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ANALYSIS OF BIASES DUE TO SURVEY NON RESPONSE IN THE FRENCH NATIONAL TRAVEL SURVEY 2007-08

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ABSTRACT

While nonresponse results in a reduced sample size, a more important concern of researchers is the possible impact of nonresponse bias. Bias is introduced when those that do not respond to the inquiry are systematically different from those that do respond on key estimates. In this circumstance, as the above section describes, the response mechanism is “confounded” with characteristics of the sample units. For example, if nonrespondents tended to take more trips, or longer trips than respondents, the estimates of travel produced from only survey respondents will be too low and not representative of the whole population (only those that responded).

Getting the advantage that for the last French National Travel Survey (FNTS) 2007-2008 the sample was drawn directly from the census and the list of new residences built since the census, and therefore we have lots of information about respondent and non-respondent to the different survey instruments in the FNTS. We will quantify these biases by using auxiliary information in different calibration that we will produce.

Travel Survey, Nonresponse, bias, Calibration on margins.

INTRODUCTION

All surveys are susceptible to a variety of types of error that affect different parts of the survey process, have different implications for data quality and are amenable to different forms of prevention or compensation (Groves, 1989; Richardson et al., 1995; Zimowski et al. 1997). Nonresponse errors are those generally associated with the failure of sample units to participate fully in the survey. It is usual to distinguish two different forms of nonresponse.

- **Unit nonresponse** refers to the failure of a unit in the sample frame to participate in the survey. In the context of travel diary surveys, unit nonresponse can arise for a number of different reasons including refusal, non-contact, infirmity or temporary absence (see, e.g., Brög and Meyburg, 1980, Kim *et al.*, 1993; Richardson and Ampt, 1994; Stopher and Stecher, 1993; Thakuria *et al.*, 1993).
- **Item nonresponse** refers to the failure to obtain complete information from a participating unit. In the context of travel diary surveys, the most significant form of item nonresponse is probably the under reporting of mobility due to respondents' failure to properly recall and/or record all the relevant journeys that they make (see, e.g., Ampt and Richardson, 1994; Brög and Meyburg, 1981; Brög *et al.*, 1982, Hassounah *et al.*, 1993). Item nonresponse can be regarded as a particular form of the more general problem of measurement error in survey research (Groves, 1989).

There is no justification for assuming that people who respond have the same characteristics as those who do not (Forsman *et al.*, 2007). Thus, in computing estimates from the available data collected, we may face biases, whose size and direction of error are unknown. In order to show how these non-response problems can be solved, we will take as an example the daily trips in the French National Travel Survey 2007-08. Most of these solutions are rather general, but some aspects are specific to this case as the sample is drawn from the census, which allows the characterization of the households that refused to answer.

THE FRENCH NATIONAL TRAVEL SURVEY 2007-08

Once per decade, the Ministry of Transport and the National Institute of Statistics use to conducting a National Household Travel Survey with the scientific support of INRETS. It is the data source providing the most transverse and consistent overview of mobility, whatever the modes and the transport situations of people living in France may be. The aim of the French National Travel survey is the description of short and long distance trips made by households living in France, as well as their access to and use of public and private transport means. Figure 1 gives an overview of FNTS 2007-2008. The survey is organized around the three following topics: Description of trips; Vehicle ownership and use and accessibility to public transport.

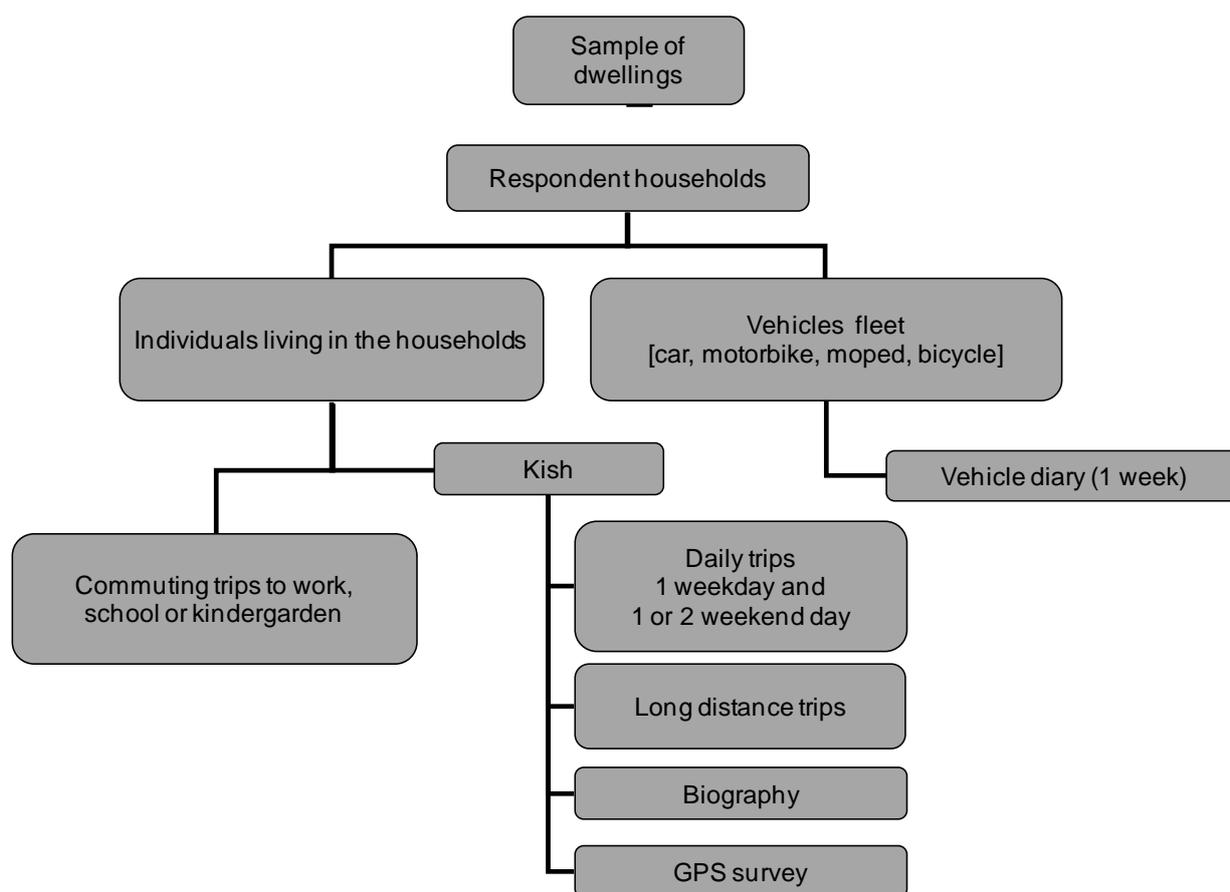


Figure 1: Overview of the French National Travel Survey (FNTS 2007-2008).

Six survey instruments were used:

1. During the first visit a CAPI questionnaire is designed to collect at household level (including household members) the socio-demographic variables, characteristics of commuting trips to work, school or kindergarden; driving licenses and car use, traffic accidents; season tickets and discounts in public transport; description of vehicles available in the household and the housing environment;
2. A 7 days vehicle diary is attributed to one of the household's vehicles (selected with unequal probability distribution to give more chance to be drawn to motor two wheelers, which are particularly interesting on the point of view of road safety) to be filled by the vehicle users;
3. During the second visit, for one person above 6 years old, selected with unequal probability distribution giving more chance to highly mobile persons (within each households), is asked to describe her/his long distance trips made during the last three months (as recalled from memory);
4. The same person was asked to describe her/his trips made one weekday before the interview, and one weekend day (either Saturday or Sunday);
5. A sub-sample of approximately 1 100 individuals was asked to fill a biographical grid in order to describe the transport means used throughout their whole past life;
6. A sub-sample of approximately 750 volunteers took a GPS receiver.

A sample size of about 30,000 dwellings (including 5 regional add-ons) was selected in the 1999 census and the list of new residences built since the census. The sample was spread over six waves covering 12 months, in order to neutralize the seasonal variations which affects mobility (especially for long distance travel).

Table 1 – Sample size and response rate

Number of dwelling drawn in the sample	Number of dwelling out of the scope	Number of Main dwelling	Number of non-respondents households (2 nd visit)	Number of survey performed
30 165	4 272	25 893	7 261	18 632

Although the majority of residences in our sample are the main residence of a household, this is not always the case: among the 30 165 dwellings visited, 4 272 (14%) were out of the scope (vacant housing, second or occasional homes). Among the 25 893 selected households in the scope, 7 261 (28%) of them refused to respond to the 2nd visit of the survey.

THE RESPONSE MECHANISM

Among the 22 724 dwellings that were main household dwellings in the 1999 French census, we have some useful information allowing us to find out the probability for a household to respond to the survey, this is usually called the response mechanism. We built a logit model to detect the response mechanism because logit modeling shows the influence of each dimension "everything being equal in other respects". Although the household living in the selected dwelling could be different from those who lived there in 1999 (at the moment of the census), we consider them as equivalent. We compute the following variables for the response mechanism:

- **Zone of residence** (people living in rural areas, people living in conurbation of less than 20 000 inhabitants, people living in conurbation from 20 000 to 100 000; people living in conurbation from 100 000 to Paris region; Paris conurbation);
- Building belonging to the municipality with « **low rents lodging** »(yes; no);
- **Type of dwelling** (house and farm ; others types);
- **Dwelling with/without interphone** (house; apartment with interphone; apartment without interphone);
- **Number of rooms** of the dwelling (0-1 room ; 2-3 rooms ; 4-5 rooms ; 6 rooms and more);
- **Surface of the dwelling** (less than 40m²; from 40 to 70 m²; from 70 to100 m²;from 100 to 150 m² ; more than 150 m²);
- **Size of the household** at the 1999 census (1 person; 2 persons; 3 persons; 4 persons and more);
- **Age of the head of the household** at the 1999 census (from 15 to 34 years old; from 35 to 49 years old; from 50 to 64 years old; from 65 years old and more);
- **Gender of the head of the household** at the 1999 census (male; female);
- **Household car fleet** at the 1999 census (0 car, 1 car ; 2 cars and more);
- **Wave of survey** (May – June 2007; July – August 2007; September – October 2007; November – December 2007; January – February 2008; March – April 2008).

Table 2 – Global significance analysis of the variables used in the Logit model

Effect	DF	Wald Chi-Square	Pr > ChiSq
Zone of residence	4	47,65	<0,0001
Wave of survey	5	41,99	<0,0001
Age of the head of the household at the 1999 census	3	23,47	<0,0001
Household car fleet at the 1999 census	2	15,28	0,00
Number of rooms of the dwelling	3	10,07	0,02
Building belonging to the municipality with « low rents lodging »	1	2,35	0,13
Type of dwelling	1	1,68	0,20
Surface of the dwelling	4	2,44	0,66
Dwelling with/without interphone	2	0,21	0,90
Gender of the head of the household at the 1999 census	1	0,02	0,90
Size of the household at the 1999 census	3	0,59	0,90

Source: INSEE-SOeS-INRETS, French National Travel Survey 2007-08

We computed a global significance analysis of the variables used in the Logit model, following the methodology in Gourieroux C. (2000), as the difference $-2\text{LogL} - (-2\text{LogL}_0)$ follows asymptotically a Chi-2 law. Among the variables we had with the census, the zone of residence, the wave of survey, the age of the head of the household at the census, the household car fleet at the census, and the number of rooms of the dwelling play a major role in the response mechanism. The other variables such as the building belonging to the municipality with « low rents lodging », the type of dwelling, the surface of the dwelling, the dwelling with/without interphone, the gender of the head of the household at the 1999 census, and the size of the household at the 1999 census are correlated with the probability to respond or not respond to the survey but adding them in the model do not add significant information (see table 2).

Table 3 – Odds ratio on the propensity of nonresponse according to variable that explain the response mechanism

Variable		Odds Ratio	Probability > CHI 2
Intercept		0.4	<0,0001
Zone of residence	People living in rural areas	0.7	<0,0001
	people living in conurbation of less than 20000 inhabitants	0.8	0,0013
	people living in conurbation from 20000 to 100000	0.9	0,0481
	people living in conurbation from 100000 to Paris region	0.9	0,0016
	Paris Conurbation	1.0	Reference
Wave of survey	May – June 2007	0.9	0,0432
	July – August 2007	1.2	0,0021
	September – October 2007	0.9	0,1836
	November – December 2007	1.0	0,8560
	January – February 2008	0.9	0,0108
	March – April 2008	1.0	Reference
Age of the head of the household at the 1999 census	From 15 to 34 years old	1.0	0,6743
	From 35 to 49 years old	0.9	0,2338
	From 50 to 64 years old	0.8	<0,0001
	From 65 years old and more	1.0	Reference
Household car fleet at the 1999 census	Non motorized household	1.3	<0,0001
	Household with one car	1.2	<0,0001
	Multi-equipped household	1.0	Reference
Number of rooms of the dwelling at the 1999 census	0-1 room	1.6	<0,0001
	2-3 rooms	1.3	<0,0001
	4-5 rooms	1.1	0,0951
	6 rooms and more	1.0	Reference

Source: INSEE-SOeS-INRETS, French National Travel Survey 2007-08

The odds ratio indicate the probability of the interviewees to be non-respondent by zone of residence, wave of survey, age of the household, household car fleet and number of rooms of the dwelling at the 1999 census.

- Failures are more often in densely populated conurbations, indeed households living in densely area have an higher probability to be non-respondent than those living in rural areas;

- Failures are more frequent during summer, a period during which we assume that households are more mobile (holidays,...). The risk to be non-respondent is 1.2 times higher among the households surveyed in July and August 2007 than among those surveyed in March and April 2008.
- Failure rates are higher for households whose head is under 35 years and for those whose head is over 65 years. When the heads of households is aged from 35 to 65, we have a reduced risk of nonresponse compared to those aged 65 year old or those younger than 35. Most likely for different reasons, for the first group it emphasizes the difficulty for interviewer to reach these households and for the second group for the reluctance of older people to answer to long and burdensome questionnaire;
- Non motorized households are less favorable to accept the survey. Indeed, households without any cars are 1.3 times more likely to be non-respondent in comparison to multi-equipped household;
- Households living in a single room dwelling are 1.6 times more likely not to respond in comparison to households living in several rooms. Let's note that this variable is correlated with the number of people living in the household. Thus, a big household size is accompanied with a greater probability to respond;

The variables of the 1999 census which explain the response mechanism to the FNTS, often emphasize the difficulty of the interviewers to reach younger households, who are probably the most actives and the most mobile, and households living in the cities most densely populated, where there are more and more buildings equipped with interphone.

STRATEGIES TO CORRECT NONRESPONSE BIAS

Calibration on margins is a weight-class method used when the total of each auxiliary information is known. Calibration on margins is an iterative process that adjusts certain sample totals or ratios, to make them match with certain corresponding totals or ratios that are known from the population. The calibration's methodology was developed by Deming and Stephan in the early 40's with the raking ratio process. We have used a software of calibration on margins called CALMAR2, which was developed by INSEE (Deville 2004; Le Guennec & Sautory 2003).

This stage is essential to ensure a representative sample and the comparison with some others statistics sources (for instance, other national surveys). The calibration on margins must be implemented on variables which explain (or are correlated with) transport behavior the variable that explain the nonresponse mechanism, and for which the total is accurately known (Deville, 1999). The population reference is ordinary households known by the rolling census.

When trying to reduce the impact of nonresponse bias by looking at known characteristics of nonrespondents and comparing them with those same characteristics of respondents. If differences in known characteristics are found between respondents and nonrespondents, weights can be developed that will reduce these biases. We had tested nine different calibrations to see the impacts of these weighting methods on the estimation of daily mobility. We choose the following margins from the census, as they are in the response mechanism

and/or correlated with mobility: the report day; professions and socioprofessional categories, age and gender, size of the households, wave of survey, motorisation, zone of residence. Let:

- **W-ALL** be the weight obtain by using a calibration all information (eg: the report day; professions and socioprofessional categories, age and gender, size of the households, wave of survey, motorisation, zone of residence);
- **W-UR** be the weight obtain by considering a uniform response mechanism (eg: the final weight is obtain by using an equal response rate);
- **W-DAY** be the weight using all available information in the calibration except the report day (eg: professions and socioprofessional categories; age and gender; size of the households; wave of survey; motorisation; zone of residence);
- **W-PCS** be the weight using all available information in the calibration except the professions and socioprofessional categories;
- **W-AGG** be the weight using all available information in the calibration except age and gender;
- **W-SHH** be the weight using all available information in the calibration except the size of the households;
- **W-WAV** be the weight using all available information in the calibration except the wave of the survey
- **W-CAR** be the weight using all available information in the calibration except the motorization;
- **W-ZON** be the weight using all available information in the calibration except the zone of residence

We consider that W-ALL is the best weight we can produce (as we use all auxiliary information we have). Let's compare the estimates of the number of individuals that the other weights give. In the Tables 4 to table 10 we show only the estimation of the number of individual for the W-ALL weight, the relative difference with W-UR for all variable in the calibration (where generally we have the deepest gap) and the difference with W-X where X is not in the calibration (it's not necessary to see the other tables because if the variable is in the calibration then we do not have any gap).

Table 4 – Gap between the estimation of number of individuals with W-ALL, W-UR and W-DAY

		Weight used		
		W-ALL	W-UR	W-DAY
		Number of individuals (in thousands)	Relative difference with W-ALL	Relative difference with W-ALL
Reporting day	Monday	11,298	-8%	-7%
	Tuesday	11,298	0%	1%
	Wednesday	11,298	-5%	-5%
	Thursday	11,298	-10%	-10%
	Friday	11,298	20%	21%

Source: INSEE-SOeS-INRETS, French National Travel Survey 2007-08

Table 5 – Gap between the estimation of number of individuals with W-ALL, W-UR and W-PCS

		Weight used		
		W-ALL	W-UR	W-PCS
		Number of individuals (in thousands)	Relative difference with W-ALL	Relative difference with W-ALL
Professions and Socioprofessional Categories	Farmer	1,436	24%	14%
	Craftsman/Tradesman	3,283	-10%	-13%
	Intermediary active	10,020	5%	5%
	Intermediary retired	4,073	15%	6%
	Blue collars active	14,769	0%	0%
	Blue collars retired	8,565	-17%	-25%
	Unemployed	6,954	13%	18%
	Between 6 and 14 years	7,392	-11%	-1%

Source: INSEE-SOeS-INRETS, French National Travel Survey 2007-08

Table 6 – Gap between the estimation of number of individuals with W-ALL, W-UR and W-AGG

		Weight used		
		W-ALL	W-UR	W-AGG
		Number of individuals (in thousands)	Relative difference with W-ALL	Relative difference with W-ALL
Age and Gender	Male from 6 to 24 years old	7,142	-15%	-17%
	Male from 25 to 34 years old	3,905	-25%	-25%
	Male from 35 to 49 years old	6,359	-8%	-8%
	Male from 50 to 64 years old	5,577	1%	0%
	Male over 65 years old	4,159	8%	11%
	Female from 6 to 24 years old	6,914	-8%	-10%
	Female from 25 to 34 years old	3,908	6%	4%
	Female from 35 to 49 years old	6,551	15%	14%
	Female from 50 to 64 years old	5,874	14%	15%
	Female over 65 years old	6,102	6%	12%

Source: INSEE-SOeS-INRETS, French National Travel Survey 2007-08

Table 7 – Gap between the estimation of number of individuals with W-ALL, W-UR and W-SHH

		Weight used		
		W-ALL	W-UR	W-SHH
		Number of individuals (in thousands)	Relative difference with W-ALL	Relative difference with W-ALL
Size of the household	1 person	8,696	1%	1%
	2 persons	17,114	2%	1%
	3 persons	10,603	-8%	-7%
	4 persons	11,477	3%	5%
	5 persons and more	8,602	-4%	-2%

Source: INSEE-SOeS-INRETS, French National Travel Survey 2007-08

Table 8 – Gap between the estimation of number of individuals with W-ALL, W-UR and W-WAV

		Weight used		
		W-ALL	W-UR	W-WAV
		Number of individuals (in thousands)	Relative difference with W-ALL	Relative difference with W-ALL
Wave of the Survey	May - June 2007	9,362	4%	6%
	July - August 2007	9,362	-7%	-5%
	September - October 2007	9,362	0%	0%
	November - December 2007	9,362	-3%	-2%
	January - February 2008	9,362	0%	0%
	March - April 2008	9,681	2%	2%

Source: INSEE-SOeS-INRETS, French National Travel Survey 2007-08

Table 9 – Gap between the estimation of number of individuals with W-ALL, W-UR and W-CAR

		Weight used		
		W-ALL	W-UR	W-CAR
		Number of individuals (in thousands)	Relative difference with W-ALL	Relative difference with W-ALL
Motorisation	0 car	7,385	2%	4%
	1 car	24,046	-3%	-2%
	2 cars or more	25,062	1%	0%

Source: INSEE-SOeS-INRETS, French National Travel Survey 2007-08

Table 10 – Gap between the estimation of number of individuals with W-ALL, W-UR and W-ZON

		Weight used		
		W-ALL	W-UR	W-ZON
		Number of individuals (in thousands)	Relative difference with W-ALL	Relative difference with W-ALL
Zone of residence	Rural municipalities in a non rural area	7,811	12%	13%
	Rural municipalities in a rural area	6,512	-1%	-1%
	City center of conurbation less than 19 999 inhabitants	7,979	-2%	-1%
	Suburbs of conurbation less than 19 999 inhabitants	1,475	16%	16%
	City center of conurbations 20 000 to 49 999 inhabitants	2,493	-20%	-19%
	Suburbs of conurbations 20 000 to 49 999 inhabitants	977	2%	4%
	City center of conurbations 50 000 to 99 999 inhabitants	2,510	-16%	-14%
	Suburbs of conurbations 50 000 to 99 999 inhabitants	1,361	11%	11%
	City center of conurbations 100 000 to 199 999 inhabitants	1,753	-9%	-6%
	Suburbs of conurbations 100 000 to 199 999 inhabitants	1,322	8%	14%
	City center of conurbations 200 000 to 1 999 999 inhabitants	5,674	-8%	-7%
	Suburbs of conurbations 200 000 to 1 999 999 inhabitants	7,090	0%	1%
	City center of the Paris region	2,016	0%	-3%
	Suburbs of the Paris region	7,520	-1%	-2%

Source: INSEE-SOeS-INRETS, French National Travel Survey 2007-08

The daily mobility is measured with a face to face interview by the description of the mobility made the day before. The protocol does not impose any particular weekday, as the interviewer and the interviewees choose the day of the visit. The relative difference with W-ALL and W-UR confirms that interviewers have difficulties to collect data on households on Mondays and Thursdays. They have therefore more complicatedness to contact households on Tuesday and on Friday. In contrast, Friday is the most describe day, as respondents are more willing to meet interviewers on Saturday. The relative difference with W-ALL and W-UR and W-ALL and W-DAY give similar results for each day. When we remove the "report day" off the calibration, the other variables of the calibration do not adjust properly at the distribution of survey days, e.g 20% for each day. If we use W-DAY we will have some bias in our estimations (the gap W-DAY and W-ALL is not negligible), it is necessary to introduce the reporting day in the calibration.

This is also true for the wave of the survey. As the interviewees are less accessible at their home in summer (probably for holidays), the response rate is lower in July and August. If we use W-WAV we will have some bias in our estimations (the gap W-WAV and W-ALL is not negligible), it is necessary to introduce the wave of the survey in the calibration.

The relative difference with W-ALL and W-AGG shows to us that interviewees are more often woman aged 35 to 65 and less often men aged 6 to 35. When we remove the "age and gender" of the calibration, the other variables of the calibration do not adjust properly the distribution by age and gender. There is no correlation between the variable "age and gender" and the other variables, it is therefore necessary to introduce the information age and gender in the calibration.

The relative difference with W-ALL and W-UR and W-ALL and W-PCS give different results. When we remove the "Professions and Socioprofessional Categories" off the calibration, the other variables of the calibration do not compensate properly the distribution of the "Professions and Socioprofessional Categories". The "Professions and Socioprofessional Categories" must be part of the variable calibration.

IN TERM OF MOBILITY

Table 11 – Gap between the estimation of number of average trips by day with W-ALL, W-X

Mean of the number of trips per day	Relative difference with W-ALL								
	W-ALL	W-UR	W-DAY	W-PCS	W-AGG	W-SHH	W-WAV	W-CAR	W-ZON
3,21		0,04%	0,05%	0,15%	-0,23%	0,05%	0,04%	-0,05%	-0,30%

Source: INSEE-SOeS-INRETS, French National Travel Survey 2007-08

When we look at the number of trips per day for the overall population, the relative difference with W-ALL and all other weights we found similar results except for the "Professions and Socioprofessional Categories", "age and gender" and "zone of residence". For the first, the removal of this variable has the effect of slightly increasing the average number of trips per day. Conversely, the other two variables have the effect of decreasing the mean number of trips per day. The fact that the average number of trips per day is quite similar does not necessarily imply that people who did not respond had the same behaviour in terms of daily mobility. These means are the result of a play of compensation between those who have not responded because they do not perform trips and those who have not responded because they are very mobile.

CONCLUSION

The methods presented in this paper depend on the context of the survey. The analysis of the nonresponse mechanism for calibrations depends on the availability of an exhaustive and up to date sampling base. Working with our National Institute of Statistics, we had the opportunity, of drawing the sample from the census. This is not always the case, as in certain countries, drawing samples from the census is forbidden for privacy reasons. We found that the best explanatory factors of total nonresponse are the zone of residence, the survey period, age &

gender of the head of the households, the households car fleet and the size of the households. It is important to minimize the biases due to measurement errors by a calibration on margins using the variables that play a role in the response mechanism.

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