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Non-observation bias in an address-register-based CATI/CAPI mixed mode survey

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Summary

In this article we study bias due to not observed sample members in a mixed mode survey, whose sample was drawn from an address-based population register. While the primary survey mode was the landline, households with no matched telephone number received a face-to-face visit. We distinguish bias from (landline) undercoverage, non-contact, and non-cooperation. Bias from non-contact and non-cooperation are distinguished by including or not the face-to-face sample members. In addition we analyze the fieldwork phase to recruit households (to complete the household grid) and the phase to recruit persons (to complete individual questionnaires) in participating households separately. Data comes from the 2013 refreshment sample of the Swiss Household Panel.

The strongest socio-demographic composition bias of the sample in the household recruitment phase is due to telephone undercoverage, which the face-to-face mode. In the combined telephone / face-to-face sample, while bias from noncontact is small, bias from non-cooperation is high in the telephone and the combined sample. The latter reduces the advantage to add the face-to-face mode somewhat. In the person recruitment phase, existing bias from the household recruitment phase remains constant. We give recommendations on the treatment of person groups who are more likely to drop out during fieldwork, depending on the reason for nonresponse and survey mode.

Key words: mixed mode, telephone number matching, paradata, coverage, contact, cooperation, representation bias.

Non-observation bias in an address-register-based CATI/CAPI mixed mode survey

Oliver Lipps[1]

1. Household composition bias from non-observation in surveys with telephone as main mode

Landline telephone surveys are challenged by a growing undercoverage bias. This results from a dramatic increase in the proportion of "mobile-only" households (Mohorko et al. 2013) and an increasing proportion of individuals who no longer wish to be listed in a public directory (Blumberg and Luke 2014, Ernst Staehli 2012, Joye et al. 2012, Link and Fahimi 2013, Von der Lippe et al. 2011). For example Brick, Williams, and Montaquila (2011), using commercial sources to match telephone numbers to an address-based sample in the US, achieved a 57% telephone matching rate. The Swiss Federal Statistical Office (SFSO) matches register-based samples against its own register of telephone numbers, which includes both publicly listed and unlisted landline numbers. SFSO matching rates of randomly sampled individuals average to 76% (Joye 2012). A comparable Swiss telephone survey, which is based on register-based samples but uses additional sources of telephone numbers like commercial databases instead of unlisted landline numbers2, reports a matching rate of 86% (Lipps and Kissau 2012). Undercoverage is compounded by the fact that people with and without a listed landline telephone number differ on socio-demographic (Busse and Fuchs 2012, Cobben and Bethlehem 2005, Lipps and Kissau 2012, Mohorko et al. 2013) and substantive variables such as political interest (Joye et al. 2012, Mohorko et al. 2013). To mitigate problems from growing telephone undercoverage, survey organizations increasingly resort to using additional survey modes to approach sample members without access to the primary mode (e.g., de Leeuw 2005). However knowledge about the extent to which sample representation can be improved due to the inclusion of additional survey modes is scarce.

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[2] The SFSO does not provide unlisted telephone numbers to commercial survey agencies.

In this research, we analyze socio-demographic representation bias from nonobservation in a survey, which adds the face-to-face mode to the (main) telephone mode for households without a landline. Specifically, we are interested in to what extent 1. the additional mode is able to decrease errors from undercoverage in the telephone sample, and 2. the two main components of nonresponse, non-contact and non-cooperation, can be decreased by adding the face-to-face mode. To distinguish non-contact and non-cooperation is not common in the literature (e.g., Peytchev et al. 2011; but see Olson 2007), even though this distinction has been mentioned already a long time ago (Deming 1947).

The article is organized as follows. First, we introduce the data and the socio-demographic frame variables. Next, we compare the distributions of the frame variables in the total sample with those in the telephone covered sample, in the contacted sample, and in the cooperating sample. These analyses are distinguished by mode (telephone alone versus combined telephone/face-to-face) and whether the variable relates to the household or the individual level. The recruitment of the household (to enumerate all members) and of all enumerated household members (to ask them to do an individual interview) is investigated separately. We conclude with recommendations for fieldwork.

2. Data

We use call data information from the 2013 refreshment sample (SHP III) of the Swiss Household Panel (SHP), a nationwide, yearly panel survey, with centralized telephone as main survey mode. The SHP started in 1999 with slightly more than 5,000 randomly selected households. Each year, a household reference person, an adult with sufficient knowledge of the household, is asked to first report the current household composition in the grid questionnaire. Conditional on the completion of the grid questionnaire, each enumerated household member from a certain age on completes his or her own individual questionnaire.

The Swiss Federal Statistical Office (SFSO) drew the refreshment sample SHP III at random from the national register of individuals residing in Switzerland. The SHP III total sample comprises 11,111 persons aged 16 years and over[3] of which a random subsample of 9,048 persons was fielded. All members living in the same household as the sampled individuals were identified via the household identifier. The register

[3] We dropped four cases because they were surveyed using the web mode or could not be matched with call data.

provides demographic information about all household members such as sex, age, nationality, civil status, and municipality, but no telephone numbers. These needed to be searched separately and matched to the sample. The SFSO matched the sample against its own register of telephone numbers. 7,396 (66.6%) households with publicly listed landline numbers were matched of which 6,068 were fielded. Households with no matched number were approached using face-to-face interviewers. All household members from the age of 16 years on were eligible for an interview in the first wave of the SHP III households considered here.

We use the following variables available from the sampling frame:

- Age groups: 16-30 years, 31-44 years, 45-58 years, 59-72 years, 73+ years,
- Nationality: Swiss or Swiss born, foreigners from one of the neighboring countries sharing one of the Swiss national languages, other foreigners (Lipps et al. 2013),
- Civil status: single and never married (hereafter referred to as single), married (including separated), divorced, widowed,
- Sex,
- Language region: Swiss-German, French, Italian,
- Size of municipality of residence, representing the degree of urbanization: more than 100,000 inhabitants, 20-100,000 inhabitants, 10-20,000 inhabitants, 5-10,000 inhabitants, 2-5,000 inhabitants, less than 2,000 inhabitants,
- Living in a household with 1 person, 2 persons, 3 persons, 4 persons, 5 or more persons,
- If children are in the household, the age of youngest child: 0-2 years, 3-6 years, 7-17 years.

Note that in the SHP, a household is defined as all people living together for a longer time span, having at least one common meal per weak, and – perhaps most important – for whom the flat/house in question is their principal residence.

3. Household grid level

Starting with the total (target) sample, we analyze the changed frame variable distributions in the different samples in each recruitment step. We distinguish the frame variables according to whether they relate to the household level (language[4], municipality size, household size, and children in the household), or the individual level (age, nationality, civil status, and sex). Distributions of the household frame variables are listed in Table 1, of the individual frame variables in Table 2. As a reading example in Table 1, we find that while 34.2% of all households in the total sample drawn from the sampling frame (column: "Total") are one-person households, this is true for only 24.2% of the cooperating telephone households. Note that because the sample of fielded households (column "Fielded All") is a random subsample of the all households (column: "Total"), the socio-demographic composition of these two samples are very similar. The same is true for the fielded telephone households (column: "Fielded CATI"), which are a random subsample of the telephone matched households (column: "Tele. matched").

We measure representation bias from the different errors of nonobservation for each socio-demographic variable. To do this, we calculate the p-value of a higher chi^2–statistic, which tests the difference between the target distribution (column "Total") and the distribution resulting from the respective nonobservation reason. For example, the target sample and the telephone matched sample in terms of language groups are different at the 90% significance level. Of course the samples in the different recruitment steps are in general very similar to the target sample (the household size distribution in the cooperation telephone sample is with a significance level of 26% the most different from the target sample). We consider a change of more than 0.1 via-à-vis the sample from the previous recruitment step as a substantial change and print these p-values in bold. As an example, between the fielded and the contacted telephone sample, in terms of household size, the p-values drop by 0.15 (from 0.87 to 0.72 in Table 1). This means that noncontact errors increase the representation bias of the telephone sample in terms of household size "substantially". Conversely, noncooperation during the household recruitment phase *improves* the representation of the telephone sample in terms of age (p-value increases from 0.35 to 0.53 in Table 2). The sum of these p-values is depicted in the 2nd last row ("Sum of diff. to total sample").

[4] In only 3 households (with 12 individuals of age 16 years or older), different communication languages are recoded for at least two household members. We therefore treat language as a household variable.

Table 1: Errors of nonobservation: Household variables during household recruitment phase.

[%]	Total	Tele. match	Fielded All	Fielded CATI	Contact All	Cont. CATI	Coop. All	Coop. CATI
1 Person	34.2	28.8	34.0	29.0	31.8	27.5	26.6	24.2
2 Persons	32.2	34.3	32.5	34.5	33.3	35.3	33.7	34.8
3 Persons	14.4	14.7	14.6	15.0	14.8	14.9	15.5	15.4
4 Persons	13.0	14.9	12.7	14.5	13.6	15.0	16.5	17.5
5+ Persons	6.3	7.2	6.2	7.1	6.5	7.3	7.7	8.1
P-value: Diff. to Total		**0.84**	1.00	0.87	0.99	**0.72**	**0.54**	**0.26**
HH w/o children under 18	75.8	75.5	75.9	75.8	74.7	75.0	71.1	71.5
HH w. youngest child 0-2	5.3	4.1	5.3	4.2	5.5	4.2	6.0	4.9
HH w. youngest child 3-6	5.8	5.3	5.7	5.1	5.9	5.3	6.6	6.1
HH w. youngest child 7-17	13.1	15.1	13.1	14.9	13.9	15.5	16.4	17.5
P-value: Diff. to Total		**0.89**	1.00	0.91	0.99	0.87	**0.72**	**0.62**
Language Swiss-German	70.9	72.8	70.8	72.5	70.9	73.1	72.2	73.1
Language French	24.1	22.7	24.1	23.1	24.4	22.5	23.2	22.1
Language Italian	5.0	4.4	5.1	4.4	4.7	4.4	4.7	4.8
P-value: Diff. to Total		0.90	1.00	0.93	0.99	0.88	0.96	0.89
Municipality size >100K	15.5	13.0	15.3	13.2	14.4	12.8	13.1	12.6
Municipality size 20-100K	15.6	14.7	15.5	14.7	15.2	14.6	15.1	15.0
Municipality size 10-20K	17.0	16.9	17.1	16.9	17.5	17.2	17.5	17.0
Municipality size 5-10K	17.5	18.1	17.8	18.5	17.9	18.3	17.5	17.6
Municipality size 2-5K	20.5	21.6	20.2	21.1	20.7	21.5	21.9	22.0
Municipality size <2K	13.9	15.6	14.0	15.6	14.3	15.7	14.9	15.8
P-value: Diff. to Total		0.98	1.00	0.98	1.00	0.97	0.99	0.97
Sum of P-values		3.62	4.00	3.69	3.97	3.44	3.22	2.74
N (households)	11,110	7,396	9,051	6,068	7,874	5,570	4,064	3,288

Source: SHP III (2013 refreshment sample). bold: change of more than 0.1 via-à-vis the previous sample

We first discuss household variables (Table 1) before we turn to individual variables (Table 2). With respect to landline coverage (column “Tele. match”), one-person households are underrepresented. Surprisingly, also households with small children under the age of 3 years are harder to match. This is in contrast to larger households containing four or more persons or households with children over the age of 6 years. As a consequence, telephone matched households are larger on average.

As for representation bias due to noncontact errors in the telephone sample (column “Cont. CATI”), we find that one-person households continue to increase their underrepresentation.

Concerning non-cooperation errors (columns “Coop.”), one-person households still continue to be underrepresented, this time both in the telephone and in the combined sample. Again this is to the contrary for households with four or more persons. In addition, households without children under the age of 18 years increase their underrepresentation, and households with children their overrepresentation due to errors of non-cooperation, again both in the telephone and in the combined sample.

Generally, the telephone samples are more biased than the samples which include face-to-face. Nevertheless, while the step from all fielded to all contacted households is not affected by an increased representation error (from a maximum value of 4.00 to 3.98 across all variables; see 2nd last row), there is a strong drop (to a value of 3.22) in the combined sample of cooperating households. This means that – unlike noncontact errors – non-cooperation errors cause representation bias not only in the telephone sample but also in the combined sample.

Table 2: Errors of nonobservation: Individual variables during household recruitment phase.

[%]	Total	Tele. match	Fielded All	Fielded CATI	Contact All	Cont. CATI	Coop. All	Coop. CATI
16-30 years old	22.1	18.4	22.0	18.4	21.1	17.9	20.8	18.5
31-44 years old	24.1	19.2	24.0	18.9	23.0	18.5	22.3	19.4
45-58 years old	25.2	27.1	25.2	27.2	25.5	27.1	26.7	27.7
59-72 years old	17.6	21.4	17.7	21.4	18.6	21.9	19.7	22.4
73+ years old	11.0	14.0	11.1	14.1	11.8	14.6	10.5	12.0
P-value: Diff. to Total		**0.49**	1.00	0.46	0.99	**0.35**	0.97	**0.53**
Swiss or Swiss-born	79.2	85.9	79.0	85.4	80.3	86.0	84.1	88.1
From neighbour. country	8.1	6.1	8.1	6.3	7.5	6.1	6.7	5.8
From another country	12.7	8.0	12.9	8.3	12.2	7.9	9.1	6.0
P-value: Diff. to Total		**0.25**	1.00	0.30	0.96	0.24	**0.46**	**0.07**
Singles	33.1	28.6	33.1	28.8	31.4	27.7	30.1	27.5
Married	52.7	56.9	52.9	56.9	54.7	58.0	57.6	60.0
Widowed	5.2	6.2	5.1	6.2	5.4	6.4	4.4	4.8
Divorced	9.0	8.2	8.9	8.2	8.5	7.9	7.9	7.6
P-value: Diff. to Total		**0.75**	1.00	0.76	0.98	**0.61**	**0.80**	0.53
Women	50.3	51.5	50.3	51.5	50.9	51.8	51.0	51.4
Men	49.7	48.5	49.7	48.5	49.1	48.2	49.0	48.6
P-value: Diff. to Total		**0.81**	1.00	0.81	0.90	0.76	0.89	0.83
Sum of P-values		2.30	4.00	2.34	3.84	1.96	3.12	1.96
N (persons)	21,264	15,067	17,330	12,309	15,349	11,426	8,284	6,913

Source: SHP III (2013 refreshment sample). bold: change of more than 0.1 via-à-vis the previous sample.

Also in terms of individual frame variables (Table 2), the telephone matched samples are more biased than the samples which include face-to-face and this is mostly due to the first step already (transition from total sample to telephone matched / CATI fielded households). This shows that the strongest bias is due to unmatched households, and this bias holds for all frame variables considered.

Although comparatively few individuals are lost due to non-contact in the telephone mode, the increased bias for age and civil status is relatively large. Although many more individuals are lost due to non-contact in the combined sample, the bias increases only marginally (from 4.00 to 3.84).

When older people are asked to cooperate, they drop out more in the telephone sample which however improves representation (change from 0.35 to 0.53 with respect to bias in age). As for nationality, representation becomes worse in both the telephone and in the combined sample, predominantly because of a higher refusal by foreigners and in particular those from another than a neighboring country. In addition, representation in terms of civil status worsens in the combined sample. In line with the bias in age, this is because more widowed people refuse to cooperate in this sample. Overall, there is an increasing difference to the total sample in both the telephone and the combined samples. While the strongest difference to the total sample for the telephone sample is due to unmatched households, for the combined sample this is due to non-cooperation. So the advantage of a strongly reduced bias when including face-to-face decreases during the household recruitment phase, especially when it comes to obtaining cooperation.

4. Person level

We now turn to representation bias in terms of individual variables due to selective losses of interview eligible persons in households with a completed grid questionnaire. Similar to Tables 1 and 2 for the household recruitment phase, we list results for the person recruitment phase in Table 3. Generally all enumerated individuals from the age of 16 years on are eligible to be interviewed. In addition we depict the distribution of selected variables according to SFSO statistics.

Table 3: Individual distribution: Person recruitment phase.

[%]	Total	Fielded All	Fielded CATI	Contact All	Cont. CATI	Coop. All	Coop. CATI	SFSO [5]
16-30 years old	22.1	20.1	18.2	20.0	18.1	21.3	19.3	21.6
31-44 years old	24.1	22.4	19.9	22.4	19.9	23.6	20.9	24.3
45-58 years old	25.2	26.8	27.6	26.7	27.5	26.6	27.6	25.6
59-72 years old	17.6	20.2	22.4	20.3	22.7	19.5	22.1	17.9
73+ years old	11.0	10.6	11.8	10.6	11.9	8.9	10.0	10.6
P-value: Diff. to Total		0.94	**0.56**	0.93	0.52	0.95	**0.69**	
Swiss or Swiss born	79.2	84.3	87.5	84.5	87.7	84.8	88.4	
From neighboring country	8.1	6.9	6.2	6.8	6.0	6.6	5.8	
From another country	12.7	8.8	6.3	8.7	6.2	8.6	5.8	
P-value: Diff. to Total		**0.43**	**0.10**	0.40	0.09	0.37	0.06	
Singles	33.1	28.8	26.8	28.7	26.6	29.6	27.4	31.9
Married	52.7	58.7	60.5	58.9	60.8	59.2	61.4	53.6
Widowed	5.2	4.4	4.9	4.4	4.8	3.8	4.2	5.2
Divorced	9.0	8.0	7.8	8.0	7.8	7.4	7.1	9.3
P-value: Diff. to Total		**0.69**	**0.47**	0.67	0.44	0.61	0.39	
Women	50.3	51.4	51.8	51.5	51.9	51.7	52.2	50.8
Men	49.7	48.6	48.2	48.5	48.1	48.3	47.8	49.2
P-value: Diff. to Total		**0.83**	**0.76**	0.81	0.75	0.78	0.70	
Sum of P-values		2.88	1.89	2.82	1.80	2.70	1.85	
N (persons)	21,264	7,839	6,793	7,706	6,668	6,174[6]	5,248	

Source: SHP III (2013 refreshment sample).

During the person recruitment phase, the bias from the previous steps (until household cooperation is obtained) stays about the same, although the number of people lost when trying to obtain cooperation is considerable. Accordingly, there are only small distribution changes across the different steps of the person recruitment phase.

As for representation of the final cooperating sample, we find that the combined sample is less biased than the telephone sample. This is true whether the final cooperating sample is compared with the total sample or with the population statistics from the SFSO (see last column in Table 3). First, in terms of age, the combined sample represents the target population well with the exception of old people who are unterrepresented mainly due to their higher refusal rates. The telephone sample has more differences to the target sample in the single age categories but represents older people better. The most underrepresented group are foreigners, in particular those

[5] Distribution in 2013 of selected variables according to population statistics from the SFSO.

[6] 6,090 individuals, of whom 15 are not contained in the call data, completed the individual questionnaire. Another 77 individuals, who cooperated according to the call data, ultimately refused. 22 individuals are only contained in the call data but did not complete an individual questionnaire. We defined cooperation according to the call data information, N = (6,090-15) + 77 + 22 = 6,174 cooperating people.

from another than a neighboring country, especially in the telephone sample. Also single, divorced and widowed people are underrepresented.

5. Summary and conclusion

The aim of this paper is to examine effects on sample composition following from the different reasons for nonobservation in a mixed-mode household survey. We used a landline/face-to-face mixed mode survey, where the landline was the mode used if a listed number could be matched and face-to-face otherwise. We were especially interested in the effects of adding the face-to-face mode on the sample composition at the different steps of nonobservation: 1) finding (listed) telephone numbers, 2) making contact, and 3) obtaining cooperation. We distinguished the phase to recruit households (where all nonobservation steps are relevant) and the phase to recruit interview eligible individuals (where steps 2) and 3) are relevant). In addition to the fact that the sample was drawn from a register of individuals which includes basic socio-demographic variables, the innovation of this research is that all household members are included in the register. This allows for the analysis of both individual and household characteristics in the samples resulting from each step.

We find that people from one-person households and those with small children at home, young adults, men, and foreigners are more difficult to be matched to the telephone register, while the opposite is true especially for those living in large households, Swiss citizens, married and older people. During the household recruitment phase, this bias tends to increase with additional recruitment steps. Because there is no undercoverage in the combined telephone / face-to-face sample, the undercoverage bias is 0 in the first step. Adding the face-to-face mode also pays off in the second step, because bias from noncontact is small in the face-to-face sample. However, bias from non-cooperation is relatively large in the face-to-face sample for household variables, and larger than in the CATI sample for individual variables. This means that the benefit of adding the face-to-face mode decreases to some extent when trying to obtain cooperation. During the recruitment of eligible individuals in cooperating households, existing bias from the household recruitment phase remains more or less constant. The sample weights provided with the data are designed to correct for this bias, and data users should use these weights when analyzing the SHP data.

As for fieldwork related consequences, to correctly represent the population socio-demographically, our findings imply that to include the face-to-face mode for

households without a landline telephone is crucial. Only non-cooperation causes a similarly high additional bias in the telephone and in the combined samples.
It is important to keep telephone non-contact to a minimum because already a small number of not contacted telephone households can cause a substantial bias. During the household recruitment phase, in particular one-person households (and – correlated – households without children under the age of 18) fall out of the sample, both when trying to establish contact and to obtain cooperation. This is true for both the telephone and in particular the face-to-face sample. The same holds for foreign households and especially those from countries not sharing one of the Swiss national languages. These household groups should be treated with special care especially in the face-to-face mode. Ideas are to send the more successful or ethnic interviewers to these households (Laganà et al. 2013), or to use an extra incentive.
During the person recruitment phase, the bias already existing in the sample of enumerated people (household grid) remains largely constant until cooperation to complete an individual questionnaire is obtained. Exceptions are older and divorced people, who are lost to a higher extent when they are asked to cooperate. This holds for both survey modes. To some extent, also foreigners from countries not sharing one of the Swiss national languages are lost in the telephone sample in this step. This means again that care should be taken not to lose these people during the step of obtaining cooperation. Possibly similar measures than for the "critical" households during the household recruitment phase should be taken.

At the end we add some limitations of this paper. Evidently, bias can only be analyzed for the representativity of the socio-demographic variables available from the population register. While these variables reflect household at-home patters and are suitable to analyze noncontact, non-cooperation depends on social participation and interest in societal well-being (Stoop 2005), for which socio-demographic variables are "fallible: they are correlates, not causes of the survey participatory behavior" (Groves and Couper 1996, p.81).
In addition, the composition of the samples after losses from the different reasons for nonobservation of course depends on the fieldwork effort from the previous steps, including the sources used to maximize the number of households with a matched telephone number. Effects from the different modes depend on possible fieldwork effort differences between these modes. Nevertheless we think that our research sheds more light on the characteristics of sample members lost at the different steps during the survey recruitment phases, and shows at which steps special care should be taken to keep socio-demographic representation bias at a reasonable level.

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