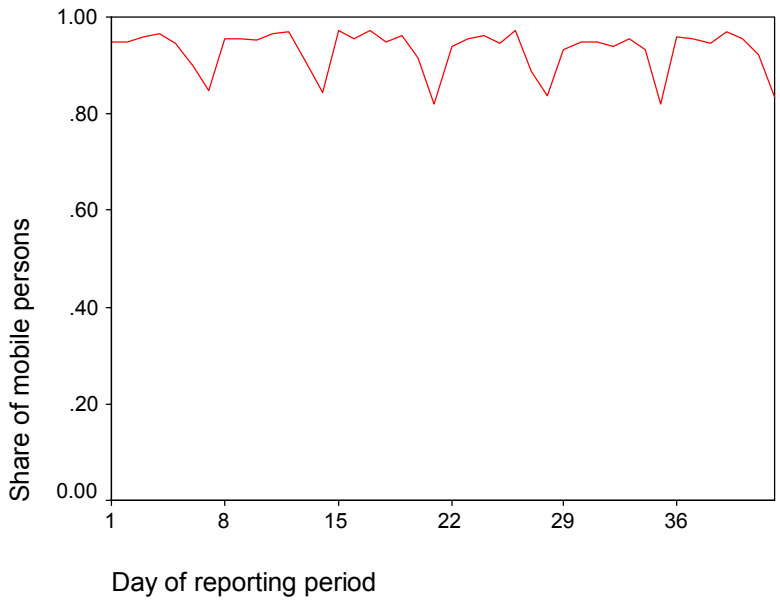


Figure 5 12 week survey: Share of mobiles persons

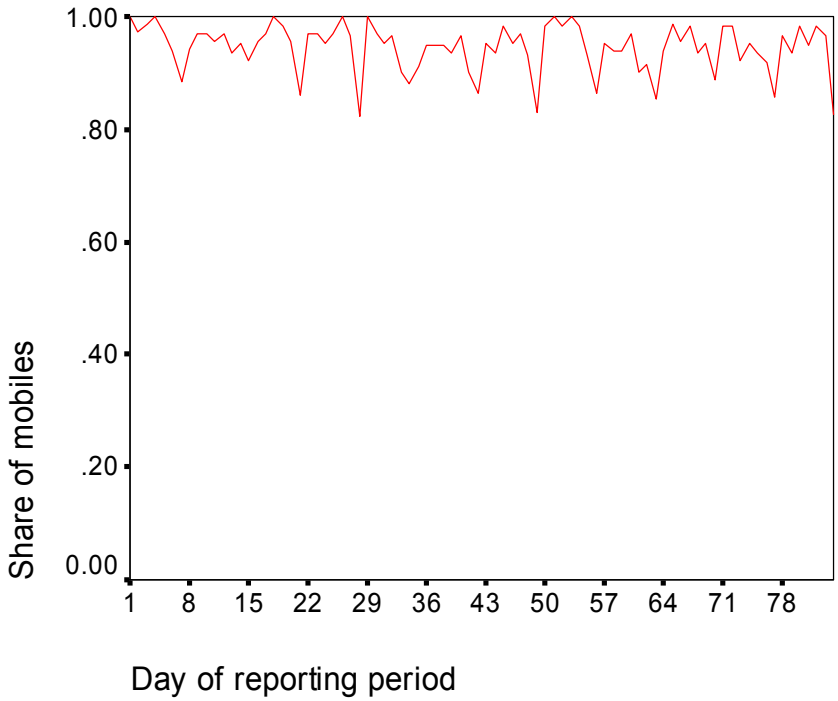
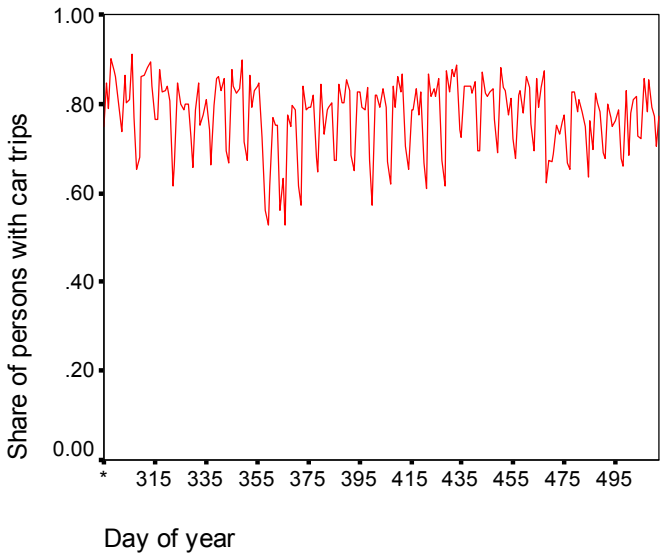
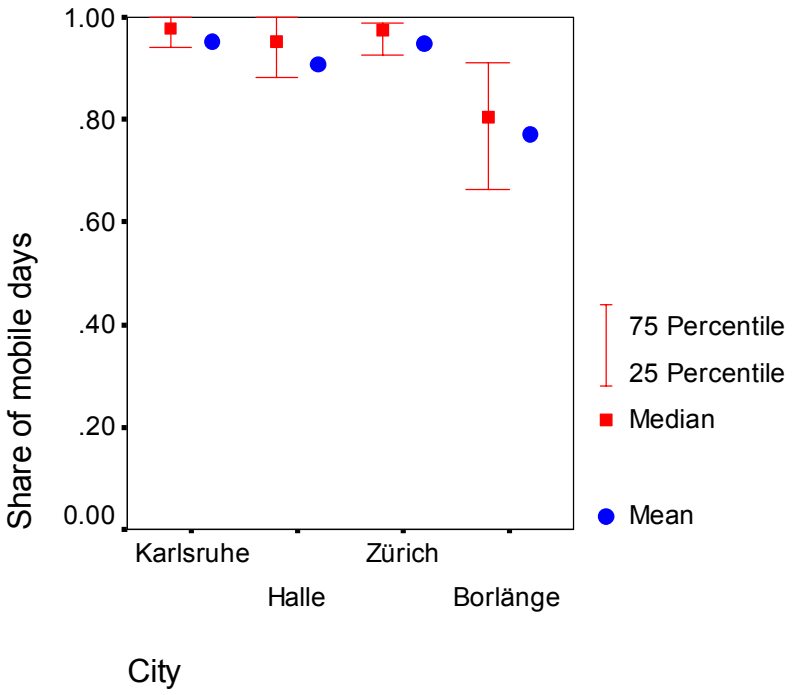


Figure 6 Rattfart: Share of days with car trips (Days with 50 and more observed persons)



* = Summary of days with less then 50 persons observed on that day

Figure 7 Comparison of mobility rates between the surveys



Rattfart: only persons with 50 or more observed days included; excluding days out-of-town

Figure 8 Distribution of the personal mobility rates over the survey periods

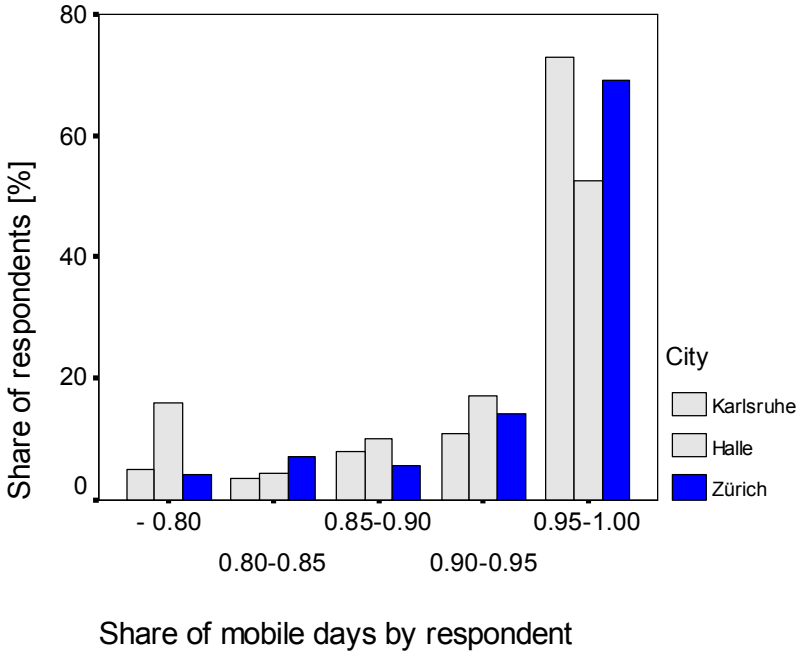
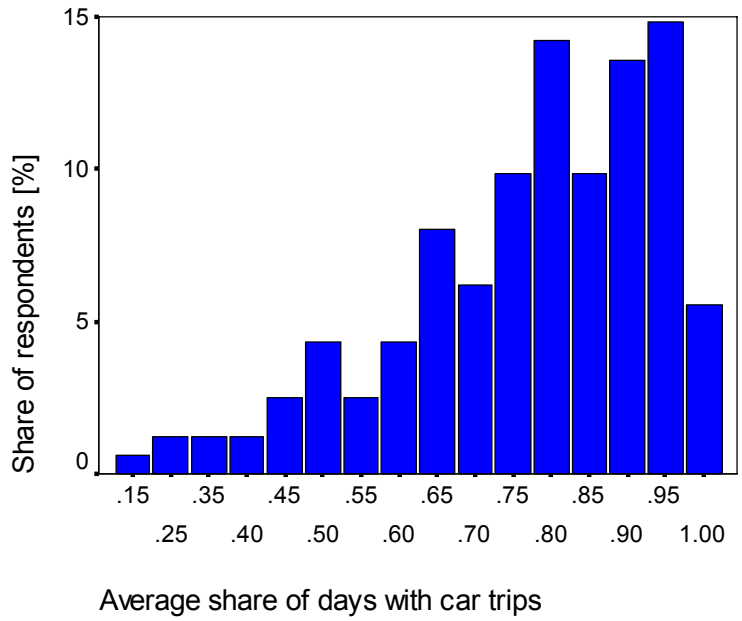


Figure 9 Rattfart: Distribution of shares of days with car trips over the survey period



Rattfart: only persons with 50 or more observed days included; excluding days out-of-town

A series of random parameter logit models were estimated for the three data sets to test for fatigue effects (only Mobidrive, 12 Week survey), for serial correlations between the days and the usual socio-demographic and day of week – effects. No serial correlations could be identified (autoregressive term, lag 1), nor significant fatigue effects. The socio-demographic variables showed the usual patterns (see above). A detailed description of all results is therefore not required, but Table 4 shows the results for the Mobidrive survey.

Table 4 Mobidrive RPL logit model of immobility

Variable	Allocation of parameter to the utility functions		Type of parameter	Value	Significance level
	Mobile	Immobile			
Constant		X	Mean	4.8576	0.0000
			St. Dev.	1.2355	0.0000
Male	x		Mean	0.9055	0.4710
Age	x		Mean	0.0399	0.0603
			St. Dev.	0.0156	0.0020
Age squared	x		Mean	-0.0367	0.1346
			St. Dev.	0.0174	0.0020
Day of reporting period		X	Mean	-0.0056	0.6747
			St. Dev.	0.0195	0.0012
Day of reporting period squared/100		X	Mean	0.0177	0.5480
			St. Dev.	0.0146	0.5453
Male * Age	x		Mean	-0.0403	0.0003
Female non-driver	x		Mean	-0.6555	0.0032
Retired	x		Mean	1.0783	0.0013
Unemployed	x		Mean	1.4857	0.0000
Saturday		X	Mean	-0.5785	0.0001
			St. Dev.	0.9721	0.0000
Sunday		X	Mean	-1.5081	0.0000
			St. Dev.	1.3265	0.0000
N				30324	
Panel model N				361	
L(0)				-10509	
L(C)				-3578	
L(β) MNL				-3211	
L(β) RPL				-2836	

While, as mentioned above, the mean effects of the day of the reporting period are not significant, the standard deviations of their distributions are. This indicates that for a share of the respondents there are significant time trends. The countervailing effects of the linear and the square term make all combinations possible. The share of number of persons for which the two effects are both negative, i.e. persons with fatigue, is small though.

The variability visible between persons is also visible for each person separately. While those persons with an above average of mobile days tend to be above average on all three types of days (Week day, Saturday, Sunday), there is also a good number of persons, who tend to be above average on just one or two of those types of days (around 50% in each of the three surveys).

Table 5 Share of respondents with above and below average levels of mobility by type of day

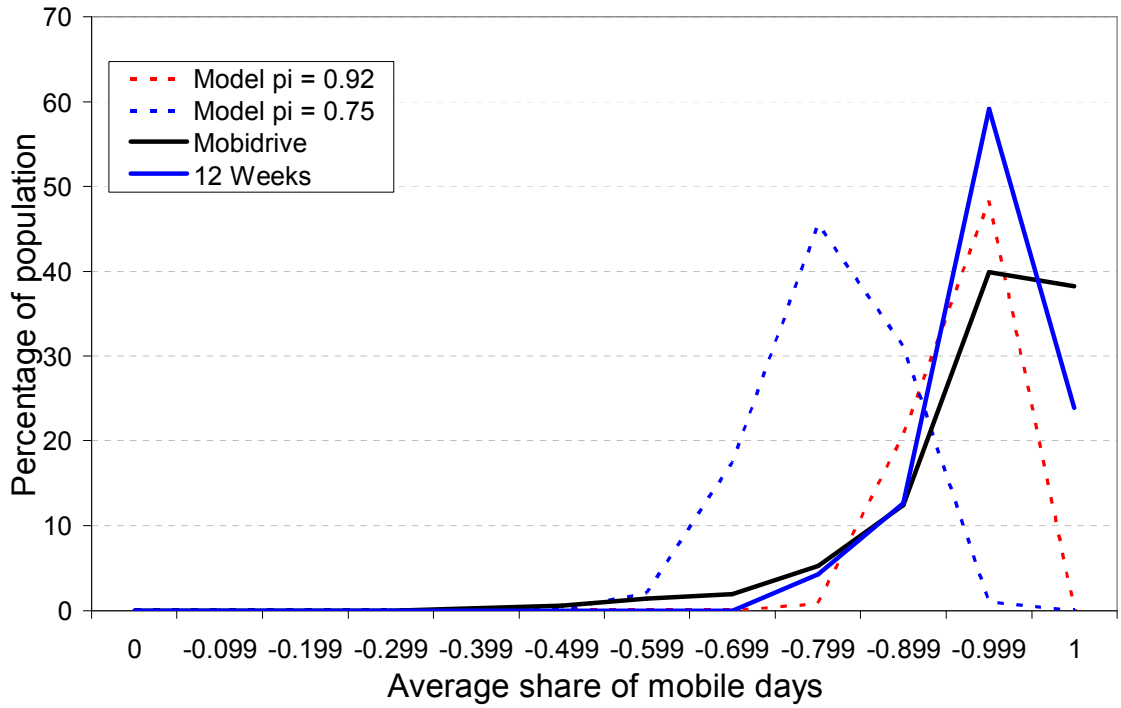
Type of day			Survey		
			Mobidrive	12 Weeks	Rattfart
Weekday	Saturday	Sunday			
Below	Below	Below	10.5%	14.1%	19.1%
		Above	3.0%	7.0%	4.9%
	Above	Below	4.7%		6.2%
		Above	4.2%	12.7%	6.8%
Above	Below	Below	11.1%	4.2%	11.1%
		Above	4.7%	9.9%	6.2%
	Above	Below	19.7%	8.5%	7.4%
		Above	42.1%	43.7%	38.3%
Total			100.0%	100.0%	100.0%

5 A WAY FORWARD

The long duration surveys and observations indicate that immobility is too some extent a random process with many respondents combining above and below average levels of mobility for different types of days. A useful methodology to characterise soft refusal would identify outliers among non-mobile persons: the discordant observations from the logit model. But the results depend on the adequacy of the model to the data. Although not conclusive, the results obtained from the 1993-94 French NPTS could hardly be generalised, because variables with a high explanatory power for immobility (e.g. physical impairment) are seldom available. Moreover, the reason given for 3 out of 4 cases of immobility "don't need to move" doesn't leave much hope for explanation. However, once taken into account of the scope of the survey (mainly more immobility when the population density of the residential zone is lower) it is clear that the surveys in which a proportion of short trips (mainly walk trips) are ommitted, also contain more immobile persons.

If immobility is indeed a random process, then one could employ the binomial distribution to predict the shares of persons with a particular level of mobility over a longer period (say a month). Figure 10 compares the results of this calculation for a low estimate of 8% immobiles and a high estimate of 25% with the observed shares from the Mobidrive and 12 Week diary. It is clear, the simple binomial distribution is not an adequate model for short period as used here (30 days), but that it needs to be expanded to allow for a disproportionate number of ones, i.e. persons who are mobile every day. On the other hand, it would be appropriate for long periods. If this were true, the high estimate of 0.25% of immobiles/day produces a profile of average mobility which seems unrealistic.

Figure 10 Comparison of binomial distribution (30 days) with observed distributions of the shares of population with certain levels of average mobility



6 Acknowledgements

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